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Chemistry

ICSE 10

Focused Theory | In-Text Exercises | Chapter Exercises | Past Exams' Questions | Sample Papers

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All in one ICSE Chemistry Class 10 has been written keeping in mind the needs of students studying in 10th ICSE. This book has been made in such a way that students will be fully guided to prepare for the exam in the most effective manner, securing higher grades.

The purpose of this book is to aid any ICSE student to achieve the best possible grade in the exam. This book will give you support during the course as well as advice you on revision and preparation for the exam itself. The material is presented in a clear & concise form and there are ample questions for practice.

KEY FEATURES

- **Focused Theory** Each chapter contains the necessary study material well supported by Definitions, Facts, Figure, etc.
- **Solved Examples** Solved Examples have been given with each concept. The Special point about these examples is, they have been given in such a way that they cover all the aspects of a concept.
- **Check Point** These are intext exercises given between the text material. These exercises have 4-5 questions based on the related concept.
- **Summary** At the end of each chapter, Summary is given. It contains crux of the chapter in pointer form that provides the quick revision of the whole chapter.
- **Exam Practice** This exercise contains questions in that format in which these are asked in the examinations. Questions have been categorised as Fill in the Blanks, MCQs, Match the Following, Very Short Answer, Short Answer and Long Answer Type Questions. All the questions given here are fully solved.
- **Chapter Exercise** It is the Assessment exercise for the complete chapter. With this exercise, students can assess their understanding of the chapter and can prepare for it accordingly.
- **Challengers** It includes some special questions based on the pattern of olympiad and other competitions to give the students a taste of the questions asked in competitions. These are not meant for school examinations.
- To make this book complete in all aspects, **Experiments** and **5 Sample Questions Papers** based on the exam pattern & syllabus have also been given.
- At the end of book there are **Latest ICSE Solved Papers** and **Latest ICSE Specimen Papers.**

At the end it can be said that **All in one** Chemistry for ICSE 10th has all the material required for examination and will surely guide students to the Way to Success.

We are highly thankful to ARIHANT PRAKASHAN, MEERUT for giving us such an excellent opportunity to write this book. The role of Arihant DTP Unit and Proof Reading team is praise worthy in making of this book.

Huge efforts have been made from our side to keep this book error free, but inspite of that if any error or whatsoever is skipped in the book then that is purely incidental, apology for the same, please write to us about that so that it can be corrected in the further edition of the book. Suggestions for further improvement of the book will also be welcomed & incorporated in further editions.

In the end, we would like to wish BEST OF LUCK to our readers!

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COURSE STRUCTURE

*There will be one paper of **two hours** duration of 80 marks and Internal Assessment of practical work carrying 20 marks.*

The paper will be divided into two sections, Section I (40 marks) and Section II (40 marks).

Section I (compulsory) will contain short answer questions on the entire syllabus.

Section II will contain **six** questions. Candidates will be required to answer any **four** of these six questions.

***Note:** All chemical process/reactions should be studied with reference to the reactants, products, conditions, observations, the (balanced) equations and diagrams.*

1. PERIODIC PROPERTIES AND VARIATIONS OF PROPERTIES - PHYSICAL AND CHEMICAL

(i) Periodic properties and their variations in groups and periods.

Definitions and trends of the following periodic properties in groups and periods should be studied:

- *atomic size*
- *metallic character*
- *non-metallic character*
- *ionisation potential*
- *electron affinity*
- *electronegativity*

(ii) Periodicity on the basis of atomic number for elements.

- The study of modern periodic table up to period 3 (students to be exposed to the complete modern periodic table but no questions will be asked on elements beyond period 3 - Argon);
- Periodicity and other related properties to be explained on the basis of nuclear charge and shells (not orbitals).

Special reference to the alkali metals and halogen groups.

2. CHEMICAL BONDING

Electrovalent, covalent and co-ordinate bonding, structures of various compounds, Electron dot structure.

(i) Electrovalent bonding

- *Electron dot structure of Electrovalent compounds NaCl, $MgCl_2$, CaO.*
- *Characteristic properties of electrovalent compounds – state of existence, melting and boiling points, conductivity (heat and electricity), dissociation in solution and in molten state to be linked with electrolysis.*

(ii) Covalent Bonding

- *Electron dot structure of covalent molecules on the basis of duplet and octet of electrons (example: hydrogen, chlorine, nitrogen, ammonia, carbon tetrachloride, methane.*
- *Polar Covalent compounds based on difference in electronegativity:*
  Examples - HCl and H_2O including structures.
- *Characteristic properties of Covalent compounds – state of existence, melting and boiling points, conductivity (heat and electricity), ionisation in solution.*

Comparison of Electrovalent and Covalent compounds.

(iii) Coordinate Bonding

- *Definition*
- *The lone pair effect of the oxygen atom of the water molecule and the nitrogen atom of the ammonia molecule to explain the formation of H_3O^+ and OH^- ions in water and NH_4^+ ion.*

The meaning of lone pair; the formation of hydronium ion and ammonium ion must be explained with help of electron dot diagrams.

3. STUDY OF ACIDS, BASES AND SALTS

(i) Simple definitions in terms of the molecules and their characteristic properties.

(ii) Ions present in mineral acids, alkalis and salts and their solutions; use of litmus and *p*H paper to test for acidity and alkalinity.

- *Examples with equation for the ionisation/dissociation of ions of acids, bases and salts.*
- *Acids form hydronium ions (only positive ions) which turn blue litmus red, alkalis form hydroxyl ions (only negative ions) with water which turns red litmus blue.*
- *Salts are formed by partial or complete replacement of the hydrogen ion of an acid by a metal. (To be explained with suitable examples).*
- *Introduction to pH Scale to test for acidity, neutrality and alkalinity by using pH paper or Universal indicator.*

(iii) Definition of salt; types of salts.

Types of salts: normal salts, acid salt, basic salt, definition and examples.

(iv) Action of dilute acids on salts.

Decomposition of hydrogen carbonates, carbonates, sulphites and sulphides by appropriate acids with heating if necessary. (Relevant laboratory work must be done.)

(v) Methods of preparation of Normal salts with **relevant equations.** (Details of apparatus or procedures not required.

Methods included are:

- *Direct combination*
- *Displacement*
- *Precipitation (double decomposition)*
- *Neutralisation of insoluble base*
- *Neutralisation of an alkali (titration)*
- *Action of dilute acids on carbonates and bi-carbonates.*

4. ANALYTICAL CHEMISTRY

(i) Action of Ammonium Hydroxide and Sodium Hydroxide on solution of salts: colour of salt and its solution; formation and colour of hydroxide precipitated for solutions of salts of Ca, Fe, Cu, Zn and Pb; special action of ammonium hydroxide on solutions of copper salt & sodium hydroxide on ammonium salts.

On solution of salts:

- *Colour of salt and its solution.*
- *Action on addition of Sodium Hydroxide to solution of Ca, Fe, Cu, Zn and Pb salts drop by drop in excess. Formation and colour of hydroxide precipitated to be highlighted with the help of equations.*
- *Action on addition of Ammonium Hydroxide to solution of Ca, Fe, Cu, Zn and Pb salts drop by drop in excess. Formation and colour of hydroxide precipitated to be highlighted with the help of equations.*
- *Special action of Ammonium Hydroxide on solutions of copper salts and sodium hydroxide on ammonium salts.*

(ii) Action of alkalies (NaOH, KOH) on certain metals, their oxides and hydroxides.

The metals must include aluminium, zinc and lead, their oxides and hydroxides, which react with caustic alkalies (NaOH, KOH), showing the amphoteric nature of these substances.

5. MOLE CONCEPT AND STOICHIOMETRY

(i) Gay Lussac's Law of Combining Volumes; Avogadro's Law.

- *Idea of mole – a number just as a dozen, a gross (Avogadro's number).*
- *Avogadro's Law statement and explanation.*
- *Gay Lussac's Law of Combining Volumes– Statement and explanation.*
- *Understanding molar volume- "the mass of 22.4 litres of any gas at S.T.P. is equal to its molar mass". (Questions will not be set on formal proof but may be taught for clear understanding).*
- *Simple calculations based on the molar volume and Gay Lussac 's law.*

(ii) Refer to the atomicity of hydrogen, oxygen, nitrogen and chlorine (proof not required).

The explanation can be given using equations for the formation of HCl, NH_3 and NO.

(iii) Vapour Density and its relation to relative molecular mass:

- *Molecular mass = 2× vapour density (formal proof not required)*
- *Deduction of simple (empirical) and molecular formula from:*
  - *(a) the percentage composition of a compound.*
  - *(b) the masses of combining elements.*

(iv) Mole and its relation to mass.

- *Relating mole and atomic mass; arriving at gram atomic mass and then gram atom; atomic mass is a number dealing with one atom; gram atomic mass is the mass of one mole of atoms.*

- *Relating mole and molecular mass arriving at gram molecular mass and gram molecule– molecular mass is a number dealing with a molecule, gram molecular mass is the mass of one mole of molecules.*
- *Simple calculations based on relation of mole to mass, volume and Avogadro's number.*

(v) Simple calculations based on chemical equations

Related to weight and/or volumes of both reactants and products.

6. ELECTROLYSIS

(i) Electrolytes and non-electrolytes.

Definitions and examples.

(ii) Substances containing molecules only, ions only, both molecules and ions.

- *Substances containing molecules only ions only, both molecules and ions.*
- *Examples; relating their composition with their behaviour* ***as strong and weak electrolytes as well as non-electrolytes.***

(iii) Definition and explanation of electrolysis, electrolyte, electrode, anode, cathode, anion, cation, oxidation and reduction (on the basis of loss and gain of electrons).

(iv) An elementary study of the migration of ions, with reference to the factors influencing selective discharge of ions (reference should be made to the activity series as indicating the tendency of metals, e.g. (Na, Mg, Fe, Cu) to form ions) illustrated by the electrolysis of:

- *Molten lead bromide*
- *acidified water with platinum electrodes*
- *Aqueous copper (II) sulphate with copper electrodes; electron transfer at the electrodes.*

The above electrolytic processes can be studied in terms of electrolyte used, electrodes used, ionization reaction, anode reaction, cathode reaction, use of selective discharge theory, wherever applicable.

(v) Applications of electrolysis:

- *Electroplating with nickel and silver, choice of electrolyte for electroplating.*
- *Electro refining of copper;*

Reasons and conditions for electroplating, names of the electrolytes and the electrodes used should be given. Equations for the reactions at the electrodes should be given for electroplating, refining of copper.

7. METALLURGY

(i) Occurrence of metals in nature:

- *Mineral and ore - Meaning only.*
- *Common ores of iron, aluminium and zinc.*

(ii) Stages involved in the extraction of metals:

(a) Dressing of the ore – hydrolytic method, magnetic separation, froth flotation method.

(b) Conversion of concentrated ore to its oxide– roasting and calcination (definition, examples with equations).

(c) Reduction of metallic oxides–some can be reduced by hydrogen, carbon and carbon monoxide (e.g. copper oxide, lead (II) oxide, iron (III) oxide and zinc oxide) and some cannot (e.g. Al_2O_3, MgO)– refer to activity series). Active metals by electrolysis e.g. sodium, potassium and calcium. (reference only).

Equations with conditions should be given.

(d) Electrorefining – reference only

(iii) Extraction of Aluminium.

(a) Chemical method for purifying bauxite by using NaOH - Baeyer's Process.

(b) Electrolytic extraction - Hall Heroult's process: Structure of electrolytic cell - the various components as part of the electrolyte, electrodes and electrode reactions.

Description of the changes occurring, purpose of the substances used and the main reactions with their equations.

(iv) Alloys – composition and uses

Stainless steel, duralumin, brass, bronze, fuse metal/solder.

8. STUDY OF COMPOUNDS

(i) **Hydrogen Chloride**

Hydrogen chloride: preparation of hydrogen chloride from sodium chloride; refer to the density and solubility of hydrogen chloride (fountain experiment); reaction with ammonia; acidic properties of its solution.

- *Preparation of hydrogen chloride from sodium chloride; the laboratory method of preparation can be learnt in terms of reactants, product, condition, equation, diagram or setting of the apparatus, procedure, observation, precaution, collection of the gas and identification.*
- *Simple experiment to show the density of the gas (Hydrogen Chloride) -heavier than air.*
- *Solubility of hydrogen chloride (fountain experiment); setting of the apparatus, procedure, observation, inference.*

- *Method of preparation of hydrochloric acid by dissolving the gas in water– the special arrangement and the mechanism by which the back suction is avoided should be learnt.*
- *Reaction with ammonia*
- *Acidic properties of its solution – reaction with metals, their oxides, hydroxides and carbonates to give their chlorides; decomposition of carbonates, hydrogen carbonates, sulphides, sulphites.*
- *Precipitation reactions with silver nitrate solution and lead nitrate solution.*

(ii) **Ammonia**

Ammonia: its laboratory preparation from ammonium chloride and collection; ammonia from nitrides like Mg_3N_2 and AIN and ammonium salts. Manufacture by Haber's Process; density and solubility of ammonia (fountain experiment); aqueous solution of ammonia; its reactions with hydrogen chloride and with hot copper II (oxide and chlorine; the burning of – ammonia in oxygen; uses of ammonia.

- *Laboratory preparation from ammonium chloride and collection; (the preparation to be studied in terms of, setting of the apparatus and diagram, procedure, observation, collection and identification)*
- *Ammonia from nitrides like Mg_3N_2 and AIN using warm water.*

  Ammonia from ammonium salts using alkalies.

  The reactions to be studied in terms of reactants, products, conditions and equations.
- *Manufacture by Haber's Process.*
- *Density and solubility of ammonia (fountain experiment).*
- *The burning of ammonia in oxygen.*
- *The catalytic oxidation of ammonia (with conditions and reaction).*
- *Its reactions with hydrogen chloride and with hot copper (II) oxide and chlorine (both chlorine in excess and ammonia in excess).*

  All these reactions may be studied in terms of reactants, products, conditions, equations and observations.
- *Aqueous solution of ammonia – reaction with sulphuric acid, nitric acid, hydrochloric acid and solutions of iron(III) chloride, iron(II) sulphate, lead nitrate, zinc nitrate and copper sulphate.*
- *Uses of ammonia – manufacture of fertilisers, explosives, nitric acid, refrigerant gas (Chlorofluro carbon and its suitable alternatives which are non-ozone depleting) and cleansing* agents.

(iii) **Nitric Acid**

Nitric Acid: one laboratory method of preparation of nitric acid from potassium nitrate or sodium nitrate. Large scale preparation. Nitric acid as an oxidising agent.

- *Laboratory preparation of nitric acid from potassium nitrate or sodium nitrate; the laboratory method to be studied in terms of reactants, products, conditions, equations, setting up of apparatus, diagram, precautions, collection and identification.*
- *Manufacture of Nitric acid by Ostwald's process (Only equations with conditions where applicable).*
- *As an oxidising agent: its reaction with copper, carbon, sulphur.*

(iv) **Sulphuric Acid**

Large scale preparation, its behaviour as an acid when dilute, as an oxidising agent when concentrated – oxidation of carbon and sulphur; as a dehydrating agent – dehydration of sugar and copper (II) sulphate crystals; its non-volatile nature.

- *Manufacture by Contact process Equations with Conditions where applicable).*
- *Its behaviour as an acid when dilute – reaction with metal, metal oxide, metal hydroxide, metal carbonate, metal bicarbonate, metal sulphite, metal sulphide.*
- *Concentrated sulphuric acid as an oxidizing agent – the oxidation of carbon and sulphur.*
- *Concentrated sulphuric acid as a dehydrating agent– (a) the dehydration of sugar (b) Copper (II) sulphate crystals.*
- *Non-volatile nature of sulphuric acid reaction with sodium or potassium chloride and sodium or potassium nitrate.*

9. ORGANIC CHEMISTRY

(i) Introduction to Organic compounds.

- *Unique nature of Carbon atom - tetra valency, catenation.*
- *Formation of single, double and triple bonds, straight chain, branched chain, cyclic compounds (only benzene).*

(ii) **Structure and Isomerism**

- *Structure of compounds with single, double and triple bonds.*
- *Structural formulae of hydrocarbons. Structural formula must be given for: alkanes, alkenes, alkynes up to 5 carbon atoms.*
- *Isomerism – structural (chain,position).*

(iii) **Homologous series** – characteristics with examples.

Alkane, alkene, alkyne series and their gradation in properties and the relationship with the molecular mass or molecular formula.

(iv) **Simple nomenclature**

Simple nomenclature – of the hydrocarbons with simple functional groups – (double bond, triple bond, alcoholic, aldehydic, carboxylic group) longest chain rule and smaliest number for functional groups rule – trivial and IUPAC names (compounds with only one functional group).

(v) **Hydrocarbons** alkanes, alkenes, alkynes.

- *Alkanes – general formula; methane (greenhouse gas) and ethane – methods of preparation from sodium ethanoate (sodium acetate), sodium propanoate (sodium propionate), from iodomethane (methyl iodide) and bromoethane (ethyl bromide). Complete combustion of methane and ethane, reaction of methane and ethane with chlorine through substitution.*
- *Alkenes – (unsaturated hydrocarbons with a double bond); ethene as an example. Methods of preparation of ethene by dehydro halogenation reaction and dehydration reactions.*
- *Alkynes – unsaturated hydrocarbons with a triple bond); ethyne as an example of alkyne; Methods of preparation from calcium carbide and 1,2 dibromoethane ethylene dibromide).*

Only main properties, particularly addition products with hydrogen and halogen namely , Cl_2 , Br_2 and I_2 pertaining to alkenes and alkynes.

- *Uses of methane, ethane, ethene, ethyne.*

(vi) Alcohols: ethanol – preparation, properties and uses.

- *Preparation of ethanol by hydrolysis of alkyl halide.*
- *Properties - Physical: Nature, Solubility, Density, Boiling Points. Chemical: Combustion, action with sodium, ester formation with acetic acid, dehydration with conc. Sulphuric acid to prepare ethene.*
- *Denatured and spurious alcohol.*
- *Important uses of Ethanol.*

(vii) Carboxylic acids (aliphatic–mono carboxylic acid): Acetic acid – properties and uses of acetic acid.

- *Structure of acetic acid.*
- *Properties of Acetic Acid: Physical properties – odour (vinegar), glacial acetic acid (effect of sufficient cooling to produce ice like crystals). Chemical properties – action with litmus, alkalis and alcohol (idea of esterification).*
- *Uses of acetic acid.*

INTERNAL ASSESSMENT OF PRACTICAL WORK

Candidates will be asked to observe the effect of reagents and/or of heat on substances supplied to them. The exercises will be simple and may include the recognition and identification of certain gases and ions listed below. The examiners will not, however, be restricted in their choice to substances containing the listed ions.

Gases: Hydrogen, Oxygen, Carbon dioxide, Chlorine, Hydrogen chloride, Sulphur dioxide, Hydrogen sulphide, Ammonia, Water vapour, Nitrogen dioxide.

Ions: Calcium, Copper, Iron, Lead, Zinc and Ammonium, Carbonate, Chloride, Nitrate, Sulphide, Sulphite and Sulphate.

Knowledge of a formal scheme of analysis is not required. Semi-micro techniques are acceptable but candidates using such techniques may need to adapt the instructions given to suit the size of the apparatus being used.

Candidates are expected to have completed the following minimum practical work:

1. Action of heat on the following substances:
   (a) Copper carbonate, zinc carbonate
   (b) zinc nitrate, copper nitrate, lead nitrate
   Make observations, identify the products and make deductions where possible. (equations not required)
2. Make a solution of the unknown substance: add sodium hydroxide solution or ammonium hydroxide solution, make observations and give your deduction. Warming the mixture may be needed. Choose from substances containing Ca^{2+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Pb^{2+}, Zn^{2+}, NH^{4+}.
3. Supply a solution of a dilute acid and alkali. Determine which is acidic and which is basic, giving two tests for each.
4. Add concentrated hydrochloric acid to each of the given substances, warm, make observations, identify any product and make deductions:
   (a) Copper oxide
   (b) Manganese dioxide.

CHAPTER

1

Periodic Properties and Their Variations

At present, about 118 elements are known to us out of which 98 are naturally occurring. For such a large number of elements it becomes a challenge to study and remember their properties. To overcome this challenge, scientists started looking for some pattern in properties. In this chapter, we will study various attempts, made time-to-time to classify a group the elements and finally we study the modern classification of element *i.e.*, the periodic table.

Chapter Objectives

- Earlier Attempts to Classify the Elements
- Periodicity
- Valency
- Periodic Properties

Earlier Attempts to Classify the Elements

Many attempts were made to classify the elements. *Some of them are given below*

1. Dobereiner's Triads (1817)

According to Dobereiner's, when three elements in a triad were arranged in the increasing order of atomic masses, then the atomic mass of the middle element was roughly the average or arithmetic mean of the atomic masses of other two elements.

He identified groups of three elements having similar properties (called triads) *e.g.*,

Elements	Li Na K	Cl Br I	Ca Sr Ba
Atomic masses	7 23 39	35.5 80 127	40 88 137
Average atomic mass of first and third element	$\frac{7+39}{2}=23$	$\frac{35.5+127}{2}=81.25$	$\frac{40+137}{2}=88.5$

Drawbacks

All the elements discovered at that time could not be classified into triads, only a limited number of elements could be arranged in such triads.

2. Newland's Law of Octaves

In 1866, John Newland, an English scientist, arranged the known elements in the increasing order of atomic masses and found that every eighth element had properties

similar to that of the first. He compared this to the octaves found in music. Therefore, he called it as "**the law of octaves**" *e.g.,*

Newland's Table of Elements Based on Notes of Music

sa(do)	re(re)	ga(mi)	ma(fa)	pa(so)	da(la)	ni(ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	–	–

Drawbacks

The law was applicable upto calcium. After that, every eighth element did not possess the same relationship with respect to the element lying above in the same group.

He thought that there are only 56 elements present on the earth. The conclusion made by him was proved wrong.

Newland's also adjusted two dissimilar elements into the same slot *e.g.,* Cobalt and nickel were in the same slot and these were placed in the same column of fluorine, chlorine and bromine, which have different properties.

3. Mendeleev's Periodic Table

Dmitri Ivanovich Mendeleev, a Russian chemist, was the most important contributor for the early development of a periodic table of elements where elements were arranged on the basis of their fundamental property the atomic mass and also on the similarity of chemical properties. There were 63 elements known at his time.

He then arranged 63 elements in the increasing order of their atomic masses and found that the elements with similar and chemical properties occur at regular intervals. He observed that elements with similar properties fall in the same vertical column. These vertical column are called **groups** and horizontal rows of elements are called **periods**.

On this basis, Mendeleev gave a periodic law, which states that "the properties of elements are a periodic function of their atomic masses".

Special Features of Mendeleev's Periodic Table

(i) This table contains 8 vertical columns, called groups and 7 horizontal rows, called periods.

(ii) He even predicted the existence of those elements which were yet to be discovered *e.g.*, Eka-boron, eka-aluminium, eka-silicon, which after their discoveries were named as scandium, gallium and germanium, respectively.

Properties of Eka-aluminium and Gallium

	Property	Eka-aluminium	Gallium
1.	Atomic mass	68	69.7
2.	Formula of oxide	E_2O_3	Ga_2O_3
3.	Formula of chloride	ECl_3	$GaCl_3$

(iii) In order to group the elements having similar properties together, at some places, he had to place an element with a slightly greater atomic mass before an element with a slightly lower atomic mass.

Drawbacks

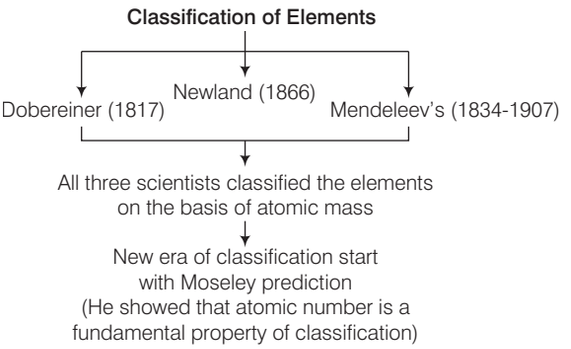
(i) **Position of Hydrogen** The position of hydrogen was not fixed in the Mendeleev's periodic table, but it was kept with alkali metals.

(ii) **Position of Isotopes** In Mendeleev's periodic table, no place was given to isotopes of elements.

(iii) **Uncertainty in Atomic Masses** Another problem was that the atomic masses do not increase in a regular manner on going from one element to the next.

(iv) **Placing of Heavier Element before the Lighter Element** Few elements, those possess higher atomic mass were placed before elements having a lower atomic mass *e.g.,* Argon (39.9) was placed before potassium (39.1).

The main foundation of the three attempts we have studied can be summarised as



CHECK POINT 01

1 What is the need of a periodic table?

2 Give one similarity between Dobereiner's triad and Newland's law of octave.

3 Why did Mendeleev left some gaps in his periodic table?

4 What are horizontal rows and vertical columns in a Mendeleev's periodic table known as?

5 Give one drawback of Mendeleev periodic table.

Modern Periodic Table and Periodic Law

In 1913, Henry Moseley modified the Mendeleev's periodic law. The modified law is called as modern periodic law. It states that "physical and chemical properties of the elements are a periodic function of their atomic numbers". When the elements are arranged in the increasing order of their atomic number, the obtained table is called modern periodic table.

Salient Features of the Modern Periodic Table

Some salient features of the modern periodic table are as follows

Groups

The modern periodic table consists of eighteen vertical columns, called **groups**. Groups are arranged from left to right in the order: I A, II A, III B, IV B, V B, VI B, VII B, VIII (3 columns), I B, II B, III A, IV A, V A, VI A, VII A and zero. But according to the latest recommendations of IUPAC (International Union of Pure and Applied Chemistry) the groups are numbered from 1 to 18 (known as long form of periodic table).

- Group 1 elements are called alkali metals. They form strong alkalies with water.
- Group 2 elements are called alkaline earth metals. They form weaker alkalies as compared to group 1.
- Group 13 elements are known as boron family.
- Group 14 elements are known as carbon family.
- Group 15 elements are known as nitrogen family.
- Group 16 elements are known as oxygen family or chalcogen family.
- Group 17 elements are known as halogen family. They form salts.
- Group 18 (zero group) elements are called noble gases or inert gases. Due to stable electronic configuration, they hardly react with other elements.

The elements of groups 1, 2, 13, 14, 15, 16 and 17 are known as main group elements or representative elements. The outermost shell of all the elements of these groups are incomplete. The elements of groups 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 are known as **transition elements**. They have incomplete outermost shells.

Note Bohr and Burry modified the modern periodic table and gave the extended form of it, known as long form of the modern periodic table.

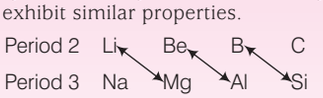
Periods

There are seven horizontal rows in the modern periodic table, called **periods**. The number of shells present in an atom determine its period.

- First period is the shortest period containing only two elements *i.e.*, hydrogen (H) and helium (He).
- Second period is a short period containing eight elements (Li, Be, B, C, N, O, F and Ne).
- Third period is also a short period containing eight elements (Na, Mg, Al, Si, P, S, Cl and Ar).

Diagonal Relationship and Typical Elements

Diagonal Relationship A diagonal relationship is said to exist between certain pairs of diagonally adjacent elements in the second and third period of the periodic table. The pairs Li-Mg, Be-Al, B-Si, etc., exhibit similar properties.



They are also called bridge elements.

Typical Elements The elements which belong to third group are called typical elements. The elements are Na, Mg, Al, Si, P, S and Cl. They represent the properties of their respective groups (groups to which they belongs).

- Fourth and fifth periods are long periods, each containing eighteen elements (atomic numbers 19-36 in the fourth period and atomic numbers 37-54 in the fifth period).
- Sixth and seventh periods are longest period, containing 32 elements (atomic number 55-86).
- In group 3 and period 6, the elements from atomic numbers 57-71 are present which are called lanthanides (rare earth metals).

- In group 3 and period 7, the elements from atomic numbers 89-103 are present which are called actinides (radioactive elements).

CHECK POINT 02

1. How modern periodic law was different from earlier periodic laws?
2. Which elements are known as representative elements?
3. Define diagonal relationship.
4. Name any two noble gases.
5. What is the position of rare earth metals in periodic table?

Periodicity

Elements show a regular variation in both physical and chemical properties within the same group or same period. This constitutes the concept of periodicity. The properties that reappear at regular intervals or in which there is a gradual variation at regular intervals are called **periodic properties** and the phenomenon is called **periodicity**. The cause of periodicity is the recurrence of similar electronic configuration *i.e.*, same number of electrons in the outermost shell as shown below.

Name of Element	Atomic Number	Electronic Configuration			
		K	*L*	*M*	*N*
Hydrogen	1	1			
Lithium	3	2	1		
Sodium	11	2	8	1	
Potassium	19	2	8	8	1

Valency

The combining capacity of the atom of an element is called valency. It entirely depends on the number of valence electrons present in an atom. If the number of electrons present in the outermost shell are 1, 2, 3 or 4, then their valency is 1, 2, 3 or 4 respectively. If the number of electrons present in the outermost shells are 5, 6 or 7, then their valency is $8 - 5 = 3$, $8 - 6 = 2$ and $8 - 7 = 1$, respectively. Thus, valency = 8 − number of valence electrons.

Trends in Valency Down a Group

As we move from top to bottom in a group, the addition of the outermost shell takes place but the number of electrons present in the outermost shell remains the same. Therefore, all elements have the same number of valence electrons or the valency.

Trends in Valency Across a Period

As we move from left to right in a period, the valency first increases and then decreases. And finally becomes zero in case of inert gases.

Elements of 3rd period

Element	Atomic Number	Electronic Configuration	Valency
Na	11	2, 8, 1	1
Mg	12	2, 8, 2	2
Al	13	2, 8, 3	3
Si	14	2, 8, 4	4
P	15	2, 8, 5	3
S	16	2, 8, 6	2
Cl	17	2, 8, 7	1
Ar	18	2, 8, 8	0

Note In the above table, valency increases till atomic number 14 and then decreases upto atomic number 18.

The above table concludes the following points

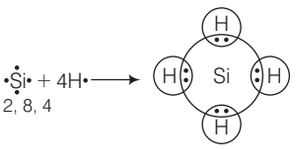
(i) Sodium (Na) has 1, Magnesium (Mg) has 2, Aluminium (Al) has 3 valence electrons. This means that these elements can easily lose electrons to acquire stable electronic configuration of the nearest noble gas *i.e.*, Neon, Ne (2, 8).

$$\underset{2,8,1}{Na} \longrightarrow \underset{2,8}{Na^+} + e^-$$

$$\underset{2,8,2}{Mg} \longrightarrow \underset{2,8}{Mg^{2+}} + 2e^-$$

Therefore, the valency of Na is 1, Mg is 2 and Al is 3.

(ii) Silicon (Si) has four electrons in the valence shell. It can achieve the stable configuration either by losing, gaining or sharing of four electrons. Since, it is not easy to gain or lose electrons. So, it prefers to achieve the stable configuration of the nearest noble gas, Argon, Ar(2, 8, 8) by sharing four electrons.



Thus, silicon (Si) has a valency of 4.
Similarly, phosphorus (P), sulphur (S) and chlorine (Cl) have 5, 6 and 7 electrons in their respective valence shells and thus, need 3, 2 and 1 more electrons respectively to acquire the stable electronic configuration of the nearest noble gas *i.e.*, Ar (2, 8, 8). Therefore, the valency of N is 3, that of sulphur is 2 and that of Cl is 1.

CHECK POINT 03

1. What do you mean by periodicity of elements?
2. Write the electronic configuration of sodium.
3. How change in valency affects the chemical properties?
4. Complete the following. The valency of Si is ..... .
5. Why noble gases usually do not react? Explain with the help of electronic configuration.

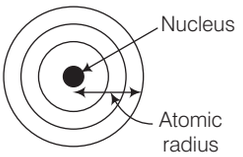
Periodic Properties

The properties which re-occur after a regular interval in periodic table are called periodic properties. According to the modern periodic law, the periodic properties are

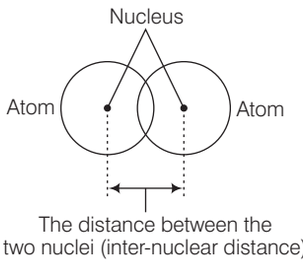
1. Atomic size
2. Metallic character
3. Non-metallic character
4. Ionisation energy
5. Electron affinity
6. Electronegativity

Atomic Size (Atomic Radius)

It refers to the radius of an atom and is defined as the distance between the centre of the nucleus and the outermost shell of an isolated atom.



It is also defined as half the inter-nuclear distance (*i.e.,* the distance between the two nuclei) between the combined atoms in a molecule.



Units Angstrom = 1 Å : 10^{-10} m

Picometer = 1 pm : 10^{-12} m

Dependence of Atomic Radius

The factors on which atomic size or atomic radius depends are as follows

(i) Number of Shells

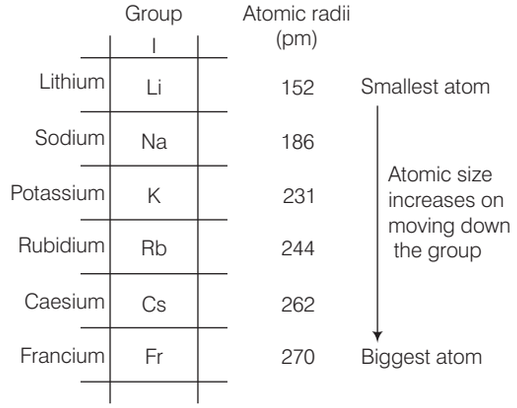
With increase in the number of shells, the atomic radius increases. This is due to the increase in distance between the outermost shell and the nucleus, which decreases the force of attraction between them.

(ii) Nuclear Charge

With increase in nuclear charge, decreases the size of the atom because the electrons are attracted towards the nucleus with a greater force, thereby bringing the outermost shell closer to the nucleus.

Trends in Atomic Radius Down a Group

On moving from top to bottom in a group, size of an atom increases due to the successive addition of shells. This increases the distance between the outermost electrons and the nucleus such that the atomic size increases inspite of the increase in nuclear charge.



Trends in Atomic Radius Across a Period

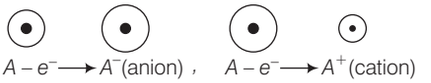
The atomic radius decreases on moving from left to right across a period. This is due to an increase in nuclear charge which tends to pull the valence electrons closer to the nucleus and reduces the size of the atom *e.g.,*

Third period elements :	Na	Mg	Al	Si	P	S	Cl
Atomic radii (pm):	186	160	143	118	110	104	99

Size of atoms decreases

Na Mg Al Si P S Cl

Example 1. Why cation is smaller and anion is larger than parent atom?



Sol. An anion is formed by the gain of electrons from parent atom. The number of protons remain the same in the anion as of parent atom. Thus, the nuclear force of attraction for the outer electrons reduces and hence, the distance between nucleus and outer electrons increases due to which anion is larger than its parent atom.

e.g., $\underset{(2,8,7)}{Cl} + e^- \longrightarrow \underset{(2,8,8)}{Cl^-}$

and *vice-versa* with cation

e.g., $\underset{(2,8,1)}{Na} - e^- \longrightarrow \underset{(2,8)}{Na^+}$

Metallic Character

Elements having a tendency to lose one or more electrons and form positive ions are called metals. These are present on the left side as well as in the centre of the periodic table.

The tendency of the elements to lose electrons is called metallic character. Because of the formation of positive ions, these are also called as **electropositive elements** and the property as electro positivity.

e.g., $\underset{(2,8,1)}{Na} - e^- \longrightarrow \underset{(2,8)}{Na^+}$

$\underset{(2,8,2)}{Mg} - 2e^- \longrightarrow \underset{(2,8)}{Mg^{2+}}$

Dependence of Metallic Character

The factors on which metallic character depends are as follows

1. Atomic Size

Larger the atomic size, lesser the nuclear pull exerted on electrons. As a result, the electrons can be removed more easily. Thus, making the elements more metallic.

2. Nuclear Charge

Greater nuclear charge makes the electron to be tightly bounded. Hence, the electrons cannot be released easily and less metallic.

Trends in Metallic Character Down a Group

On moving top to bottom in a group, the atomic radius increases and nuclear charge also increases. But the atomic radius enhancement dominates over the nuclear charge. So, metallic character increases.

e.g., In group 1, lithium is the least metallic element while francium is the most metallic element.

Trends in Metallic Character Across a Period

On moving left to right in a period, nuclear pull increases due to the increase in atomic number and thus, the atomic size decreases. Hence, metallic character also decreases.
e.g., In 2nd period, lithium has highest metallic nature.

Note

(i) Metals form basic oxides while non-metals form acidic oxides.

(ii) When we move from left to right in a period, the formation of acidic oxide increases and that of basic oxide decreases.

$\underset{\text{Strongly basic}}{Na_2O}$, $\underset{\text{Basic}}{MgO}$, $\underset{\text{Amphoteric}}{Al_2O_3}$, $\underset{\text{Feebly acidic}}{SiO_2}$, $\underset{\text{Acidic}}{P_2O_5}$, $\underset{\text{More acidic}}{SO_3}$, $\underset{\text{Most acidic}}{Cl_2O_7}$

Non-Metallic Character

Non-metals are the elements which have a tendency to gain one or more electrons to form negative ions. Thus, these are also called as **electronegative elements**. These are present on the right side of periodic table. The non-metallic character of the elements is due to their electron accepting tendency.

e.g., $\underset{(2,8,7)}{Cl} + e^- \longrightarrow \underset{(2,8,8)}{Cl^-}$, $\underset{(2,6)}{O} + 2e^- \longrightarrow \underset{(2,8)}{O^{2-}}$

Dependence of Non-metallic Character

The factors on which non-metallic character depends are as follows

1. Atomic Size

Smaller the atomic size, greater the nuclear pull which increases the tendency to gain electrons. Therefore, makes the element more non-metallic in nature.

2. Nuclear Charge

Greater the nuclear charge, greater the tendency to gain electrons. Hence, more non-metallic is the element.

Trends in Non-metallic Character Down a Group

On moving top to bottom in a group atomic size increases and nuclear charge also increases. But the increase in atomic size is greater than nuclear pull. So, as a result non-metallic character decreases down a group. *e.g.*, Group 14 elements.

Carbon	C	↓ Non-metallic character decreases
Silicon	Si	
Germanium	Ge	
Tin	Sn	
Lead	Pb	

Trends in Non-metallic Character Across a Period

On moving left to right in a period nuclear pull increases. As a result, tendency to gain electron also increases. Hence, non-metallic character increases *e.g.*, 3rd period.

$$Na < Mg < Al < Si < P < S < Cl \longrightarrow$$

Non-metallic character increases

Note

(i) Elements that lose electrons to complete their octet are called **reducing agents** while those elements that gain electrons are called **oxidising agents**.

(ii) Non-metals are oxidising agents while metals are reducing agents.

Ionisation Energy

It is defined as the energy required to remove an electron from the outermost shell of an atom in its isolated gaseous state.

$$M(g) + IE \longrightarrow M^+(g) + e^-$$

M can be any element.

Unit It is measured in eV/atom and SI unit is kJ mol^{-1}.

Note The energy required to remove the residual electrons, one by one is called successive ionisation energy (IE_1, IE_2, ...).

Dependence of Ionisation Energy

The factors on which ionisation energy depends are as follows

(i) **Atomic Size** Greater the atomic size, more easily the electrons can be removed resulting into the decrease in ionisation energy.

(ii) **Nuclear Charge** When the nuclear charge is greater, electrons cannot be removed easily. As a result, the ionisation energy increases.

Trends in Ionisation Energy Down a Group

As we move from top to bottom in a group, ionisation energy decreases. This is due to the addition of a shell that increases atomic size. Electron are now far apart from nucleus and hence, ionisation energy decreases.

e.g., Ionisation energy decreases on moving down the group 1 elements.

Element	IE (kJ mol^{-1})	
H	1312	Atomic size increases, ionisation energy decreases.
Li	520	
Na	498	
K	419	
Rb	403	

Trends in Ionisation Energy Across a Period

As we move across a period, atomic size decreases. As a result, ionisation energy increases.

e.g., 2nd period elements

Element	Li	<	Be	<	B	<	C	<	N	<	O	<	F
IE (kJ mol^{-1})	520		899		801		1088		1402		1314		1681

Ionisation energy increases →

Note Inert gases have maximum ionisation energy while metals have low ionisation energy.

Electron Affinity (EA) or Electron Gain Enthalpy

The amount of energy released by the addition of electron to the outermost shell of an atom in its isolated gaseous state is called electron affinity.

$$X(g) + e^- \longrightarrow X^-(g) + EA$$

X is any element taken in its gaseous state.

Unit Its SI unit is kJ/mol.

Dependence of Electron Affinity

The factors on which electron affinity depends are as follows

(i) **Atomic Size** Smaller the atomic size, greater the electron affinity. Small size atoms are attracted more towards the nucleus and thus electron are held firmly.

(ii) **Nuclear Charge** Greater the nuclear charge, greater is the electron affinity because increase in nuclear charge increases the effective attractive force on the valence electrons.

Trends in Electron Affinity Down a Group

As we move from top to bottom in a group, the atomic size increases more than the nuclear charge, so there is a net decrease in electron affinity.

Trends in Electron Affinity Across a Period

As we move from left to right, the atomic size decreases and nuclear charge increases. Hence, electron affinity increases.

Note (i) Inert gases have zero electron affinity while non-metals have high electron affinity.

(ii) Halogens have maximum electron affinity in their respective periods.

Electronegativity

It is the tendency of an atom in a molecule to attract the shared pair of electrons toward itself. Noble gases have complete octet, so they do not have tendency to attract electrons. Electronegativity is a dimensionless quantity.

It is measured on several scales. The most widely used scale of electronegativity was given by Lewis Pauling (1932) in which the highest electronegativity is of fluorine (4.0) and the lowest is of caesium (0.7).

Dependence of Electronegativity

The factors on which electronegativity depends are as follows

(i) **Atomic Size** As the atomic size increases, the electronegativity decreases. This is due to the reason that electrons are farther away from the nucleus and hence, experience a lesser force of attraction.

(ii) **Nuclear Charge** As nuclear charge increases, electronegativity of an element also increases. This is due to the increase in nuclear charge causes the electron attraction with a greater force.

Trends in Electronegativity Down a Group

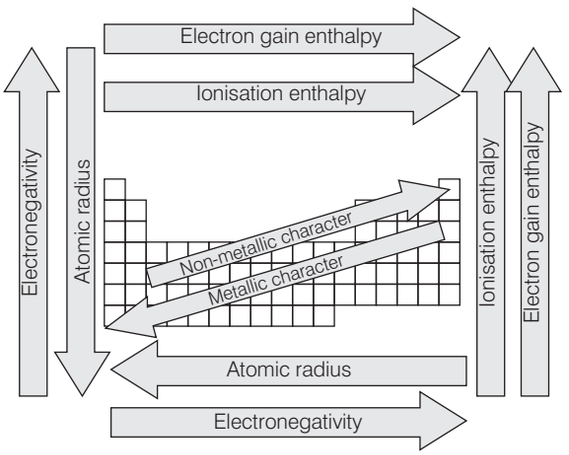
On moving from top to bottom in a group, atomic size and nuclear charge increases. But the effect of an increase

in the atomic size overcomes the effect of an increase in the nuclear charge, hence electronegativity decreases down the group.

Trends in Electronegativity Across a Period

Electronegativity increases from left to right in a period. This is due to an increase in atomic number and nuclear charge.

Summary of Periodic Trends



The periodic trends of elements in the periodic table

Variations of Periodic Properties

	Properties	Down the Group (Top to bottom)	Along a Period (Left to right)
(i)	Atomic radius	Increases	Decreases
(ii)	Metallic character	Increases	Decreases
(iii)	Non-metallic character	Decreases	Increases
(iv)	Ionisation energy	Decreases	Increases
(v)	Electron affinity	Decreases	Increases
(vi)	Electronegativity	Decreases	Increases

Comparison of Properties of Alkali Metals and Halogens

	Alkali Metals [Group1]	**Halogens** [Group 17]
Elements	Li, Na, K, Rb, Cs, Fr	F, Cl, Br, I, At
Physical state	Shining white solid metals. They are soft and can be cut with a knife. Lithium is the hardest.	Non-metals, diatomic in the gaseous state. Fluorine (gas), chlorine (gas) bromine (liquid), iodine (solid).
Conduction	Good conductors of electricity.	Non-conductors of electricity.
Nature	Highly reactive, electropositive metals. Metallic character increases from lithium (Li) to francium (Fr).	Highly reactive, electronegative non-metals. Non-metallic character, decreases from fluorine (F) to iodine (I).
Atomic size	They have the largest atomic size in their period (except inert gases).	They have the smallest atomic size in their period. The atomic size increases down the group.
Ionisation energy	They have lower ionisation energy in their period. It decreases down the group.	They have high ionisation energy (lower than noble gases) in their period.
Electron affinity	They have low electron affinity values which further decreases down the group.	They have high electron affinity values in the period. It decreases down the group.
Electronegativity	They have the lowest electronegativity in their period.	They have the highest electronegativity in their period.
Reactivity	They are reactive metals. Reactivity further increases down the group.	They are reactive non-metals. The reactivity of these non-metals decreases down the group.
Reaction with water and acids	They react vigorously with water and acids liberating hydrogen. Reactivity further increases down the group.	Generally, they do not react with dilute acids and water.
Reducing/ oxidising agents	Strong reducing agents, as they lose electrons to complete their octet.	Strong oxidising agents, as they accept electrons to complete their octet.
Compound formation	Forms electrovalent compounds with non-metals. *e.g.,* KCl, $CaCl_2$, etc.	Forms covalent compounds with hydrogen and other non-metals. *e.g.,* HBr, HCl, HI, CCl_4, etc.

CHECK POINT 04

1. What role does nucleus play in the variation of size within the elements of a period?
2. Name the most electronegative element.
3. Which one is more electropositive-Li or Na?
4. How does atomic size affect the ionisation energy?
5. How does nuclear charge affect the electron affinity?
6. Write any two differences in physical states of alkali metals and halogens.
7. Why does an alkali metal atom is smaller in size than a halogen atom of same period?

SUMMARY

- Periodic table is an arrangement of elements having similar properties placed together.
- Earlier attempts to classify elements are as follows
  (i) Dobereiner's Triads Dobereiner (1817) classified the elements into groups of three elements (triads) having similarity in physical and chemical properties. He also noticed that atomic mass of central element was the arithmetic mean of other two elements.
  (ii) Newland's Law of Octaves (1866) Newland observed that when elements are arranged in increasing order of their atomic mass, every eighth element beginning from any element resembles the first element in its physical and chemical properties.
  (iii) Mendeleev's Periodic Table (1869) Mendeleev arranged the elements known at that time on the basis of his famous periodic law given as
    (a) Atomic weight is the fundamental property of elements.
    (b) The physical and chemical properties of elements are periodic function of their atomic weight.
- Modern Periodic Law (1972) Moseley modified Mendeleev's periodic law and proposed modern periodic law as "the physical and chemical properties of the elements are periodic functions of their atomic numbers".
- In modern periodic table, Moseley arranged elements in the order of increasing atomic number. It consists of seven periods and eighteen groups.
- Bohr and Burry modified the modern periodic table and gave the extended form of it, known as long form of the modern periodic table.
- Periodic trends are observed in atomic sizes, ionisation enthalpies, electron gain enthalpies, electronegativity and valency.
- The atomic radii decreases while going from left to right in a period and increases with atomic number in a group. The size of isoelectronic species decreases with increase in the nuclear charge.
- Ionisation enthalpies generally increase across a period and decrease down a group. However, the elements having extra stable configuration have extra ordinarily high ionisation enthalpies. Electronegativity also shows a similar trend.
- Electron affinity is defined as the energy released when an electron is added to an isolated gaseous atom. It decreases on moving from top to bottom in a group and increases on moving from left to right.
- Metallic character increases with increasing atomic number in a group whereas decreases from left to right in a period. The physical and chemical properties of elements vary periodically with their atomic numbers.
- Electronegativity increases from left to right in a period and it decreases on moving down the group.

EXAM PRACTICE

Fill in the Blanks

1. At the time of Mendeleev, only …… elements were known.

Sol. *63*

2. …… was considered as the most fundamental property of an element by Moseley.

Sol. Atomic number

3. The properties of the elements are a periodic function of their …… (atomic number/mass number/relative atomic mass).

Sol. atomic number

4. The elements of the second period shows
(i) …… in properties with the elements of the
(ii) …… period. These elements are called as
(iii) …… and the relationship experienced by them are called (iv)…… .

Sol. (i) resemblance (ii) third
(iii) bridge elements (iv) diagonal relationship

5. The (i) …… consists of eighteen (ii) ……, called groups. Group 1 elements are called (iii) …… They form strong alkali in water, Group 2 elements are called (iv) …… . They form weaker alkalies as compared to group 1. Group 13 elements are known as (v) …… and group 14 elements are known as (vi) …… and group 16 elements are known as (vii) …… and group 17 elements are known as (viii) …… .

Sol. (i) modern periodic table (ii) vertical columns
(iii) alkali metals (iv) alkaline earth metals
(v) boron family (vi) carbon family
(vii) chalcogen family (viii) halogen family

6. …… are the longest periods, containing 32 elements each.

Sol. Sixth and seventh

7. Across a period, the ionisation potential …… (increases/decreases/remains the same).

Sol. increases

8. Down the group, electron affinity …… (increases/decreases/remains the same).

Sol. decreases

9. The similarities in the properties of a group of elements is because they have the similar …… (electronic configuration/number of valence electrons/atomic number).

Sol. electronic configuration

10. Fill in the blanks by selecting the correct word from the brackets.
(i) If an element has a low ionisation energy, then it is likely to be …… (metallic/non-metallic).
(ii) If an element has seven electrons in its outermost shell, then it is likely to have the …… (largest/smallest) atomic size among all the elements in the same period. ***[2017]***

Sol. (i) metallic (ii) smallest

11. Fill in the blanks from the choices given in brackets. The energy required to remove an electron from a neutral isolated gaseous atom and convert it into a positively charged gaseous ion is called …… . (electron affinity/ionisation potential/electronegativity). ***[2017]***

Sol. ionisation potential

12. Moving across a …… (period/group) of the periodic table, the tendency of an element to gain electrons increases, thus …… (metallic/non-metallic) character increases.

Sol. period, non-metallic

Multiple Choice Questions

13. How many elements have been discovered till now?
(a) 120 (b) 118 (c) 116 (d) 114

Sol. (b)

14. Which law is like the seven notes of music; sa, re, ga, ma, pa, …… ?
(a) Law of triad (b) Law of octaves
(c) Both (a) and (b) (d) None of these

Sol. (b)

15. What is the fundamental property of classification in modern periodic law?
(a) Atomic number (b) Atomic volume
(c) Atomic radius (d) Atomic mass
Sol. (a)

16. Among the following, which are the bridge elements?
(a) C-Mg (b) Li-Mg
(c) Be-Si (d) Be-B
Sol. (b)

17. Which period of the periodic table consist of elements known as typical elements?
(a) 1st period (b) 2nd period
(c) 3rd period (d) 4th period
Sol. (c)

18. The atomic size on moving across the period
(a) decreases
(b) increases
(c) remains the same
(d) sometimes increases and sometimes decreases
Sol. (a)

19. The non-metallic character of the elements down the group
(a) decreases (b) increases
(c) remains the same (d) depends on the period
Sol. (a)

20. An element with the atomic number 19 will most likely combine chemically with the element whose atomic number is
(a) 17 (b)11 (c) 18 (d) 20 ***[2016]***
Sol. (a)

21. An element *X* has an atomic number 15. With which of the following elements will it show similar chemical properties?
(a) Ne (10) (b) N (7)
(c) O (8) (d) Be (4)
Sol. (b)

22. Which of the following properties do not match with elements of the halogen family?
(a) They have seven electrons in their valence shell
(b) They are highly chemically reactive
(c) They are metallic in nature
(d) They are diatomic in their molecular form
Sol. (c)

23. If an element *A* belongs to period III and group II, then it will have
(a) 3 shells and 2 valence electrons
(b) 2 shells and 3 valence electrons
(c) 3 shells and 3 valence electrons
(d)2 shells and 2 valence electrons
Sol. (a)

24. The set representing the correct order of first ionisation energy is
(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C
Sol. (b)

25. Ionisation potential increases across a period from left to right because the ***[2014]***
(a) atomic radius increase and nuclear charge increases
(b) atomic radius decreases and nuclear charge decreases
(c) atomic radius increases and nuclear charge decreases
(d) atomic radius decreases and nuclear charge increases
Sol. (d)

26. Which of the following elements would lose an electron easily?
(a) Mg (b) Na (c) K (d) Ca
Sol. (c)

27. Among the elements of period 2, the element which has high electron affinity is
(a) lithium (b) carbon
(c) chlorine (d) fluorine
Sol. (d)

28. The electronegativity on moving from left to right in a period
(a) depends on the number of valence electrons
(b) remains the same
(c) decreases
(d) increases
Sol. (d)

29. Which of the following is most electronegative?
(a) Carbon (b) Silicon (c) Lead (d) Tin
Sol. (a)

30. With reference to the variation of properties in the periodic table, which of the following is generally true?
(a) Atomic size increases from left to right across a period
(b) Ionisation potential increases from left to right across a period

(c) Electron affinity increases on moving down the group
(d) Electronegativity increases on moving down the group

Sol. (b)

Match the Following

31. Match the following columns.

	Column I		Column II
(i)	Actinides	(a)	Group 2
(ii)	Alkali metals	(b)	Group 3, 6th period
(iii)	Lanthanides	(c)	Group 1
(iv)	Alkaline earth metals	(d)	Group 3, 7th period

Sol. (i) (d), (ii) (c), (iii) (b), (iv) (a)

32. Match the following columns.

	Column I		Column II
(i)	Strongly basic oxide	(a)	Al_2O_3
(ii)	Feebly acidic oxide	(b)	N_2O
(iii)	Amphoteric oxide	(c)	Cl_2O_7
(iv)	Most acidic oxide	(d)	SiO_2

Sol. (i) (b), (ii) (d), (iii) (a), (iv) (c)

33. Match the following columns.

	Column I		Column II
(i)	Atomic radius	(a)	No unit
(ii)	Ionisation potential	(b)	eV/atom
(iii)	Electron affinity	(c)	Angstrom
(iv)	Electronegativity	(d)	kJ mol^{-1}

Sol. (i) (c), (ii) (b), (iii) (d), (iv) (a)

α 1 Mark Questions

34. What was Dobereiner's basis for classifying elements?

Sol. According to Dobereiner, elements having similar properties can be arranged into triads in which atomic mass of the middle element is the mean of the atomic masses of the other two elements.

35. Why the noble gases are placed in separate group?

Sol. Noble gases are not reactive due to their stable configuration. They are inert and hence, they are placed in a separate group.

36. Give **one word** or a **phrase** for the following statement.
The energy released when an electron is added to a neutral gaseous isolated atom to form a negatively charged ion. ***[2018]***

Sol. Electron gain enthalpy

37. Name a metal present in 3rd period and group 1 of the periodic table.

Sol. 3rd period indicates that number of shells is 3, (*i.e.*, *K*, *L*, *M*) and group 1 indicates that number of electrons in the outermost shell *i.e.*, valence shell is 1.
So, its electronic configuration is $\begin{matrix} K & L & M \\ 2 & 8 & 1 \end{matrix}$.
Thus, the metal is sodium (Na) with atomic number 11.

38. Identify the group and the period, of the element having three shells and three electrons in valence shell.

Sol. Three shells indicate that period is 3. Three electrons in valence shell indicates that group number is 13, so electronic configuration is $\begin{matrix} K & L & M \\ 2 & 8 & 3 \end{matrix}$.

39. Give a reason for each of the following. ***[2018]***
(i) Inert gases do not form ions.
(ii) Ionisation potential increases across a period, from left to right.

Sol. (i) Inert gases do not form ions due to stable electronic configuration *i.e.*, they have completely filled outermost shell and thus neither donate nor gain electrons.
(ii) On moving from left to right in a periodic table, the atomic size decreases due to increase in the nuclear charge.
Thus, more energy is required to remove the electron(s) from outermost shell resulting into increase in ionisation potential across a period.

40. Out of the two elements *X* and *Y* which has bigger atomic radius if
(i) *X* has atomic number 18 and atomic mass 40.
(ii) *Y* has atomic number 20 and atomic mass 40.

Sol. Radius of *Y* is bigger than that of *X*. This is because in *X*, the number of shells is three (2, 8, 8) while in *Y*, it is four (2, 8, 8, 2).

41. Name two elements that you would expect to show chemical reactions similar to calcium.

Sol. Magnesium and strontium are chemically similar to calcium because they have same number of electrons in their valence shells like calcium.

42. Which among the two has a greater radii, Cl^- or Cl atom?

Sol. Cl^- anion is greater because on adding an electron, the nuclear charge remains the same and the atomic size increases.

43. How does metallic character vary along a period?

Sol. Metallic character decreases along a period from left to right as the size decreases.

44. Arrange the following elements in the increasing order of their non-metallic character.

Li, O, C, Be, F

Sol. All the given elements belong to same period *i.e.*, 2nd period. In a period, on moving from left to right non-metallic character increases. Thus, the order of increasing non-metallic character is
Li < Be < C < O < F.

45. Give reason as to why?
The oxidising nature of elements increase on moving from left to right along a period in the periodic table.

Sol. Oxidising nature means tendency to oxidise the other element which increases with increase in non-metallic nature.

Non-metals are oxidising agents. On moving across a period, the tendency to gain electrons(s) increases due to an increase in nuclear pull and a decrease in the atomic size. So, non-metallic character increases from left to right in a period.

46. Which of the following elements does not lose an electrons easily :
Na, F, Mg, Al?

Sol. F, because it contains 7 electrons in its valence shell and it is the most electronegative element.

47. Name the element which is soft and reactive metal.

Sol. Alkali metals are soft and reactive *e.g.,* Na, K, etc.

48. Name the element which has the highest ionisation potential.

Sol. Helium (He) will have the highest ionisation energy (or ionisation potential).

49. Give one word or phrase for the following. The amount of energy released when an atom in the gaseous state accepts an electron to form an anion. ***[2014]***

Sol. Electron affinity.

b 2 Marks Questions

50. Use Mendeleev's periodic table to predict the formulae for the oxides of the following elements. K, C, Al.

Sol. Oxygen is a member of group VIA in Mendeleev's periodic table. Its valency is 2. Similarly, the valencies of all the given elements can be predicted from their respective group. This can help in writing the formula of their oxides. ***[1]***

(i) Potassium (K) is a member of group IA. Its valency is 1. Therefore, formula of its oxide is K_2O.

(ii) Carbon (C) is a member of group IVA. Its valency is 4. Therefore, the formula of its oxide is C_2O_4 or CO_2.

(iii) Aluminium (Al) belongs to group IIIA and its valency is 3. Therefore, the formula of its oxide is Al_2O_3. ***[1]***

51. (i) Atomic number is considered to be a more appropriate parameter than atomic mass for classification of elements in a periodic table. Why?

(ii) Element X form a chloride with the formula XCl_2. State the position of the element X in the periodic table.

Sol. (i) The properties of elements depend upon valence electrons in the atom which in turn depends on the total number of electrons, *i.e.,* atomic number. Therefore, atomic number is a more appropriate parameter than atomic mass for the classification of elements. ***[1]***

(ii) The formula of the chloride, XCl_2 suggests that the valency of element X is 2. Since, group II elements possess a valency of 2, therefore X is placed in group II of the periodic table. ***[1]***

52. An element Z has atomic number 16. Answer the following questions.

(i) State the period and group to which Z belongs.

(ii) Is Z a metal or a non-metal?

Sol. (i) Atomic number of element, $Z = 16$

	K	L	M
Electronic configuration	2	8	6

Number of shells is 3, (*i.e.*, K, L, M). So, period is 3.

Group number VIA ***[1]***

(ii) Z is non-metal. Since, non-metals usually have 5, 6 or 7 electrons in their outermost orbits. ***[1]***

53. The metals of group 2 from top to bottom are Be, Mg, Ca, Sr and Ba.

(i) Which one of these elements will form ions most readily and why?

(ii) State the common feature in the electronic configuration of all these elements. *[2015]*

Sol. (i) Ba will form ions most readily as it is most electropositive among the given ones. *[1]*

(ii) They all belong to a common group (IIA) and have same number of valence electrons. *[1]*

54. Element X is a metal with a valency of 2, Y is a non-metal with a valency of 3.

(i) Write an equation to show how Y forms an ion?

(ii) If Y is a diatomic gas, write an equation for the direct combination of X and Y to form a compound.

Sol. (i) $Y + 3e^- \longrightarrow Y^{3-}$ *[1]*

(ii) $3X + 2Y \longrightarrow X_3Y_2$ *[1]*

55. Arrange the following elements in the increasing order of their atomic radii.

(i) Li, Be, F, N (ii) Cl, At, Br, I

Sol. (i) F < N < Be < Li *[1]*

(ii) Cl < Br < I < At *[1]*

Because atomic radii decreases along a period and increases on moving down the group.

56. An element X placed in 2nd group and 4th period of the periodic table burns in the presence of oxygen to form a basic oxide.

(i) Identify the element.

(ii) Write its electronic configuration.

Sol. (i) Calcium (It contains four shells and two electrons in the valence shell). *[1]*

(ii) Electronic configuration of Ca – $\begin{matrix} K & L & M & N \\ 2 & 8 & 8 & 2 \end{matrix}$ *[1]*

57. (i) If an element is in group 17 (or group VIIA), is it likely to be metallic or non-metallic comment.

(ii) Write the missing word from those in brackets. If an element has one electron in its outermost energy level (shell), then it is likely to be ..... (metallic/non-metallic).

Sol. (i) All the members of group VIIA are non-metals except astatine, which is a metalloid. *[1]*

(ii) metallic. *[1]*

58. Define the following terms.

(i) Ionisation potential

(ii) Electron affinity

Sol. (i) **Ionisation potential** (Ionisation energy) It is defined as the energy required to remove an electron from outermost shell in its isolated gaseous state. *[1]*

(ii) **Electron affinity** It is defined as the amount of energy released by the addition of an electron to the outermost shell of an atom in its isolated gaseous state. *[1]*

59. Rewrite the following sentence by using the correct symbol: > (greater than) or < (less than) in the blanks given.

(i) The ionisation potential of potassium is ..... that of sodium.

(ii) The electronegativity of iodine is ..... that of chlorine. *[2016]*

Sol. (i) The ionisation potential of potassium is less than (<) that of sodium. *[1]*

(ii) The electronegativity of iodine is less than (<) that of chlorine. *[1]*

60. Identify the term/substance in each of the following.

(i) The tendency of an atom to attract electrons towards itself when combined in a compound.

(ii) The electrons present in the outermost shell of an atom. *[2016]*

Sol. (i) Electronegativity *[1]*

(ii) Valence electrons *[1]*

61. (i) Why do group 1 elements form unipositive ions?

(ii) Why do all elements in a group have similar properties?

Sol. (i) Group 1 elements contain one electron in their outermost shell. These elements lose this electron easily to attain the octet (8 electrons) in their outermost shell. Hence, they form unipositive ion. *[1]*

(ii) All the elements in a group have similar properties because they have identical valence shell electronic configuration. *[1]*

C 3 Marks Questions

62. How could the modern periodic table remove various anomalies of Mendeleev's periodic table?

Sol. (i) The modern periodic table is based on atomic number. As isotopes have same atomic number and chemical properties, so they can be placed at one place in the same group of the periodic able. *[1]*

(ii) A separate group for noble gases was created. *[1]*

(iii) In this periodic table, a unique position has been given to the hydrogen. It is kept at the top left corner because of its unique characteristics. *[1]*

63. (i) There are three elements E, F, G with atomic number 19, 8 and 17, respectively. Classify the elements as metals and non-metals.

(ii) Elements of group 18 are called zerovalent.

Sol. (i) Electronic configuration of E is $\begin{matrix} K & L & M & N \\ 2 & 8 & 8 & 1 \end{matrix}$

Electronic configuration of F is $\begin{matrix} K & L \\ 2 & 6 \end{matrix}$

Electronic configuration of G is $\begin{matrix} K & L & M \\ 2 & 8 & 7 \end{matrix}$

E is a metal because it has one electron in its outermost shell.

Non-metals usually have 5, 6, or 7 electrons in their outermost shell. So, F and G are non-metals. ***[1 ½]***

(ii) Elements of group 18 have completely filled outermost shell and have no tendency to gain or lose electrons. So, they are called zerovalent. ***[1 ½]***

64. Answer the following in respect of element, ${}^{31}_{15}X$

(i) Name the element.

(ii) Write down its electronic configuration.

(iii) What is its valency?

Sol. (i) Element is phosphorus. ***[1]***

(ii) P ($Z = 15$): 2, 8, 5 ***[1]***

(iii) Valency = 3 and 5 ***[1]***

65. In period 3 of the periodic table, element B is placed to the left of element A. On the basis of this information, choose the correct word from the brackets to complete the following statements. ***[2018]***

(i) The element B would have (lower/higher) metallic character than A.

(ii) The element A would probably have (lesser/higher) electron affinity than B.

(iii) The element A would have (greater/smaller) atomic size than B.

Sol. If in period 3 of the periodic table, element B is placed to the left of element A, then

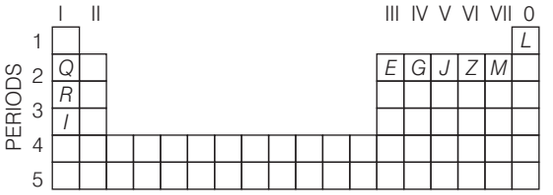
(i) The element B would have higher metallic character than A. Due to increase in effective nuclear charge experienced by valence electrons, metallic character decreases across a period.

(ii) The element A would probably have higher electron affinity than B. As we move from left to right in the periodic table, the atomic size decreases and the nuclear charge increases, thus the electron affinity increases.

(iii) The element A would have smaller atomic size than B. An increase in nuclear charge tends to pull the valence electrons closer to the nucleus and reduces the size of the atom.

d 4 Marks Questions

66. Use the letters only written in the periodic table given below to answer the questions that follows.



(i) State the number of valence electrons in atom J.

(ii) Which elements forms ions with a single negative charge?

(iii) Out of I and R which one is more reactive?

(iv) Which element has its electrons arranged in four shells? ***[2016]***

Sol. (i) Since, J belongs to V group of periodic table, hence number of valence electrons are 5. ***[1]***

(ii) Elements belonging to the VII group of periodic table form ions with a single negative charge. ***[1]***

(iii) I is more reactive than R. ***[1]***

(iv) Since, I belongs to 4th period, therefore, it has electron arranged in four shells. ***[1]***

67. Why does the elements of group 1 and elements of group 17 both have valency equals to 1? Explain.

Sol. Valency is defined as the combining capacity of the atom of an element. It depends on the number of valence electrons. Sodium (atomic number = 11) has electronic configuration 2, 8, 1, which suggest that it has one electron in the outermost shell. It can easily lose one electron from its valence electron.

$$\underset{(2,\,8,\,1)}{Na} - e^- \longrightarrow \underset{(2,\,8)}{Na^+}$$

Chlorine (atomic number = 17) has electronic configuration 2, 8, 7, which means that it has the tendency to gain one electron to complete its octet.

$$Cl + e^- \longrightarrow \underset{(2,\,8,\,8)}{Cl^-}$$

$\underset{(2,\,8,\,7)}{}$

Hence, both sodium and chlorine possess valency1. ***[4]***

68. The electronegativites (according to Pauling) of the elements in period 3 of the periodic table are as follows (the elements are arranged in alphabetical order).

Al	Cl	Mg	Na	P	S	Si
1.5	3.0	1.2	0.9	2.1	2.5	1.8

(i) Arrange the elements in the order in which they occur in the periodic table from left to right. (The group 1 elements first, followed by the group 2 elements and so on, upto group 7).

(ii) Choose the word or phrase from the brackets which correctly completes each of the following statements.

(a) The elements below sodium in the same group would be expected to have a ..... (lower/higher) electronegativity than sodium and the *Y* element above chlorine would be expected to have a ..... (lower/higher) ionisation potential than chlorine.

(b) On moving from left to right in a given period, the number of shells ..... (remains the same/increases/decreases).

(c) On moving down the group, the number of valence electrons ..... (remains the same/increases/decreases).

Sol. (i) Elements arranged in the order from left to right are

Na	Mg	Al	Si	P	S	Cl
0.9	1.2	1.5	1.8	2.1	2.5	3.0

[1]

(ii) (a) lower, higher *[1]*

(b) remains the same *[1]*

(c) remains the same *[1]*

69. Choose the most appropriate answer from the following list of oxides which fits the description. Each answer must be used once.

$[SO_2, SiO_2, Al_2O_3, MgO, CO, Na_2O]$

(i) A basic oxide.

(ii) An oxide which dissolves in water forming an acid.

(iii) An amphoteric oxide.

(iv) A covalent oxide of a metalloid. *[2015]*

Sol. (i) Na_2O (ii) SO_2 *[2]*

(iii) Al_2O_3 (iv) SiO_2 *[2]*

70. Arrange the following as per the instructions given in the brackets.

(i) Cs, Na, Li, K, Rb (increasing order of metallic character)

(ii) Mg, Cl, Na, S, Si (decreasing order of atomic size)

(iii) Na, K, Cl, S, Si (increasing order of ionisation energy)

(iv) Cl, F, Br, I (increasing order of electron affinity) *[2015]*

Sol. (i) Li < Na < K < Rb < Cs *[1]*

(ii) Na > Mg > Si > S > Cl *[1]*

(iii) K < Na < Si < S < Cl *[1]*

(iv) I < Br < Cl < F *[1]*

71. Arrange the following as per the instruction given in the brackets

(i) He, Ar, Ne (increasing order of the number of electron shells)

(ii) Na, Li, K (increasing ionisation energy)

(iii) F, Cl, Br (increasing electronegativity)

(iv) Na, K, Li (increasing atomic size) *[2017]*

Sol. (i) Number of electron shells increases down the group .

He < Ne < Ar *[1]*

(ii) Ionisation energy decreases down the group.

K < Na < Li *[1]*

(iii) Electronegativity decreases down the group.

Br < Cl < F *[1]*

(iv) Atomic size increases down the group.

Li < Na < K *[1]*

e 5 Marks Questions

72. Which elements has

(i) two shells, both of which are completely filled with electrons?

(ii) the electronic configuration 2, 8, 2?

(iii) a total of three shells with four electrons in its valence shell?

(iv) a total of two shells with three electrons in its valence shell?

(v) twice as many electrons in its second shell as in first shell?

Sol. (i) Noble gases are the elements which have completely filled shells. The noble gas with two shells (*K*, *L*) is Ne having atomic number 10 and electronic configuration 2, 8 both of which are completely filled. *[1]*

(ii) Electronic configuration 2, 8, 2 suggests that atomic number is 12 (2 + 8 + 2). Magnesium (Mg) has atomic number 12. *[1]*

(iii) The element with three shells and four electrons in the valence shell will have electronic configuration 2, 8, 4. The atomic number of this element is 14 (2 + 8 + 4), so it will belong to group 14 hence, it is silicon (Si). *[1]*

(iv) Element having two shells with 3 electrons in the valence shell will exist in second period and will have the electronic configuration 2, 3. The atomic number of this element will be 5 (2 + 3). So, it will be boron (B). *[1]*

(v) The element has two shells. We know that first shell can have only 2 electrons, so according to the question there will be 4 electrons (double the number of electrons in the first shell) in the valence shell. The electronic configuration will be 2, 4, so the atomic number is 6. Hence, the element is carbon (C). *[1]*

73. Answer any 5 questions

Group number	IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
Period	1	2	13	14	15	16	17	18
Second	Li		D			O	J	Ne
Third	A	Mg	E	Si		G	M	
Fourth	R	T	L		Q	X		Y

Some elements are given in their own symbol and position in the periodic table while others are shown with a letter. With reference to the above table, answer the following questions.

(i) Identify the most electronegative element.

(ii) Identify the most reactive element of group 1.

(iii) Identify the element from period 3 with least atomic size.

(iv) How many valence electrons are present in Q?

(v) Which element from group 2 would have the least ionisation energy?

(vi) Identify the noble gas of the fourth period.

Sol. (i) J is the most electronegative element. *[1]*

(ii) R is the most reactive element of group I. *[1]*

(iii) M has least atomic size. *[1]*

(iv) Outermost electronic configuration of $Q = 2, 8, 5$. So, number of valence electrons are five. *[1]*

(v) T will have least ionisation energy. *[1/2]*

(vi) Y is the krypton (Kr) gas. *[1/2]*

74. Match the atomic number 2, 4, 8, 15 and 19 with each of the following

(i) A solid non-metal belonging to the third period.

(ii) A metal with valency 1

(iii) A gaseous element with valency 2

(iv) An element belonging to group 2

(v) A rare gas *[2017]*

Sol. (i) Atomic number - 15 (Phosphorus) *[1]*

(ii) Atomic number - 19 (Potassium) *[1]*

(iii) Atomic number - 8 (Oxygen) *[1]*

(iv) Atomic number - 4 (Beryllium) *[1]*

(v) Atomic number - 2 (Helium) *[1]*

75. A group of elements in the periodic table are given below (boron is the first member of the group and thallium is the last).

Boron, aluminium, gallium, indium, thallium

Answer the following questions in relation to the above group of elements.

(i) Which element has the most metallic character?

(ii) Which element would be expected to have the highest electronegativity?

(iii) If the electronic configuration of aluminium is 2, 8, 3, how many electrons are there in the outermost shell of thallium?

(iv) The atomic number of boron is 5. Write the chemical formula of the compound formed when boron reacts with chlorine.

(v) Will the elements in group of the right of this boron group be more metallic or less metallic in character? Justify your answer.

Sol. (i) Thallium has the most metallic character. *[1]*

(ii) Boron has the highest electronegativity because electronegativity decreases down the group. *[1]*

(iii) Three electrons are present in the outermost shell of thallium because both belong to the same group III A. *[1]*

(iv) Atomic number of $B = 5$ (2, 3)

Electronic configuration of Cl

(atomic number 17)

K	L	M
2	8	7

So, valency of Cl is -1.

Thus, chemical formula is BCl_3 *[1]*

(v) Less metallic in character because on moving across a period, metallic nature decreases. *[1]*

76. The following table represents the first three periods of the modern periodic table. Study the table and answer the questions that follows.

IA												IIIA	IVA	VA	VIA	VIIA	
1 H	IIA																2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36

(i) Write the formula of the sulphate of the element with atomic number 13.

(ii) Which feature of the atomic structure accounts for the similarities in the chemical properties to the element in group VIIA of the periodic table?

(iii) Name the element which has the highest ionisation potential?

(iv) How many electrons are present in the valence shell of the element with the atomic number 18?

(v) What is the electronic configuration of the element in the third period which gains one electron to change into an anion?

Sol. (i) Element with atomic number 13 is Al. Electronic configuration $\begin{matrix} K & L & M \\ 2 & 8 & 3 \end{matrix}$

Valency of Al is 3 (Al^{3+}) and that of sulphate is − 2. Thus, the formula is $Al_2(SO_4)_3$. ***[1]***

(ii) All elements of group VIIA have 7 valence electrons. So, these elements have similar chemical properties. ***[1]***

(iii) Helium (He) has the highest ionisation potential. ***[1]***

(iv) Atomic number 18.

Electronic configuration $\begin{matrix} K & L & M \\ 2 & 8 & 8 \end{matrix}$

So, 8 valence electrons are present in the valence shell. ***[1]***

(v) Element is chlorine with atomic number 17. Its electronic configuration is 2, 8, 7. So it, gains one electrons to change into an anion. ***[1]***

77. Consider the section of the periodic table given below.

Group number	IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
Period	1	2	13	14	15	16	17	18
Second	Li		*D*		G	O	*J*	Ne
Third	A	Mg	*E*	Si		*H*	*K*	
Fourth	*B*	C		*F*	*Q*			*L*

Note In this table B does not represent boron, C does not represent carbon, F does not represent fluorine, H does not represent hydrogen, K does not represent potassium. You must see the position of the element in the periodic table

(i) Which is the most electronegative?

(ii) How many valence electrons are present in *G*?

(iii) Write the formula of the compound between *B* and *H*.

(iv) In the compound between *F* and *J*, what type of bond will be formed?

(v) Draw the electron dot structure for the compound formed between *C* and *K*. ***[2013]***

Sol. (i) Element *J* is most electronegative. ***[1]***

(ii) Group of *G* = 15, *G* has five valence electrons ***[1]***

(iii) Valency of element, *B* = 1

Valency of element, *H* = 2

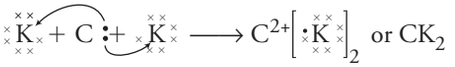
(Group number = 16)

So, formula is B_2H ***[1]***

(iv) Between *F* and *J* covalent bond will be formed ***[1]***

(v) Valence electron of *C* = 2, valence electron of *K* = 7

Thus, electron dot structure for compound formed by *C* and *K* is



or CK_2 ***[1]***

Numerical Types Questions

78. Observe the table and fill the blanks.

Li (7)	Cl	Ca (40)
–	Br	–
K (39)	I	Ba (137)

Sol. According to Dobereiner's triads, when elements are arranged in the increasing order of atomic masses, the atomic mass of middle element was roughly the average of atomic masses of other two elements.

So, atomic mass of middle element

$$= \frac{7+39}{2} = 23$$

23 is the atomic mass of sodium (Na).

Similarly, atomic mass of other element

$$= \frac{40+137}{2} = 88.5 \approx 88$$

88 is the atomic mass of strontium (Sr). ***[2]***

79. Can the following groups of elements be classified as Dobereiner's triad?

(a) Na, Si, Cl (b) Be, Mg, Ca

Atomic mass of Be = 9; Na = 23; Mg = 24; Si = 28; Cl = 35, Ca = 40

Explain by giving reason.

Sol. (a) Na, Si and Cl have different properties, therefore they do not form a Dobereiner's triad even though the atomic mass of the middle element Si (*i.e.*, 28) is approximately the average of the atomic masses of Na and Cl *i.e.*, (23 + 35)/ 2 = 29. ***[1]***

(b) Be, Mg and Ca have many similar properties and also the atomic mass of the middle element Mg (*i.e.*, 24) is approximately the average of the atomic masses of Be and Ca *i.e.*, $\frac{(9+40)}{2} = 24.5$, therefore they form a Dobereiner's triad. ***[1]***

80. *X*, *Y* and *Z* are the electrons of a Dobereiner's triad. If the atomic mass of *X* is 7 and that of *Z* is 39, what should be the atomic mass of *Y*?

Sol. In a Dobereiner's triad, the atomic mass of the middle element is roughly the average of the atomic masses of the other two elements. Thus, in the given triad, the atomic mass of *Y*,

$$= \frac{\text{Atomic mass of } X + \text{Atomic mass of } Z}{2}$$

$$= \frac{7+39}{2} = \frac{46}{2} = 23 \text{ u}$$

[2]

CHAPTER EXERCISE

Fill in the Blanks

1. (i) ……, a Russian chemist was the most important contributor for the development of periodic table (ii) …… elements were known at this time. He examined the relationship between (iii) …… of the element and their (iv) …… and (v) …… properties.

2. The properties of elements are a periodic function of their ……

3. Group 18 elements are called as …… and also known as …… .

4. The properties that …… at regular intervals or in which there is a gradual …… are called …… and the phenomenon is called …… .

The cause of periodicity is the …… of similar electronic configuration.

5. An (i) …… is formed by the gain of electrons of the parent atom. The number of (ii) …… remains the (iii) …… in the anion but nuclear force of attraction for the outer electrons (iv) ……. . Hence, the distance between (v) …… and (vi) …… increases due to which anion is (vii) …… than the parent atom.

Multiple Choice Questions

6. What was the major drawback of Newland's law?
(a) Limited element follow the law of octave
(b) Put unlike elements in the same slot
(c) Isotopes position
(d) No drawbacks

7. In Mendeleev's periodic table, hydrogen was supposed to be
(a) halogens (b) alkaline earth metals
(c) alkali metals (d) noble gases

8. The element in which outermost shell is completely filled?
(a) Beryllium (b) Xenon
(c) Aluminium (d) Hydrogen

9. Before modern periodic law, the classification of elements was done on the basis of which property?
(a) Atomic number (b) Atomic radius
(c) Number of electrons (d) Atomic mass

10. How many elements are present in period 2?
(a) Eighteen (b) Eight
(c) Two (d) Thirty two

11. An element *X* have atomic number (12). What is the position of an element in the group and period?
(a) 4th period, 4th group
(b) 3rd group, 4th period
(c) 7th group, 2nd period
(d) 2nd group, 3rd period

12. An element *X* has an atomic number of 18. With which of the following elements will it show similar chemical properties?
(a) N (7) (b) Be (4)
(c) O (8) (d) He (2)

13. Arrange Be, Mg, Ca, Sr in the ascending order of ionisation enthalpy.
(a) Sr > Ca > Mg > Be (b) Sr > Mg > Ca > Be
(c) Be > Ca > Mg > Sr (d) Be > Mg > Ca > Sr

Match the Following

14. Match the following columns.

	Column I		Column II
(i)	Noble gases	(a)	F, Cl, Br, I
(ii)	Transition elements	(b)	O, S, Se, Te
(iii)	Chalcogens	(c)	Sc, Ti, V, Cr
(iv)	Halogens	(d)	He, Ne, Ar, Kr

15. Match the following columns.

	Column I		Column II
(i)	Most electronegative	(a)	Lithium
(ii)	Highest ionisation enthalpy	(b)	Caesium
(iii)	Least electronegative	(c)	Helium
(iv)	Lowest electron affinity	(d)	Fluorine

1 Mark Questions

16. From the following elements, select the elements which forms the Dobereiner's triad.

F, Mg, Ca, Br, Li, K, Rb, Cl, Sr, I

17. Which group of elements was missing from Mendeleev's periodic table?

18. Which are the two elements whose properties were predicted on the basis of their position in Mendeleev's periodic table?

19. The electronic configuration of an element X is 2, 8, 3.

(i) What is the group number of X?

(ii) What is the period number of X?

20. Give reason for the following.

Ionisation potential of the element increases across a period.

21. Why does chlorine has valency 1 and carbon has valency 4?

22. Name an inert gas having two electrons as its valency.

23. The three elements X, Y and Z have ionic radii 1.33 Å, 0.95 Å and 0.60 Å, respectively. Arrange them in increasing order of atomic numbers.

2 Marks Questions

24. A section which was common in Newland's and Mendeleev's classification is shown below :

Li	Be	B	C	N	O
Na	Mg	Al	Si	P	S

(i) Comment whose classification was better and why?

(ii) Give the point of difference (atleast two) between these two system of classification.

25. Write two reasons responsible for late discovery of noble gases.

26. The position of three elements X, Y and Z in the periodic table is shown below.

Group 1	Group 2
–	–
X	–
–	–
Y	Z

(i) Which type of ion-cation or anion, will be formed by an element X?

(ii) Which element Y or Z, has the atom of comparatively larger size? Give reason in each case.

27. Arrange the following sets of elements in increasing order of their atomic volume.

(i) K, Li, Na

(ii) O, C, N

28. Give reason.

(i) Electron affinity of halogens is comparatively high.

(ii) Electronegativity of chlorine is higher than sulphur.

29. Metallic character changes to non-metallic character as one moves from left to right, is it correct? Explain your answer.

30. (i) The metals of group 2 from top to bottom are Be, Mg, Ca, Sr, Ba. Which of these metals will form ions most readily and why?

(ii) What property of an element is measured by electronegativity?

3 Marks Questions

31. Newland's gave the law of octaves. Following questions are based on this law.

(i) How many elements were known at the time of Newland?

(ii) If one considered nitrogen as the first member of Newland's octaves, then which element is present at the eighth position from it?

(iii) "Newland adjusted two dissimilar elements under the same slot". Comment on this statement.

32. Give the atomic mass, formula of oxide and formula of hydride of the following elements as given by Mendeleev on the basis of his prediction.

(i) Eka-boron (ii) Eka-aluminium

(iii) Eka-silicon

33. Comment on the following statements.

(i) Atomic size of halogens is smallest in their period.

(ii) Anions are bigger than the atom.

(iii) Fluorine is the most electronegative element.

34. Name the following periodic property.

(i) Tendency of an atom to attract the shared pair of electrons.

(ii) Amount of energy required to remove an electron from an isolated gaseous atom.

(iii) Character of an element which loses one or more electrons when supplied with energy?

35. (i) Give reason, why the first period of periodic table has only two elements and second period has eight elements?

(ii) Give two advantages of the modern periodic table.

(iii) What is the significance of ionisation enthalpy?

4 Marks Questions

36. Explain the following.

(i) Ionisation enthalpy of Li is greater than Be.

(ii) Electron affinity of halogens is comparatively high.

(iii) Electronegativity of Br is greater than Se.

(iv) Atomic size of the elements on moving from left to right in a period decreases.

37. Five elements *A*, *B*, *C*, *D* and *E* have atomic number 1, 2, 5, 6 and 8 respectively. Answer the following questions.

(i) Which element forms positive ions?

(ii) Which elements has five electrons in the valence shell?

(iii) Which element has highest electron affinity?

(iv) Which element has highest ionisation potential?

5 Marks Questions

38. Properties of the elements are given below.

Where would you locate the following elements in the periodic table?

(i) A soft metal stored under kerosene.

(ii) An element with variable (more than one) valency stored under water.

(iii) An element which is tetravalent and forms the basis of organic chemistry.

(iv) An element which is an inert gas with atomic number 2.

(v) An element whose thin oxide layer is used to make other elements corrosion resistant by the process of 'anodising'.

39. The element of one short period of the periodic table are given below in the order from the left to right.

Li, Be, B, C, O, F, Ne

(i) To which period do these elements belong?

(ii) One element of this period is missing. Which is the missing element and where should it be placed?

(iii) Which one of the elements in this period show the property of catenation?

(iv) Place fluorine, beryllium and nitrogen in the increasing order of electronegativity.

(v) Which one of the above elements belong to the halogen series?

40. How do the following properties vary in periodic table?

(i) Atomic radius (ii) Metallic character
(iii) Non-metallic character (iv) Ionisation enthalpy
(v) Electronegativity

ARCHIVES*

(Last 6 Years)

Collection of Questions Asked in Last 6 Years' (2018-2013) ICSE Class 10th Examinations

2018

1 Give **one word** or a **phrase** for the following statement:
The energy released when an electron is added to a neutral gaseous isolated atom to form a negatively charged ion. ***[1]***

2 Give a reason for each of the following.

(i) Inert gases do not form ions. ***[1]***

(ii) Ionisation potential increases across a period, from left to right. ***[1]***

3 In period 3 of the periodic table, element *B* is placed to the left of element *A*. On the basis of this information, choose the correct word from the brackets to complete the following statements.

(i) The element *B* would have (lower/higher) metallic character than *A*.

(ii) The element *A* would probably have (lesser/higher) electron affinity than *B*.

(iii) The element *A* would have (greater/smaller) atomic size than *B*. ***[3]***

2017

4 Fill in the blanks by selecting the correct word from the brackets.

(i) If an element has a low ionisation energy, then it is likely to be ..... (metallic/non-metallic).

(ii) If an element has seven electrons in its outermost shell, then it is likely to have the ..... (largest/smallest) atomic size among all the elements in the same period. ***[1]***

5 Arrange the following as per the instruction given in the brackets.

(i) He, Ar, Ne (Increasing order of the number of electron shells).

(ii) Na, Li, K (Increasing ionisation energy)

(iii) F, Cl, Br (Increasing electronegativity).

(iv) Na, K, Li (Increasing atomic size). ***[4]***

6 Fill in the blanks from the choices given in brackets.
The energy required to remove an electron from a neutral isolated gaseous atom and convert it into a positively charged gaseous ion is called .....
(electron affinity, ionisation potential, electronegativity). ***[1]***

7 Match the atomic number 2, 4, 8, 15 and 19 with each of the following

(i) A solid non-metal belonging to the third period.

(ii) A metal of valency 1.

(iii) A gaseous element with valency 2.

(iv) An element belonging to group 2.

(v) A rare gas. ***[5]***

2016

8 Choose the correct answer from the options given below.
An element with the atomic number 19 will most likely combine chemically with the element whose atomic number is ***[1]***

(a) 17 (b) 11 (c) 18 (d) 20

9 Identify the term/substance in each of the following

(i) The tendency of an atom to attract electrons towards itself when combined in a compound.

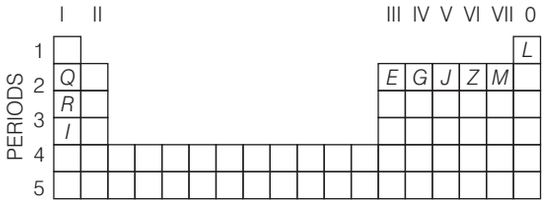
(ii) The electrons present in the outermost shell of an atom. ***[2]***

10 Rewrite the following sentences by using the correct symbol > (greater than) or < (less than) in the blanks given.

(i) The ionisation potential of potassium is ..... that of sodium.

(ii) The electronegativity of iodine is ..... that of chlorine. ***[2]***

11 Use the letters only written in the periodic table given below to answer the questions that follow



(i) State the number of valence electrons in atom *J*.
(ii) Which elements forms ions with a single negative charge?
(iii) Out of *I* and *R* which one is more reactive?
(iv) Which element has its electrons arranged in four shells? *[4]*

2015

12 The metals of group 2 from top to bottom are Be, Mg, Ca, Sr and Ba.
(i) Which one of these elements will form ions most readily and why?
(ii) State the common feature in the electronic configuration of all these elements. *[2]*

13 (a) Arrange the following as per the instructions given in the brackets
(i) Cs, Na, Li, K, Rb
(Increasing order of metallic character)
(ii) Mg, Cl, Na, S, Si
(Decreasing order of atomic size)
(iii) Na, K, Cl, S, Si
(Increasing order of ionisation energy)
(iv) Cl, F, Br, I
(Increasing order of electron affinity) *[4]*

(b) Choose the most appropriate answer from the following list of oxides which fit the description. Each answer may be used only once.
[SO_2, SiO_2, Al_2O_3, MgO, CO, Na_2O]
(i) A basic oxide.
(ii) An oxide which dissolves in water forming an acid.
(iii) An amphoteric oxide.
(iv) A covalent oxide of a metalloid.

(c) Element *X* is a metal with a valency 2, *Y* is a non-metal with a valency 3.
(i) Write an equation to show how *Y* forms an ion?
(ii) If *Y* is a diatomic gas, write an equation for the direct combination of *X* and *Y* to form a compound. *[4]*

2014

14 Give one word or phrase for the following.
The amount of energy released when an atom in the gaseous state accepts an electron to form an anion. *[1]*

15 Ionisation potential increases across a period from left to right because the
(a) atomic radius increases and nuclear charge increases
(b) atomic radius decreases and nuclear charge decreases
(c) atomic radius increases and nuclear charge decreases
(d) atomic radius decreases and nuclear charge increases *[1]*

2013

16 Name the element which has the highest ionisation potential. *[1]*

17 Among the elements of period 2, the element which has high electron affinity is
(a) lithium
(b) carbon
(c) chlorine
(d) fluorine *[1]*

18 Answer any five questions.

Group number	IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
Period	1	2	13	14	15	16	17	18
Second	Li		*D*			*O*	*J*	Ne
Third	*A*	Mg	*E*	Si		*H*	*M*	
Fourth	*R*	*T*	*I*		*Q*	*U*		*Y*

Note In this table, H does not represent hydrogen. Some elements are given in their own symbol and position in the periodic table while others are shown with a letter.

With reference to the above table answer the following questions.
(i) Identify the most electronegative element.
(ii) Identify the most reactive element of group 1.
(iii) Identify the element from period 3 with least atomic sizes.
(iv) How many valence electrons are present in *Q*?
(v) Which element from group 2 would have the least ionisation energy?
(vi) Identify the noble gas of the fourth period. *[5]*

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 Which of the following is not a periodic property?
(a) Atomic mass (b) Atomic volume
(c) Atomic radius (d) Electronegativity

2 Electronic configuration of an element *X* having atomic number 24 is
(a) 2, 8, 8, 3 (b) 2, 8, 8, 6
(c) 2, 8, 2, 8 (d) 2, 8, 7, 7

3 Element with atomic number 38 belongs to
(a) II A group and 5th period (b) II A group and 2nd period
(c) V A group and 2nd period (d) III A group and 5th period

4 Among the following, the atom of smallest radius is
(a) Na (b) K
(c) Br (d) Li

5 The group of elements in which the differentiating electron enters in the antipenultimate shell of atoms are called
(a) *f*-block elements (b) *p*-block elements
(c) *s*-block elements (d) *d*-block elements

6 Amongst the following, select the element with highest ionisation enthalpy.
(a) Sodium (b) Potassium
(c) Beryllium (d) Magnesium

7 Which one of the following is the correct order of the size of ions?
(a) $Na^+ > Mg^{2+} > F^- > O^{2-}$ (b) $O^{2-} > F^- > Na^+ > Mg^{2+}$
(c) $Mg^{2+} > Na^+ > F^- > O^{2-}$ (d) $O^{2-} > F^- > Mg^{2+} > Na^+$

8 The electron affinity of Be is similar to
(a) He (b) B
(c) Li (d) Na

9 Which of the following is correct order for ionisation energy?
(a) N > O > F (b) N < O < F
(c) N > O < F (d) N < O > F

10 The correct order of electron affinities of N, O, S and Cl is
(a) N < O < S < Cl (b) O < N < Cl < S
(c) O ≈ Cl < N ≈ S (d) O < S < Cl < N

Answers

1. (a) **2.** (b) **3.** (a) **4.** (d) **5.** (a) **6.** (c) **7.** (b) **8.** (a) **9.** (c) **10.** (a)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 259.

CHAPTER

2

Chemical Bonding

Each element found in nature want to achieve stable electronic configuration *i.e.*, either 2 or 8 electrons in its ourtermost shell. Thus, sharing or transfer of electrons develop force of attraction between atoms. This force of attraction is known as **chemical bond**. The tendency or potential of an element to combine with other elements to form a chemical bond is called **valency**.

A stable electronic configuration to attain stability can be achieved by

(i) Transfer of valence electrons from one atom to another (ionic bond or electrovalent).

(ii) Sharing the pair of electrons between two atoms (covalent bond).

(iii) Donation of a pair of electrons from one atom to another (coordinate bond).

Chapter Objectives

- Kossel-Lewis Approach to Chemical Bond Formation
- Types of Chemical Bond

Kossel-Lewis Approach to Chemical Bond Formation

In 1961, Kossel and Lewis proposed a concept that was based upon the electronic configuration of elements. This concept was called electronic concept of **valency** or **octet rule**. The tendency of the atoms of the element to have eight electrons in its valence shell was considered in this rule. Langmuir later on, modified this rule.

The main points are as follows

(i) The outermost shell of an atom is called the **valence shell** and the electrons present in it are called **valence electrons**.

(ii) The elements with eight electrons (except He which has two electrons in its valence shell), have complete octet, are chemically inert.

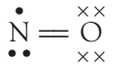
(iii) Those elements which do not have complete octet have tendency to attain stable configuration either by losing or gaining or sharing electrons to the atoms of same or other elements.

Exceptions of Octet Rule

Be and B have less than four valence electrons, hence, their octet cannot be completed even if they bind to their full strength.

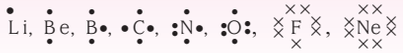
e.g., $Be + 2F \longrightarrow BeF_2$ (total 4 electrons in the outer most shell)

In a molecule with an odd number of electrons, the octet rule is not satisfied for all atoms.

e.g.,  (odd electron molecule)

Lewis Symbols (Electron Dot Formulae)

The simple notation to represent the valence electrons of an atom are called Lewis symbols. These symbols were introduced by an American Chemist, G N Lewis. In these symbols, the valence electrons are represented by placing dot (•) or cross (×) around the symbol e.g., the Lewis symbols for the atoms of second period are



Types of Chemical Bond

There are mainly three types of chemical bond which are as follows

(i) Electrovalent bond or ionic bond
(ii) Covalent bond or molecular bond
(iii) Coordinate bond or dative bond

Electrovalent Bond or Ionic Bond

A chemical bond formed by the complete transfer of electrons from one atom to another is called ionic bond. Such compounds are called ionic compounds. A metal gives electron(s) to form cations (+ve ions). A non-metal gains electrons to form anions (– ve ions). It means an ionic bond is formed between a metal and a non-metal.

Important Terms to Understand the Formation of Electrovalent Bonds

Electrovalency The number of electrons donated or accepted by the valence shell of an atom of an element, to achieve the stable electronic configuration is called electrovalency.

Electropositive Elements Atoms are electrically neutral, they possess equal number of protons and electrons. On losing an electron, an atom becomes positively charged because number of protons exceeds the number of electrons (cation is formed).

e.g., Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, etc.

$$Na \longrightarrow \underset{\text{(Cation)}}{Na^+} + e^-$$

Electronegative Elements When an atom gains an electron, the number of electrons exceed the number of protons and thus, atom becomes negatively charged (anion is formed).

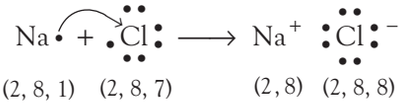
e.g., Cl^-, Br^-, I^-, F^-, O^{2-}, S^{2-}, N^{3-}, etc.

$$Cl + e^- \longrightarrow \underset{\text{(Anion)}}{Cl^-}$$

Note Group 1 elements are most electropositive. The metallic nature increases down the group (Cs is the most electropositive element). In same way, group 17 elements are most electronegative and electronegativity decreases down the group (F is the most electronegative element). Therefore, CsF is ionic in nature.

Formation of Electrovalent Bonds

Electrovalent bond is formed only when an atom can easily lose electron(s) while other can gain easily to acquire the stable electronic configuration (or arrangement) of nearest noble gas. *e.g.,* Formation of sodium chloride.



(2, 8, 1) (2, 8, 7) (2, 8) (2, 8, 8)

Conditions for the Formation of an Electrovalent Bond

(i) **Low Ionisation Energy of Metal Atom** Such that it loses electron(s) easily and a cation is formed.

(ii) **High Electron Gain Enthalpy or Electron Affinity of Non-metal Atom** such that an anion will be formed easily.

(iii) **Large Electronegativity Difference** such that the transfer of electron will be easier.

Electron Dot Structure of Some Electrovalent Compounds

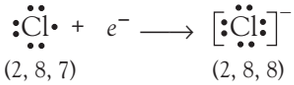
Electron dot structure of some electrovalent compounds are as follows

A. Sodium Chloride (NaCl)

The electronic configuration of sodium (atomic number is 11) is 2, 8, 1. It loses one electron from its outermost shell and acquires the inert gas configuration of nearest noble gas (*i.e.,* neon), thus, cation is formed.

$$\underset{(2,8,1)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + e^-$$

The electronic configuration of chlorine (atomic number is 17) is 2, 8, 7. It accepts one electron (which was released by sodium) and, thus anion is formed.



(2, 8, 7) (2, 8, 8)

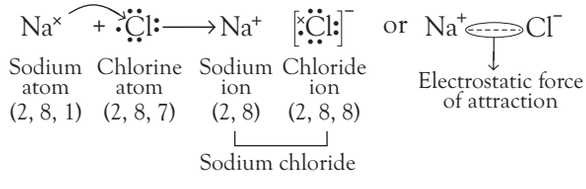
The above two oppositely charged ions (i.e. chloride and sodium ions) approach each other. They are held together by the strong electrostatic force of attraction. In this way, formation of sodium chloride takes place.

(i) **Ionic Equations of NaCl**

$$Na \longrightarrow Na^+ + e^- \qquad \text{(Cation)}$$

$$Cl + e^- \longrightarrow Cl^- \qquad \text{(Anion)}$$

(ii) **Electron Dot Structure of NaCl**



Sodium atom (2, 8, 1) Chlorine atom (2, 8, 7) Sodium ion (2, 8) Chloride ion (2, 8, 8) Sodium chloride

or

Electrostatic force of attraction

B. Magnesium Chloride ($MgCl_2$)

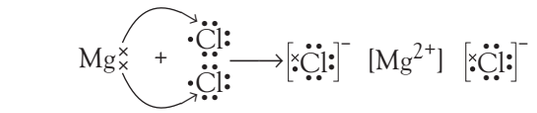
The number of valence electrons in magnesium atom (atomic number is 12) and chlorine atom (atomic number is 17) are 2 and 7, respectively. Therefore, magnesium atom loses its two electrons, acquire a stable noble gas configuration (2, 8) and attains +2 charge (cation). Each chlorine atoms containing seven electrons in its valence shell can accept one-one electron of the two electrons that are donated by the magnesium atom. Therefore, two chloride ions will combine with one magnesium ion (Mg^{2+}) to form magnesium chloride molecule ($MgCl_2$).

(i) Ionic Equations of $MgCl_2$

$$\underset{\substack{(2,8,2)\\\text{Atom}}}{Mg} - 2e^- \longrightarrow \underset{\substack{(2,8)\\\text{Cation}}}{Mg^{2+}}$$

$$\underset{\substack{(2,8,7)\\\text{Atom}}}{2Cl} + 2e^- \longrightarrow \underset{\substack{(2,8,8)\\\text{Anion}}}{2Cl^-}$$

(ii) Electron Dot Structure of $MgCl_2$



Magnesium atom (2, 8, 2) Chlorine atom (2, 8, 7)

or $[Mg^{2+}]$ $\left[\times\underset{\times}{\overset{\times}{\underset{\times}{Cl}}}:\right]^-_2$ or $MgCl_2$

Magnesium ion (2, 8) Chloride ion (2, 8, 8)

Magnesium chloride

C. Calcium Oxide (CaO)

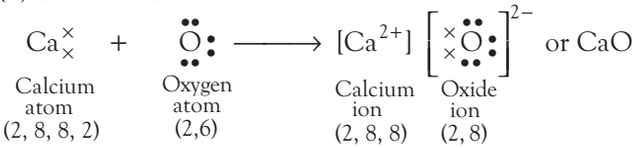
Calcium (atomic number is 20, electronic configuration = 2, 8, 8, 2) loses two electrons and attains +2 charge by forming calcium ion and acquires stable noble gas electronic configuration (*i.e.*, argon). On the other hand, oxygen (atomic number is 8, electronic configuration = 2, 6) gain two electrons to form oxide ion and acquires stable configuration of nearest noble gas (*i.e.*, neon).

(i) Ionic Equations of CaO

$$\underset{(2,8,8,2)}{Ca} - 2e^- \longrightarrow \underset{(2,8,8)}{Ca^{2+}} \quad \text{(Cation)}$$

$$\underset{(2,6)}{O} + 2e^- \longrightarrow \underset{(2,8)}{O^{2-}} \quad \text{(Anion)}$$

(ii) Electron Dot Structure of CaO



Calcium atom (2, 8, 8, 2) Oxygen atom (2,6) Calcium ion (2, 8, 8) Oxide ion (2, 8)

Calcium oxide

Properties of Electrovalent Compounds

(i) **Physical State** These compounds generally exist as crystalline solids known as crystal lattice, which consist of orderly three dimensional arrangements of cations and anions held together by the coulombic forces. *e.g.* Sodium chloride, NaCl (rock salt).

(ii) **Melting and Boiling Points** In ionic compounds, the ions are tightly held together by strong electrostatic forces of attraction and hence, a large amount of energy is required to break the crystal lattice, thus, they possess high melting and boiling points.

(iii) **Solubility** These compounds are soluble in solvents like water having high polarity and high dielectric constant. It is because of the fact that the polar solvent interacts with the ions of the crystals and further the high dielectric constant of the solvent cuts off the force of attraction between these ions.

Non-polar solvents such as carbon tetrachloride, benzene, etc., having low dielectric constant are not capable to dissolve ionic solids.

(iv) **Electrical Conductivity** Ionic compounds are good conductors of electricity in the aqueous solution or in their molten states because of the presence of free ions in these states. However, they do not conduct electricity in their solid state because of the absence of free ions as strong electrostatic forces of attraction is present between the ions.

(v) **Ionic Reactions** These compounds split up into oppositely charged ions when dissolved in water. Thus, the chemical reactions of these compounds are characteristic of their constituent ions and are known as ionic reactions. These reactions are almost instantaneous. *e.g.*,

$$Na^+Cl^-(aq) + Ag^+NO_3^-(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

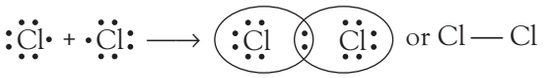
(vi) **Non-directional Character** The ionic bond is non-directional in nature.

CHECK POINT 01

1. All types of chemical bonds are result of electrostatic interaction. Justify this statement.
2. How cations and anions formed in a chemical reaction?
3. Electrovalent compounds are formed in the following reactions:
   (i) $2Na + Cl_2 \longrightarrow 2Na^+Cl^-$
   (ii) $2Mg + O_2 \longrightarrow 2Mg^{2+}O^{2-}$
   Write the electronic configuration of the ions of the electrovalent products.
4. Write the electron dot structure of $MgCl_2$.
5. Ionic compounds are soluble in water. Explain.

Covalent Bond or Molecular Bond

A chemical bond formed by the mutual sharing of electrons between the combining atoms of the same or different elements is called the **covalent bond.** This bond is generally formed between two electronegative *i.e.*, non-metallic elements. The number of electrons shared by an atom in order to complete its octet is called the **covalency** of that atom. *e.g.,* Formation of chlorine molecule.



Covalent bond between two Cl-atoms

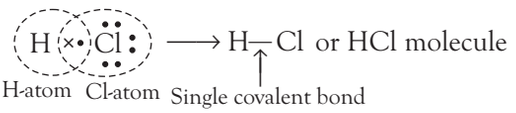
Note Number of covalent bonds formed depend upon the number of shared pair of electrons between the two atoms.

Types of Covalent Bonds

Covalent bonds are broadly classified into following types

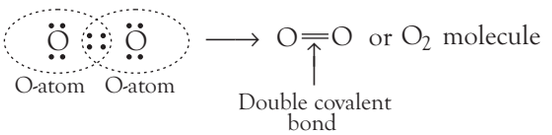
(i) **Single Covalent Bond** It is formed by the sharing of one pair of electrons between two atoms. It is represented by a single line (—).

e.g.,

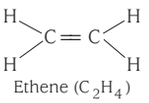


(ii) **Double Covalent Bond** It is formed by the sharing of two pair of electrons between two atoms. It is represented by a double line (═).

e.g.,

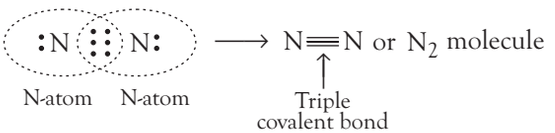


Note Some molecules like C_2H_4 (ethene) have the combination of one double covalent bond and four single covalent bonds.

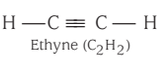


(iii) **Triple Covalent Bond** It is formed by the sharing of three pair of electrons between two atoms. It is represented by a triple line (≡).

e.g.,



Note Some molecules like C_2H_2 (ethyne) have the combination of one triple and two single covalent bonds.



Polar and Non-polar Covalent Compounds

Depending upon the electronegative character of combining atoms, the covalent bonds can be of two types

(i) **Non-polar Covalent Compound** When a covalent bond is formed between two atoms having almost same electronegativity, then the shared pair of electrons are equally shared by the two atoms situated exactly between the two identical nuclei. This type of covalent bond is called non-polar covalent bonds. The compound which exhibit this type of bond is called non-polar covalent compound. *e.g.*, Hydrogen (H_2), chlorine (Cl_2), oxygen (O_2), etc.

(ii) **Polar Covalent Compounds** When a covalent bond is formed between two atoms having significant difference in their electronegativities, then the shared pair of the electrons slightly shift towards the more electronegative atom. Thus, the bond formed attain partial ionic character. This type of covalent bond is called polar covalent bond. The compound which exhibit this type of bond is called polar covalent compound. *e.g.,*

$\overset{\delta+}{H}—\overset{\delta-}{Cl}$, $\overset{\delta+}{H}—\overset{\delta-}{F}$, $\overset{\delta+}{H}—\overset{\delta-}{O}—\overset{\delta+}{H}$, etc.

Conditions for the Formation of a Covalent Bond

Following conditions are necessary for the formation of a covalent bond

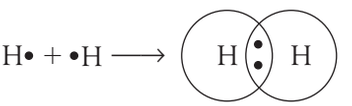
(i) Both atoms should have four or more electrons in outermost shell.
(ii) Both atoms should have high electronegativity.
(iii) Both atoms should have high electron affinity.
(iv) Both atoms should have high ionisation energy.

Electron Dot Structure of Some Covalent Compounds

The structures of some covalent compounds are as follows

A. Hydrogen Molecule (H_2) (Non-polar Covalent Compound)

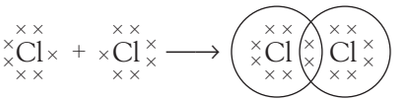
A hydrogen atom has one electron in its outermost shell. It needs one more electron to complete its duplet. Thus, hydrogen atom shares its electron with another hydrogen atom to form H_2 molecule.



B. Chlorine Molecule (Cl_2) (Non-polar Covalent Compound)

Electronic configuration of Cl-atom is 2, 8, 7. So, it needs one electron to complete its octet. Hence, it shares one electron with another Cl-atom to form Cl_2 molecule.

e.g.,

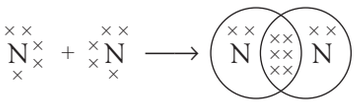


Cl_2 molecule

C. Nitrogen Molecule (N_2) (Non-polar Covalent Compound)

Electronic configuration of N is 2, 5. To complete its octet, nitrogen needs three electrons. Hence, two N-atoms share three pair of electrons to form N_2 molecule.

e.g.,

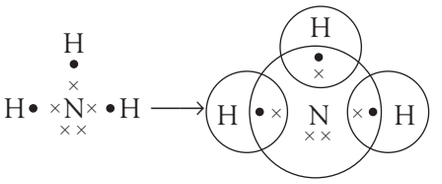


N_2 molecule

D. Ammonia Molecule (NH_3) (Polar Compound)

Electronic configuration of N is 2, 5 and H is 1. Nitrogen needs three electrons to complete its octet while hydrogen needs one electron to complete its duplet. Number of covalent bonds in NH_3 = 3.

e.g.,

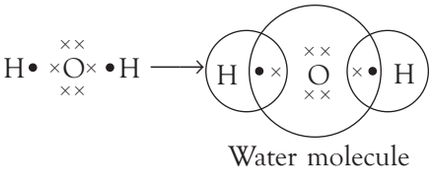


Ammonia molecule

E. Water Molecule (H_2O) (Polar Compound)

Electronic configuration of H is 1 and O is 2, 6.
Hydrogen needs one electron to complete its duplet while oxygen needs two electrons to complete its octet. Hence, one O-atom shares its two electrons with two H-atoms.

e.g.,

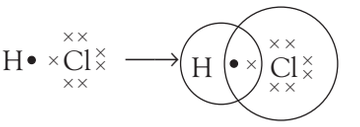


Water molecule

F. Hydrogen Chloride Molecule (HCl) (Polar Compound)

Electronic configuration of H is 1 and Cl is 2, 8, 7.
Hydrogen needs one electron to complete its duplet while chlorine needs one electron to complete its octet.
Hence, one Cl-atom shares its one electron with one H-atom.

e.g.,

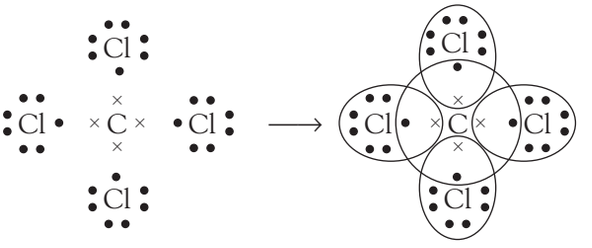


HCl molecule

G. Carbon Tetrachloride Molecule (CCl_4) (Non-polar Compound)

Electronic configuration of C = 2, 4 and Cl = 2, 8, 7.
Carbon needs 4 electrons while Cl requires one more electron to attain the stable electronic configuration of nearest noble gas by completing their octet.

e.g.,

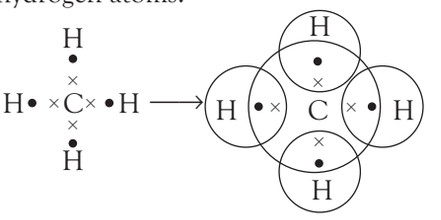


CCl_4 molecule

H. Methane (CH_4) (Non-polar Compound)

Carbon atom has four electrons in its valence shell. In order to complete octet, it shares four electrons, one each with four hydrogen atoms.

e.g.,



CH_4 molecule

Properties of Covalent Compounds

Some of the important properties of covalent compounds are as follows

(i) **Physical State** The covalent compounds exist in all the three states *viz* solid, liquid and gas. They usually contain molecules rather than ions.

(ii) **Low Melting and Boiling Points** These compounds have low melting and boiling points because of the presence of weak forces of attraction between the molecules which are easily overcome at low temperatures.

(iii) **Solubility** Being non-polar, these are generally insoluble or less soluble in water and in other polar solvents. However, these are soluble in non-polar solvents such as benzene, carbon tetrachloride, etc.

(iv) **Electrical Conductivity** Since, there are no free ions in covalent compounds, they are bad conductors of electricity. However, graphite is an exception.

(v) **Molecular Reactions** Since, these compounds are molecular in nature, they give molecular reactions and proceed at a much slower rate as compared to the ionic compounds.

(vi) **Ionisation in Solution** When electricity is passed, non-polar covalent compounds do not ionise but covalent compounds which are polar in nature ionizes in their solutions and can acts as an electrolyte.

(vii) **Directional Characteristics** Since, the covalent bond is localised in between the nuclei of atoms, it is directional in nature.

CHECK POINT 02

1 Show the formation of covalent bonds, using Lewis dot structure in the following molecules
(i) $CHCl_3$ (ii) O_2 (iii) H_2 (iv) N_2

2 Classify the following molecules as polar and non-polar molecules. Give reason for your classification.
(i) H_2 (ii) O_2 (iii) H_2O (iv) CCl_4
(v) NH_3 (vi) Cl_2 (vii) HCl

3 Covalent compounds exhibit different physical properties in comparison to electrovalent compounds. Justify by giving suitable reasons.

4 Why HCl is a bad conductor of electricity?

5 Name a neutral molecule which contains two lone pairs of electrons.

Comparison of Electrovalent and Covalent Compounds

	Electrovalent Compounds			Covalent Compounds	
	Property	**Reason**		**Property**	**Reason**
(i)	*Nature* Their constituent particles are ions. They are hard solids.	These have strong electrostatic forces of attraction between their ions which cannot be separated easily.	(i)	*Nature* Their constituent particles are molecules. These are gases, liquids or soft solids.	They have weak forces of attraction between their molecules.
(ii)	*Boiling and Melting Points* These are non-volatile, with high boiling and melting points.	Strong forces of attraction exists between the oppositely charged ions, so, a large amount of energy is required to break this strong forces of attraction.	(ii)	*Boiling and Melting Points* These are volatile with low melting and boiling points.	They have weak forces of attraction between the binding molecules, thus, less energy is required to break this force of attraction.
(iii)	*Conducting (Electricity) Nature* They do not conduct electricity in the solid state. They are good conductors of electricity in the fused (or in aqueous) state.	Electrostatic forces of attraction between ions in the solid state are very strong. These forces weaken in fused state or in solution state. Hence, ions become mobile.	(iii)	*Conducting (Electricity) Nature* They are non-conductors of electricity in solid, molten or aqueous state.	Due to the absence of free ions.
(iv)	*Solubility* These are soluble in polar solvents like water but insoluble in organic solvents.	As water is a polar compound, it decreases the electrostatic forces of attraction, resulting in the formation of free ions in aqueous solution. Hence, they dissolve.	(iv)	*Solubility* These are insoluble in water but dissolve in organic solvents.	As organic solvents are non-polar, hence, these compounds dissolves in non-polar covalent compounds.
(v)	*Ionisation/Dissociation in Solution* When electricity is passed through their aqueous solution or molten state, these compounds dissociate into their ions and the ions migrate to the opposite electrodes.	Compounds dissociate in water or in molten state into their ions.	(v)	*Ionisation/Dissociation in Solution* When electricity is passed through their solutions no dissociation of molecules into ions takes place.	Covalent compounds do not dissociate because they contain molecules, rather than the ions.

Coordinate Bond or Dative Bond

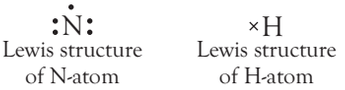
The bond formed between two atoms by sharing a pair of electrons, both of which are provided or contributed by only one of the bonding atoms but shared by both atoms is called coordinate bond or dative bond. *e.g.*, Ammonium ion (NH_4^+) and hydronium ion (H_3O^+).

Note

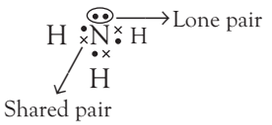
- The atom which provides the electron pair for the formation of a coordinate bond is called **donor**.
- The atom or ion sharing the donated electron pair is called **acceptor.**
- The bond is shown by an arrow with its head pointing away from the donor to acceptor atom (⟶).

Formation of Ammonium Ion (NH_4^+)

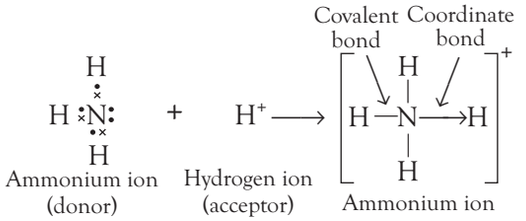
Formation of ammonium ion (NH_4^+) involves ammonia molecule and hydrogen ion. Ammonia contains one nitrogen atom and three hydrogen atoms. Nitrogen atom has five and hydrogen atom has one valence electron, respectively.



In ammonia, covalent bond formation takes place in which each of three hydrogen atoms are bonded to nitrogen atom by sharing a pair of electrons and one lone pair of electrons present on N-atom of ammonia after completing its octet.



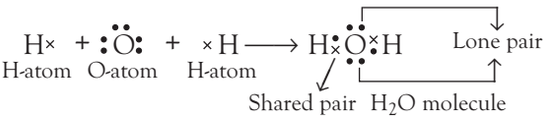
The hydronium ions, from water, accepts this lone pair of electrons of nitrogen atom of ammonia molecule leading to the formation of a coordinate bond (and hydronium ion acquires helium configuration).



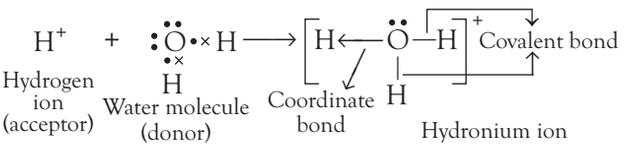
Note Ammonium chloride (NH_4Cl) has all three types of bonds i.e., covalent, coordinate and ionic. NH_4Cl formed cation, NH_4^+ have three covalent and one coordinate bond and an anion Cl^-. These ions are attracted towards each other due to electrical charge existing between them, which results in the formation of ionic bond.

Formation of Hydronium Ion (H_3O^+)

The hydronium ion, $[H_3O]^+$ involves water molecule and hydrogen ion. Water molecule contains two hydrogen atoms and one oxygen atom. Oxygen atom contains six valence electrons and hydrogen atom contains one valence electron.

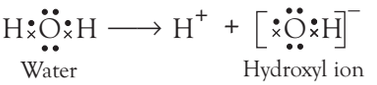


Out of these two lone pair of electrons, one lone pair is used to donate to hydrogen ion.



Formation of Hydroxyl Ion (OH^-)

Hydroxyl ion or hydroxide ion is formed when one hydrogen ion (H^+) is removed from water molecule. After removing H^+, the shared pair of electron remains with oxygen as it is more electronegative and as a result hydroxyl ion attains negative charge.



Self Ionisation of Water

A water molecule after ionisation gives a positive hydrogen ion, H^+ and a hydroxyl ion, OH^-.

$$H_2O \longrightarrow H^+ + OH^-$$

This H^+ ion will transfer to another H_2O molecule to form H_3O^+ ion. Thus, H_3O^+ and OH^- ions are formed from two water molecules.

$$H_2O + H_2O \longrightarrow H_3O^+ + OH^-$$

CHECK POINT 03

1. On the basis of electron transfer or sharing, distinguish coordinate bonds from electrovalent and covalent bonds.
2. Using the examples of ammonium ion (NH_4^+) and hydronium ion (H_3O^+), discuss the significance of lone pair in the formation of coordinate bond.
3. Draw the electron dot structure of hydroxyl ion.
4. Name the compound which contains all the three types of bonds.
5. What is self-ionisation of water?

SUMMARY

- The attractive forces which holds various constituents (atoms, ions, etc.) together in different chemical species is called a chemical bond.
- The atoms of different elements combine with each other in order to complete their respective octets (i.e., 8 electrons in their outermost shell) or duplet (i.e., outermost shell contaning 2 electrons) in case of hydrogen, lithium and beryllium.
- Lewis symbols are the simple symbols used to denote the valence shell electrons in an atom. The valence shell electrons are shown by dots surrounding the symbol of the atom.
- There are three types of chemical bond
  - (i) Electrovalent bond
  - (ii) Covalent bond
  - (iii) Coordinate bond
- A chemical bond formed by the complete transfer of electrons from one atom to another is called electrovalent bond or ionic bond. e.g., NaCl.
- A chemical bond formed by the mutual sharing of electrons between the combining atoms of the same or different elements is called covalent bond. e.g., CH_4.
- The bond formed between two atoms by sharing a pair of electrons, both of which are provided or contributed by only one of the bonding atoms but shared by both atoms is called coordinate bond or dative bond. e.g., Ammonium ion (NH_4^+).

EXAM PRACTICE

Fill in the Blanks

1. Ionic compound is formed when the difference between the values of electronegativities of two combining atoms is very …… (large/less).

Sol. large

2. Ionic or electrovalent compounds do not conduct electricity in their ..... state. (fused/solid) ***[2018]***

Sol. solid

3. …… bond is rigid and non-directional.

Sol. Ionic

4. Electrovalent compounds have …… (high/low) melting points. ***[2016]***

Sol. high

5. The total number of electrons in the O^{2-} ion is …… .

Sol. 10

6. When both the atoms entering in a chemical reaction are non-metallic, the chemical bond formed between them is …… .

Sol. covalent

7. In covalent compounds, the bond is formed due to the …… (sharing/transfer) of electrons. ***[2011]***

Sol. sharing

8. The compound that does not have a lone pair of electrons is …… (water, ammonia, carbon tetrachloride). ***[2017]***

Sol. carbon tetrachloride

9. A fluorine molecule is formed by sharing …… electron pair between the two atoms of fluorine.

Sol. one

10. A nitrogen molecule is formed by sharing …… electron pair between the two atoms of nitrogen.

Sol. three

11. Hydrogen atom is a (i) …… and chlorine is a (ii) …… . When hydrogen combines with chlorine to form (iii) ……, the (iv) …… of electrons takes place between hydrogen and chlorine atoms and (v) …… bond is formed. It should be noted that a covalent bond can also be formed between two atoms of (vi) …… non-metals.

Sol. (i) non-metal (ii) non-metal
(iii) hydrogen chloride (iv) sharing
(v) covalent (vi) same

12. A polar covalent bond is generally formed between dissimilar atoms having different …… .

Sol. electronegativity

13. Covalent bond between two similar atoms or dissimilar atoms which have (i)…… electronegativity difference is called (ii)…… bond. These compounds (iii)…… in water.

Sol. (i) negligible or zero
(ii) non-polar covalent
(iii) do not ionise

14. Melting and boiling points of covalent compounds are generally …… . (high/low).

Sol. low

15. The hydronium ion involves water molecule and …… ion.

Sol. hydrogen

Multiple Choice Questions

16. What kind of bond is formed between the metallic and non-metallic element?

(a) Coordinate bond (b) Covalent bond
(c) Ionic bond (d) None of these

Sol. (c)

17. When a metal atom becomes an ion

(a) it loses electrons and is oxidised
(b) it gains electrons and is reduced
(c) it gains electrons and is oxidised
(d) it loses electrons and is reduced

Sol. (a)

18. The property which is characteristic of an electrovalent compound is that ***[2006]***

(a) it is easily vaporised
(b) it has a high melting point

(c) it is a weak electrolyte
(d) it often exists as a liquid

Sol. (b)

19. Which of the following is not a typical property of an ionic compound?
(a) High melting point
(b) Conducts electricity in the molten and in the aqueous solution state.
(c) They are insoluble in water.
(d) They exist as oppositely charged ions even in the solid state.

Sol. (c)

20. Which of the following is a common characteristic of a covalent compound? ***[2017]***

Sol. (a) High melting point
(b) Consist of molecules
(c) Always soluble in water
(d) Conducts electricity when it is in the molten state

Sol. (b)

21. The bond between oxygen atoms in a molecule is
(a) single covalent bond (b) double covalent bond
(c) triple covalent bond (d) ionic bond

Sol. (b)

22. The molecule containing a triple covalent bond is ***[2014]***
(a) ammonia (b) methane
(c) water (d) nitrogen

Sol. (d)

23. Which of the following is not a polar molecule?
(a) CCl_4 (b) HCl (c) H_2O (d) NH_3

Sol. (a)

24. Among the following, the one which is composed of all the three kinds of bonds (ionic, covalent and coordinate). ***[2009]***
(a) Sodium chloride (b) Ammonia
(c) Carbon tetrachloride (d) Ammonium chloride

Sol. (d)

Match the Following

25. Match the following columns.

Column I	Column II
(i) Ionic compound	(a) Low melting point
(ii) Neon	(b) High melting point
(iii) Helium	(c) Octet
(iv) Covalent compounds	(d) Duplet

Sol. (i) → (b), (ii) → (c), (iii) → (d), (iv) → (a)

26. Match the following columns.

Column I	Column II
(i) Methane	(a) Increases
(ii) Hydronium ion	(b) Decreases
(iii) Hydrogen chloride	(c) Covalent bond
(iv) Electronegativity across period	(d) Polar covalent compound
(v) Electronegativity down the group	(e) Covalent and coordinate bond

Sol. (i) → (c), (ii) → (e), (iii) → (d), (iv) → (a), (v) → (b)

27. Match the Column I with Column II.

Column I	Column II
(i) Covalent compound	(a) Bromine
(ii) Non-metal	(b) Carbon dioxide
(iii) Cation	(c) Aluminium
(iv) Anion	(d) Water
(v) Electrovalent compound	(e) F^-
(vi) Polar	(f) Li
(vii) Metal	(g) Methane
(viii) Non-polar	(h) Potassium chloride

Sol. (i) → (b) (ii) → (a)
(iii) → (f) (iv) → (e)
(v) → (h) (vi) → (d)
(vii) → (c) (viii) → (g)

1 Mark Questions

28. State why noble gases are unreactive while atoms of elements other than noble gases are chemically reactive?

Sol. Noble gases are unreactive because they have stable electronic configuration *i.e.,* their outermost (valence) shell is complete. Generally they do not lose, gain or share electrons.

29. Give **one word** or a **phrase** for the following statements.
Process of formation of ions from molecules which are not in ionic state. ***[2018]***

Sol. Ionisation

30. Why do the electrovalent compounds form the crystalline solids?

Sol. Because they have strong electrostatic forces of attraction between oppositely charged ions that holds them together and form a regular crystal structure.

31. Why an aqueous solution of sodium chloride conducts electricity? ***[2012]***

Sol. Sodium chloride (Na^+Cl^-) is an ionic compound. When dissolved in water, the ions present in it can migrate towards the oppositely charged electrodes and such an aqueous solution of sodium chloride conducts electricity.

32. Give a reason for each of the following.
Ionic compounds have a high melting point.

Sol. Ionic compounds have high melting point due to the presence of strong electrostatic force of attraction. It requires a large amount of energy to break these forces of attraction. ***[2018]***

33. Why non-polar compounds are insoluble in water?

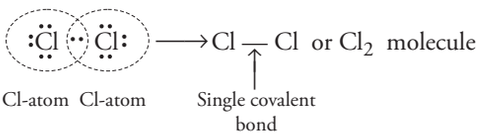
Sol. Non-polar covalent compounds do not have free ions. Thus, they are insoluble in polar covalent water. However, they dissolve in non-polar covalent liquids such as benzene, carbon tetrachloride, etc.

34. What is the condition required for the formation of polar molecule?

Sol. There should be significant electronegativity difference between the two combining atoms.

35. Show the formation of covalent bond in chlorine by dot diagram.

Sol.



36. Write a covalent compound which behaves like an ionic compound in aqueous solution. ***[2009]***

Sol. HCl being a covalent compound shows polar nature due to large electronegativity difference between H and Cl. Hence, when it is dissolved in water, behaves like an ionic compound.

37. Give one word or phrase for the following 'Formation of ions from molecules'. ***[2014]***

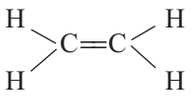
Sol. Ionisation

38. An element *L* consists of molecules. What type of bonding is present between its atoms?

Sol. Covalent bonding ***[2015]***

39. How many single, double, triple bonds are formed by ethene molecule?

Sol.



4-single bonds, 1-double bond, no triple bond

40. What is the term that can be defined in the following case? A bond formed by a shared pair of electrons, each bonding atom contributing one electron to the pair. ***[2013, 2008]***

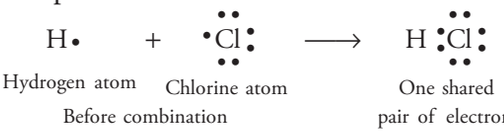
Sol. Covalent bond

41. What type of compound is formed by the atoms *X* and *Y* with atomic number 12 and 9, respectively?

Sol. $X = 2, 8, 2, Y = 2, 7.$
So, compound formed is XY_2. Thus, it is an electrovalent compound.

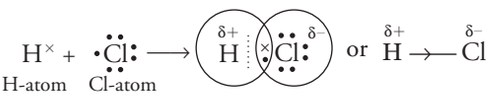
42. Draw the electron dot structure of polar covalent compound HCl.

Sol.



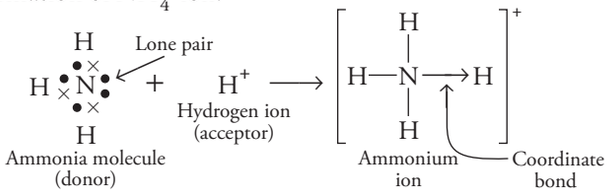
43. Give reason, hydrogen chloride can be termed as a polar covalent compound. ***[2011]***

Sol. In hydrogen chloride, chlorine is more electronegative than that of hydrogen. So, it attracts the shared electron pair towards itself.
Due to this, Cl acquire partial negative charge and H acquire partial positive charge.
Therefore, a polar covalent bond is formed.



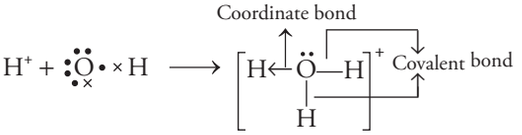
44. By drawing an electron dot diagram, show the lone pair effect leading to the formation of ammonium ion from ammonia gas and hydrogen ion. ***[2011]***

Sol. In ammonia (NH_3), N-atom has one lone pair of electrons, which is used for donation to H^+ ion for the formation of NH_4^+ ion.



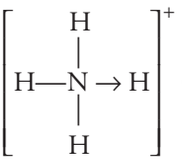
45. Draw an electron dot diagram to show the structure of hydronium ion. State the type of bonding present in it. ***[2012, 2006]***

Sol.



46. State the type of bonding in ammonium chloride.

Sol.



Ionic (between NH_4^+ and Cl^- ions), covalent (between N and H-atom) and coordinate (between N and H).

b 2 Marks Questions

47. Use Lewis symbols to show electron transfer between the following atoms to form cations and anions :
(i) K and S (ii) Al and N

Note Metals lose electrons to complete their octet while non-metals gain electrons to complete octet. So, write the Lewis symbol, i.e. symbols with valence electrons to show the transfer of electron from metal to non-metal.

Sol. (i) $2K^{\bullet} + \underset{2,8,6}{\overset{\bullet\bullet}{\underset{\bullet\bullet}{:S:}}} \longrightarrow 2K^{+}\left[:\overset{\bullet\bullet}{\underset{\bullet\bullet}{S}}:\right]^{2-}$; K_2S [1]

(ii) $\underset{2,8,3}{\overset{\bullet\bullet}{Al}\bullet} + \bullet\underset{2,5}{\overset{\bullet\bullet}{N}}: \longrightarrow Al^{3+}\left[:\overset{\bullet\bullet}{\underset{\bullet\bullet}{N}}:\right]^{3-}$; AlN [1]

48. What is the difference between the fluoride ion and neon atom even when the electronic configuration of both are same?

Sol. Electronic configuration

For fluoride ion (F^-), K M = 2 8 [1]

For neon (Ne) atom, K M = 2 8

Neon atom is a neutral atom but fluoride ion is negatively charged. [1]

49. Show the formation of covalent bonds in (i) oxygen (ii) nitrogen molecule by dot diagram.

Sol. (i) **Oxygen**

$:\ddot{O}: + :\ddot{O}: \longrightarrow \ddot{O}::\ddot{O}$ or O=O

O-atom O-atom

Two electron pairs are shared [1]

(ii) **Nitrogen**

$\ddot{N}: + :\ddot{N} \longrightarrow \ddot{N}:::\ddot{N}$ or $\ddot{N}\equiv\ddot{N}$

N-atom N-atom

Three electron pairs are shared [1]

50. Explain, polar covalent bond with the help of suitable example.

Sol. When covalent bond is formed between two dissimilar atoms *e.g.,* HF (heteronuclear molecule), the shared pair of electrons between the two atoms get displaced towards more electronegative atom, fluorine. As a result, hydrogen atom becomes slightly positively charged and fluorine becomes slightly negatively charged. This type of bond is called polar covalent bond.

$H:\ddot{F}:$, $\overset{\delta+}{H}—\overset{\delta-}{F}$

Attracted more towards fluorine [2]

51. The non-polar and polar covalent compounds are generally formed between what kind of atoms?

Sol. **Non-polar covalent bonds** *These type of bonds are generally formed between*

(a) similar atoms such as in H_2, O_2, N_2, F_2, etc.

(b) atoms having negligible or zero electronegativity difference *e.g.,* CH_4. [1]

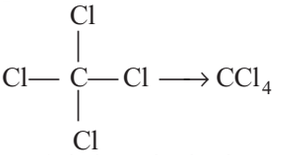
Polar covalent bonds *These type of bonds are generally formed between*

(a) dissimilar atoms such H_2O, NH_3.

(b) atoms having different electronegativities and atomic radii, such as in HCl, HF, etc. [1]

52. Draw the appropriate structural formula of carbon tetrachloride and state the type of bond present in it. [2009]

Sol.

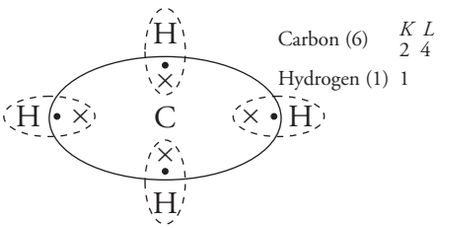


CCl_4

4-single covalent bonds [2]

53. Explain the bonding in methane molecule using electron dot structure. [2015]

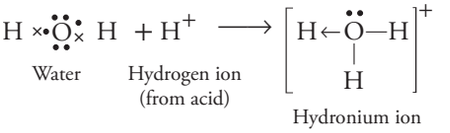
Sol. To attain the stable electronic configuration of the nearest noble gas, in methane (CH_4), carbon (C) needs four electrons and hydrogen (H) needs one electron. When a molecule of methane is formed, one atom of carbon shares four electron pairs, one with each of the four atoms of hydrogen. [1]



Methane (CH_4) [1]

54. Draw the structure of stable positive ion when an acids is dissolved in water. [2014, 2005]

Sol.



$H\times\ddot{\underset{\times}{O}}H + H^+ \longrightarrow \left[H\leftarrow\ddot{O}(H)—H\right]^+$

Water Hydrogen ion (from acid) Hydronium ion [2]

55. Why do covalent compounds exist as gases, liquids or soft solids? [2014]

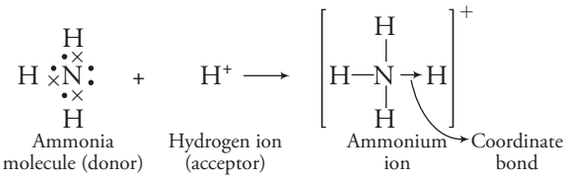
Sol. They have weak force of attraction between their molecule that is why they exist in gases, liquids or soft solid form. [2]

56. Explain, why hydrogen chloride can be termed as a polar covalent compound? *[2011]*

Sol. In hydrogen chloride, chlorine has greater electronegativity than hydrogen and, so, attracts the shared electron pair towards itself, thus, developing a slight negative charge and hydrogen acquires an equivalent amount of slight positive charge. Thus, forming a polar covalent bond. *[2]*

57. By drawing an electron dot diagram, show the formation of ammonium ion (Atomic number : N = 7 and H = 1). *[2016]*

Sol.



[2]

58. State the type of bonding in the following molecules. *[2017]*

(i) Water (ii) Calcium oxide

Sol. (i) Water (H_2O)-Covalent bond *[1]*

(ii) Calcium oxide (CaO)-Ionic bond *[1]*

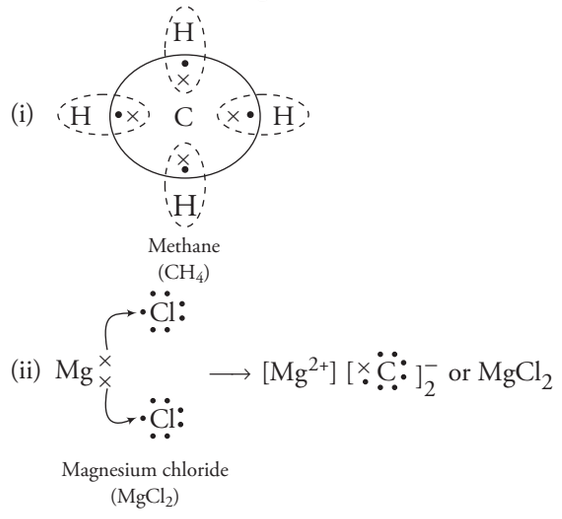
59. Draw an electron dot diagram to show the formation of each of the following compounds.

(i) Methane

(ii) Magnesium chloride

[H = 1, C = 6, Mg = 12, Cl = 17] *[2017]*

Sol.



[2]

C 3 Marks Questions

60. An atom *A* gives one electron to each *B* atom to form a compound AB_2. What is the nature of bonds in AB_2? Give two properties of AB_2.

Sol. The nature of bond in AB_2 is electrovalent (or ionic). *[1]*

The properties are as follows

(i) It will be a solid compound.

(ii) Its crystals will be hard and brittle.

(iii) It is soluble in water.

(iv) Have high melting and boiling points.

(v) It will conduct electricity when present in molten state or dissolved in water. *[2]*

61. Compound *X* consists of molecules. Choose the letter corresponding to the correct answer from the choices (a), (b), (c) and (d) given below. *[2005]*

(i) The type of bonding in *X* will be

(a) ionic (b) electrovalent

(c) covalent (d) molecular

(ii) *X* is likely to have a

(a) low melting and high boiling points

(b) high melting and low boiling points

(c) low melting and low boiling points

(d) high melting and high boiling points

(iii) In the liquid state, *X* will

(a) become ionic (b) be an electrolyte

(c) conduct electricity (d) not conduct electricity

Sol. (i) (c) Compound *X* consists of molecules not ions. So, the type of bonding in compound *X* will be covalent. *[1]*

(ii) (c) Covalent compounds have low melting and low boiling points because they have weak forces of attraction between the binding molecules, thus, less energy is required to break the force of binding. *[1]*

(iii) (d) In the liquid state, *X* will not conduct electricity because it does not have free ions. *[1]*

62. (i) What is lone pair of electrons ? *[2006]*

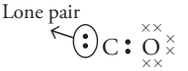
(ii) Draw an electron dot diagram of a hydronium ion and the lone pair of electrons.

(iii) Name a neutral covalent molecule which contains one lone pair of electrons.

Sol. (i) Lone pair of electrons is the unshared pair of electrons left on the atom in a covalent molecule. *[1]*

(ii) Refer to text on page 32. *[1]*

(iii) Neutral covalent molecule is carbon monoxide, CO



[1]

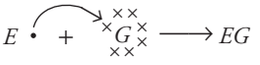
63. There are three elements *E, F* and *G* with atomic numbers 19, 8 and 17, respectively. Give the molecular formula of the compound formed between *E* and *G* and state the type of chemical bond in this compound. *[2012]*

Sol. *Electronic configuration of elements E, F, G are*

	K	*L*	*M*	*N*
E (Atomic no. 19)	2	8	8	1
F (Atomic no. 8)	2	6		
G (Atomic no. 17)	2	8	7	

[1/2 × 3 = 1½]

Thus, *E* and *G* being metals and non-metals form ionic or electrovalent compound.



[1]

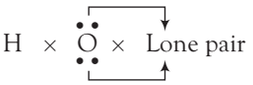
Hence, molecular formula of the compound is *EG*. ***[1/2]***

64. (i) What do you understand by a lone pair of electrons?

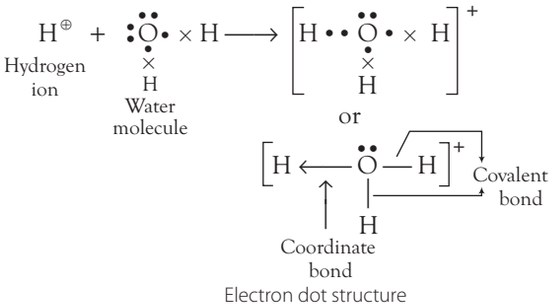
(ii) Draw the electron dot diagram of hydronium ion. (H = 1, O = 8) ***[2018] [3]***

Sol. (i) A lone pair of electrons can be defined as the pair of valence shell electrons that are not shared with another atom.

(ii) Electronic configuration of H = 1 and O = 2, 6. Hydronium ion is formed by the combination of water molecule and hydrogen ion. The oxygen atom of a water molecule possess two lone pair of electrons.



Out of these two lone pair of electrons, one lone pair is used to donate to hydrogen ion.



65. An element *A* is placed on left side of periodic table with a valency 2 and element *B* is placed on right side of periodic table with valency 3.

(i) Write the equation to show how *A* and *B* form ions.

(ii) Which of the two elements will show reduction?

(iii) If *B* is a diatomic gas, write the equation for the direct combination of *A* and *B* to form a compound.

Sol. (i) Elements placed on the left side of the periodic table are electropositive (metals) and hence, will lose electron(s) for stability. While elements present at right side are electronegative and will gain electron(s) for stability.

$$A \longrightarrow A^{2+} + 2e^-$$

$$B + 3e^- \longrightarrow B^{3-}$$

[1]

(ii) Element *B* will show reduction. ***[1]***

(iii) $3A + B_2 \longrightarrow A_3B_2$ ***[1]***

d 4 Marks Questions

66. (i) Name the charged particles, which attract one another to form electrovalent compounds.

(ii) In the formation of electrovalent compounds, electrons are transferred from one element to another. How are electrons involved in the formation of a covalent compound?

(iii) The electronic configuration of nitrogen is 2, 5. How many electrons in the outer shell of a nitrogen atom are not involved in the formation of a nitrogen molecule?

(iv) In the formation of magnesium chloride (by direct combination between magnesium and chlorine), name the substance that is oxidised and the substance that is reduced. ***[2007]***

Sol. (i) Ions *i.e.*, cations and anions ***[1]***

(ii) Electrons are mutually shared ***[1]***

(iii) Three ***[1]***

(iv) Magnesium is oxidised, chlorine is reduced. ***[1]***

67. (i) What is the difference between the properties of Na atom and Na^+ ion with respect to

(a) atomic structure? (b) electrical state?

(c) chemical action? (d) toxicity?

(ii) Draw the electron dot structure of NaCl.

Sol. (i) *Comparison of properties between sodium atom and sodium ion*

	Property	**Sodium atom** (Na)	**Sodium ion** (Na^+)
(a)	Atomic structure	Outermost shell incomplete	Outermost shell complete
(b)	Electrical state	Neutral	Positively charged
(c)	Chemical action	Very active	Inactive
(d)	Toxicity	Toxic	Non-toxic

[2]

(ii) Refer to text on page 27. ***[2]***

68. Elements *A*, *B* and *C* have atomic number 12, 17 and 10, respectively.

(i) State which one is metal, non-metal and chemically inert?

(ii) Write down the formula of the compound formed by two of the above elements.

Sol. (i) Electronic configuration of *A* : 2, 8, 2.

Electronic configuration of *B* : 2, 8, 7.

Electronic configuration of C : 2, 8.

Element A is metal.

Element B is non-metal.

Element C is a noble gas (chemically inert). ***[3 × 1 = 3]***

(ii) B_2A is the formula of the compound formed by A and B elements. ***[1]***

69. (i) Explain the following.

(a) Polar covalent compounds conduct electricity.

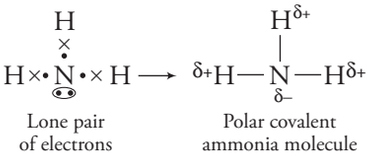
(b) Ammonium ion is an example of coordinate compound.

(ii) How many atoms of each kind are present in the water and chlorine?

Sol. (i) (a) Polar covalent compounds have free ions and hence, dissociate in water. Thus, they are good conductors of electricity. ***[1]***

(b) Nitrogen $^{14}_{7}N$, electronic configuration, $\underset{2}{K}\ \underset{5}{L}$

Hydrogen $^{1}_{1}H$, electronic configuration, 1



[2]

(ii) Refer to text on page 29. ***[1]***

70. The element X has the electronic configuration 2, 8, 7.

(i) Identify the element X.

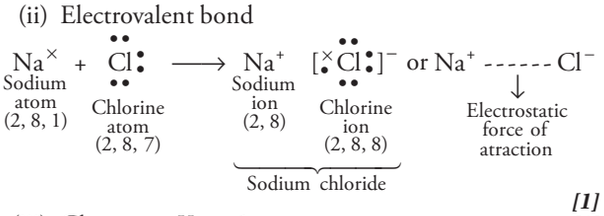
(ii) What type of bond X will form with Y of electronic configuration (2, 8, 1)?

(iii) Predict the sign and charge on simple ion of X.

(iv) X will be oxidised or reduced.

Sol. (i) X = Cl (chlorine) ***[1]***

(ii) Electrovalent bond



[1]

(iii) Charge on $X = -1$ ***[1]***

(iv) X gains one electron, therefore, it gets reduced.

$$X + e^- \longrightarrow X^- \qquad \text{(Reduction)}$$ ***[1]***

71. Explain the following.

(i) A molecule of methane has four single covalent bonds.

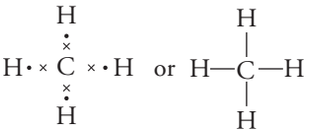
(ii) The oxygen atom of the H_2O molecule leading to the formation of hydronium $[H_3O^+]$.

Sol. (i) Methane (CH_4)

Atom	Symbol	Electronic Configuration	Nearest Noble Gas	To Attain Stable Electronic Configuration of Nearest Noble Gas
Carbon	C	$\underset{2}{K}\ \underset{4}{L}$	Neon [2, 8]	Need four electrons to attain stable octet.
Hydrogen	H	1	Helium [2]	Need one electron to attain stable duplet.

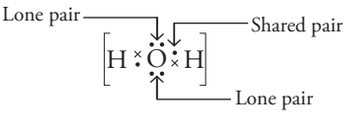
[1]

One atom of carbon shares four electron pairs, one with each of four atoms of hydrogen



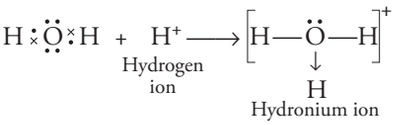
[1]

(ii) In water, two hydrogen atoms share one electron each with oxygen atom to form water molecule.



[1]

Two lone pair of oxygen atom (in water molecule) is donated to hydrogen to form H_3O^+ ion.



[1]

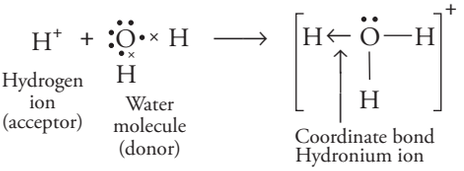
72. (i) Acids dissolve in water to produce positively charged ions. Draw the structure of these positive ions.

(ii) Explain, why carbon tetrachloride does not dissolve in water ?

(iii) Elements Q and S react together to form an ionic compound. Under normal conditions, in which physical state will the compound QS exists?

(iv) Can Q and S, both be metals? Justify your answer. ***[2013]***

Sol. (i) H_3O^+ ion is produced when acids dissolve in water to produce positively charged ions.



[1]

(ii) Carbon tetrachloride is a non-polar covalent compound and water is a polar covalent compound. So, carbon tetrachloride does not dissolve in water. ***[1]***

(iii) Under normal conditions, an ionic compound exists in solid state. Thus, the compound QS will exist in solid state. ***[1]***

(iv) To form an ionic compound if one element gives electrons then the other accepts electrons. Metals can only lose electrons and provide positive ions and non-metals accept electrons and form negative ions. Therefore, both *Q* and *S* cannot be metal because they form ionic com pound with each other. If *Q* is a metal then *S* will be non-metal or *vice-versa*. ***[1]***

e 5 Marks Questions

73. State the term electrovalency. Why potassium (atomic number = 19) has an electropositive valency of +1 and chlorine (atomic number = 17) an electronegative valency of −1?

Sol. The number of electrons donated or accepted by the valence shell of an atom of an element, so as to achieve stable electronic configuration is called electrovalency. ***[1]***

Potassium (atomic number = 19)

Electronic configuration,

K	*L*	*M*	*N*
2	8	8	1

[1]

When it loses one electron, then it attains a stable nearest noble gas electronic configuration (*i.e.*, argon).

Electronic configuration of K^+

K	*L*	*M*
2	8	8

[1]

Similarly, for chlorine (atomic number = 17), it is non-metallic, so it can gain one electron in its valence shell to attain nearest noble gas configuration (*i.e.*, argon).

Cl-atom (atomic number = 17)

K	*L*	*M*
2	8	7

Cl^- ion =

K	*L*	*M*
2	8	8

[2]

74. (i) Define electrovalent compounds.

(ii) Write the two properties of these compounds.

(iii) An atom *A* has one electron more than noble gas configuration (neon). Write the formula of it with

(a) chloride (b) oxide

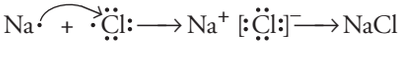
Sol. (i) A chemical compound formed as a result of the transfer of electrons from a metal to non-metal, is called electrovalent compounds (or ionic compounds). ***[1]***

(ii) (a) Ionic compounds do not conduct electricity in their solid state, as the ions are not free. But they can conduct electricity in their fused, molten and in their aqueous solutions. ***[1]***

(b) Ionic compounds are soluble in water but insoluble in organic solvents. ***[1]***

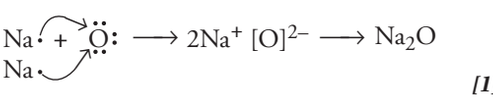
(iii) *A* has one electron more than the noble gas configuration *i.e.,* neon (2, 8) gas = 2, 8, 1.

(a) Its formula with chloride is



[1]

(b) Its formula with oxide is



[1]

75. How many lone pair(s) of electrons present in the following molecule?

(i) Water

(ii) Methane

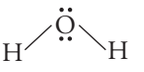
(iii) Ammonia

(iv) Hydrogen sulphide

(v) Magnesium chloride

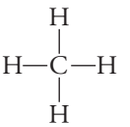
Sol. To find out the lone pair(s) present in a molecule, we first find total valence electrons of each atom of molecules. Subtracting number of electrons used in bonding we get the number of non-bonding electrons usually in pair(s) called lone pair(s).

(i) H_2O (Water)



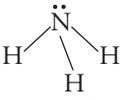
2 lone pairs of electrons ***[1]***

(ii) CH_4 (Methane)



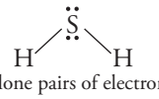
No lone pair of electrons ***[1]***

(iii) NH_3 (Ammonia)



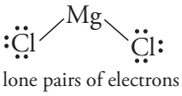
1 lone pair of electrons ***[1]***

(iv) H_2S (Hydrogen sulphide)



2 lone pairs of electrons ***[1]***

(v) $MgCl_2$ (Magnesium chloride)



6 lone pairs of electrons ***[1]***

CHAPTER EXERCISE

Fill in the Blanks

1. The tendency or potential of an element to combine with other elements to form a chemical bond is called …… .

2. (i) …… is a simple notation which is used to represent the (ii) …… of an atom. These symbols were introduced by (iii) …… . In these symbols, valence electrons are represented by (iv) …… and (v) …… .

3. Ethyne is a combination of …… covalent bond and …… covalent bond.

4. For the formation of a covalent bond, both atoms should have …… ionisation energy.

5. A coordinate bond has properties of both (i)…… and (ii)…… bonds. Therefore, it is also called (iii)…… bond. The atom which provides the electron pair for the formation of a coordinate bond is called (iv)…… and the atom or ion sharing the donated electron pair is called (v)…… .

6. Coordinate bonds are identical to a normal …… bond.

7. A compound has the formula H_2Y (where, Y = non-metal) state the following

Table A	Table B
(i) Electronic configuration	
(ii) Type of bonding	
(iii) Number of shared pair and lone pair	
(iv) Number of bond in its molecule	

Multiple Choice Questions

8. Which of the following is correct about compound X (Atomic number = 18)?
(a) Reactive (b) Metal
(c) Metalloids (d) Inert gas

9. Name the bond formed by a calcium and oxide ions.
(a) Ionic
(b) Covalent
(c) Covalent as well as ionic
(d) Coordinate

10. Potassium and potassium ions
(a) have same number of electrons
(b) are chemically same
(c) have same number of protons
(d) None of the above

11. Which is not the property of a covalent compound?
(a) Crystalline hard solid
(b) Volatile
(c) Bad conductor of heat
(d) Soluble in organic solvents

12. The electronegativity of two elements in the same period is 2.4 and 3, respectively. What kind of bond is formed between them?
(a) Ionic (b) Coordinate
(c) Covalent (d) None of these

13. How many electrons are required for the octet structure of chlorine?
(a) One electron each of chlorine
(b) Seven electrons each of chlorine
(c) Three electrons each of chlorine
(d) None of the above

14. Elements X, Y and Z have atomic number 6, 9 and 12 respectively. Which one of the given element form an anion and cation, respectively?
(a) X, Y (b) Y, Z
(c) Z, Z (d) X, Z

15. Which pair of elements given below will undergo covalent bond formation?
(a) Na and Cl
(b) K and Cl
(c) C and Cl
(d) Mg and Cl

Match the Following

16. Match the following columns.

	Column I (Nobles gases)		Column II (Electronic configuration)
(i)	Helium	(a)	2, 8
(ii)	Neon	(b)	2, 8, 8
(iii)	Argon	(c)	2
(iv)	Krypton	(d)	2, 8, 8, 18

17. Match the following columns.

Column I		Column II	
(i)	A polar covalent compound.	(a)	CO_2
(ii)	A non-polar covalent compound.	(b)	HCl
(iii)	A gaseous molecule containing single covalent bond.	(c)	Oxygen
(iv)	A gaseous molecule with double covalent bonds and lone pairs of electrons.	(d)	Chlorine

1 Mark Questions

18. How many electron pairs are shared between fluorine molecules?

19. Give two factors responsible for the formation of covalent bond.

20. State whether hydrocarbons are polar or non-polar compounds.

21. Why solution of sugar cane does not conduct electricity?

22. Name a compound in which shared pair of electrons are equally distributed between the reacting atoms.

23. Draw the electron dot diagram and orbit diagram of $MgCl_2$.

2 Marks Questions

24. State two periodic properties which is responsible for the formation of ionic compounds.

25. Why NaCl (in molten state) can conduct electricity but, CCl_4 cannot ?

3 Marks Questions

26. Write the three conditions for the formation of ionic bonds.

27. In which type of compounds does lone pair effect occur? Support your answer by giving atleast one example.

28. Why melting and boiling points of coordinate compounds are higher than covalent compounds but lower than ionic compounds?

29. Differentiate between polar and non-polar covalent compounds.

4 Marks Questions

30. Explain the formation of calcium oxide (Atomic number : Ca = 20 and O = 8) with the help of

(i) an ionic equation

(ii) electron dot structural diagram

31. (i) Explain why, methane molecule is a non-polar covalent compound.

(ii) Name two compounds that are covalent when taken pure but produce ions when dissolved in water.

5 Marks Questions

32. (i) Give reasons for the following.

(a) A molecule of carbon tetrachloride has four single covalent bonds.

(b) The nitrogen atom of the ammonia molecules leads to the formation of ammonium ion.

(ii) Draw the electron dot structural diagram of ammonia.

33. (i) How does common salt solution ionise in water which is a polar covalent compound?

(ii) Draw the electron dot diagrams of carbon dioxide, water, and ammonia.

34. (i) How coordinate bond is formed?

(ii) What are the characteristics of coordinate compounds?

(iii) Oxygen and water are both covalent compounds but oxygen is a gas and water is a liquid at room temperature. Explain.

ARCHIVES*

(Last 8 Years)

Collection of Questions Asked in Last 8 Years' (2018-2011) ICSE Class 10th Examinations

2018

1 Ionic or electrovalent compounds do not conduct electricity in their ..... state. (fused/solid) *[1]*

2 Give **one word** or a **phrase** for the following statements.
Process of formation of ions from molecules which are not in ionic state. *[1]*

3 Give a reason for each of the following.
Ionic compounds have a high melting point. *[1]*

4 (i) What do you understand by a lone pair of electrons? *[2]*

(ii) Draw the electron dot diagram of hydronium ion. (H = 1, O = 8)

2017

5 Which of the following is a common characteristic of a covalent compound?

(i) High melting point

(ii) Consists of molecules

(iii) Always soluble in water

(iv) Conducts electricity when it is in the molten state *[1]*

6 Fill in the blanks from the choices given in bracket.

The compound that does not have a lone pair of electrons is …… (water, ammonia, carbon tetrachloride). *[1]*

7 State the type of bonding in the following molecules.

(i) Water

(ii) Calcium oxide *[2]*

8 Draw an electron dot diagram to show the formation of each of the following compounds.

(i) Methane

(ii) Magnesium chloride
(H = 1, C = 6, Mg = 12 and Cl = 17) *[2]*

2016

9 Fill in the blanks with the choice given in brackets.

Electrovalent compounds have …… (high/low) melting points. *[1]*

10 By drawing an electron dot diagram show the formation of ammonium ion
(Atomic number N = 7 and H = 1). *[2]*

2015

11 Bonding in this molecule can be understood to involve coordinate bonding. *[1]*

(a) Carbon tetrachloride
(b) Hydrogen
(c) Hydrogen chloride
(d) Ammonium chloride

12 An element *L* consists of molecules. What type of bonding is present between its atoms? *[1]*

13 Explain the bonding in methane molecule using the electron dot structure. *[2]*

2014

14 (i) Choose the correct answer from the options given below.

(a) A compound *X* consists of only molecules. Hence, *X* will have
- a crystalline hard structure
- a low melting and boiling points
- an ionic bond
- a strong force of attraction between its molecules

(b) The molecule containing a triple covalent bond is
- ammonia
- methane
- water
- nitrogen

(ii) Give one word or phrase for the following.
Formation of ions from molecules.

(iii) Why do covalent compounds exist as gases, liquids or soft solids? *[5]*

2013

15 (i) Give suitable chemical terms for the following statement.
A bond formed by a shared pair of electrons with both electrons coming from the same atom.

(ii) (a) Among the following compounds, identify the compound that has all three bonds (ionic, covalent and coordinate bond).
- Ammonia
- Ammonium chloride
- Sodium hydroxide
- Calcium chloride

(b) Which of the following is not a typical property of an ionic compound?
- High melting point
- Conducts electricity in the molten and in the aqueous solution state
- They are insoluble in water
- They exist as oppositely charged ions even in the solid state

(iii) Compare the compounds carbon tetrachloride and sodium chloride with regard to solubility in water and electrical conductivity. *[5]*

2012

16 There are three elements *E*, *F*, *G* with atomic numbers 19, 8 and 17, respectively. Give the molecular formula of the compound formed between *E* and *G* and state the type of chemical bond in this compound. *[3]*

17 Draw an electron dot diagram to show the structure of hydronium ion. State the type of bonding present in it. *[1]*

18 Fill in the blanks from the choices given below.
(i) In covalent compounds, the bond is formed due to the …… (sharing/transfer) of electrons.
(ii) Electrovalent compounds have a…… (low/high) boiling point.
(iii) A molecule of …… (hydrogen/ammonia/ nitrogen) contains a triple bond. *[3]*

2011

19 Give reason, hydrogen chloride can be termed as a polar covalent compound. *[1]*

20 By drawing an electron dot diagram, show the lone pair effect leading to the formation of ammonium ion from ammonia gas and hydrogen ion. *[1]*

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 The compound which does not contain ionic bond is
(a) NaOH (b) HCl (c) K_2S (d) LiH

2 Ionic compounds in general possess both
(a) high melting point and non-directional bonds (b) high melting point and low boiling points
(c) directional bonds and low boiling points (d) high solubilities in polar and non-polar compounds

3 The electronic configurations of four elements
$L: 1s^2 2s^2 2p^4$ $Q: 1s^2 2s^2 2p^6 3s^2 3p^5$ $P: 1s^2 2s^2 2p^6 3s^1$ $R: 1s^2 2s^2 2p^6 3s^2$
The formulae of ionic compounds that can be formed between them are
(a) L_2P, RL, PQ, R_2Q (b) LP, RL, PQ, RQ (c) P_2L, RL, PQ, RQ_2 (d) LP, R_2L, P_2Q, RQ

4 The maximum number of covalent bonds by which the two atoms can be bonded to each other is
(a) four (b) two (c) three (d) None of these

5 The total number of double and triple bonds in the structure, $(CN)_2C = C(CN)_2$ are
(a) 1 (b) 9 (c) 5 (d) Unpredictable

6 In a covalent solid, the lattice points are occupied by
(a) atoms (b) ions (c) molecule (d) electrons

7 Which of the following does not have a co-ordinate bond ?
(a) H_3O^+ (b) PCl_5 (c) O_3 (d) HNO_3

8 Which of the following is incorrect about a coordinate bond ?
(a) A co-ordinate bond once formed cannot be distinguished from a covalent bond.
(b) A co-ordinate bond is also called a semi-polar bond.
(c) A co-ordinate bond is non-directional in nature.
(d) Due to co-ordinate bond, the formal charges on donor and acceptor atoms are positive and negative, respectively.

9 Which of the following does not conduct electricity?
(a) Molten NaOH (b) Molten KOH (c) Solid NaCl (d) Aqueous NaCl

10 NH_3 and BF_3 form adduct readily because they form
(a) ionic bond (b) covalent bond (c) co-ordinate bond (d) hydrogen bond

Answers

1. (b) **2.** (a) **3.** (c) **4.** (c) **5.** (c) **6.** (a) **7.** (b) **8.** (c) **9.** (c) **10.** (c)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 259-260.

CHAPTER

3

Acids, Bases and Salts

Acids, bases and salts play an important role in our daily life. They have definite properties which distinguish these compounds from each other. Lemon juice is sour as it contains acid while bitter gourd is bitter in taste as it contains base.

Salt is generally used in our daily life as common salt. In language of chemistry, the term 'salt' covers all electrovalent compounds formed by the reactions of corresponding acids and bases.

In this chapter, we will deal with these compounds to study their nature, classification, preparation, properties, etc.

Chapter Objectives

- Theories of Acids and Bases
- Acids
- Bases
- Strength of Acid and Base
- pH Scale
- Salts

Theories of Acids and Bases

Various theories and relationships has been described to define acids and bases. These are as follows

Arrhenius Theory

According to this theory, acids are the substances that produce hydrogen ions (H^+) or hydronium ions (H_3O^+) and bases are the substances that produce hydroxide ions (OH^-) in solution.

Bronsted Lowry Theory

According to this theory, "an acid is a proton (H^+) donor (protogenic), while a base is a proton acceptor (protophilic)".

Lewis Theory

According to this theory, "an acid is an electron pair acceptor, while a base is an electron pair donor".

Acids

The word acid comes from the Latin words 'acidus or acere' which means 'sour'. These chemical substances have sour taste and turn blue litmus solution to red. Some common fruits such as unripe mango, lemon, orange, tamarind, etc., are sour in taste, due to the presence of acid.

An acid is a compound which on dissolving in water produces hydrogen ions (H^+) or hydronium ions (H_3O^+). All acids essentially contain hydrogen.

e.g., $\underset{\text{Sulphuric acid}}{H_2SO_4} \xrightarrow{H_2O} 2H^+ + SO_4^{2-}$

$\underset{\text{Hydrochloric acid}}{HCl} \xrightarrow{H_2O} H^+ + Cl^-$

The acid can be naturally occurring and can be chemically synthesised as well.

Properties of Acids

The acids can exhibit the following properties

A. Physical Properties

Physical properties of acid are as follows

(i) Acids have sour taste.
(ii) Acids turn blue litmus to red, methyl orange to pink and phenolphthalein to colourless.
(iii) Acids are electrolytes (*i.e.*, they conduct electricity in solution).
(iv) Acids are corrosive in nature.
(v) Acids are soluble in water.

Note All mineral acids are not corrosive e.g., Carbonic acid is used in making soft drinks.

B. Chemical Properties

Chemical properties of acid are as follows

(i) **Reaction with Metals** Dilute acids (*e.g.*, HCl and H_2SO_4), react with certain active metals like zinc (Zn), iron (Fe), etc., to evolve H_2 gas.

e.g., Metal + Acid ⟶ Salt + Hydrogen gas

$\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

$\underset{\text{Iron}}{Fe(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Ferrous chloride}}{FeCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

Test for H_2 gas When a burning matchstick is brought near the hydrogen gas, it burns with pop sound.

Note Since, the sour substances and curd are the sources of acids. The acid present in them may react with the metals of container, so these substances should not be stored in the metallic container.

(ii) **Reaction with Metal Oxides** Acids react with certain metal oxides (basic oxides) to form salt and water. *e.g.*,

$\underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2(aq)} + \underset{\text{Water}}{H_2O(l)}$

$\underset{\text{Magnesium oxide}}{MgO(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Magnesium sulphate}}{MgSO_4(aq)} + \underset{\text{Water}}{H_2O(l)}$

(iii) **Reaction with Chlorides** Generally, chlorides do not react with any dilute acids but reacts with conc. H_2SO_4 to liberate HCl.

$\underset{\text{Sodium chloride}}{2NaCl} + \underset{\text{(conc.)}}{H_2SO_4} \xrightarrow[\text{heat}]{\text{Below } 200^\circ C} NaHSO_4 + 2HCl\uparrow$

$\underset{\text{Sodium chloride}}{2NaCl} + \underset{\text{(conc.)}}{H_2SO_4} \xrightarrow{\text{Above } 200^\circ C} Na_2SO_4 + 2HCl\uparrow$

(iv) **Reaction with Nitrates** Generally, nitrates do not react with dilute acids but lead nitrate [$Pb(NO_3)_2$] react with dil. HCl and dil.H_2SO_4 to form insoluble lead salts.

$\underset{\text{Lead nitrate}}{Pb(NO_3)_2} + 2HCl \longrightarrow \underset{\text{Lead chloride}}{PbCl_2} + 2HNO_3$

$\underset{\text{Potassium nitrate}}{2KNO_3} + H_2SO_4 \xrightarrow{\text{Above } 200^\circ C} K_2SO_4 + 2HNO_3$

Uses

Some important uses of acids are as follows

A. General Uses of Acids

(i) Vinegar (acetic acid) is used to preserve pickles and chinese foods.
(ii) In stomach, hydrochloric acid is released, which makes the medium acidic and leads to coagulation of proteins. It also helps in digestion and kills the bacteria coming to the stomach along with the food.
(iii) Cold drinks contain carbonic acid.
(iv) Oxalic acid is used to remove ink or rust stains.
(v) Boric acid is used as an antiseptic and for eye wash.
(vi) Sodium benzoate is used as a preservative in cold drinks and food stuffs.
(vii) Oranges and amla contain ascorbic acid (vitamin C) which prevents scurvy.

B. Synthetic Uses of Mineral Acids in Industry

(i) **Sulphuric Acid** It is called as king of chemicals. As it is used in the manufacture of fertilisers like ammonium sulphate, explosives, synthetic fibres, dyes, etc., and in the storage batteries.
(ii) **Nitric Acid** It is used in the manufacture of fertilisers like ammonium nitrate, explosives like TNT, dyes, etc.
(iii) **Hydrochloric acid** It is used for cleaning the surface of metals. It is also used in textile, food and dye industries.

Precautions While Handling Acids in Laboratory

Concentrated acids are highly corrosive and are very dangerous. These should be handled using protection gear. We should take the following precautions while dealing with acids in laboratory.

(i) The acids must always be added slowly to water.
(ii) Always use labcoats, goggles, so that concentrated acids may not come in contact with your clothes as well as body and eyes.
(iii) Never try to touch or taste acids.
(iv) Handle acids with care and tilt the test tube holding hot concentrated acids towards sink while heating.
(v) Water should not be added to concentrated acid. This can break glass container due to excessive heating and may cause the mixture to splash out and burn.

CHECK POINT 01

1 Based on the theories of acid and base, discuss whether water ($H_2\ddot{O}:$) is an acid, base or neutral compound.
2 What is the action of litmus paper on acid?
3 What do you observe when burning matchstick is brought near the hydrogen gas?
4 Complete the reactions

(i) $2NaCl + \underset{(conc.)}{H_2SO_4} \xrightarrow{\text{Above } 200^\circ C} \ldots\ldots + \ldots\ldots$

(ii) $Pb(NO_3)_2 + 2HCl \longrightarrow \ldots\ldots + \ldots\ldots$

5 Name an acid which is used to flavour and preserve food.
6 Name the acid that is used to preserve pickles and chinese foods.

Bases

The substances that furnish hydroxide ions (OH^-) in aqueous solution are called bases *e.g.*, Caustic soda or sodium hydroxide (NaOH), calcium hydroxide $Ca(OH)_2$, caustic potash or potassium hydroxide (KOH), milk of magnesia or magnesium hydroxide [$Mg(OH)_2$], etc.

$$NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)$$

$$Mg(OH)_2(aq) \longrightarrow Mg^{2+}(aq) + 2OH^-(aq)$$

Note Alkalies are water soluble bases e.g., NaOH, KOH, etc. All alkalies are bases, but all bases are not alkalies e.g., Ferric hydroxide [$Fe(OH)_3$] and cupric hydroxide [$Cu(OH)_2$] are bases, but not alkalies because they are insoluble in water.

Properties of Bases

The bases can exhibit the following properties

A. Physical Properties

(i) Bases have bitter taste.
(ii) Bases feel soapy to touch.
(iii) Bases turn red litmus to blue, methyl orange to yellow and phenolphthalein to pink.
(iv) Bases are electrolytes (*i.e.*, they conduct electricity in solution).

B. Chemical Properties

The bases can exhibit the following chemical properties

(i) Strong alkalies absorb carbon dioxide from the air to form carbonates.

Strong alkali + Carbon dioxide ⟶ Carbonate + Water

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

(ii) They neutralise acids to form salt and water.

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

$$Fe(OH)_2 + 2HCl \longrightarrow FeCl_2 + 2H_2O$$

(iii) They precipitate as insoluble metallic hydroxides when added to the solutions of the salts of the heavy metals.

Metallic salt + Alkali ⟶ Salt + Insoluble metallic hydroxide

$$CuSO_4(aq) + 2NH_4OH \longrightarrow (NH_4)_2SO_4 + \underset{\text{(Pale blue)}}{Cu(OH)_2}\downarrow$$

$$ZnSO_4(aq) + 2NaOH \longrightarrow Na_2SO_4 + Zn(OH)_2\downarrow$$

(iv) When they are warmed with an ammonium salt, ammonia gas is evolved, which can be checked by Nessler's reagent (turns brown).

Ammonium salt + Alkali ⟶ Salt + Water + Ammonia

$$NH_4Cl + NaOH \longrightarrow NaCl + H_2O + NH_3\uparrow$$

(v) Insoluble bases decompose on heating to form metallic oxides and water.

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} \xrightarrow{\Delta} \underset{\text{Zinc oxide}}{ZnO} + H_2O$$

$$\underset{\text{Copper hydroxide}}{Cu(OH)_2} \xrightarrow{\Delta} \underset{\text{Copper oxide}}{CuO} + H_2O$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} \xrightarrow{\Delta} \underset{\text{Lead oxide}}{PbO} + H_2O$$

Uses

Some important uses of bases are as follows

(i) Sodium hydroxide is used in the manufacturing of soap.
(ii) Potassium hydroxide is used in the manufacturing of salts and soaps. It is also used in batteries.
(iii) Slaked lime is used in the manufacturing of bleaching powder and softening of hard water.
(iv) Magnesium hydroxide can be used as an antacid.
(v) Aluminium hydroxide acts as a foaming agent in fire extinguishers.

(vi) Magnesia is used in making refractory bricks.
(vii) Calcium oxide is used as drying agent, basic flux.

CHECK POINT 02

1 Write the difference between an alkali and a base.
2 State whether bases conduct electricity or not.
3 What is the product of following reaction?
$Ca(OH)_2 + 2HCl \longrightarrow$
4 What happens when strong alkali reacts with carbon dioxide?
5 Give the name of reagent which is used to check the presence of Nessler's reagent.
6 Name a base which is used as an antacid.

Strength of Acid and Base

The strength of an acid or a base depends on the number of H^+ ions or OH^- ions produced by the substances.

Larger the number of H^+ ions produced by an acid, stronger is the acid. Similarly, larger the number of OH^- ions produce by a base, stronger is the base.

So, the nature of solution depends upon the concentration of H^+ ions in solution.

Note The strength of an acid depends on the degree of ionisation (α) and concentration of (H_3O^+) ions produced by that acid in aqueous solution.

pH Scale

(Measurement of Relative Acidity or Alkalinity of Solution)

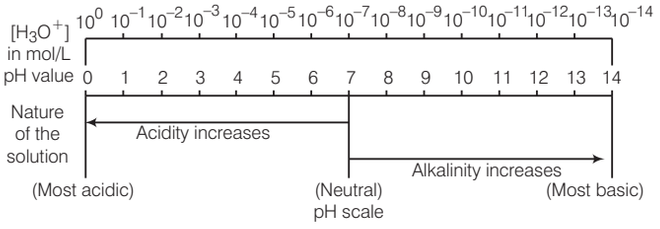
It is a scale used for measuring hydrogen ion concentration. The 'p' in the pH stands for potenz which means power in German. pH is a number which indicates the acidic or basic nature of a solution. In 1909, Sorenson devised the pH scale on which the strength of acidic solutions as well as basic solutions can be determined.

He defines the pH in simple terms as follows

"The pH of a solution is inversely proportional to the concentration of hydrogen ions present in it." *i.e.*,

(i) A solution having high concentration of hydrogen ions has a low pH value.

(ii) A solution having low concentration of hydrogen ions has a high pH value.



From the above scale, it can be easily concluded that

(i) **Neutral substances have a pH of exactly 7** Neutral substance such as pure water, which is neither acidic nor basic has a pH value 7. A substance having pH 7 will have no effect on litmus or on any other common indicator such as methyl orange or phenolphthalein.

(ii) **Acids have a pH of less than 7** A solution whose pH is less than 7, is an acidic solution.
More acidic a solution is, the lower will be its pH. *i.e.*, a solution of pH 1 is much more acidic than another solution of pH 4.

(iii) **Bases have a pH of more than 7** A solution whose pH is greater than 7, is a basic solution or alkaline solution.
e.g., More basic the solution is, the higher will be its pH and a solution of pH 14 will be much more basic than another solution of pH 10.

pH Value

pH is defined as the negative logarithm (to the base 10) of the hydrogen ion concentration expressed in mole/litre.

$$pH = -\log_{10}[H^+]$$

pH of pure water is 7. The variation in a pH value defines the following nature of the solutions.

pH equals to 7 — neutral *i.e.*, $[H^+(aq)]$ equal to $[OH^-]$
pH less than 7 — acidic *i.e.*, $[H^+(aq)]$ more than $[OH^-]$
pH more than 7 — basic *i.e.*, $[OH^-]$ more than $[H^+(aq)]$

pH value represents the strength of acids and bases expressed in terms of hydrogen ion concentration.

Example 1. Calculate the pH of an acid with $[H^+] = 10^{-4}$.

Sol. We know that,

$$pH = -\log[H^+] = \log\frac{1}{[H^+]} = \log\frac{1}{10^{-4}} = 4$$

Example 2. Calculate the pH of 10^{-5} M NaOH solution.

Sol. NaOH is a strong base. It ionises completely in aqueous solution as

$$NaOH \rightleftharpoons Na^+(aq) + OH^-(aq)$$

$$\therefore \quad [OH^-] = [NaOH] = 10^{-5}\ M$$

To calculate the pH of the solution, we should know $[H^+]$.

$$[H^+][OH^-] = K = 10^{-14}M^2$$

or $$[H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{10^{-5}} = 10^{-9}\ M$$

Now, the pH value can be calculated as

$$pH = -\log_{10}[H^+]$$

$$\Rightarrow \quad pH = -\log_{10} 10^{-9} = 9$$

Factors Affecting the pH Value

pH value is generally affected by dilution, dissociation and association of the molecule.

(i) **Dilution** When a solution gets diluted, the concentration of H^+ ions changes and hence, the pH changes.

(ii) **Dissociation and Association of Molecules** If on dilution, the molecules of solution undergoes association or dissociation, then the values of pH changes.

Procedure for Dilution

A dilute acid is obtained by mixing the concentrated acid with water. The process of mixing of concentrated acid with water is exothermic (heat producing). The dilution of a concentrated acid should always be done by adding concentrated acid to water gradually with stirring and not by adding water to concentrated acid.

Universal Indicator

It is a mixture of many different indicators which gives different colours at different pH values of the entire pH scale. When an acid or a base solution is added to the universal indicator, the indicator produces a new colour. pH paper is a universal indicator. The colour produced by universal indicator is used to find the pH value of the acid or base solution by matching the colour with the colours on pH colour chart.

The colours produced by the universal indicator at various pH values are given below

pH range	Description	Colour
< 3	Strong acid	Red
3-6	Weak acid	Orange or yellow
7	Neutral	Green
8-11	Weak base	Blue
>11	Strong base	Violet or indigo

Litmus

It is a most commonly used natural indicator. It is a purple dye which is extracted from a type of a plant called 'lichen'. Lichen is a plant belonging to the division thallophyta. It is of two types

(i) Blue litmus (ii) Red litmus.

Important features of litmus are

(i) An acid turns blue litmus to red.
(ii) A base turns red litmus to blue.
(iii) It can be used in the form of litmus solution or in the form of litmus paper.

CHECK POINT 03

1. If a solution turns red litmus blue, then what is its range of pH value?
2. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd?
3. Arrange the following substances in the increasing order of their pH value.
   Gastric juice, vinegar, wine, milk, blood, rain water, urine, tooth paste
4. Calculate the pH of an acid with $[H^+] = 10^{-2}$.
5. If the colour produced by the universal indicator is dark purple, then what can you say about its nature (acid or base)?

Salts

A salt is a compound formed from an acid by the replacement of the hydrogen from the acid by a metal. Salts are generally formed when acids react with bases. In this way, we can say that salts have two parents *i.e.*, an acid and a base. The reaction which involves the formation of salts are called neutralisation reaction.

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HX + MOH \longrightarrow \underset{\text{Salt}}{MX} + HOH$$

Here, X is a non-metal and M is a metal.

Classification of Salts

Different kinds of salts are as follows

(i) Normal Salts

The salts which are formed by the complete replacement of hydrogen ion of an acid molecule by a basic radical (metallic or ammonium ion) are called normal salts.

e.g.,

$$\underset{\text{Excess}}{2NaOH} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Normal salt (sodium sulphate)}}{Na_2SO_4} + 2H_2O$$

$$\underset{\text{Sodium hydroxide}}{2NaOH} + \underset{\text{Sulphurous acid}}{H_2SO_3} \longrightarrow \underset{\text{Sodium sulphite}}{Na_2SO_3} + \underset{\text{Water}}{2H_2O}$$

Both 'H' ions in sulphuric and sulphurous acid are replaced by metallic radical *i.e.*, sodium.

(ii) Acidic Salts

The salts which are formed by the partial replacement of replaceable hydrogen ion of an acid molecule by a basic radical (metallic or ammonium ion) are called acidic salts.

e.g.,

$$\underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Acidic salt}}{NaHSO_4} + \underset{\text{Water}}{H_2O}$$

$$\underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Sulphurous acid}}{H_2SO_3} \longrightarrow \underset{\text{Sodium hydrogen sulphite}}{NaHSO_3} + \underset{\text{Water}}{H_2O}$$

Only one H ion in sulphuric and sulphurous acid is replaced by metallic radical *i.e.*, sodium.

(iii) Basic Salts

The salts which are formed by the partial replacement of hydroxyl radicals of a diacidic or triacidic base with an acid radical are called basic salts.

e.g., $Cu[OH]NO_3$ (Basic copper nitrate)

$Cu[OH]Cl$ (Basic copper chloride)

Preparation of Normal Salts

The preparation of normal salts from soluble and insoluble salts are discussed below

A. From Soluble Salts

Following methods are used for the preparation of soluble salts

1. Direct Combination Reaction

In this method, two elements get combined together to form salts such as

$$\text{Metal} + \text{Non-metal} \longrightarrow \text{Salt}$$

$$2Na(\text{molten}) + Cl_2 \longrightarrow 2NaCl$$

$$2Fe + 3Cl_2 \longrightarrow 2FeCl_3$$

2. Displacement Reaction

In this method, active metals are displaced by dilute acids.

$$\text{Active metal} + \text{Acid} \longrightarrow \text{Salt} + \text{Hydrogen}$$

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

$$Fe + 2HCl \longrightarrow FeCl_2 + H_2\uparrow$$

3. Decomposition Reaction
(Action of Dilute Acids on Salts)

In this method, the single reactant breaks into two or more elements.

(i) **Reaction with Metal Carbonates and Bicarbonates** Acids on reaction with metal carbonates and bicarbonates, liberates a colourless, odourless gas with brisk effervescence which turns lime water milky.

$$CaCO_3 + 2HCl\,(\text{dil.}) \longrightarrow CaCl_2 + H_2O + CO_2\uparrow$$

$$CuCO_3 + 2HCl\,(\text{dil.}) \longrightarrow CuCl_2 + H_2O + CO_2\uparrow$$

$$KHCO_3 + H_2SO_4\,(\text{dil.}) \longrightarrow KHSO_4 + H_2O + CO_2\uparrow$$

$$NaHCO_3 + HCl(\text{dil.}) \longrightarrow NaCl + H_2O + CO_2\uparrow$$

(ii) **Reaction with Metallic Sulphites and Bisulphites** Acids on reaction with metallic sulphites liberates a colourless gas having burnt sulphur, which turns orange acidified potassium dichromate to green and $KMnO_4$ solution from purple to colourless *i.e.*, it gets decolourised.

$$\underset{\text{Potassium sulphite}}{K_2SO_3} + 2HCl(\text{dil.}) \longrightarrow \underset{\text{Potassium chloride}}{2KCl} + H_2O + SO_2\uparrow$$

$$\underset{\text{Sodium sulphite}}{Na_2SO_3} + H_2SO_4(\text{dil.}) \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4} + H_2O + SO_2\uparrow$$

(iii) **Reaction with Sulphides** Acids react with metal sulphides to produce H_2S gas that can be checked by its foul gas odour.

$$\underset{\text{Zinc sulphide}}{ZnS} + 2HCl \longrightarrow ZnCl_2 + H_2S\uparrow$$

$$\underset{\text{Iron sulphide}}{FeS} + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$$

4. Neutralisation of an Acid with Soluble Base

Salts are readily produced by the neutralisation reaction between acid and base. Neutralising an acid with a soluble base is also known as **titration**.

$$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

5. Neutralisation of an Acid with Insoluble Base

Acids react with an insoluble base (such as MgO, PbO, $Cu(OH)_2$, $Pb(OH)_2$) to give corresponding salts.

$$2HCl + MgO \longrightarrow MgCl_2 + H_2O$$

$$2HNO_3 + PbO \longrightarrow Pb(NO_3)_2 + H_2O$$

$$H_2SO_4 + Cu(OH)_2 \longrightarrow CuSO_4 + 2H_2O$$

$$2HNO_3 + Pb(OH)_2 \longrightarrow Pb(NO_3)_2 + 2H_2O$$

6. Reaction of Metals with Alkali

On reaction of metals with alkali, evolution of hydrogen gas takes place.

$$Zn + 2NaOH \xrightarrow{\text{Boiling}} \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2$$

$$Pb + 2KOH \xrightarrow{\text{Boiling}} \underset{\text{Potassium plumbate}}{K_2PbO_2} + H_2$$

$$2Al + 2NaOH + 2H_2O \xrightarrow{\text{Boiling}} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2$$

B. From Insoluble Salts

Following methods are used for the preparation of insoluble salt

1. Direct Combination Reaction

In this method, reactants directly combine to form insoluble salts.

e.g.,

$$Pb + S \longrightarrow PbS$$

$$Fe + S \longrightarrow FeS$$

2. By the Combination of an Acidic Oxide with a Basic Oxide

When acidic oxide reacts with basic oxide, calcium sulphite is formed

e.g.,

$$\underset{\text{Acidic oxide}}{SO_2} + \underset{\text{Basic oxide}}{CaO} \longrightarrow \underset{\text{Calcium sulphite}}{CaSO_3}$$

3. Precipitation Reaction (by Double Decomposition Reaction)

When soluble salt react with acid (or soluble salt), insoluble salt and acid (or salt) are formed

e.g.,

$$BaCl_2 + H_2SO_4 \longrightarrow \underset{\text{Barium sulphate}}{BaSO_4 \downarrow} + 2HCl$$

$$AgNO_3 + HCl \longrightarrow \underset{\text{Silver chloride}}{AgCl \downarrow} + HNO_3$$

$$Na_2SO_4 + BaCl_2 \longrightarrow \underset{\text{Barium sulphate}}{BaSO_4 \downarrow} + 2NaCl$$

$$CuSO_4 + H_2S \longrightarrow \underset{\text{Copper sulphide}}{CuS \downarrow} + H_2SO_4$$

Note Insoluble salts can also be obtained from another insoluble salt by double decomposition. e.g., Insoluble lead sulphate is prepared from insoluble lead carbonate or insoluble lead oxide by first converting either of them into soluble lead nitrate.

$$PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$$

$$PbCO_3 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + CO_2 \uparrow$$

$$Pb(NO_3)_2 + H_2SO_4 \longrightarrow PbSO_4 + 2HNO_3$$

$$Pb(NO_3)_2 + Na_2SO_4 \longrightarrow PbSO_4 \downarrow + 2NaNO_3$$

CHECK POINT 04

1. What happen when sodium hydroxide react with sulphuric acid?
2. Give an example of basic salt.
3. How a soluble salt can be formed when a metal is displaced by dilute acid? Give suitable reaction to support your answer.
4. Define neutralisation reaction.
5. Give an example of precipitation reaction.

Laboratory Preparation of Some Important Salts

The laboratory preparation of some salts by decomposition, neutralisation, displacement, etc., are discussed below:

A. Iron (III) Chloride ($FeCl_3$)

It is also called as ferric chloride which is an industrial scale chemical compound. When dissolved in water, iron (III) chloride undergoes hydrolysis and evolve heat, which is an exothermic reaction.

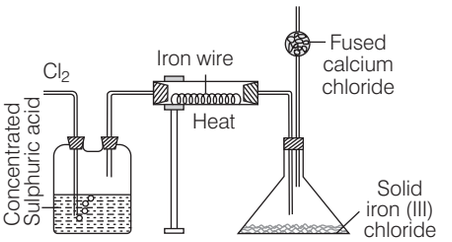
Preparation Anhydrous iron (III) chloride may be prepared by the union of the elements. Industrially, iron (III) chloride is prepared by the reaction of iron with chlorine.

Reaction involved $2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$

The product is highly deliquescent, so it is kept dry using calcium chloride as drying agent.

Procedure In a combustion tube, thin wire of iron is placed. Initially, dry chlorine gas is passed through the combustion tube.The combustion tube is slowly heated for a few minutes and dry chlorine gas is passed through it slowly.

The iron turns to be hot as a result of exothermic reaction.



Preparation of iron (III) chloride

Iron (III) chloride is formed, which volatilises and condenses in the receiver as brown scales.

B. Copper (II) Sulphate ($CuSO_4$)

It is an inorganic compound with the chemical formula $CuSO_4$. It is also known as blue vitriol.

Preparation Copper (II) sulphate can be easily prepared industrially by treating copper hydroxide, copper oxide or copper carbonate with dilute acid.

Reactions Involved

$$Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + 2H_2O$$

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

$$CuCO_3 + H_2SO_4 \longrightarrow CuSO_4 + H_2O + CO_2 \uparrow$$

$$CuSO_4 + 5H_2O \longrightarrow \underset{\text{Blue vitriol}}{CuSO_4 \cdot 5H_2O}$$

Procedure To prepare copper (II) sulphate, take dilute H_2SO_4 in a beaker and heat on a wire gauze. Add copper hydroxide or black cupric oxide or copper carbonate at a time and keep stirring the solution till no more dissolution takes place.

After that, filter the hot solution and allow the solution to cool. Collect the bright blue crystals of copper (II) sulphate pentahydrate, $CuSO_4 \cdot 5H_2O$.

C. Zinc Sulphate ($ZnSO_4$)

It is an inorganic compound with the formula $ZnSO_4$. It is historically known as white vitriol.

Preparation Zinc sulphate is produced by treating any zinc containing material with sulphuric acid.

Reactions Involved

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4 + H_2 \uparrow$$

$$ZnSO_4 + 7H_2O \longrightarrow \underset{\text{White vitriol}}{ZnSO_4 \cdot 7H_2O}$$

Procedure Take dil. sulphuric acid in a beaker and heat on a wire gauze. To this, add some granulated zinc pieces with constant stirring. The formation of effervescence is a result of the evolution of hydrogen gas. When effervescence stops, it indicates that all acid has been used up. The excess of zinc is filtered off. Collect the solution in a china dish. Evaporate the solution to get crystals.

D. Iron (II) Sulphate ($FeSO_4$)

It is also known as ferrous sulphate or green vitriol.

Preparation It is made by reacting iron with sulphuric acid. The reaction releases hydrogen gas and leaves behind iron (II) sulphate.

Reactions Involved

$$Fe(s) + H_2SO_4 \longrightarrow FeSO_4 + H_2 \uparrow$$

$$FeSO_4 + 7H_2O \longrightarrow \underset{\text{Green vitriol}}{FeSO_4 \cdot 7H_2O}$$

Procedure The procedure for the preparation of iron (II) sulphate is same as zinc sulphate. Pale green crystals of hydrated iron (II) sulphate are formed.

E. Calcium Carbonate ($CaCO_3$)

It is formed by three main elements carbon, oxygen and calcium. It is an insoluble salt.

Preparation It can be prepared by mixing the solutions of calcium chloride and sodium carbonate.

Reaction Involved

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$$

Procedure Dissolve excess of sodium carbonate solution to a hot solution of calcium chloride. Collect the white precipitate formed and wash repeatedly with cold water.

F. Lead Chloride ($PbCl_2$)

It is an inorganic compound with formula, $PbCl_2$ which is a white solid under ambient conditions. It is one of the most important lead-based reagents.

Preparation It can be obtained by mixing solutions of lead nitrate and dil. hydrochloric acid.

Reaction Involved

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$$

Procedure Dissolve approx. 5 g lead nitrate solution in 25 mL distilled water. Add dilute HCl dropwise to the lead nitrate solution. The heavy, white precipitate of lead chloride accumulate as residue. Filter them repeatedly with cold water. After that, dissolve $PbCl_2$ ppt. in water. Allow it to cool. Pure crystals $PbCl_2$ are obtained.

G. Sodium Bicarbonate ($NaHCO_3$)

It is a white solid that is crystalline but often appears as a fine powder.

Preparation It can be prepared by treating carbon dioxide gas with sodium carbonate solution.

Reaction Involved

$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$$

Procedure Dissolve approx. 5 g of sodium carbonate in 25 mL of distilled water in a beaker. Cool the solution. After that, pass carbon dioxide gas in the solution. The crystals of sodium bicarbonate are obtained. The crystals can be easily filtered.

H. Sodium Sulphate Crystals (Na_2SO_4)

Sodium sulphate is a salt of sulphuric acid. When anhydrous, it is a white crystalline solid with formula Na_2SO_4.

Preparation It is prepared by the neutralisation of caustic soda with dilute sulphuric acid.

Reaction Involved

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$

This method is only applicable for the preparation of soluble salts of only sodium, potassium and ammonium.

Procedure Since, it is a neutralisation reaction, a titration is performed to produce the products. In a conical flask, $25cm^3$ of sodium hydroxide solution is measured. To this, phenolphthalein indicator is added. The solution will turn pink.

A burette is filled with dilute sulphuric acid and the reading on the burette is noted. The acid is then allowed to run into the conical flask until the solution turns colourless. This is known as end point. At this point, the burette reading is noted. The difference between the two readings is the volume of acid required. The solution obtained after titration is sodium sulphate and water. On evaporating this solution, crystals of $Na_2SO_4 \cdot 10H_2O$ are obtained.

General Properties of Salts

General properties of salts are as follows

(i) Salts are non-volatile in nature *i.e.*, when exposed at room temperature, they do not evaporate.

(ii) They readily form electrovalent compounds.

(iii) They have high melting point. The high melting point is a result of formation of ionic compounds. They have greater force of attraction between the molecules.

(iv) Those substances that can remove water molecules even from compounds are known as **dehydrating agents** *e.g.*, Conc. H_2SO_4 can remove water from blue vitriol ($CuSO_4 \cdot 5H_2O$).

(v) The salts readily undergo **hydrolysis.** It is the phenomenon due to which salt of strong acid and

weak base, (or weak acid and strong base) dissolves in water reacts with it to form parent acid and alkali.

This leads to the result that whether the solution is acidic or alkaline in nature.

Are all Salts Soluble in Water?

Salts are generally soluble in water due to the presence of ionic bond between cation and anion, but there are some exceptions also such as

(a) All sulphites are insoluble in water except Na_2SO_3, K_2SO_3 and $(NH_4)_2SO_3$.

(b) All sulphides are insoluble in water except Na_2S, K_2S and $(NH_4)_2S$.

(c) All carbonates are insoluble in water except Na_2CO_3, K_2CO_3 and $(NH_4)_2CO_3$.

CHECK POINT 05

1 Name the drying agent which is used during the preparation of $FeCl_3$ from iron and chlorine.

2 Give the other name copper sulphate.

3 Name the reactants used for the preparation of iron (II) sulphate.

4 Complete the following reactions.

(i) $CaCl_2 + Na_2CO_3 \longrightarrow \ldots\ldots + \ldots\ldots .$

(ii) $Na_2CO_3 + CO_2 + H_2O \longrightarrow \ldots\ldots\ldots .$

5 Write the reaction involved in the preparation of sodium sulphate.

SUMMARY

- Acids are those chemical substances which are sour in taste, turns blue litmus to red and when dissolved in water produce hydronium ions, H_3O^+.
- Active metals react with acids to produce metallic salts and hydrogen, metal oxides react with acids to produce salts and water.
- Chlorides reacts with conc. H_2SO_4 to liberate HCl.
- Bases are those chemical substances, which are bitter in taste, soapy to touch and turns red litmus to blue; and when dissolved in water produce hydroxide ions, OH^-.
- Strong alkali absorb carbon dioxide from the air to form carbonates.
- Alkali neutralise acids to form salt and water, precipitate as insoluble metallic hydroxides when added to the solutions of the salts of heavy metals.
- Strength of an acid or base depend on the number of H^+ ions or OH^- ions produced by them, respectively.
- Larger the number of H^+ ions produced by an acid, stronger is the acid.
- pH scale This is a scale used for measuring hydrogen ion concentration.
- pH is a number, which indicates the acidic or basic nature of a solution.
- Salts are produced by the neutralisation reaction between acid and base.
- Different kinds of salts are normal salts, acidic salts, basic salts, double salts, complex salts, mixed salts.
- Normal salts are prepared from soluble salts by direct combination, displacement, decomposition, neutralisation reactions.
- They can also be prepared from insoluble salts by direct combination, precipitation reaction.
- Laboratory preparation of some salts
  - (i) Iron (III) chloride : $2(Fe)(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$
  - (ii) Copper (II) sulphate : $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$
  - (iii) Zinc sulphate : $Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4 + H_2\uparrow$
  - (iv) Iron (II) sulphate : $Fe(s) + H_2SO_4 \longrightarrow FeSO_4 + H_2\uparrow$
  - (v) Calcium carbonate : $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$
  - (vi) Lead chloride : $Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$
  - (vii) Sodium bicarbonate : $Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$
  - (viii) Sodium sulphate : $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$
- Salts are non-volatile in nature, hygroscopic, deliquescent and are efflorescent.

EXAM PRACTICE

Fill in the Blanks

1. The number of …… ions which can be liberated by …… molecule of an acid on complete …… is called as …… .

Sol. hydronium, one, ionisation, basicity

2. The salt prepared by the method of direct combination is ..... .
(iron II chloride/iron III chloride) ***[2018]***

Sol. iron II chloride

3. An acid is a compound which when dissolved in water forms hydronium ions as the only (i) …… ion. A base is a compound which is soluble in water contains (ii) …… ions. A base reacts with an acid to form a (iii) ..... and water only. This type of reaction is known as (iv) ..... . ***[2005]***

Sol. (i) positive (ii) hydroxide
(iii) salt (iv) neutralisation

4. (i) …… is a scale used for measuring (ii) …… ion concentration. The 'p' in the pH stands for (iii) …… which means power in German.

Sol. (i) pH (ii) hydrogen (iii) potenz

5. Higher the pH value of a solution, the more …… (acidic/alkaline) it is. ***[2016]***

Sol. alkaline

6. Copper (II) chloride reacts with NaOH to form …… gas and water.

Sol. insoluble

7. In making copper sulphate crystals, a black powder called (i) …… is added to dilute (ii) …… acid and the mixture is warmed. Excess black powder is added to a small volume of acid so as to (iii) …… The excess insoluble black powder is got rid by (iv) …… . The resulting clear solution looks (v) …… in colour.

This solution is heated to get rid of some of the (vi) ……, slow cooling of the remaining solution gives (vii) …… of pure copper sulphate.

Sol. (i) copper oxide
(ii) sulphuric
(iii) neutralise the excess of the acid
(iv) filtration
(v) blue
(vi) copper sulphide as impurity
(vii) well-defined crystals

8. Superphosphate is an example of a compound called …… .

Sol. acidic salt

9. From the list given below, select the word(s) required to correctly complete blanks (i) to (v) in the following passage. The words from the list are to be used only once. Write the answers as (a) (i), (ii), (iii) and so on. Do not copy the passage.
(ammonia, ammonium carbonate, carbon dioxide, hydrogen, hydronium, hydroxide, precipitate, salt, water)
A solution *M* turns blue litmus red, so it must contain (i) ..... ions, another solution *O* turns red litmus blue and hence, must contain (ii) ..... ions.
When solutions *M* and *O* are mixed together, the products will be (iii) ..... and (iv) .....

If a piece of magnesium was put into a solution *M*, (v) ..... gas would be evolved.

Sol. (i) hydronium $[H_3O^+]$ (ii) hydroxide $[OH^-]$
(iii) salt (iv) water
(v) hydrogen
(**Reason** Active metal like Mg reacts with acid, liberate hydrogen gas.)

Multiple Choice Questions

10. When hydrogen reacts with non-metals, the formation of …… takes place.

(a) acid (b) base
(c) salt (d) hydronium ions

Sol. (a)

11. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solution would reverse the change?

(a) Baking powder
(b) Lime

(c) Ammonium hydroxide solution
(d) Hydrochloric acid

Sol. (d)

12. If few drops of a concentrated acid accidentally spills over the hand of a student, what should be done?
(a) Wash the hand with saline solution
(b) Wash the hand immediately with plenty of water and apply a paste of sodium hydrogen carbonate
(c) After washing with plenty of water apply solution of sodium hydroxide on the hand
(d) Neutralise the acid with a strong alkali

Sol. (b)

13. Which of the following gives the correct increasing order of acid strength?
(a) Water < acetic acid < hydrochloric acid
(b) Water < hydrochloric acid < acetic acid
(c) Acetic acid < water < hydrochloric acid
(d) Hydrochloric acid < water < acetic acid

Sol. (a)

14. A solution whose pH is greater than 7, then the solution is ..... in nature.
(a) acidic (b) basic
(c) neutral (d) None of these

Sol. (b)

15. To increase the pH value of a neutral solution, we should add *[2017]*
(a) an acid (b) an acid salt
(c) an alkali (d) a salt

Sol. (c)

16. A sample of soil is mixed with water and allowed to settle. The clean supernatant solution turns the pH paper yellowish-orange. Which of the following would change the colour of this pH paper to greenish-blue?
(a) Lemon juice (b) Vinegar
(c) Common salt (d) Antacid

Sol. (d)

17. The metal oxide which can react with an acid as well as base is
(a) silver oxide
(b) calcium oxide
(c) aluminium oxide
(d) copper (II) oxide

Sol. (c)

18. A salt is dissolved in water. The pH of this salt solution was found to be 7 by measuring the pH with a universal indicator paper. The salt is most likely to be
(a) Na_2CO_3 (b) KCl
(c) NH_4Cl (d) CH_3COONa

Sol. (b)

19. A black colour solid, which on reaction with dilute sulphuric acid forms a blue coloured solution. It is
(a) carbon (b) manganese (IV) oxide
(c) lead (II) oxide (d) copper (II) oxide

Sol. (d)

20. The reaction, which involves the formation of salts is
(a) combination reaction (b) redox reaction
(c) decomposition reaction (d) neutralisation reaction

Sol. (d)

21. Anhydrous iron (III) chloride is prepared by *[2017]*
(a) direct combination (b) simple displacement
(c) decomposition (d) neutralisation

Sol. (a)

22. $NaHSO_3$ is an example of which type of salts?
(a) Acidic salts (b) Basic salts
(c) Normal salts (d) Complex salts

Sol. (a)

23. The salt in which the solution gives a pale green precipitate with sodium hydroxide solution and a white precipitate with barium chloride solution is *[2008]*
(a) iron (III) sulphate (b) iron (II) sulphate
(c) iron (II) chloride (d) iron (III) chloride

Sol. (b)

24. Dilute sulphuric acid will produce a white precipitate when added to a solution of *[2008]*
(a) copper nitrate (b) zinc nitrate
(c) lead nitrate (d) sodium nitrate

Sol. (c)

25. When dilute sulphuric acid reacts with iron sulphide, the gas evolved is ..... . *[2011]*
(a) hydrogen sulphide (b) sulphur dioxide
(c) sulphur trioxide (d) vapour of sulphuric acid

Sol. (a)

Match the Following

26. Match the following with correct answers.

Substance	pH
(i) Tomato juice	(a) 9.2
(ii) Rain water	(b) 4.1
(iii) Pure water	(c) 7.0
(iv) Borax solution	(d) 6.5

Sol. (i) (b), (ii) (d), (iii) (c), (iv) (a)

27. Match the following columns.

Column I	Column II
(i) Oranges	(a) Oxalic acid
(ii) Apples	(b) Lactic acid
(iii) Tomatoes	(c) Citric acid
(iv) Tamarind	(d) Maleic acid
(v) Sour milk/curd	(e) Tartaric acid

Sol. (i) (c), (ii) (d), (iii) (a), (iv) (e), (v) (b)

28. Match the following with correct answers.

Column I	Column II
(i) Normal salt	(a) NaCl
(ii) Acidic salt	(b) Pb(OH)Cl
(iii) Basic salt	(c) $NaHSO_4$

Sol. (i) (a), (ii) (c), (iii) (b)

1 Mark Questions

29. Which acid is present in vinegar?

Sol. Acetic acid (CH_3COOH).

30. The basicity of acetic acid is .... (3, 1, 4) ***[2014]***

Sol. The basicity of acetic acid is one. On ionisation it gives only one H_3O^+ ion.

$$CH_3COOH + H_2O \longrightarrow \underset{\text{Acetate ion}}{H_3O^+ + CH_3COO^-}$$

31. Write the appropriate term for the following. A compound which is soluble in water and the only negative ions in the solution are hydroxide ions? ***[2005]***

Sol. Alkali

32. Why does an aqueous solution of an acid conduct electricity?

Sol. An acid molecule dissociates in an aqueous solution to produce H^+ (or H_3O^+) ions and corresponding anions A^-. These free ions carry the electrical charge from one place to other hence, conduct electricity.

33. Name the gas produced on reaction of dilute sulphuric acid with a metallic sulphide. ***[2012]***

Sol. Hydrogen sulphide (H_2S)

$$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S$$

34. Why do acids not show acidic behaviour in the absence of water?

Sol. Ions are produced only in aqueous medium and presence of H^+ ions is responsible for the existence of acidic properties. Hence, acids show acidic behaviour only in the presence of water and not in its absence.

35. Give **one word** or a **phrase** for the following statements.
The property by which certain hydrated salts, when left exposed to atmosphere, lose their water of crystallisation and crumble into powder. ***[2018] [1]***

Sol. Efflorescence

36. Name one natural indicator and write its origin.

Sol. Litmus is a natural indicator. It is a purple coloured dye which is extracted from a type of plant called 'lichen'.

37. Identify the term or substance based on the descriptions given below.
Ice like crystals formed on cooling an organic acid sufficiently. ***[2017]***

Sol. Glacial acetic acid.

38. Give an example of a salt which is formed by the direct combination.

Sol. Ferric chloride is a salt which is formed by the direct combination.

$$2Fe + 3Cl_2 \longrightarrow 2FeCl_3$$

39. How many types of salts can be prepared from orthophosphoric acid?

Sol. There are three types of salts which can be prepared from orthophosphoric acid [H_3PO_4], two acidic salts and one normal salt.

$$H_3PO_4 + OH^- \longrightarrow \underset{\text{Acidic salt}}{H_2PO_4^-} + H_2O$$

$$H_2PO_4^- + OH^- \longrightarrow \underset{\text{Acidic salt}}{HPO_4^{2-}} + H_2O$$

$$HPO_4^{2-} + OH^{2-} \longrightarrow \underset{\text{Normal salt}}{PO_4^{3-}} + H_2O$$

40. Which gas is evolved when sodium hydrogen carbonate ($NaHCO_3$) is added to acetic acid?

Sol. Carbon dioxide (CO_2) gas is evolved when sodium hydrogen carbonate is added to acetic acid.

41. Name the type of salt which is formed by the incomplete neutralisation of an acid molecule by a basic radical.

Sol. Acidic salt

42. State one relevant observation for the following reaction. *[2017]*

A solid formed by reaction of two gases, one of which is acidic and the other basic in nature.

Sol. Salt

43. If copper sulphate with five molecules of water is heated, then what will be the colour of anhydrous copper sulphate?

Sol. Anhydrous copper sulphate will be white in colour.

44. State one relevant observation for each of the following.

(i) Anhydrous calcium chloride is exposed to air for sometime.

(ii) Barium chloride solution is slowly added to sodium sulphate solution. *[2018]*

Sol. (i) Anhydrous calcium chloride ($CaCl_2$), when left exposed to air for sometime absorbs moisture from the atmosphere and get converted into its saturated solution *i.e.*, it shows the property of deliquescen

(ii) When barium chloride solution is slowly added to sodium sulphate solution, a white precipitate of barium sulphate is formed.

$$\underset{}{BaCl_2} + \underset{}{Na_2SO_4} \longrightarrow \underset{\text{Barium sulphate (White ppt.)}}{BaSO_4} + 2NaCl$$

b 2 Marks Questions

45. Three solutions P, Q and R have pH value of 3.5, 5.2 and 12.2, respectively. Which one of these is a *[2018]*

(i) weak acid ? (ii) strong alkali?

Sol. (i) During the preparation of nitric acid at suitable temperature (<200°C), sodium and potassium bisulphates are formed.

$$\underset{}{KNO_3} + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Potassium bisulphate}}{KHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$$

$$\underset{}{NaNO_3} + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$$

(ii) For the preparation of nitric acid, entire apparatus should be made up of glass. It is because nitric acid is highly corrosive in nature and will damage, rubber and cork of the apparatus. *[1]*

46. (i) Why do HCl, HNO_3, etc., show acidic character in aqueous solution?

(ii) Why do compounds like alcohol and glucose do not show acidic character?

Sol. (i) HCl and HNO_3 furnish $H^+(aq)$ ions on dissolving in water which are responsible for their acidic character. *[1]*

(ii) Alcohol and glucose do not furnish $H^+(aq)$ ion on dissolving in water and hence, these solutions do not show acidic character. *[1]*

47. Name the ions present in the following salts. Name the acid and base from which they can be obtained.

Magnesium sulphate, sodium carbonate.

Sol. *Ions, acids and bases of given salts are tabulated below*

S.No.	Salt	Ions	Acid required	Base required
(i)	Magnesium sulphate	Mg^{2+} SO_4^{2-}	H_2SO_4	$Mg(OH)_2$ *[1]*
(ii)	Sodium carbonate	Na^+ CO_3^{2-}	H_2CO_3	NaOH *[1]*

48. Write a balanced equation for the preparation of each of the following salts. *[2018]*

(i) Copper sulphate from copper carbonate.

(ii) Zinc carbonate from zinc sulphate.

Sol. *Following are the balanced chemical equations for the preparation of*

(i) **Copper Sulphate from Copper Carbonate**

$$\underset{\text{Copper carbonate}}{CuCO_3} + H_2SO_4 \longrightarrow \underset{\text{Copper sulphate}}{CuSO_4} + H_2O + CO_2$$

(ii) **Zinc Carbonate from Zinc Sulphate**

$$\underset{\text{Zinc sulphate}}{ZnSO_4} + Na_2CO_3 \longrightarrow \underset{\text{Zinc carbonate}}{ZnCO_3} + \underset{\text{Nitric acid}}{Na_2SO_4}$$ *[2]*

49. The pH values of 1 M aqueous solution of three acids X, Y and Z are 2.0, 1.0 and 3.0, respectively. Arrange these acids in the increasing order of their acidic strength.

Sol. The acid having minimum pH, has the highest concentration of H^+ ions and hence, is the strongest acid. Thus, acid Y is the strongest, while Z is the weakest acid. The order of acidic strength is $Z < X < Y$. *[2]*

50. Write a reaction each for the formation of

(i) normal salt

(ii) basic salt

Sol. (i) $NaOH + HCl \longrightarrow \underset{\text{Normal salt}}{NaCl} + H_2O$

(ii) $Mg(OH)_2 + HCl \longrightarrow \underset{\text{Basic salt}}{Mg(OH)Cl} + H_2O$ *[2 × 1 = 2]*

51. Write a balanced chemical equation for the preparation of each of the following salts:

(i) Copper carbonate

(ii) Ammonium sulphate crystals

Sol. (i) Copper chloride on reaction with sodium carbonate give copper carbonate and sodium chloride.

$\underset{\text{Copper chloride}}{CuCl_2} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Copper carbonate}}{CuCO_3} + \underset{\text{Sodium chloride}}{2NaCl}$ *[1]*

(ii) Ammonium hydroxide on reaction with sulphuric acid give ammonium sulphate and water.

$\underset{\text{Amonium hydroxide}}{2NH_4OH} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + 2H_2O$ *[1]*

52. Salt *A* commonly used in bakery products on heating gets converted in another salt *B* which itself is used for the removal of hardness of water and gas *C* is evolved. The gas *C* when passed through lime water, turns milky. Identify *A*, *B* and *C*.

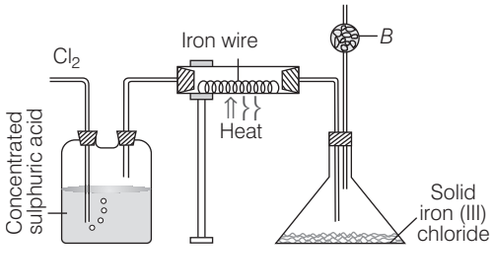
Sol. Heating of salt, evolves gas *C* which turns lime water milky. This suggests that the gas *C* is CO_2. It can also be inferred that bicarbonates on heating produces carbonates with the evolution of CO_2. Salt *A* is sodium bicarbonate $NaHCO_3$ (as it is used in bakery products and gives Na_2CO_3 on heating).

Salt *B* is sodium carbonate Na_2CO_3 (it is used for the removal of hardness of water). Gas *C* is carbon dioxide, CO_2 (as it turns lime water milky). *[1]*

This can be shown as follows

$\underset{\text{Sodium bicarbonate}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O + CO_2 \uparrow$ *[1]*

53. The diagram given below is used to prepare iron (III) chloride in the laboratory.



(i) What is substance *B*?

(ii) What is the purpose of *B*?

(iii) Why is iron (III) chloride to be stored in a closed container?

(iv) Write the equation for the reaction between iron and chlorine.

Sol. (i) Substance *B* is anhydrous calcium chloride, $CaCl_2$.

(ii) Anhydrous calcium chloride is a drying agent which does not allow the moisture to enter into the receiver.

(iii) Iron (III) chloride is highly deliquescent. So, it should be kept dry by storing in a closed container.

(iv) $\underset{\text{Heated}}{2Fe} + \underset{\text{Dry}}{3Cl_2} \longrightarrow 2FeCl_3$ *[4 × 1/2 = 2]*

54. Copy and complete the following table. Column III has the names of gases to be prepared using the substance you enter in Column I along with dilute or concentrated sulphuric acid as indicated in Column II.

Column I	Column II	Column III
Substance reacted with acid	Dilute or concentrated sulphuric acid	Hydrogen gas
A	*B*	Carbon dioxide

Sol.

Column I	Column II	Column III
Zinc	Dilute sulphuric acid	Hydrogen
Calcium carbonate	Concentrated sulphuric acid	Carbon dioxide *[2]*

C 3 Marks Questions

55. Solution *A* is a sodium hydroxide solution. Solution *B* is a weak acid.

Solution *C* is dilute sulphuric acid. Which solution will *[2010]*

(i) liberate sulphur dioxide from sodium sulphite?

(ii) give a white precipitate with zinc sulphate solution?

(iii) contain solute molecule and ions?

Sol. (i) *C*—Dilute sulphuric acid *[1]*

(ii) *A*—Sodium hydroxide *[1]*

(iii) *B*—Weak acid contain molecules and ions *[1]*

56. *A* is a soluble acidic oxide and *B* is a water soluble base.
What should be the pH of
(i) aqueous solution of *A*?
(ii) aqueous solution of *B*?
(iii) distilled water?

Sol. (i) *A* + Water ⟶ Acid, hence, pH < 7.
(ii) *B* is a water soluble base, hence, pH > 7.
(iii) Distilled water is neutral (pH = 7). *[3]*

57. Name the kind of particles present in *[2014]*
(i) sodium hydroxide solution.
(ii) carbonic acid.
(iii) sugar solution.

Sol. (i) Na^+ and OH^- ions are present in sodium hydroxide solution. *[1]*
(ii) Carbonic acid, H_2CO_3 is a weak acid. So, ions and molecules are present. *[1]*
(iii) Sugar solution ($C_{12}H_{22}O_{11}$) do not dissociates, thus, molecules are present in sugar solution. *[1]*

58. Some of the salts are given below. Classify them on the basis of the formation of acidic solutions, alkaline solutions and neutral solutions in water. Potassium nitrate, ammonium sulphate, potassium carbonate, sodium chloride, sodium acetate, copper sulphate.

Sol. (i) **Acidic solutions** Ammonium sulphate, copper sulphate. *[1]*
(ii) **Alkaline solutions** Potassium carbonate, sodium acetate. *[1]*
(iii) **Neutral solutions** Potassium nitrate, sodium chloride. *[1]*

59. What is neutralisation reaction? Give two examples.

Sol. Reaction between acid and base dissolved in aqueous solution to form salt and water is called neutralisation reaction.

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water} \quad [1]$$

e.g., $HNO_3(aq) + KOH(aq) \longrightarrow KNO_3(aq) + H_2O(l)$ *[1]*

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l) \quad [1]$$

60. Write the chemical name and water of crystallisation of the following substances: Blue vitriol, washing soda crystals, plaster of paris.

Sol.

	Substance	Chemical name	Water of crystallisation
(i)	Blue vitriol	Copper (II) sulphate pentahydrate	5
(ii)	Washing soda crystal	Sodium carbonate decahydrate	10
(iii)	Plaster of Paris	Calcium sulphate semihydrate	1/2

[1 × 3 = 3]

61. Identify the anion present in each of the following compounds
(i) A salt *M* on treatment with concentrated sulphuric acid produces a gas which fumes in moist air and gives dense fumes with ammonia.
(ii) A salt *D* on treatment with dilute sulphuric acid produces a gas which turns lime water milky but has no effect on acidified potassium dichromate solution.
(iii) When barium chloride solution is added to salt solution *E*, a white precipitate insoluble in dilute hydrochloric acid is obtained.

Sol. (i) Salt *M* is NaCl (sodium chloride) and anion present is Cl^- ion. *[1]*
(ii) Salt *D* is carbonate salt and anion present is CO_3^{2-} ion. *[1]*
(iii) Salt *E* is sodium sulphate (Na_2SO_4) and anion present is SO_4^{2-} ion. *[1]*

d 4 Marks Questions

62. Solution *A* is a strong acid *[2009]*
Solution *B* is a weak acid
Solution *C* is a strong alkali
(i) Which solution contains solute molecules in addition to water molecules?
(ii) Which solution will give a gelatinous white precipitate with zinc sulphate solution? The precipitate disappears when an excess of the solution is added?
(iii) Which solution could be a solution of glacial acetic acid?
(iv) Given an example of solution which is a weak alkali.

Sol. (i) Solution *B* which is weak acid contains solute molecules in addition to water molecules. *[1]*
(ii) Solution *C* which is strong alkali give a gelatinous white precipitate with zinc sulphate solution. *[1]*
(iii) Solution *B* which is weak acid could be a solution, of glacial acetic acid. *[1]*
(iv) Ammonium hydroxide solution, NH_4OH. *[1]*

63. Give the equation for the preparation of each of the following salts from the starting material given.

(i) Copper sulphate from copper (II) oxide.

(ii) Iron (III) chloride from iron. *[2010]*

(iii) Potassium sulphate from potassium hydroxide solution.

(iv) Lead chloride from lead carbonate (two equations).

Sol. (i) $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$ *[1]*

(ii) $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$ *[1]*

(iii) $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$ *[1]*

(iv) $PbCO_3 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + CO_2$

$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$ *[1]*

64. Making use only of substances chosen from those given below.

Dilute sulphuric acid	Sodium carbonate
Zinc	Sodium sulphate
Lead	Calcium carbonate

Give the equations for the reactions by which you could obtain *[2008]*

(i) hydrogen (ii) sulphur dioxide

(iii) carbon dioxide

(iv) zinc carbonate (two steps required)

Sol. (i) $Zn + H_2SO_4\,(dil.) \longrightarrow ZnSO_4 + H_2\uparrow$ *[1]*

(ii) $S + O_2 \longrightarrow SO_2\uparrow$ *[1]*

(iii) $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2\uparrow$ *[1]*

(iv) $Zn + H_2SO_4\,(dil.) \longrightarrow ZnSO_4 + H_2\uparrow$

$ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4$ *[1]*

65. A metal carbonate X on reacting with an acid gives a gas which when passed through a solution Y gives the carbonate back. On the other hand, a gas G that is obtained at anode during the electrolysis of brine and when passed on dry Y, it gives a compound Z, used for disinfecting drinking water. Identify X, Y, G and Z.

Sol. X is calcium carbonate and the gas evolved is carbon dioxide, when calcium carbonate reacts with acid, calcium chloride is formed.

$$\underset{X}{CaCO_3} + 2HCl\,(dil.) \longrightarrow CaCl_2 + H_2O + CO_2\uparrow$$ *[1]*

Solution Y is lime water $Ca(OH)_2$ because, when CO_2 is passed through it, it gives the carbonate back as shown by the given equation.

$$\underset{Y}{Ca(OH)_2} + CO_2 \longrightarrow \underset{X}{CaCO_3}\downarrow + H_2O$$ *[1]*

The gas evolved at anode during the electrolysis of brine is chlorine (G).

$$\underset{\text{Sodium chloride (brine)}}{2NaCl} + 2H_2O \xrightarrow{\text{Electrolysis}} 2NaOH + \underset{\text{Chlorine gas (G)}}{Cl_2(g)} + H_2(g)$$ *[1]*

When chlorine gas is passed through dry $Ca(OH)_2$ (Y), it produces bleaching powder (Z), used for disinfecting drinking water.

$$Ca(OH)_2 + Cl_2 \longrightarrow \underset{\text{Bleaching powder } (Z)}{CaOCl_2} + H_2O$$ *[1]*

e 5 Marks Questions

66. (i) While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

(ii) How is the concentration of hydronium ions (H_3O^+) affected when a solution of an acid is diluted?

(iii) Under what soil condition do you think a farmer would treat the soil of his fields with quicklime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)?

Sol. (i) Dissolution of an acid in water is an exothermic process. If water is added to a container containing concentrated acid, a vigorous reaction takes place. The drops of acid may splash out and burn the person, who is handling this process. But when water is taken in the first container (*e.g.,* beaker) and the concentrated acid is slowly added to it, the reaction is less vigorous due to high specific heat of water and can be controlled. Therefore, the latter is preferred. *[1½]*

(ii) When a solution of an acid is diluted *i.e.,* water is added to it, the concentration of H_3O^+ ions per unit volume decreases. *[2]*

(iii) These fertilizers [CaO, $Ca(OH)_2$, $CaCO_3$] are of basic nature. Therefore, their use will be beneficial, if the soil is acidic. The purpose is to neutralise or decrease acidity of the soil. *[1½]*

67. Give the equations for the following conversions A to E. *[2010]*

$$ZnSO_4 \xrightarrow{A} ZnCO_3 \xrightarrow{B} Zn(NO_3)_2 \xrightarrow{C} Zn(OH)_2 \xrightarrow{D} ZnO \xrightarrow{E} ZnSO_4$$

Sol. (A) $ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4$ *[1]*

(B) $ZnCO_3 + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O + CO_2$ *[1]*

(C) $Zn(NO_3)_2 + 2NaOH \longrightarrow Zn(OH)_2 + 2NaNO_3$ *[1]*

(D) $Zn(OH)_2 \xrightarrow{\Delta} ZnO + H_2O$ *[1]*

(E) $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$ *[1]*

68. Identify the acid which matches the following description (i) to (v).

(i) The acid which is used in the preparation of a non-volatile acid.

(ii) The acid which produces sugar charcoal from sugar.

(iii) The acid which is prepared by the catalytic oxidation of ammonia.

(iv) The acid on mixing with lead nitrate solution produces a white precipitate which is insoluble even on heating.

(v) The acid on mixing with silver nitrate solution produces a white precipitate which is soluble in excess ammonium hydroxide.

Sol. (i) Pyrosulphuric acid or oleum ($H_2S_2O_7$) is used for the preparation of H_2SO_4, while sulphuric acid is used in the preparation of phosphoric acid which is a non-volatile acid. *[1]*

(ii) Sulphuric acid

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}(s)} \xrightarrow{\text{Conc.}H_2SO_4} \underset{\text{Sugar charcoal}}{12C(s)} + 11H_2O$$ *[1]*

(iii) Nitric acid is prepared by the catalytic oxidation of ammonia. *[1]*

(iv) Sulphuric acid

$$Pb(NO_3)_2 + H_2SO_4 \longrightarrow \underset{\substack{\text{Lead sulphate}\\\text{(White precipitate)}}}{PbSO_4} + 2HNO_3$$ *[1]*

(v) Hydrochloric acid

$$AgNO_3 + HCl \longrightarrow \underset{\substack{\text{Silver chloride}\\\text{(White ppt)}}}{AgCl\downarrow} + HNO_3$$ *[1]*

69. Hydrogen chloride gas has no effect on dry litmus paper. When blue litmus paper is moist, hydrogen chloride gas will turn the litmus paper from blue to red, because it forms a 'strong acid'.

(i) Why does hydrogen chloride gas not have an effect on dry litmus paper?

(ii) Explain the term strong acid.

(iii) Draw the dot and cross diagram of hydrogen chloride, showing only the valence electrons.

(iv) When hydrogen chloride is bubbled through aqueous silver nitrate, a chemical reaction occurs and a salt is formed.

(a) What will be observed when hydrogen chloride is bubbled through aqueous silver nitrate?

(b) Write the chemical equation, with state symbols, for the above reaction.

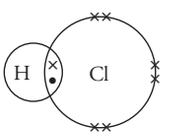
(c) What is the name given to this type of reaction used in the production of salts?

Sol. Compounds made up of two non-metals (like HCl) are covalent and not exist in ionic form, hence has no effect on pH indicator. But in aqueous state they produce ion (H^+ and other acid radicals like Cl^-) hence shows acidity.

(i) Hydrogen chloride gas is a covalent molecule. It does not have an effect on dry litmus paper due to the lack of hydrogen ions present. *[1]*

(ii) A strong acid is an acid that dissociates completely in water to give a large concentration of hydrogen ions. *[1]*

(iii)



[1]

(iv) (a) A white precipitate is formed. *[1/2]*

(b) $HCl(aq) + AgNO_3(aq) \longrightarrow AgCl(s) + HNO_3(aq)$ *[1]*

(c) Precipitation *[1/2]*

CHAPTER EXERCISE

Fill in the Blanks

1. An acid is a compound which, when dissolved in water give …… (hydronium/hydroxide) ions as the only …… (positive/negative) ions.

2. The number of atoms present in one …… (mole/molecule) of an element is called its …… (acidity/atomicity).

3. Litmus is a …… indicator.

4. The salts of the acid HNO_2 are called ..... and those of the acid HNO_3 are called ..... .

5. Fill up the missing data in the given table.

	Name of the salt	Formula	Salt Obtained from	
			Base	Acid
(i)	Ammonium chloride	NH_4Cl	NH_4OH	–
(ii)	Copper sulphate	–	–	H_2SO_4
(iii)	Sodium chloride	NaCl	NaOH	–
(iv)	Magnesium nitrate	$Mg(NO_3)_2$	–	HNO_3
(v)	Potassium sulphate	K_2SO_4	–	–
(vi)	Calcium nitrate	$Ca(NO_3)_2$	$Ca(OH)_2$	–

6. Deliquescence takes place because of the difference in (i) ..... of atmospheric (ii) ..... and that of the deliquescent substance. The vapour pressure of atmospheric humidity is (iii) ..... than that of the deliquescent substance. The substances which take up water on exposure to atmosphere, without forming a solution are known as (iv) ..... substances.

Multiple Choice Questions

7. "An acid is a proton donor". This theory was given by

(a) Lewis theory (b) Bronsted-Lowry theory

(c) Arrhenius theory (d) None of these

8. Select the acid which contains four hydrogen atoms in it. ***[2009]***

(a) Formic acid (b) Sulphuric acid

(c) Nitric acid (d) Acetic acid

9. A solution has pH value of 5. On adding 10 mL of NaCl to it, what will be the pH of the new solution?

(a) More than 5 (b) Less than 5

(c) Seven only (d) No change in pH

10. A yellow strain of curry on a white cloth turns reddish-brown when it comes in contact with soap. Why does it happen?

(a) Soap is basic in nature

(b) Due to the presence of water

(c) Neutral solution

(d) Soap is acidic in nature

11. The table below shows information about three common indicators used in a school laboratory.

Indicator	Colour in strong acid	Colour in strong alkali	pH colour change
Bromothymol blue	Yellow	Blue	7
Screened methyl orange	Red	Yellow	4
Phenolphthalein	Colourless	Pink	9

What colour will be observed at pH 6 if equal volumes of these three indicators are mixed together?

(a) Green (b) Yellow

(c) Red (d) Blue

12. Soluble salt like sodium sulphite can be prepared in laboratory by the process of

(a) titration (b) synthesis

(c) displacement (d) decomposition

13. An example of a complex salt is ***[2010]***

(a) zinc sulphate

(b) sodium hydrogen sulphate

(c) iron (II) ammonium sulphate

(d) tetraammine copper (II) sulphate

14. What happens when a solution of an acid is mixed with a solution of base in a test tube?

(i) The temperature of the solution increases.

(ii) The temperature of the solution decreases.

(iii) The temperature of the solution remains the same.

(iv) Salt formation takes place.

(a) Only (iv) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i) and (iv)

15. A sample of dry ammonium chloride was heated in a test tube. Pieces of damp litmus paper were used to test for any gases that were produced in the process. Which of the statements is correct?

(a) The blue litmus paper turned red. No further change was observed.

(b) The red litmus paper turned blue. No further change was observed.

(c) The blue litmus paper turned red first. After sometime, both the red and blue litmus papers turned blue.

(d) The red litmus paper turned blue first. After sometime, both the red and blue litmus papers turned red.

Match the Following

16. Match the following columns.

	Column I		Column II
(i)	Boric acid	(a)	Food preservation
(ii)	Citric acid	(b)	Eye wash
(iii)	Oxalic acid	(c)	Ink stain remover
(iv)	Carbonic acid	(d)	Baking powder
		(e)	Flavoured drinks

1 Mark Questions

17. Write a fully balanced equation for the following. Magnesium metal is treated with dilute hydrochloric acid. ***[2009]***

18. The pH of fresh milk is 6. How do you think the pH will change as it turns into curd?

19. Name the compound which is insoluble in cold water but soluble in hot water.

20. Which of the following salt has blue colour and why?

$$CuSO_4 \cdot 5H_2O \text{ or } CuSO_4$$

2 Marks Questions

21. Write the synthetic uses of mineral acid in industry.

22. Find the odd one out and explain your choice.

(i) $Al(OH)_3$, $Pb(OH)_2$, $Mg(OH)_2$ and $Zn(OH)_2$

(ii) Formic acid, nitric acid, acetic acid and propanoic acid.

23. Identify the following substance which are underlined.

(i) An acid which is present in vinegar.

(ii) A dilute mineral acid which forms a white precipitate when treated with barium chloride solution.

3 Marks Questions

24. Write the chemical reactions involved when

(i) Zn(*s*) reacts with sulphuric acid.

(ii) Fe(*s*) reacts with hydrochloric acid.

(iii) calcium oxide reacts with HCl.

25. You have two solutions *A* and *B*. The pH of solution *A* is 6 and pH of solution *B* is 8.

(i) Which solution is acidic and which is basic?

(ii) Which solution has more H^+ ion concentration?

(iii) Why is HCl a stronger acid than acetic acid?

26. (i) Give the balanced equations for the following reactions.

(a) Dilute nitric acid and copper carbonate.

(b) Silver nitrate solution and sodium chloride solution.

(ii) Write the procedure for the formation of sodium sulphate crystals.

27. What is meant by the concentrated alkali and dilute alkali? What are the general methods of preparation of bases?

28. Give a suitable chemical term for

(i) a salt formed by the incomplete neutralisation of an acid molecule by a base radical.

(ii) a definite number of water molecules bound to some salts.

(iii) the process in which a substance absorbs moisture from the atmospheric air to become moist and ultimately dissolves in the absorbed water.

29. Give the product of the following chemical reactions.

(i) $C + HNO_3\,(conc.) \longrightarrow \ldots\ldots + \ldots\ldots + \ldots\ldots$

(ii) $Fe + H_2O \longrightarrow \ldots\ldots + \ldots\ldots$

(iii) $Na_2CO_3 + H_2SO_4 \longrightarrow \ldots\ldots + \ldots\ldots + \ldots\ldots$

(iv) $Al_2O_3 + HCl \longrightarrow \ldots\ldots + \ldots\ldots$

(v) $KOH + H_2SO_4 \longrightarrow \ldots\ldots + \ldots\ldots$

(vi) $Na_2S + H_2SO_4 \longrightarrow \ldots\ldots + \ldots\ldots$

4 Marks Question

30. (i) An aqueous solution turns red litmus solution blue. Excess addition of which solution would reverse the change?

(ii) An aqueous solution of sodium carbonate is basic and not acidic. Give the reason.

5 Marks Questions

31. From the list of oxides given, choose the oxide(s) that fit the description stated. Each oxide can be used once, more than once or not at all.

Sulphur Dioxide	Magnesium Oxide	Lithium Oxide
Aluminium (III) oxide	Carbon dioxide	Carbon monoxide
Nitrogen dioxide	Nitrogen monoxide	Lead (II) oxide

(i) Reacts with both acids and alkalies.

(ii) Does not react with either acids or alkalies.

(iii) Reacts with a base to form salt and water, but does not react with any acids.

(iv) Turns litmus paper red when added to water.

(v) Dissolves in water to form an alkaline solution.

32. (i) Classify the following indicators as natural, synthetic or universal : methyl orange, litmus, turmeric, phenophthalein, pH scale.

(ii) Define pH. Write the value of pH in the term of H^+ ion concentration.

33. Name the method used for the preparation of the following salts from the list given below.

(i) Sodium nitrate (ii) Iron (III) chloride

(iii) Lead chloride (iv) Zinc sulphate

(v) Sodium hydrogen sulphate

List

A. Simple displacement

B. Neutralisation

C. Decomposition by acid

D. Double decomposition

E. Direct synthesis ***[2011]***

34. Salts *A*, *B*, *C*, *D* and *E* undergo reactions (i) to (v) respectively. Identify the anion present in these salts on the basis of these reactions. Tabulate your answers in the format given below.

(i) When silver nitrate solution is added to a solution of *A*, a white precipitate, insoluble in dilute nitric acid, is formed.

(ii) Addition of dilute hydrochloric acid to *B* produces a gas, which turns lead acetate paper black.

(iii) When a freshly prepared solution of ferrous sulphate is added to a solution of *C* and concentrated sulphuric acid is gently poured from the side of the test tube, a brown ring is formed.

(iv) When dilute sulphuric acid is added to *D* a gas is produced, which turns acidified potassium dichromate solution from orange to green.

(v) Addition of dilute hydrochloric acid to *E* produces an effervescence. The gas produced turns lime water milky but does not affect the acidified potassium dichromate solution.

[2007]

Salt	Anion
A	
B	
C	
D	
E	

ARCHIVES*

(Last 7 Years)

Collection of Questions Asked in Last 7 Years' (2018-2012) ICSE Class 10th Examinations

2018

1 The salt prepared by the method of direct combination is ..... .
(iorn II chloride/iorn III chloride) *[1]*

2 Give **one word** or a **phrase** for the following statements.
The property by which certain hydrated salts, when left exposed to atmosphere, lose their water of crystallisation and crumble into powder. *[1]*

3 State one relevant observation for each of the following.
(i) Anhydrous calcium chloride is exposed to air for sometime. *[1]*
(ii) Barium chloride solution is slowly added to sodium sulphate solution. *[1]*

4 Three solutions *P*, *Q* and *R* have pH value of 3.5, 5.2 and 12.2, respectively. Which one of these is a
(i) weak acid ? (ii) strong alkali? *[2]*

5 Write a balanced equation for the preparation of each of the following salts.
(i) Copper sulphate from copper carbonate. *[2]*
(ii) Zinc carbonate from zinc sulphate.

2017

6 To increase the pH value of a neutral solution, we should add *[1]*
(a) an acid (b) an acid salt
(c) an alkali (d) a salt

7 Anhydrous iron (III) chloride is prepared by *[1]*
(a) direct combination (b) simple displacement
(c) decomposition (d) neutralisation

8 Identify the term or substance based on the descriptions given. Ice like crystals formed on cooling an organic acid sufficiently. *[1]*

9 State one relevant observation for the following reaction. A solid formed by reaction of two gases, one of which is acidic and the other basic in nature. *[1]*

10 Write a balanced chemical equation for the preparation of each of the following salts
(i) Copper carbonate
(ii) Ammonium sulphate crystals *[2]*

2016

11 Fill in the blanks with the choices given in brackets.
Higher the pH value of a solution, the more ..... (acidic/alkaline) it is. *[1]*

2015

12 Identify the acid which matches the following description (i) to (v).
(i) The acid which is used in the preparation of a non-volatile acid.
(ii) The acid which produces sugar charcoal from sugar.
(iii) The acid which is prepared by catalytic oxidation of ammonia.
(iv) The acid on mixing with lead nitrate solution produces a white precipitate which is insoluble even on heating.
(v) The acid on mixing with silver nitrate solution produces a white precipitate which is soluble in excess ammonium hydroxide. *[5]*

13 Identify the anion present in each of the following compounds. *[2014]*
(i) *A* salt *M* on treatment with concentrated sulphuric acid produces a gas which fumes in moist air and gives dense fumes with ammonia.
(ii) *A* salt *D* on treatment with dilute sulphuric acid produces a gas which turns lime water milky but has no effect on acidified potassium dichromate solution.
(iii) When barium chloride solution is added to salt solution *E*, a white precipitate insoluble in dilute hydrochloric acid is obtained. *[3]*

2014

14 The basicity of acetic acid is ..... (3, 1, 4) *[1]*

15 Name the kind of particles present in
(i) sodium hydroxide solution
(ii) carbonic acid
(iii) sugar solution *[3]*

2013

16 Give the balanced chemical equations to prepare the following salts.
(i) Lead sulphate from lead carbonate.
(ii) Sodium sulphate using dilute sulphuric acid.
(iii) Copper chloride using copper carbonate. *[3]*

17 Identify the following substances which are underlined.
(i) An acid which is present in <u>vinegar</u>.
(ii) A <u>dilute mineral acid</u> which forms a white precipitate when treated with barium chloride solution. *[2]*

18 Give a suitable chemical term for
(i) a salt formed by incomplete neutralisation of an acid by a base.
(ii) a definite number of water molecules bound to some salts.
(iii) the process in which a substance absorbs moisture from the atmospheric air to become moist and ultimately dissolves in the absorbed water. *[3]*

19 Choosing the substances from the list given below, write the balanced chemical equations for the reactions which would be used in the laboratory to obtain the following salts.

Dilute sulphuric acid	Copper, iron sodium	Copper (II) carbonate, sodium carbonate, sodium chloride Zinc nitrate

(i) Sodium sulphate
(ii) Zinc carbonate
(iii) Copper (II) sulphate
(iv) Iron (II) sulphate *[4]*

2012

20 Give the balanced equations for the following reactions.
(i) Dilute nitric acid and copper carbonate.
(ii) Silver nitrate solution and sodium chloride solution. *[2]*

21 Match the following columns.

	Column A		Column B
(i)	Acid salt	(a)	Sodium potassium carbonate
(ii)	Mixed salt	(b)	Alum
(iii)	Complex salt	(c)	Sodium carbonate
(iv)	Double salt	(d)	Sodium zincate
(v)	Normal salt	(e)	Sodium hydrogen carbonate

[3]

22 Rewrite the statement in the correct form using the appropriate word/words.
Magnesium reacts with nitric acid to liberate hydrogen gas. *[2]*

23 Name the gas produced on reaction of dilute sulphuric acid with a metallic sulphide. *[2]*

24 Give the balanced equation for the following.
Zinc sulphide and dilute sulphuric acid. *[2]*

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 Which gas is evolved when acids react with metal carbonates?
(a) CO_2 (b) H_2
(c) NH_3 (d) O_2

2 Which of the following does not give H^+ ions in aqueous solution?
(a) H_2CO_3 (b) C_2H_5OH
(c) CH_3COOH (d) H_3PO_4

3 A blue litmus paper was first dipped in dil. HCl and then in dil. NaOH solution. It was observed that the colour of the litmus paper
(a) changed to red (b) changed first to red and then to blue
(c) changed blue to colourless. (d) remain blue in both the solution

4 Which of the following metals can displace hydrogen from the aqueous solution of NaOH?
(a) Hg (b) Cu
(c) Al (d) Ag

5 On diluting solution to pH of 4, its pH will
(a) remain same (b) increase
(c) decrease (d) None of these

6 The equation between an acid and a base is

$$XOH + HY \rightarrow XY + H_2O$$

In the given equation, which specie act as a cation?
(a) *X* (b) OH
(c) H (d) *Y*

7 The solution with the lowest concentration of H^+ ion is
(a) pH = 7 (b) pH = 8.6
(c) pH = 2.0 (d) pH = 6.7

8 Which of the following statement is correct?
(a) Bases turn blue litmus solution to red
(b) Anion can be used as an oil factory indicator to check acid or base
(c) Bases are sour in taste
(d) pOH is defined as the logarithm of $[OH^-]$ ions.

9 Aqueous solution of copper sulphate reacts with aqueous ammonium hydroxide solution to give
(a) brown ppt (b) pale blue ppt
(c) white ppt (d) green ppt

10 10^{-6}M HCl is divided to 100 times. Its pH will be
(a) 6.0 (b) 8.0
(c) 6.95 (d) 9.5

Answers

1. (a) **2.** (b) **3.** (b) **4.** (c) **5.** (b) **6.** (a) **7.** (b) **8.** (c) **9.** (b) **10.** (c)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 260.

CHAPTER

4

Analytical Chemistry: Uses of Sodium and Ammonium Hydroxides

Analytical chemistry is a branch of chemistry that deals with the identification of unknown compounds by qualitative analysis and composition of a mixture by quantitative analysis. It is not a well defined branch of chemistry, rather it is considered as an application of knowledge acquired *via* the study of chemistry.

The qualitative analysis is carried out with the help of a reagent. A **reagent** is a substance that is added to another substance(s) in order to bring about a chemical change.

Chapter Objectives

- Sodium and Ammonium Hydroxide
- Action of Sodium Hydroxide (NaOH) on Metallic Salt Solutions
- Action of Ammonium Hydroxide on Metallic Salt Solutions
- Amphoteric Nature of Metals
- Amphoteric Nature of Metal Oxides and Hydroxides

Sodium and Ammonium Hydroxide

Alkalies such as NaOH (sodium hydroxide) KOH (potassium hydroxide) and NH_4OH (ammonium hydroxide) are important laboratory reagents.

Sodium hydroxide (NaOH) is a strong alkali which dissociates completely to furnish OH^- ions whereas ammonium hydroxide (NH_4OH) is a weak alkali which dissociates partially to furnish sufficient OH^- ions and precipitate as insoluble metal hydroxides.

NaOH and NH_4OH (bases soluble in water) give characteristic tests with various metal ions from which metal ion can be identified.

Thus, these alkalies on reaction with different metallic oxides gives precipitate and colour of precipitate identifies the metal ion.

Therefore, before discussing about the reactions involved, let us first discuss about the colour of the salts and their solution.

Colour of the Salts and their Solution

The salts of representative elements *i.e.,* the elements of groups 1, 2 and 13 to 17 are generally colourless. Salts of transition elements *i.e.,* the elements of group 3 to 12 are generally coloured.

During qualitative analysis, different colours of salts help in their identification.

Some Coloured and Colourless Ions

Colourless Ions		Coloured Ions		
Anion	**Symbol**	**Anion**	**Symbol**	**Colour**
Chloride ion	Cl^-	Permanganate ion	MnO_4^-	Pink or purple
Sulphate ion	SO_4^{2-}			
Carbonate ion	CO_3^{2-}	Dichromate ion	$Cr_2O_7^{2-}$	Orange
Nitrate ion	NO_3^-			
Hydrogen carbonate ion	HCO_3^-	Chromate ion	CrO_4^{2-}	Yellow
Sulphide ion	S^{2-}			
Bromide ion	Br^-			
Acetate ion	CH_3COO^-			
Cation	**Symbol**	**Cation**	**Symbol**	**Colour**
Ammonium ion	NH_4^+	Cupric ion	Cu^{2+}	Blue
Sodium ion	Na^+	Ferrous ion	Fe^{2+}	Light green
Potassium ion	K^+			
Calcium ion	Ca^{2+}	Ferric ion	Fe^{3+}	Yellowish brown
Magnesium ion	Mg^{2+}			
Aluminium ion	Al^{3+}	Nickel ion	Ni^{2+}	Green
Lead ion	Pb^{2+}	Chromium ion	Cr^{3+}	Green
Zinc ion	Zn^{2+}	Manganese ion	Mn^{2+}	Pink

Action of Sodium Hydroxide (NaOH) on Metallic Salt Solutions

On adding sodium hydroxide solution drop by drop to the given solution of metallic salts, the metal hydroxide is formed which get precipitated and the colour of the precipitate identifies the metal ion. When excess of sodium hydroxide solution is added to precipitated metallic hydroxide, then some hydroxides dissolve in it to give soluble complexes.

1. Reaction of Sodium Hydroxide with Soluble Salt of Calcium (Ca^{2+} ion)

On adding sodium hydroxide drop by drop to a solution of calcium salt, a white precipitate is formed which is **sparingly soluble** in excess of sodium hydroxide.

$$\underset{\text{Calcium nitrate (Colourless)}}{Ca(NO_3)_2} + \underset{\text{Caustic soda (Colourless)}}{2NaOH} \longrightarrow \underset{\text{Calcium hydroxide (White ppt.)}}{Ca(OH)_2\downarrow} + \underset{\text{Sodium nitrate (Colourless)}}{2NaNO_3}$$

2. Reaction of Sodium Hydroxide with Soluble Salt of Iron

(i) Ferrous [Fe^{2+} ion or iron (II) salts]

On adding sodium hydroxide drop by drop to a solution of ferrous salt, a dirty green precipitate is formed. After sometime it turns into reddish brown colour and is **insoluble** in excess of sodium hydroxide.

$$\underset{\text{Ferrous sulphate (Pale green)}}{FeSO_4} + \underset{\text{Caustic soda (Colourless)}}{2NaOH} \longrightarrow \underset{\text{Ferrous hydroxide (Dirty green ppt.)}}{Fe(OH)_2\downarrow} + \underset{\text{Sodium sulphate (Colourless)}}{Na_2SO_4}$$

(ii) Ferric [Fe^{3+} ion or iron (III) salts]

On adding sodium hydroxide (NaOH) drop by drop to a ferric salt solution, a reddish brown precipitate is formed which is **insoluble** in excess of sodium hydroxide.

$$\underset{\text{Ferric chloride (yellow)}}{FeCl_3} + \underset{\text{Caustic soda (colourless)}}{3NaOH} \longrightarrow \underset{\text{Ferric hydroxide (reddish brown ppt.)}}{Fe(OH)_3\downarrow} + \underset{\text{Sodium chloride (colourless)}}{3NaCl}$$

3. Reaction of Sodium Hydroxide with Soluble Salt of Copper (Cu^{2+} ion)

On adding sodium hydroxide (NaOH) solution drop by drop to a solution of copper salt, a bluish white precipitate is formed which is **insoluble** in excess of sodium hydroxide.

$$\underset{\text{Copper sulphate (Blue)}}{CuSO_4} + \underset{\text{Sodium hydroxide (Colourless)}}{2NaOH} \longrightarrow \underset{\text{Copper (II) hydroxide (Pale blue ppt.)}}{Cu(OH)_2} + \underset{\text{Sodium sulphate (Colourless)}}{Na_2SO_4}$$

4. Reactions of Sodium Hydroxide with Soluble Salt of Zinc (Zn^{2+} ion)

On adding sodium hydroxide (NaOH) drop by drop to a solution of zinc salt, a white precipitate is formed which is **soluble** in excess of sodium hydroxide.

$$\underset{\text{Zinc sulphate (colourless)}}{ZnSO_4} + \underset{\text{Caustic soda (colourless)}}{2NaOH} \longrightarrow \underset{\text{Zinc hydroxide (white ppt.)}}{Zn(OH)_2\downarrow} + \underset{\text{Sodium sulphate (colourless)}}{Na_2SO_4}$$

or $$\underset{\text{Zinc nitrate}}{Zn(NO_3)_2} + \underset{\text{Caustic soda (colourless)}}{2NaOH} \longrightarrow \underset{\text{Zinc hydroxide (white gelatinous ppt.)}}{Zn(OH)_2\downarrow} + \underset{\text{Sodium nitrate}}{2NaNO_3}$$

$$\underset{\text{Zinc hydroxide (white gelatinous ppt.)}}{Zn(OH)_2} + \underset{\text{(Excess)}}{2NaOH} \longrightarrow \underset{\text{Sodium zincate (soluble salt) (colourless)}}{Na_2ZnO_2} + 2H_2O$$

5. Reactions of Sodium Hydroxide with Soluble Salt of Lead (Pb^{2+} ion)

On adding sodium hydroxide (NaOH) drop by drop to a solution of lead salt, a white precipitate is formed which is **soluble** in excess of sodium hydroxide.

$$\underset{\text{Lead nitrate (colourless)}}{Pb(NO_3)_2} + \underset{\text{Caustic soda (colourless)}}{2NaOH} \longrightarrow \underset{\text{Lead hydroxide (white ppt.)}}{Pb(OH)_2\downarrow} + \underset{\text{Sodium nitrate (colourless)}}{2NaNO_3}$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} + \underset{\text{(Excess)}}{2NaOH} \longrightarrow \underset{\text{Sodium plumbite (soluble salt)}}{Na_2PbO_2} + 2H_2O$$

6. Reactions of Sodium Hydroxide Solution with Ammonium Salt (NH_4^+ ion)

On heating sodium hydroxide (NaOH) solution (or any other alkali) with ammonium salts, ammonia gas is evolved.

$$\underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Caustic soda}}{NaOH} \xrightarrow{\Delta} \underset{\text{Sodium chloride}}{NaCl} + H_2O + \underset{\text{Ammonia gas}}{NH_3\uparrow}$$

$$\underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + \underset{\text{Caustic soda}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium sulphate}}{Na_2SO_4} + 2H_2O + 2NH_3$$

Action of Ammonium Hydroxide on Metallic Salt Solutions

On adding ammonium hydroxide drop by drop to the solution of metallic salts, a colour precipitate of metal hydroxide is formed, which identifies the metal ion.

Some metallic hydroxides are soluble in excess of ammonium hydroxide because of the formation of soluble amino complexes.

1. Reaction of Ammonium Hydroxide with Soluble Salt of Calcium (Ca^{2+} ion)

On adding ammonium hydroxide to calcium salt solution, no precipitate formation occurs, not even with the addition of excess of ammonium hydroxide.

Because the concentration of OH^- ions produced by the ionisation of NH_4OH is very low that cannot precipitate the hydroxide of calcium.

2. Reactions of Ammonium Hydroxide with Soluble Salts of Iron

(i) Ferrous [Fe^{2+} ion or iron (II) salts]

On adding ammonium hydroxide drop by drop to a solution of ferrous salt, a dirty green precipitate is formed, which turns reddish brown after sometime and is **insoluble** in excess of ammonium hydroxide.

$$\underset{\text{Ferrous sulphate (Green)}}{FeSO_4} + \underset{\text{Ammonium hydroxide}}{2NH_4OH} \rightarrow \underset{\text{Ferrous hydroxide (Dirty green ppt.)}}{Fe(OH)_2}\downarrow + \underset{\text{Ammonium sulphate (Colourless)}}{(NH_4)_2SO_4}$$

(ii) Ferric [Fe^{3+} ion or iron (III) salts]

In case of ferric salt, a reddish brown precipitate is formed which is **insoluble** in excess of ammonium hydroxide.

$$\underset{\text{Ferric chloride (Yellow solution)}}{FeCl_3} + \underset{\text{Ammonium hydroxide}}{3NH_4OH} \longrightarrow \underset{\text{Ferric hydroxide (Reddish brown ppt.)}}{Fe(OH)_3\downarrow} + \underset{\text{Ammonium chloride (Colourless)}}{3NH_4Cl}$$

3. Reactions of Ammonium Hydroxide with Soluble Salts of Copper (Cu^{2+} ion)

On adding ammonium hydroxide drop by drop to a solution of copper salt, a pale blue precipitate is formed which **solublises** in excess of ammonium hydroxide to give deep blue or Prussian blue solution.

$$\underset{\text{Copper sulphate (Blue)}}{CuSO_4} + \underset{\text{Ammonium hydroxide}}{2NH_4OH} \longrightarrow \underset{\text{Copper hydroxide (Pale blue ppt.)}}{Cu(OH)_2}\downarrow + \underset{\text{Ammonium sulphate (Colourless)}}{(NH_4)_2SO_4}$$

$$\underset{\text{Copper hydroxide}}{Cu(OH)_2} + \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + \underset{\text{(Excess)}}{2NH_4OH} \longrightarrow \underset{\text{Tetraammine copper (II) sulphate (Deep blue solution)}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$

4. Reactions of Ammonium Hydroxide with Soluble Salts of Zinc (Zn^{2+} ion)

On adding ammonium hydroxide drop by drop to a solution of zinc salt, a white gelatinous precipitate is formed that solublises in excess of ammonium hydroxide.

$$ZnSO_4 + 2NH_4OH \longrightarrow Zn(OH)_2 \downarrow + (NH_4)_2SO_4$$

Zinc sulphate (Colourless solution); Ammonium hydroxide; Zinc hydroxide (White gelatinous ppt.); Colourless

$$Zn(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Zn(NH_3)_4]SO_4 + 4H_2O$$

Zinc hydroxide; Ammonium sulphate; (Excess); Tetraammine zinc (II) sulphate (Colourless)

5. Reaction of Ammonium Hydroxide with Soluble Salt of Lead (Pb^{2+} ion)

On adding ammonium hydroxide drop by drop to a solution of lead salt, a white precipitate is formed which is **insoluble** in excess of ammonium hydroxide.

$$Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2 \downarrow + 2NH_4NO_3$$

Lead nitrate (Colourless); Ammonium hydroxide; Lead hydroxide (Chalky white ppt.); Ammonium nitrate

CHECK POINT 01

1. Name the class of elements which usually form coloured compounds.
2. Mention the different colours observed in cationic and combined anionic state of manganese (Mn) and chromium (Cr).
3. Classify the following metal salts, whose precipitate is formed by the action of NaOH which is soluble and insoluble in excess of NaOH solution.
   $Ca(NO_3)_2$, $FeSO_4$, $CuSO_4$, $ZnSO_4$, $Pb(NO_3)_2$
4. Both zinc sulphate and lead nitrate are colourless solid substances. Write the chemical reactions used to identify them.
5. Name the metal salt which are
   (a) sparingly soluble (b) insoluble
   (c) soluble
   in ammonium hydroxide solution.
6. Complete the following reaction.
   $Zn(OH)_2 + (NH_4)SO_4 + 2NH_4OH \longrightarrow ..... + 4H_2O$

Amphoteric Nature of Metals

Metals which can react with both acids and bases are called amphoteric metals. *e.g.*, Zn, Al and Pb.

Action of Alkalies on Certain Metals

Amphoteric metals like Al, Zn and Pb react with hot concentrated caustic alkali (NaOH and KOH) to give the corresponding soluble salt and liberate hydrogen gas.

Aluminium Metal (Al)

It reacts only with boiling and concentrated alkali.

$$2Al + 2NaOH + 2H_2O \xrightarrow{\Delta} 2NaAlO_2 + 3H_2\uparrow$$

Aluminium; Sodium hydroxide; Sodium meta aluminate (Colourless)

$$2Al + 2KOH + 2H_2O \xrightarrow{\Delta} 2KAlO_2 + 3H_2\uparrow$$

Aluminium; Potassium hydroxide; Potassium meta aluminate

Zinc Metal (Zn)

It reacts only with boiling and concentrated alkali.

$$Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2\uparrow$$

Zinc; (Hot and conc.) Sodium hydroxide; Sodium zincate (Colourless)

$$Zn + 2KOH \xrightarrow{\Delta} K_2ZnO_2 + H_2\uparrow$$

Zinc; Potassium hydroxide; Potassium zincate

Lead Metal (Pb)

It reacts only with boiling and concentrated alkali.

$$Pb + 2NaOH \xrightarrow{\Delta} Na_2PbO_2 + H_2\uparrow$$

Lead; Sodium hydroxide; Sodium plumbite (Colourless)

$$Pb + 2KOH \xrightarrow{\Delta} K_2PbO_2 + H_2\uparrow$$

Lead; Potassium hydroxide; Potassium plumbite (Colourless)

Action of Acids on Certain Metals

Amphoteric metals (like Zn, Al, Pb) react with dilute hydrochloric acid or sulphuric acid to give corresponding salt and liberate hydrogen gas.

Aluminium Metal (Al)

$$2Al + 3H_2SO_4(dil.) \longrightarrow Al_2(SO_4)_3 + 3H_2\uparrow$$

Aluminium; Sulphuric acid; Aluminium sulphate

$$2Al + 6HCl(dil.) \longrightarrow 2AlCl_3 + 3H_2\uparrow$$

Aluminium; Hydrochloric acid; Aluminium chloride

Zinc Metal (Zn)

$$Zn + H_2SO_4 (dil.) \longrightarrow ZnSO_4 + H_2\uparrow$$

Zinc; Sulphuric acid; Zinc sulphate

$$Zn + 2HCl(dil.) \longrightarrow ZnCl_2 + H_2\uparrow$$

Zinc; Hydrochloric acid; Zinc chloride

Lead Metal (Pb)

$$\underset{\text{Lead}}{Pb} + \underset{\text{Sulphuric acid}}{H_2SO_4\ (dil.)} \longrightarrow \underset{\text{Lead sulphate}}{PbSO_4} + H_2\uparrow$$

$$\underset{\text{Lead}}{Pb} + \underset{\text{Hydrochloric acid}}{2HCl\ (dil.)} \longrightarrow \underset{\text{Lead chloride}}{PbCl_2} + H_2\uparrow$$

Amphoteric Nature of Metal Oxides and Hydroxides

Most of the metal oxides are basic in nature and dissolve in water to give hydroxide or alkali. These metal oxides and hydroxides neutralise acids and do not react with bases.

e.g.,

$$\underset{\text{Sodium oxide}}{Na_2O} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH}$$

$$Na_2O + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow 2\underset{\text{Sodium chloride}}{NaCl} + H_2O$$

$$\underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Hydrochloric acid}}{HCl} \longrightarrow \underset{\text{Sodium chloride}}{NaCl} + H_2O$$

But oxides and hydroxides of few metals (like Zn, Al and Pb) are amphoteric in nature *i.e.,* they react with both acids and base *e.g.,* Zinc oxide (ZnO) and zinc hydroxide [$Zn(OH)_2$].

Amphoteric oxide/hydroxide + acid ⟶ Salt + water

Amphoteric oxide/hydroxide + alkali ⟶ Salt + water

Alkaline Nature of Amphoteric Metal Oxides and Hydroxides

1. Zinc Oxide and Hydroxide

$$\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Zinc chloride (Salt)}}{ZnCl_2} + H_2O$$

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Zinc chloride (Salt)}}{ZnCl_2} + 2H_2O$$

$$\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Sulphuric acid}}{H_2SO_4\ (dil.)} \longrightarrow \underset{\text{Zinc sulphate (Salt)}}{ZnSO_4} + H_2O$$

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} + \underset{\text{Sulphuric acid}}{H_2SO_4(dil.)} \longrightarrow \underset{\text{Salt}}{ZnSO_4} + 2H_2O$$

2. Aluminium Oxide and Hydroxide

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Hydrochloric acid}}{6HCl\ (dil.)} \longrightarrow \underset{\text{Aluminium chloride (Salt)}}{2AlCl_3} + 3H_2\uparrow$$

$$\underset{\text{Aluminium hydroxide}}{Al(OH)_3} + 3HCl\ (dil.) \longrightarrow \underset{\text{(Salt)}}{AlCl_3} + 3H_2O$$

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Sulphuric acid}}{3H_2SO_4(dil.)} \longrightarrow \underset{\text{Aluminium sulphate (Salt)}}{Al_2(SO_4)_3} + 3H_2O$$

$$Al(OH)_3 + 3H_2SO_4(dil.) \longrightarrow \underset{\text{(Salt)}}{Al_2(SO_4)_3} + 6H_2O$$

3. Lead Oxide and Hydroxide

$$\underset{\text{Lead oxide}}{PbO} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Lead chloride (Salt)}}{PbCl_2} + H_2O$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} + 2HCl \longrightarrow \underset{\text{Lead chloride (Salt)}}{PbCl_2} + 2H_2O$$

$$\underset{\text{Lead oxide}}{PbO} + H_2SO_4\ (dil.) \longrightarrow \underset{\text{Lead sulphate (Salt)}}{PbSO_4} + H_2O$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} + H_2SO_4(dil.) \longrightarrow \underset{\text{(Salt)}}{PbSO_4} + 2H_2O$$

Acidic Nature of Amphoteric Metal Oxides and Hydroxides

1. Zinc Oxide and Hydroxide

$$\underset{\text{Zinc oxide (White)}}{ZnO} + \underset{\text{Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium zincate (Colourless, soluble)}}{Na_2ZnO_2} + H_2O$$

$$\underset{\text{Zinc oxide (White)}}{ZnO} + \underset{\text{Potassium hydroxide}}{2KOH} \xrightarrow{\Delta} \underset{\text{Potassium zincate (Colourless, soluble)}}{K_2ZnO_2} + H_2O$$

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} + \underset{\text{Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium zincate}}{Na_2ZnO_2} + 2H_2O$$

$$Zn(OH)_2 + 2KOH \xrightarrow{\Delta} K_2ZnO_2 + 2H_2O$$

2. Aluminium Oxide and Hydroxide

$$\underset{\text{Aluminium oxide (White)}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium meta aluminate (Colourless soluble)}}{2NaAlO_2} + H_2O$$

Note This process is called Baeyer's process and is used in the extraction of aluminium from bauxite.

$$\underset{\text{Aluminium oxide (white)}}{Al_2O_3} + \underset{\text{Potassium hydroxide}}{2KOH} \xrightarrow{\Delta} \underset{\text{Potassium meta aluminate}}{2KAlO_2} + H_2O$$

$$\underset{\text{Aluminium hydroxide}}{Al(OH)_3} + \underset{\text{Sodium hydroxide}}{NaOH} \xrightarrow{\Delta} \underset{\text{Sodium meta aluminate (Colourless, soluble)}}{NaAlO_2} + 2H_2O$$

$$\underset{\text{Aluminium hydroxide}}{Al(OH)_3} + \underset{\text{Potassium hydroxide}}{KOH} \xrightarrow{\Delta} \underset{\text{Potossium meta aluminate}}{KAlO_2} + 2H_2O$$

3. Lead Oxide and Hydroxide

$$\underset{\text{Lead oxide (Yellow)}}{PbO} + \underset{\text{Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium plumbite (Colourless, soluble)}}{Na_2PbO_2} + H_2O$$

$$\underset{\text{Lead oxide (Yellow)}}{PbO} + \underset{\text{Potassium hydroxide}}{2KOH} \xrightarrow{\Delta} \underset{\text{Potassium plumbite (Colourless, soluble)}}{K_2PbO_2} + H_2O$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} + \underset{\text{Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium plumbite}}{Na_2PbO_2} + 2H_2O$$

$$\underset{\text{Lead hydroxide}}{Pb(OH)_2} + \underset{\text{Potassium hydroxide}}{2KOH} \longrightarrow \underset{\text{Potassium plumbite}}{K_2PbO_2} + 2H_2O$$

CHECK POINT 02

1. Zinc oxide is said to have amphoteric nature but sodium oxide is not. Explain.
2. Complete the following equations.
   (a) $NaOH + _____ \longrightarrow NaCl + H_2O$
   (b) $ZnO + H_2SO_4\,(dil) \longrightarrow _____ + H_2O$
   (c) $Pb(OH)_2 + 2KOH \longrightarrow _____ + 2H_2O$
3. Name a white insoluble oxide that dissolves in hot and concentrated caustic alkali.
4. Write the equation when sodium hydroxide is added to a solution of ferric chloride.
5. Give the action of acid and base with aluminium metal.

SUMMARY

- Reaction of sodium hydroxide on solutions of salts

Salts	Ions	Reactions involved	Hydroxides formed	Colour of ppt.	Solubility in excess of NaOH
$Ca(NO_3)_2$ (white) Calcium nitrate	Ca^{2+}	$Ca(NO_3)_2 + 2NaOH \longrightarrow 2NaNO_3 + Ca(OH)_2\downarrow$	Calcium hydroxide	White	Slightly soluble
MSO_4 [M = Fe, Cu, Zn]	M^{2+}	$MSO_4 + 2NaOH \rightarrow Na_2SO_4 + M(OH)_2\downarrow$	Iron (II) hydroxide Copper (II) hydroxide Zinc (II) hydroxide	Dirty green Pale blue White gelatinous	Insoluble Insoluble Soluble
$FeCl_3$ (yellow) Ferric chloride	Fe^{3+}	$FeCl_3$ (Deliquescent) $+ 3NaOH \longrightarrow 3NaCl + Fe(OH)_3\downarrow$	Iron (III) hydroxide	Reddish brown	Insoluble
$Pb(NO_3)_2$ Lead nitrate	Pb^{2+}	$Pb(NO_3) + 2NaOH \longrightarrow Pb(OH)_2\downarrow + 2NaNO_3$ $Pb(OH)_2 + 2NaOH$ (Excess) $\longrightarrow 2H_2O + Na_2PbO_2$	Lead (II) hydroxide	Chalky white sodium plumbite	Soluble

- Reaction of ammonium hydroxide on solutions of salts

Salts	Ions	Reactions involved	Hydroxides formed	Colour of ppt.	Solubility in excess of NH_4OH
Calcium salt	Ca^{2+}	No reaction (because the concentration of OH^- ions produced by the ionisation of NH_4OH is so low that it cannot precipitate the hydroxide of calcium).	No ppt.	–	–
MSO_4 [M = Fe, Zn, Cu]	M^{2+}	$MSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + M(OH)_2\downarrow$	Iron (II) hydroxide Copper (II) hydroxide Zince hydroxide	Dirty green Pale blue White gelatinous	Insoluble Soluble Soluble
$FeCl_3$ (yellow) Ferric chloride	Fe^{3+}	$FeCl_3 + 3NH_4OH \longrightarrow 3NH_4Cl + Fe(OH)_3\downarrow$	Iron [III] hydroxide	Reddish brown	Insoluble
$Pb(NO_3)_2$	Pb^{2+}	$Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$	Lead hydroxide	Chalky white	Insoluble

- Metals which can react with both acids and bases are called amphoteric metals. Zn, Al and Pb.
- Amphoteric metals react with hot concentrated caustic alkali to give the corresponding soluble salt and liberate hydrogen gas.
- Amphoteric metals react with dilute hydrochloric acid or sulphuric acid to give cooresponding salt and liberate hydrogen gas.
- Amphoteric oxide/hydroxide + acid → Salt + Water
- Amphoteric oxide/hydroxide + alkali → Salt + Water

EXAM PRACTICE

Fill in the Blanks

1. …… analysis deals with the identification of unknown substance by chemical tests.

Sol. Qualitative

2. Sodium hydroxide solution when added to solution of …….. gives reddish brown precipitate.

Sol. $FeCl_3$

3. Sodium hydroxide when added to solution of …… gives pale blue precipitate which do not dissolve in excess.

Sol. $CuSO_4$

4. …… ($AgCl/PbCl_2$), a white precipitate, is soluble in excess NH_4OH. ***[2016]***

Sol. AgCl

5. ..... is used to distinguish zinc nitrate solution from magnesium nitrate solution.

Sol. NH_4OH or NaOH

6. Ammonium hydroxide solution when added to the solution of …… gives white precipitate which dissolves in excess.

Sol. $ZnSO_4$

7. When ammonium hydroxide is added in small quantity, pale blue precipitate of …… is formed.

Sol. $Cu(OH)_2$

8. The metal oxide which can react with acid as well as alkali is …… .

Sol. amphoteric oxide

Multiple Choice Questions

9. Which of the following analysis deals with the identification of unknown substance?

(a) Qualitative analysis
(b) Quantitative analysis
(c) Both (a) and (b)
(d) None of the above

Sol. (a)

10. A chloride which forms a precipitate that is soluble in excess of ammonium hydroxide, is

(a) calcium chloride (b) ferrous chloride
(c) ferric chloride (d) copper chloride

Sol. (d)

11. Hydroxide of this metal is soluble in sodium hydroxide solution. ***[2011]***

(a) Magnesium (b) Lead (c) Silver (d) Copper

Sol. (b)

12. The salt which gives a dirty green precipitate with sodium hydroxide solution is ***[2008]***

(a) iron (III) sulphate (b) iron (II) sulphate
(c) iron (II) chloride (d) iron (III) chloride

Sol. (b)

13. Which of the following hydroxides possesses pale blue colour?

(a) Lead hydroxide (b) Copper hydroxide
(c) Zinc hydroxide (d) Ferrous hydroxide

Sol. (b)

14. Choose the correct answer from the options given below.

The salt solution which does not react with ammonium hydroxide is ***[2018]***

(a) calcium nitrate (b) zinc nitrate
(c) lead nitrate (d) copper nitrate

Sol. (a)

15. A metal which is amphoteric in nature.

(a) Manganese (b) Copper
(c) Sodium (d) Zinc

Sol. (d)

16. A yellow monoxide that dissolves in hot and concentrated alkali.

(a) ZnO (b) CuO (c) PbO (d) AgO

Sol. (c)

17. An amphoteric hydroxide having gelatinous white ppt.

(a) Zinc hydroxide (b) Sodium hydroxide
(c) Copper (II) hydroxide (d) None of these

Sol. (a)

18. The metal oxide which can react with acid as well as alkali is ***[2009]***

(a) silver oxide (b) copper (II) oxide
(c) aluminium oxide (d) calcium oxide

Sol. (c)

Match the Following

19. Match the following columns.

	Column I		Column II
(i)	Metal which forms more than one type of positive ions.	(a)	Zinc oxide
(ii)	Metal that evolve a gas (which gives a pop sound) when boiled with alkali solution.	(b)	Iron
(iii)	Amphoteric	(c)	Zinc
(iv)	A strong alkali	(d)	All oxides of transition elements
		(e)	NaOH

Sol. (i) (b), (ii) (c), (iii) (a), (iv) (e)

20. Sodium hydroxide solution is added to the solution containing the ions mentioned in Column I and Column II, gives the details of the precipitate. Match the ions with their coloured precipitates. ***[2011]***

S. No.	Column I		Column II
(i)	Pb^{2+}	(a)	Reddish brown
(ii)	Fe^{2+}	(b)	White insoluble in excess
(iii)	Zn^{2+}	(c)	Dirty green
(iv)	Fe^{3+}	(d)	White soluble in excess
(v)	Cu^{2+}	(e)	Blue
(vi)	Ca^{2+}	(f)	

Sol. Correct match is given below.

S. No.	Column I		Column II
(i)	Pb^{2+}	(a)	White soluble in excess
(ii)	Fe^{2+}	(b)	Dirty green
(iii)	Zn^{2+}	(c)	White soluble in excess
(iv)	Fe^{3+}	(d)	Reddish brown
(v)	Cu^{2+}	(e)	Blue
(vi)	Ca^{2+}	(f)	White insoluble in excess

a 1 Mark Questions

21. Write the colour of the following salts,

(i) Cuprous salts (ii) Aluminium salts

(iii) Cupric salts

Sol. (i) White (ii) Colourless (iii) Blue

22. Write a balanced chemical equation for each of the following. ***[2018]***

Reaction of sodium hydroxide solution with iron (III) chloride solution.

Sol. $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3NaCl$

Ferric chloride; Sodium hydroxide; Ferric hydroxide; Sodium chloride

23. State relavant observation. Action of sodium hydroxide solution on ferrous sulphate solution. ***[2017]***

Sol. On adding sodium hydroxide drop by drop to a solution of ferrous ion, a dirty green precipitate is formed which turns reddish brown after sometime and is insoluble in excess of sodium hydroxide.

$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 \downarrow + Na_2SO_4$

Ferrous sulphate (Pale green); Sodium hydroxide (Colourless); Ferrous hydroxide (Dirty green gelatinous ppt.); Sodium sulphate (Colourless)

24. State your observation, when excess sodium hydroxide is added to calcium nitrate solution. ***[2014, 13]***

Sol. A white precipitate of $Ca(OH)_2$ will be formed which is sparingly soluble in excess of NaOH.

25. Sodium hydroxide is added dropwise, followed by in excess to a solution of zinc sulphate. Write the observation.

Sol. White precipitate of zinc hydroxide [$Zn(OH)_2$] is formed.

26. State the observation. Sodium hydroxide solution is added to ferric chloride solution first a little and then in excess. ***[2012]***

Sol. When sodium hydroxide solution is added in a little amount, a reddish brown precipitate of $Fe(OH)_3$ is formed which solublises in excess of sodium hydroxide solution.

27. Identify the substance *P*.

The deliquescent salt *P*, turns yellow when dissolved in water and gives a reddish brown precipitate with sodium hydroxide solution. ***[2009]***

Sol. The deliquescent salt *P* is iron (III) chloride ($FeCl_3$) which turns yellow when dissolved in water and gives a reddish brown precipitate with NaOH solution.

$FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3NaCl$

Ferric chloride; Sodium hydroxide; Ferric hydroxide (Reddish brown precipitate); Sodium chloride

28. Give the appropriate term.

A solution of this compound gives a dirty green precipitate with sodium hydroxide. ***[2006]***

Sol. Ferrous sulphate gives a dirty green precipitate with sodium hydroxide solution.

$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 \downarrow + Na_2SO_4$

Ferrous sulphate (Pale green); Ferrous hydroxide (Dirty green gelatinous ppt.)

29. Give an equation for the conversion of $Zn(NO_3)_2$ to $Zn(OH)_2$. *[2010]*

Sol. $Zn(NO_3)_2 + 2NaOH \longrightarrow Zn(OH)_2 \downarrow + 2NaNO_3$
(Zinc nitrate; Zinc hydroxide)

30. Give two examples of metallic salt which gives white precipitate with sodium hydroxide when added in little amount.

Sol. (a) $ZnSO_4$ (b) $Ca(NO_3)_2$

31. Write the equation when ammonium chloride is heated with sodium hydroxide. *[2010]*

Sol. When sodium hydroxide is heated with ammonium chloride, ammonia gas is evolved.

$$NH_4Cl + NaOH \xrightarrow{\Delta} NaCl + H_2O + NH_3 \uparrow$$
(Ammonium chloride; Sodium hydroxide; Ammonia gas)

32. Give an example of metal hydroxide which is, respectively
(a) soluble (b) insoluble
(c) sparingly soluble in excess of sodium hydroxide solution.

Sol. (a) $Zn(OH)_2$ (soluble in excess of NaOH solution)
(b) $Fe(OH)_3$ (insoluble in excess of NaOH solution)
(c) $Ca(OH)_2$ (sparingly soluble in excess of NaOH solution)

33. Choose the correct answer.
(i) Solution *A* is a strong acid.
(ii) Solution *B* is a weak acid.
(iii) Solution *C* is a strong alkali.
Which solution will give a gelatinous white precipitate with zinc sulphate solution?
The precipitate disappears when an excess of the solution is added. *[2009]*

Sol. Solution (*C*) is a strong alkali. A strong alkali *e.g.,* NaOH gives a white precipitate with zinc sulphate solution and precipitate disappears when excess of NaOH solution is added.

34. In a solution *X*, sodium hydroxide solution is added. A white precipitate is formed which is insoluble in excess of sodium hydroxide solution. Which metal ion is present in solution *X*?

Sol. Calcium ion $[Ca^{2+}]$

35. State one chemical test between ferrous nitrate and lead nitrate. *[2012]*

Sol. On adding sodium hydroxide solution to given solution, a dirty green precipitate is formed (which turns brown after sometime) that indicates the presence of ferrous salt. On adding NH_4OH to a given solution, if a white precipitate is formed which is insoluble in excess of ammonium hydroxide that indicates the presence of lead nitrate.

36. State one relevant observation for each of the following. *[2018]*
Lead nitrate solution is treated with sodium hydroxide solution dropwise till it is in excess.

Sol. When sodium hydroxide is added drop by drop to a solution of lead nitrate, a white precipitate is formed which is soluble in excess of sodium hydroxide.

$$Pb(NO_3)_2 + 2NaOH \longrightarrow Pb(OH)_2 \downarrow$$
(Lead nitrate; Sodium hydroxide; Lead hydroxide (white ppt.))

$$Pb(OH)_2 + 2NaOH \longrightarrow Na_2PbO_2 + 2H_2O + 2NaNO_3$$
(Excess; Sodium plumbite (soluble salt); Sodium nitrate)

37. Name a metallic hydroxide which is insoluble in excess of ammonium hydroxide solution.

Sol. Lead (II) hydroxide is insoluble in excess of NH_4OH.

38. Name a salt solution which on reaction with excess of ammonium hydroxide solution gives a deep blue solution.

Sol. Copper sulphate solution

39. What would you observe when ammonium hydroxide is first added in a small quantity and then in excess to a solution of copper sulphate? *[2011]*

Sol. A pale blue or a bluish white precipitate appears which dissolves in excess to give deep blue solution or Prussian blue solution.

40. Give one example of metal hydroxide which are
(a) soluble
(b) insoluble in ammonium hydroxide solution

Sol. (a) Zinc (II) hydroxide, $Zn(OH)_2$ (White precipitate)
(b) Iron (II) hydroxide, $Fe(OH)_2$ (Dirty green precipitate)

41. Give one test to distinguish between iron (III) chloride and copper (II) chloride solutions. *[2006]*

Sol.

Iron (III) Chloride	Copper (II) Chloride
When ammonium hydroxide solution is added, a reddish brown ppt. is formed, which is also insoluble in excess of ammonium hydroxide solution.	In this, pale blue precipitate is formed which get dissolved in excess of ammonium hydroxide solution.

42. Write the balanced chemical equation when zinc oxide dissolves in sodium hydroxide. ***[2011, 10]***

Sol. $ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$
(Zinc oxide; Sodium hydroxide (Base); Sodium zincate)

43. What do you understand by amphoteric oxides?

Sol. Amphoteric oxides are the oxides which react with both acids and alkalies to form salt and water *e.g.*, ZnO.

44. Name an oxide which forms salt when it reacts with both acids and alkalies. ***[2005]***

Sol. Amphoteric oxides (like Al_2O_3 or ZnO) forms salts when they react with both acids and alkalies.

45. Write the balanced chemical equation of aluminium oxide and sodium hydroxide solution. ***[2010]***

Sol. $Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$
(Aluminium oxide; Sodium meta aluminate)

46. Name the gas evolved on reaction of aluminium with boiling concentrated caustic alkali solution. Write the equation. ***[2012]***

Sol. Hydrogen gas (*i.e.*, H_2). The reaction is

$$\underset{\text{Aluminium}}{2Al} + \underset{\substack{\text{Caustic}\\\text{Soda}}}{2NaOH + 2H_2O} \longrightarrow \underset{\substack{\text{Sodium}\\\text{meta aluminate}}}{2NaAlO_2} + 3H_2\uparrow$$

b 2 Marks Questions

47. A precipitate is produced when sodium hydroxide solution is added to zinc sulphate solution in excess.
Explain with reactions involved.

Sol. A white precipitate is produced that dissolves in an excess of sodium hydroxide.

$$\underset{\text{Zinc sulphate}}{ZnSO_4} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Zinc hydroxide (white ppt.)}}{Zn(OH)_2}\downarrow + \underset{\text{Sodium sulphate}}{Na_2SO_4}$$ ***[1]***

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\substack{\text{Sodium zincate}\\\text{(soluble, colourless solution)}}}{Na_2ZnO_2} + 2H_2O$$ ***[1]***

48. State your observations when ammonium hydroxide solution is added drop by drop and then in excess to each of the following solutions:
(i) Copper sulphate solution.
(ii) Zinc sulphate solution ***[2016]***

Sol. (i) **$CuSO_4$ solution** When ammonium hydroxide solution is added drop by drop to copper sulphate solution, a pale blue precipitate of copper hydroxide is formed.

$$CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Pale blue ppt.}}{Cu(OH)_2}\downarrow + (NH_4)_2SO_4$$

And in excess of NH_4OH, deep blue coloured complex of copper is formed. ***[1]***

(ii) **$ZnSO_4$ solution** When ammonium hydroxide solution is added drop by drop to $ZnSO_4$ solution, a white precipitate of $[Zn(OH)_2]$, zinc hydroxide is formed.

$$ZnSO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Zinc hydroxide}\\\text{(White ppt.)}}}{[Zn(OH)_2]}\downarrow + (NH_4)_2SO_4$$

Whereas, in excess of ammonium hydroxide, ammonia complex of zinc is formed. ***[1]***

49. Write a balanced chemical equation for
(i) zinc oxide (ii) zinc hydroxide
that are warmed with NaOH solution.

Sol. (i) Zinc oxide (ZnO)

$$\underset{\text{(Conc.)}}{ZnO + 2NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium zincate}\\\text{(Colourless, soluble)}}}{Na_2ZnO_2} + H_2O$$ ***[1]***

(ii) Zinc hydroxide $[Zn(OH)_2]$

$$\underset{\text{(White)}}{Zn(OH)_2} + \underset{\text{(Conc.)}}{2NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium zincate}\\\text{(Colourless, soluble)}}}{Na_2ZnO_2} + 2H_2O$$ ***[1]***

50. The following table shows the test for solution *A* and *B*. Write down the observation for the given test.

Test	Observation	Conclusions
(i) To solution *A* sodium hydroxide solution was added.	(a)	*A* contains Fe^{3+} ions
(ii) To solution *B* ammonium hydroxide was added slowly followed by in excess.	(b)	*B* contains Cu^{2+} ions

Sol. **Observations**
(i) Reddish brown precipitate of $Fe(OH)_3$ is formed. ***[1]***
(ii) Pale blue precipitate is formed which gives deep blue solution with excess of ammonium hydroxide. ***[1]***

51. State one observation for each of the following.
(i) Excess ammonium hydroxide solution is added to lead nitrate solution.
(ii) Sodium hydroxide solution is added to ferric chloride solution at first a little and then in excess. ***[2012]***

Sol. (i) White precipitate appears which remains insoluble in excess of ammonium hydroxide. *[1]*

(ii) Reddish brown precipitate appears which is insoluble in excess sodium hydroxide solution. *[1]*

52. Distinguish between the following pairs of compounds using the test given within brackets. *[2014, 13, 12]*

(i) A lead salt [Pb^{2+}] and a zinc salt [Zn^{2+}] (using excess ammonium hydroxide).

(ii) Iron (II) sulphate and iron (III) sulphate (using ammonium hydroxide).

Sol. (i)

Lead salt (Pb^{2+})	**Zinc salt** (Zn^{2+})
When ammonium hydroxide solution is added, a chalky white precipitate is formed which is insoluble in excess of ammonium hydroxide.	A white precipitate is formed when ammonium hydroxide is added drop by drop and this precipitate solublise in excess of ammonium hydroxide.

[1]

(ii)

Iron (II) sulphate	**Iron (III) sulphate**
When ammonium hydroxide solution is added, a dirty green precipitate is formed which turns reddish brown after sometime and is insoluble in excess of ammonium hydroxide.	In this case, a reddish brown precipitate is formed, which is also insoluble in excess of ammonium hydroxide solution.

[1]

53. What will be the action of alkalies on

(i) amphoteric metal oxides?

(ii) amphoteric metal hydroxides?

Sol. (i) (a) $\underset{\text{Zinc oxide (White)}}{ZnO} + \underset{\text{(Conc.) Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium zincate (Colourless, soluble)}}{Na_2ZnO_2} + H_2O$ *[1/2]*

(b) $\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{(Conc.) Sodium hydroxide}}{2NaOH} \xrightarrow{\Delta} \underset{\text{Sodium meta aluminate (Colourless, soluble)}}{2NaAlO_2} + H_2O$ *[1/2]*

(ii) (a) $\underset{\text{Zinc hydroxide (White)}}{Zn(OH)_2} + \underset{\text{(Conc.) Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{(Colourless, soluble)}}{Na_2ZnO_2} + H_2O$ *[1/2]*

(b) $\underset{\text{Aluminium hydroxide}}{Al(OH)_3} + \underset{\text{(Conc.) Sodium hydroxide}}{NaOH} \xrightarrow{\Delta} \underset{\text{(Colourless, soluble)}}{NaAlO_2} + 2H_2O$ *[1/2]*

C 3 Marks Questions

54. Write the product of the following reactions.

(i) $Ca(NO_3)_2 + 2NaOH \longrightarrow$

(ii) $FeSO_4 + NaOH \longrightarrow$

(iii) $FeCl_3 + 3NaOH \longrightarrow$

(iv) $CuSO_4 + NaOH \longrightarrow$

(v) $ZnSO_4 + NaOH \longrightarrow$

(vi) $Pb(NO_3) + \underset{\text{In excess}}{2NaOH} \longrightarrow$

Sol. Products of given reactions are

(i) $Ca(OH)_2 \downarrow + 2NaNO_3$ (ii) $Fe(OH)_2 \downarrow + Na_2SO_4$

(iii) $Fe(OH)_3 \downarrow + 3NaCl$ (iv) $Cu(OH)_2 \downarrow + Na_2SO_4$

(v) $Zn(OH)_2 \downarrow + Na_2SO_4$

(vi) $Pb(OH)_2 \downarrow + 2NaNO_3$ *[6 × 1/2 = 3]*

55. (i) How will you distinguish between ammonium hydroxide and sodium hydroxide using copper sulphate solution?

(ii) Identify the salts *P* and *Q* from the observations given below.

(a) On performing the flame test salt *P* produces a lilac coloured flame and its solution gives a white precipitate with silver nitrate solution, which is soluble in ammonium hydroxide solution.

(b) When dilute HCl is added to a salt *Q*, a brisk effervescence is produced and the gas turns lime water milky. When NH_4OH solution is added to the above mixture (after adding dil. HCl), it produces a white precipitate which is soluble in excess NH_4OH solution.

Sol. (i) On adding NaOH drop by drop to a solution of copper salt, a bluish white precipitate is formed that is insoluble in excess of sodium hydroxide.

$\underset{\text{Copper sulphate (Blue)}}{CuSO_4} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Copper (II) hydroxide (Pale blue ppt.)}}{Cu(OH)_2 \downarrow} + \underset{\text{Sodium sulphate (Colourless)}}{Na_2SO_4}$

On adding ammonium hydroxide drop by drop to a solution of copper salt, a pale blue precipitate is formed which dissolves in excess of ammonium hydroxide to give deep blue or inky blue or Prussian blue solution.

$\underset{\text{Copper sulphate (Blue)}}{CuSO_4} + \underset{\text{Ammonium hydroxide}}{2NH_4OH} \rightarrow \underset{\text{(Pale blue ppt.)}}{Cu(OH)_2 \downarrow} + \underset{\text{Ammonium sulphate (Colourless)}}{(NH_4)_2SO_4}$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\text{(Excess)}}{}$$

$$[Cu(NH_3)_4]SO_4 + 4H_2O$$

Tetraammine copper (II) sulphate (Deep blue solution)

This reaction shows a characteristic property of Cu^{2+} ion and is used to distinguish between ammonium hydroxide and sodium hydroxide. ***[1½]***

(ii) (a) $\underset{(P)}{KCl} + AgNO_3 \longrightarrow KNO_3 + AgCl\downarrow$

$$AgCl + 2NH_4OH \longrightarrow \underset{\text{Diammine silver (I) chloride}}{[Ag(NH_3)_2]^+ Cl^-} + 2H_2O$$

(b) $\underset{(Q)}{CuCO_3} + 2HCl \longrightarrow 2CuCl_2 + H_2O + CO_2\uparrow$

Brisk effervescence is due to carbon dioxide produced during the reaction, which turns lime water milky.

$$CuCl_2 + 2NH_4OH \longrightarrow \underset{\text{White ppt.}}{Cu(OH)_2} + 2NH_4Cl$$

$$Cu(OH)_2 + 2NH_4OH \longrightarrow \underset{\text{Soluble}}{[Cu(NH_3)_4]Cl} + 4H_2O$$

[1½]

56. There are three test tubes *A, B* and *C* containing copper sulphate solution, calcium nitrate solution and zinc nitrate solution, respectively. Half of each solutions is treated with excess of sodium hydroxide and rest half of each solution is treated with excess of ammonium hydroxide. Note down the observation, precipitate formed initially and their solubility in excess.

Sol. (i) Reaction with sodium hydroxide (NaOH)

	Salts	Small amount	In excess
A	Copper sulphate	Pale blue ppt.	Insoluble
B	Calcium nitrate	White ppt.	Sparingly soluble
C	Zinc nitrate	White ppt.	Soluble

[1½]

(ii) Reaction with ammonium hydroxide (NH_4OH)

	Salts	Small amount	In excess
A	Copper sulphate	Pale blue	Soluble
B	Calcium nitrate	No ppt.	No ppt.
C	Zinc sulphate	White gelatinous	Soluble

[1½]

d 4 Marks Questions

57. The following table shows the tests performed by a student on four different aqueous solutions which are *X, Y, Z* and *W*. Based on the observations provided, identify the cation present. ***[2015]***

Chemical test	Observation	Conclusion
To solution *X*, ammonium hydroxide is added in minimum quantity first and then in excess.	A dirty white precipitate is formed which dissolves in excess to form a clear solution.	(i)
To solution *Y*, ammonium hydroxide is added in minimum quantity first and then in excess.	A pale blue precipitate is formed which dissolves in excess to form a clear inky blue solution.	(ii)
To solution *W*, a small quantity of sodium hydroxide solution is added and then in excess.	A white precipitate is formed which remains insoluble.	(iii)
To solution *Z*, sodium hydroxide solution is added and then heated.	A pungent smelling gas turning moist red litmus paper blue.	(iv)

Sol. (i) Zn^{2+} is present (ii) Cu^{2+} is present
(iii) Ca^{2+} is present (iv) NH_4^+ is present ***[4 × 1 = 4]***

58. (i) Name the following.
(a) A strong alkali (b) A weak alkali
(ii) Give a balanced equation for the following.
(a) A coloured metallic oxide which dissolves in alkalies to yield colourless solution.
(b) A metal, when boiled with alkali solution evolved a gas which burns with a pop sound.

Sol. (i) (a) NaOH, sodium hydroxide ***[1]***
(b) NH_4OH, ammonium hydroxide ***[1]***
(ii) (a) Lead monoxide (PbO).

$$\underset{\text{Yellow}}{PbO} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Sodium plumbate (colourless, soluble)}}{Na_2PbO_2} + H_2O$$

[1]

(b) Zinc (Zn)

$$Zn + \underset{\text{(Hot and conc.)}}{2NaOH} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + \underset{\text{(Burns with pop sound)}}{H_2\uparrow}$$

[1]

59. Write the balanced chemical equation of the following.
(i) Aluminium and sodium hydroxide solution
(ii) Aluminium oxide and sodium hydroxide
(iii) Zinc oxide and caustic soda
(iv) Zinc is heated with caustic soda

Sol. (i) $\underset{\text{Aluminium}}{2Al} + \underset{\text{Caustic soda}}{2NaOH} + 2H_2O \longrightarrow \underset{\text{Sodium meta aluminate}}{2NaAlO_2} + 3H_2\uparrow$ ***[1]***

(ii) $\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Sodium meta aluminate}}{2NaAlO_2} + H_2O$ ***[1]***

(iii) $ZnO + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2O$
Zinc oxide, Caustic soda, Sodium zincate [1]

(iv) $Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2\uparrow$
Zinc, Caustic soda, Sodium zincate [1]

60. Give a chemical test to distinguish between the following pairs of chemicals.
(i) Lead nitrate solution and zinc nitrate solution.
(ii) Sodium chloride solution and sodium nitrate solution. **[2018]**

Sol. *Following are the chemical tests to distinguish between*

(i) **Lead Nitrate Solution and Zinc Nitrate Solution**
On adding ammonium hydroxide drop by drop to a solution of zinc nitrate, a white gelatinous precipitate is formed which is soluble in excess of ammonium hydroxide.

$Zn(NO_3)_2 + 2NH_4OH \longrightarrow 2NH_4NO_3 + Zn(OH)_2\downarrow$
Zinc nitrate, Ammonium hydroxide, Ammonium nitrate, Zinc hydroxide (white gelatinous ppt)

$Zn(OH)_2 + 2NH_4NO_3 + 2NH_4OH \longrightarrow [Zn(NH_3)_4](NO_3)_2 + 4H_2O$
(Excess)

On the other hand, in case of lead nitrate, a white precipitate is formed which is insoluble in excess of ammonium hydroxide.

$Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$
Lead nitrate, Ammonium hydroxide, Lead hydroxide (white ppt), Ammonium nitrate

(ii) **Sodium Chloride Solution and Sodium Nitrate Solution** To a solution of sodium chloride when a few drops of $AgNO_3$ (silver nitrate) solution is added, a white precipitate of AgCl (silver chloride) is obtained while in case of sodium nitrate, no such reaction takes place.

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$
(White ppt)

$NaNO_3 + AgNO_3 \longrightarrow$ No reaction

61. (i) Write one use of sodium and ammonium hydroxide in analytical chemistry.
(ii) Some metallic ions are given below:
Al^{3+}, Ca^{2+}, Zn^{2+}; identify which one forms a white ppt. of hydroxide, which dissolves in an excess of ammonium hydroxide solution.
(iii) Name the reagent that can be used to distinguish a solution containing a lead salt from a solution containing zinc salt.
(iv) What do you mean by amphoteric metal? Give two examples.

Sol. (i) Sodium hydroxide and ammonium hydroxide are used in analytical chemistry to precipitate insoluble metal hydroxide. **[1]**
(ii) Zn^{2+} **[1]**
(iii) Ammonium hydroxide **[1]**
(iv) Those metals which react with both alkalies as well as acids are known as amphoteric metals.
e.g., Zn, Al, etc. **[1]**

e 5 Marks Questions

62. Define the following terms.
(i) Analysis
(ii) Quantitative analysis
(iii) Qualitative analysis
(iv) Reagent
(v) Precipitation

Sol. (i) **Analysis** A process of determination of chemical component in a given sample. **[1]**
(ii) **Quantitative analysis** This kind of analysis involves the determination of composition of a mixture. **[1]**
(iii) **Qualitative analysis** This kind of analysis involves the identification of the unknown substance. **[1]**
(iv) **Reagent** A reagent is a substance that is added to a system in order to bring about a chemical reaction. **[1]**
(v) **Precipitation** A process of formation of an insoluble solid when solutions are mixed. **[1]**

63. Sodium hydroxide solution is added first in a small quantity, then in excess to the aqueous salt solution of copper (II) sulphate, zinc nitrate, lead nitrate, calcium chloride and iron (III) sulphate. Write the colour of the precipitate formed and nature of the precipitate soluble or insoluble.

Sol.

Aqueous salt solution	Colour of precipitate when NaOH is added in a small quantity	Nature of precipitate when NaOH is added in excess (Soluble or insoluble)
Copper (II) sulphate	(i) Blue	(i) Insoluble
Zinc nitrate	(ii) White	(ii) Soluble
Lead nitrate	(iii) White	(iii) Soluble
Calcium chloride	(iv) White	(iv) Insoluble
Iron (III) sulphate	(v) Reddish brown	(v) Insoluble

[5]

CHAPTER EXERCISE

Fill in the Blanks

1. ..... salt solution on reacting with ammonium hydroxide solution gives a deep blue solution.

2. The metal that react with acid as well as alkali are called ..... .

Multiple Choice Questions

3. Among the following which precipitate is soluble in excess of ammonium hydroxide solution?
(a) Lead nitrate
(b) Copper (II) sulphate
(c) Iron (III) salt
(d) Iron (II) salt

4. Which of the following is an amphoteric metal?
(a) Calcium (b) Iron
(c) Aluminium (d) None of these

Match the Following

5. Match the following columns.

	Column I (Salt solution)		Column II (Colour of the salt solution)
(i)	Calcium nitrate	(a)	Black
(ii)	Copper sulphate	(b)	White
(iii)	Zinc sulphate	(c)	Green
(iv)	Ferric salt	(d)	Blue
(v)	Ferrous salt	(e)	Brown

1 Mark Questions

6. Name any two colourless metal ions.

7. Give any one metal which forms more than one type of positive ions.

8. Name the ion that is responsible for the blue colour of an aqueous solution of a salt.

9. What do you observe, when ammonium hydroxide is added to calcium nitrate and zinc sulphate?

10. Give a chemical test to distinguish between the following pair of compounds. Calcium nitrate solution and zinc nitrate solution. ***[2013, 2006]***

11. Give one chemical test to distinguish between iron (II) chloride and iron (III) chloride solution. ***[2009]***

2 Marks Questions

12. A metal which is used in the rechargeable battery, was added to sodium hydroxide solution, a colourless gas was evolved and after the complete reaction the solution was colourless.
(i) Name the metal added to sodium hydroxide solution.
(ii) Name the gas evolved.

13. Write the equation for the reaction of Zn metal/zinc salt solution with each of the following.
(i) Ammonium hydroxide.
(ii) Sodium hydroxide and H_2 gas is evolved. ***[2005]***

14. Name the compound
(i) in which the solution becomes a deep/inky blue colour when excess of ammonium hydroxide is added to it.
(ii) in which the solution gives a white precipitate with excess ammonium hydroxide solution.

3 Marks Question

15. You are provided with two solutions in the test tube *A* and *B*. In one test-tube, NH_4OH solution is present and in another test-tube, NaOH solution is present. How will you identify them?

4 Marks Questions

16. What are the colour of the following salts?
(i) Calcium nitrate
(ii) Ferrous sulphate
(iii) Copper sulphate
(iv) Lead nitrate

17. How would you distinguish between the following salts?
(i) Zinc salt solution and calcium salt solution
(ii) Calcium salt solution and lead salt solution
(iii) Copper salt solution and ferrous salt solution
(iv) Fe (II) salt solution and Fe (III) salt solution

18. (i) Give the balanced equations for the reaction with two different amphoteric oxides with caustic soda.

(ii) What do you observe when NH_4OH is added to iron (II) sulphate?

(iii) How does ammonium hydroxide react to distinguish $FeCl_2$ solution from $FeCl_3$ solution?

5 Marks Questions

19. Complete and balance the following equations.

(i) $FeSO_4 + NH_4OH \longrightarrow$

(ii) $FeCl_3 + NH_4OH \longrightarrow$

(iii) $CuSO_4 + NH_4OH \longrightarrow$

(iv) $Cu(OH)_2 + (NH_4)_2SO_4 + NH_4OH \longrightarrow$ (Excess)

(v) $Pb(NO_3)_2 + NH_4OH \longrightarrow$

20. The following table shows the tests performed by a student on aqueous solution (given below). Write down the missing observation and conclusion that were made. *[5]*

Test	Observation	Conclusions
To solution *A*, ammonium hydroxide was added slowly followed by in excess.	…(i)…	Ca^{2+} ion present
To solution *B*, sodium hydroxide was added slowly followed by in excess.	Dirty green insoluble	…(ii)…
To solution *C*, ammonium hydroxide was added slowly followed by in excess.	…(iii)…	Cu^{2+} ion present
To solution *D*, sodium hydroxide was added slowly followed by in excess.	Gelatinous white	…(iv)…
To solution *E*, sodium hydroxide was added slowly followed by in excess.	…(v)…	Zn^{2+} ion present

ARCHIVES*

(Last 6 Years)

Collection of Questions Asked in Last 6 Years' (2018-2013) ICSE Class 10th Examinations

2018

1 Choose the correct answer from the options given below. The salt solution which does not react with ammonium hydroxide is *[1]*

(a) calcium nitrate (b) zinc nitrate
(c) lead nitrate (d) copper nitrate

2 Write a balanced chemical equation for each of the following.
Reaction of sodium hydroxide solution with iron (III) chloride solution. *[1]*

3 State one relevant observation for each of the following.
Lead nitrate solution is treated with sodium hydroxide solution dropwise till it is in excess. *[1]*

4 Give a chemical test to distinguish between the following pairs of chemicals.
(i) Lead nitrate solution and zinc nitrate solution. *[4]*
(ii) Sodium chloride solution and sodium nitrate solution.

2017

5 Choose the correct answer from the options given below:
(i) A chloride which forms a precipitate that is soluble in excess of ammonium hydroxide, is *[1]*

(a) calcium chloride (b) ferrous chloride
(c) ferric chloride (d) copper chloride

6 (i) State relevant observation. Action of sodium hydroxide solution on ferrous sulphate solution. *[1]*
(ii) Identify the substance underlined **cation** that does not form a precipitate with ammonium hydroxide but forms one with sodium hydroxide. *[1]*

7 (i) How will you distinguish between ammonium hydroxide and sodium hydroxide using copper sulphate solution?
(ii) Identity the salts *P* and *Q* from the observations given below :
(a) On performing the flame test salt *P* produces a lilac coloured flame and its solution gives a white precipitate with silver nitrate solution, which is soluble in ammonium hydroxide solution.
(b) When dilute HCl is added to a salt *Q*, a brisk effervescence is produced and the gas turns lime water milky. When NH_4OH solution is added to the above mixture (after adding dilute HCl), it produces a white precipitate which is soluble in excess NH_4OH solution. *[3]*

2016

8 ..... ($AgCl$ / $PbCl_2$), a white precipitate, is soluble in excess NH_4OH. *[1]*

9 State your observations when ammonium hydroxide solution is added drop by drop and then in excess to each of the following solutions:
(i) Copper sulphate solution.
(ii) Zinc sulphate solution. *[1]*

2015

10 The following table shows the tests performed by student on four different aqueous solutions which are *X, Y, Z* and *W*. Based on the observations provided, identify the cation present. *[4]*

Chemical test	Observation	Conclusion
To solution *X*, ammonium hydroxide is added in minimum quantity first and then in excess.	A dirty white precipitate is formed which dissolves in excess to form a clear solution.	(i)
To solution *Y*, ammonium hydroxide is added in minimum quantity first and then in excess.	A pale blue precipitate is formed which dissolves in excess to form a clear inky blue solution.	(ii)
To solution *W*, a small quantity of sodium hydroxide solution is added and then in excess.	A white precipitate is formed which remains insoluble.	(iii)
To a salt Z, calcium hydroxide solution is added and then heated.	A pungent smelling gas turning moist red litmus paper blue is obtained.	(iv)

2014

11 State your observation. When excess of sodium hydroxide is added to calcium nitrate solution. *[1]*

12 Distinguish between the following pairs of compounds using the test given within brackets.
(i) A lead salt (Pb^{2+}) and a zinc salt (Zn^{2+}) (using ammonium hydroxide).
(ii) Iron (III) sulphate and iron (II) sulphate (using ammonium hydroxide). *[2]*

2013

13 Give a chemical test to distinguish between the following pair of compounds. Calcium nitrate and zinc nitrate solutions.

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 A metal hydroxide which is unsoluble in caustic but soluble in excess of NH_4OH is

(a) $Cu(OH)_2$ (b) $Zn(OH)_2$ (c) $CO(OH)_2$ (d) None of these

2 A metal *M* shows different colour in differently combined state as listed in the table below.

Metal Compound	Colour
K_2MO_4	Yellow
$K_2M_2O_7$	Orange

Identify the metal.

(a) Fe (b) Mn (c) Cr (d) Ni

3 Zn metal shows amphoteric behaviour. It can be shown by

(a) its reaction with dil. NaOH only

(b) its reaction with dil. HCl only

(c) its reaction with both dil. HCl and dil. NaOH

(d) it does not react with either dil. HCl or dil. NaOH

4 Which of the following hydroxide is soluble in excess of NaOH?

(a) $Cr(OH)_3$ (b) $Ca(OH)_2$ (c) $Zn(OH)_2$ (d) $Fe(OH)_3$

5 A colourless gas having pungent irritating odour gives dense white fumes with conc. HCl and turns Nessler's reagent brown. The colourless gas is

(a) H_2 (b) NH_3 (c) NH_4Cl (d) Cl_2

6 You are provided with two test-tubes, *A* and *B*. In *A*, when NaOH was added white ppt. is formed. *B* which is yellow in colour, when NaOH was added, a colourless solution is formed. *A* and *B* are respectively.

(a) $FeSO_4$ and Al_2O_3

(b) $Ca(NO_3)_2$ and $Pb(NO_3)_2$

(c) $CuSO_4$ and KOH

(d) $ZnSO_4$ and ZnO

Answers

1. (a) **2.** (c) **3.** (c) **4.** (c) **5.** (b) **6.** (b)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 261.

CHAPTER

5

Mole Concept and Stoichiometry

In chemistry, the mole is a fundamental unit that is used to measure the amount of substance. This quantity is also referred as the chemical amount. The word 'stoichiometry' is derived from the combination of two Greek words *i.e., stoicheion* (means element) and *metron* (means measure).

Stoichiometry, thus deals with the calculations of masses (sometimes volume) of the reactants and the products involved in a chemical reaction. In this chapter, we will deal with these chemical calculations using the mole concept and stoichiometry to understand molecules and chemical reactions involved.

Chapter Objectives

- Gay-Lussac's Law
- Avogadro's Law
- Mole Concept
- Cell Wall
- Atomicity
- Percentage Composition
- Empirical Formula of a Compound
- Molecular Formula of a Compound
- Stoichiometry and Stoichiometric Calculations

Gay-Lussac's Law

Joseph Lewis Gay-Lussac in 1805, based on his experimental works evaluate a relationship between the combining volumes of gases used and produced under the same conditions of temperature and pressure containing equal number of molecules. According to his law "when gases react, they do so in volumes which bear a simple ratio to one another and to the volume of gaseous product, provided that all the volumes are measured at the same temperature and pressure".

Note This law is useful for gases only. The volume of solid and liquid is considered to be zero while applying this law.

Examples Based on Gay-Lussac's Law

This law explains the formation of the following compounds

(i) **Hydrogen Chloride** One volume of hydrogen combines with one volume of chlorine to give two volumes of hydrogen chloride gas at the same temperature and pressure.

$$H_2 + Cl_2 \longrightarrow 2HCl$$

Ratio $1 : 1 : 2$

(ii) **Ammonia** Two volumes of ammonia are formed when one volume of nitrogen combines with three volumes of hydrogen.

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Ratio $1 : 3 : 2$

(iii) **Formation of Water** Two volumes of steam are formed when two volumes of hydrogen reacts with one volume of oxygen.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Ratio 2 : 1 : 2

Example 1. **What volume of oxygen would be required to burn completely 200 mL of ethylene (C_2H_4) and what would be the volume of carbon dioxide formed?**

$$\underset{1\text{ vol}}{C_2H_4} + \underset{3\text{vol}}{3O_2} \longrightarrow \underset{2\text{vol}}{2CO_2} + \underset{2\text{vol}}{2H_2O}$$

Sol. According to the given equation, 1 volume of ethylene requires 3 volumes of oxygen for complete combustion and to produce 2 volumes of carbon dioxide.

$\therefore$ 200 mL of ethylene will require $= \frac{3}{1} \times 200$ mL of oxygen

$= 600$ mL of oxygen

Now, 3 volumes of oxygen produces 2 volumes of CO_2.

$\therefore$ 600 mL of oxygen produces $= \frac{2 \times 600}{3} = 400$ mL of CO_2

Thus, 600 mL of oxygen is required to produce 400 mL of carbon dioxide.

Hence, 600 mL of oxygen would be required to burn completely 200 mL of ethylene thereby producing 400 mL of carbon dioxide.

CHECK POINT 01

1 Define Gay-Lussac's law.

2 What are the conditions required to measure the volumes of gases in Gay-Lussac's law?

3 Complete the following sentence.
The volumes of solids and liquids are considered to be .....

4 What volume of oxygen would be required to burn completely 100 mL of acetylene (C_2H_2)? ***Ans.*** 250 mL

5 What volume of propane is burnt for every 100 cm^3 of oxygen in the following reaction?

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$ 20 cm^3

Avogadro's Law

Amedeo Avogadro in 1811 made a distinction between atoms and molecules of gaseous elements. It is an experimental law relating volume of a gas to the amount of substance of gas present.

He stated that, "equal volumes of all gases, at the same temperature and pressure, have the same number of molecules".

It can be written as $V \propto n$, or $\frac{V}{n} = K$

where, V = volume of the gas, n = amount of the gas

and K = constant equal to RT/p.

For comparing the same substance under two different set of conditions, *the law is expressed as follows*

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

According to Avogadro, atoms and molecules are defined as follows

An **atom** is the smallest particle of an element that can take part in a chemical reaction, however it may or may not exist independently.

A **molecule** is the smallest particle of an element or compound that has the chemical properties similar to that of element or compound and can exist by itself. Molecules are made up of atoms that are held together by chemical bonds.

Some terms related to Avogadro's law are discussed below

Relative Atomic Mass (RAM) (Atomic Weight)

The relative atomic mass or atomic weight of an element is the number of times, one atom of the element is heavier than $\frac{1}{12}$th times of the mass of an atom of carbon-12 (C-12).

Relative Atomic Mass (RAM)

$$= \frac{\text{Mass of 1 atom of the element}}{\text{1/12th mass of one C-12 atom}}$$

- Atomic mass is expressed in atomic mass unit (amu).
- Atomic mass unit is defined as $\frac{1}{12}$ the mass of carbon atom. ^{12}C is assigned to a mass of exactly 12 atomic mass unit and masses of all other atoms are given relative to this standard.

Note Relative atomic mass can also be defined with respect to hydrogen. It is the number that represents, how many times one atom of an element is heavier than one atom of hydrogen whose weight has been taken as unity.

$$\text{RAM} = \frac{\text{Mass of one atom of an element}}{\text{Mass of one atom of hydrogen taken as unity}}$$

Example 2. **Find the relative atomic mass of oxygen if mass of one atom of oxygen is 15.99u and that of carbon (C - 12) is 12.0 u.**

Sol. Relative atomic mass

$$= \frac{\text{Mass of 1 atom of oxygen}}{\frac{1}{12}\text{th mass of C-12 atom}} = \frac{15.99}{\frac{1}{12} \times 12.0} = 15.99 \text{ u}$$

Fractional Atomic Mass

The fractional atomic mass of any element is the weighted average of the relative atomic masses of its natural isotope. Various naturally occurring elements have more than one

isotope. Thus, the fractional atomic mass of an element is determined by taking into account the existence of these isotope. *e.g.*,

The average relative atomic mass of chlorine

$$= \frac{35 \times 3 + 37 \times 1}{4} = 35.5$$

(^{35}Cl and ^{37}Cl are in the ratio of 3 : 1)

Gram Atomic Mass

The relative atomic mass of an element expressed in grams is known as **gram atomic mass** or **gram atom** of that element. *e.g.*, Gram atomic mass of oxygen is 16, atomic mass of oxygen is 16 u. So, a 16 g sample of oxygen is equal to one gram atom of oxygen.

$$\text{Gram atom} = \frac{\text{Mass in grams}}{\text{Relative atomic mass}}$$

Example 3. **Find the gram atomic mass of 32 g of oxygen atoms, if the relative atomic mass of oxygen is 15.99u .**

Sol. $\text{Gram atomic mass} = \frac{\text{Given mass}}{\text{Relative atomic mass}} = \frac{32}{15.99}$

$$= 2.001 \simeq 2$$

Relative Molecular Mass (RMM) (Molecular Weight)

Relative molecular mass of an element or compound is the number of times, one molecule of the substance is heavier than 1/12 th times of the mass of an atom of C-12.

Relative Molecular Mass (RMM)

$$= \frac{\text{Mass of one molecule of the substance}}{\text{1/12th mass of one atom of carbon, C-12}}$$

RMM is obtained by adding together the relative atomic weight of all the atoms present in a molecule.

e.g., Relative molecular mass of H_2SO_4.

$$= 2 \times 1 + 32 + 4 \times 16 = 98 \text{ u}$$

Molecular mass of H_2SO_4 is 98 u *i.e.*, one molecule of H_2SO_4 is 98 times as heavy as 1/12th mass of carbon, C-12 atom.

Gram Molecular Mass

The relative molecular mass of a substance expressed in grams is called as **gram molecular mass** or **gram molecule** of that element. *e.g.*, Molecular mass of water (H_2O) is 18u and its gram molecular mass is 18.00 g.

$$\text{Gram molecule} = \frac{\text{Mass in grams of substance}}{\text{Relative molecular mass}}$$

Example 4. **How many gram molecular mass are there in 90 g of water if the relative molecular mass of water is 18.00?**

Sol. $\text{Gram molecular mass} = \frac{\text{Given mass}}{\text{Relative molecular mass}} = \frac{90}{18} = 5$

Mole Concept

Wilhelm Ostwald introduced the term mole (in Latin '*mole*' means 'heap') in 1896, which was accepted as unit to represent a large quantity of atoms in 1967.

The mole is the amount of a substance which contains as many particles (atoms/ions/molecules/formula units, etc.) as in 12 g of C-12. Thus, one mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams.

e.g., 1 mole of carbon (C, atomic mass = 12) is equal to 12 g.

1 mole of oxygen (O_2, molecular mass = 2×16) is equal to 32 g.

1 mole of water (H_2O, molecular mass = $2 \times 1 + 1 \times 16$) is equal to 18 g. The number of particles present in 1 mole of any substance is same and fixed, which is equal to 6.022×10^{23}.

This is a constant, known as **Avogadro constant** or **Avogadro number** (N_A) named in honour of the Italian scientist, Amedeo Avogadro. Thus, mole is also defined as number of particles equal to the Avogadro constant, N_A (6.022×10^{23}).1 mole = 6.022×10^{23} particles, in number.

Avogadro's Number

It is defined as the number of atoms present in 12 g of C-12 isotope *i.e.*, 6.022×10^{23} atoms.

or

"It is defined as the number of elementary units *i.e.*, atoms, ions or molecules present in one mole of a substance.

It is denoted by N_A ".

Mole of Atoms (Relating Mole and Atomic Mass)

One mole of atoms contains 6.022×10^{23} atoms having mass equal to its gram atomic mass *e.g.*, One mole of oxygen atoms contains 6.022×10^{23} atoms of oxygen and weighs 16 g.

Mole of Molecules (Relating Mole and Molecular Mass)

One mole contains 6.022×10^{23} molecules and is equivalent to the gram molecular mass of any given substance. *e.g.*, 1 mole of O_2 contains 6.022×10^{23} molecules and weighs 32 g.

Note

- Number of atoms of an element = Number of moles $\times$ 6.022×10^{23}
- Actual mass of 1 atom of an element = $\frac{\text{Gram atomic mass}}{6.022 \times 10^{23}}$
- Actual mass of 1 molecule of a substance = $\frac{\text{Gram molecular mass}}{6.022 \times 10^{23}}$

Example 5. Calculate the weight of (i) one molecule of nitrogen (ii) one atom of oxygen.

Sol. (i) Molecular weight of nitrogen (N_2) = 2×14

$\therefore$ Gram molecular weight of nitrogen = 28g

Now, 6.022×10^{23} molecules of nitrogen = 28g

$\therefore$ Mass of 1 molecule of nitrogen = $\frac{28}{6.022 \times 10^{23}}$

$= 4.65 \times 10^{-23}$ g

(ii) Number of oxygen atoms in 16g of atomic oxygen

$= 6.022 \times 10^{23}$ atoms

$\therefore$ Mass of one atom of oxygen = $\frac{16}{6.022 \times 10^{23}}$

$= 2.657 \times 10^{-23}$ g

Mole Number or Number of Moles

It is equal to a number which states that how many times one gram molecular mass comes in a certain mass of a substance in grams.

Thus, number of moles

$$= \frac{\text{Mass (weight) of the substance in grams}}{\text{Gram molecular mass of the substance}}$$

Gram molecular mass of a gas = Gram molecular volume

$= 22.4 \text{ dm}^3$ at STP

Example 6. Calculate the number of moles in the following.

(i) 7.85 g of iron (ii) 4.68 mg of silicon

(iii) 65.6 µg of carbon

Sol. (i) Moles of iron = $\frac{\text{Mass of iron}}{\text{Atomic mass of iron}} = \frac{7.85}{55.8} = 0.141$ mol

(ii) Moles of silicon = $\frac{\text{Mass of silicon}}{\text{Atomic mass of silicon}}$

$= \frac{4.68 \times 10^{-3}}{28.1}$

$= 1.66 \times 10^{-4}$ mol

(iii) Moles of carbon = $\frac{\text{Mass of carbon}}{\text{Atomic mass of carbon}}$

$= \frac{65.6 \times 10^{-6}}{12} = 5.47 \times 10^{-6}$ mol

Mole and Molar Volume

One mole of any gaseous molecule occupy 22.4 dm^3 (litre) or 22400 cm^3 (mL) at STP. This volume is known as molar volume. The molar volume of a gas can be defined as the volume occupied by one mole of a gas at STP.

Gram molecular volume (Molar volume)

$$= \frac{\text{Gram molecular weight}}{\text{Weight per litre of gas at STP}}$$

Example 7. A cylinder contains 68 g of CO_2 gas at STP, then find the volume occupied by this gas?

Sol. Molecular mass of CO_2 gas = $12 + 2 \times 16 = 44$ g

If 44 g of CO_2 contains 22.4 L at STP

Then, 68 g of CO_2 contains = $\frac{22.4}{44} \times 68 = 34.61$ L

Molar Mass and Moles

The mass of 1 mole of a substance is equal to its relative atomic or molecular mass in gram. The atomic mass of an element gives us the mass of one atom of that element in atomic mass units (u). Thus, to get the mass of 1 mole of an atom of that element we have to take the same numerical value but change the units from 'u' to 'g'.

Molar mass of atoms is also known as **gram atomic mass.** To find the gram molecular mass or molar mass we keep the numerical value same but change the units from 'u' to 'g'.

e.g., we know molecular mass of water (H_2O) is 18 u,
i.e., 18 u water = one mole of water.

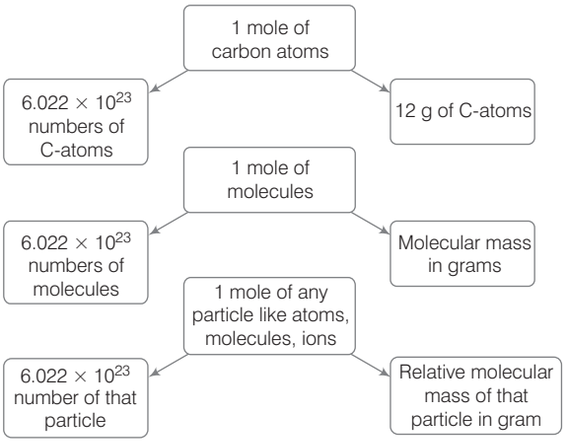
18 g water = one mole of water

$= 6.022 \times 10^{23}$ molecules of water

Number of moles can be calculated directly by using the formula.

(i) Number of moles = $\frac{\text{Given mass}}{\text{Molar mass}}$

(ii) Number of moles = $\frac{\text{Given number of particles (atoms / molecules)}}{\text{Avogadro number}}$



Relationship between mole, Avogadro number and molecular mass

Example 8. Find the mass of
(i) 1 mole of nitrogen atoms
(ii) 8 moles of aluminium atoms
(iii) 0.2 mole of oxygen atoms
(iv) 2 moles of water molecules.

Sol. (i) Mass of 1 mole of nitrogen atoms
= molar mass in gram = 14 g
(ii) We know that,
mass of 1 mole of Al-atoms = 27 g
∴ Mass of 8 moles of Al-atoms = 8 × 27 = 216 g
(iii) Mass of 0.2 mole of oxygen atoms = 0.2 × 16 = 3.2 g
(mass of 1 mole of oxygen atoms = 16 g)
(iv) Mass of 2 moles of water molecules = 2 × 18 = 36 g
(mass of 1 mole of water molecule = 18 g)

Example 9. Find the number of moles of
(i) 48 g of oxygen gas (ii) 18 g of H_2O molecules
(iii) 22 g of CO_2 gas (iv) 51 g of NH_3 gas.

Sol. (i) Molecular weight of O_2 = 2 × 16 = 32 u
i.e., mass of 1 mole of O_2 = 32 g
∵ 32 g of O_2 = 1 mol
∴ 48 g of O_2 = (1 × 48)/32 = 3/2 = 1.5 mol
or Number of moles = $\frac{\text{Given mass}}{\text{Molar mass}} = \frac{48}{32} = 1.5$ mol

(ii) Molar mass of H_2O = 2 × 1 + 16 = 18 g/mol
∴ 18 g of H_2O = 1 mol
or Number of moles = $\frac{\text{Given mass}}{\text{Molar mass}} = \frac{18}{18} = 1$ mol

(iii) Molar mass of CO_2 = 12 + 2 × 16 = 44 g/mol
∵ 44 g of CO_2 = 1 mol
∴ 22 g of $CO_2 = \frac{1}{44} \times 22 = 0.5$ mol
or Number of moles = $\frac{\text{Given mass}}{\text{Molar mass}} = \frac{22}{44} = 0.5$ mol

(iv) Molar mass of NH_3 = 14 + 3 × 1 = 17 g/mol
∵ 17 g of NH_3 = 1 mol
∴ 51 g of $NH_3 = \frac{1}{17} \times 51 = 3$ mol
or Number of moles = $\frac{\text{Given mass}}{\text{Molar mass}} = \frac{51}{17} = 3$ mol

CHECK POINT 02

1. Write the mathematical relation of Avogadro's law for a substance under two different set of conditions.
2. Complete the following sentence.
An …… is the smallest particle of an element that can take part in a chemical reaction.
3. What is the difference between relative atomic mass and relative molecular mass of oxygen?
4. If 22 g of CO_2 occupy *V* litre at STP then what volume would 32 g of O_2 occupy at STP? Justify your answer.
5. Which one is heavier, 1 mole of CO_2 or 1 mole of CO?

Atomicity

It is defined as the number of atoms present in a molecule of an element or substance.

(a) **Monoatomic molecule** These consist of only one atom. *e.g.,* He, Ne, Ar, etc.

(b) **Diatomic molecule** These consist of two similar atoms. *e.g.,* H_2, O_2, Cl_2, N_2, etc.

(c) **Triatomic molecule** These consist of three similar atoms. *e.g.,* O_3.

Atomicity can be determined using Avogadro's law which is shown in the given examples.

(i) Atomicity of molecule of hydrogen and chlorine gases.

$$H_2 + Cl_2 \longrightarrow 2HCl$$

Using Avogadro's law, 1 molecule of hydrogen combines with 1 molecule of hydrogen to give 2 molecule of hydrogen chloride. So, one molecule of hydrogen and chlorine contains two atoms each.

(ii) Atomicity of nitrogen and oxygen

$$N_2 + O_2 \longrightarrow 2NO$$

1 molecule of nitrogen combines with 1 molecule of oxygen to give 2 molecule of nitric oxide. So, one molecule of nitrogen and oxygen contain two atoms each.

Relation between Relative Molecular Mass and Vapour Density

Relative molecular mass

$$= \frac{\text{Mass of 1 molecule of a substance}}{\text{Mass of 1 atom of hydrogen}}$$

Relative vapour density is the ratio of a certain mass of a gas or vapour to the mass of same volume of hydrogen, at the same temperature and pressure. Applying Avogadro's law to the formula of vapour density,

$$\text{Vapour density} = \frac{\text{Mass of 1 molecule of a gas or vapour}}{\text{Mass of 1 molecule of hydrogen}}$$

$$\text{or Vapour density} = \frac{\text{Mass of 1 molecule of substance(gas)}}{\text{Mass of 2 atoms of hydrogen}}$$

∴ Relative molecular mass = 2 × vapour density

Thus, the relative molecular mass of a gas or vapour is twice its vapour density.

Example 10. Calculate the vapour density of ammonia.

Sol. The molecular weight of ammonia (NH_3)
= 14 + 1 + 1 + 1 = 17

$$\text{Vapour density} = \frac{\text{Relative molecular mass}}{2} = \frac{17}{2} = 8.5$$

Explanation of Gay-Lussac's Law by Avogadro's Law

According to Avogadro's law, equal volume of all gases, at the same temperature and pressure, have the same number of molecules.

As elements or substances react in simple ratio by number of molecules, volumes of reactant and products in gaseous phase will also bear a simple whole number ratio to our another, which is stated by Gay-Lussac's law.

H_2	+	Cl_2	$\longrightarrow$	$2HCl$	
1 vol		1 vol		2 vol	(by Gay-Lussac's law)
n		n		$2n$	(by Avogadro's law)
molecules		molecules		molecules	

CHECK POINT 03

1. Calculate the mass of one atom of oxygen. ***Ans.*** 2.657×10^{-23} g
2. What is the mass (in grams) of 2.5 moles of slaked lime, $Ca(OH)_2$? 111g
3. Identify the atomicity of the following elements; Fe, Al_3, P_5, O_3.
4. The vapour density of CO_2 gas is 22. Find its molecular mass.
5. Taking the example of combustion of hydrogen, as represented below, show how Avogadro's law explain Gay-Lussac's Law.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

Percentage Composition

The percentage composition of an element in a compound is the percentage of the mass contributed by the element to the total mass of the compound. It is obtained by dividing mass of that element in the compound by the total mass of the compound and multiplying by 100 *i.e.*,

Percentage composition of element

$$= \frac{\text{Mass contributed by the element}}{\text{Total molar mass of compound}} \times 100$$

Example 11. Calculate the mass percent of each element of water.

Sol. Molar mass of H_2O $= 2\times$ atomic mass of $H + 1\times$ atomic mass of O

$= 2\times 1.01 + 1\times 16.00 = 18.02$ g

$$\text{Mass \% of hydrogen} = \frac{2\times 1.008}{18.02}\times 100 = 11.18\%$$

$$\text{Mass \% of oxygen} = \frac{16.00}{18.02}\times 100 = 88.79\%$$

Empirical Formula of a Compound

It is the simplest formula, which shows the simplest whole number ratio between the atoms of the elements in the compound. The empirical formula of a compound represents only the atomic ratio of the various elements present in its molecule.

Compound	Molecular Formula	Whole Numbers	Simplest Ratio of Empirical Formula
Glucose	$C_6H_{12}O_6$	1 : 2 : 1	CH_2O
Benzene	C_6H_6	1 : 1	CH

Determination of Empirical Formula From the Percentage Composition

Step I Write down the percentage composition and the atomic weight of each element present in the given compound.

Step II Divide the percentage (%) composition of each element by its atomic weight. The ratio gives the number of atoms in a molecule of the compound.

Step III (a) Select the smallest ratio among the relative number of atoms and divide the remaining ratios by it to give the simplest ratio of atoms present in the compound.

(b) If the simplest ratio is not a whole number multiply each ratio by the smallest suitable integer so that a whole number ratio is obtained.

(c) Empirical formula is now derived by writing the symbols of various elements with the number of atoms of each one as the subscript.

In the tabular form empirical formula can be calculated as

Element	% Composition	Atomic Weight	Relative Number of Atoms	Simplest Ratio

Example 12. Find the empirical formulae of the compounds with the following percentage compositions,

(i) Zn = 47.8 (ii) Cl = 52.2

Sol.

Element	Percentage Composition	Atomic Weight	Atomic Ratio	Simplest Ratio
Zn	47.8	65	$\frac{47.8}{65} = 0.73$	$\frac{0.73}{0.73} = 1$
Cl	52.2	35.5	$\frac{52.2}{35.5} = 1.46$	$\frac{1.46}{0.73} = 2$

Thus, the ratio of Zn : Cl atoms = 1 : 2. The empirical formula of the compound is $ZnCl_2$.

Example 13 Determine the empirical formula of a compound of sodium, sulphur and oxygen having the percentage composition, Na = 29.11%, S = 40.51% and O = 30.38% (Na = 23 and S = 32 and O = 16).

Sol.

Element	%Composition	Atomic Weight	Relative Number of Atoms	Simplest Ratio
Sodium (Na)	29.11	23	$\frac{29.11}{23} = 1.266$	$\frac{1.266}{1.266} = 1 \times 2 = 2$
Sulphur (S)	40.51	32	$\frac{40.51}{32} = 1.266$	$\frac{1.266}{1.266} = 1 \times 2 = 2$
Oxygen (O)	30.38	16	$\frac{30.38}{16} = 1.898$	$\frac{1.898}{1.266} = 1.5 \times 2 = 3$

∴ The empirical formula of the compound is $Na_2S_2O_3$.

Molecular Formula of a Compound

It is defined as the chemical formula which shows the exact number of different types of atoms present in a molecule of a compound. *e.g.*,

Compound	Molecular Formula	Actual Number of Atoms Present in a Compound
Glucose	$C_6H_{12}O_6$	6 atoms of carbon, 12 atoms of hydrogen, 6 atoms of oxygen
Sulphuric acid	H_2SO_4	2 atoms of hydrogen, 1 atom of sulphur, 4 atoms of oxygen

Determination of the Molecular Formula of a Compound

Step I Determine the empirical formula as already described.

Step II Calculate the empirical formula mass by adding the atomic masses of the atoms in the empirical formula.

Step III Determine the molecular mass by suitable method.

Step IV Determine the value of n as

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

Change n to the nearest whole number.

Step V Multiply empirical formula by n to get the molecular formula.

Molecular formula = $n \times$ Empirical formula.

Example 14. Determine the molecular formula of a compound having the percentage composition, C = 26.59%, H = 2.22% and O = 71.19%. Vapour density of the compound is 45(C = 12, H = 1 and O = 16).

Sol. Calculate the empirical formula (as used in the example –12).

The empirical formula was found to be CHO_2

∴ Empirical formula weight = 12 + 1 + 16 × 2 = 45

[C] [H] [2(O)]

As, the vapour density = 45 (given)

∴ Molecular weight = 2 × Vapour density = 2 × 45 = 90

Molecular weight = $n \times$ Empirical formula weight

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{90}{45} = 2$$

Molecular formula = (Empirical formula)$_n$ *i.e.,* $[CHO_2]_2$

Hence, molecular formula = $C_2H_2O_4$

CHECK POINT 04

1 In ammonia (NH_3) there are three hydrogen atoms and one nitrogen atom but still the percentage composition of nitrogen is higher. Discuss.

2 Write the empirical formulae for the following molecular formulae.
(a) $C_6H_{12}O_6$ (b) C_4H_{10} (c) N_2H_4 (d) C_6H_6

3 Write any two examples of compounds which have same molecular and empirical formulae.

4 When empirical formula of a compound is C_2H_4O and its molecular weight is 88, then find out its molecular formula.

5 An organic compound contains oxygen, 26.24% and hydrogen, 4.92%. Find its empirical formula.

Empirical formula is $C_7H_6O_2$

Stoichiometry and Stoichiometric Calculations

Stoichiometry deals with the calculation of masses (sometimes volumes also) of the reactants and products involved in a chemical reaction or in other words, the relationship between the amounts of reactants and products is called the stoichiometry.

The number before the formula unit or molecules used to balance the equations are called stoichiometric coefficients. These shows the number of moles/molecules of that particular substance. Calculations based on chemical equations are termed as stoichiometric calculations.

Algorithm for Stoichiometric Calculations

Step I Write the balanced chemical equations.

Step II Write the stoichiometric coefficient that shows the moles of the respective substance.

Step III Convert moles into required quantity.

Step IV Write the given data.

Step V Calculate the required information by unitary method.

These are the general steps involved in all types of stroichiometric calculations. These calculations are of following types

(a) Calculations Involving Mass-Mass Relationship

In such problems, the mass of one of the reactant/product is to be calculated, if we have the mass of others.

Example 15. Calculate the amount of water (*g*) produced by the combustion of 16 g of methane.

Sol. *Solution of such problems involve following steps*

***Step* I** Write the balanced chemical equation.

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

***Step* II** Write the Stoichiometric coefficients of each substance. These represent mole of that particular substance.

$$\underset{1\text{ mol}}{CH_4(g)} + \underset{2\text{ mol}}{2O_2(g)} \longrightarrow \underset{1\text{ mol}}{CO_2(g)} + \underset{2\text{ mol}}{2H_2O(s)}$$

***Step* III** Convert moles into mass by multiplying them with molar mass.

$$\underset{1\text{ mol}\ =16\text{ g}}{CH_4(g)} + \underset{2\times32\ =64\text{ g}}{2O_2(g)} \longrightarrow \underset{1\times44\ =44\text{ g}}{CO_2(g)} + \underset{2\times18\ =36\text{ g}}{2H_2O(g)}$$

***Step* IV** Write the given mass under the respective substance.

$$\underset{16\text{ g}}{CH_4(g)} + \underset{64\text{ g}}{2O_2(g)} \longrightarrow \underset{44\text{ g}}{CO_2(g)} + \underset{36\text{ g}}{2H_2O(g)}$$

***Step* V** Calculate the mass of unknown substance by unitary method.

From the equation, it is already clear that 16 g of methane produces 36 g of water.

(b) Calculations Involving Mass-Mole or Mole-Mass Relationship

In such problems, the mass or mole of one of the reactant/product is to be calculated, if we have the mole or mass of others.

Example 16. Oxygen is prepared by the catalytic decomposition of potassium chlorate ($KClO_3$). Decomposition of potassium chlorate gives potassium chloride (KCl) and oxygen (O_2). If 2.4 moles of oxygen is needed for an experiment, how many grams of potassium chlorate must be decomposed?

Sol. The balanced equation is

$$\underset{2\text{ mol}}{2KClO_3(s)} \longrightarrow 2KCl(s) + \underset{3\text{ mol}}{3O_2(g)}$$

$$2\times(39+35.5+3\times16)=245\text{ g} \qquad ? \qquad 2.4\text{ moles}$$

$\because$ 3 moles of O_2 is produced by decomposition of $KClO_3 = 245$ g

$\because$ 2.4 moles of O_2 will be produced by the decomposition of

$$KClO_3 = \frac{245\times2.4}{3} = 196.0\text{ g}$$

Example 17. How many moles of methane are required to produce 22 g $CO_2(g)$ after combustion?

Sol. According to the chemical equation,

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

44 g $CO_2(g)$ is obtained from 16 g $CH_4(g)$.

[$\because$ 1 mol CO_2 (g) is obtained from 1 mol of CH_4 (g)]

$$\text{Moles of } CO_2(g) = 22\text{g } CO_2(g) \times \frac{1\text{ mol } CO_2(g)}{44\text{g } CO_2(g)}$$

$$= 0.5\text{ mol } CO_2\ (g)$$

Hence, 0.5 mol $CO_2(g)$ would be obtained from 0.5 mol $CH_4(g)$ or 0.5 mol of CH_4 (g) would be required to produce 22 g CO_2 (g).

(c) Calculations Involving Mass-Volume Relationship

In these problems, mass or volume of one of the reactants or products is calculated from the mass or volume of other substances.

Example 18. Calculate the amount of $KClO_3$ needed to supply sufficient oxygen for burning 112 L of CO gas at NTP.

Sol. Calculation of O_2 gas required to burn 112 L of CO.

$$\underset{1\text{ mol}\ =22.4\text{L}}{CO} + \underset{0.5\text{ mol}}{\frac{1}{2}O_2} \longrightarrow \underset{1\text{ mol}}{CO_2}$$

22.4 L of CO at NTP require O_2 = 0.5 mol

112 L of CO at NTP will require

$$O_2 = \frac{0.5}{22.4}\times112 = 2.5\text{ mol}$$

This O_2 is to be obtained by heating $KClO_3$.

$$\underset{2\text{ mol}}{2KClO_3} \longrightarrow 2KCl + \underset{3\text{ mol}}{3O_2}$$

$$2(39+35.5+3\times16)=245\text{ g}$$

3 moles of O_2 are produced from $KClO_3$ = 245 g

2.5 moles of O_2 will be produced from $KClO_3$

$$= \frac{245\times2.5}{3} = 204.167\text{ g}$$

Example 19. Hydrogen gas is prepared in the laboratory by reacting dilute HCl with granulated zinc. Following reaction takes place.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

Calculate the volume of hydrogen gas liberated at STP when 32.65 g of zinc reacts with HCl. 1 mole of a gas occupies 22.7 L volume at STP; atomic mass of Zn = 65.3u.

Sol. Given, mass of Zn = 32.65 g

1mole of gas occupies = 22.7 Lvolume at STP

Atomic mass of Zn = 65.3 u

The given equation is

$$\underset{65.3\text{ g}}{Zn} + 2HCl \longrightarrow ZnCl_2 + \underset{1\text{ mol} = 22.7\text{ L at STP}}{H_2}$$

From the above equation, it is clear that

65.3 g Zn, when reacts with HCl, produces

= 22.7 L of H_2 at STP

$\therefore$ 32.65 g Zn, when reacts with HCl, will produce

$$= \frac{22.7 \times 32.65}{65.3} = 11.35 \text{ L of } H_2 \text{ at STP}$$

(d) Calculations Involving Volume-Volume Relationship

In these problems, the volume of one of the reactant/product is given and that of the other is to be calculated.

Example 20. What volume of oxygen at STP is required to effect complete combustion of 200 cm^3 of acetylene and what would be the volume of carbon dioxide formed?

Sol. The balanced chemical equation is

$$\underset{2\text{ mol}}{2\,C_2H_2} + \underset{5\text{ mol}}{5\,O_2} \longrightarrow 4\,CO_2 + \underset{4\text{ mol}}{2\,H_2O}$$

$$2 \times 22400\ cm^3 \quad 5 \times 22400\ cm^3 \quad 4 \times 22400\ cm^3$$

$\because 2 \times 22400\ cm^3$ of acetylene require O_2 for complete combustion = $5 \times 22400\ cm^3$

200 cm^3 of acetylene will require O_2 for complete combustion = $\frac{5 \times 22400}{2 \times 22400} \times 200 = 500\ cm^2$ at STP

Further $2 \times 22400\ cm^3$ of acetylene produce CO_2

$= 4 \times 22400\ cm^3$

$\therefore$ 200 cm^3 of acetylene will produce CO_2

$$= \frac{4 \times 22400}{2 \times 22400} \times 200 = 400\ cm^3 \text{ at STP}$$

Limiting and Excess Reagents

The reactant which is present in the lesser amount and gets consumed after sometime *i.e.,* which limits the amount of product formed is called the **limiting reagent**.

The reactant other than the limiting reagent, which is in somewhat excess is called the **excess reagent.** The remaining amount of excess reagent is calculated by subtracting the available amount of limiting reagent from the amount of the excess reagent. Remember that in stoichiometric calculations, it is very important to choose the limiting reagent as it decides the amount of the product obtained.

Example 21. 50.0 kg of $N_2(g)$ and 10.0 kg of $H_2(g)$ are mixed to produce $NH_3(g)$. Calculate the $NH_3(g)$ formed. Identify the limiting reagent in the production of NH_3 in this situation.

Sol. ***Step*** **I** A balanced equation for the above reaction is written as follows.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Step **II** Calculation of moles.

$$\text{Moles of } N_2 = 50.0\text{kg}N_2 \times \frac{1000\text{ g } N_2}{1\text{ kg } N_2} \times \frac{1\text{ mol } N_2}{28.0\text{g } N_2}$$

$$= 17.86 \times 10^2 \text{ mol}$$

$$\text{Moles of } H_2 = 10.00\text{ kg } H_2 \times \frac{1000\text{ g } H_2}{1\text{ kg } H_2} \times \frac{1\text{mol } H_2}{2.016\text{ g } H_2}$$

$$= 4.96 \times 10^3 \text{ mol}$$

Step **III** Then, find out the limiting reagent.

$$17.86 \times 10^2 \text{ mol } N_2 \times \frac{3\text{mol } H_2\ (g)}{1\text{ mol } N_2\ (g)}$$

$$= 5.36 \times 10^3 \text{ mol } H_2$$

But we have only 4.96×10^3 mol H_2. Hence, dihydrogen is the limiting reagent in this case. So, NH_3 (g) would be formed only from that amount of available dihydrogen *i.e.,* 4.96×10^3 mol.

Step **IV** After that, find out the amount of ammonia.

Since, 3 mol $H_2(g)$ gives 2 mol NH_3 (g)

$$4.96 \times 10^3 \text{ mol } H_2\ (g) \times \frac{2\text{mol } NH_3\ (g)}{3\text{ mol } H_2\ (g)}$$

$$= 3.30 \times 10^3 \text{ mol } NH_3\ (g)$$

3.30×10^3 mol $NH_3(g)$ is obtained from 4.96×10^3 mol $H_2(g)$.

If they are to be converted to grams, it is done as follows

$$1 \text{ mol } NH_3(g) = 17.0g\,NH_3(g)\ 3.30 \times 10^3 \text{ mol}$$

$$NH_3\ (g) \times \frac{17.0\text{ g } NH_3\ (g)}{1\text{ mol } NH_3\ (g)}$$

$$3.30 \times 10^3 \times 17\text{g } NH_3\ (g) = 56.1 \times 10^3 \text{ g } NH_3$$

$$= 56.1\text{kg } NH_3$$

Example 22. In a reaction, $A + B_2 \longrightarrow AB_2$ identify the limiting reagent, if any in the following reaction mixtures.

(i) 300 atoms of A + 200 molecules of B

(ii) 2 moles of A + 3 moles of B

(iii) 100 atoms of A + 100 molecules of B

(iv) 5 moles of A + 2.5 moles of B

(v) 2.5 moles of A + 5 moles of B

Sol. The given equation shows that 1 mole of A reacts with 1 mole of B_2 and 1 atom of A reacts with 1 molecule of B_2.

(i) B is the limiting reagent because 200 molecules of B_2 will react with 200 atoms of A and 100 atoms of A will be left in excess.

(ii) A is the limiting reagent because 2 moles of A will react with 2 moles of B and 1 mole of B will be left in excess.

(iii) Both will react completely because it is stoichiometric mixture. No limiting reagent.

(iv) 2.5 moles of B will react with 2.5 moles of A, hence B is the limiting reagent.

(v) 2.5 moles of A will react with 2.5 moles of B. Hence, A is the limiting reagent.

CHECK POINT 05

1 Define stoichiometry.

2 What do you understand by stoichiometric coefficients in a chemical equation?

3 What are limiting reagents?

4 Calculate the amount of carbon dioxide that could be produced when

(a) 1 mole of carbon is burnt in air. 44 g

(b) 1 mole of carbon is burnt in 16 g of dioxygen. 22 g

(c) 2 moles of carbon are burnt in 16 g of dioxygen. 22 g

SUMMARY

- Gay-Lussac's law states that, when gases react, they do so in volumes which bear a simple ratio to one another and to the volume of the gaseous product, provided that all the volumes are measured at the same temperature and pressure.
- Avogadro's law Volume $(V) \propto n$ (amount of gas) [at constant temperature and pressure]
- Atomic weight or atomic mass, $A = \dfrac{\text{Weight of one atom of an element}}{\frac{1}{12}\text{th part by weight of an atom of C-12 isotope}}$
- Atomic mass is expressed in atomic mass unit (amu or u).

  u = mass exactly equal to the $\frac{1}{12}$ of the weight of an atom of C-12 isotope.

  $1\text{u} = \frac{1}{N_A}\text{ g} = 1.66 \times 10^{-24}\text{ g}$
- C-12 is choosen as standard because in such case, the masses of most of the elements are whole number or nearest to the whole number.
- Atomic mass of an element expressed in gram is called its gram atomic mass.
- The sum of atomic masses of the elements present in a molecule is called its molecular mass.
- The relative molecular masses of the elements expressed in grams is called as gram molecular mass.
- Mole concept

  (i) 1 mole of particles = 6.023×10^{23} particles

  1 mole = 22.4 L (for gases)

  (ii) Number of atoms of an element = Number of moles $\times 6.022 \times 10^{23}$

  (iii) Actual mass of 1 atom of an element = $\dfrac{\text{Gram atomic mass}}{6.022 \times 10^{23}}$

  (iv) Actual mass of 1 molecule of a substance = $\dfrac{\text{Gram molecular mass}}{6.022 \times 10^{23}}$

  (v) Number of moles = $\dfrac{\text{Mass}}{\text{Atomic or molar mass}}$
- Atomicity is the number of atoms present in one molecule of an element.
- The relative vapour density is the ratio between the masses of equal volumes of gas or vapour and hydrogen under the same conditions of temperature and pressure.
- Percentage or mass % of an element = $\dfrac{\text{Mass of that element in the compound}}{\text{Molar mass of the compound}} \times 100$
- Empirical formula of a chemical compound is the simplest positive integer ratio of atoms present in a compound.
- Formula showing exact number of atoms, present in a molecules is called molecular formula.
- Molecular formula = $n \times$ Empirical formula.
- Values (number of moles) used for calculation based on balanced chemical equations are called stoichiometric calculations.

EXAM PRACTICE

Fill in the Blanks

1. Law of …… volumes of gas, states that when gases react together to form other gases, all …… are measured at the …… temperature and pressure.

Sol. Combining, volumes, same

2. …… is defined as the amount of substance which contains same number of units as the number of atoms in 12 g of carbon-12.

Sol. Mole

3. 1 mole of He = ……g of helium.

Sol. 4

4. 1 mole = ... L at STP if substance is a gas.

Sol. 22.4

5. A formula which shows the simplest whole number ratio is …… .

Sol. Empirical formula

6. A formula of a chemical substance which tells the actual number of atoms in one molecule of a substance is …… .

Sol. molecular formula

7. Complete the following, $n = \frac{\text{Molecular mass}}{\text{_____}}$

Sol. Empirical formula mass

8. Fill in the blanks in the given steps which should be followed to find the molecular formula.

(i) Calculate the ..... of the compound from its empirical formula.

(ii) Divide its ..... by empirical weight which gives the number (n).

(iii) ..... the empirical formula by this number to get the molecular formula.

Sol. (i) empirical weight

(ii) molecular weight

(iii) Multiply

9. CH_2O is an ..... for the molecular formula, $C_6H_{12}O_6$.

Sol. empirical formula

Multiple Choice Questions

10. The application of Gay-Lussac's law is applicable

(a) only to solids (b) only to liquids

(c) to both liquids and gases (d) only to gases

Sol. (d)

11. The volume occupied by 1 mole of gas at STP is

(a) 2.24 L (b) 22.4 L

(c) 2.42 L (d) 2.44 L

Sol. (b)

12. One atomic mass unit is how much part the mass of C-12 atoms?

(a) $\frac{1}{4}$ (b) $\frac{1}{12}$

(c) $\frac{1}{8}$ (d) $\frac{1}{16}$

Sol. (b)

13. A gas cylinder of capacity of 20 dm^3 is filled with a gas X, the mass of which is 10 g. When the same cylinder is filled with hydrogen gas at the same temperature and pressure the mass of the hydrogen is 2 g, hence the relative molecular mass of the gas is ***[2009]***

(a) 5 (b) 10

(c) 15 (d) 20

Sol. (b)

14. The element which has two atoms in its molecule is

(a) phosphorus (b) oxygen

(c) ozone (d) helium

Sol. (b) O_2 (oxygen)

15. The vapour density of carbon dioxide (C = 12 and O = 16) is ***[2012]***

(a) 32 (b) 16

(c) 44 (d) 22

Sol. (d)

16. Percentage of calcium in calcium carbonate ($CaCO_3$) is

(a) 40 (b) 30

(c) 48 (d) 36

Sol. (a)

17. The empirical formula of butane is

(a) C_2H_{15} (b) C_2H_5

(c) C_4H_{12} (d) C_3H_8

Sol. (b)

18. What will be the empirical formula of CH_3COOH?

(a) CHO_2 (b) C_2HO

(c) CH_2O (d) $C_2H_2O_2$

Sol. (c)

19. The '*n*' of CBr_3 molecule is 2. Then, what is the molecular formula?

(a) C_3Br_8 (b) C_3Br_9

(c) C_2Br_6 (d) C_2Br_5

Sol. (c)

20. If the empirical formula of an organic compound is CH_2O, then its molecular formula can be

(a) $C_2H_2O_2$ (b) C_2H_4O

(c) C_3H_6O (d) $C_6H_{12}O_6$

Sol. (d)

21. The ratio between the number of molecules in 2g of hydrogen and 32g of oxygen is *[2016]*

(a) 1:2 (b) 1:0.01 (c) 1:1 (d) 0.01:1

Sol. (c)

	H_2	:	O_2
Molecular mass	2g		32g

(Given, mass are in the ratio of 2g : 32 g)

∴ Ratio of number of molecules is 1 : 1.

22. How many moles of oxygen are produced by the decomposition of six moles of potassium chlorate?

$$2KClO_3 \longrightarrow 2KCl + 3O_2 \uparrow$$

(a) 3 moles (b) 6 moles

(c) 9 moles (d) 12 moles

Sol. (c)

Match the Following

23. Match the following columns.

	Column I (Equations)		Column II (Ratios)
(i)	$H_2 + Cl_2 \longrightarrow 2HCl$	(a)	1 : 3 : 2
(ii)	$N_2 + 3H_2 \longrightarrow 2NH_3$	(b)	2 : 1 : 2
(iii)	$2H_2 + O_2 \longrightarrow 2H_2O$	(c)	1 : 1 : 2

Sol. (i) – (c), (ii) – (a), (iii) – (b)

24. Match the following columns.

	Column I		Column II
(i)	Gay-Lussac's law	(a)	Hydrogen
(ii)	Avogadro's law	(b)	Volume-molecule relationship
(iii)	Molar volume	(c)	22.4 dm^3
(iv)	Empirical formula	(d)	Simplest ratio
(v)	Diatomic	(e)	Combining volumes of gases

Sol. (i)–(e), (ii)–(b), (iii)–(c), (iv)–(d), (v)–(a)

25. Match the following columns.

	Column I (Molecular formula)		Column II (Empirical formula)
(i)	C_6H_6	(a)	BH_2
(ii)	$C_{10}H_{20}Fe_2$	(b)	CH
(iii)	B_6H_{12}	(c)	NO_2
(iv)	N_2O_4	(d)	BH_3
(v)	B_2H_6	(e)	$C_5H_{10}Fe$

Sol. (i)–(b), (ii)–(e), (iii)–(a), (iv)–(c), (v)–(d)

a 1 Mark Questions

26. Define Avogadro's law. *[2014]*

Sol. Avogadro's law states that equal volumes of all gases, at the same temperature and pressure, have the same number of molecules.

$$V \propto n$$

$$\therefore \quad V/n = K$$

27. In which year Avogadro made a distinction between atoms and molecules?

Sol. In 1811, Avogadro made a distinction between atoms and molecules.

28. Give one word for the following statement.
Mass of 1 atom of the element to the 1/12 th the mass of an atom of carbon-12.

Sol. Relative atomic mass.

29. Atomic weight of many elements is fractional why?

Sol. The atomic weight of the elements is fractional because the atomic weight of an element is the average relative weight of all naturally occurring isotopes of the given element.

30. Define 1 mole.

Sol. It is defined as the amount of a substance that contains as many particles as there are atoms in exactly 12 g of ^{12}C isotope.

31. Define moles of atoms.

Sol. "One mole of atoms contains 6.022×10^{23} atoms having mass equal to its atomic mass".

32. A vessel contains X number of molecules of hydrogen gas at a certain temperature and pressure. How many molecules of nitrogen gas would be present in the same vessel under the same conditions of temperature and pressure?

Sol. X number of molecules of nitrogen gas. According to Avogadro's law, equal volume of gases contain equal number of molecules under similar conditions of temperature and pressure.

33. "When stating the volume of a gas, the pressure and temperature should also be given," why?

Sol. It is because, the volume of a gas changes, if the pressure or temperature or both changes. Thus, while stating the volume of a gas, pressure and temperature has to be specified along with the volume.

34. Define atomicity.

Sol. The number of atoms present in one molecule of an element is called atomicity.

35. Give one word or phrase for the following. The ratio of the mass of a certain volume of a gas to the mass of an equal volume of hydrogen under the same conditions of temperature and pressure.

Sol. Vapour density

b 2 Marks Questions

36. (a) What do you understand by Avogadro's number?
(b) Write the symbol which is used to denote it.

Sol. Refer to text on page 89.

37. What are the applications of Avogadro's law?

Sol. (i) It determines the molecular formula of a gas.
(ii) It determines atomicity of gases.
(iii) It explains Gay-Lussac's law of combining volumes.
(iv) It establishes the relation between molecular weight and vapour density of a gas. ***[1/2 × 4 = 2]***

38. How does Avogadro's law explain Gay-Lussac's law of gaseous volumes?

Sol. According to Avogadro's law, equal volumes of all gases under similar condition of temperature and pressure contain equal number of molecules. Since, substances or elements riact in simple ratio by number of molecules, volumes of reactant and products in gascous phase will also bear a simple whole number ratio to one another, which is stated by gay luccac's law. ***[2]***

c 3 Marks Questions

39. How can one distinguish between mole of atoms and mole of molecules?

Sol. Refer to text on pages 90 and 91.

40. The volume of gases A, B, C and D are in the ratio, 1: 2 : 2 : 4 under the same conditions of temperature and pressure.
(i) Which sample of gas contains the maximum number of molecules?
(ii) If the temperature and the pressure of gas A are kept constant, then what will happen to the volume of A when the number of molecules is doubled?
(iii) If this ratio of gas volume refers to the reactants and products of a reaction, which gas law is being observed?

Sol. (i) Sample of gas D contains the maximum number of molecules. ***[1]***
(ii) When the number of molecules is doubled, then the volume of the gas A will also get doubled. ***[1]***
(iii) Gay-Lussac's law of combining volumes. ***[1]***

d 4 Marks Question

41. Define the following terms.
(a) Relative atomic mass (RAM)
(b) Fractional atomic mass
(c) Relative molecular mass (RMM)
(d) Gram molecular mass

Sol. Refer to text on pages 89 and 90.

e 5 Marks Questions

42. Calcium carbondate reacts with aqueous HCl to give $CaCl_2$ and CO_2 aceording to the reaction given below

$$CaCO_3(s) + 2HCl(eq) \longrightarrow CaCl_2(ag) + CO_2(g) + H_2O(l)$$

What mass of $CaCl_2$ will be formed when 250 ml of 0.76 M HCl reacts with 1000 g of $CaCO_3$? Name the limiting reagest. Calculate the number of moles of $CaCl_2$ formed in the reaction.

Sol. Number of moles of HCl

$$= 250\text{ mL} \times \frac{0.7\text{ M}}{1000} = 0.19\text{ mol}$$

$$\text{Number of moles of } CaCO_3 = \frac{1000\text{g}}{100\text{g mol}^{-1}} = 10\text{ mol} \quad \textit{[2]}$$

For the 10 moles of $CaCO_3$ (s) number of HCl required would be $10 \times \frac{2}{1} = 20$ mol HCl (aq) *[1]*

But we have only 0.19 mole HCl (aq), hence HCl (aq) is the limiting reagent. Since 2 moles HCl (aq) forms 1 mole of $CaCl_2$ therefore 0.19 moles of HCl (aq) would give $= 0.19 \times \frac{1}{2} = 0.095$ mol *[1]*

$$\text{Mass of } CaCl_2 = 0.095 \times 111 = 10.54\,(g) \quad \textit{[1]}$$

Numerical Type Questions

43. If 6 L of hydrogen and 4 L of chlorine are mixed and exploded and if water is added to the gases formed, find the volume of the residual gas. *[2015]*

Sol. $H_2 + Cl_2 \longrightarrow 2HCl$

4 L of Cl_2 will need only 4 L of H_2.

6 L of H_2 is mixed with 4 L of Cl_2.

$\therefore (6 - 4 =)$ 2 L of H_2 will remain unreacted. *[1]*

44. Calcium carbide is used for the artificial ripening of fruits. Actually the fruit ripens because of the heat evolved while calcium carbide reacts with moisture. During this reaction, calcium hydroxide and acetylene gas formed. If 200 cm^3 of acetylene is formed from a certain mass of calcium carbide, find the volume of oxygen required and carbon dioxide formed during the complete combustion. The combustion reaction can be represented as below: *[2009]*

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

Sol. $2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$

2 volumes 5 volumes 4 volumes

By Gay-Lussac's law,

$\because$ 2 volumes of acetylene requires 5 volumes of oxygen

$\therefore$ 200 cm^3 of acetylene requires $= \frac{5}{2} \times 200 = 500\,cm^3$ of oxygen

$\because$ 2 volumes of acetylene gives 4 volumes of CO_2

$\therefore$ 200 cm^3 of acetylene gives $= \frac{4}{2} \times 200$

$= 400\,cm^3$ of CO_2 *[2]*

45. A gas cylinder can hold 1kg of hydrogen at room temperature and pressure.

(i) Find the number of moles of hydrogen present.

(ii) What weight of CO_2 can the cylinder hold under similar conditions of temperature and pressure? (H = 1, C = 12, O = 16)

(iii) If the number of molecules of hydrogen in the cylinder is X, calculate the number of molecules of carbon dioxide would be present in some vessel under the some condition of temperature and pressure.

(iv) Name the law that helped you to arrive at the above result. *[2017]*

Sol. (i) Given, weight of $H_2 = 1\text{ kg} = 1000\text{ g}$

$$\text{Number of moles of } H_2 = \frac{\text{Weight}}{\text{Molecular mass}}$$

$$\therefore \text{ Number of moles of } H_2 = \frac{1000}{2} \text{ mole}$$

$= 500$ moles *[1]*

(ii) Since,

p and T are constant and volume (V) is also constant.

$\therefore \quad n_1 = n_2$ or $n_{H_2} = n_{CO_2} = 500$ mol

As we know, number of moles $= \frac{\text{Weight}}{\text{Molecular mass}}$

$\therefore$ Weight of $CO_2 = 500 \times 44 = 22000\text{ g} = 22\text{kg}$ *[1]*

(iii) Number of molecules of $H_2 = X$

$\therefore$ Number of molecules of $CO_2 = X$ *[1]*

(iv) Avogadro's law *[1]*

46. Calculate the number of moles in the 460 g of H_2SO_4.

Sol. $$\text{Number of moles} = \frac{\text{Mass of the compound}}{\text{Molecular mass of the compound}}$$

$$= \frac{460}{98} \simeq 5\text{ mol}$$

($\because$ molecular mass of $H_2SO_4 = 98\text{ g mol}^{-1}$)

47. Which of the following would weight the least? 2 g atoms of nitrogen, 1 mole of silver, 22.4 L of oxygen gas at 1 atm pressure and 273 K, 6.02×10^{23} atoms of carbon. *[2015]*

(Atomic masses: Ag = 108, N = 14, O = 16, C = 12)

Sol. 6.02×10^{23} atoms of carbon have the least weight.

(i) $N_2 = 2 \times 14 = 28\text{ g}$

(ii) 1 mole of silver = 108 g

(iii) 22.4 L of O_2 gas = 16 g

(iv) 6.02×10^{23} atoms of carbon

$$=\frac{\text{Mass}}{12}\times6.02\times10^{23}$$

Mass of carbon $=12$ g

So, weight of carbon is least. *[2]*

48. Calculate the mass of calcium that will contain the same number of atoms as present in 3.2 g of sulphur. (Atomic masses : S = 32, Ca = 40) *[2015]*

Sol. Number of atoms in 3.2 g of sulphur

$$N_A=\frac{3.2}{32}\times6.02\times10^{23}=6.02\times10^{22}$$

= Number of atoms in Ca

Molecular mass of Ca = 40

Let the mass of calcium = x

$$6.02\times10^{22}=\frac{x}{40}\times6.02\times10^{23}$$

$$x=4\text{ g}$$ *[2]*

49. O_2 is evolved by heating $KClO_3$ using MnO_2 as a catalyst

$$2KClO_3 \xrightarrow{MnO_2} 2KCl+3O_2$$

(i) Calculate the mass of $KClO_3$ required to produce 6.72 L of O_2 at STP. (Atomic masses of K = 39, Cl = 35.5, O = 16)

(ii) Calculate the number of moles of oxygen present in the above volume and also the number of molecules.

(iii) Calculate the volume occupied by 0.01 mole of CO_2 at STP. *[2013]*

Sol.

$$\underset{2\times(39+35.5+3\times16)\,=\,2\times122.5\,=\,245.0}{2KClO_3} \xrightarrow{MnO_2} \underset{2\times74.5\,=\,149\text{ g}}{2KCl}+\underset{=67.2}{3O_2}$$

(i) 67.2 L of O_2 produced by $KClO_3$ = 245 g of $KClO_3$

1 L of O_2 produced by $KClO_3=\frac{245}{67.2}$

6.72 L of O_2 produced by $KClO_3=\frac{245\times6.72}{67.2}$

$=24.5$ g *[1]*

(ii) 245 g of $KClO_3$ contain = 3 moles of oxygen

24.5 of $KClO_3$ contain $=\frac{3\times24.5}{245}$

= 0.3 mol of oxygen

Since, 1 mole of oxygen contain = 6.022×10^{23} molecule

$\therefore$ 0.3 mole of oxygen contain = $6.022\times10^{23}\times0.3$

$=1.8066\times10^{23}$ molecules *[1]*

(iii) Since, 1 mole of CO_2 occupied = 22.4 L

$\therefore$ 0.01 mole of CO_2 occupied = $22.4\times0.01=0.224$ L *[1]*

50. A gas cylinder contains 12×10^{24} molecules of oxygen gas. If Avogadro's number is 6×10^{23}. Calculate

(i) the mass of oxygen present in the cylinder.

(ii) the volume of oxygen at STP present in the cylinder. (O = 16) *[2016]*

Sol. Number of molecules of oxygen gas $=12\times10^{24}$

Avogadro's number $=6\times10^{23}$

(i) $\frac{\text{Mass of oxygen present}}{(\text{Molecular mass of } O_2 \text{ gas}=32\text{ g})}$

$$=\frac{\text{Number of molecules of } O_2 \text{ gas}}{\text{Avogadro's number}}$$

$$\text{Mass of oxygen}=\frac{12\times10^{24}\times32}{6\times10^{23}}=640\text{ g}$$ *[1]*

(ii) $\text{Number of moles}=\frac{\text{Given weight}}{\text{Molecular weight}}=\frac{640}{32}=20$

Volume occupied by 1 mole = 22.4 L

Volume occupied by 20 moles = 448 L *[1]*

51. How many molecules are present in the following?

(i) 2.2 g of CO_2 (ii) 16 g of SO_2

(iii) 2 g of oxygen

Sol. (i) 44 g of CO_2 contains 6×10^{23} molecules at STP.

$$2.2\text{ g of } CO_2=\frac{6\times10^{23}}{44}\times2.2$$

$=3\times10^{22}$ molecules. *[1]*

(ii) 64 g of SO_2 contains 6×10^{23} molecules at STP

$$16\text{ g of } SO_2=\frac{6\times10^{23}}{64}\times16=1.5\times10^{23}\text{ molecules.}$$ *[1]*

(iii) 32 g of O_2 contains 6×10^{23} molecules at STP.

$$2\text{ g of } O_2=\frac{6\times10^{23}}{32}\times2=3.75\times10^{22}\text{ molecules.}$$ *[1]*

52. A cylinder contains 68 g of ammonia gas at STP.

(i) What is the volume occupied by this gas?

(ii) How many moles of ammonia are present in the cylinder?

(iii) How many molecules of ammonia are present in the cylinder? (N-14, H-1) *[2014]*

Sol. (i) Molecular mass of NH_3 gas $= 14 + 3 = 17$

If 17 g of NH_3 contains 22.4 L at STP

Then, 68 g of NH_3 contains $= \frac{22.4}{17} \times 68 = 89.60$ L *[1]*

(ii) Number of moles $= \frac{\text{Mass in gram}}{\text{Gram molecular mass}} = \frac{68}{17}$

$= 4$ mol *[1]*

(iii) Here, we apply the Avogadro's law,

One mole of NH_3 contains $= 6.022 \times 10^{23}$ molecules

$\therefore$ 4 moles of NH_3 contains $= 4 \times 6.022 \times 10^{23}$

$= 2.4088 \times 10^{24}$ molecules *[1]*

53. (a) The percentage composition of a gas is nitrogen – 82.35%, hydrogen – 17.64%. Find the empirical formula of the gas. [N = 14, H = 1] *[2]*

(b) Aluminum carbide reacts with water according to the following equation.

$Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4$

(i) What mass of aluminum hydroxide is formed from 12 g of aluminum carbide?

(ii) What volume of methane at STP is obtained from 12 g of aluminum carbide? (Relative molecular weight of $Al_4C_3 = 144$, $Al(OH)_3 = 78$) *[4]*

(c) (i) If 150 cc of gas, *A* contains *X* molecules, how many molecules of gas *B* will be present in 75 cc of *B* ? The gases *A* and *B* are under the same temperature and pressure.

(ii) Name the law on which the above problem is based ? *[2]*

Sol. (a) Calculation of empirical formula

Element	% by mass	Atomic mass	No. of atoms	Simplest ratio
N	82.35	14	$\frac{82.35}{14} = 5.88$	$\frac{5.88}{5.88} = 1$
H	17.64	1	$\frac{17.64}{1} = 17.64$	$\frac{17.64}{5.88} = 3$

$\therefore$ Empirical formula of the gas $= NH_3$

(b) $\underset{\substack{1 \text{ mol} \\ 144 \text{ g}}}{Al_4C_3} + 12H_2O \longrightarrow \underset{\substack{4 \text{ mol} \\ 4 \times 78 \text{ g}}}{4Al(OH)_3} + \underset{3 \text{ mol}}{3CH_4}$

144 g of Al_4C_3 produced $= 4 \times 78$ g of $Al(OH)_3$

$\therefore$ 12 g of Al_4C_3 produced $= \frac{4 \times 78}{144} \times 12$ of

$Al(OH)_3 = 26$ g of $Al(OH)_3$

(ii) $\underset{\substack{1 \text{ mol} \\ 144 \text{ g}}}{Al_4C_3} + \underset{12 \text{ mol}}{12H_2O} \longrightarrow \underset{4 \text{ mol}}{4Al(OH)_3} + \underset{\substack{3 \text{ mol} \\ 3 \times 22.4 \text{ L at STP}}}{3CH_4}$

144 g of Al_4C_3 will produce $= 3 \times 22.4$L of CH_4

$\therefore$ 12 g of Al_4C_3 will produce $= \frac{22.4 \times 3 \times 12}{144} = 5.6$ L

(c) (i) Given, 150 cm^3 of gas *A* contains *X* molecules.

Let 75 cm^3 of gas *B* contains *Y* molecules.

According to Avogadro's law,

$V \propto n$, (at constant *T* and *p*)

$\therefore \quad \frac{V_1}{V_2} = \frac{n_1}{n_2}$

where, V_1 and V_2 are the volumes of gas *A* and *B* respectively and n_1 and n_2 are the number of moles of gas *A* and *B*, respectively.

$\because$ 1 mol $= 6.023 \times 10^{23}$ molecules

$= N_A$ molecules

$\therefore \quad \frac{150}{75} = \frac{N_A \times X}{N_A \times Y} \Rightarrow \quad Y = \frac{X}{2}$

Thus, number of molecules of *B* will be the half of the number of molecules of *A*.

(ii) The law on which the above problem is based is known as Avogadro's law which states that "under the same conditions of temperature and pressure, equal volumes of all gases contain equal number of molecules, irrespective of the nature of the gas".

54. Ethane burns in oxygen to form CO_2 and H_2O according to the equation,

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

If 1250 cc of oxygen is burnt with 300 cc of ethane.

Calculate

(i) the volume of CO_2 formed.

(ii) the volume of unused O_2 .

Sol. $\underset{\substack{2 \text{ mol} \\ 2 \times 22400 \\ cm^3}}{2C_2H_6} + \underset{\substack{7 \text{ mol} \\ 7 \times 22400 \\ cm^3}}{7O_2} \longrightarrow \underset{\substack{4 \text{ mol} \\ 4 \times 22400 \\ cm^3}}{4CO_2} + 6H_2O$

2×22400 cm^3 of C_2H_6 reacts with

7×22400 cm^3 of O_2

$\therefore 1$ cm^3 of C_2H_6 will reacts with $\frac{7 \times 22400}{2 \times 22400}$

$= 3.5$ cm^3 of O_2

$\therefore 300$ cm^3 of C_2H_6 will rect with

$3.5 \times 300 = 1050$ cm^3 of O_2

Hence, C_2H_6 is the limiting reagent and O_2 is in excess.

(i) $2 \times 22400\ cm^3$ of C_2H_6 will produce $4 \times 22400\ cm^3$ of CO_2

Thus, $300\ cm^3$ of C_2H_6 will produce CO_2

$$= \frac{4 \times 22400}{2 \times 22400} \times 300 = 600\ cm^3$$

(ii) Volume of unused $O_2 = (1250 - 1050)\ cm^3$

$= 200\ cm^3$

55. The vapour density of a gas is 8. What would be the volume occupied by 24.0 g of the gas at STP?

Sol. Vapour density of gas = 8

Molecular weight of gas = 2 × vapour density (VD)

$= 2 \times 8 = 16\ g$

Volume of 16 g of gas = 22 .4 L

Volume of 24 g of gas $= \frac{22.4}{16} \times 24 = 33.6\ L$ ***[2]***

56. (i) Calculate the number of moles and the number of molecules present in 1.4 g of ethylene gas. What is the volume occupied by the same amount of ethylene?

(ii) What is the vapour density of ethylene? (Avogadro's number = 6×10^{23}; atomic weight of C = 12, H = 1; molar volume = 22.4 L at STP).

Sol. (i) Molecular weight of ethylene ($CH_2 = CH_2$)

$= 12 + 2 + 12 + 2 = 28\ g$

$$\text{Number of moles} = \frac{\text{Given weight}}{\text{Molecular weight}}$$

$$= \frac{1.4}{28} = 0.05\ \text{mol}$$

Number of molecules in 1 mole = 6×10^{23}

∴ Number of molecules in 0.05 mole

$= 6 \times 10^{23} \times 0.05 = 0.3 \times 10^{23}$

$= 3 \times 10^{22}$ molecules

Volume occupied by 1 mole = 22 . 4 L

∴ Volume occupied by 0.05 mole = 22 . 4 × 0.05

= 1.12 L ***[1/2]***

(ii) Vapour density can be calculated using the following formula,

$$\text{Vapour density (VD)} = \frac{\text{Molecular weight}}{2} = \frac{28}{2} = 14$$ ***[1/2]***

57. Find the total percentage of magnesium in magnesium nitrate crystals, $Mg(NO_3)_2 \cdot 6H_2O$. (Mg = 24, N = 14, O = 16 and H = 1)

Sol. Molecular mass of $Mg(NO_3)_2 \cdot 6H_2O$

$= 24 + 2(14 + 48) + 6 \times 18 = 256\ g$

$$\text{Percentage of Mg} = \frac{24}{256} \times 100 = 9.375\%$$ ***[1]***

58. If the empirical formula of a compound is CH and it has a vapour density of 13, find the molecular formula of the compound. ***[2015]***

Sol. Empirical formula of a compound = CH

Empirical formula mass = 12 + 1 = 13 g

Molecular formula mass = 2 × Vapour density

$= 2 \times 13 = 26\ g$

$$n = \frac{26}{13} = 2$$

Molecular formula = $(\text{Empirical formula})_n$

∴ Molecular formula = $(CH)_2 = C_2H_2$ ***[2]***

59. A gaseous hydrocarbon contain 82.76% of carbon. Given that its vapour density is 29, find its molecular formula. (C = 12, H = 1)

Sol.

Element	% Composition	Atomic Mass	No. of Atoms	Simplest Ratio
C	82.76	12	$\frac{82.76}{12} = 6.89$	$\frac{6.89}{6.89} = 1$
H	100 − 82.76 = 17.24	1	$\frac{17.24}{1} = 17.24$	$\frac{17.24}{6.89} = 2$

Empirical formula of the compound = CH_2

Empirical formula weight = 12 + 2 × 1 = 14

Vapour density = 29 (given)

Molecular weight = 2 × vapour density

$= 2 \times 29 = 58$

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}}$$

$$= \frac{58}{14} = 4$$

Molecular formula = $(CH_2)_4 = C_4H_8$ ***[3]***

60. An organic compound with vapour density 94 contains C = 12. 67%, H = 2.13 %, and Br = 85. 11%. Find the molecular formula. (Atomic mass of C = 12 , H = 1 and Br = 80)

Sol. Calculation of empirical formula

Element	% Composition	Atomic mass	Simplest ratio
C	12.67	12	$\frac{12.67}{12}=1$
H	2.13	1	$\frac{2.13}{1}=2$
Br	85.11	80	$\frac{85.11}{80}=1$

Empirical formula of compound = CH_2Br

Empirical formula weight = $12+2\times1+80=94$

Vapour density = 94 (given)

Molecular mass = $2\times$ Vapour density = $2\times94=188$

$$n=\frac{\text{Molecular weight}}{\text{Empirical formula weight}}=\frac{188}{94}=2$$

Molecular formula = $(CH_2Br)_2 = C_2H_4Br_2$ *[3]*

61. (i) A compound has the following percentage composition by mass, carbon 14.4%, hydrogen 1.2% and chlorine 84.5%. Determine the empirical formula of this compound. (H = 1, C = 12 and Cl = 35.5)

(ii) The relative molecular mass of this compound is 168, so, what is its relative molecular formula?

Sol. (i) It can be solved using the same concept as discussed in the previous problem.

Element	% by mass	Atomic mass	Number of atoms	Simplest ratio
H	1.2	1 g	1.2	$\frac{1.2}{1.2}=1$
C	14.4	12 g	1.2	$\frac{1.2}{1.2}=1$
Cl	84.5	35.5 g	2.38	$\frac{2.38}{1.2}=1.98\simeq2$

∴ Empirical formula of compound = $CHCl_2$

Empirical formula weight = $12+1+2(35.5)=84.0$

Molecular weight = 168

$$n=\frac{\text{Molecular weight}}{\text{Empirical formula weight}}$$

$$=\frac{168}{84}=2$$

Molecular formula = $(\text{Empirical formula})_n$

$= (CHCl_2)_2$

$= C_2H_2Cl_4$ *[2]*

(ii) Formula mass of both molecular formula and relative molecular formula is same hence both will be similar *i.e.*, $C_2H_2Cl_4$. *[1]*

62. (i) Calculate the number of gram atom in 4.6g of sodium (Na = 23).

(ii) Calculate the percentage of water of crystallisation in $CuSO_4\cdot5H_2O$ (H = 1, O = 16, S = 32, Cu = 64).

(iii) A compound of X and Y has the empirical formula XY_2. Its vapour density is equal to its empirical formula weight. Determine its molecular formula. *[2017]*

Sol. (i) 1 g atom of sodium = 23g of sodium *[1]*

∴ 4.6g atom of sodium = $23\times4.6g = 105.8$ g of Na.

(ii) Percentage of an element in a compound

$$=\frac{\text{Total weight of the element in one molecule}}{\text{Gram molecular weight of the compound}}\times100$$

Molecular mass of $CuSO_4\cdot5H_2O$

$= 64+32+(4\times16)+5(2\times1+16)$

$= 64+32+64+90+=250$

∴ Percent of water of crystallisation

$$=\frac{5\times18}{250}\times100=0.3\%\text{ of }H_2O$$ *[1]*

(iii) $$n=\frac{2\times\text{Vapour density (VD)}}{\text{Empirical formula weight}}$$

$n = 2$ (∵ vapour density = empirical formula weight)

Empirical formula = XY_2

Molecular formula = $n\times$ Empirical formula

∴ Molecular formula = $2\times$ Empirical formula

$= 2\times XY_2 = X_2Y_4$ *[1]*

63. The equation,

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

represents the catalytic oxidation of ammonia. If 100 cm^3 of ammonia is used, calculate the volume of oxygen required to oxidise the ammonia completely.

Sol. (c) The given equation is

$$\underset{\text{4 volume}}{4NH_3} + \underset{\text{5 volume}}{5O_2} \longrightarrow 4NO + 6H_2O$$

4 volumes of NH_3 is completely oxidised by 5 volumes of O_2, 1 volume of NH_3 is completely oxidised by 5/4 volumes of O_2.

∴ 100 cm^3 volume of NH_3 is completely oxidised by $\frac{5}{4}\times100\,cm^3$ of $O_2 = 125\,cm^3$. *[2]*

64. Calculate the volume of oxygen required for the complete combustion of 8.8 g of propane (C_3H_8). (Atomic mass of C = 12, O = 16 and H = 1, Molar volume = 22.4 dm^3 at STP).

Sol. Balanced chemical equation is

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

Molar mass of propane = $3\times 12 + 8\times 1 = 44$

44 g of propane require 5×22.4 L of oxygen at STP

8.8 g of propane require $= \frac{5\times 22.4}{44}\times 8.8 = 22.4$ L *[2]*

65. Solve the following.
What volume of oxygen is required to burn completely 90 dm^3 of butane under similar condition of temperature and pressure? *[2013]*

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

Sol. The reaction is

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

2 volumes of butane is completely burned by 13 volumes of O_2

90 volumes of butane is completely burned by $\frac{13}{2}\times 90$ volumes of O_2

$\therefore$ Volume of O_2 required $= 13\times\frac{90}{2} = 585\,dm^3$

66. (i) Propane burns in air according to the following equation,

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

What volume of propane is consumed on using 1000 cm^3 of air, considering only 20% of air contains oxygen?

(ii) The mass of 11.2L of a certain gas at STP is 24g. Find the gram molecular mass of the gas. *[2017]*

Sol. (i) Oxygen present in air $= \frac{20}{100}\times 1000 = 200\,cm^3$

$$C_3H_8 + \underset{1\text{vol}}{} 5O_2 \longrightarrow \underset{5\text{vol}}{} 3CO_2 + 4H_2O$$

5 vol of O_2 is required for 1 vol of C_3H_8.

$\therefore$ 200 cm^3 of O_2 is required

$= \frac{200}{5}\,cm^3$ of $C_3H_8 = 40\,cm^3$ of C_3H_8 *[1]*

(ii) The mass of 22.4 L of a gas at STP is equal to its gram molecular mass.

11.2L of gas at STP weight = 24g

$\therefore$ 22.4 L of gas will weight $= \frac{24}{11.2}\times 22.4 = 28$ g *[1]*

67. (i) A gas of mass 32 g has a volume of 20 L at STP. Calculate the gram molecular weight of the gas.

(ii) How much calcium oxide is formed, when 82g of calcium nitrate is heated?
Also, find the volume of nitrogen dioxide evolved.

$$2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$$

(Ca = 40, N = 14, O = 16) *[2016]*

Sol. (i) Mass of the gas = 32 g

Volume of gas at STP = 20 L

20 L of gas at STP occupies 32 g

$\therefore$ 1 L of gas at STP occupies $\frac{32}{20}$ g = 1.6g

Gram molecular volume (molar volume)

$$= \frac{\text{Gram molecular weight}}{\text{Weight per litre of gas at STP}}$$

$\therefore$ Gram molecular weight

= molar volume × weight per litre of gas at STP

$= 22.4\,L \times 1.6\,gL^{-1} = 35.84$ g *[1½]*

(ii) The given equation is

$$\underset{2[40+2(14+3\times16)]=328}{2Ca(NO_3)_2} \longrightarrow \underset{2(40+16)=112g}{2CaO} + \underset{4\times22.4L=89.6L}{4NO_2} + O_2$$

328 g of $Ca(NO_3)_2$ produces 112 g of CaO

Then, 82g of $Ca(NO_3)_2$ produces $= \frac{112}{328}\times 82 = 28$g

Now, since 328g of $Ca(NO_3)_2$ releases 89.6L of NO_2 at STP.

Thus, 82 g of $Ca(NO_3)_2$ release $\frac{89.6}{328}\times 82 = 22.4$L *[1½]*

CHAPTER EXERCISE

Fill in the Blanks

1. ..... of an element is the number of times one molecule of the substance is ..... than ..... the mass of an atom of C-12.

2. Number of molecules = ...× Avogadro's number.

3. % mass of an element

$$= \frac{\text{————————}}{\text{Molar mass of the compound}} \times 100$$

Multiple Choice Questions

4. Which of the following needs to remain constant in Gay-Lussac's law
(a) volume
(b) pussure and temperature
(c) temperature and volume
(d) Temperature

5. 1g of an element or 1g molecule of a substance is equal to
(a) 2 particles
(b) 1 mole
(c) 1 molecule
(d) 3 moles

6. The relative molecular mass of $(NH_4)_2PtCl_6$ is
(a) 326
(b) 333
(c) 444
(d) 428

7. Which of the following would weigh most?
(a) 1 mole of H_2O
(b) 1 mole of CO_2
(c) 1 mole of NH_3
(d) 1 mole of CO

8. How many number of molecules present in 73 g of HCl ?
(a) 5.6×10^{23} (b) 2.4×10^{26}
(c) 2.3×10^{22} (d) 1.2×10^{24}

9. What is the percentage of Na in Na_2CO_3?
(a) 11.3% (b) 43.4%
(c) 45.3% (d) 50%

Match the Following

10. Match the following columns.

	Column I		Column II
(i)	Percentage of iron in $K_3[Fe(CN)_6]$	(a)	32 amu
(ii)	Relative molecular mass of CH_3OH	(b)	6.023×10^{23} molecules of chlorine
(iii)	One mole of chlorine contains	(c)	17.02 g

11. Match the following columns.

	Column I (Organic compounds)		Column II (% of carbon)
(i)	CH_3CHO	(a)	80
(ii)	C_2H_5OH	(b)	54.54
(iii)	CH_3COCH_3	(c)	52.17
(iv)	CH_3COOH	(d)	62.06
(v)	C_2H_6	(e)	40

1 Mark Questions

12. State Gay-Lussac's law of combining volumes.

13. What will be the mass of one atom of C -12 in gram?

14. What is the symbol for SI unit of mole?

15. 66 g of ammonium sulphate is produced by the action of ammonia on sulphuric acid. Write a balanced equation and calculate mass of ammonia required.

2 Marks Question

16. Define the following terms.
(i) Mole number
(ii) Molar volume

3 Marks Question

17. Why there is a need of STP of gases? If we use the ordinary method for calculations, then what would be the affect?

4 Marks Question

18. What is the relationship between gram molecular weight and gram molecular volume at STP?

5 Marks Question

19. Define atomicity of a gas. Why is it important for an element? Give at least six examples.

Numerical Type Questions

20. Calculate the volume of 320 g of SO_2 at STP. (Atomic mass of S = 32 and O = 16).

21. Calculate the number of Cl^- and Ca^{2+} ions in 222g anhydrous $CaCl_2$.

22. A certain gas *X* occupies a volume of 100 cm^3 at STP and weighs 0.5 g. Find its relative molecular mass.

23. (i) Calculate the number of moles in the 11.2 g of iron and 63.5 μg of carbon.

(ii) The cost of table salt (NaCl) and table sugar ($C_{12}H_{22}O_{11}$) is 2 per kg and 6 per kg, respectively. Calculate their costs per mole.

24. The volume of gases *A, B, C* and *D* are in the ratio 1 : 2 : 2 : 4 under same conditions of temperature and pressure.

(i) If the volume of *A* is actually 5.6 dm^3 at STP, calculate the number of molecules in the actual volume of *D* at STP. (Avogadro's number is 6.023×10^{23})

(ii) Using your answer, state the mass of *D*, if the gas is dinitrogen oxide (N_2O) (N = 14, O = 16).

25. A hydrocarbon contains 10.5 g of carbon per gram of hydrogen. Calculate the empirical formula.

26. A compound made up of two elements *A* and *B*, has *A* = 70%, *B* = 30%. Their relative number of moles in the compound are 1.25 and 1.88. Calculate the

(i) atomic masses of the elements *A* and *B*.

(ii) molecular formula of the compound, if its molecular mass is found to be 160.

26. From the equation,

$$C + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2$$

Calculate

(i) the mass of carbon oxidised by 49 g of sulphuric acid (C = 12, relative molecular mass of sulphuric acid = 98).

(ii) the volume of sulphur dioxide measured at STP liberated at the same time. (Volume occupied by 1 mole of a gas at STP is 22.4 dm^3)

27. (i) Calculate the mass of copper required to react 63 g of dilute nitric acid (Cu = 64, H = 1, N = 14 and O = 16).

(ii) A 3 g sample of $Na_2CO_3 \cdot 10H_2O$ is heated to a constant mass. How much anhydrous salt remains?

28. The following reaction takes place as

$$Pb_3O_4 + 8HCl \longrightarrow 3PbCl_2 + 4H_2O + Cl_2$$

Calculate

(i) mass of lead chloride formed by the action of 6.85 g of red lead (Pb_3O_4); ***Ans.*** 27.8 g

(ii) the mass of chlorine; ***Ans.*** 0.71 g

(iii) the volume of chlorine evolved at STP. ***Ans.*** 224 mL

ARCHIVES*

(Last 7 Years)

Collection of Questions Asked in Last 7 Years' (2018-2012) ICSE Class 10th Examinations

2018

1 (a) The percentage composition of a gas is nitrogen – 82.35%, hydrogen – 17.64%. Find the empirical formula of the gas. [N = 14, H = 1] ***[2]***

(b) Aluminum carbide reacts with water according to the following equation.

$$Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4$$

(i) What mass of aluminum hydroxide is formed from 12 g of aluminum carbide?

(ii) What volume of methane at STP is obtained from 12 g of aluminum carbide? (Relative molecular weight of Al_4C_3 = 144, $Al(OH)_3$ = 78) ***[4]***

(c) (i) If 150 cc of gas, *A* contains *X* molecules, how many molecules of gas *B* will be present in 75 cc of *B* ? The gases *A* and *B* are under the same temperature and pressure.

(ii) Name the law on which the above problem is based ?

2 Ethane burns in oxygen to form CO_2 and H_2O according to the equation,

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

If 1250 cc of oxygen is burnt with 300 cc of ethane. Calculate

(i) the volume of CO_2 formed.

(ii) the volume of unused O_2. ***[4]***

2017

3 (i) Propane burns in air according to the following equation, $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$ What volume of propane is consumed on using 1000 cm^3 of air considering only 20% of air contains oxygen?

(ii) The mass of 11.2L of a certain gas at STP is 24g. Find the gram molecular mass of the gas.

4. A gas cylinder can hold 1kg of hydrogen at room temperature and pressure.

(i) Find the number of moles of hydrogen present.

(ii) What weight of CO_2 can the cylinder hold under similar conditions of temperature and pressure? (H = 1, C = 12, O = 16)

(iii) If the number of molecules of hydrogen in the cylinder is *X*, calculate the number of CO_2 molecules in the cylinder under the same conditions of temperature and pressure.

(iv) State the law that helped you to arrive at the above result.

5 (i) Calculate the number of gram atom in 4.6 g of sodium (Na = 23).

(ii) Calculate the percentage of water of crystallisation in $CuSO_4 . 5H_2O$ (H = 1, O = 16, S = 32, Cu = 64).

(iii) A compound of *X* and *Y* has the empirical formula XY_2. Its vapour density is equal to its empirical formula weight. Determine its molecular formula.

2016

6 The ratio between the number of molecules in 2g of hydrogen and 32g of oxygen is

(a) 1 : 2 (b) 1:0.01

(c) 1:1 (d) 0.01:1

7 (i) A gas of mass 32g has a volume of 20 L at STP. Calculate the gram molecular weight of the gas.

(ii) How much calcium oxide is formed when 82g of calcium nitrate is heated? Also, find the volume of nitrogen dioxide evolved.

$$2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$$

(Ca = 40, N = 14, O = 16)

8 (a) A gas cylinder contains 12×10^{24} molecules of oxygen gas. If Avogadro's number is 6.022×10^{23}. Calculate

(i) the mass of oxygen present in the cylinder.

(ii) the volume of oxygen at STP present in the cylinder (O = 16).

(b) A gaseous hydrocarbon contains 82.76% of carbon. Given that its vapour density is 29, find its molecular formula. (C = 12, H = 1)

(c) The equation, $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$, represents the catalytic oxidation of ammonia. If 100 cm^3 of ammonia is used , calculate the volume of oxygen required to oxidise the ammonia completely.

2015

9 Which of the following would weigh the least?

(i) 2 g atoms of nitrogen

(ii) 1 mole of silver

(iii) 22.4 L of oxygen gas at 1 atm pressure and 273 K
(iv) 6.02×10^{23} atoms of carbon
(Ag = 108, N = 14, O = 16 and C = 12)

10 (i) Calculate the mass of calcium that will contain the same number of atoms as present in 3.2 g of sulphur. (S = 32 and Ca = 40)
(ii) If 6 L of hydrogen and 4 L of chlorine are mixed and exploded and if water is added to the gases formed, find the volume of the residual gas.
(iii) If the empirical formula of a compound is CH and it has a vapour density of 13, find the molecular formula of the compound.

2014

11 State Avogadro's law.

12 A cylinder contains 68 g of ammonia gas at STP.
(i) What is the volume occupied by this gas?
(ii) How many moles of ammonia are present in the cylinder?
(iii) How many molecules of ammonia are present in the cylinder? (N = 14 and H = 1)

13 Oxygen oxidises ethyne to carbon dioxide and water as shown by the equation

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$

What volume of ethyne gas at STP is required to produce 8.4dm^3 of carbon dioxide at STP?
(H = 1, C = 12 and O = 16)

14 Given one word or phrase for the following.
The ratio of the mass of a certain volume of a gas to the mass of an equal volume of hydrogen under the same conditions of temperature and pressure.

2013

15 Solve the following. What volume of oxygen is required to burn completely 90 dm^3 of butane under the similar condition of temperature and pressure?

$$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$$

16 A vessel contains *X* number of molecules of hydrogen gas at a certain temperature and pressure. How many molecules of nitrogen gas would be present in the same vessel under the same conditions of temperature and pressure?

17 O_2 is evolved by heating $KClO_3$ using MnO_2 as a catalyst

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

(i) Calculate the mass of $KClO_3$ required to produce 6.72 L of O_2 at STP. (K = 39, Cl = 35.5 and O = 16)
(ii) Calculate the number of moles of oxygen present in the above volume and also the number of molecules.
(iii) Calculate the volume occupied by 0.01 mole of CO_2 at STP.

2012

18 The vapour density of carbon dioxide (C = 12 and O = 16) is
(a) 32 (b) 16 (c) 44 (d) 22

19 67.2 L of hydrogen combines with 44.8 L of nitrogen to form ammonia under specific conditions as

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

Calculate the volume of ammonia produced. What is the other substance, if any that remains in the resultant mixture?

20 Concentrated nitric acid oxidises phosphorus to phosphoric acid according to the following equation.

$$P + 5HNO_3(conc.) \longrightarrow H_3PO_4 + H_2O + 5NO_2$$

If 9.3 g of phosphorus was used in the reaction, calculate
(i) the number of moles of phosphorus taken.
(ii) the mass of phosphoric acid formed.
(iii) the volume of nitrogen dioxide produced at STP.
(H = 1, N = 14, P = 31, O = 16)

21 Find the total percentage of magnesium in magnesium nitrate crystals, $Mg(NO_3)_2 \cdot 6H_2O$.
(Mg = 24, N = 14, O = 16 and H = 1)

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 Which one of the following will have the largest number of atoms?
(a) 1 g Au(s) (b) 1 g Na(s) (c) 1 g Li(s) (d) 1 g Cl_2(s)

2 A gas has a vapour density of 11.2. The volume occupied by 1 gram of the gas at NTP will be
(a) 11.2 L (b) 22.4 L (c) 1L (d) Unpredictable.

3 The average molar mass of a mixture of methane (CH_4) and ethene (C_2H_4) present in the ratio of $a : b$ is found to be 20.0 g mol^{-1}. If the ratio was reversed, what would be the molar mass of the mixture?
(a) 18 g mol^{-1} (b) 22 g mol^{-1} (c) 24 g mol^{-1} (d) 26 g mol^{-1}

4. Water decomposes to O_2 and H_2 under suitable conditions as represented by the equation given below,

$$2H_2O \longrightarrow 2H_2 + O_2$$

If 2500 cm^3 of H_2 is produced, what volume of O_2 is liberated at the same time and under the same conditions of temperature and pressure
(a) 1014 cm^3 (b) 1125 cm^3 (c) 1250 cm^3 (d) 1312 cm^3

5 The mass of 112 cm^3 of CH_4 gos at STP is
(a) 0.16g (b) 0.8g (c) 0.08g (d) 1.6g

6 If N_A is Avogadro's number, then the number of oxygen atom in one *g*-equivalent of oxygen is
(a) N_A (b) $N_A / 2$ (c) $N_A / 4$ (d) $2N_A$

7 Two oxides of a metal contains 50% and 40% metal (M), respectively. If the formula of first oxide is MO_2, the formula of second oxide will be
(a) MO_2 (b) MO_3 (c) M_2O (d) M_2O_5

8 The vapour density of a gas A is four times that of B. If molecular mass of B is M, then molecular mass of A is
(a) M (b) $4M$ (c) $\frac{M}{4}$ (d) $2M$

9 60g of a compound on analysis gave 24 g C, 4 g H and 32 g O. The empirical formula of the compound is
(a) $C_2H_4O_2$ (b) $C_2H_2O_2$ (c) CH_2O_2 (d) CH_2O

10 A sample of Na_2CO_3 contains 6.02×10^{23} Na^+ ion. The mass of the sample is [Na = 23, C = 12, O = 16]
(a) 53 g (b) 106 gs (c) 165 g (d) 212 g

Answers

1. (c) **2.** (c) **3.** (c) **4.** (c) **5.** (c) **6.** (c) **7.** (b) **8.** (b) **9.** (d) **10.** (a)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 261-262.

CHAPTER

6

Electrolysis

Chapter Objectives

- Terms Related to Electrolysis
- Electrolytic Dissociation
- Ionisation
- Preferential or Selective Discharge of Ions at Electrodes
- Examples of Electrolysis
- Applications of Electrolysis

The word " electrolysis" contains two terms 'electro' which means flow of electricity or electrons and 'lysis' which means separating. It is defined as a process of decomposition of a chemical compound by the passage of electricity through its aqueous solution or molten (fused) state .

During electrolysis a change is brought about by electrical energy. In electrolysis, the process of reduction takes place at cathode and oxidation at anode.

Terms Related to Electrolysis

Some basic terms on which the foundation of electrolysis is based are discussed below

1. Conductors

The substances, which have very high conductivity for the flow of electric current are known as conductors *e.g.*, Metals and their alloys, certain non-metals like carbon-black, graphite and some organic polymers are electrically conducting.

Different types of conductors are as follows

Metallic Conductors

In metallic conductors, the flow of electricity takes place due to the flow of electrons only *i.e.*, no flow of matter. Thus, the matter does not decompose. Conductivity decreases with increase of temperature *e.g.*, Cu, Zn, etc.

Electrolytic Conductors

In electrolytic conductors, the flow of electricity takes place due to the flow of charges, *i.e.*, matter decomposed into ions. The electrical conduction increases with increase of temperature due to increase in dissociation *e.g.*, $CuSO_4$, $ZnSO_4$, etc.

Note The substances which have very low conductivity due to negligible flow of electric current are known as **insulators** while which have conductivity between conductors and insulators are known as **semiconductors**.

2. Electrolytes

The compounds which conduct electricity when dissolved in water or in the molten state are called electrolytes. Electrolytes are electrovalent compounds and polar covalent compounds that forms ions in water *e.g.*, Acids (HCl, H_2SO_4, HNO_3), bases (NaOH, KOH, NH_4OH, $Ca(OH)_2$) and salts (NaCl, $CuSO_4$, $PbBr_2$).

Electrolytes are of two types

(i) Strong electrolyte

(ii) Weak electrolyte

Comparative Study of Strong and Weak Electrolytes

Strong electrolytes	Weak electrolytes
The electrolytes which allow a large amount of electricity to flow through them are called strong electrolytes.	The electrolytes which allow small amount of electricity to flow through them are called weak electrolytes.
These are good conductors of electricity.	These are poor conductors of electricity.
Strong electrolytes are completely dissociated	Weak electrolytes are partially dissociated in fused state or in aqueous solution.
These electrolytes contain only free mobile ions.	These electrolytes contain ions as well as molecules.
e.g., **Acids** Dil. HCl, H_2SO_4, HNO_3, HBr, HI. **Bases** NaOH, KOH, LiOH solutions. **Salts** NaCl, KCl, Na_2SO_4, $NaNO_3$, $CuCl_2$, $PbSO_4$, $Pb(NO_3)_2$, $PbBr_2$, AgI aqueous solutions.	**Acids** Carbonic acid (H_2CO_3), acetic acid (CH_3COOH), oxalic acid $(COOH)_2$, formic acid (HCOOH). **Bases** NH_4OH, $Ca(OH)_2$, $Mg(OH)_2$. **Salts** Na_2CO_3, $NaHCO_3$, oxalate and formate salts.

3. Non-electrolytes

Chemical compounds which do not conduct electricity in the fused state or in aqueous solution are called non-electrolytes *e.g.*, Pure or distilled water, alcohol, kerosene, cane sugar, glucose, urea, carbon disulphide, liquid carbon tetrachloride, etc.

4. Electrodes

Two graphite (carbon) rods or metal plates immersed in the electrolyte through which the current enters and leaves the electrolytic cell are called electrodes.

(i) **Cathode** The electrode connected to the negative terminal of the battery is called cathode. During electrolysis, cathode acquires a negative charge and hence, ions in a solution which are positively charged (*i.e.*, cations) migrate to the cathode.

(ii) **Anode** The electrode connected to the positive terminal of the battery is called anode. During electrolysis, anode acquires a positive charge and hence, ions in a solution which are negatively charged (*i.e.*, anions) migrate to the anode.

Note Electrodes attract opposite charged ions.

Anion (negative) $\xrightarrow{\text{goes to}}$ Anode (positive electrode)

Cation (Positive) $\xrightarrow{\text{goes to}}$ Cathode (negative electrode)

i.e., A to A and C to C.

5. Ions

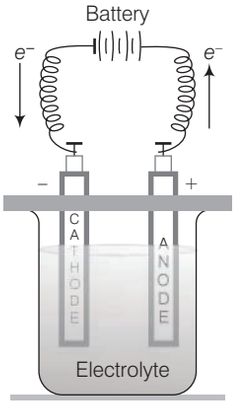
Atoms or group of atoms which carry a positive or a negative charge are known as ions. The charge on an ion, positive or negative is equal to the valency of the atom or the ion. *The two types of ions are*

(i) **Anions** They migrate to the anode during electrolysis. Anions donate or lose electrons to the anode (oxidation process) and get oxidised to neutral atom. Anions are negatively charged ions, *e.g.*, PO_4^{3-}, Cl^-, SO_2^-, OH^-

(ii) **Cations** They migrate to the cathode during electrolysis. Cations accept or gain electrons from the cathode (reduction process) and get reduced to neutral atom. Cations are positively charged ions, *e.g.*, Na^+, Ca^{2+}, Al^{3+}

6. Electrolytic Cell

The device in which electrolysis is carried out is called electrolytic cell or voltameter which contains electrode (cathode and anode) and the electrolytic solution. It converts electrical energy into chemical energy.



Electrolytic cell

7. Electrochemical Cell

It is a device which is used to convert chemical energy of the redox reaction into electrical energy *e.g.*, Daniell cell. The reactions carried out electrochemically are energy sufficient and less polluting.

8. Oxidation

It is a process which involves the addition of oxygen or removal of hydrogen or loss of electron.

e.g., $Na \longrightarrow Na^+ + e^-$

$C + O_2 \longrightarrow CO_2$

Oxidising Agent

An oxidising agent may be defined as a substance which supplies oxygen or any other electronegative element or removes hydrogen or any other electropositive element. An oxidising agent after carrying out oxidation is itself reduced in a chemical reaction. Some examples of oxidising agents are manganese dioxide, red lead, hydrogen peroxide, conc. nitric acid, oxygen, ozone, chlorine, sulphur dioxide, etc.

9. Reduction

It is a process which involves the removal of oxygen or addition of hydrogen or gain of electrons.

e.g., $Cu^{2+} + 2e^- \longrightarrow Cu$

$ZnO + C \longrightarrow Zn + CO$

Reducing Agent

A reducing agent may be defined as a substance which supplies hydrogen or any other electropositive element, or removes oxygen or any other electronegative element. A reducing agent after carrying out reduction is itself oxidised in a chemical reaction *e.g.*, carbon, metals like Zn, Al, Cu, hydrogen peroxide, HI, HBr, H_2S, CO and SO_2, etc.

Note Redox reaction in which oxidation and reduction take place in the same container are called direct redox reactions. When oxidation and reduction take place in separate containers, it is called indirect redox reactions.

CHECK POINT 01

1. Give one word for the substance which conduct electricity.
2. Name the fundamental particle of the atom that move when electric current is passed through metal wire.
3. How the conductivity of the metallic conductors is different from that of electrolytic conductors?
4. How does the electrolytic cell differ from electrochemical cell in the principle of flow of energy?
5. Considering the electrolysis of potassium chloride (KCl), write the oxidation and reduction reactions taking place at different electrodes.
6. Write the reaction that is carried out when zinc (II) oxide is reduced to Zn.

Electrolytic Dissociation

The process due to which an ionic compound in the molten state or in the aqueous state dissociate into ions by the passage of electric current through it is called electrolytic dissociation.

$$\underset{\text{Ionic}}{PbBr_2} \rightleftharpoons Pb^{2+} + 2Br^-$$

Arrhenius Theory

A Swedish chemist, Svante Arrhenius, in 1887, gave an ionic theory (also called theory of electrolytic dissociation).

The important points of this theory are given below

(i) An electrolyte on dissolving in water dissociates into free cations (positive ions) and anions (negative ions) and allow the flow of electric current through it. The number of positive charges equals to the number of negative charges and thus the solution is in electrolytic equilibrium.

(ii) Ions (carrying electric charge) are responsible for the flow of current through the solution.

(iii) The conductivity of the electrolyte depends upon the concentration of ions in the solution.

(iv) In non-electrolytes, there is no dissociation and hence only molecules are present in solution.

(v) The degree of dissociation is the extent to which an electrolyte dissociates into ions.

Characteristics of Electrolytic Dissociation

(i) When an electric current is passed through an electrolyte, the positive charged ions *i.e.*, cations migrate towards the cathode and negative charged ions *i.e.*, anions migrate towards the anode.

(ii) The number of electrons gained by anode is equal to the number of electrons donated by the cathode.

(iii) The products of electrolysis are formed at the anode and cathode since the exchange of electrons takes place only at the surface of electrodes.

(iv) The discharge of ions will takes place according to the position in the electrochemical series.

(v) Only hydrogen gas and metals are liberated at the cathode and hence, are called electropositive elements. Only non-metals are liberated at the anode and hence, called electronegative elements.

(vi) The process of electrolysis is based on the redox reaction.

The reaction at the cathode involves reduction of cations as they gain electrons to become neutral while that at anode involves oxidation of anions as they lose electrons to become neutral.

e.g., $\underset{\text{Molten}}{NaCl} \rightleftharpoons Na^+ + Cl^-$

At cathode $Na^+ + e^- \longrightarrow Na$(reduction)

At anode $Cl^- \longrightarrow Cl + e^-$(oxidation)

$Cl + Cl \longrightarrow Cl_2$

Overall reaction $2NaCl \longrightarrow 2Na + Cl_2$

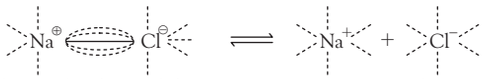
(vii) The alternating current (AC) does not cause any chemical change and therefore does not help in the occurring of electrolysis. Electrolysis is caused by the direct current (DC).

(viii) The cathode donates the electrons to the cation and the anode accepts the electrons from the anion. This result in the flow of current through the electrolyte. This flow is basically due to the migration of the ions (*i.e.*, cation and anions).

Note The mass of a substance produced at an electrode during electrolysis is proportional to the quantity of electricity passing through the electrolyte. This constitutes the Faraday's laws of electrolysis.

Electrolytic Dissociation of Electrovalent Compound (NaCl)

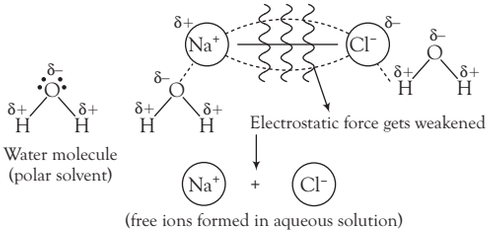
In solid state, sodium chloride ions are not free to move, they are held together by an electrostatic force of attraction. But it dissociates in molten (or aqueous) state and conducts electricity.



Sodium chloride in solid state — Free ions in molten state

Water is a polar solvent. It exhibits a charge distribution in which each hydrogen atom develops a slightly positive and oxygen exhibits slightly negative charge. In aqueous solution of NaCl, the negatively charged oxygen atom of polar water molecule attracts the positively charged sodium. Similarly, the hydrogen atom of water molecule (having slightly positive charge) attracts the negatively charged chlorine.

Thus, sodium and chlorine ions becomes free in solution and conducts electricity.



Water molecule (polar solvent)

(free ions formed in aqueous solution)

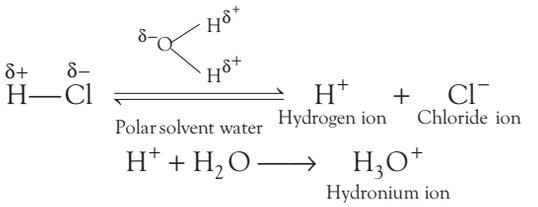
Ionisation

It is a process of formation of positive and negative charged ion from molecules which are not initially in the ionic state. Ionisation generally occurs in polar covalent compound. These compounds are non-electrolytes in gaseous state but ionise in aqueous state.

e.g., Hydrogen chloride is polar covalent in nature (*i.e.*, show uneven distribution of charges in its molecule). Hydrogen atom has a slightly positive charge and chlorine having slightly negative charge.

$$H^{\delta+}—Cl^{\delta-}$$

When HCl is added to water (which is also a polar solvent), the slightly negative charged oxygen atom of water molecule exerts an electrostatic pull on slightly positive charged hydrogen ion of HCl which results in the formation of H_3O^+ and Cl^- ion. The chloride ion remains as residual in the solution.



Difference between Ionisation and Dissociation

Ionisation	Dissociation
This process take place in covalent compounds.	This process only takes place in electrovalent (ionic) compounds.
It is a process of formation of charged ions from the molecules of polar covalent compounds	It is a process of separation of the ions which are already present in an ionic compounds.
e.g., $HCl\,(aq) \rightleftharpoons H^+ + Cl^-$ (covalent)	*e.g.*, $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$ (ionic)

Preferential or Selective Discharge of Ions at Electrodes

The preferential discharge of ions present in an electrolyte at the respective electrodes is also known as selective discharge of ions. If a solution contains more than two cations and anions, the selective discharge of ions depends on three factors.

These factors can be understand by using electrochemical series. Hence, before discussing these factors let us first discuss about electrochemical series.

Electrochemical Series (Activity Series)

The tendency to lose valence electron(s) varies from metal to metal. According to this tendency, the metallic elements are arranged in decreasing order of their tendency to lose valence electron(s).

In series, the arrangement is done in such a way that the elements that ionise most readily are placed at the top and those which are not easily ionise are placed at the bottom. This series is called electrochemical series (activity series).

Electropositive Series
(Electrochemical Series of Cations)

In this series, metals are arranged according to their tendency to lose electrons from their valence shell to form ions.

Electropositive Series of Cations

Metal	Cation	
K	K^+	Discharge with most difficulty.
Ca	Ca^{2+}	The cations are dicharged at cathode by gain of electrons.
Na	Na^+	The tendency of cation to reduce, increases on moving from top to bottom in the series.
Mg	Mg^{2+}	
Al	Al^{3+}	
Zn	Zn^{2+}	
Fe	Fe^{2+}	
Pb	Pb^{2+}	
H	H^+	Discharged most easily
Cu	Cu^{2+}	
Hg	Hg^{2+}	
Ag	Ag^+	

Increasing ease of reduction ↓

Electronegative Series
(Electrochemical Series of Anions)

It is a series in which non-metal are arranged according to their tendency to gain electrons to form ions. This series is called electronegative series.

Electronegative Series of Anions

Anion	
SO_4^{2-}	Discharge with most difficulty.
NO_3^-	The anions are discharged at anode by loss of electrons.
Cl^-	The tendency of anion to get oxidised at anode increases from top to bottom in electrochemical series.
Br^-	
I^-	Discharge with maximum ease.
OH^-	

Increasing ease of oxidation ↓

Factors on which Selective Discharge of Ions depends

The three factors on which selective discharge of ions depends are as follows

1. The Relative Position of the Ions in an Electrochemical Series

Lower the position of an ion in an electrochemical series more easily it will get discharged at the respective electrode (discuss earlier).

Some examples are as follows

(i) Aqueous Solution of Copper Sulphate

$$CuSO_4 \longrightarrow Cu^{2+} + SO_4^{2-}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Cation Cu^{2+}, H^+, **Anion** SO_4^{2-}, OH^-

- Both Cu^{2+} and H^+ cations migrate to the cathode but only Cu^{2+} ion will discharge in preference of H^+ ions, as the position of Cu^{2+} ion is lower than H^+ ions in electrochemical series.
- Both SO_4^{2-} and OH^- anions migrate to anode but only OH^- ion will discharge, as the position of OH^- is lower than SO_4^{2-} ions in electrochemical series.

(ii) Diluted Solution of Sodium Chloride

$$NaCl \longrightarrow Na^+ + Cl^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Cation Na^+ and H^+

Anion Cl^- and OH^-

- Both Na^+ and H^+ cation will migrate to cathode but only H^+ ions will discharge in preference to Na^+ ions as the position of H^+ is lower than Na^+ ions in the electrochemical series.
- Both Cl^- and OH^- anion will migrate to anode but only OH^- ions will discharge in preference to Cl^-, because position of OH^- ion is lower than Cl^- ion in electrochemical series.

2. Concentration of Ions in the Electrolyte

Higher the concentration of the ion, greater the probability of it, being discharged at the respective electrode.

e.g., **Electrolysis of concentrated NaCl solution**

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Cathode Na^+ ions discharged

Anode Cl^- ions discharged

Concentration of Na^+ and Cl^- ions are much higher than H^+ and OH^- ions, respectively.

Electrolysis of Dilute NaCl Solution

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Cathode H^+ ions discharged

Anode OH^- ions discharged

Concentration of H^+ and OH^- ions are much higher than Na^+ and Cl^- ions, respectively.

3. Nature of the Electrodes

Electrodes used in the process of electrolysis are either inert or active. If the electrodes are active (*i.e.*, Cu, Ni, Ag) they will take part in a chemical reaction. Then, the anions (*e.g.*, SO_4^{2-} and OH^- ions) migrate to the anode but are not discharged.

An active electrode (Cu, Ag) itself loses electrons and forms ions *e.g.*, Cu^{2+}, Ag^+ at the anode. If inert electrode like iron, graphite, platinum are used, they will not take part in electrolytic reaction.

CHECK POINT 02

1. Metals are called electropositive elements and non-metals are called electronegative elements. Explain on the basis of their activity in an electrolytic cell.
2. Common salt is a bad conductor of electricity in solid form but conducts electricity when present in aqueous state or in molten state. Why?
3. Explain ionisation of HCl in aqueous state.
4. Give one point of difference between ionisation and dissociation.
5. Why iron decolourises the blue colour of copper sulphate solution but silver does not?
6. During electrolysis of copper sulphate and sodium chloride in aqueous medium, name the cations which would be preferably discharged at cathode.

Examples of Electrolysis

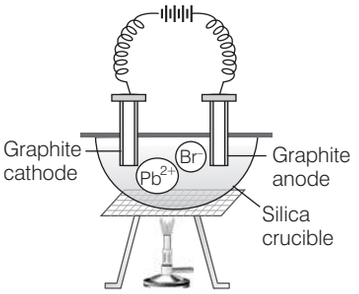
The various examples of electrolysis are discussed below

1. Electrolysis of Molten Lead Bromide

Electrolytic cell Crucible (*i.e.*, made of silica)

Electrolyte Molten lead bromide ($PbBr_2$)

Electrodes Cathode and anode both are made up of graphite plate (inert electrode).



Electrolysis of molten lead bromide

Electrode Reactions

At cathode Pb^{2+} ions migrate to cathode. They take two electrons each and become neutral lead atoms.

$$Pb^{2+} + 2e^- \longrightarrow Pb$$

At anode Br^- ion migrate to anode. It gives an electron and become bromine atom.

Two bromine atoms combine to form bromine molecules.

$$Br^- \longrightarrow Br + e^-$$

$$Br + Br \longrightarrow Br_2$$

Overall reaction

$$PbBr_2(l) \xrightarrow{380°C} Pb(s) + Br_2(g)$$

Observation

(i) Dark reddish brown fumes of bromine evolve at the anode.

(ii) Greyish white metal lead is formed at the cathode.

Note The silica crucible is heated from outside to keep lead bromide in the molten state. The silica is used because it can withstand high temperature and acts as a non-conductor. It is non-reactive in nature.

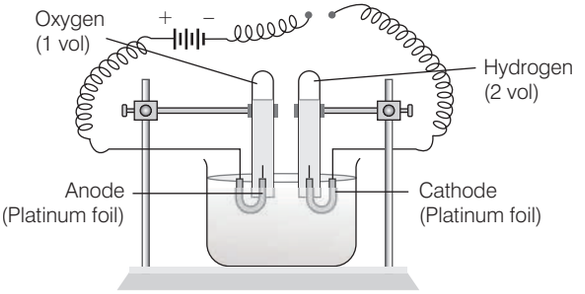
2. Electrolysis of Acidified Water Using Platinum Electrode

Electrolytic cell Hoffmann voltmeter

Electrolyte Acidified water (water + dil. H_2SO_4)

Note Dil. H_2SO_4 is preferred because it is a non-volatile acid while dil. HNO_3 or HCl acids are volatile acid.

Electrodes Platinum foils (inert), **Current** 3A



Electrolysis of acidified water using platinum electrodes

Ionisation of Acidified Water

Water is a non-conductor of electricity. It is a polar covalent compound and can form ions, when traces of dil. H_2SO_4 is added and hence, dil. H_2SO_4 catalysed the ionisation.

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

At cathode H^+ ion migrate to cathode. It gains an electron and become a neutral hydrogen atom.

$$H^+ + e^- \longrightarrow [H]$$

Now, the H_2 gas is formed as two hydrogen atoms combine to form a molecule.

$$[H] + [H] \longrightarrow H_2 \uparrow$$

At anode SO_4^{2-} and OH^- both ions migrate to the anode. OH^- loses one electron to the anode and becomes neutral OH.

$$OH^- - e^- \longrightarrow OH$$
$$4OH \longrightarrow 2H_2O + O_2 \uparrow$$

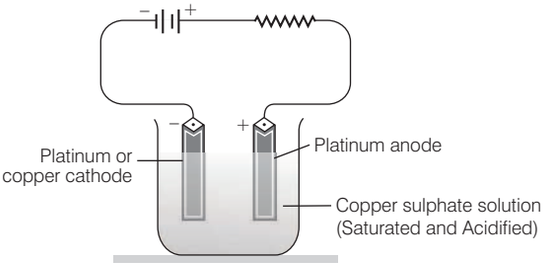
The electrolysis of acidified water can be summarised as

$$2H_2O \xrightarrow[\text{Electric current}]{H_2SO_4} \underset{\text{(cathode) 2 Vol}}{2H_2(g)} + \underset{\text{(anode) 1 Vol}}{O_2(g)}$$

The ratio of hydrogen and oxygen liberated at the cathode and anode is in the ratio of 2 : 1 by volume.

3. Electrolysis of Copper Sulphate Solution using Platinum Anode and Copper or Platinum Cathode

Electrolytic cell – Glass or a porcelain jar
Electrolyte → Saturated solution of copper (II) sulphate
Electrode : Cathode → Platinum or copper
Anode → Platinum



Electrolysis of copper sulphate solution

Dissociation of Aqueous Copper Sulphate

$$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$$
$$H_2O \rightleftharpoons H^+ + OH^-$$

At cathode Cu^{2+} and H^+ ions migrate to the cathode. The position of Cu^{2+} ions is lower than H^+ in the electrochemical series. Thus, Cu^{2+} ions are discharged at the cathode as neutral copper atoms by accepting electrons.

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

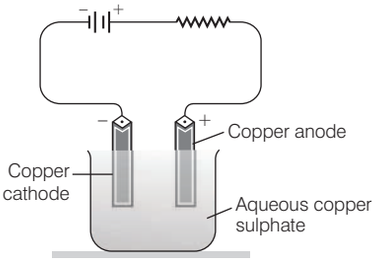
At anode SO_4^{2-} and OH^- ions migrate to the anode but OH^- ions are discharged since they are lower than SO_4^{2-} ions in the electrochemical series.

$$[OH^- - e^- \longrightarrow OH] \times 2$$
$$2OH \longrightarrow H_2O + (O)$$
$$4OH \longrightarrow 2H_2O + O_2$$

Note When the deposition of Cu^{2+} ions is completed then electrolysis of water takes place. Hydrogen gas is liberated at the cathode and oxygen gas is liberated at the anode. The blue colour of Cu^{2+} ions in the electrolyte solution fades slowly due to decrease in Cu^{2+} ions and as soon as Cu^{2+} ions are finished, the solution becomes colourless.

4. Electrolysis of Aqueous Copper Sulphate using Copper Electrodes

Electrolytic cell → Iron crucible/glass voltmeter
Electrolyte → Aqueous copper sulphate
Electrode → **Cathode** : Copper, **Anode** : Copper
Current → 3A



Electrolysis of aqueous copper sulphate

Dissociation of Copper Sulphate (*aq*)

$$\underset{\text{Copper sulphate}}{CuSO_4} \rightleftharpoons Cu^{2+} + SO_4^{2-}$$
$$H_2O \rightleftharpoons H^+ + OH^-$$

Thus, ions present are Cu^{2+}, H^+, SO_4^{2-}, OH^-

At cathode Both Cu^{2+} ions and H^+ ions migrate to the cathode but Cu^{2+} ions are discharged in preference to H^+. (Cu^{2+} is lower than H^+ in the electrochemical series).

$$Cu^{2+} + 2e^- \longrightarrow Cu \text{ (reduction reaction)}$$

Brownish pink metal Cu is deposited at the cathode during electrolysis of $CuSO_4$ solution.

At anode SO_4^{2-} and OH^- ions migrate to the anode but neither get discharged. The copper anode loses electrons more easily than SO_4^{2-} and OH^- ions because the copper is an active electrode and hence, copper anode itself ionises to give Cu^{2+} ions.

$$Cu \longrightarrow Cu^{2+} + 2e^- \text{ (oxidation reaction)}$$

Note The blue colour of aqueous copper (II) sulphate solution remains unchanged during its electrolysis due to the presence of copper electrode but fades when platinum electrodes are used.

Summary of Product at Cathode and Anode During Electrolysis Process

	Electrolysis process	Cathode	Anode
(i)	Molten lead bromide with inert electrodes	Lead metal	Bromine vapours
(ii)	Acidified water with inert electrodes	Hydrogen	Oxygen
(iii)	Copper sulphate solution using Pt anode and Cu or Pt cathode	Pink or reddish brown copper	Oxygen
(iv)	Aqueous copper sulphate with copper electrode	Reddish brown copper metal	Nil

CHECK POINT 03

1. Name the anions and cations deposited at the respective electrodes during the following electrolysis.
   (i) Electrolysis of molten lead bromide.
   (ii) Electrolysis of aqueous copper sulphate using copper electrodes.
2. Give the overall reaction for the electrolysis of molten lead bromide.
3. Why dil. H_2SO_4 is preferred as electrolyte in the electrolysis of acidified water?
4. Give the reactions that occur at cathode and anode in the electrolysis of copper sulphate solution using platinum anode and copper or platinum cathode.

Applications of Electrolysis

The main applications of electrolysis are

(i) electroplating of metals
(ii) electro-refining or purification of metals
(iii) extraction of metals *i.e.*, electrometallurgy

Electroplating of Metals

Electroplating is the electrolytic process of deposition of a superior metal (*e.g.*, Nickel, silver, chromium, gold) on the surface of a base metal or article (*e.g.*, Iron, copper, brass).

Electroplating is required to prevent corrosion or rusting. *e.g.*, Iron is plated with nickel or chromium. They are also used for decoration purposes *i.e.*, it makes the article attractive and gives it an expensive appearance.

e.g., Brass metal plated with silver or gold.

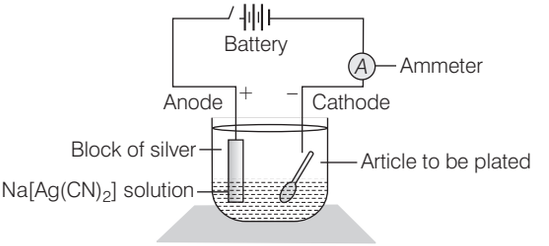
Conditions to be Maintained during Electroplating

(i) The article to be deposited is always made the cathode in electrolysis since the metal is deposited at the cathode.
(ii) The metal to be plated on the article is always made the anode since metal at anode continuously dissolves into the solution and it has to be replaced periodically.
(iii) The electrolyte solution must contain the metal ions like Ag, Au, Ni since these ions travel towards cathode and get deposited on the metal placed at cathode.
(iv) Low current has to be supplied for longer time.
(v) Only direct current is to be used because alternating current causes discharge or ionisation on alternate electrode. No effective coating takes place on cathode.

Some cases of electroplating are discussed below

Electroplating an Article with Silver

In order to get a perfect deposit of silver on brass spoon, the spoon is first cleaned, washed with caustic soda followed by hydrochloric acid and water (to remove impurity, if present). The spoon is then dried and made the cathode.



Electroplating an article with silver

Electrolyte

Aqueous solution of sodium silver cyanide *i.e.*, sodium argentocyanide, $Na[Ag(CN)_2]$. It is prepared by adding sodium cyanide to a solution of silver nitrate till the precipitate is formed.

$$AgNO_3 + NaCN \longrightarrow AgCN\downarrow + NaNO_3$$

$$AgCN + NaCN \longrightarrow \underset{\text{(sodium argentocyanide)}}{Na[Ag(CN)_2]}$$

Nature of Electrode

Cathode Cleaned article to be electroplated.

Anode Active electrode plate or block of silver metal from anode goes into electrolyte.

Electrode Reactions

(Dissociation of aqueous sodium silver cyanide)

$$Na[Ag(CN)_2] \rightleftharpoons Na^+ + Ag^+ + 2CN^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$NaCN \rightleftharpoons Na^+ + CN^-$$

Reaction at Cathode

$$\underset{\text{(from electrolyte)}}{Ag^+ + e^-} \longrightarrow Ag\,[\text{deposited}]$$

In the presence of Na^+, OH^-, H^+, Ag^+, only Ag^+ ions move towards the cathode and discharged as Ag atoms by gaining of electrons and deposits on spoon as a firm coating. The thickness of coating will depend on the duration of the current passed.

Reaction at Anode

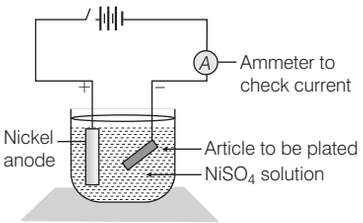
$$Ag - e^- \longrightarrow \underset{\substack{\text{Goes into}\\ \text{electrolyte}}}{Ag^+} \quad [\text{cation}]$$

The anions *i.e.*, CN^- and OH^- migrate to the anode but neither get discharged because their reduction potential is higher than silver. The atoms of silver anode lose electrons

to form Ag^+ ions (low electrode potential) and enter into the solution. The overall strength of Ag^+ ions does not change in the electrolyte as the number of Ag^+ ions entering and the number of Ag^+ ions discharged at the cathode are equal.

Electroplating an Article with Nickel

Iron article gets easily rusted when exposed to air. Iron articles if coated with nickel, rusting can be prevented.



Electroplating an article with nickel

Electrolyte

Aqueous solution of nickel sulphate [$NiSO_4$] with few drops of dilute H_2SO_4 is used as electrolyte.

Nature of Electrode

Cathode Cleaned article to be electroplated.

Anode Block of pure nickel metal.

Electrode Reactions

(Dissociation of aqueous nickel sulphate)

$$NiSO_4 \rightleftharpoons Ni^{2+} + SO_4^{2-}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Reaction at Cathode

$$Ni^{2+} + 2e^- \longrightarrow Ni \quad \text{[deposited]}$$

In presence of H^+, Ni^{2+} ions only nickel ion *i.e.*, Ni^{2+} move towards the cathode and discharged as neutral Ni atoms. Nickel is deposited on the article.

Reaction at Anode

$$Ni \longrightarrow Ni^{2+} + 2e^- \quad \text{[cation]}$$

Anion *i.e.*, SO_4^{2-} and OH^- ions migrate to the anode but neither get discharged due to the nature of electrode. Instead the nickel anode loses electrons to give Ni^{2+} ions in solution. Hence, anode diminishes in mass.

Nature of Electrode Ni active electrode.

CHECK POINT 04

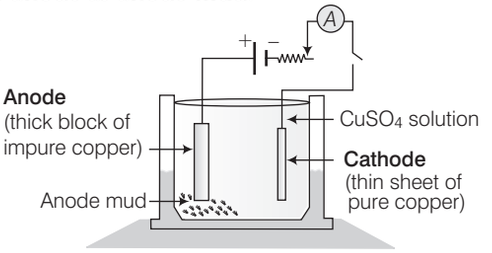
1. Which two conditions should be maintained during electroplating?
2. At which electrode, a spoon should be placed in order to electroplate it with silver?
3. Why silver nitrate solution is not used for electroplating with silver?
4. How electroplating with nickel can prevent iron from rusting?
5. Name the electrolyte which is used during the electroplating of an article with nickel.

Electrolytic Refining or Electrorefining of Metals

The word 'electrolytic refining' contains two terms, 'electrolytic' which means a method employed for chemical decomposition and 'refining' which means removing the impurities to make the metal pure. Thus, electrolytic refining or electrorefining is a process by which impurities are removed from an impure metal, during electrolysis. Metals such as copper, nickel, silver, zinc are refined by electrolytic refining.

Electrolytic Refining or Purificaion of Copper

The purest copper is obtained by an electrolytic process, using a slab of impure copper as the anode and a thin sheet of pure copper as the cathode. The electrolyte is an acidic solution of copper sulphate. By passing electricity through the cell, copper is dissolved from the anode and get deposited on the cathode. However, impurities either remains in solution or which are insoluble get collected near the anode as anode mud.



Electro-refining of copper

Electrolyte

Solution of copper sulphate and hot sulphuric acid is used as an electrolyte.

Nature of Electrode

Cathode Pure thin sheet of copper

Anode Impure plate of copper

Electrode Reactions

(Dissociation of aqueous copper sulphate)

$$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Reaction at Cathode When the electric current is passed through the electrolyte, the copper ions (from the solution of copper sulphate) are attracted to the cathode.

$$Cu^{2+} + 2e^- \longrightarrow Cu \quad \text{(anion)}$$

At cathode, copper ion gains electron (change into neutral) and get deposited on the pure copper strip.

Reaction at Anode The impure copper (anode) loses electrons to give Cu^{2+} ions in the solution. These ions migrate to copper at the cathode and get deposited. Hence,

anode (the impure slab) gets diminished in mass and thin strip of pure copper becomes thicker.

$$Cu - 2e^- \longrightarrow Cu^{2+} \qquad \text{(cation)}$$

After electrolysis this strip is melted and transformed into desired shapes. The copper deposited is 99.9% pure.

Note The insoluble impurity gets collected at anode (anode mud) and recovered e.g., Silver and gold.

Electrometallurgy

It is the process of extraction of metals by electrolysis. Metals which are comparatively higher in the electrochemical series are extracted by electrolysis.

(i) Metals at the top of series K, Na, Ca, Mg, Al are extracted by the electrolysis of their fused salts.

(ii) Metals which are in the middle of the activity series like Zn, Fe, Pb, Cu (*i.e.,* below Al) are extracted by reduction of their oxides. They are generally extracted by using reducing agents like carbon (C), carbon monoxide (CO) and hydrogen (H_2), as their oxides are less stable because their ionic bond easily breaks.

(iii) Metals existing at the bottom side in the activity series like Pt and Au, are generally extracted by the thermal decomposition of their oxides.

K Na Ca Mg Al	Zn Fe Pb H Cu Hg Ag	Pt Au
Highly electropositive metals which are reduced by electrolytic method	Reduced by using conventional reducing agents, C, CO and H_2	Extracted by thermal decomposition of their oxides

Reactive metals are extracted from their halides by electrolysis using inert electrodes and cathode is usually made up of iron and anode of graphite.

Different examples are given below

Extraction of Potassium

Electrolyte Potassium bromide [fused]

Dissociation Reaction of Electrolyte

$$KBr \rightleftharpoons K^+ + Br^-$$

Reaction at Cathode $K^+ + e^- \longrightarrow K$

Reaction at Anode $Br^- - e^- \longrightarrow Br$

$$Br + Br \longrightarrow Br_2$$

Extraction of Sodium

Electrolyte Sodium chloride [fused]
Cathode Iron
Anode Graphite

Dissociation Reaction of Electrolyte

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

Reaction at cathode $Na^+ + e^- \longrightarrow Na$

Reaction at Anode $Cl^- - e^- \longrightarrow Cl$

$$Cl + Cl \longrightarrow Cl_2$$

Extraction of Magnesium

Electrolysis Magnesium chloride (fused)

Dissociation Reaction of Electrolyte

$$MgCl_2 \rightleftharpoons Mg^{2+} + 2Cl^-$$

Reaction at cathode $Mg^{2+} + 2e^- \longrightarrow Mg$

Reaction at anode $Cl^- - e^- \longrightarrow Cl$

$$Cl + Cl \longrightarrow Cl_2$$

Extraction of Calcium

Electrolyte Calcium chloride (fused)
Cathode Iron
Anode Graphite

Dissociation Reaction of Electrolyte

$$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$$

Reaction at the cathode $Ca^{2+} + e^- \longrightarrow Ca$

Reaction at anode $Cl^- - e^- \longrightarrow Cl$

$$Cl + Cl \longrightarrow Cl_2$$

Extraction of Aluminium

Electrolyte Aluminium oxide (Al_2O_3)

Cathode Gas carbon lining
Anode Graphite rod

Dissociation Reaction of Electrolyte

$$Al_2O_3 \rightleftharpoons 2Al^{3+} + 3O^{2-}$$

Reaction at Cathode $2Al^{3+} + 6e^- \longrightarrow 2Al$

Reaction at Anode $3O^{2-} - 6e^- \longrightarrow 3[O]$

$$3[O] + 3[O] \longrightarrow 3O_2$$

CHECK POINT 05

1. Explain the process of formation of anode mud during the electrorefining of copper.
2. Describe the process of extraction of an active metal from its chloride.
3. Write all chemical reactions involved in the electrolytic dissociation of $CuSO_4$.
4. Complete the following sentence.
   Metals exist at the bottom side in the activity series like …… and …… are extracted by the thermal decomposition of their oxides.

SUMMARY

- The substances which have very high conductivity are known as conductors.
- Conductors are of two types, metallic and electrolytic.
- The compounds which conduct electricity when dissolved in water or in molten state are called electrolytes and these are either strong or weak.
- Electrolytic cell is the device in which electrolysis is carried out.
- Electrochemical cell is a device which is used to convert chemical energy into electrical energy.
- Electrode is a metallic rod or plate through which the electric current enters or leaves the electrolyte during electrolysis.
- The electrode at which oxidation occurs is called anode. Anions move towards anode during electrolysis.
- The electrode at which reduction occurs is called cathode. Cations move towards cathode.
- The process due to which an ionic compound in the molten state or in aqueous state dissociates into ions by the passage of electric current through it is called electrolytic dissociation.
- Ionisation is the process of formation of positively and negatively charge ions from molecule which are not initially in the ionic state.
- The series in which the various metals are arranged in the decreasing order of their tendencies to lose electrons is called electrochemical series.
- If the electrolyte contains more than one type of cations or anions, the cation and anion which are discharged preferentially at the respective electrodes depends upon position of the ion in the electrochemical series, concentration of the ion in the solution, nature of the material of the electrode.
- The applications of electrolysis includes electroplating of metals, electrorefining of metals and extraction of metals.

EXAM PRACTICE

Fill in the Blanks

1. ..... is an electrically charged atom.

Sol. Ion

2. Electrolysis is the passage of ..... (electricity/electrons) through a liquid or a solution accompanied by a ..... (physical/chemical) change.

Sol. electricity, chemical

3. Cations are formed by ..... (loss/ gain) of electrons and anions are formed by …… (loss/gain) of electrons.

Sol. loss, gain

4. NaCl is a ..... electrolyte.

Sol. strong

5. Water is a ..... electrolyte.

Sol. weak

6. Electrolysis of aqueous sodium chloride solution will form ..... at the cathode. (hydrogen gas/sodium metal) ***[2018]***

Sol. hydrogen gas

7. …… is negative electrode in electrolytic cell.

Sol. Cathode

8. Pure water consists almost entirely of …… (ions/molecules).

Sol. molecules

9. We can expect that pure water …… (will/will not) normally conduct electricity.

Sol. will not

10. Those elements which are liberated at anode during the electrolysis are called …… elements.

Sol. electronegative

11. As we descend the electrochemical series containing cations, the tendency of the cations to get …… (oxidised/reduced) at the cathode increases.

Sol. reduced

12. The …… (higher/lower) the concentration of an ion in a solution, the greater is the probability of it being discharged at its appropriate electrode.

Sol. higher

13. The sodium chloride is an (i)..... compound. It contain (ii) ..... and (iii)..... ions in its crystal. In solid state, NaCl ions are (iv)..... to move because of the presence of (v) ..... force of attraction. Thus it (vi)..... electricity.

Sol. (i) electrovalent (ii) Na^+
(iii) Cl^- (iv) not free
(v) electrostatic (vi) will not conduct

14. When we use platinum electrode, oxygen is liberated at …… and hydrogen is at …… during electrolysis of acidified water.

Sol. anode, cathode

15. …… is a process of electrolytic deposition of superior metal on base metal.

Sol. Electroplating

Multiple Choice Questions

16. Identify the weak electrolyte from the following. ***[2012]***

(a) Sodium chloride solution
(b) Dilute hydrochloric acid
(c) Dilute sulphuric acid
(d) Aqueous acetic acid

Sol. (d)

17. The particles present in strong electrolytes are ***[2016]***

(a) only molecules (b) mainly ions
(c) ions and molecules (d) only atoms

Sol. (b) Greater the number of ions in solution, stronger is the electrolyte.

18. Which of these will act as a non-electrolyte? ***[2013]***

(a) Liquid carbon tetrachloride
(b) Acetic acid
(c) Sodium hydroxide aqueous solution
(d) Potassium chloride aqueous solution

Sol. (a)

19. The electrolysis of acidifed water is an example of ***[2018]***

(a) reduction (b) oxidation
(c) redox reaction (d) synthesis

Sol. (a)

20. During the electrolysis of molten lead bromide, which of the following takes place? *[2008]*
(a) Bromine is released at the cathode
(b) Lead is deposited at the anode
(c) Bromine ions gain electrons
(d) Lead is deposited at the cathode

Sol. (a)

21. When fused lead bromide is electrolysed, we observe *[2014]*
(a) a silver grey fumes form at anode and reddish brown fumes formed at cathode.
(b) a silver grey deposit at cathode and reddish brown fumes formed at anode.
(c) a silver grey deposit at cathode and a reddish brown deposit at anode
(d) a silver grey deposit at anode and a reddish brown deposit at cathode

Sol. (b)

22. A compound which liberates reddish brown gas around the anode during electrolysis in its molten state is
(a) sodium chloride (b) copper (II) oxide
(c) copper (II) sulphate (d) lead (II) bromide

Sol. (d)

23. During the electrolysis of copper sulphate solution, the mass of anode gradually
(a) remains same (b) decreases
(c) increases (d) None of these

Sol. (b)

24. Which of the following is correct?
(a) The metal to be plated on the article is always made the cathode.
(b) The metal to be plated on the article is always made the anode.
(c) For electroplating, high amount of electricity is supplied for longer time.
(d) All are correct statement.

Sol. (b)

25. What would be the anode during the silver plating of an article having argentocyanide as an electrolyte?
(a) Fe (b) Pt
(c) Cu (d) Ag

Sol. (d)

26. Which of the following is incorrect about electro-refining of copper?
(a) Cathode is pure copper rod
(b) Anode is impure copper block
(c) Electrolyte is copper sulphate solution, acidified with sulphuric acid
(d) Anode consists of both copper metal and its impurities.

Sol. (d)

Match the Following

27. Match the following columns.

	Column I		Column II
(i)	Ammonium hydroxide solution	(a)	Contains only ions
(ii)	Dilute hydrochloric acid	(b)	Contains only molecules
(iii)	Carbon tetrachloride	(c)	Contains ions and molecules

[2012]

Sol. (i) (c) , (ii) (a), (iii) (b)

28. Match the following columns.

	Column A		Column B
(i)	Article to be electroplated	(a)	at anode
(ii)	Impure copper during electrorefining	(b)	in electrolytic solution
(iii)	Anode mud during electrorefining	(c)	at cathode

Sol. (i) (c), (ii) (a), (iii) (b)

29. Choose (i), (ii) and (iii) or (iv) to match the description (a) to (e) given below. Some points may be repeated.
(i) Non-electrolyte
(ii) Strong electrolyte
(iii) Weak electrolyte
(iv) Metallic conductor
(a) Molten ionic compound
(b) Carbon tetrachloride
(c) An aluminium wire
(d) A solution containing solvent molecules, solute molecules and ions formed by the dissociation of solute molecules.
(e) A sugar solution with sugar molecules and water molecules.

Sol.

(a)	Molten ionic compound	Strong electrolyte
(b)	Carbon tetrachloride	Non-electrolyte
(c)	An aluminium wire	Metallic conductor
(d)	Solution containing solvent, solute and ions	Weak electrolyte
(e)	Sugar solution	Non-electrolyte

α 1 Mark Questions

30. Name the particle that move when electric current is passed through metal wire.

Sol. Electron

31. Give reason for the following.
An aqueous solution of sodium chloride conducts electricity.

Sol. Aqueous solution of sodium contains mobile ions like $Na^+, Cl^-, H^+, OH^-, H_3O^+$ ions which are responsible for conduction of electricity.

32. Name the following. *[2017]*
The process of coating of iron with zinc.

Sol. Galvanization

33. Which type of water does not conduct electricity?

Sol. Pure water

34. Give one word/phrase for the following.
Some compound/solution do not conduct electricity.

Sol. Non-electrolytes

35. State one relevant observation for each of the following.
At the anode, when molten lead bromide is electrolysed using graphite electrodes. *[2018]*

Sol. When molten lead bromide is electrolysed using graphite electrode, dark reddish brown fumes of bromine is evolved at anode.

At anode

$$Br^- \longrightarrow Br + e^-$$
$$Br + Br \longrightarrow \underset{\text{(Reddish brown fumes)}}{Br_2}$$

36. State the term used for a liquid or solution which conducts electricity with accompanying chemical change.

Sol. Electrolyte

37. Some word/words are missing in the following statements. You are required to rewrite the statements in the correct form using the appropriate word/words.
Cations migrate during electrolysis.

Sol. Cations migrate towards cathode during electrolysis.

38. Give one word or phrase for the following.
Formation of ions from molecules. *[2014]*

Sol. Ionisation

39. Name the process by which a particle gains or loses electrons.

Sol. Ionisation

40. Name an acidic solution in which there is only partial ionisation of the solute molecules.

Sol. Acetic acid solution.

41. Why is carbon tetrachloride, which is a liquid, a non-electrolyte?

Sol. Carbon tetrachloride being a non-polar covalent compound does not have ions. So, does not conduct electricity and hence, called a non-electrolyte.

42. State one appropriate observation for the following.
Electricity is passed through molten lead bromide.

Sol. Molten lead bromide dissociates as silvery white metal (lead) at cathode, brown vapours of bromine comes at anode.

43. Name the pink metal which gets deposit at the cathode during the electrolysis of the solution of copper sulphate using Pt anode and Cu or Pt cathode.

Sol. Copper

44. Give a reason for each of the following.
Conductivity of dilute hydrochloric acid is greater than that of acetic acid. *[2018]*

Sol. Conductivity of a solution depends upon the number of ions produced into the solution. Hydrochloric acid (HCl) being a strong electrolyte completely ionised in solution, whereas acetic acid (CH_3COOH) is a weak electrolyte and hence does not completely ionised. Therefore, the conductivity of dilute hydrochloric acid is more as compared to acetic acid.

45. Why $CuSO_4$ solution cannot be stored in a zinc vessel?

Sol. Because Zn is more reactive than copper. Therefore, it will displace Cu from $CuSO_4$ solution.

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

46. Name the gas that is produced in each of the following cases.
At the anode during the electrolysis of acidified water. *[2018]*

Sol. Oxygen (O_2) gas

$$4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^- \text{ (At anode)}$$

47. Name the gas obtained at the cathode, when electric current is passed through the dilute HCl solution.

Sol. Chlorine gas.

48. Identify the substance underlined in the following case
The <u>electrolyte</u> used for electroplating an article with silver. *[2017]*

Sol. Aqueous solution of sodium argentocyanide, $Na[Ag(CN)_2]$ or potassium argentocyanide, $K[Ag(CN)_2]$ are used as electrolyte for electroplating an article with silver.

49. Which type of ions must be present in a solution used for electroplating a particular metal?

Sol. Metal ions must be present in solution because metal ions make anode or ions of the metal with which cathode metal is to be electroplated.

50. Name an electrolyte used in the process of nickel plating?

Sol. Nickel ammonium sulphate

51. Name an electrolyte used in the process of silver plating.

Sol. Potassium argentocyanide.

52. A solution of silver nitrate is a good electrolyte but it is not used for electroplating an article with silver. Why?

Sol. Silver nitrate is not used for electroplating because electroplating is not uniform due to fast reaction.

53. Name the process that is used for obtaining highly electropositive metals.

Sol. Electrometallurgy.

54. Name the electrolyte used as anode during the extraction of aluminium.

Sol. Carbon rods

b 2 Marks Questions

55. Which electrode, anode or cathode is the oxidising electrode? Why? ***[2014]***

Sol. An electrode that is connected to positive terminal of battery is an oxidising electrode *i.e.,* anode.

During electrolysis, anode acquires a positive charge and hence ions in a solution which are negative charged migrate to anode. The anions donate excess electrons to the anode and are oxidised to neutral atoms. ***[2]***

56. Differentiate between the terms strong and weak electrolytes (stating any two differences). ***[2015]***

Sol.

Strong electrolyte	Weak electrolyte
It dissociates into ions to a large extent.	It dissociates into ions to a small extent.
In aqueous solution, it consists of mainly ions.	In aqueous solution, it consists of ions as well as molecules.

[2]

57. Explain how electrolysis is an example of redox reaction?

Sol. The reaction at the cathode involves reduction of cations as they gain electrons to become neutral atoms while that at anode involves oxidation of anions as they lose electrons to become neutral atoms.

e.g., $NaCl \rightleftharpoons Na^+ + Cl^-$

At cathode $Na^+ + e^- \longrightarrow Na$ (reduction)

At anode $Cl^- \longrightarrow Cl + e^-$ (oxidation)

Overall reaction $2NaCl \longrightarrow 2Na + Cl_2$ ***[2]***

58. Give reason, why electrolysis of acidulated water is considered to be an example of catalysis?

Sol. Pure water is a poor conductor of electricity and can form ions, when traces of dil. H_2SO_4 is added and hence dil. H_2SO_4 catalysed the ionisation. ***[2]***

59. Give reason

(i) Dilute acids are strong acids

(ii) Sea water is a strong electrolyte

Sol. (i) Because dilute acid produces a large number of hydronium ions. ***[1]***

(ii) Sea water is not a pure water, it contains NaCl which dissociates completely into free mobile ions and behave as strong electrolyte.

$NaCl \rightleftharpoons Na^+ + Cl^-$ ***[1]***

60. Give reason

(i) A graphite anode is prefered to other inert electrodes during electrolysis of fused lead bromide

(ii) Copper is a good conductor of electricity but act as non electrolyte.

Sol. (i) Because graphite is unaffected by reactive bromine vapours. ***[1]***

(ii) Copper is a good conductor of electricity because during metallic conduction, their is flow of electricity but it is a non-electrolyte, as its chemical properties are intact means it does not undergo any chemical decomposition (no new product formed) only heat and energy is produced. ***[1]***

61. (i) Name the gas released at the cathode when acidulated water is electrolysed.

(ii) Explain why solid sodium chloride does not allow electricity to pass through?

Sol. (i) When acidulated water is electrolysed, hydrogen (H_2) gas is evolved. ***[1]***

(ii) Solid sodium chloride does not allow electricity to pass through because solid NaCl does not have free ions (Na^+, Cl^-) to carry the electric current. Free ions are responsible for the current to flow. ***[1]***

62. Give reason.

(i) Blue colour of $CuSO_4$ solution slowly disappear when iron rod is dipped in it.

(ii) Wax is not a good conductor of electricity.

Sol. (i) Iron displace copper from $CuSO_4$ to form $FeSO_4$ which is light green in colour.

$$Fe(s) + CuSO_4(aq) \longrightarrow Cu(s) + \underset{\text{Light green}}{FeSO_4}(aq)$$

$$Fe + Cu^{2+} \longrightarrow \underset{\text{Light green}}{Fe^{2+}} + Cu$$

[1]

(ii) Wax does not have free ions to move because it is a covalent compound, thus it does not conduct electricity. *[1]*

63. Select the ion in each case, that would get selectively discharged from the aqueous mixture of the ions listed below.

(i) SO_4^{2-}, NO_3^- and OH^-

(ii) Pb^{2+}, Ag^+ and Cu^{2+} *[2017]*

Sol. (i) Based on the tendency to lose electrons and get discharged at the anode, the anions have been arranged in increasing order (on moving downward) in electrochemical series. For given ions, *order is as follows*

$$SO_4^{2-} < NO_3^- < OH^-$$ *[1]*

(ii) Based on the case with which atoms of metal lose electrons to form positively charged ions the metals are arranged in increasing order in electrochemical series. For given ions, *order is as follows*

$$Pb^{2+} < Cu^{2+} < Ag^+$$ *[1]*

64. Differentiate between electrical conductivity of copper sulphate solution and copper metal. *[2012]*

Sol. During electrolysis of copper (II) sulphate solution, the $CuSO_4$ splits into Cu^{2+} and SO_4^{2-} ions. *[1]*

Copper metal only conducts electricity but does not undergo any change. *[1]*

65. Three different electrolytic cells *A*, *B* and *C* are connected in separate circuits. Electrolytic cell, *A* contains sodium chloride solution.

When the circuit is completed, a bulb in the circuit glows brightly. Electrolytic cell, *B* contains acetic acid solution and in this case, the bulb in the circuit glows dimly. The electrolytic cell, *C* contains sugar solution and the bulb does not glow. Give a reason for each of these observations.

Sol. *A* has a sodium chloride solution which is a strong electrolyte containing only ions. So, more electricity is conducted and bulb glows brightly.

B contains acetic acid which is weak electrolyte. So, acetic acid has less number of ions and conducts less electricity. Hence, bulb glows dimly.

C contains sugar solution which is a non-electrolyte and a covalent compound. It does not contain ions in the solution so, electricity is not conducted and bulb does not glow. *[2]*

66. (i) Name the product formed at the anode during the electrolysis of acidified water using platinum electrodes.

(ii) Name the metallic ions that should be present in the electrolyte when an article made of copper is to be electroplated with silver. *[2016]*

Sol. (i) During electrolysis of water using platinum electrode, following reaction takes place at anode.

$$4OH^-(aq) \longrightarrow 2H_2O + O_2(g) + 4e^-$$ *[1]*

Oxygen gas (O_2) is evolved at anode.

(ii) Ag^+ and Na^+ are present in the electrolyte when an article made of copper is electroplated with silver because the electrolyte used is sodium argento cyanide. *[1]*

67. For the electro-refining of copper, *[2018]*

(i) what is the cathode made up of ? *[1]*

(ii) write the reaction that takes place at the anode. *[1]*

Sol. For the electrolytic refining of copper

(i) Pure copper strip is taken as cathode and Cu^{2+} ions are discharged at the cathode. Thus, pure copper deposited on the thin sheet of copper placed at a cathode.

(ii) Reaction at anode,

$$Cu \longrightarrow Cu^{2+} + 2e^-$$

Impure copper is taken as anode and acidified solution of copper sulphate $(CuSO_4)$ acts as an electrolyte. Both SO_4^{2-} and OH^- migrate to the anode but neither are discharged. Instead, the copper anode itself looses electrons to give Cu^{2+} ions in solution.

68. Define electroplating. Give two requirement for electroplating.

Sol. Electroplating is a electrolytic process of deposition of a superior metal (*e.g.,* Nickel, silver on the surface of a base metal or article).

Two requirements for electroplating are

(i) To prevent corrosion. *[1]*

(ii) For decoration. *[1]*

c 3 Marks Questions

69. Identify the following reactions as either oxidation or reduction.

(i) $O + 2e^- \longrightarrow O^{2-}$

(ii) $K \longrightarrow K^+ + e^-$

(iii) $Fe^{3+} + e^- \longrightarrow Fe^{2+}$

Sol. (i) Reduction

(ii) Oxidation

(iii) Reduction *[1 × 3 = 3]*

70. Name the kind of particle present in *[2014]*

(i) sodium hydroxide solution

(ii) carbonic acid

(iii) sugar solution

Sol. (i) Sodium hydroxide solution is a strong electrolyte.

Particle present in sodium hydroxide solution are ions only.

i.e., Na^+ and OH^- ion.

$$NaOH \rightleftharpoons Na^+ + OH^-$$ *[1]*

(ii) Carbonic acid is weak electrolyte, so particles present in weak electrolyte are ions and unionised molecules. *[1]*

(iii) Sugar particles present in sugar solution are molecules only. *[1]*

71. Electrons are getting added to an element Y

(i) What charge will Y have after the addition of electrons?

(ii) On which electrode will Y migrate during the process of electrolysis?

Sol. (i) After the addition of an electron, Y will have negative charge. *[1½]*

(ii) Y will migrate to anode during the process of electrolysis. *[1½]*

72. Write the cell reaction for the electrolysis of dilute $AgNO_3$, solution using Ag anode and Cu cathode.

Sol. In presence of $AgNO_3$, water molecules dissociate into ions.

This result in the evolution of hydrogen gas from cation (H^+) at cathode and oxygen gas from anion (OH^-) at anode.

Reaction of $AgNO_3$ solution

$$AgNO_3 \rightleftharpoons Ag^+ + NO_3^-$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

At cathode $H^+ + e^- \longrightarrow H$

$$H + H \longrightarrow H_2 \uparrow$$

At anode $4OH^- - 4e^- \longrightarrow 4OH$

$$4OH \longrightarrow 2H_2O + O_2 \uparrow$$ *[3]*

73. Write the three different conditions to be maintained during electroplating.

Sol. (i) In electrolysis the article deposited is always made the cathode since, the metal is deposited at cathode. *[1]*

(ii) The metal to be plated on the article is always made the anode since, metal anode continuously dissolve into the solution, it has to be replaced periodically. *[1]*

(iii) Less amount of current is supplied for longer time. *[1]*

d 4 Marks Questions

74. Differentiate between

(i) anode and cathode.

(ii) electrolytic cell and electrochemical cell.

(iii) Give reason, why hydrochloric acid is a good conductor of electricity?

Sol. (i)

Anode	Cathode
It is a positive electrode	It is a negative electrode.
During electrolysis, current enters the electrolyte through the anode.	During electrolysis, current leaves the electrolyte through the cathode.

[1]

(ii) Electrolytic cell is a device used for converting electrical energy into chemical energy.

Electrochemical cell is a device which uses chemical change occurring at the two electrodes to produce and conducts electricity. *[1½]*

(iii) Hydrochloric acid dissociates into ions in aqueous solution.

$$HCl \rightleftharpoons H^+ + Cl^-$$

These ions will move towards opposite electrodes when electric current is passed through the solution. *[1½]*

75. (i) What is an electrolyte?

(ii) Classify the following substance under three headings. Strong electrolytes, weak electrolytes, non-electrolytes. Acetic acid, ammonium chloride, ammonium hydroxide, carbon tetrachloride, dilute hydrochloric acid, sodium acetate, dilute sulphuric acid.

Sol. (i) Compounds which conduct electricity when dissolved in water or in molten state are called electrolytes. *[2]*

(ii)

Strong electrolyte	Weak electrolyte	Non-electrolyte
Ammonium chloride	Acetic acid	Carbon tetrachloride
Dilute HCl	Ammonium hydroxide	
Dilute H_2SO_4	Sodium acetate	

[2]

76. State the observations at the anode and at the cathode during the electrolysis of *[2017]*

(i) fused lead bromide using graphite electrodes.

(ii) copper sulphate solution using copper electrodes.

Sol. (i) **At anode** Dark reddish brown fumes of bromine evolve at the anode.

$$2Br^- \longrightarrow Br_2 + 2e^-$$

At cathode Greyish white metal lead is formed at the cathode.

$$Pb^{2+} + 2e^- \longrightarrow Pb$$ *[2]*

(ii) **At cathode** Cu^{2+} ions and H^+ ions migrate towards the cathode. But Cu^{2+} ions are discharged in preference to H^+

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

At anode SO_4^{2-} and OH^- ions migrate to anode but neither of them are discharged due to nature of the anode (copper loses electrons more easily than SO_4^{2-} and OH^-) because copper anode itself ionises to give Cu^{2+} ions.

$$Cu - 2e^- \longrightarrow Cu^{2+}$$ *[2]*

77. Write equations for the reactions taking place at the two electrodes (mentioning clearly the name of the electrode) during the electrolysis of

(i) acidified copper sulphate solution with copper electrodes.

(ii) molten lead bromide with inert electrodes. *[2016]*

Sol. (i) **At anode** Electrode is of platinum metal.

$$4OH^- \longrightarrow 2H_2O + O_2$$

At cathode Electrode is of copper metal.

$$2Cu^{2+} + 4e^- \longrightarrow 2Cu$$ *[2]*

(ii) **At anode** Electrode is of graphite.

$$2Br^- \longrightarrow Br_2 + 2e^-$$

At cathode Electrode is of graphite

$$Pb^{2+} + 2e^- \longrightarrow Pb$$ *[2]*

78. Copy and complete the following table which refers to the conversion of ions to neutral particles. *[2018]*

Conversion	Ionic equation	Oxidation/Reduction
Chloride ion to chlorine molecule	(i)	(ii) .....
Lead (II) ion to lead ≠	(iii)	(iv) .....

Sol. *[4]*

Conversions	Ionic equation	Oxidation/Reduction
Chloride ion to chlorine molecule	(i) $2Cl^- \longrightarrow \overset{0}{Cl_2} + 2e^-$	(ii) Oxidation (Loss of electron)
Lead (II) ion to lead	(iii) $Pb^{2+} + 2e^- \longrightarrow \overset{0}{Pb}$	(iv) Reduction (Gain of electron)

79. Write the type of ions present, the product obtained and the electrode reactions that occur when

(i) water is acidified with sulphuric acid between platinum electrodes

(ii) aqueous copper sulphate between copper electrodes

Sol.

		Electrode used	Ions	Products	Reactions
(i)	Cathode	Platinum	H^+	Hydrogen	$4H^+ + 4e^- \rightarrow 2H_2$
	Anode	Platinum	OH^- SO_4^{2-}	Oxygen	$4OH^- - 4e^- \rightarrow 2H_2O + O_2$
(ii)	Cathode	Copper	Cu^{2+} H^+	Copper atom	$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$
	Anode	Copper	OH^- SO_4^{2-}	Copper ion	$Cu(s) - 2e^- \longrightarrow Cu^{2+}(aq)$

[4]

80. (i) At which electrode (anode or cathode) would the following reaction take place? Is this an example of oxidation or reduction?

$$Cu \longrightarrow Cu^{2+} + 2e^-$$

(ii) A solution contains magnesium ions (Mg^{2+}), iron (II) ions (Fe^{2+}) and copper ions (Cu^{2+}). On passing an electric current through this solution which ions will be the first to be discharged at the cathode? Write the equation for the cathode reaction.

Sol. (i) The reaction will take place at anode. It is an example of oxidation as loss of electrons takes place. *[2]*

(ii) Cu^{2+} ions will be discharged first (electropositive series).

$Cu^{2+} + 2e^- \longrightarrow Cu$ (at cathode) *[2]*

81. During the electrolysis of copper (II) sulphate solution using platinum as cathode and carbon as anode.

(i) What do you observe at the cathode and the the anode?

(ii) What change is noticed in the electrolyte?

(iii) Write the reactions at the cathode and at the anode. ***[2012]***

Sol. (i) Red copper metal deposits at cathode and colourless and odourless gas (oxygen gas) at anode. ***[1]***

(ii) The blue colour of copper sulphate solution fades very soon. ***[1]***

(iii) **At cathode** $Cu^{2+} + 2e^- \longrightarrow Cu$

At anode $OH^- - 4e^- \longrightarrow 4OH$

$$2OH + 2OH \longrightarrow 2H_2O + O_2$$ ***[2]***

82. Write the electrolyte, electrodes and reactions at electrodes during electroplating of an article with nickel.

Sol. **Electroplating of an article with nickel**

Electrolyte Aqueous solution of $NiSO_4$ with few drops of dil. H_2SO_4.

Electrodes are as follows

Cathode Cleaned article to be electroplated.

Anode Block of pure nickel.

Electrode reaction

$$NiSO_4 \rightleftharpoons Ni^+ + SO_4^{2-}$$

$$H_2O \rightleftharpoons H^+ + OH^-$$

At cathode $Ni^{2+} + 2e^- \longrightarrow Ni$

At anode Ni anode undergoes oxidation to give Ni^{2+} ions which pass into the solution.

$$Ni - 2e^- \longrightarrow Ni^{2+}$$ ***[4]***

83. Complete the table given below.

	Process	Ions discharged at		Ions present in electrolyte	Anode	Cathode
		Anode	Cathode			
(i)	Electroplating of an iron rod with silver					
(ii)	Electro refining of silver					
(iii)	Extraction of aluminium from Al_2O_3					
(iv)	Electroplating of a copper sheet with nickel.					

Sol.

Process	Ions present in electrolyte	Ions discharged at		Anode	Cathode
		Cathode	Anode		
(i)	Ag^+, Na^+, Cl^-	Ag^+	Ag anode dissolves forming Ag^+	Silver	Iron
(ii)	Ag^+, NO_3^-, H^+, OH^-	Ag^+	Ag anode dissolves forming ions	Impure silver	Pure silver
(iii)	Al^{3+}, O^{2-}	Al^{3+}	O^{2-}	Carbon	Carbon
(iv)	Cu^2, SO_4^{2-}, H^+, OH^-	Cu^{2+}	Ni anode dissolves forming Ni^{2+} ions	Nickel	Copper

[1 × 4 = 4]

84. Copy and complete the following table which refers to two practical applications of electrolysis.

	Electrolyte	Cathode	Anode
Silver plating of a spoon	Solution of potassium argentocyanide		
Purification of copper			

Sol.

	Electrolyte	Cathode	Anode
Silver plating of a spoon	Solution of potassium argentocyanide	Spoon	Pure silver
Purification of copper	Copper sulphate solution	Pure strip of copper	Impure block of copper

[4]

e 5 Marks Questions

85. Give appropriate scientific reasons for the following statements.

(i) Zinc oxide can be reduced to zinc by using carbon monoxide but aluminium oxide cannot be reduced by a reducing agent.

(ii) Carbon tetrachloride does not conduct electricity.

(iii) During electrolysis of molten lead bromide, graphite anode is preferred to other electrodes.

(iv) The electrical conductivity of acetic acid is less in comparison to the electrical conductivity of dilute sulphuric acid at a given concentration.

(v) Electrolysis of molten lead bromide is considered to be a redox reaction. ***[2015]***

Sol. (i) Zinc oxide can be reduced to zinc by using carbon monoxide but aluminium oxide cannot be reduced by a reducing agent because aluminium being higher in the activity series form more stable oxides. Aluminium has a strong affinity for oxygen and therefore cannot be reduce by common reducing agent.

(ii) Carbon tetrachloride is a non-polar covalent compound that contains molecules and not free ions. Hence, carbon tetrachloride does not conduct electricity.

(iii) Graphite anode is preferred to other inert electrodes such as platinum since, graphite is unaffected by the reactive bromine vapours.

(iv) The electrical conductivity of acetic acid is less because it contain ions as well as molecules but sulphuric acid contains only (almost) free ions so, it conducts more electricity than acetic acid.

(v) **At cathode** $Pb^{2+} + 2e^- \longrightarrow Pb$ (reduction)

At anode $Br^- - e^- \longrightarrow Br$ (oxidation)

$Br + Br \longrightarrow Br_2$

Since both oxidation and reduction take place hence, it shows redox reaction. ***[1 × 5 = 5]***

86. Select the correct answer from the list given in brackets.

(i) An aqueous electrolyte consists of the ions mentioned in the list, the ion which could be discharged most readily during electrolysis.
(Fe^{2+}, Cu^{2+}, Pb^{2+}, H^+)

(ii) The metallic electrode which does not take part in an electrolytic reaction.
(Cu, Ag, Pt, Ni)

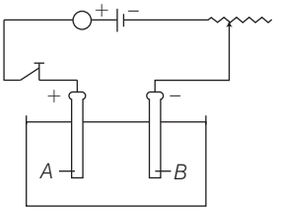
(iii) The ion which get discharged at the anode during the electrolysis of copper sulphate solution using copper electrodes as anode and cathode.
(Cu^{2+}, OH^-, SO_4^{2-}, H^+)

(iv) When dilute sodium chloride is electrolysed using graphite electrodes, the cation is discharged at the cathode most readily.
(Na^+, OH^-, H^+, Cl^-)

(v) During silver plating of an article using potassium argentocyanide as an electrolyte, the anode material should be (Cu, Ag, Pt, Fe) ***[2012]***

Sol. (i) Cu^{2+} (ii) Pt (iii) Cu^{2+}
(iv) H^+ (v) Ag ***[1 × 5 = 5]***

87. Study the diagram given below and answer the questions that follows.



(i) (a) Give the names of the electrodes *A* and *B*.
(b) Which electrode is the oxidising electrode?

(ii) A strip of copper is placed in four different colourless salt solutions. They are KNO_3, $AgNO_3$, $Zn(NO_3)_2$, $Ca(NO_3)_2$. Which one of the solutions will finally turn blue?

(iii) Write the equations of the reactions which take place at the cathode and anode when acidified water is electrolysed.

Sol. (i) (a) *A*-anode; *B*-cathode
(b) Anode *A* is the oxidising electrode. ***[1 × 2 = 2]***

(ii) $AgNO_3$ solution
Copper can displace a metal from its salt to form blue salt solution only when the metal is less active than copper. ***[1]***

(iii) **At cathode** $H^+ + e^- \longrightarrow H$

$H + H \longrightarrow H_2$

At anode $OH^- \longrightarrow OH + e^-$

$OH + OH \longrightarrow H_2O + O$

$O + O \longrightarrow O_2$ ***[2]***

88. Mr. Ramu wants to electroplate his key chain with nickel to prevent rusting. For this electroplating,

(i) name the electrolyte used
(ii) name the cathode.
(iii) name the anode.
(iv) give the reaction at the cathode.
(v) give the reaction at the anode..

Sol. (i) Nickel sulphate
(ii) key chain
(iii) pure nickel plate
(iv) $Ni^{2+} + 2e^- \longrightarrow Ni$
(v) $Ni - 2e^- \longrightarrow Ni^{2+}$ ***[1 × 5 = 5]***

CHAPTER EXERCISE

Fill in the Blanks

1. In electrolysis process anion undergo ..... .

2. The selective discharge of ions depends upon the relative positions of the ions in the (i) ....., the relative concentration of (ii) ....., and nature of the (iii) ..... .

3. The solid lead bromide will (i)..... an electric current, because (ii)..... are held in (iii).....by strong (iv).....force. The ions are (v).....to move to (vi).....when the solid is (vii)....., it (viii)..... and ……(ix) the flow of an electric current (x)..... is liberated at cathode and (xi).....at anode.

4. ..... metals cannot be extracted from their aqueous salt solutions by electrolysis.

5. Aluminium is obtained by the electrolysis of ..... where, ... lining of electrolytic cell act as ....., and graphite rod as ..... . The electrolyte used is ..... .

Reaction at — : $Al^{3+} + — \longrightarrow Al$

Reaction at — : $O^{2-} - — \longrightarrow 3[O]$.

6. $FeSO_4$ solution ..... (can/cannot) be kept in zinc vessel.

7. The article which is to be electroplated is always placed at the ..... .

Multiple Choice Questions

8. During ionisation, metals lose electrons. What does this change called?
(a) Reduction (b) Oxidation
(c) Redox (d) None of these

9. Which statement is true about oxidising agents?
(a) Their oxidation state is zero
(b) They are easily oxidised
(c) They never contain hydrogen
(d) They readily accept electrons

10. Which of the following metallic electrode will not take part in an electrolytic reaction?
(a) Pt (b) Ni (c) Ag (d) Cu

11. Which of the following apparatus is used for carrying out electrolysis of lead bromide?
(a) Glass vessel (b) Clay crucible
(c) Silica crucible (d) Aluminium vessel

12. In the process of electrolysis of NaCl, the gas released at anode is
(a) hydrogen (b) chlorine
(c) oxygen (d) None of these

13. Most reactive element among the following is
(a) hydrogen (b) calcium (c) sodium (d) copper

14. In which of the following will a redox reaction occur?
(a) Addition of aqueous ammonium chloride to aqueous silver nitrate
(b) Addition of aqueous sodium carbonate to dilute hydrochloric acid
(c) Addition of aqueous ammonia to aqueous zinc sulphate
(d) Addition of magnesium to iron (III) nitrate

15. Electrolysis of a concentrated solution of *X* using graphite electrodes produces a brown colouration around one electrode and a deposition of metal on the other. What could *X* be?
(a) Zinc bromide (b) Sodium bromide
(c) Copper (II) bromide (d) Silver iodide

16. The process of electrolysis is used for
(a) electrorefining
(b) electroplating
(c) electrometallurgical process
(d) All of the above

Match the Following

17. Match the following columns.

	Column I		Column II
(i)	Electrode connected to positive terminal of battery.	(a)	Cathode
(ii)	Electrode connected to negative terminal of battery.	(b)	Anode
(iii)	Substance which undergoes decomposition in aqueous solution, when current is passed.	(c)	Non-electrolyte
(iv)	Substance which does not allow electric current to pass through it neither in aqueous nor in molten state.	(d)	Electrolyte

18. Match the following columns.

	Column I		Column II
(i)	Electroplating	(a)	For purification
(ii)	Electrorefining	(b)	For the extraction of metal.
(iii)	Electrometallurgy	(c)	For decoration purpose.

19. Match the following columns.

Column I		Column II
(i) Potassium	(a)	Generally extracted by the reducing agent.
(ii) Iron	(b)	Extracted by thermal decomposition.
(iii) Platinum	(c)	Can be extracted by electrolysis in fused state.

1 Mark Questions

20. How can we classify an electrolyte as a strong, weak or non-electrolyte?

21. Give one phrase/word for the following. An acidic solution in which there occurs only partial ionisation of the solute molecules.

22. What do you meant by reactive metals?

23. Give three examples of metal of activity series which can be electrolysed in their fused state.

24. Name the particles present in aqueous solution of potassium chloride.

25. Why ammonia is unionised in the gaseous state but act as weak electrolyte in aqueous solution?

26. Why aluminium is extracted from its oxide by electrolytic reduction and not by conventional reducing agents?

2 Marks Questions

27. Write the equations for the chemical reaction which take place at cathode and at anode when acidified water is electrolysed.

28. Write the equations for the reaction taking place at cathode and at anode during
(i) the electrolysis of acidified nickel sulphate solution with nickel electrode.
(ii) molten lead bromide with inert electrode.

29. Write the name of electrolyte during reaction involved in the extraction of magnesium and potassium.

30. In the electrolysis of aqueous copper sulphate between copper electrodes, the sulphate and hydroxyl ions remain as spectator ions. Why?

3 Marks Questions

31. Write the three characteristics of electrolysis.

32. Give one word for the following.
(i) Impurities which remain behind at the bottom of the cell.
(ii) A process of extraction of metals from its ores by electrolysis.
(iii) A process by which impurities from metals are removed electrolytically.

33. Mention
(i) ions present
(ii) product obtained
(iii) electrode reactions in the following cases.
(a) Molten lead bromide between steel cathode and graphite anode.
(b) Aqueous copper sulphate between copper cathode and platinum anode.

4 Marks Questions

34. Explain the following terms.
(i) Oxidation (ii) Reduction
(iii) Oxidising agent (iv) Reducing agent

35. (i) Define electrochemical series.
(ii) List three important factors that influence the preferential discharge of ions at the electrodes.

36. What is the difference in the passage of electric current through an electrolyte and through a metal wire?

37. (i) What type of particle will be present in the dilute solution of a weak acid of H *X* except from water?
(ii) For electroplating a particular metal, which ions must be present in a solution?

38. Indicate the electrolyte, anode, cathode, cathodic reaction during the extraction of sodium, potassium, calcium and aluminium, electrolytically.

5 Marks Questions

39. Define the following terms.
(i) Electrolyte (ii) Non-electrolyte
(iii) Insulator (iv) Conductor
(v) Strong and weak electrolyte

40. Divide the following redox reactions into oxidation and reduction half reactions.
(i) $2Cu^{+} \longrightarrow Cu + Cu^{2+}$
(ii) $Sn^{2+} + 2Hg^{2+} \longrightarrow Sn^{4+} + Hg_2^{2+}$
(iii) $Cl_2 + 2Br^{-} \longrightarrow Br_2 + 2Cl^{-}$
(iv) $Zn + Cu^{2+} \longrightarrow Zn^{+} + Cu$
(v) $Zn + Pb^{2+} \longrightarrow Zn^{2+} + Pb$

41. Describe the electrolysis of molten solution of lead bromide.

42. What are the electrolyte, electrodes and electrode reactions used during the electroplating of an article with (i) Ni (ii) Ag?

ARCHIVES*

(Last 6 Years)

Collection of Questions Asked in Last 6 Years' (2017-2012) ICSE Class 10th Examinations

2018

1 Electrolysis of aqueous sodium chloride solution will form ..... at the cathode. (hydrogen gas/sodium metal) *[1]*

2 The electrolysis of acidifed water is an example of
(a) reduction (b) oxidation
(c) redox reaction (d) synthesis *[1]*

3 State one relevant observation for each of the following.
At the anode, when molten lead bromide is electrolysed using graphite electrodes. *[1]*

4 Give a reason for each of the following.
Conductivity of dilute hydrochloric acid is greater than that of acetic acid. *[1]*

5 Name the gas that is produced in each of the following cases.
At the anode during the electrolysis of acidified water.

6 For the electro-refining of copper, *[2]*
(i) what is the cathode made up of ?
(ii) write the reaction that takes place at the anode.

7 Copy and complete the following table which refers to the conversion of ions to neutral particles.

Conversion	Ionic equation	Oxidation/Reduction
Chloride ion to chlorine molecule	(i)	(ii) .....
Lead (II) ion to lead ≠	(iii)	(iv) .....

[4]

2017

8 Name the following,
the process of coating of iron with zinc. *[1]*

9 Identify the substance underlined, in the following case.
The <u>electrolyte</u> used for electroplating an article with silver. *[1]*

10 Select the ion in each case, that would get selectively discharged from the aqueous mixture of the ions listed below.
(i) SO_4^{2-}, NO_3^- and OH^- (ii) Pb^{2+}, Ag^+ and Cu^{2+} *[2]*

11 State the observation at the anode and at the cathode during the electrolysis of
(i) fused lead bromide using graphite electrodes.
(ii) copper sulphate solution using copper electrodes. *[3]*

2016

12 The particles present in strong electrolytes are *[1]*
(a) only molecules
(b) mainly ions
(c) ions and molecules
(d) only atoms

13 (i) Name the product formed at the anode during the electrolysis of acidified water using platinum electrodes.
(ii) Name the metallic ions that should be present in the electrolyte when an article made of copper is to be electroplated with silver. *[2]*

14 Write equation for the reactions taking place at the two electrodes (mentioning clearly the name of the electrode) during the electrolysis of
(i) acidified copper sulphate solution with copper electrodes.
(ii) molten lead bromide with inert electrodes. *[4]*

2015

15 Give appropriate scientific reasons for the following statements.
(i) Zinc oxide can be reduced to zinc by using carbon monoxide but aluminium oxide cannot be reduced by a reducing agent.
(ii) Carbon tetrachloride does not conduct electricity.
(iii) During electrolysis of molten lead bromide, graphite anode is preferred to other electrodes.
(iv) Electrolysis of molten lead bromide is considered to be a redox reaction. *[5]*

16 Differentiate between the terms strong and weak electrolytes (stating any two differences). *[2]*

2014

17 Which electrode, anode or cathode is the oxidising electrode. Why?

18 When fused lead bromide is electrolysed, we observe
(a) a silver grey deposit at anode and a reddish brown deposit at cathode *[1]*
(b) a silver grey deposit at cathode and a reddish brown deposit at anode
(c) a silver grey deposit at cathode and reddish brown fumes at anode
(d) silver grey fumes at anode and reddish brown fumes at cathode

19 Given one word or phrase for the following.
Formation of ions from molecules. *[1]*

20 Name the kind of particles present in
(i) sodium hydroxide solution
(ii) carbonic acid
(iii) sugar solution *[3]*

2013

21 State one appropriate observation for the following.
Electricity is passed through molten lead bromide. *[1]*

22 Which of these will act as a non-electrolyte?
(a) Liquid carbon tetrachloride
(b) Acetic acid
(c) Sodium hydroxide aqueous solution
(d) Potassium chloride aqueous solution *[1]*

2012

23 Some word/words are missing in the following statements. You are required to rewrite the statement in the correct form using the appropriate word/words.
Cations migrate during electrolysis. *[2]*

24 Identify the weak electrolyte from the following. *[1]*
(a) Sodium chloride solution.
(b) Dilute hydrochloric acid.
(c) Dilute sulphuric acid.
(d) Aqueous acetic acid.

25 Match the following columns.

Column I	Column II
Ammonium hydroxide solution	Contains only ions
Dilute hydrochloric acid	Contains only molecules
Carbon tetrachloride	Contains ions and molecules

[1]

26 Select the correct answer from the list given in brackets.
(i) An aqueous electrolyte consist of the ions mentioned in the list, the ion which could be discharged most readily during electrolysis (Fe^{2+}, Cu^{2+}, Pb^{2+}, H^+).
(ii) The metallic electrode which does not take part in an electrolytic reaction (Cu, Ag, Pt, Ni).
(iii) The ion which is discharged at the anode during the electrolysis of copper sulphate solution using copper electrodes as anode and cathode (Cu^{2+}, OH^-, SO_4^{2-}, H^+).
(iv) When dilute sodium chloride is electrolysed using graphite electrodes the cation is discharged at the cathode most readily (Na^+, OH^-, H^+, Cl^-).
(v) During silver plating of an article using potassium argentocyanide as an electrolyte, the anode material should be (Cu, Ag, Pt, Fe). *[5]*

27 Give reason for the electrolysis of acidulated water is considered to be an example of catalysis. *[2]*

28 Differentiate between electrical conductivity of copper sulphate solution and copper metal. *[2]*

29 During the electrolysis of copper (II) sulphate solution using platinum as cathode and carbon as anode.
(i) What do you observe at the cathode and at the anode?
(ii) What changes are noticed in the electrolyte?
(iii) Write the reactions at the cathode and at the anode. *[4]*

* Explanations/Answers to all these questions are given in the chapter Theory and Exam Practice.

CHALLENGERS*

1 A simple cell is set up with magnesium and copper as the electrodes and dilute sulphuric acid as the electrolyte. Which of the following will not occur?
(a) The bulb will light up
(b) A gas will be given off at the copper electrode
(c) A gas will be given off at the magnesium electrode
(d) The electrons will flow from the magnesium electrode to the copper electrode

2 Which of the following requires the least number of electrons for discharge to take place?
(a) Two moles of aluminium ions
(b) Five moles of hydroxide ions
(c) Three moles of oxide ions
(d) Six moles of hydrogen ions

3. Identify the correct statement for the following reaction,

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

(a) Zinc is acting as an oxidant
(b) Chlorine is acting as a reductant
(c) Hydrogen ion is acting as an oxidant
(d) Zinc is acting as a reductant

4. A solution of Na_2SO_4 in water is electrolysed using Pt electrodes. The products at the cathode and anode are respectively
(a) H_2, SO_2 (b) O_2, NaOH (c) H_2, O_2 (d) O_2, SO_2

5. The electrochemical cell stops working after sometime because
(a) electrode potential of both the electrodes becomes zero
(b) electrode potential of both the electrodes become equal
(c) one of the electrode is eaten away
(d) the reaction starts proceeding in opposite direction

6. Which of the following solution can be safely stored in a copper vessel?
(a) $ZnSO_4$ (b) $AgNO_3$
(c) $AuCl_3$ (d) All of them

7. The process at anode is
(a) oxidation (b) reduction
(c) Both (a) and (b) (d) None of these

8. Which of the following does not differentiate between electrochemical cell and electrolytic cell?
(a) Spontaneous or non-spontaneous nature of chemical process
(b) Chemical reactions occurring at the electrodes
(c) Positive or negative nature of anode
(d) None of the above

Answers

1. (b) **2.** (c) **3.** (d) **4.** (c) **5.** (b) **6.** (a) **7.** (a) **8.** (b)

* These questions may or may not be asked in the examination, have been given just for additional practice required for olympiads Scholarship Exams etc. For detailed explanations refer Page No. 262-263.

CHAPTER

7

Metallurgy

About 118 chemical elements are known at present. On the basis of their properties, all the elements can be divided into two main groups *i.e.,* **metals** and **non-metals**. Apart from these, some elements show properties of both metals and non-metals. These are called **metalloids**. All these metals and non-metals and their large number of compounds are very important in our everyday life. Due to high reactive nature of metals, they are found in combined state with other elements. The entire process of extraction or isolation of metals from their combined state is called **metallurgy**.

Chapter Objective

- Occurrence of Metals
- Extraction of Metals
- Extraction of Aluminium
- Ores of Aluminium
- Alloy

Occurrence of Metals

Some metals are found in earth's crust in free state while some are found in the form of their compounds. The metals present at the bottom of the reactivity series (Ag and Au) are least reactive, so they are found in free state *e.g.,* Gold, silver, platinum, copper, etc.

Copper and silver are found in the combined state in their sulphide or oxide ores.The metals at the top of the reactivity series (K, Na, Ca, Mg and Al) are highly reactive, so they are not found in nature as free elements. The metals in the middle of the reactivity series (Zn, Fe, Pb and Cu) are moderately reactive, found as oxides, sulphides or carbonates.

Reactivity series (Activity series) of Metals

	K	Potassium	(Most reactive metal)
	Na	Sodium	
	Ca	Calcium	
	Mg	Magnesium	
These metals are more reactive than hydrogen	Al	Aluminium	
	Zn	Zinc	
	Fe	Iron	
	Sn	Tin	
	Pb	Lead	
	H	Hydrogen	
	Cu	Copper	
These metals are less reactive than hydrogen	Hg	Mercury	
	Ag	Silver	
	Au	Gold	(Least reactive metal)

Decreasing chemical reactivity

Note Hydrogen also have non-metallic properties but, due to its electropositive nature, it has been placed in the reactivity series.

Extraction of Metals

Attainment of pure metal from its compound is called extraction of metals.

Terms Used in the Isolation and the Extraction of Metals

The following terms are used in the isolation and the extraction of metals

(i) **Minerals** The naturally occurring chemical substances in the earth's crust obtained by mining are called minerals. *e.g.,* Bauxite and kaolinite.

(ii) **Ores** The minerals, from which a metal can be extracted conveniently and profitably are called ores. *e.g.,* Bauxite is an ore of aluminium.

(iii) **Gangue** An ore is usually contaminated with earthly or undesired materials known as gangue. In other words, 'the undesired materials with which metal is contaminated are known as gangue (matrix impurities)'.

(iv) **Flux** The substance which is added in the ore to convert non-fusible gangue to fusible compound is called flux.

(v) **Slag** The fusible compound formed by the combination of flux and gangue is called slag.

$$\text{Flux} + \text{Gangue} \longrightarrow \text{Slag}$$

e.g., In the extraction of iron from haematite ore,

$$\underset{\text{Flux}}{CaO} + \underset{\text{Gangue}}{SiO_2} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

(vi) **Volatile Elements** These substances can be easily changed into vapours or they can form volatile compounds on heating *e.g.,* C, Hg, Zn, etc.

(vii) **Non-volatile Elements** These elements do not vaporise easily *e.g.,* Fe, Co, Ni, Ca, etc.

Important Ores and their Compostion

Metals	Main Ores
K	Carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$)
Na	Rock salt (NaCl) (from sea water)
Ca	Limestone, marble ($CaCO_3$), calcium sulphate dihydrate ($CaSO_4 \cdot 2H_2O$), gypsum ($CaSO_4$)
Mg	Carnallite, magnesium carbonate or magnesite ($MgCO_3$)
Al	Bauxite ($Al_2O_3 \cdot 2H_2O$), Cryolite (Na_3AlF_6), Feldspar ($KAlSi_3O_8$)
Zn	Zinc blende (ZnS), Calamine ($ZnCO_3$), Zincite (ZnO)
Fe	Haematite (Fe_2O_3), Magnetite (Fe_3O_4), Siderite ($FeCO_3$)
Pb	Galena (PbS)
Cu	Copper pyrites ($CuFeS_2$)
Hg	Cinnabar (HgS)
Ag	Argentite (Ag_2S), horn silver (AgCl)

Steps Involved in the Extraction of Metals

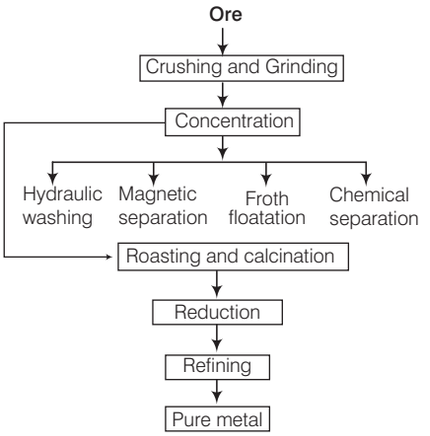
The extraction and isolation of metals from ores involve the following major steps

(i) Concentration or dressing of the ore

(ii) Isolation of the metal from its concentrated ore

(iii) Purification of the metal

Flowchart for Extraction of Metals



The ores are first subjected to the crushing and grinding in a big jaw crushers and ball mills. This process is called pulverisation. After that, the extraction of metals start.

Concentration or Dressing of Ores

Removal of the unwanted materials (*e.g.,* Sand, clays, etc.) from the ore is known as **concentration, dressing** or **benefaction**. It involves several steps and selection of these steps depend upon the differences in physical properties of the compound of the metal present and that of the gangue. It also depends upon the type of the metal, the available facilities and the environmental factors.

Some of the important procedures are described below

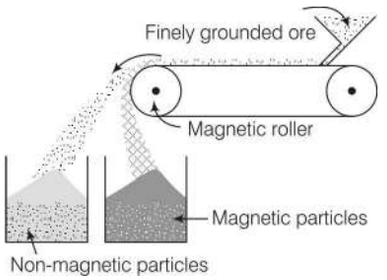
1. Hydraulic Washing

This method is based upon the differences in gravities of ores and the gangue particles. Therefore, it is also known as **gravity separation or levigation.**

In this process, powdered ore is washed with the upward stream of running water. The heavier ore particles settle down whereas lighter impurities are washed away. This method is used for oxide and carbonate ores *e.g.,* Haematite.

2. Magnetic Separation

This method is based upon the differences in the magnetic properties of the ore components. If either the ore or gangue is magnetic in nature, then such separation is carried out



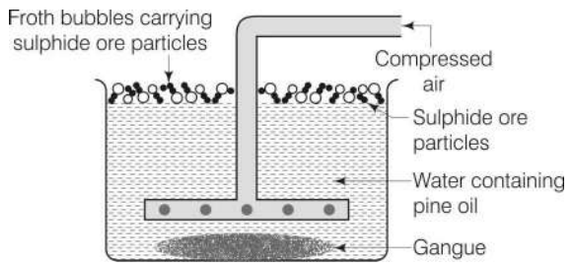
Magnetic separation

The powdered ore is placed on the conveyer belt moving on two rollers one of which is strong magnet. The particles which are magnetic in nature attracted by the magnets and fall closer to the roller while non-magnetic particles fall away from the roller.

This method is used to remove tungsten ore particles from cassiterite (SnO_2). It is also used to concentrate magnetite (Fe_3O_4), chromite ($FeCr_2O_4$) and pyrolusite (MnO_2) from gangue.

3. Froth Floatation Method

This method is based upon the preferential wetting properties with the frothing agent like pine oil, fatty acids etc. (collector) and water. In this process, powdered ore is mixed with water containing collectors and froth stabilisers like cresols, aniline, etc.



Froth floatation process for the concentration of sulphide ores

The mineral particles become wet with oil while the gangue particles by water. A stream of hot compressed air is passed which agitates the mixture and produces froth. Froth carries mineral particles.

The froth is light and is skimmed off. It is then dried for recovery of ore particles.

Water wets the gangue particles which sink to bottom. This method is used for removing gangue from sulphide ores *e.g.*, Copper pyrites, argentite, etc.

4. Chemical Separation or Leaching

This method is based upon the differences between the chemical properties of the ore and the gangue. The ore is treated with a suitable reagent such that the ore is soluble in it but the impurities are not. The impurities are removed by filtration while the filtrate is treated with suitable reagent which precipitates the ore.

This method is used for concentration of silver, gold and aluminium, etc.

CHECK POINT 01

1. Which section of reactivity series is most likely to be found in free state in nature?
2. Select from the following metals which can form sulphates with sulphuric acid : Ca, Cu, Hg, Mg, Al, Fe, Ag, Pb, Au, Sn and Zn.
3. How does the pine oil used in froth floatation method to separate the ores from impurities?
4. Give the other name of hydraulic washing which is used for the dressing of ores.
5. Name a depressant used in the froth floatation process.

Extraction of Crude Metal from Concentrated Ore

The concentrated ore must be converted into a form which is suitable for the reduction. Usually the sulphide ore is converted to oxide before reduction. Oxides are easier to reduce.

Therefore, isolation of metals from the concentrated ore involves two major steps which are as follows

1. Conversion to Oxide

The concentrated ore is converted into oxide by the following two methods

(i) **Calcination** The process of heating the concentrated ore in the absence or limited supply of air at a temperature not sufficient to melt the ore is called calcination. Carbonate ores are calcined and hence, carbon dioxide is given out.

e.g., $CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$

$ZnCO_3(s) \xrightarrow{\Delta} ZnO\,(s) + CO_2\uparrow$

(ii) **Roasting** In roasting, the ore is heated in a regular supply of air in a furnace at a temperature below the melting point of the metal.

e.g., $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2\uparrow$

$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2\uparrow$

2. Reduction of Metallic Oxides

(i) **By Reducing Agents** Metal oxides which are present in the middle of the reactivity series like Zn, Fe, Pb, etc., are reduced to free metals by using suitable reducing agents like carbon, aluminium, sodium or calcium.

(a) Copper oxide

$$CuO + C \xrightarrow{\Delta} Cu + CO$$

$$CuO + CO \xrightarrow{\Delta} Cu + CO_2$$

$$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$$

(b) Lead (II) oxide

$$PbO + C \xrightarrow{\Delta} Pb + CO$$

$$PbO + CO \xrightarrow{\Delta} Pb + CO_2$$

$$PbO + H_2 \xrightarrow{\Delta} Pb + H_2O$$

(c) Zinc oxide

$$ZnO + C \longrightarrow Zn + CO$$

(d) Iron oxide

$$FeO + C \xrightarrow{\Delta} Fe + CO$$

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3$$

The ore of iron *i.e.*, haematite (Fe_2O_3) is reduced in blast furnace by using coke and $CaCO_3$ (flux). The washed and dried haematite, coke and limestone are introduced from the top of the blast furnace and hot air is blown at the lower region. The following reactions take place in blast furnace.

Lower region $C + O_2 \longrightarrow CO_2$

Middle region $CO_2 + C \longrightarrow 2CO$

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

Upper region

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

(ii) **By Thermal Decomposition** Oxides of metals which are low in the reactivity series are least stable and can be reduced to metal by heating alone.

$$2HgS + 3O_2 \xrightarrow{\text{Roasting}} 2HgO + 2SO_2$$

$$2HgO \xrightarrow[\text{Reduction}]{\text{Heat}} 2Hg + O_2$$

$$2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$$

(iii) **By Electrolysis** Most reactive metal oxide (high in the reactivity series of metals) like aluminium, sodium, potassium, magnesium and calcium cannot be reduced by the reducing agents or by thermal decomposition, hence they are extracted by the electrolytic reduction of their molten oxides or chlorides.

e.g., Al is extracted by the electrolysis of molten aluminium oxide, Al_2O_3.

$$Al_2O_3 \xrightarrow{\text{Electrolysis}} 2Al^{3+} + 3O^{2-}$$

At cathode $2Al^{3+} + 6e^- \longrightarrow 2Al$

At anode $6O^{2-} \longrightarrow 3O_2 + 12e^-$

K and Na are extracted by the electrolysis of fused KBr and NaCl, respectively.

$$KBr \rightleftharpoons K^+ + Br^-$$

At cathode $K^+ + e^- \longrightarrow K$

At anode $Br^- - e^- \longrightarrow Br$

$$Br + Br \longrightarrow Br_2$$

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

At cathode $Na^+ + e^- \longrightarrow Na$

At anode $Cl^- - e^- \longrightarrow Cl$

$$Cl + Cl \longrightarrow Cl_2$$

Metal chlorides are reduced by the electrolysis in the molten state.

$$2NaCl \xrightarrow{\text{Electrolysis}} 2Na^+ + 2Cl^-$$

At cathode $2Na^+ + 2e^- \longrightarrow 2Na$

At anode $2Cl^- - 2e^- \longrightarrow Cl_2$

Note **Pyrometallurgy** The process of extraction of a metal by heating the metal oxide with a suitable reducing agent is known as pyrometallurgy. Here, heat is the principal means of extracting metals from ores.
Hydrometallurgy The process of extraction of metal by dissolving the ore in a suitable reagent followed by the precipitation or displacement of the metal by a more electropositive metal is known as hydrometallurgy.

Refining of Impure Metal

The process of removal of impurities to get more pure metal is called refining. Depending upon the nature of metals and associated impurities, *the methods employed to purify metals are as follows*

(i) **Distillation** For refining volatile metals and low boiling metals *e.g.*, Zn, Hg.

On heating, metal vaporises and is condensed. Pure metal is collected while non-volatile impurities remain behind.

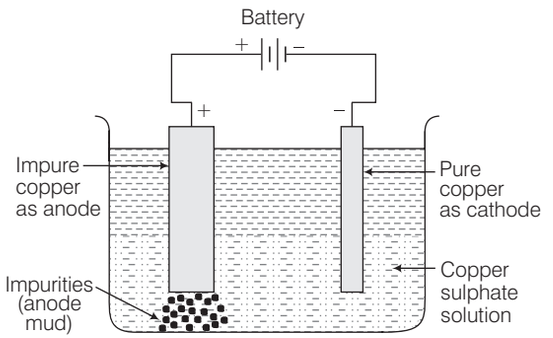
(ii) **Liquation** For refining metals with low melting point *e.g.*, Pb, Sn.

On heating, pure metal liquifies and flow down the sloping furnace and non-volatile impurities are infusible and remains behind.

(iii) **Oxidative Refining** For refining metals by oxidation from their impurities. *e.g.*, Fe.

On oxidation, pure metal remains behind in molten form and impurities oxidised by air to their respective oxides.

(iv) **Electrolytic Refining** For refining impure metal by electrolysis *e.g.*, Cu, Al, Pb. Impure metal is used as anode, a thin strip of pure metal is used as cathode and a soluble salt of metal is used as electrolyte. On passing electric current, pure metal is deposited at the cathode and impurities settle down forming anode mud.



Experimental set up for the electrolytic refining of copper

CHECK POINT 02

1. What is the importance of calcination and roasting in the extraction of metals?
2. Give the examples of metals which are extracted by electrolytic reduction of their molten oxides or chlorides.
3. Name a depressant used in the froth floatation process.
4. Define hydrometallurgy.
5. Name the metal which is refined by electrolytic method.

Extraction of Aluminium

It is the most abundant metal in the earth's crust. It was discovered by Oersted in 1825. It always occur in the combined state, as it is very reactive in nature.

Symbol	:	Al
Appearance	:	Silvery grey metallic
Atomic number	:	13
Standard atomic weight	:	26.98
Element category	:	Post-transition metal
Group and period	:	Group 13, period 3
Electronic configuration	:	2, 8, 3
Valency	:	3
Density	:	2.70 g /cm^3
Relative atomic mass	:	27

Ores of Aluminium

Ores	Formula	Chemical Name
Bauxite	$Al_2O_3 \cdot 2H_2O$	Hydrated aluminium oxide
Cryolite	Na_3AlF_6	Sodium aluminium fluoride
Corundum	Al_2O_3	Anhydrous aluminium oxide

The extraction of aluminium was done by Hall and Heroult, in 1885. The chief ore for the extraction is bauxite.

Purification of Bauxite Ore (Baeyer's process)

Bauxite ore is impure aluminium oxide ($Al_2O_3 \cdot 2H_2O$) containing iron (III) oxide (Fe_2O_3) and silica (SiO_2) as the main impurities. Baeyer's process is used to obtain pure aluminium oxide from bauxite ore. In this method of chemical purification, the finely powdered ore is treated with hot sodium hydroxide solution.

$$\underset{\text{Impure bauxite}}{Al_2O_3 \cdot 2H_2O} + \underset{\text{Conc. solution}}{2NaOH} \xrightarrow{150\text{-}200^\circ C} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2O$$

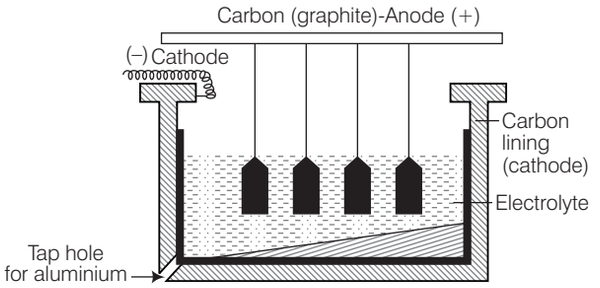
$$\underset{\text{Sodium aluminate}}{NaAlO_2} + 2H_2O \xrightarrow{50\text{-}60^\circ C} \underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Aluminium hydroxide}}{Al(OH)_3}\downarrow$$

$$\underset{\text{Aluminium hydroxide}}{2Al(OH)_3} \xrightarrow{1100^\circ C} \underset{\text{Pure alumina}}{Al_2O_3} + 3H_2O$$

Electrolytic Reduction of Fused Alumina (Hall-Heroult's Process)

The electrolytic reduction of fused alumina takes place in electrolytic cell. In this cell, rectangular iron tank with sloping bottom which facilitates the removal of the molten aluminium is present. The tank is lined with carbon. It acts as cathode. The anode of the cell is made up of carbon (graphite). The anode needs to be replaced regularly as it oxidises to form CO_2 gas during the process.

Powdered coke is sprinkled over the surface of the electrolyte. Cryolite is added to lower the fusion temperature from 2050°C to 950°C and increases the conductivity.



Extraction of aluminium

Fluorspar acts as a solvent for electrolytic mixture and increases its conductivity. Powdered coke reduces heat lose by the radiation and prevents the burning of anode.

Reactions The following reactions takes place.

$$\underset{\text{Cryolite}}{Na_3AlF_6} \rightleftharpoons 3Na^+ + Al^{3+} + 6F^-$$

$$\underset{\text{Fluorspar}}{CaF_2} \rightleftharpoons Ca^{2+} + 2F^-$$

$$\underset{\text{Alumina}}{Al_2O_3} \rightleftharpoons 2Al^{3+} + 3O^{2-}$$

Various form of ions are present in the solution such as Na^+, Ca^{2+}, Al^{3+}(positive ions) and F^-, O^{2-}(negative ions). Aluminium is present at lower position in the activity series, hence, preferred to be discharged at the cathode while oxygen at the anode.

At cathode Carbon lining (gas carbon) of the cell.

$$4Al^{3+} + 12e^- \longrightarrow 4Al$$

At anode Thick rods of graphite are suspended into the fused electrolyte.

$$6O^{2-} - 12\,e^- \longrightarrow 6[O]$$

$$6\,[O] \longrightarrow 3O_2$$

Anode oxidises carbon to carbon monoxide and then to carbon dioxide.

$$2C + O_2 \longrightarrow 2CO$$

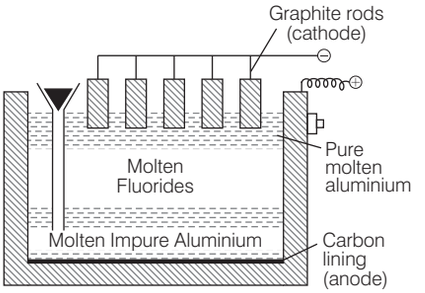
$$2CO + O_2 \longrightarrow 2CO_2$$

The oxygen evolved at the anode escapes as a gas or reacts with carbon anode. The carbon anode is thus, oxidised. The carbon anode is, hence consumed and renewed periodically after a certain period of usage. Further purification can be done by the electrolysis.

Refining of Aluminium

It is done by Hoope's electrolytic process. The process involves an electrolytic tank which contains three immiscible layer of molten substance. Upper layer consist of pure molten Al with carbon electrodes serve as cathode.

Middle layer consist of a mixture of cryolite BaF_2, AlF, CaF_2. Lower layer consist of impure Al along with carbon lining.



Refining of aluminium

When the current is passed, aluminium moves from the middle layer to the top layer and simultaneously, equivalent amount is shifted from lower layer to middle layer. By this method, pure aluminium can be easily obtained.

Flow chart for the Extraction of Aluminum

Ore:Bauxite ($Al_2O_3 \cdot 2H_2O$)

↓

Concentration by NaOH to obtain Al_2O_3

$$Al_2O_3 \cdot 2H_2O + 2NaOH \xrightarrow{140°C - 150°C} 2NaAlO_2 + 3H_2O$$

$$NaAlO_2 + 2H_2O \xrightarrow{50°C} NaOH + Al(OH)_3$$

$$2Al(OH)_3 \xrightarrow{1000°C} Al_2O_3 + 3H_2O$$

↓

Electrolytic reduction of alumina

Electrolyte Alumina, cryolite, fluorspar (1 : 3 : 1)

At cathode $Al^{3+} + 3e^- \longrightarrow Al$

At anode $2O^{2-} - 4e^- \longrightarrow O_2$

$C + O_2 \longrightarrow CO_2$

↓

Refining of aluminium

At cathode $Al^{3+} + 3e^- \longrightarrow Al$

At anode $Al - 3e^- \longrightarrow Al^{3+}$

Uses of Aluminium

(i) Aluminium metal is moulded into metals as it is light, cheap, corrosion resistant and good conductor of heat.

(ii) Aluminium powder mixed with linseed oil are generally applied on iron poles which prevents the corrosion of iron.

(iii) Thin Al foil is used in food packaging as it is corrosion resistant and has a bright appearance.

(iv) Aluminium wires are used as cable and transmission wires as it is a good conductor of electricity.

(v) It is used in making the alloys such as duralumin and magnalium. These alloys are used in aeroplanes and light tools.

(vi) Aluminium mixed with haematite is used for thermite welding process. Reduction of metallic oxide with aluminium is known as thermite process. The product is used for welding broken ends of an iron girder. Al powder is a strong reducing agent and reduces Fe_2O_3 to iron.

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe + \text{heat}$$

CHECK POINT 03

1 Name the group and period in which aluminium is present in the periodic table.
2 Give the chemical formula of bauxite.
3 Name the process by which electrolytic reduction of fused alumina is carried out.
4 Give the name of mixture present in the middle layer of Hoope's electrolytic process.
5 Write two uses of aluminium.

Alloy

An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal. It is prepared by mixing the metals in molten state and then cooling the mixture. The electrical conductivity and melting point of an alloy is less than that of pure metals.

e.g., Brass, an alloy of copper and tin (Cu and Sn) is not the good conductor of electricity whereas, copper is used for making electrical circuits.

(i) **Amalgam** If an alloy contains mercury as one of its components, it is called amalgam. *e.g.*, Sodium-mercury amalgam, silver-mercury amalgam, etc.

(ii) **Alloying of Gold** Pure gold is very soft. It is called 24 carat gold. To increase the strength and hardness of gold and to make it suitable for making jewellery, alloy of gold is made with either silver or copper. *e.g.*, 22 carat gold means 22 parts of gold mixed with 2 parts of Cu or Ag.

(iii) **Alloying of Iron** Pure iron is very soft and stretched easily when hot. It is mixed with a small amount of carbon (about 0.05%) and becomes strong. Iron is mixed with many metals to form different alloys.

Purpose of Making an Alloy

(i) Alloy does not corrode or corrode to very less extent.

(ii) Alloy is much harder and stronger than the pure metal.

(iii) Alloy has less conductivity than pure metal.

(iv) Some alloys have low melting point and hence, used for soldering of metals.

Composition, Properties and Uses of Alloys

Alloys	Principle Metal	Composition	Properties	Used for Making
Duralumin	Aluminium	95% Al, 4% Cu, 0.5% Mg, 0.5% Mn	(i) Light but as strong as steel (ii) Hard and resistant to corrosion (iii) Highly ductile	(i) Bodies of aircraft and other vehicles (ii) Pressure cookers
Magnalium	Aluminium	90-95% Al, 10-5% Mg	(i) Resists corrosion (ii) Light (iii) Strong	(i) Scientific instruments (ii) Metal mirrors (iii) Light tools (iv) Beam of balance
Alnico	Aluminium	Al, Ni, Co, Fe	(i) Light (ii) Shiny (iii) Resists corrosion	Powerful magnets
Stainless steel	Iron	73% Fe, 18% Cr, 8% Ni, 1% C	(i) Resists corrosion (ii) Lustrous, hard (iii) Resistant to acids and alkalies	(i) Utensils (ii) Cutlery (iii) Ornamental objects (iv) Surgical instruments

Alloys	Principle Metal	Composition	Properties	Used for Making
Nickel steel	Iron	95-98% Fe, 5-3% Ni	(i) Hard and elastic (ii) Resistant to corrosion	(i) Electric wire cables (ii) Automobile parts
Invar	Iron	Fe 63%, Ni 36%, C 1%	Negligible expansion	(i) Metre scales (ii) Scientific precision instruments
Brass	Copper	60-70% Cu, 40-30% Zn	(i) Malleable and ductile (ii) Can be easily cast (iii) Resists corrosion (iv) Yellow/silvery in colour	(i) Utensils (ii) Screws and handles (iii) Cartridge (iv) Parts of watches (v) Musical instruments (vi) Electrical goods
Bronze	Copper	80% Cu, 18% Sn, 2% Zn	(i) Hard and easy to cast (ii) Can be polish (iii) Resists corrosion	(i) Medals (ii) Statues (iii) Coins
German silver	Copper	50% Cu 30% Zn, 20% Ni	(i) White and light like silver (ii) Malleable and ductile (iii) High electrical resistance	(i) Decorative articles (ii) Electric heaters, rheostats (iii) Resistors
Bell metal	Copper	78% Cu, 22% Sn	(i) Sonorous (produces sound) (ii) Hard and brittle	(i) Bell, gongs (ii) Statues
Solder or fuse metal	Lead	Pb, Sn	Low melting point, high tensile strength	(i) Welding and soldering (ii) Electrical fuse

CHECK POINT 04

1 What is an amalgam?
2 Give one purpose of making an alloy.
3 Name the alloys which contain zinc and state their composition.
4 Name the constituents of
(a) Duralumin (b) Solder
5 Compare the following properties of brass and copper.
(i) Corrosion resistance (ii) Hardness and strength (iii) Conductivity

SUMMARY

- Reactive metal can displace a comparitively less reactive metal from its compounds in aqueous salt solution or in molten form.
- The elements or compounds which occur naturally in the earth's crust are known as minerals.
- Minerals from which metals can be extracted profitably are called ores.
- The process of extracting the pure metal from its ore is called metallurgy.
- The extraction and isolation of metals from ores involves the steps, concentration of the ore, isolation of the metal from its concentrated ore and purification of the metal.
- Ore dressing or concentration is the pre-treatment of ores based on physical properties and without bringing out any major chemical change in the ore. In case of heavy ores (like tin stone, chromite) gravity separation is used, for magnetic substances (to separate them from non-magnetic substance) magnetic separation is used. In case of sulphide ores, Forth floatation process is used. Leaching is done for Ag, Au, Al, etc.
- Calcination is the process of heating of concentrated ore below its melting point in absence or limited supply of air while roasting is the process of heating of concentrated ore below its melting point in excess of air. Both the processes are carried out in reverberatory furnace.
- Refining is the process of purification of metal and is done by distillation (for Zn, Hg, Cd), liquation (for Pb, Sn), oxidative refining (for Fe) and electrolysis (for Cu, Ag, Au, Pb, Zn, Al).
- Extraction of aluminium

  (i) Concentration by NaOH to obtain Al_2O_3

$$Al_2O_3 \cdot 2H_2O + 2NaOH \xrightarrow{140^\circ\text{-}150^\circ C} 2NaAlO_2 + 3H_2O$$

$$NaAlO_2 + 2H_2O \xrightarrow{50^\circ C} NaOH + Al(OH)_3$$

$$2Al(OH)_3 \xrightarrow{1000^\circ C} Al_2O_3 + 3H_2O$$

  (ii) Electrolytic reduction of alumina

  At cathode $Al^{3+} + 3e^- \longrightarrow Al$

  At anode $2O^{2-} - 4e^- \longrightarrow O_2$

$$C + O_2 \longrightarrow CO_2$$

  (iii) Refining of aluminium

  At cathode $Al^{3+} + 3e^- \longrightarrow Al$

  At anode $Al - 3e^- \longrightarrow Al^{3+}$

- An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal.

EXAM PRACTICE

Fill in the Blanks

1. Metals are good …… (oxidising agents/reducing agents) because they are electron …… (acceptors /donors). ***[2016]***

Sol. reducing agents, donors

2. Siderite is mainly composed of …… .

Sol. $FeCO_3$

3. Copper oxide on reduction with carbon gives …… .

Sol. copper

4. The substance which is added in the ore to convert non-fusible (i) …… to fusible compound is called (ii) …… .

Sol. (i) gangue (ii) flux

5. When a metallic oxide is dissolved in water, the solution formed has a high concentration of …… ions. (H^+, H_3O^+, OH^-) ***[2017]***

Sol. $\bar{O}H$

6. …… is a process of forming a thick oxide layer on the …… of metal. This oxide layer is …… and prevents the metal from further …… .

Sol. Anodising, surface, protective, oxidation

7. Al_2O_3 is the chemical composition of …… ore.

Sol. corundum

8. Hall-Heroult process is used for the extraction of …… .

Sol. aluminium

9. The raw materials required for the extraction of iron from haematite are (i) ……, (ii) …… and hot air. The mineral present in haematite is (iii) …… which is reduced by (iv) …… to iron.

Sol. (i) coke
(ii) limestone
(iii) iron (III) oxide
(iv) carbon monoxide (CO)

10. The most common ore of iron is ..... . (calamine/haematite) ***[2018]***

Sol. haematite

11.

	X	***Y***
Electronic configuration	2, 8, 7	2, 8, 2
Nature of oxide	Dissolves in water and turns blue litmus to red.	Very low solubility in water. Dissolves in hydrochloric acid.
Tendency for oxidising and reducing reactions	Tends to oxidise elements and compounds.	Tends to act as a reducing agent.
Electrical and thermal conductivity	Very poor electrical conductor. Poor thermal conductivity.	Good electrical conductor. Good thermal conductor.
Tendency to form alloys and amalgams	No tendency to form alloys.	Form alloys.

Using the above information, complete the following.

(i) …… is the metallic element.

(ii) Metal atoms tend to have a maximum …… electrons in the outermost energy level.

(iii) Non-metallic elements tend to form …… oxides while metals tend to form …… oxides.

(iv) Non-metallic elements tend to be …… conductor of heat and electricity.

(v) Metals tend to …… electrons and act as …… agents in their reactions with elements and compounds. ***[2013]***

Sol. (i) *Y* (ii) three
(iii) acidic, basic (iv) poor
(v) lose, reducing

Multiple Choice Questions

12. Which one is an alkaline earth metal? ***[2012]***

(a) Potassium
(b) Calcium
(c) Lead
(d) Copper

Sol. (b)

13. Which metal is a liquid at room temperature? ***[2011]***

(a) Potassium (b) Zinc
(c) Gold (d) Mercury

Sol. (d)

14. Which among the following is at the top of the activity series?
(a) Na (b) K (c) Ca (d) Mg

Sol. (b)

15. The main ore used for the extraction of iron is *[2014]*
(a) haematite (b) calamine
(c) bauxite (d) cryolite

Sol. (a)

16. Heating an ore in a limited supply of air or in the absence of air at a temperature just below its melting point is known as *[2014]*
(a) smelting (b) ore dressing
(c) calcination (d) bessemerisation

Sol. (c)

17. Which of the following metallic oxides cannot be reduced by normal reducing agents? *[2012]*
(a) Magnesium oxide (b) Copper (II) oxide
(c) Zinc oxide (d) Iron (III) oxide

Sol. (a)

18. In the metallurgy of aluminium,
(a) Al^{3+} is oxidised to Al(*s*)
(b) graphite anode is oxidised to carbon monoxide and carbon dioxide
(c) oxidation state of oxygen changes in the reaction at anode
(d) oxidation state of oxygen changes in the overall reaction involved in the process

Sol. (b)

19. Aluminium powder is used in thermite welding because *[2014]*
(a) it is a strong reducing agent
(b) it is a strong oxidising agent
(c) it is a corrosion resistant
(d) it is a good conductor of heat

Sol. (a)

20. Commercially available fizzy drinks and fruit juices such as lemonade are often sold in aluminium cans. Why is aluminium a suitable metal for making cans?
(a) It is the most abundant metal in the earth's crust
(b) It can be recycled
(c) It is resistant to corrosion by weak acids
(d) It is resistant to corrosion by water

Sol. (c)

21. Stainless steel is very useful material for our life. In stainless steel, iron is mixed with
(a) Ni and Cr (b) Cu and Cr
(c) Ni and Cu (d) Cu and Au

Sol. (a)

22. What does 22 carat gold means?
(a) 22 parts of gold only
(b) 22 parts gold mixed with 2 parts of Al
(c) 22 parts gold mixed with 2 parts of Cu or Ag
(d) 22 parts gold mixed with 3 parts of Zn

Sol. (c)

23. This is not an alloy of copper
(a) brass (b) bronze
(c) solder (d) duralumin

Sol. (c)

24. The two main metals in bronze are *[2016]*
(a) copper and zinc (b) copper and lead
(c) copper and nickel (d) copper and tin

Sol. (d)

25. Brass is an alloy of *[2008]*
(a) copper and tin (b) copper and zinc
(c) zinc and lead (d) lead and tin

Sol. (b)

Match the Following

26. Match the following columns.

Column I (Metal)		Column II (Ore)	
(i)	Iron	(a)	Calamine
(ii)	Zinc	(b)	Bauxite
(iii)	Aluminium	(c)	Haematite

Sol. (i) → (c), (ii) → (a) (iii) → (b)

27. Match the following columns.

Column I		Column II	
(i)	Magnesite	(a)	HgS
(ii)	Carnallite	(b)	$MgCO_3$
(iii)	Cinnabar	(c)	PbS
(iv)	Galena	(d)	$KCl \cdot MgCl_2 \cdot 6H_2O$

Sol. (i) → (b), (ii) → (d), (iii) → (a), (iv) → (c)

28. Match the properties and uses of alloys in column I with the appropriate answer from column II.

	Column I	Column II
(i)	The alloy containing Cu and Zn is hard, silvery and is used in decorative articles.	(a) Duralumin
(ii)	It is stronger than aluminium, light and is used in making light tools.	(b) Brass
(iii)	It is lustrous, hard, corrosion resistant and used in surgical instruments.	(c) Bronze
(iv)	Tin lowers the melting point of the alloy and is used for soldering purpose.	(d) Stainless steel
(v)	The alloy is hard, brittle and is used for making statues.	(e) Solder

Sol. (i) → (b), (ii) → (a), (iii) → (d), (iv) → (e), (v) → (c)

a 1 Mark Questions

29. Give reasons for the following. ***[2018, 2012]***
Alkali metals are good reducing agents.

Sol. Alkali metals have greater tendency to lose or donate electrons which make them good reducing agents.

30. The process by which sulphide ore is concentrated.

Sol. Froth floatation method ***[2018]***

31. What does "reactivity series of metals" mean ?

Sol. The arrangement of metals in the decreasing order of their reactivities is called reactivity series of metals.

32. Name the ore of zinc containing its sulphide. ***[2014]***

Sol. Ore of zinc is zinc blende (ZnS).

33. Identify the term/substance for the following.
The method used to separate ore from gangue by preferential wetting. ***[2016]***

Sol. Hydraulic washing.

34. Write a balanced chemical equation for each of the following. ***[2018]***
(i) Action of heat on aluminum hydroxide.
(ii) Reaction of zinc with potassium hydroxide solution.

Sol. (i) $\underset{\text{Aluminium hydroxide}}{2Al(OH)_3} \xrightarrow{\Delta} \underset{\text{Aluminium oxide}}{Al_2O_3} + 3H_2O$

(ii) $\underset{\text{Zinc}}{Zn} + \underset{\text{Potassium hydroxide}}{2KOH} \xrightarrow{\Delta} \underset{\text{Potassium Zincate}}{K_2ZnO_2} + H_2\uparrow$

35. Which chemical process is used for obtaining a metal from its oxide?

Sol. Metal can be obtained from its oxide by reduction. The reduction can be done either by heating with carbon (coke) or by using highly reactive metals.

36. Name the following.
A black powdery substance used for the reduction of zinc oxide during its extraction. ***[2011]***

Sol. Coke is used for the reduction of zinc oxide during its extraction.

37. Name the following.
A compound which is added to lower the fusion temperature of the electrolytic bath in the extraction of aluminium.

Sol. Cryolite, Na_3AlF_6 is added to lower the fusion temperature.

38. Which metal is used as wrapper for chocolates and sweets ?

Sol. Aluminium foil is used as wrapper for chocolates and sweets.

39. Why food cans are coated with tin and not with zinc?

Sol. Food cans are coated with tin and not with zinc because zinc is more reactive than tin, it can react with the organic acids present in the food items.

40. Define an alloy.

Sol. An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal. It is prepared by mixing the metals in molten state and then cooling the mixture.

41. Name an alloy that contains a non-metal as one of its constituents.

Sol. Steel (iron + carbon) is an alloy that contains a non-metal as one of its constituents.

42. What are the two different alloys of aluminium?

Sol. (i) Duralumin (ii) Magnalium

b 2 Marks Questions

43. Match each substance (a, b, c, d, and e) with its properties (i, ii).
(a) Sulphur (b) Silver chloride
(c) Hydrogen chloride (d) Copper (II) sulphate
(e) Graphite
(i) A non-metal which is a good conductor of electricity.
(ii) A non-metal which reacts with concentrated nitric acid to form its own acid as one of the product. ***[2009]***

Sol. (i) Graphite is a non-metal and good conductor of electricity.

(ii) Sulphur *[2 × 1 = 2]*

44. Arrange Cu, Ca, Al, Fe, Mg, Pb, Na and Zn in the decreasing order of chemical reactivity.

Sol. *The decreasing order of reactivity of the given elements is as follows*

Na, Ca, Mg, Al, Zn, Fe, Pb, Cu *[2 × 1 = 2]*

45. Name the main component of the following alloys *[2 × 1 = 2]*

(i) Brass (ii) Duralumin *[2018]*

Sol. *The main components of alloys brass and duralumin with their composition are as follows*

(i) Brass – Cu (60-70%) and Zn (40-30%).

(ii) Duralumin – Al (95%), Cu (4%), Mg (0.5%) and Mn (0.5%).

46. Why the reduction process is always involved in the extraction of metals?

Sol. Metals are always available in nature in the form of ores, in which the metal remains as cation. Extraction of metal from the ore is to get the metal in its elemental state. For this purpose, any metal compound always require to be reduced. *[2]*

47. From the list of terms given, choose the most appropriate term to match the given description. (Calcination, roasting, pulverisation, smelting)

(i) Crushing of the ore into fine powder. *[2017]*

(ii) Heating of the ore in the absence of air to a high temperature.

Sol. (i) Pulverisation (ii) Calcination *[2 × 1 = 2]*

48. Giving examples, differentiate between roasting and calcination. *[2]*

Sol. Differences between roasting and calcination.

Roasting	Calcination
Ore is heated in the excess of air.	Ore is heated in the absence or limited supply of air.
This is used for sulphide ores.	This is used for carbonate ores.
SO_2 is produced along with metal oxide.	CO_2 is produced along with metal oxide.
e.g., $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$	*e.g.*, $ZnCO_3 \longrightarrow ZnO + CO_2$

49. Brass is preferred over copper for door settings. Give reason.

Sol. Brass, an alloy of copper and zinc is more corrosion resistant than its constituent elements (copper or zinc alone). Moreover, yellow lustre of brass give a decorative appearance also. *[2]*

C 3 Marks Questions

50. Name the following metals. *[2013]*

(i) A metal present in cryolite other than sodium.

(ii) A metal which is unaffected by dilute or concentrated acids.

(iii) A metal present in period 3, group 1 of the periodic table.

Sol. (i) Aluminium

(ii) Aluminium or platinum or gold

(iii) Sodium *[3 × 1 = 3]*

51. Define the following terms.

(i) Minerals (ii) Ores (iii) Gangue

Sol. (i) The naturally occurring elements or compounds of metals present in the earth's crust are called **minerals.** *[1]*

(ii) **Ores** are those minerals from which a particular metal can be extracted profitably. *[1]*

(iii) The undesirable impurities present in the ore are called **gangue** or matrix. *[1]*

52. How can metals at the top of the reactivity series be extracted from their ores? Explain with an example.

Sol. The metals at the top of the reactivity series can be extracted from their ores by an electrolytic process known as electrolytic reduction *e.g.,* Sodium is obtained by the electrolysis of molten sodium chloride. **[1½]**

$$\underset{\text{Molten}}{NaCl} \longrightarrow \underset{\text{Cathode}}{Na^+} + \underset{\text{Anode}}{Cl^-}$$ **[1/2]**

At cathode $Na^+ + e^- \longrightarrow Na$ (Deposited) **[1/2]**

At anode $Cl^- \longrightarrow \underset{\text{(Evolved)}}{\frac{1}{2}Cl_2} + e^-$ **[1/2]**

53. During the extraction of metals, electrolytic refining is used to obtain pure metals.

(i) Which material will be used as anode and cathode for refining of copper metal by this process?

(ii) Suggest a suitable electrolyte also.

(iii) In this electrolytic cell, where do we get pure copper after passing electric current?

Sol. (i) Thin strip of pure copper is made the cathode (connected to the negative terminal of the battery). And impure, copper block is made anode (connected to the positive terminal of the battery). *[1]*

(ii) The electrolyte is copper sulphate solution ($CuSO_4$). *[1]*

(iii) On passing electric current, impure metal dissolves from the anode and goes into the electrolyte solution and pure metal from the electrolyte deposits on the cathode. *[1]*

54. Answer the following questions with respect to the electrolytic process in the extraction of aluminium.

(i) Identify the components of the electrolyte other than pure alumina and the role played by each.

(ii) Explain why powdered coke is sprinkled over the electrolytic mixture.

Sol. (i) (a) Cryolite is added to lower the fusion temperature from 2050°C to 950°C and increases conductivity.

(b) Fluorspar acts as a solvent for electrolytic mixture that increases conductivity.

(ii) Powdered coke reduces heat loss by radiation and prevents the burning of anode. *[3 × 1 = 3]*

55. Write the reaction involved at cathode and anode during the electrolysis of aluminium oxide and potassium bromide.

Sol. Aluminium oxide, Al_2O_3

$$Al_2O_3 \xrightarrow{\text{Electrolysis}} 2Al^{3+} + 3O^{2-}$$

At cathode $2Al^{3+} + 6e^- \longrightarrow 2Al$

At anode $6O^{2-} \longrightarrow 3O_2 + 12e^-$ *[1½]*

Potassium bromide, KBr

$$KBr \rightleftharpoons K^+ + Br^-$$

At cathode $K^+ + e^- \longrightarrow K$

At anode $Br^- + e^- \longrightarrow Br$

$Br + Br \longrightarrow Br_2$ *[1 ½]*

56. Compound X and aluminium are used to join railway tracks.

(i) Identify the compound X.

(ii) The metal present in X is present in which part of reactivity series.

(iii) Write down its reaction.

Sol. (i) Compound X is iron (III) oxide, Fe_2O_3. *[1]*

(ii) Middle of the reactivity series. *[1]*

(iii) *The reaction that takes place is as follows*

$$\underset{\substack{\text{Iron (III) oxide}\\(X)}}{Fe_2O_3(s)} + \underset{\substack{\text{Aluminium powder}\\\text{(reducing agent)}}}{2Al(s)} \xrightarrow{\Delta} \underset{\substack{\text{Iron metal}\\\text{(molten state)}}}{2Fe(l)} + \underset{\text{Aluminium oxide}}{Al_2O_3(s)} + \text{Heat}$$ *[1]*

57. Name the following.

(i) An alloy of lead and tin that is used in electrical circuits.

(ii) An ore of zinc containing its sulphide.

(iii) A metal oxide that can be reduced by hydrogen. *[2017]*

Sol. (i) Solder

(ii) Zinc blende (ZnS)

(iii) Copper oxide (CuO) *[3 × 1 = 3]*

58. An alloy, which is known to be a mixture of two metals, was added to an excess of dilute sulphuric acid. A pink solid and a colourless solution were formed. Addition of aqueous ammonia to the colourless solution produced a white precipitate which was soluble in excess aqueous ammonia.

(i) Name the pink solid and colourless solution.

(ii) Name the two metals present in the alloy.

(iii) Explain, why lead cannot be present as one of the metals in the alloy?

Sol. The description suggests that one of the constituent is more reactive than hydrogen as it formed solution with acid and other one is less reactive as it simply deposited in powdered form. So, with the help of activity series the constituent metals can be predicted.

(i) Copper and zinc sulphate solution, respectively.

(ii) Copper and zinc.

(iii) Lead will initially react with sulphuric acid to produce lead (II) sulphate which forms an insoluble protective layer over the underlying lead metal, preventing further reaction. As such, a colourless solution will not be obtained. Lead cannot be unreacted with metal as well as it is not pink in colour. *[3 × 1 = 3]*

d 4 Marks Questions

59. How will you bring out the reduction of the following metal oxides?

ZnO, HgO, Ag_2O and MnO_2

Sol. ZnO and MnO_2 are reduced to respective metal by the action of reducing agents, C and Al respectively as shown below

$$ZnO + C \longrightarrow Zn(s) + CO(g)$$ *[1]*

$$3MnO_2 + 4Al \longrightarrow 3Mn(s) + 2Al_2O_3(s)$$ *[1]*

HgO and Ag_2O are reduced by simply thermal decomposition.

$$2HgO \xrightarrow{\Delta} 2Hg + O_2$$ *[1]*

$$2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$$ *[1]*

60. Why the aluminium is extracted through electrolytic process and not by using a reducing agent? Write the reactions taking place at anode and cathode during the electrolytic reduction of alumina.

Sol. Aluminium is an active metal hence, it is not easy and economically not feasible to use reducing agents (like C, Na etc) to extract it.

Electrolysis of alumina takes place as

$$Al_2O_3 \rightleftharpoons 2Al^{3+} + 3O^{2-}$$

At cathode $4Al^{3+} + 12e^- \longrightarrow 4Al$

At anode $6O^{2-} - 12e^- \longrightarrow 6[O]$

$$6[O] \longrightarrow 3O_2$$ *[4]*

61. In the manufacture of iron, a mixture of limestone, coke and iron ore is added to the blast furnace.

In this context, *[2005]*

(i) State the purpose of adding limestone to the furnace.

(ii) Give the equation for the reduction of the iron ore.

(iii) Name the substance which is collected along with cast iron at the bottom of the furnace.

(iv) Write the chemical equation for the formation of the substance named in (iii) above.

Sol. (i) Limestone acts as a flux. *[1]*

(ii) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ *[1]*

(iii) Fusible slag (calcium silicate, $CaSiO_3$) is collected along with cast iron. *[1]*

(iv) $CaO + SiO_2 \longrightarrow CaSiO_3$ *[1]*

62. (i) Name the most common ore of the metal aluminium from which the metal is extracted. Write the chemical formula of the ore.

(ii) Name the process by which impure ore of aluminium gets purified by using concentrated solution of an alkali.

(iii) Write the equation for the formation of aluminum at the cathode during the electrolysis of alumina. *[2018] [4]*

Sol. (i) The most common ore of the metal aluminium is bauxite having chemical formula, $Al_2O_3 \cdot 2H_2O$.

(ii) Baeyer's process is used to obtain pure aluminium oxide from bauxite ore. In this method of chemical purification, the finely powdered ore is treated with hot concentrated solution of sodium hydroxide.

The reactions are as follows

$$\underset{\text{Impure bauxite}}{Al_2O_3 \cdot 2H_2O} + \underset{\text{Conc. solution}}{2NaOH} \xrightarrow{150\text{-}200^\circ C} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2O$$

$$NaAlO_2 + 2H_2O \xrightarrow{50\text{-}60^\circ C} \underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Aluminium hydroxide}}{Al(OH)_3\downarrow}$$

$$2Al(OH)_3 \xrightarrow{1100^\circ C} \underset{\text{Pure alumina}}{Al_2O_3} + 3H_2O$$

(iii) During electrolysis of alumina, the reaction which occurs at cathode is

$$Al^{3+} + 3e^- \longrightarrow Al$$

e 5 Marks Questions

63. From the list of characteristics given below, select the five which are relevant to non-metals and their compounds. **[2007]**

(i) Ductile (ii) Conduct electricity

(iii) Brittle (iv) Acidic oxides

(v) Basic oxides (vi) Discharged at anode

(vii) Discharged at cathode

(viii) Ionic chlorides (ix) Covalent chlorides

(x) Reaction with dilute sulphuric acid yields hydrogen

(xi) 1, 2 or 3 valence electrons

(xii) 5, 6 or 7 valence electrons

Sol. *Non-metals are*

(iii) Brittle (iv) Acidic oxides

vi) Discharged at anode (ix) Covalent chlorides

(xii) 5, 6 or 7 valence electrons *[5]*

64. *M* is a metal above hydrogen in the activity series and its oxide has the formula, M_2O. This oxide when dissolved in water forms the corresponding hydroxide which is a good conductor of electricity?

In the above context answer the following.

(i) What kind of combination exists between *M* and O?

(ii) How many electrons are there in the outermost shell of *M* ?

(iii) Name the group to which *M* belongs.

(iv) State the reaction taking place at the cathode.

(v) Name the product at the anode. ***[2014]***

Sol. (i) Between *M* and O, electrovalent or ionic bond is formed.

(ii) In the outermost shell of *M*, only one electron is present.

(iii) *M* belongs to alkali metal group. *i.e.,* group IA.

(iv) Reaction at the cathode

$$M^+ + e^- \longrightarrow M \quad \text{(Reduction)}$$

(v) Oxygen gas is produced at the anode. ***[1 × 5 = 5]***

65. (i) Explain, what happens if bauxite containing iron and silica as impurities is directly subjected to the process of electrolytic reduction without prior purification.

(ii) Give the flow chart for the extraction of aluminium.

Sol. (i) Crude bauxite contains iron oxide and silica as impurities. If any iron is present in the bauxite, it will get deposited at the cathode in preference to aluminium because iron is less electropositive than aluminium. ***[2]***

(ii) Refer to text on page 141. ***[3]***

66. (i) For each of the substance listed below, describe the role played in the extraction of aluminium.

(a) Cryolite

(b) Sodium hydroxide

(c) Graphite

(ii) Explain. Why?

(a) In the electrolysis of alumina using the Hall Heroult's process the electrolyte is covered with powdered coke?

(b) Iron sheets are coated with zinc during galvanisation? ***[2015]***

Sol. (i) (a) Cryolite bring down the fusion temperature in electrolytic cell thus, saving electricity.

(b) Sodium hydroxide (NaOH) converts bauxite ($Al_2O_3 \cdot 2H_2O$) into sodium aluminate.

(c) Graphite act as anode. ***[3 × 1 = 3]***

(ii) (a) Coke reduce the heat loss during electrolysis and also save graphite anode from oxidation.

(b) Zinc form a protective layer of zinc oxide which save iron from being corroded due to activity of atmospheric oxygen. ***[2 × 1 = 2]***

67. (i) Name the solution used to react with bauxite as a first step in obtaining pure aluminium oxide in the Baeyer's process.

(ii) Write the equation for the reaction where the aluminium oxide for the electrolytic extraction of aluminium is obtanined by heating aluminium hydroxide.

(iii) Name the compound added to pure alumina to lower the fusion temperature during the electrolytic reduction of alumina.

(iv) Write the equation for the reaction that occurs at the cathode during the extraction of aluminium by electrolysis.

(v) Explain why it is preferable to use a number of graphite electrodes as anode instead of a single electrode, during the above electrolysis? ***[2016]***

Sol. (i) Hot sodium hydroxide solution is used to react with bauxite as a first step in obtaining pure aluminium oxide in the Baeyer's process.

(ii) $\underset{\text{(Aluminium hydroxide)}}{2Al(OH)_3} \xrightarrow{1100\,^\circ C} \underset{\text{(Pure alumina)}}{Al_2O_3} + 3H_2O$

(iii) Cryolite (Na_3AlF_6)

(iv) Reaction at cathode,

$$4Al^{3+} + 12e^- \longrightarrow 4Al$$

(v) During electrolytic reduction of alumina, oxygen gas is evolved at anode which oxidises graphite to carbon dioxide.

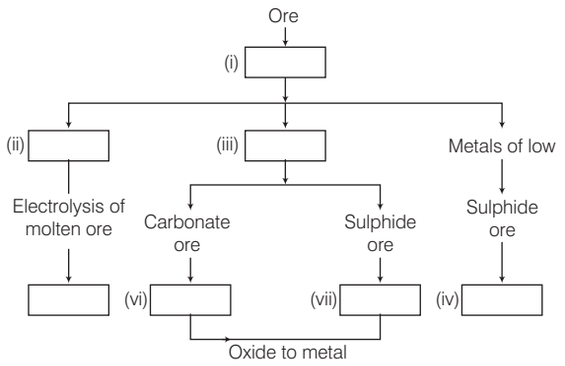
$$\underset{\text{Graphite}}{C} + O_2 \longrightarrow CO_2$$

Therefore, it is preferable to use a number of graphite electrodes as anode instead of a single electrode, during the above electrolysis. ***[5 × 1 = 5]***

CHAPTER EXERCISE

Fill in the Blanks

1. Calamine is an ore of ..... .
2. The fusible compound formed by the combination of flux and gangue is called ..... .
3. Fe_3O_4 is the chemical composition of ..... ore.
4. Complete the following.



5. Pure aluminium oxide is dissolved in ..... to make a conducting solution. *[2005]*
6. Removal of the (i) ..... materials from the ore is known as (ii) ..... of ore. It involves various steps and the selection of these steps depends upon the (iii) ..... in physical properties of the compound of the metal (iv) ..... and that of the (v) ..... .
7. Write down the word which correctly completes the following sentence.
   By dissolving aluminium oxide in cryolite, a ..... (conducting/non-conducting) solution is produced.

Multiple Choice Questions

8. In the periodic table, alkali metals are placed in the group *[2011]*
   (a) 1 (b) 11 (c) 17 (d) 18
9. Which one of the following four metals would be displaced from the solution of its salts by other three metals?
   (a) Mg (b) Ag (c) Zn (d) Cu
10. Which one of the following is not true about metals? *[2010]*
    (a) Metals are good conductor of electricity.
    (b) Metals are malleable and ductile.
    (c) Metals form non-polar covalent compounds.
    (d) Metals will have 1, 2 or 3 electrons in their valence shell.
11. Identify the metallic oxide which is amphoteric in nature. *[2013]*
    (a) Calcium oxide (b) Barium oxide
    (c) Zinc oxide (d) Copper (II) oxide
12. The metals, zinc and tin are present in the alloy *[2013]*
    (a) solder (b) brass
    (c) bronze (d) duralumin

Match the Following

13. Match the following columns.

Column I (Alloys name)		Column II (Composition)	
(i)	Stainless steel	(a)	Pb and Sn
(ii)	Magnalium	(b)	Fe, Cr, Ni and C
(iii)	Brass	(c)	Al and Mg
(iv)	Solder	(d)	Cu and Zn

1 Mark Questions

14. Name the method of purification for producing semiconductor or other metals of very high purity.
15. Write the reaction involved during the reduction of zinc oxide.

2 Marks Questions

16. (i) Name the oxide which acts as flux in the blast furnace.
    (ii) Is the amount of carbon in pig iron/cast iron more than, less than or the same as the amount of carbon in steel? *[2006]*

17. Find the odd one out and explain your choice (Note : valency is not a criterion). *[2]*

(i) Sulphur, phosphorus, carbon, iodine

(ii) Copper, lead, zinc, mercury *[2005]*

18. State the property of the metal being utilised in the following. *[2009]*

Uses of Metal	Property
Zinc in galvanisation	
Aluminium in thermite welding	

3 Marks Questions

19. What are different steps involved in the extraction of pure metal from its ore?

20. Why should the metal sulphides and carbonates be converted to metal oxides in the process of extraction of metal from them?

21. A metal that exists as a liquid at room temperature is obtained by heating its sulphide in the presence of air. Identify the metal and its ore and give the reactions involved.

22. The following questions are related to the extraction of aluminium by electrolysis.

(i) Name the other aluminium containing compound added to alumina and state its significance.

(ii) Give the equation for the reaction that takes place at the cathode.

(iii) Explain, why is it necessary to renew the anode periodically? *[2013]*

23. Name the main constituent metal in the following alloys. *[2014, 2010]*

(i) Duralumin

(ii) Brass

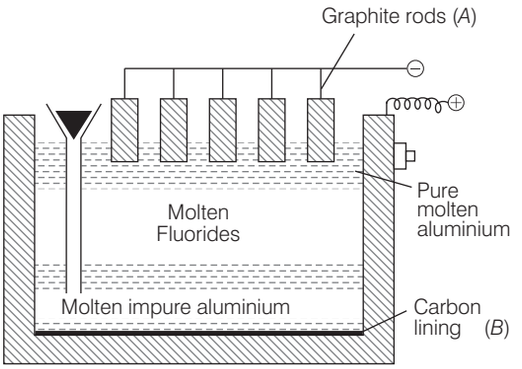
(iii) Stainless steel

4 Marks Questions

24. (i) What are the different types of metallurgy involved?

(ii) Define electrolytic refining. Give an example.

25. The sketch given below illustrates the refining of aluminium by Hoope's process. *[2009]*

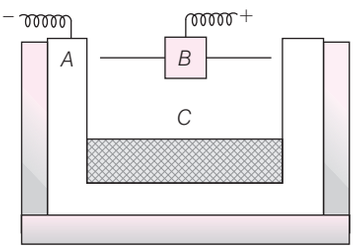


(i) Which among *A* and *B* is the cathode and which one is anode?

(ii) What is the electrolyte in the tank?

(iii) Which material is used for the cathode?

26. Following is the sketch of electrolytic cell used in the extraction of aluminium.



(i) Name the substance of which electrodes *A* and *B* are made?

(ii) At which electrode (*A* or *B*) is the aluminium formed?

(iii) What are the two aluminium compounds in the electrolyte *C*?

(iv) Why is it necessary for electrode *B* to be continuously replaced?

5 Marks Questions

27. Answer the following questions. *[2011]*

(i) Name a metal which is found abundantly in the earth's crust.

(ii) What is the difference between calcination and roasting?

(iii) Name the process used for the enrichment of sulphide ore.

(iv) Write the chemical formulae of one main ore of iron and aluminium.

(v) Write the constituents of electrolyte for the extraction of aluminium.

28. Choose from the following metals to answer the questions given below.

Aluminium, calcium, copper, iron, magnesium, potassium, nickel, zinc

Each metal can be used once.

Name a metal which

(i) is manufactured by the electrolysis of its molten oxide.

(ii) is used to galvanise iron.

(iii) is alloyed with zinc to make brass.

(iv) reacts with aqueous copper (II) sulphate to give a pink solid.

(v) does not react with cold water.

29. Explain the following.

(i) Reactivity of Al decreases, if it is dipped in HNO_3.

(ii) Carbon cannot reduce the oxides of Na or Mg.

(iii) NaCl is not a good conductor of electricity in solid state whereas it does conduct electricity in aqueous solution as well as in molten state.

(iv) Iron articles are galvanised.

(v) Metals like Na, K, Ca and Mg are never found in their free state in nature.

ARCHIVES*

(Last 6 Years)

Collection of Questions Asked in Last 6 Years' (2018-2013) ICSE Class 10th Examinations

2018

1 The most common ore of iron is ..... . (calamine/haematite) *[1]*

2 Give reasons for the following.
Alkali metals are good reducing agents. *[1]*

3 The process by which sulphide ore is concentrated. *[1]*

4 Write a balanced chemical equation for each of the following. *[2]*
(i) Action of heat on aluminum hydroxide.
(ii) Reaction of zinc with potassium hydroxide solution.

5 Name the main component of the following alloys *[2]*
(i) Brass (ii) Duralumin

6 (i) Name the most common ore of the metal aluminium from which the metal is extracted. Write the chemical formula of the ore.
(ii) Name the process by which impure ore of aluminium gets purified by using concentrated solution of an alkali.
(iii) Write the equation for the formation of aluminum at the cathode during the electrolysis of alumina. *[4]*

2017

7 When a metallic oxide is dissolved in water, the solution formed has a high concentration of …… ions (H^+, H_3O^+, OH^-).

8 From the list of terms given, choose the most appropriate term to match the given description. (calcination, roasting, pulverisation, smelting).
(i) Crushing of the ore into a fine powder. (ii) Heating of the ore in the absence of air to a high temperature.

9 Name the following.
(i) An alloy of lead and tin that is used in electrical circuits.
(ii) An ore of zinc containing its sulphide.
(iv) A metal oxide that can be reduced by hydrogen.

2016

10 Metals are good …… (oxidising agents/reducing agents) because they are electron …… (acceptors/donors).

11 The two main metals in bronze are
(a) copper and zinc (b) copper and lead
(c) copper and nickel (d) copper and tin

12 Identify the term/substance in the following. The method used to separate ore from gangue by preferential wetting.

13 (i) Name the solution used to react with bauxite as a first step in obtaining pure aluminium oxide in the Baeyer's process.
(ii) Write the equation for the reaction where the aluminium oxide for the electrolytic extraction of aluminium is obtained by heating aluminium hydroxide.
(iii) Name the compound added to pure alumina to lower the fusion temperature during the electrolytic reduction of alumina.
(iv) Write the equation for the reaction that occurs at the cathode during the extraction of aluminium by electrolysis.
(v) Explain, why it is preferable to use a number of graphite electrodes as anode instead of a single electrode, during the above electrolysis?

2015

14 (i) For each of the substance listed below, describe the role played in the extraction of aluminium.
I. Cryolite II. Sodium hydroxide III. Graphite
(ii) Explain, why?
I. In the electrolysis of alumina using the Hall Heroult's process the electrolyte is covered with powdered coke?
II. Iron sheets are coated with zinc during galvanisation?

2014

15 Name the following. The property possessed by metals by which they can be beaten into sheets.

16 The main ore used for the extraction of iron is

(a) haematite (b) calamine
(c) bauxite (d) cryolite

17 Heating an ore in a limited supply of air or in the absence of air at a temperature just below its melting point is known as

(a) smelting (b) ore dressing
(c) calcination (d) bessemerisation

18 Aluminium powder is used in thermite welding because

(a) it is a strong reducing agent
(b) it is a strong oxidising agent
(c) it is a corrosion resistant
(d) it is a good conductor of heat

19 Name the following.

(i) A compound added to lower the fusion temperature of electrolytic bath in the extraction of aluminium.

(ii) The ore of zinc containing its sulphide.

20 Name the main constituent metal in the following alloys.

(i) Duralumin (ii) Brass (iii) Stainless steel

21 *M* is a metal above hydrogen in the activity series and its oxide has the formula, M_2O. This oxide when dissolved in water forms the corresponding hydroxide which is a good conductor of electricity?

In the above context answer the following.

(i) What kind of combination exists between *M* and O?

(ii) How many electrons are there in the outermost shell of *M*?

(iii) Name the group to which *M* belongs.

(iv) State the reaction taking place at the cathode.

(v) Name the product at the anode.

2013

22 Identify the metallic oxide which is amphoteric in nature.

(a) Calcium oxide (b) Barium oxide
(c) Zinc oxide (d) Copper (II) oxide

23 The metals zinc and tin are present in the alloy

(a) solder (b) brass
(c) bronze (d) duralumin

24 Name the following metals.

(i) A metal present in cryolite other than sodium.

(ii) A metal which is unaffected by dilute or concentrated acids.

(iii) A metal present in period 3, group 1 of the periodic table.

25 Answer the following questions related to the extraction of aluminium by electrolysis.

(i) Name the other aluminium containing compound added to alumina and state its significance.

(ii) Give the equation for the reaction that takes place at the cathode.

(iii) Explain, why is it necessary to renew the anode periodically?

26

	X	*Y*
Electronic configuration.	2, 8, 7	2, 8, 2
Nature of oxide.	Dissolves in water and turns blue litmus red.	Very low solubility in water. Dissolves in hydrochloric acid.
Tendency for oxidising and reducing reactions.	Tends to oxidise elements and compounds.	Tends to act as a reducing agent.
Electrical and thermal conductivity.	Very poor electrical conductor. Poor thermal conductivity.	Good electrical conductor. Good thermal conductor.
Tendency to form alloys and amalgams.	No tendency to form alloys.	Form alloys.

Using the information above, complete the following.

(i) ..... is the metallic element.

(ii) Metal atoms tend to have a maximum of ..... electrons in the outermost energy level.

(iii) Non-metallic elements tend to form ..... oxides while metals tend to form ..... oxides.

(iv) Non-metallic elements tend to be ..... conductors of heat and electricity.

(v) Metals tend to ..... electrons and act as ..... agents in their reactions with elements and compounds.

CHALLENGERS*

1 Froth floatation process for the concentration of ores is an illustration of the practical application of
(a) adsorption (b) absorption (c) coagulation (d) sedimentation

2 Which of the following concentration processe will you use when the gangue is light?
(a) Gravity separation (b) Magnetic separation (c) Froth floatation (d) None of these

3 Name of metal, *M* which is extracted based on the following equation,

$$4M + 8CN^- + 2H_2O + O_2 \longrightarrow 4[M(CN)_2]^- + 4OH^-$$

$$2[M(CN)_2]^- + Zn \longrightarrow [Zn(CN_4)]^{2-} + 2M$$

(a) Cu (b) Au (c) Hg (d) Ni

4 An ore after levigation is found to have basic impurities. Which of the following can be used as flux during smelting?
(a) H_2SO_4 (b) $CaCO_3$ (c) SiO_2 (d) Both CaO and SiO_2

5 The reason for floating of ore particles in concentration by froth floatation process is that they are
(a) light (b) soluble (c) heavy (d) hydrophobic

6 Among the following statements the incorrect one is
(a) calamine and siderite are carbonates (b) argentite and cuprite are oxide
(c) zinc blende and iron pyrites are sulphides (d) malachite and azurite are ores of copper

7 Pb and Sn are extracted, respectively from their chief ore by
(a) carbon reduction and self reduction (b) self reduction and carbon reduction.
(c) electrolysis and self reduction (d) self reduction and electrolysis

8 Which of the following represents correct matching of metals with their minerals?

	Mg	Na	Cu	Al
(a)	Chloride	Chloride	Sulphide	Silicate
(b)	Carbonate	Chloride	Sulphide	Oxide
(c)	Carbonate	Carbonate	Oxide	Phosphate
(d)	Oxide	Chloride	Sulphide	Oxide

9 Alumnium is extracted from purified bauxite by electrolysis but iron is extracted from haematite by reduction with coke. Why is iron not extracted by electrolysis?
(a) Haematite needs to be purified but bauxite does not.
(b) Iron is less reactive than alumnium.
(c) Reduction with coke is cheaper than electrolysis.
(d) Reduction with coke gives a pure product than electrolysis.

10 In which of the following isolation, no reducing agent is required?
(b) Iron from haematite (c) Alumnium from bauxite
(d) Zinc from zinc blende (c) Mercury from cinnabar

Answers

1. (a) **2.** (a) **3.** (b) **4.** (c) **5.** (d) **6.** (b) **7.** (b) **8.** (b) **9.** (b) **10.** (d)

* These questions may or may not be asked in the examination, have been given just for additional practice

CHAPTER

8

Study of Compounds

There are a total of 118 elements known to us. Most of these elements combine with one another to form numerous compounds. To study such a large number of compounds, they have been classified into two main groups, namely organic compounds and inorganic compounds. Organic compounds include compounds of carbon formed with other elements (like hydrogen, oxygen, nitrogen, etc.), which we will study in upcoming chapters. Inorganic compounds include all the other non-carbon compounds. In this chapter, we will study few scientifically and commercially important compounds.

Chapter Objective

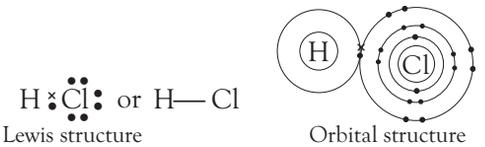
- Hydrogen Chloride Gas
- Hydrochloric Acid
- Ammonia
- Nitric Acid
- Sulphuric Acid

Hydrogen Chloride Gas

Hydrogen chloride (HCl) is a monobasic acid having molecular mass equal to 36.5 u. It is a colourless gas with highly pungent odour and is highly corrosive in nature.

Structure

In HCl, the bond between H-atom and Cl-atom is covalent bond. *Its structure can be represented as follows*



Preparation

Some important methods of preparation of HCl gas are as follows

A. General Methods for the Preparation

1. **By Direct Combination**

(i) Hydrogen chloride gas is synthesised from its elements *i.e.*, hydrogen and chlorine in the presence of diffused sunlight. In the dark, no reaction occurs, so activation of the reaction by light energy is required.

$$H_2(g) + Cl_2(g) \xrightarrow[\text{sunlight}]{\text{Diffused}} 2HCl(g)$$

Note If activated carbon is used as a catalyst, then the reaction takes place even in the dark because activated carbon adsorbs hydrogen due to which reactivity will increase.

2. **By Heating Metallic Chlorides with Conc. Sulphuric Acid**

Hydrogen chloride may also be prepared by heating concentrated sulphuric acid (*i.e.*, H_2SO_4) with metallic chlorides (*i.e.*, NaCl, $MgCl_2$, etc).

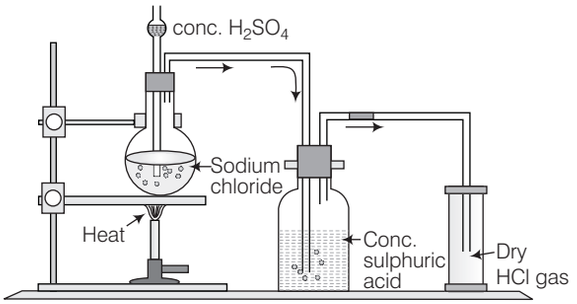
$$MgCl_2 + H_2SO_4 \xrightarrow{\Delta} MgSO_4 + 2HCl(g)$$

B. Laboratory Preparation

Hydrogen chloride gas is prepared in the laboratory by the reaction of sodium chloride (common salt) with concentrated H_2SO_4.

Procedure Common salt is taken in a flask and conc. H_2SO_4 is added through the thistle funnel. On heating the mixture gently, HCl gas is evolved with effervescence. The gas is collected by the upward displacement of air in a gas jar. It is not collected over water, since, it is highly soluble in water.

Note Concentrated nitric acid is not used during the preparation of HCl because it is volatile and may volatilise out alongwith HCl gas.



Laboratory preparation of dry hydrogen chloride gas

Reactions

$$\underset{\text{Reactants}}{NaCl + H_2SO_4} \xrightarrow[200°C]{\text{Below}} \underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Hydrogen chloride gas}}{HCl\uparrow}$$

$$\underset{\text{(Conc.)}}{2NaCl + H_2SO_4} \xrightarrow[200°C]{\text{Above}} \underset{\text{Sodium sulphate}}{Na_2SO_4} + 2HCl\uparrow$$

Observation The HCl gas in the flask is passed through concentrated sulphuric acid and is collected in the jar as dry HCl. The reaction can occur upto the stage of formation of sodium sulphate on heating above 200°C.

Purification of HCl Gas It can be dried by passing through concentrated H_2SO_4. Drying agents like phosphorus pentaoxide (P_2O_5) and quick lime (CaO) cannot be used, since, they react with HCl.

$$2P_2O_5 + 3HCl \longrightarrow POCl_3 + 3HPO_3$$

$$CaO + 2HCl \longrightarrow CaCl_2 + H_2O$$

Precautions

(i) The lower end of the thistle funnel must be dipped below the acid level in flask, otherwise the HCl gas obtained will escape out from the thistle funnel.

(ii) Temperature should be maintained at 200°C, otherwise sodium sulphate forms a hard crust which sticks to the glass and is difficult to remove, fuel is wasted, glass apparatus may crack.

Note Sodium chloride is very cheap (easily available) therefore, it is preferred for the preparation of HCl over other metal chlorides.

Properties

HCl gas exhibit following physical and chemical properties

A. Physical Properties

The physical properties of HCl are as follows

(i) **Colour, Odour and Taste** Colourless, pungent choking smell, sour in taste. In moist air, it is present as fume because it dissolves in water vapour to form tiny droplets of HCl.

(ii) **Physiological Nature** Corrosive in nature, if inhaled causes burning sensation.

(iii) **Density** 1.28 times heavier than air.

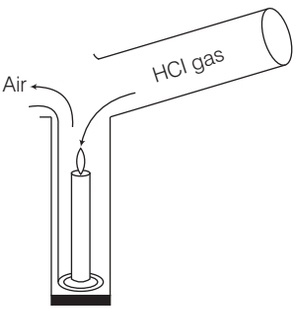
(iv) **Solubility** Highly soluble in water (1 volume of water dissolves 452 volume of gas at room temperature.)

(v) **Liquefaction** Liquefies at temperature of around 10°C and 40 atm. pressure.

(vi) **Boiling point** is –83° C and **melting point** is –113° C.

Experiment to Demonstrate Density

Hydrogen chloride gas is heavier than air. It can be proved by transferring the HCl gas in a jar containing burning candle. As a result, the candle gets extinguished because HCl gas being heavier occupies the lower portion of the jar and forces the air out of it.



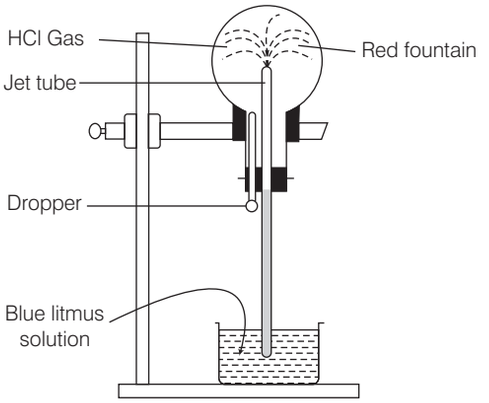
To show that HCl gas is heavier than air

Experiment to Demonstrate Solubility

The extreme solubility of hydrogen chloride gas is demonstrated by fountain experiment.

Procedure Arrange the apparatus as shown in the figure. On the mouth of the flask, fix a rubber stopper with two holes. Through one hole pass a long jet tube and through one hole pass a dropper with few drops of water. Put the jet tube in the beaker. Press the dropper.

Observation It is seen that the blue litmus solution enters the jet tube with a great force, forming a red fountain.



Fountain experiment

Reason Due to high solubility of HCl gas in water, the pressure inside the flask lowers. The pressure of outside is still higher that pushes the blue litmus solution inside through the jet tube.

B. Chemical Properties

The chemical properties of hydrochloric gas are as follows

(i) **Acidic Nature** Pure HCl does not show acidity. But when dissolved in water, due to the presence of H^+, HCl imparts acidic properties. It is monobasic in nature.

$$HCl \overset{H_2O}{\rightleftharpoons} H^+(aq) + Cl^-(aq)$$

(ii) **Combustibility** This gas is neither combustible nor supporter of combustion. If we put a burning wood in a jar containing HCl gas, the fire get extinguishes.

(iii) **Thermal Dissociation** When it is heated above 500°C, it dissociates into hydrogen and chlorine.

$$2HCl \xrightarrow{\text{Above } 500°C} H_2 + Cl_2$$

(iv) **Reaction with Ammonia** When HCl gas is mixed with ammonia gas, a dense white fumes are formed due to the formation solid NH_4Cl particles.

$$NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$$

This reaction is used for the identification of HCl gas.

(v) **Reaction with Metals** All the metals that are placed above hydrogen, *i.e.*, from potassium to iron, in the electrochemical series on reacting with HCl gas form their corresponding chlorides and liberate hydrogen. *e.g.*,

Metal + Hydrogen chloride gas $\xrightarrow{\Delta}$ Metal chloride + Hydrogen

$$2K + 2HCl \xrightarrow{\Delta} 2KCl + H_2\uparrow$$

$$Ca + 2HCl \xrightarrow{\Delta} CaCl_2 + H_2\uparrow$$

$$2Na + 2HCl \xrightarrow{\Delta} 2NaCl + H_2\uparrow$$

$$Mg + 2HCl \xrightarrow{\Delta} MgCl_2 + H_2\uparrow$$

$$Zn + 2HCl \xrightarrow{\Delta} ZnCl_2 + H_2\uparrow$$

$$Fe + 2HCl \xrightarrow{\Delta} FeCl_2 + H_2\uparrow$$

CHECK POINT 01

1. Draw the Lewis dot structure of hydrogen chloride gas.
2. Write the laboratory method to prepare hydrogen chloride gas.
3. Why hydrogen chloride gas is not collected over water?
4. Sulphuric acid is preferred over calcium oxide as drying agent for hydrogen chloride. Why?
5. Hydrogen chloride gas is not acidic but when dissolved in water behaves acidic. Explain.

Hydrochloric Acid

It is formed when hydrogen chloride gas is dissolved in water. Hydrochloric acid is a polar covalent compound and it ionises in water to give H_3O^+ and Cl^- ions.

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

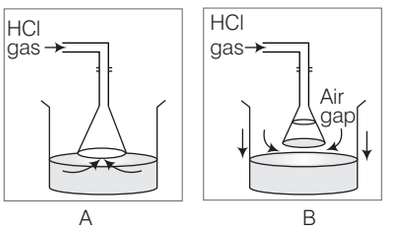
Liquefied hydrogen chloride gas is covalent in nature, thus, it does not conduct electricity. It also does not turn blue litmus paper red. Thus, it is non-acidic in nature. The HCl gas is soluble in toluene but in that condition it neither conducts electricity nor turns blue litmus to red.

Preparation of Hydrochloric Acid

Hydrochloric acid is prepared by dissolving hydrogen chloride gas in water using a special funnel arrangement.

Procedure

A special funnel arrangement for dissolving hydrogen chloride gas in water is shown in Fig. B.



Funnel arrangement of dissolving HCl into H_2O

Hydrogen chloride gas is highly soluble in water and if delivery tube through which HCl gas is passed is directly immersed in water, then the partial vacuum is created in the tube because rate of absorption of HCl gas is high. The pressure outside being higher causes the water to be pushed up into the delivery tube. This is called **back-suction**.

Precautions

An empty flask (anti-suction device) is put between the generative flask and the water trough. In case, the back-suction occurs, the water will collect in it and will not reach the generating flask.

HCl forms azeotropes with water having boiling point around 110°C.

Note Azeotrope is a solution or it is a constant boiling mixture which boils without any change in its composition.

Properties of Hydrochloric Acid

Following properties are exhibited by hydrochloric acid

A. Physical Properties

Physical properties of hydrochloric acid are as follows

(i) **Colour, Odour and Taste** Colourless, pungent choking smell and acidic.

(ii) **Physiological Action** Concentrated acid is corrosive.

(iii) **Solubility** Readily soluble in water in all proportions.

(iv) **Boiling Point** is 110°C

(v) **Action on Skin** It is corrosive acid and burn the skin.

B. Chemical Properties

The chemical properties of hydrochloric acid are as follows

(i) **Nature** It is acidic in nature. It turns blue litmus to red. It changes the colour of indicator methyl orange to pink. It ionises in water to give H_3O^+ and Cl^- ions

(ii) **Action on Metals** Hydrochloric acid reacts with metals which are placed above the hydrogen in the activity series and forms metal chlorides and hydrogen.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow$$

$$2K + 2HCl \longrightarrow 2KCl + H_2\uparrow$$

(iii) **Action on Oxides and Hydroxides** Hydrochloric acid reacts with oxides and hydroxides to form salt and water.

$$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$$

$$Zn(OH)_2 + 2HCl \longrightarrow ZnCl_2 + 2H_2O$$

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$

$$CuO + 2HCl \longrightarrow CuCl_2 + H_2O$$

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

$$NH_4OH + HCl \longrightarrow NH_4Cl + H_2O$$

(iv) **With Salts of Weaker Acids** HCl decomposes salts of weaker acids (*e.g.*, Carbonates, bicarbonates, sulphates and sulphides).

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2\uparrow$$

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$$

$$Na_2SO_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2\uparrow$$

$$Na_2S + 2HCl \longrightarrow 2NaCl + H_2S\uparrow$$

$$ZnS + 2HCl \longrightarrow ZnCl_2 + H_2S\uparrow$$

(v) **Action on Thiosulphates** It reacts with thiosulphate to produce SO_2 gas and yellow sulphur is precipitated.

$$Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2 + S\downarrow$$

Uses This reaction can be used to distinguish between thiosulphates and sulphites.

Because sulphur is not precipitated when sulphite reacts with dil. HCl.

(vi) **Precipitation reactions** Lead nitrate and mercury (I) nitrate reacts with hydrochloric acid to give white precipitate of lead chloride and mercury (I) chloride, respectively.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

$$Hg_2(NO_3)_2 + 2HCl \longrightarrow Hg_2Cl_2\downarrow + 2HNO_3$$

Silver nitrate gives thick curdy white precipitate of silver chloride.

$$AgNO_3 + HCl \longrightarrow AgCl\downarrow + HNO_3$$

This precipitate *i.e.*, AgCl is insoluble in HNO_3 but soluble in NH_4OH. AgCl on reacting with NH_4OH gives complex salt called diammine silver (I) chloride.

$$AgCl + 2NH_4OH \longrightarrow \underset{\text{Diammine silver (I) chloride}}{[Ag(NH_3)_2]^+Cl^-} + 2H_2O$$

To the solution of diammine silver (I) chloride, if nitric acid is added, then a white precipitate of AgCl is formed.

$$[Ag(NH_3)_2]^+Cl^- + \underset{\text{Nitric acid}}{HNO_3} \longrightarrow \underset{\text{White precipitate}}{AgCl\downarrow}$$

Note $AgNO_3$ is used for testing chloride ion or hydrochloric acid.

When AgCl is exposed to sunlight, it decomposes into metallic silver and chlorine.

$$2AgCl \xrightarrow{\text{Sunlight}} 2Ag + Cl_2$$

(vii) **Oxidation of hydrochloric Acid** Powerful oxidising agents such as manganese dioxide (MnO_2), lead oxide (PbO_2), red lead (Pb_3O_4), potassium permanganate ($KMnO_4$) and potassium dichromate ($K_2Cr_2O_7$) oxidise conc. HCl, liberating chlorine gas.

$$MnO_2 + \underset{(Conc.)}{4HCl} \xrightarrow{\Delta} MnCl_2 + 2H_2O + Cl_2$$

$$PbO_2 + \underset{(Conc.)}{4HCl} \xrightarrow{\Delta} PbCl_2 + 2H_2O + Cl_2$$

$$Pb_3O_4 + 8HCl \xrightarrow{\Delta} 3PbCl_2 + 4H_2O + Cl_2$$

$$2KMnO_4 + \underset{(Conc.)}{16HCl} \xrightarrow{\Delta} 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

$$K_2Cr_2O_7 + 14HCl \xrightarrow{\Delta} 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$$

(viii) **Formation of Aqua-regia** Mixture of three parts of conc. HCl and one part of conc. HNO_3 is called aqua-regia.

$$\underset{Conc.}{3HCl} + \underset{Conc.}{HNO_3} \longrightarrow \underset{\text{Nitrosyl chloride}}{NOCl} + 2H_2O + 2\underset{\text{Nascent chlorine}}{[Cl]}$$

Nascent chlorine reacts with noble metals like gold and platinum to give their soluble chlorides.

$$Au + 3[Cl] \longrightarrow \underset{\text{Gold (III) chloride}}{AuCl_3}$$

$$Pt + 4[Cl] \longrightarrow \underset{\text{Platinum (IV) chloride}}{PtCl_4}$$

Uses of Hydrochloric Acid

Some uses of hydrochloric acid are as follow

General Uses

(i) It is used in laboratory as a reagent.

(ii) It is used for the preparation of aqua-regia.

Industrial Uses

(i) In the manufacturing of dyes, drugs and paints.

(ii) For making chlorides,
e.g., NH_4Cl, AgCl (used in photographic films).

(iii) To obtain glucose from starch.

(iv) In pickling of metals before galvanising.

(v) To purify bone black as HCl dissolves calcium phosphate present in bones.

(vi) As tanning agent in leather industry.

Medicinal Uses

(i) It is prescribed to patients with decreased activity of their gastric juices as it helps in digestion of proteins.

(ii) Destroy the microorganisms that enter in alimentary canal alongwith the food.

Test for Hydrogen Chloride gas and Hydrochloric Acid

(i) HCl gas gives thick white fumes of ammonium chloride, when a glass rod dipped in ammonia solution is held near the vapours of the acid.

$$NH_3 + HCl \longrightarrow NH_4Cl\uparrow$$

(ii) With silver nitrate solution, both gas and acid gives white precipitate of silver chloride.

$$AgNO_3 + HCl \longrightarrow AgCl\downarrow + HNO_3$$

Precipitate is insoluble in nitric acid but soluble in ammonium hydroxide.

(iii) When hydrochloric acid is heated with manganese dioxide, then greenish yellow gas, i.e., chlorine is evolved which turns moist starch iodide paper blue black.

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$$

CHECK POINT 02

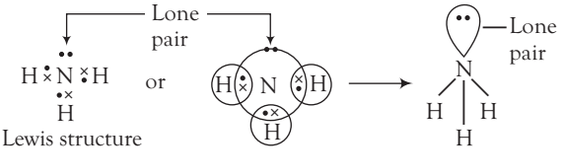
1. What is the main difference between hydrogen chloride and hydrochloric acid?
2. How can you form chloride salts of noble metals like gold and platinum?
3. How is hydrochloric acid obtained from hydrogen chloride gas?
4. Name the gas evolved when hydrochloric acid is added to
   (a) zinc sulphate (b) sodium sulphite
5. Write any two uses of hydrochloric acid.

Ammonia

Ammonia is a compound of nitrogen and hydrogen. Its molecular mass is found to be 17u and its molecular formula is deduced as NH_3. It is also produced by the natural decomposition of animal and vegetable bodies. The death and decay of plants and animals cause the nitrogen compounds present in them to get decomposed, giving ammonia. It also occurs in the soil in form of ammonium salts.

Structure

In NH_3, nitrogen atom has three covalent bonds with each of three hydrogen atoms, along with a lone pair of electron.
Its structure can be represented as follow



Different forms of Ammonia

Ammonia is present in the following forms

(i) **Gaseous ammonia** (Dry NH_3 gas)

(ii) **Liquid ammonia** Dry NH_3 gas is liquefied under high pressure, and is known as liquid ammonia.

(iii) **Liquor ammonia fortis** It is a saturated solution of ammonia in water.

(iv) **Laboratory bench reagent** Dilute solution of liquor ammonia is a laboratory reagent.

Note Liquor ammonia fortis is also known as 880 ammonia. It has a relative density of 0.880. It is stored in cold place with tightly stoppered bottles.

Preparation of Ammonia Gas

Following methods are employed for the preparation of NH_3 *gas*

A. General Methods of preparation

From Ammonium Salts Ammonia gas is obtained by treating ammonium salt with caustic alkali such as caustic soda, caustic potash or slaked lime.

$$\text{Ammonium salt} + \text{Alkali} \xrightarrow{\Delta} \text{Metal salt} + \text{Water} + \text{Ammonia gas}$$

$$(NH_4)_2SO_4 + \underset{\text{Slaked lime}}{Ca(OH)_2} \xrightarrow{\Delta} CaSO_4 + 2H_2O + 2NH_3\uparrow$$

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3\uparrow$$

Note Some compounds of ammonia (e.g. ammonium nitrate and ammonium nitrite) which on warming with alkalies do not produce ammonia, because these compounds are highly unstable and decompose by heating only.

Reactions

$$\underset{\text{Ammonium nitrate}}{NH_4NO_3} \xrightarrow{\Delta} \underset{\text{Nitrous oxide}}{N_2O} + 2H_2O$$

$$\underset{\text{Ammonium nitrite}}{NH_4NO_2} \xrightarrow{\Delta} \underset{\text{Nitrogen}}{N_2}\uparrow + 2H_2O$$

B. Laboratory Preparation

(i) From Ammonium Chloride

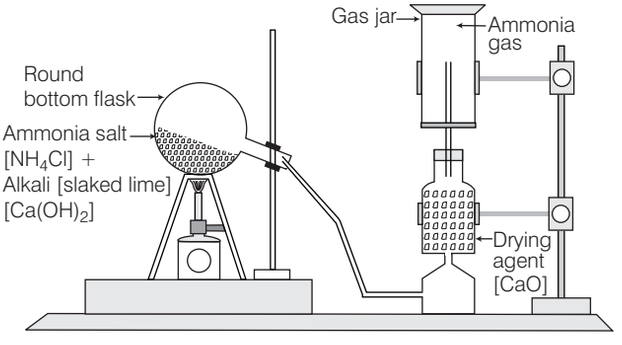
A mixture of ammonium chloride (NH_4Cl) and calcium hydroxide $Ca(OH)_2$ in the ratio of 2 : 3 by weight.

The preparation is carried out by heating a mixture of ammonium salt (NH_4Cl) with an alkali [$Ca(OH)_2$].

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$$

Ammonia can also be produced by heating ammonium chloride with other caustic alkalies such as NaOH, KOH, etc.

$$NH_4Cl + NaOH \longrightarrow NaCl + NH_3\uparrow + H_2O$$



Laboratory method for the preparation of ammonia

Procedure The reactants *i.e.*, ammonium chloride and calcium hydroxide are ground together and heated slowly in a round bottom flask with its neck sloping downward.

Observation The ammonia gas obtained in the flask passes through a delivery tube into a drying tower and is collected in an inverted gas jar.

Drying Agent Quick lime (CaO) is used as a drying agent. Being a basic gas, ammonia cannot be dried by passing it through concentrated sulphuric acid or phosphorous pentaoxide, as it reacts with them to form ammonium sulphate or ammonium phosphate, respectively.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

$$6NH_3 + 3H_2O + P_2O_5 \longrightarrow 2(NH_4)_3PO_4$$

Calcium chloride also cannot be used for drying ammonia gas, as it forms ammoniates with $CaCl_2$.

$$CaCl_2 + 8NH_3 \longrightarrow CaCl_2 \cdot 8NH_3$$

Collection Ammonia gas is collected by the downward displacement of air, because it is lighter than air (has vapour density of 8.5). It is highly soluble in water, hence not collected over water.

Note To check whether a gas jar is filled by ammonia gas, hold a glass rod (dipped in dil.HCl) near the mouth of gas jar. Dense white fumes around the glass rod confirms that the jar is filled with ammonia gas.

Precautions

(i) All the apparatus such as gas jar, delivery tube, flask, etc., must be dry, because ammonia is highly soluble in water.

(ii) The flask should be placed well, so that the water formed in the reaction does not come back into the heated flask.

(iii) Heating should be done gently.

(ii) From Metal Nitrides

Ammonia can also be obtained by the action of warm water on magnesium, aluminium or calcium nitride.

$$\text{Metal nitride } (Mg_3N_2 \text{ or } AlN \text{ or } Ca_3N_2) + \text{Warm water}$$

$$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3\uparrow$$

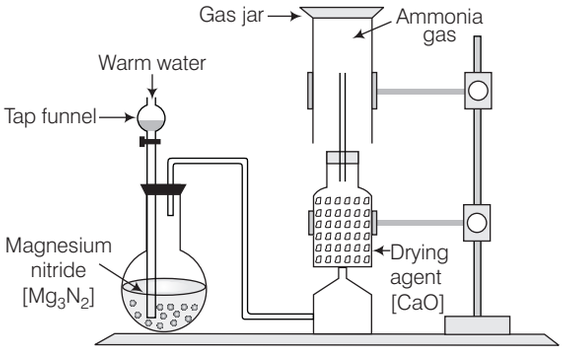
$$AlN + 3H_2O \longrightarrow Al(OH)_3 + NH_3\uparrow$$

$$Ca_3N_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2NH_3\uparrow$$

Procedure Magnesium nitride or aluminium nitride is kept in a round bottom flask fitted with a thistle funnel and a delivery tube (as shown in the figure). Warm water is also added very slowly. Along with ammonia which is liberated and escapes through the delivery tube, magnesium or aluminium hydroxide, is also formed.

Observation The ammonia gas obtained in the gas jar passes through a delivery tube into a drying tower and is collected in an inverted gas jar.

Drying Agent Quick lime (CaO) in the drying tower.



Laboratory method for the preparation of ammonia

Collection Ammonia gas is collected by the downward displacement of air.

Precaution The lower end of the thistle funnel should dip into the warm water.

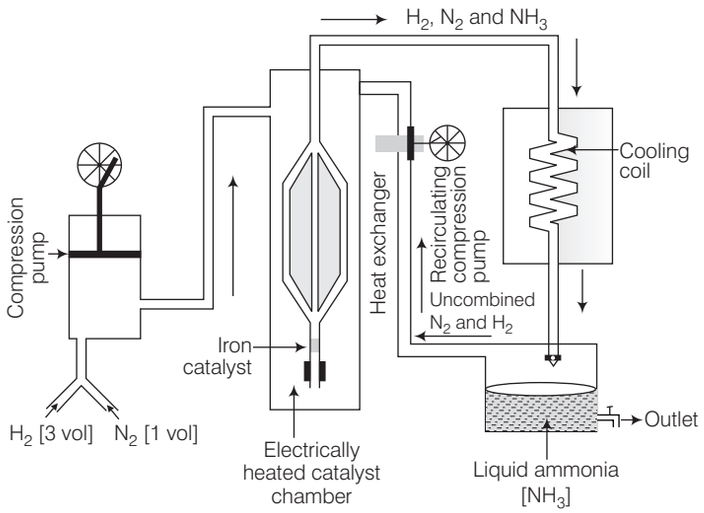
Note An aqueous solution of ammonia is prepared by dissolving ammonia in water.

CHECK POINT 03

1. Why ammonia gas is called alkaline air?
2. Draw the Lewis structure of ammonia showing lone pair.
3. Ammonium phosphate produces ammonia but ammonium nitrate does not, why?
4. How can you detect the presence of ammonia?
5. Write the reactions involved during preparation of ammonia form metal nitride.

C. Manufacturing by Haber's process

The manufacture of ammonia by Haber's process involves the direct combination of nitrogen and hydrogen.



Manufacture of ammonia-Haber's process

Reactants

Nitrogen (N_2) and hydrogen (H_2) in the ratio of 1 : 3 by volume. Hydrogen gas is obtained from water gas by Bosch process or from natural gas. Nitrogen gas is obtained by liquefaction and fractional distillation of liquid air.

Product

Nitrogen reacts with hydrogen under specific conditions liberating 2 volumes of ammonia (NH_3).

$$\underset{[1\text{ vol}]}{N_2} + \underset{[3\text{ vol}]}{3H_2} \underset{\text{Above 200 atm (Fe and Mo)}}{\overset{450\text{-}500^\circ C}{\rightleftharpoons}} \underset{[2\text{ vol}]}{2NH_3} + \text{Heat}$$

The above reaction is exothermic and reversible in nature. It proceeds with decrease in volume.

Procedure

Three parts of hydrogen gas (pure and dried) by volume is mixed with one part of nitrogen gas (pure and dried) and compressed at relatively high pressure.

This mixture is passed to catalytic chamber containing catalyst *i.e.*, finely divided iron with aluminium oxide or a little amount of molybdenum (as promoter) at a temperature of 500°C. When the mixture of gases comes in contact with the catalyst they react to form ammonia gas and heat is released.

The mixture of hot ammonia gas and unreacted hydrogen and nitrogen exchange their heat with the incoming unreacted nitrogen and hydrogen mixture.

Note To start the reaction, catalyst is heated initially after that no further heating is done (as reaction is exothermic). This heat is absorbed by incoming gas. This warms up the gas. Rate of flow should be maintain, so that it does not interfere the temperature.

Recovery of Ammonia

1. **By Liquefaction** The mixture of gases (NH_3 along with unreacted nitrogen and hydrogen) under pressure is allowed to expand suddenly through a small nozzle into a region of low pressure (results in fall in temperature).
   On sudden expansion, ammonia gas liquefies and collected. The unreacted nitrogen and hydrogen is recycled into the catalyst chamber.
2. **By Dissolving in water** Another way is by dissolving ammonia in water because ammonia is highly soluble in water, while N_2 and H_2 are very slightly soluble.

Favourable Conditions for the Haber's Process

As the reaction is reversible and exothermic , therefore low temperature (450-500°C) and high pressure (above 200 atm) favour the forward reaction.

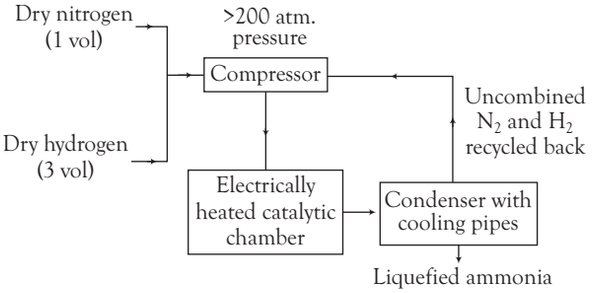
Temperature An optimum temperature of 450-500°C is used in the Haber's process. According to **Le-Chatelier's principle,** if a reaction is exothermic, the reaction is favoured (*i.e.,* higher percentage yield of ammonia) by lowering the temperature. However, if the temperature is low, the speed of the reaction is slow and the yield of ammonia is also low. External heating is therefore not required.

Pressure An optimum pressure of 200-900 atm is used during the process. Since, four volumes of reactants produces two volumes of products and if a reaction proceeds with decrease in volume then the forward reaction is favoured by increasing the pressure.

Catalyst A catalyst is required to accelerate the reaction at optimum temperature. The catalyst used is finely divided iron, it is mixed with small amounts of the promoter molybdenum or Al_2O_3 which enhances the efficiency of the catalyst.

Note Time to time, the purification of nitrogen and hydrogen should be done because impurities (e.g., CO, H_2S, CO_2, etc.) can poison the catalyst.

Flowchart of Haber's Process



Properties of Ammonia

Properties of ammonia are as follow

A. Physical Properties

Physical properties of ammonia are as follows

(i) **Colour, Odour and Taste** Colourless, strong, pungent choking smell may bring tears to eyes and alkaline taste.

(ii) **Physiological Action** Non-poisonous but if inhaled, it can damage the respiratory system.

(iii) **Density** Vapour density = 8.5 [Lighter than air].

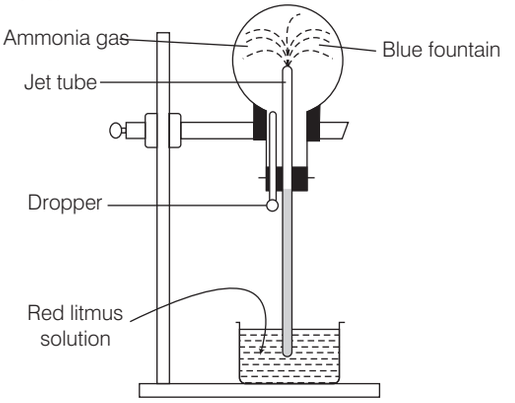
(iv) **Nature** Alkaline nature.

(v) **Boiling and Melting Points** Liquid ammonia boils at –33.5°C. Solid NH_3 melts at – 77.7°C.

(vi) **Solubility** Highly soluble in water *i.e.,* one volume of water dissolves about 700 volumes of a gas at 20°C temperature and one atmospheric pressure.

Experiment to Demonstrate the High Solubility of Ammonia gas in water

Ammonia gas is highly soluble in water. The extreme solubility of ammonia is demonstrated by **fountain's experiment**.



Fountain experiment

The outside pressure of flask is higher and a partial vacuum is created in the flask as NH_3 gas present in the flask gets dissolved in water. In case of ammonia, a blue fountain emerges out.

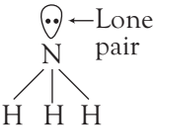
B. Chemical Properties

Chemical properties of ammonia are as follows

(i) **Thermal Dissociation** At high pressure it gives nitrogen and hydrogen.

$$2NH_3 \rightleftharpoons N_2 + 3H_2$$

(ii) **Basic Properties** Ammonia (dry) is a covalent compound. Its aqueous solution is a weak base and basicity is due to the presence of lone pair of electrons.



Its aqueous solution *i.e.,* NH_4OH is a weak base as it undergoes partial dissociation to give hydroxyl ions *i.e.,* OH^-.

Reactions $NH_3 + H_2O \rightleftharpoons NH_4OH$

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

(iii) **Reaction with Indicator** Ammonium hydroxide (NH_4OH) which is alkaline in nature, shows characteristic colour change with indicators.

Action on Indicators

Indicator	Change in Colour	
	Original	To
Moist litmus	Red	Blue
Methyl orange	Orange	Yellow
Phenolphthalein	Colourless	Pink

(iv) **Reaction with Acids** It reacts with acids to form ammonium salts as it is a weak base.

Ammonia gas + Acid ⟶ Ammonium salt

$$2NH_3 + H_2SO_4 \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$$

$$NH_3 + HNO_3 \longrightarrow \underset{\text{Ammonium nitrate}}{NH_4NO_3}$$

$$NH_3 + HCl \longrightarrow \underset{\text{Ammonium chloride}}{NH_4Cl\ (solid)}$$

NH_4Cl is one of the example, where two colourless gases react to form a solid compound.

Ammonium hydroxide (*aq.* ammonia) + Acid ⟶ Ammonium salt + Water

$$2NH_4OH + H_2SO_4 \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + 2H_2O$$

$$NH_4OH + HNO_3 \longrightarrow \underset{\text{Ammonium nitrate}}{NH_4NO_3} + H_2O$$

$$NH_4OH + HCl \longrightarrow \underset{\text{Ammonium chloride}}{NH_4Cl} + H_2O$$

(v) **Reaction with Soluble Metal Salts** Ammonium hydroxide (NH_4OH) reacts with soluble salts of metals to give insoluble precipitates of their metallic hydroxide (except Na and K). These precipitates are different in colour, thus, NH_4OH is used in qualitative analysis for identification of cations.

Metallic Salt Solution		Ammonium Hydroxide		Ammonium Salt		Metallic Hydroxide [ppt]
$FeSO_4$	+	$2NH_4OH$ (Insoluble)	⟶	$(NH_4)_2SO_4$	+	$Fe(OH)_2\downarrow$ Dirty green
$FeCl_3$	+	$3NH_4OH$ (Insoluble)	⟶	$3NH_4Cl$	+	$Fe(OH)_3\downarrow$ Reddish brown
$Pb(NO_3)_2$	+	$2NH_4OH$ (Insoluble)	⟶	$2NH_4NO_3$	+	$Pb(OH)_2\downarrow$ White
$Zn(NO_3)_2$	+	$2NH_4OH$ (Soluble)	⟶	$2NH_4NO_3$	+	$Zn(OH)_2\downarrow$ White gelatinous
$CuSO_4$	+	$2NH_4OH$ (Soluble)	⟶	$(NH_4)_2SO_4$	+	$Cu(OH)_2\downarrow$ Pale blue

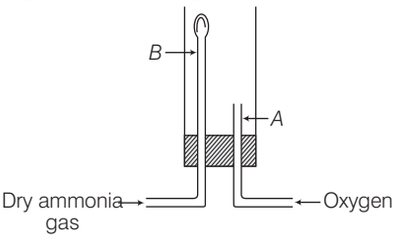
(vi) **Reaction with Oxygen** NH_3 is not a supporter of combustion. It extinguishes a burning splint and does not burn in air. This can be illustrated by following experiment.

Experiment Burning of ammonia in oxygen.

Step I **Procedure** Set up the apparatus as shown in the figure below. First, only pass the ammonia gas and apply lighted match at nozzle *B*.
Observation The gas will not burn.

Step II **Procedure** Now pass oxygen gas from tube *A* for few minutes, so that a atmosphere of oxygen is created. Now, again pass the ammonia gas from nozzle *B* and ignite it.

Observation This time ammonia gas burns in oxygen at nozzle *B* with yellowish green flame and produces water vapour and nitrogen.



Burning of ammonia in oxygen

Reaction $4NH_3 + 3O_2 \longrightarrow 2N_2 + 6H_2O$

Conclusion Mixture of ammonia and oxygen is explosive and therefore, dangerous. NH_3 gas is not a supporter of combustion.

(vii) **Reaction with Carbon Dioxide** Ammonia reacts with carbon dioxide at 150°C and 150 atm. pressure to form urea which is a valuable nitrogenous fertilizer.

$$2NH_3 + CO_2 \xrightarrow[150\ atm]{150^\circ C} \underset{\text{Urea}}{NH_2CONH_2} + H_2O$$

(viii) **Reaction with Bleaching Powder** Ammonia reacts with bleaching powder to form calcium chloride and nitrogen.

$$\underset{\text{Ammonia}}{2NH_3} + \underset{\text{Bleaching powder}}{3CaOCl_2} \longrightarrow \underset{\text{Calcium chloride}}{3CaCl_2} + 3H_2O + N_2\uparrow$$

(ix) **Ammonia as a Reducing Agent**

(a) **Reduction of Chlorine to Hydrogen Chloride** Chlorine reacts with ammonia to give HCl which further combines with excess of ammonia and forms NH_4Cl.

When ammonia is in excess,

Step I $2NH_3 + 3Cl_2 \longrightarrow N_2(g) + 6HCl$

Step II $6NH_3 + 6HCl \longrightarrow 6NH_4Cl$

Resultant

$$\underset{\text{(Excess)}}{8NH_3} + 3Cl_2 \longrightarrow N_2\uparrow + \underset{\text{White fumes}}{6NH_4Cl}$$

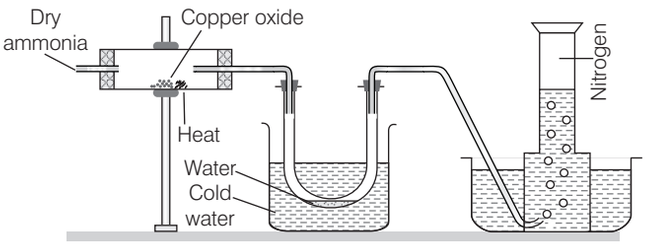
Observation Initially, ammonia reacts with chlorine to form HCl and N_2 gas (*i.e.*, chlorine is reduced to hydrogen chloride). Then, HCl further reacts with ammonia to form dense white fumes of ammonium chloride (NH_4Cl).

When chlorine is in excess,

$$\underset{\text{(Excess)}}{NH_3} + 3Cl_2 \longrightarrow 3HCl + \underset{\text{(Explosive)}}{NCl_3}$$

(b) **Reduction of Metallic Oxides** In a hard glass tube, pass ammonia gas over heated copper oxide.

Ammonia reduces oxides to give metals, water vapour and N_2.



Reducing action of ammonia

Reaction

$$2NH_3 + 3CuO \longrightarrow \underset{\text{Black solid}}{3Cu} + \underset{\text{Reddish brown solid}}{3H_2O} + \underset{\text{Gas}}{N_2}\uparrow$$

Observation The black copper oxide is reduced to reddish brown copper.

Similarly, ammonia also reduces lead oxide (PbO).

$$\underset{\text{Yellow}}{3PbO} + 2NH_3 \longrightarrow \underset{\text{Greyish}}{3Pb} + 3H_2O + N_2\uparrow$$

Note Liquid ammonia is used as refrigerant, because it is highly volatile, has a high latent heat of evaporation and can be easily liquefies under pressure and low temperature.

(x) **Catalytic Oxidation of ammonia** This reaction is used for preparation of nitric acid.

Tests for Ammonia Gas

(i) It gives dense white fumes with concentrated hydrochloric acid.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

(ii) Ammonium salt gives brown colour or precipitates with Nessler's solution, K_2HgI_4.

(iii) It forms a blue precipitate with copper sulphate solution and then further dissolves to form a deep blue coloured solution on addition of excess of ammonia solution.

Uses of Ammonia

Various uses of ammonia are as follows

(i) **Act as Nitrogenous fertilisers** Ammonium sulphate $(NH_4)_2SO_4$, ammonium nitrate (NH_4NO_3), urea (NH_2CONH_2), diammonium hydrogen phosphate $(NH_4)_2HPO_4$ and calcium ammonium nitrate $[Ca(NO_3)_2\,NH_4NO_3]$.

(ii) **Explosives** Ammonium nitrate (NH_4NO_3) decomposes explosively leading no residue behind.

$$NH_4NO_3 \xrightarrow{\Delta} N_2O(g) + 2H_2O\,(vap.)$$

(iii) Other ammonium salts such as ammonium carbonate, ammonium chloride used in dry cell and in the preparation of nitrogen gas.

$$\underset{\text{Sodium nitrite}}{NaNO_2(aq)} + NH_4Cl(aq) \longrightarrow NaCl(aq) + NH_4NO_2(aq)$$

$$\underset{\text{Ammonium nitrite}}{NH_4NO_2\,(aq)} \xrightarrow{\Delta} N_2(g) + 2H_2O(g)$$

(iv) Liquid ammonia is used as a refrigerant in ice plants. Ammonia is a good refrigerant because anhydrous ammonia is a clear, colourless liquid under pressure. It evaporates rapidly and produce cooling effect which make ammonia a good refrigerant. Main refrigerants used are freons, chloro fluoro carbons (CFCs). They cause **ozone depletion** and also contribute to **global warming**.

$$CF_2Cl_2(g) \xrightarrow[\text{(Ultraviolet)}]{\text{Decompose}} \underset{\text{Free radical}}{CF_2Cl^{\bullet}} + Cl^{\bullet}(g)$$

$$Cl^{\bullet}(g) + \underset{\text{Ozone gas}}{O_3(g)} \longrightarrow ClO(g) + O_2(g)$$

This free radical $[Cl^{\bullet}]$ destroys ozone and process continues thereby giving rise to ozone depletion.

(v) It is used as a source of hydrogen , nitric acid (by Ostwald's process), baking soda, washing soda, ammonium carbonate, NH_4Cl, etc.

(vi) It can be used in the manufacture of dyes, drugs plastics, resins and artificial silk.

(vii) Liquor ammonia can be used as cleansing agent for removing oil (as it is a good emulsifier).

Note Suitable alternatives to chlorofluorocarbons which are non-ozone depleting, include hydrochlorofluorocarbons [HCFC] which act as a substitute for CFCs.

CHECK POINT 04

1 What is the role of iron and molybdenum in the Haber's process for the synthesis of ammonia?

2 What are the conditions of pressure and temperature required in Haber's process?

3 Explain the role of lone pair, present in ammonia, for its alkaline nature.

4 How does ammonia reacts with different acids? Give an example.

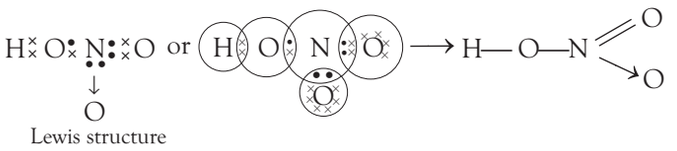
5 Ammonia can be used as a reducing agent. Give suitable reactions in support of this statement.

Nitric Acid

In the 8th century, nitric acid was known by the name "aqua fortis" which means strong water, because it reacts with nearly all the metals and can dissolve silver. In 1648, **Glauber** obtained nitric acid by distilling nitre, (potassium nitrate, KNO_3) with concentrated sulphuric acid. In 1776, **Lavoisier** proved that nitric acid contains one oxygen atom. In 1784, **Cavendish** proved that it also contains hydrogen and nitrogen along with oxygen. Its molecular mass is found to be 63u and its molecular formula is HNO_3.

Structure

In HNO_3, there are four covalent bonds and one coordinate bond. *Its structure can be represented as shown below*



Preparation of Nitric Acid

Methods for preparation of nitric acid are as follows

A. Laboratory Preparation

It is prepared in the laboratory by distilling a mixture of potassium or sodium nitrate with concentrated sulphuric acid.

$$KNO_3 + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Potassium bisulphate}}{KHSO_4} + HNO_3$$

$$NaNO_3 + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Sodium bisulphate}}{NaHSO_4} + HNO_3$$

Procedure A mixture of equal parts by weight of sodium nitrate or potassium nitrate and concentrated sulphuric acid are heated gently (to 180°C-200°C) in the glass retort.

Observation On heating the mixture in glass retort, the volatile nitric acid is displaced and the vapours are collected in the receiver which is cooled from outside with cold water.

Collection Vapours of nitric acid are condensed to a light yellow liquid. The yellow colour is due to the dissolution of NO_2 gas. This gas is produced due to the thermal decomposition of HNO_3.

$$4HNO_3 \longrightarrow 2H_2O + 4NO_2 + O_2$$

The yellow colour of the acid is removed

(i) by passing dry air or CO_2 in it, since it drives NO_2 out from warm acid and a colourless solution is formed.

(ii) by adding excess of water, the NO_2 gas dissolves in water and yellow colour is removed.

Why conc. H_2SO_4 is Preferred over conc. HCl for the Preparation of Nitric acid?

For the preparation of nitric acid (HNO_3), conc. sulphuric acid is used not conc. hydrochloric acid, because conc. sulphuric acid is a non-volatile acid having boiling point of 338°C and conc. hydrochloric acid is not. Hence, when a mixture of potassium nitrate and conc. sulphuric acid is heated over 200°C, only nitric acid gets volatilise and thus, only pure nitric acid distills over other. In case of conc. hydrochloric acid, it reacts with sodium nitrate (or potassium nitrate) to give nitric acid. But the boiling point of conc. HCl is lower than 200°C i.e., 109.8°C (volatile in nature). Hence, both nitric acid and conc. HCl change into vapour at 200°C and a mixture of nitric acid and hydrochloric acid is collected.

Precautions

(i) Nitric acid can react with rubber and cork thus, glass apparatus should be used.

(ii) High temperature (*i.e.*, above 200°C) should not be used because it may damage the glass apparatus. It is also a wastage of fuel.

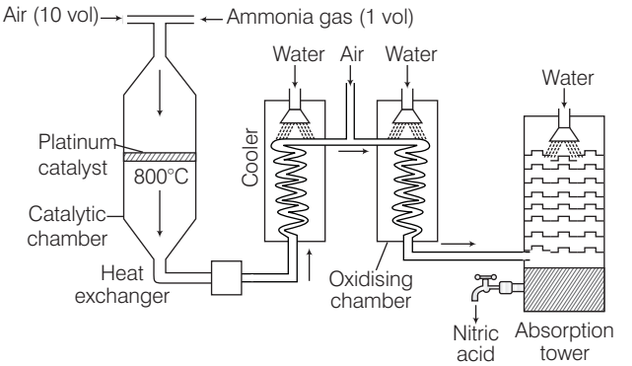
$$NaNO_3 + NaHSO_4 \xrightarrow{>200°C} Na_2SO_4 + HNO_3$$

At high temperature, a sticky residue is formed (*i.e.*, Na_2SO_4), which is a poor conductor of heat. This sticks to the wall and is very difficult to remove. Due to high temperature, decomposition of nitric acid may also occur.

B. Industrial Process : Ostwald's Process

This process involves catalytic oxidation of ammonia to prepare nitric acid. *The process is explained in three steps which are as follows*

Step I **Catalytic Oxidation of Ammonia**
(In catalytic chamber)



Manufacture of nitric acid by Ostwald's process

A mixture of dry air and dry ammonia in the ratio 1:10 is compressed first and then passed into the catalytic chamber containing platinum gauge as catalyst at temperature of 700-800°C. In this chamber, the catalyst is platinum. Oxidation of ammonia into nitrogen monoxide takes place.

$$4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + \underset{\text{Steam}}{6H_2O} + \text{Heat}$$

[Catalysed reaction]

The hot gases passed through a heat exchanger, mixed with air and passed into another cooling chamber called oxidising chamber. The above reaction is exothermic reaction, which means a large amount of heat is evolved, that's why the electrical heating is done initially only.

Step II **Oxidation of Nitric Oxide in Oxidation Chamber**

The gas comes from the catalytic chamber is passed through a heat exchanger *i.e.*, through

cooling coil. This gas mainly contains nitric oxide and oxygen. The cooling is done upto the temperature of 50°C. In this chamber, oxidation of nitric oxide (NO) to nitrogen dioxide (NO_2) will takes place at about 50°C.

$$2NO + O_2(g) \xrightarrow{50°C} 2NO_2(g)$$

Note Low temperature should be maintained, so that the oxidation of nitric oxide takes place easily and minimise the decomposition of NO_2.

Step III **Absorption of Nitrogen dioxide** (In Absorption Tower)

The gas enters the absorption tower (leaves from oxidation chamber) contains nitrogen dioxide and residual oxygen, that move upwards and dissolve in the water forming nitric acid at the base of the tower in the presence of excess of air.

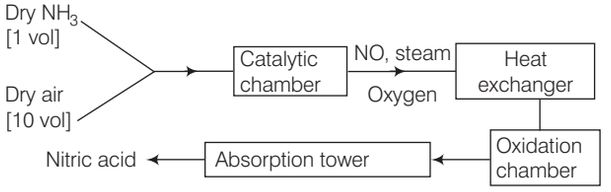
$$4NO_2(g) + 2H_2O(l) + O_2(g) \rightarrow 4HNO_3(aq)$$

Note Absorption tower is a steel tower filled with quartz stone packed in layer and has a spray of water trickling from the top.
Quartz is acid resistant. It is packed in layer to slow down the movement of gases entering from bottom and initiates better absorption of NO_2 to water.

Concentration of Nitric Acid

The nitric acid is obtained at the base of the tower which is 50% concentrated. It can be concentrated further by distillation or boiling, a constant boiling mixture is obtained. The mixture formed after distillation contains 68% of nitric acid. On further distillation of 68% of nitric acid with concentrated sulphuric acid results in the formation of fuming nitric acid (98%). 100% nitric acid is formed by cooling 98% acid, at about – 42° C. A colourless crystal of pure nitric acid will be formed.

Flowchart of Ostwald's Process



CHECK POINT 05

1. Draw the Lewis structure of nitric acid molecule. Explain the role of lone pair of nitrogen in the bonding.
2. Why does nitric acid turns yellow when stand for long time?
3. Although, hydrogen chloride reacts with sodium nitrate to produce nitric acid but it is not preferred to obtain pure nitric acid, why?
4. Write the liberating method to prepare nitric acid.
5. Why quartz is used in the manufacture of nitric acid by Ostwald's process?

Properties of Nitric Acid

Properties of nitric acid are as follows

A. Physical Properties

Physical properties of nitric acid are as follows

(i) **Colour** Pure nitric acid is colourless but commercial acid (68% concentrated) is yellowish in colour.

(ii) **Odour** Suffocating smell.

(iii) **Taste** Sour taste (acidic).

(iv) **Nature** It is non-poisonous, highly corrosive in nature. It stains the skin yellow as it reacts with protein of skin and forms xanthoproteic acid.

Note Nitric acid is hygroscopic and gives fumes in air. Thus, the bottle of nitric acid should always be well stoppered.

(v) **Density** Pure acid (98% conc.) has 1.54 g/cm^3 and commercial nitric acid (68% conc.) has 1.42 g/cm^3 density.

(vi) **Solubility** It is highly soluble in water in all proportions.

(vii) **Boiling and Melting Points** It boils at 86° C and melts at – 42° C .

B. Chemical Properties

Chemical properties of nitric acid are as follows

Stability Pure nitric acid is colourless and unstable. It decomposes slightly even at ordinary temperature in the presence of sunlight.

$$4HNO_3 \xrightarrow[\text{Sunlight}]{\Delta} \underset{\text{Brown colour}}{4NO_2} + 2H_2O + O_2$$

Thus, the nitric acid stored in a plain glass bottle turns yellow. To avoid the decomposition, nitric acid is generally stored in coloured bottles.

Acidic Properties It is a strong monobasic acid. It ionises completely in aqueous solution.

$$HNO_3(aq) \rightleftharpoons H^+ + NO_3^-$$

It turns blue litmus to red, methyl orange to pink and phenolphthalein remains colourless.

(i) **Reaction with Alkalies** It neutralises alkalies to form salt and water. Metallic oxides and hydroxides react with dilute HNO_3 to form salt and water.

$$Na_2O + 2HNO_3 \longrightarrow 2NaNO_3 + H_2O$$
$$ZnO + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O$$
$$NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$$
$$Fe(OH)_3 + 3HNO_3 \longrightarrow Fe(NO_3)_3 + 3H_2O$$
$$Mg(OH)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O$$

(ii) **Reaction with Carbonates and Bicarbonates** These react with dil. HNO_3 to give salt, water and carbon dioxide.

$$Na_2CO_3 + 2HNO_3 \longrightarrow 2NaNO_3 + H_2O + CO_2\uparrow$$

$$NaHCO_3 + HNO_3 \longrightarrow NaNO_3 + H_2O + CO_2\uparrow$$

$$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2\uparrow$$

(iii) **Reaction with Metallic Sulphites and Bisulphites** These react with dil. HNO_3 to form soluble metallic nitrates, water and SO_2 gas.

$$K_2SO_3 + 2HNO_3 \longrightarrow 2KNO_3 + H_2O + SO_2\uparrow$$

$$CuSO_3 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2O + SO_2\uparrow$$

Oxidising Properties Oxidising properties are due to nascent oxygen which nitric acids gives on decomposition.

$$2HNO_3(conc.) \longrightarrow 2NO_2 + H_2O + [O]$$

$$2HNO_3(dil.) \longrightarrow 2NO + H_2O + 3[O]$$

(i) **Action on Non-metals**

$$\underset{\text{Carbon}}{C} + 4HNO_3 \longrightarrow CO_2 + 2H_2O + 4NO_2$$

$$\underset{\text{Sulphur}}{S} + 6HNO_3 \longrightarrow H_2SO_4 + 2H_2O + 6NO_2$$

$$\underset{\text{Phosphorus}}{P_4} + 20HNO_3 \longrightarrow 4H_3PO_4 + 4H_2O + 20NO_2$$

(ii) **Action on Metals** Nitric acid reacts with all metals except gold and platinum. Cold and dilute nitric acid oxidises metal to their nitrates and liberate nitric oxide.

$$\underset{\text{Copper}}{3Cu} + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$$

$$\underset{\text{Zinc}}{3Zn} + 8HNO_3 \longrightarrow 3Zn(NO_3)_2 + 4H_2O + 2NO$$

$$\underset{\text{Iron}}{3Fe} + 8HNO_3 \longrightarrow 3Fe(NO_3)_2 + 4H_2O + 2NO$$

Concentrated nitric acid, in the presence of heat, oxidises metal to their nitrates and liberates nitrogen dioxide.

$$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$$

$$Zn + 4HNO_3 \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$

$$Fe + 6HNO_3 \longrightarrow Fe(NO_3)_3 + 3H_2O + 3NO_2$$

Metals like Fe, Al, Co and Ni become passive (inert) when treated with pure concentrated nitric acid because of the formation of metal nitrate which further form extremely thin layer of insoluble metallic oxide which stops the reaction.Very dilute nitric acid reacts with magnesium and manganese metals to give their nitrates and hydrogen gas.

$$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2\uparrow$$

$$Mn + 2HNO_3 \longrightarrow Mn(NO_3)_2 + H_2\uparrow$$

Tests for Nitric Acid and Nitrates

(i) Concentrated nitric acid gives brown fumes on heating.

$$4HNO_3 \xrightarrow{\Delta} 2H_2O + \underset{\text{Brown fumes}}{4NO_2\uparrow} + O_2$$

(ii) Nitrates (other than potassium, sodium and ammonium) produce reddish brown fumes of nitrogen dioxide (NO_2).

$$\text{Metallic nitrate} \xrightarrow{\Delta} \text{Metallic oxide} + \underset{\text{fumes}}{\underset{\text{Brown}}{NO_2}} + O_2$$

(iii) Dense reddish brown fumes of nitrogen dioxide (NO_2) are evolved, when copper reacts with nitric acid or acidified nitrates

$$Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2H_2O + 2NO_2$$

$$Cu + 4NaNO_3 + 4H_2SO_4 \xrightarrow{\Delta} 4NaHSO_4 + Cu(NO_3)_2 + 2H_2O + 2NO_2$$

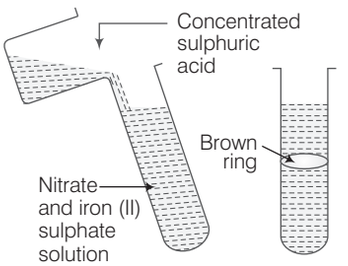
(iv) **Brown Ring Test** Take aqueous solution of a nitrate or nitric acid in a test tube.

(a) Add freshly prepared saturated solution of iron (II) sulphate.

(b) Now add concentrated sulphuric acid carefully from the sides of the test tube, such that it should not fall dropwise in the test tube.

(iii) Cool the test tube in water.

(iv) A brown ring appears at the junction of the two liquids.



Brown ring test

Reactions

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$$

$$FeSO_4 + NO \longrightarrow FeSO_4NO$$

[Nitroso ferrous sulphate, a brown compound]

Note A freshly prepared iron (II) sulphate, (i.e., ferrous sulphate) solution is used , as on exposure to atmosphere iron (II) sulphate oxidised to iron (III) sulphate, (i.e., ferric sulphate).

Uses of Nitric Acid

Some uses of nitric acid are follows

A. General Uses

(i) **In the preparation of aqua-regia** Aqua-regia is a mixture of HNO_3 (1 vol) and HCl (3 vol) which dissolves noble metals.

$$\underset{\text{Conc.}}{HNO_3} + 3\underset{\text{Conc.}}{HCl} \longrightarrow 2H_2O + \underset{\text{Nitrosyl chloride}}{NOCl} + 2\underset{\text{Nascent chlorine}}{[Cl]}$$

Reaction with noble metal

$$Au + 3[Cl] \longrightarrow AuCl_3 \text{ [Gold (III) chloride]}$$

(ii) It is used as a constituent of rocket fuel.

(iii) **To etch designs on copper and brassware**
Reason Since it is a good solvent, can dissolve large number of metals (excluding noble metals).

(iv) **For purification of gold**
Reason As crude gold contains impurities (Cu, Ag, Zn and Pb) which dissolves in HNO_3 while gold is unaffected.

(v) **In the preparation of fertilisers**
The fertiliser includes calcium nitrate $[Ca(NO_3)_2]$, ammonium nitrate (NH_4NO_3), nitro chalk $(NH_4NO_3 + CaCO_3)$ and basic calcium nitrate $[CaO \cdot Ca(NO_3)_2]$.

(vi) **In the preparation of nitrates**
Nitrates are formed by the replacement of the hydrogen atom. It is a normal salt of monobasic nitric acid.
e.g., $KOH + HNO_3(dil.) \longrightarrow KNO_3 + \underset{\text{(Neutralisation)}}{H_2O}$

B. Industrial Uses

(i) For the manufacturing of explosives *e.g.*, Tri-nitro toluene, tri-nitro cellulose, etc.

(ii) For the preparation of nitrates *e.g.*, Potassium nitrate, ammonium nitrate (used in fertilisers) and silver nitrate (used in photography).

(iii) In the manufacture of dyes, drugs and perfumes.

(iv) For the manufacture of synthetic silk *e.g.*, Cellulose, nitrate, nylon, etc.

CHECK POINT 06

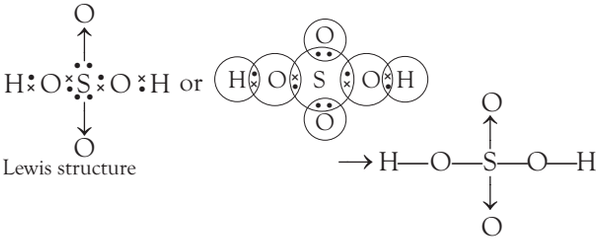
1. Give two suitable examples to, demonstrate the acidic properties of HNO_3.
2. Show a reaction in which nitric acid produces hydrogen gas upon action with a metral.
3. Write a test to detect nitrate ion.
4. Write any two industrial use of nitric acid.
5. Nitric acid is used as a bleaching agent. Give examples with suitable reaction in support of this statement.

Sulphuric Acid

It is known as the king of chemicals as it is used in large number of reactions as a reagent. Its historical name is oil of vitriol, because it was obtained as an oily viscous liquid by heating crystals of green vitriol (hydrated ferrous sulphate). Its molecular mass is found to be 98u and its molecular formula is deduced as H_2SO_4.

Structure

There are four covalent bonds and two coordinate bonds in the molecule of H_2SO_4. Its structure can be represented as shown below:



Preparation of Sulphuric Acid

Various methods for the preparation of sulphuric acid are as follows

A. General Methods of Preparation

(i) **By the action of sulphur with conc. nitric acid**

$$S + 6HNO_3 \longrightarrow H_2SO_4 + 6NO_2 + 2H_2O$$

(ii) **By the passage of chlorine, bromine and oxygen through an aqueous solution of sulphur dioxide**

$$2SO_2 + 2H_2O + O_2 \longrightarrow 2H_2SO_4$$
$$SO_2 + 2H_2O + Cl_2 \longrightarrow H_2SO_4 + 2HCl$$
$$SO_2 + 2H_2O + Br_2 \longrightarrow H_2SO_4 + 2HBr$$

(iii) **By the hydrolysis of sulphuryl chloride**

$$SO_2Cl_2 + 2H_2O \longrightarrow H_2SO_4 + 2HCl$$

(iv) **By the hydrolysis of sulphur trioxide**

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

B. Manufacture of Sulphuric Acid By Contact Process

Various steps of contact process are as follows

(i) **Production of Sulphur Dioxide** Sulphur dioxide is produced by burning Louisiana sulphur (99.5% pure) in oxygen (air).

$$S + O_2 \longrightarrow SO_2$$

It is also produced by roasting metallic sulphides in oxygen (air).

$$4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$$

(ii) **Purification of Gases** Impurities must be removed from the mixture of sulphur dioxide and air, otherwise the efficiency of catalyst gets decreased. The mixture is passed through a purifier called electric precipitator. The electric precipitator consists of a chamber with high electric potential, which attract solid particles and removed. Then mixture enter to a water **scrubber** where it is freed from dust particles. Then, it is dried by using spray conc. sulphuric acid, and it goes to arsenic purifier where impurity of arsenic oxide is removed.

(iii) **Catalytic Oxidation of Sulphur Dioxide** Dried and clean gaseous mixture of sulphur dioxide and air enter into contact tower, which is loosely packed with vanadium pentaoxide (V_2O_5) or platinum (Pt), which act as catalyst. These catalyst placed in vertical iron pipes inside a cylindrical iron tower, called converter. In this chamber, the mixture of SO_2 and O_2 is passed over preheated catalyst pipes (containing V_2O_5), forms sulphur trioxide.

$$2SO_2 + O_2 \underset{450°C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3$$

The catalyst is heated only in the beginning to about 450°C, as the reaction is highly exothermic.

Note Temperature is maintained by the heat evolved during the reaction.

SO_3 formed in catalytic chamber is not directly absorbed in water because

(i) the reaction is highly exothermic in nature.

(ii) it forms a homogeneous mixture and a dense mist of minute particles of sulphuric acid which is not easily condensed.

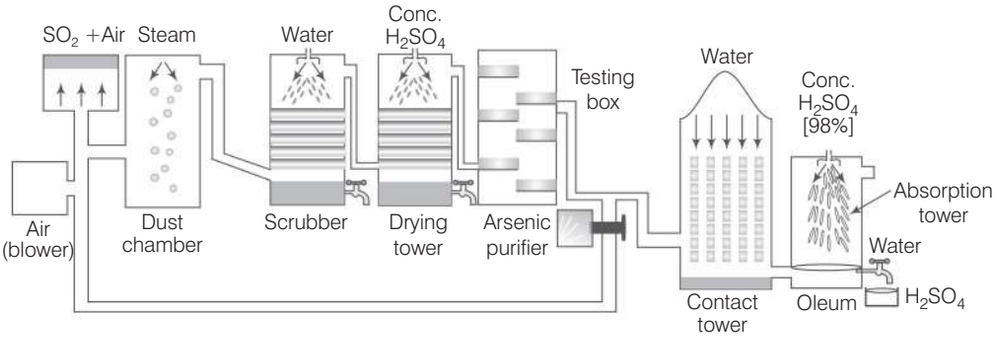
(iv) Absorption of Sulphur trioxide in sulphuric Acid.

The cooled gas comes from the catalytic chamber is introduced at the base of absorption tower from the top of which H_2SO_4 (98%) is added, SO_2 moves above and absorbed by H_2SO_4 forming oleum.

$$SO_3 + H_2SO_4 \longrightarrow \underset{\text{Oleum (or pyrosulphuric acid)}}{H_2S_2O_7}$$

(v) **Dilution of Pyrosulphuric Acid ($H_2S_2O_7$) to give Sulphuric Acid** Pyrosulphuric acid is diluted in dilution tank by adding measured or fixed amount of water to obtain sulphuric acid of desired concentration.

$$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$$



Manufacture of sulphuric acid by contact process

Favourable Conditions for Conversion of SO_2 into SO_3

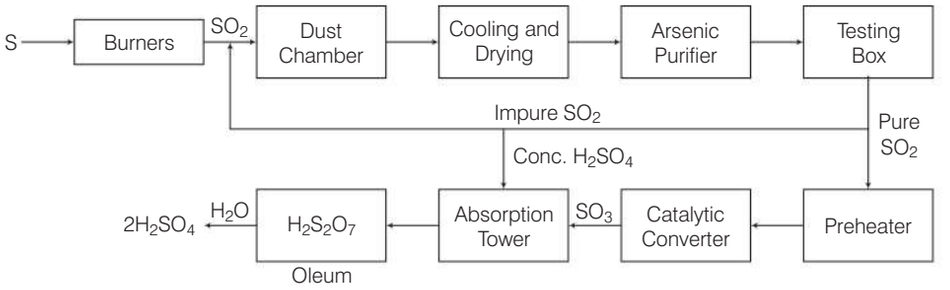
(i) Exothermic reactions are favoured at low temperature (410–450°C).

(ii) High pressure of 1-2 atmosphere is used because high pressure favours the reaction.

(iii) Excess of oxygen increases the production of sulphur trioxide.

(iv) A suitable catalyst, vanadium pentaoxide (V_2O_5) is used as a catalyst.

Flowchart Diagram of Contact Process



Properties of Sulphuric Acid

Properties of sulphuric acid are as follows

Physical Properties

Physical properties of sulphuric acid are as follows

(i) **Colour, odour and taste** Colourless, odourless and sour in taste.

(ii) **Nature** Dense, oily and hygroscopic liquid.

(iii) **Density** Pure acid 1.85 g/cc.

(iv) **Boiling point** It boils at 338°C.

(v) **Melting point** Pure sulphuric acid freezes to colourless crystals at 10.4°C

(vi) **Solubility soluble in water** Pure acid is almost a non-conductor of electricity.

(vii) **Conductivity** Dilute acid is a good conductor of electricity.

(viii) **Constant boiling mixture** It forms a constant boiling mixture at 338°C containing 98.5% of the acid.

(ix) **Physiological nature** Concentrated acid is highly corrosive in nature.

Chemical Properties

Chemical properties of sulphuric acid are as follows

(A) **Properties of dilute sulphuric acid**

Acidic Property

(i) Dilute sulphuric acid reacts with metals which are above the hydrogen in the activity series to give hydrogen and metallic sulphate.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$
$$Ca + H_2SO_4 \longrightarrow CaSO_4 + H_2\uparrow$$
$$2Na + H_2SO_4 \longrightarrow Na_2SO_4 + H_2\uparrow$$
$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$$
$$Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2\uparrow$$

(ii) It neutralises bases to form salt and water.

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$
$$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$$
$$2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$$
$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$
$$FeO + H_2SO_4 \longrightarrow FeSO_4 + H_2O$$

(iii) With metallic carbonates or bicarbonates, it liberates carbon dioxide gas.

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2\uparrow$$
$$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2\uparrow$$
$$2KHCO_3 + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O + 2CO_2\uparrow$$

(iv) With metal sulphides, it evolves hydrogen sulphide gas.

$$Na_2S + H_2SO_4 \longrightarrow Na_2SO_4 + H_2S\uparrow$$
$$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$$
$$ZnS + H_2SO_4 \longrightarrow ZnSO_4 + H_2S\uparrow$$

(v) It evolves sulphur dioxide from sulphites and bisulphites.

$$Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2\uparrow$$
$$2NaHSO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2SO_2\uparrow$$
$$K_2SO_3 + H_2SO_4 \longrightarrow K_2SO_4 + H_2O + SO_2\uparrow$$
$$KHSO_3 + H_2SO_4 \longrightarrow KHSO_4 + H_2O + SO_2\uparrow$$

Note Sulphur dioxide is poisonous and thus, responsible for polluting the environment.

(B) **Properties of Concentrated Sulphuric Acid**

(i) **Non-volatile Nature** Concentrated sulphuric acid is a non-volatile solid as it has a high boiling point 338°C. It is used for preparing volatile acids like HCl, HNO_3 and CH_3COOH.

$$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$$
$$KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$$
$$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$
$$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3$$
$$\underset{\text{Sodium acetate}}{CH_3COONa} + H_2SO_4 \longrightarrow NaHSO_4 + \underset{\text{Acetic acid}}{CH_3COOH}$$

(ii) **As an Oxidising Agent** Oxidising property of conc. H_2SO_4 is due to fact that on thermal decomposition, it gives nascent oxygen.

$$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$$

Nascent oxygen oxidises, metal, non-metal and inorganic compounds.

(a) Metals

$$\underset{\text{Copper}}{Cu} + 2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2\uparrow$$
$$\underset{\text{Zinc}}{Zn} + 2H_2SO_4 \longrightarrow ZnSO_4 + 2H_2O + SO_2\uparrow$$

(b) Non-metals

$$\underset{\text{Carbon}}{C} + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2\uparrow$$
$$\underset{\text{Sulphur}}{S} + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$$
$$\underset{\text{Phosphorus}}{2P} + 5H_2SO_4 \longrightarrow 2H_3PO_4 + 2H_2O + 5SO_2\uparrow$$

(c) Inorganic compounds

$$2HBr + H_2SO_4 \longrightarrow Br_2 + 2H_2O + SO_2 \uparrow$$
Hydrogen bromide

$$H_2S + H_2SO_4 \longrightarrow S + 2H_2O + SO_2 \uparrow$$
Hydrogen sulphide

Sulphur dioxide gas is an oxidising as well as reducing agent. It also shows bleaching property due to its reducing nature.

$$SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$$
Coloured material; Colourless product; Nascent hydrogen

It is used to bleach only delicate material, coloured wet flower petals or fresh green grass.

(iii) **As a Dehydrating Agent** H_2SO_4 acts as a dehydrating agent as H_2SO_4 has a great affinity for water.

(a) Carbohydrates such as glucose, sugar and cellulose react with conc. H_2SO_4 to give a black spongy mass of carbon, called sugar charcoal.

$$C_{12}H_{22}O_{11}(s) \xrightarrow{\text{Conc. } H_2SO_4} 12C(s) + 11H_2O$$
Cane Sugar; Sugar charcoal

$$C_6H_{12}O_6(s) \xrightarrow{\text{Conc. } H_2SO_4} 6C + 6H_2O$$
Glucose; Sugar charcoal

Note The black charcoal is formed because sulphuric acid removes atoms of hydrogen and oxygen from glucose molecules.

(b) **Action on Acid** Organic acids and organic compounds are dehydrated by conc. H_2SO_4 as follows

$$HCOOH \xrightarrow{\text{Conc. } H_2SO_4} CO + H_2O$$
Formic acid

$$\begin{matrix} COOH \\ | \\ COOH \end{matrix} \xrightarrow{\text{Conc. } H_2SO_4} CO + CO_2 + H_2O$$
Oxalic acid

When ethyl alcohol is warmed with sulphuric acid dehydration takes place with the evolution of ethylene.

$$C_2H_5OH + H_2SO_4(\text{conc.}) \longrightarrow C_2H_4 + H_2O$$
Ethyl alcohol; Ethylene

(c) Concentrated sulphuric acid removes water of crystallisation from salts. When conc. H_2SO_4 is poured over copper sulphate crystals, the blue colour of copper sulphate crystals starts changing into dirty white powder.

$$CuSO_4 \cdot 5H_2O \xrightarrow{\text{Conc. } H_2SO_4} CuSO_4(s) + 5H_2O$$
Blue; Dirty white; (Removed by acid)

Difference between Dehydrating and Drying Agent

	Dehydrating agent	Drying agent
(i)	It removes hydrogen and oxygen atom in the form of water molecules from the composition of a substance.	It only removes superficial water that present on the surface of a substance.
(ii)	It changes the chemical composition of a substance.	No change in chemical composition takes place.
(iii)	It only brings about chemical change.	It brings about a physical change.

(e) Preparation of Insoluble Salts

Sulphuric acid precipitates the insoluble sulphates of lead, barium and calcium.

$$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 \downarrow + 2HCl$$

$$Pb(NO_3)_2 + H_2SO_4 \longrightarrow PbSO_4 \downarrow + 2HNO_3$$

Test for Sulphuric Acid and Sulphates

(i) Conc. H_2SO_4 reacts with copper to give sulphur dioxide.

$$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2 \uparrow$$

(ii) Sulphur dioxide turns acidified potassium dichromate solution green.

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow \underset{\text{Green}}{Cr_2(SO_4)_3} + K_2SO_4 + H_2O$$

(iii) When $BaCl_2$ solution is added to sulphuric acid, white precipitate of barium sulphate is formed.

$$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 \downarrow + 2HCl$$

(iv) Dilute sulphuric acid gives a white precipitate with lead nitrate solution.

$$Pb(NO_3) + \text{dil. } H_2SO_4 \longrightarrow \underset{\text{Lead sulphate (White ppt.)}}{PbSO_4} \downarrow + 2HNO_3$$

Uses of Sulphuric Acid

Some uses of sulphuric acid are as follows

Industrial uses

(i) **In manufacturing explosives**

Examples Trinitrotoluene, trinitroglycerine and picric acid.

(ii) **In manufacturing fertilisers**

Examples Calcium dihydrogen phosphate $[Ca(H_2PO_4)_2 + CaSO_4]$, ammonium sulphate $[(NH_4)_2SO_4]$.

(iii) In manufacturing dyes and drugs.

(iv) In manufacturing acids (hydrochloric acid, nitric acid and phosphoric acid) by distilling metal chlorides, metal nitrates, metal phosphates respectively with conc. H_2SO_4.

(v) Manufacturing plastic (cellophane, synthetic rubber) and artificial fibres (rayon, nylon and terylene).

B. General Uses

(i) In pickling metals, dilute sulphuric acid removes impurities from the surface of the metals, so cleaved metal can be easily cleaned.

(ii) It can be used in the extraction of metals by leaching the metallic oxides by dil. H_2SO_4 which yield soluble salt sulphate solutions, which on electrolysis give pure metals.

(iii) For removing harmful chemicals from petrol, kerosene oil, etc.

(iv) As an important laboratory agent.

(v) As drying agent for gases (like HCl).

CHECK POINT 07

1. How many covalent and coordinate bonds are present in the structure of sulphuric acid?
2. During the conversion of sulphur dioxide into sulphur trioxide, the reaction is initially heated in the presence of the catalyst, V_2O_5 later on the reaction proceeded on its own. Explain, how?
3. Sulphur dioxide is an oxidising as well as reducing agent. Explain with suitable reactions.
4. Write examples to show that H_2SO_4 is both, a drying agent as well as a dehydrating agent.
5. Write two uses of sulphuric acid.

SUMMARY

- Hydrogen chloride gas was first prepared by Glauber. Humphry Davy proved that the gas is the compound of hydrogen and chlorine.
- The general methods of preparation of HCl includes direct combination and heating metallic chlorides with conc. H_2SO_4
- In laboratory HCl gas is prepared by the reaction of sodium chloride with conc. H_2SO_4.

- HCl gas is colourless, pungent choking smell, corrosive in nature, highly soluble in water.
- HCl gas is acidic in nature, reacts with ammonia to form NH_4Cl, reacts with metals to form metal chloride and liberate hydrogen.
- HCl acid is prepared by dissolving HCl gas in water using a special funnel arrangement.
- HCl acid is acidic in nature, reacts with metals which are placed above the hydrogen in the activity series.
- It is used in the manufacturing of dyes, drugs, to obtain glucose from starch, etc.

- The molecular mass of ammonia is 17u and its molecular formula is NH_3.
- Ammonia is present in different forms such as gaseous ammonia, liquid ammonia, liquor ammonia fortis, laboratory bench reagent.
- The general method of preparation of ammonia gas is from ammonium salts.
- In laboratory, ammonia is prepared by heating ammonium salt with an alkali and from metal nitrides.
- The manufacture of NH_3 by Haber's process involves the direct combination of N_2 and H_2.
- It is colourless, strong, pungent choking smell and alkaline in nature.
- At high pressure, ammonia dissociates to give nitrogen and hydrogen.
- It reacts with acids to form ammonium salts and NH_3 gas is not a supporter of combustion.
- It is used as a source of hydrogen, nitric acid, baking soda, etc.

- Nitric acid is HNO_3 and in laboratory it prepared by distilling a mixture of potassium or sodium nitrate with conc. H_2SO_4.
- It is colourless, suffocating smell, sour in taste.
- It is a strong monobasic acid, neutralises alkalies to form salt and water.
- It exhibit oxidising properties due to presence of nascent oxygen.
- Nitric acid is used in the preparation of aqua-regia, nitrates, in the manufacturing of dyes, drugs, etc

- Sulphuric acid is known as king of chemicals and its formula is H_2SO_4.
- Generally, it is prepared by the action of sulphur on conc. HNO_3, by hydrolysis of sulphuryl chloride .
- It is also prepared by contact process.

$$2SO_2 + O_2 \xrightarrow[450^\circ C]{V_2O_5} 2SO_3$$

- It is colourless odourless, dense, non conductor of electrity (in pure form).
- It shows acidic property, non-volatile nature, act as an oxdising and dehydrating agent.
- It is used in manufacturing of dyes, acids (HCl, HNO_3) pickling metals, as drying agent for gases.

EXAM PRACTICE

Fill in the Blanks

1. Quick lime is not used to dry HCl gas because …… (CaO is alkaline, CaO is acidic, CaO is neutral)

Sol. CaO is alkaline. ***[2014]***

2. Hydrogen chloride gas is a …… compound.

Sol. polar

3. The mixture of (i) …… and (ii) …… is not heated above (iii) …… in preparing hydrogen chloride gas because at higher temperature (iv)…… is formed which is a (v) …… substance and (vi) …… to remove from the flask.

Sol. (i) sodium chloride
(ii) conc. H_2SO_4
(iii) 170°C
(iv) sodium sulphate
(v) hard
(vi) difficult

4. Hydrogen chloride gas is collected by the …… of air.

Sol. upward displacement

5. …… gas is heavier than air.

Sol. Hydrogen chloride

6. Potassium sulphite on reacting with hydrochloric acid releases ..... gas. (Cl_2, SO_2 H_2S) ***[2017]***

Sol. SO_2

7. Ammonia can be obtained by adding water to …… .

Sol. magnesium nitride

8. Ammonia gas is collected by ..... (an upward displacement of air, the downward water, the downward displacement of air).

Sol. the downward displacement of air

9. Ammonia is soluble in water because it is an…… molecule.

Sol. alkaline

10. …… gas gives rotten egg smell.

Sol. Hydrogen sulphide

11. Dry ammonia ……the colour of red litmus paper.

Sol. changes

12. Nitrogen and hydrogen combine in the presence of a catalyst to give (i) ……gas. When the above mentioned gas is passed through water it forms a solution which will be (ii) ……in nature and the solution contains (iii) ……ions and (iv) …… ions. The above solution when added to iron sulphate solution, gives a (v) …… coloured precipitate of iron hydroxide.

Sol. (i) ammonia (ii) alkaline
(iii) ammonium (iv) hydroxyl
(v) dirty green

13. …… and …… are the reactants used during the preparation of nitric acid in laboratory.

Sol. Potassium nitrate, conc. H_2SO_4

14. ……sample of nitric acid is pale yellow in colour due to the presence of dissolved …… .

Sol. Commercial, nitrogen dioxide

15. Nitric acid is manufactured by …… process.

Sol. Ostwald's

16. …… acid does not liberate hydrogen on reacting with metal.

Sol. Nitric

17. Cold and dilute nitric acid reacts with copper to form …… (hydrogen, nitrogen dioxide, nitric oxide). ***[2014]***

Sol. nitric oxide

18. Fill in the blanks using the appropriate words given below. (sulphur dioxide, nitrogen dioxide, nitric oxide, sulphuric acid) ***[2016]***

(i) Cold, dilute nitric acid reacts with copper to give .....
(ii) Hot, concentrated nitric acid reacts with sulphur to form .....

Sol. (i) nitric oxide
(ii) nitrogen dioxide and sulphuric acid

19. Nitric acid on heating gives ……, …… and ……. .

Sol. NO_2, H_2O, O_2

20. Pure nitric acid is (i)..... The nitric acid collected by the distillation of (ii)..... and conc. sulphuric acid is (iii)..... in colour. Because at a temperature of (iv)....., the vapours of nitric acid decomposes to form (v)..... gas, which is (vi)..... in colour.

Sol. (i) colourless (ii) sodium nitrate
(iii) yellowish brown (iv) 200°C
(v) nitrogen dioxide (vi) reddish brown gas

21. Nitric oxide gives …… colour with ferrous sulphate solution.

Sol. black

22. Sulphuric acid is called …… .

Sol. oil of vitriol

23. Sulphuric acid is called (i)……, as there is no other manufactured compound that is used in (ii)…… number of industries. Earlier, it was obtained by heating crystals of (iii) …… ……, that's why it was known by the name of (iv)……

Sol. (i) king of chemicals (ii) large
(iii) green vitriol (iv) oil of vitriol

24. ……. and …… gas are produced during contact process.

Sol. SO_2, SO_3

25. Dry hydrogen chloride gas can be collected by ..... displacement of air. (downward/upward) *[2018]*

Sol. upward

26. …… property is shown by sulphuric acid when it is treated with metals like Zn, Mg, etc.

Sol. Oxidising

27. When acid is mixed with bleaching powder …… gas is liberated.

Sol. chlorine

28. Oxalic acid on reacting with sulphuric acid gives …… and …… .

Sol. carbon monoxide, carbon dioxide.

29. …… and …… acid can be prepared by using sulphuric acid.

Sol. HCl, HNO_3

Multiple Choice Questions

30. Hydrogen chloride gas being highly soluble in water is dried by *[2011]*
(a) anhydrous calcium chloride
(b) phosphorous pentaoxide
(c) quick lime
(d) concentrated sulphuric acid

Sol. (d)

31. Which of the following is not used to detect hydrochloric acid?
(a) NH_3 (b) H_2SO_4
(c) $AgNO_3$ (d) MnO_2

Sol. (b)

32. The name of aqueous solution of HCl is
(a) aqua-regia (b) oil of vitriol
(c) muriatic acid (d) aqua fortis

Sol. (c)

33. Aqua-regia is a mixture of
(a) conc. hydrochloric acid (3 parts) and conc. nitric acid (1 part)
(b) conc. HCl (1 part) and conc. nitric acid (3 parts)
(c) dil. hydrochloric acid and conc. nitric acid
(d) conc. hydrochloric acid and dil. nitric acid

Sol. (a)

34. The aim of the fountain experiment is to prove that *[2016]*
(a) HCl turns blue litmus red
(b) HCl is denser than air
(c) HCl is highly soluble in water
(d) HCl fumes in moist air

Sol. (a)

35. Name the gas produced when ammonium sulphate is heated with sodium hydroxide solution.
(a) Hydrogen chloride gas (b) Ammonia
(c) Sulphuric acid (d) Chlorine

Sol. (b)

36. Nitrogen gas can be obtained by heating *[2013]*
(a) ammonium nitrate (b) ammonium nitrite
(c) magnesium nitride (d) ammonium chloride

Sol. (b)

37. Which compound liberates ammonia on reaction with water?
(a) Nitride (b) Nitrate
(c) Nitrite (d) None of these

Sol. (a)

38. The catalyst used in the contact process is *[2018]*
(a) copper
(b) iron
(c) vanadium pentoxide
(d) manganese dioxide

Sol. (c)

39. Ammonia is manufactured by the Haber's process using iron catalyst. Which of the following statements is incorrect?
(a) Nitrogen is reduced by hydrogen
(b) It is not possible to obtain a 100% yield of ammonia
(c) A higher temperature will increase the yield of ammonia
(d) The iron catalyst is used to increase the speed of the reaction.

Sol. (c)

40. The nitrogen gas used in Haber's process is obtained by the
(a) decomposition of nitrate
(b) decomposition of nitrite
(c) decomposition of nitrogen by bacteria
(d) fractional distillation of air

Sol. (d)

41. A fertiliser containing ammonium sulphate and calcium carbonate is sometimes used by agricultural farmers. Why is the fertiliser useful?
(a) It provides nitrogen required for plant growth while reducing the acidity of the soil.
(b) It provides all the essential nutrients required for plant growth
(c) It provides both nitrogen and carbon dioxide required for plant growth
(d) It helps to reduce excess acidity of the soil.

Sol. (a)

42. Diammonium hydrogen phosphate, $(NH_4)_2HPO_4$, is a widely used fertiliser. Which of the following substance could be added to this compound to produce a mixture that provides the three principle elements needed for plant growth?
(a) Ammonium sulphate (b) Magnesium nitrate
(c) Ammonium phosphate (d) Potassium chloride

Sol. (d)

43. The molecular formula of nitric acid is
(a) HNO_3 (b) KNO_3
(c) $NaNO_3$ (d) None of these

Sol. (a)

44. How many lone pair(s) involved in the formation of coordinate bond(s) in nitric acid?
(a) 1 (b) 2
(c) 3 (d) 4

Sol. (a)

45. Nitric acid was also called as
(a) aqua-regia (b) aqua fortis
(c) aqua nitrate (d) aqua hydroxide

Sol. (b)

46. The formula of chile salt petre is
(a) KNO_3 (b) $NaNO_3$
(c) HNO_3 (d) None of these

Sol. (b)

47. The ratio of ammonia and air taken in Ostwald's process is
(a) 1 : 10 (b) 10 : 1
(c) 1 : 3 (d) 3 : 1

Sol. (a)

48. Name the oxidising agent used in Ostwald's process.
(a) NO (b) NO_2
(c) CO (d) O_2

Sol. (d)

49. Which acid does not evolve H_2 gas with metals?
(a) HNO_3 (b) H_2SO_4
(c) HCl (d) All of these

Sol. (a)

50. When sulphur reacts with conc. HNO_3, the product formed is
(a) H_2SO_4 (b) NO_2
(c) SO_2 (d) None of these

Sol. (a)

51. The brown ring test is used for the detection of *[2011]*
(a) CO_3^{2-} (b) NO_3^-
(c) SO_3^{2-} (d) Cl^-

Sol. (b)

52. Brown ring test is carried out with freshly prepared
(a) HNO_3 (b) H_2SO_4
(c) $FeSO_4$ (d) None of these

Sol. (c)

53. Filter paper soaked in KI turns brown due to the liberation of
(a) potassium (b) iodine
(c) nitrogen dioxide (d) hydrogen iodide

Sol. (b)

54. Concentrated sulphuric acid is
(a) yellow in colour (b) blue in colour
(c) a colourless liquid (d) green in colour

Sol. (c)

55. The reaction occurs in catalytic chamber during contact process is
(a) endothermic reaction (b) exothermic reaction
(c) reaction does not occur (d) cannot be decided

Sol. (b)

56. In the given equation, identify the role played by concentrated sulphuric acid. *[2013]*

$$S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$$

(a) Non-volatile acid (b) Oxidising agent
(c) Dehydrating agent (d) None of these

Sol. (b)

57. Pyrosulphuric acid is also called
(a) oleum (b) sulphuric acid
(c) nitric acid (d) None of these

Sol. (a)

Match the Following

58. Match the following columns.

	Column I (Compounds)		Column II (Occurrence)
(i)	Sulphuric acid	(a)	Rain water
(ii)	Ammonia	(b)	Barytes, gypsum
(iii)	Hydrochloric acid	(c)	Volcanic emissions
(iv)	Nitric acid	(d)	In air in trace amount

Sol. (i) (b), (ii) (d), (iii) (c), (iv) (a)

59. Column I contains the gas that evolved when hydrochloric acid is added to compound given in Column II. Match the gas evolved corresponding to their compounds.

	Column I		Column II
(i)	Calcium bicarbonate	(a)	Hydrogen sulphide
(ii)	Sodium sulphite	(b)	Carbon dioxide
(iii)	Zinc sulphide	(c)	Sulphur dioxide
(iv)	Magnesium	(d)	Hydrogen

Sol. (i) (b), (ii) (c), (iii) (a), (iv) (d)

60. Match the following columns.

	Column I		Column II
(i)	Fertilisers	(a)	NH_4NO_2
(ii)	Production of N_2	(b)	NH_4NO_3
(iii)	Dry cell	(c)	NH_4Cl

Sol. (i) (b), (ii) (a), (iii) (c)

61. Match the following columns.

	Column I		Column II
(i)	Reactants of Ostwald's process.	(a)	Nitric oxide
(ii)	Action of nitric acid on sulphur.	(b)	Nitrogen oxide
(iii)	Gas that exits the catalytic chamber during Ostwald's process.	(c)	Ammonia and oxygen
(iv)	Nitric acid comes in contact with air.	(d)	Sulphuric acid
		(e)	Sulphur dioxide

Sol. (i) (c), (ii) (d), (iii) (a), (iv) (b)

62. Match the following columns.

	Column I (Reactions)		Column II (Capacity of sulphuric acid)
(i)	Conc. sulphuric acid reacts with zinc to liberate sulphur dioxide.	(a)	Least volatile acid
(ii)	Action of dil. sulphuric acid on active metals to give hydrogen.	(b)	Dehydrating agent
(iii)	Reaction of conc. sulphuric acid with formic acid to give carbon monoxide.	(c)	Typical acid
(iv)	Action of conc. sulphuric acid on rock salt (preparation of HCl).	(d)	Oxidising agent
(v)	H_2S gas is passed through conc. sulphuric acid to give sulphur.	(e)	Drying agent
(vi)	Moist sulphur dioxide is passed through conc. sulphuric acid.	(f)	Oxidising agent

Sol. (i) (d), (ii) (c), (iii) (b), (iv) (a), (v) (f), (vi) (e)

1 Mark Questions

63. Name the gas which does not conduct electricity in the liquid state but conducts electricity when dissolved in water? *[2013]*

Sol. Hydrogen chloride

64. What will you observe when ammonia is mixed with hydrogen chloride gas?

Sol. Dense white fumes are produced.

65. How hydrogen chloride gas is dried?

Sol. It can be dried by using concentrated sulphuric acid.

66. Why hydrogen chloride gas is not collected over water?

Sol. Because it is highly soluble in water.

67. What happens when silver nitrate is added to hydrochloric acid followed by ammonia?

Sol. A white precipitate is obtained which is soluble in ammonia.

68. Name an alkaline gas which produces dense white fumes when reacted with hydrogen chloride gas.

Sol. Ammonia ***[2013, 2008]***

69. Write the balanced chemical equation for each of the following reactions.
Sodium thiosulphate is reacted with dilute hydrochloric acid. ***[2011]***

Sol. $Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2 + S$

70. Name the two black coloured oxidising agents which react with concentrated hydrochloric acid to obtain chlorine.

Sol. MnO_2 and CuO

71. Write a balanced chemical equation for each of the following.
Action of dilute hydrochloric acid on magnesium sulphite. ***[2018]***

Sol. $\underset{\text{Magnesium sulphite}}{MgSO_3} + \underset{\text{Dil. hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_2} + H_2O + SO_2 \uparrow$

72. Name a compound of ammonia which sublimes on heating.

Sol. Ammonium chloride

73. Which property of ammonia is shown by fountain experiment?

Sol. High solubility in water.

74. What do you observe when ammonia drop is poured over red litmus paper?

Sol. It turns blue.

75. Write the balanced chemical equation for the following. ***[2011]***
Chlorine reacts with excess of ammonia.

Sol. $8NH_3 + 3Cl_2 \longrightarrow 6NH_4Cl + N_2 \uparrow$

76. State one relevant observation for the following statement ***[2015]***
When ammonia gas is burnt in an atmosphere of excess oxygen.

Sol. Ammonia burns with yellow flame to produce nitrogen and water vapour.

77. Write the observation.
Glass rod dipped in ammonium hydroxide is brought near the mouth of the concentrated hydrochloric acid bottle. ***[2010]***

Sol. Dense white fumes of ammonium chloride (NH_4Cl) are formed.

78. Name of the solution which turns brown when it comes in contact with ammonia.

Sol. Nessler's reagent

79. Give one example of nitrate which on heating leaves no residue behind.

Sol. NH_4NO_3

80. Lead nitrate solution is mixed with dilute hydrochloric acid and heated. ***[2018]***

Sol. Lead nitrate reacts with dilute hydrochloric acid to give white precipitate of lead chloride.

$$Pb(NO_3)_2 + 2HCl\ (dil.) \xrightarrow{\Delta} PbCl_2 + 2HNO_3$$

81. Name the orange salt of ammonia which on heating gives green mass in the form of volcano.

Sol. Ammonium dichromate

82. Nitric acid can be prepared from potassium nitrate. Write the reaction involved during the preparation.

Sol. $KNO_3 + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{< 200^\circ C} KHSO_4 + HNO_3$

83. Name the reactants or raw materials used during Ostwald's process.

Sol. Ammonia and air

84. Name the catalyst used in the manufacture of nitric acid by Ostwald's process. ***[2011]***

Sol. Platinum

85. Write the balanced chemical equation for the following.
Ammonia and oxygen in the presence of a catalyst. ***[2010]***

Sol. $4NH_3 + 5O_2 \xrightarrow{Pb,\ 800^\circ C} 6H_2O + 4NO \uparrow + Heat$

$2NO + O_2 \longrightarrow 2NO_2$ (Brown gas)

86. Give a balanced chemical equation.
Ferric hydroxide reacts with nitric acid. ***[2011]***

Sol. $Fe(OH)_3 + 3HNO_3 \longrightarrow Fe(NO_3)_3 + 3H_2O$

87. Give the balanced equation for the following reaction.

Dilute nitric acid and copper carbonate *[2010]*

Sol. $CuCO_3 + 2HNO_3 \longrightarrow Cu(NO_3)_2 + CO_2 + H_2O$

88. Name the product formed when nitric acid reacts with hydrochloric acid.

Sol. Nitrosyl chloride

89. Why conc. HNO_3 act as stronger oxidising agent?

Sol. Conc. HNO_3 on decomposition gives nascent oxygen. This nascent oxygen oxidises other substances.

90. How does nitric acid render iron inert?

Sol. Nitric acid upon reaction with a metal, forms thin layer of insoluble metallic oxide which stops further reaction.

91. Name the gas that is produced in each of the following cases. *[2018]*

(i) Sulphur is oxidised by concentrated nitric acid.

(ii) Action of dilute hydrochloric acid on sodium sulphide.

(iii) Action of cold and dilute nitric acid on copper.

Sol. (i) Nitrogen dioxide (NO_2) gas

$$\underset{\text{Sulphur}}{S} + 6HNO_3 \longrightarrow \underset{\text{Sulphuric acid}}{H_2SO_4} + 2H_2O + 6NO_2$$

(ii) Hydrogen sulphide (H_2S) gas

$$\underset{\text{Sodium sulfide}}{Na_2S} + 2HCl \longrightarrow \underset{\text{Sodium chloride}}{2NaCl} + H_2S$$

(iii) Nitric oxide (NO) gas

$$\underset{\text{Copper}}{3Cu} + 8HNO_3 \longrightarrow \underset{\text{Copper nitrate}}{3Cu(NO_3)_2} + 4H_2O + NO$$

92. Write any two conditions for the conversion of sulphur dioxide to sulphur trioxide.

Sol. In the presence of vanadium pentaoxide (V_2O_5) or Pt as catalyst at 450°C temperature.

93. What is the name of the compound formed when both sulphur trioxide and sulphuric acid reacts?

Sol. Oleum ($H_2S_2O_7$) or fuming sulphuric acid.

$$SO_3 + \underset{\text{(Conc.)}}{H_2SO_4} \longrightarrow \underset{\text{Oleum}}{H_2S_2O_7}$$

94. Write the balanced chemical equation.

Dehydration of concentrated sulphuric acid with sugar crystals. *[2012, 11, 10]*

Sol. $$\underset{\text{Sugar charcoal}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O$$

b 2 Marks Questions

95. When we open a stopper of a bottle full of hydrogen chloride there are fumes in air, why?

Sol. Because hydrogen chloride has a great affinity of water, so, when stopper is opened, it immediately reacts with water vapour of atmosphere which lead to the formation of fumes. *[2]*

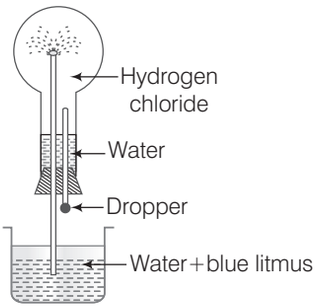
96. Why phosphorous pentaoxide and quick lime cannot be used for drying hydrochloric acid gas?

Sol. We cannot use phosphorous pentaoxide and quick lime because they both react with hydrochloric acid. *[1]*

$$2P_2O_5 + 3HCl \longrightarrow 3HPO_3 + POCl_3$$

$$CaO + 2HCl \longrightarrow CaCl_2 + H_2O \quad \textit{[1]}$$

97. Consider The diagram shown



(i) Name the experiment illustrated above.

(ii) Which property of hydrogen chloride is demonstrated by this experiment?

(iii) State the colour of the water that has entered in the round-bottom flask.

Sol. (i) Fountain experiment

(ii) Hydrogen chloride is highly soluble in water and acidic in nature.

(iii) Red colour *[2]*

98. Name the gas evolved when the following mixtures are heated. *[2016]*

(i) Calcium hydroxide and ammonium chloride.

(ii) Sodium nitrite and ammonium chloride

Sol. (i) When mixture of calcium hydroxide and ammonium chloride are heated, ammonia (NH_3) is evolved. The following reaction takes place

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3(g)\uparrow + 2H_2O \quad \textit{[1]}$$

(ii) When mixture of sodium nitrite and ammonium chloride are heated, nitrogen (N_2) gas is evolved.

The following reaction takes place.

$$NaNO_2 + NH_4Cl \longrightarrow NaCl + N_2(g)\uparrow + 2H_2O$$ *[1]*

99. Why ammonia cannot be obtained in laboratory from ammonium nitrate and sodium hydroxide?

Sol. Because on heating, ammonium nitrate decomposes explosively with the formation of nitrous oxide and water. *[2]*

100. Write the conditions required for the preparation of ammonia by Haber's process.

Sol. (i) Catalyst used – Iron (Fe)
(ii) Promoter – Molybdenum (Mo)
(iii) Temperature – 450-500°C
(iv) Pressure – 200-1000 atm *[1/2 × 4 = 2]*

101. Write the balanced chemical equation for the following.
Ammonia gas is burnt in an atmosphere of oxygen in the absence of a catalyst. *[2010]*

Sol. A jet of ammonia burns in an atmosphere of oxygen with a yellowish green flame forming water and nitrogen. *[1]*

$$4NH_3 + 3O_2 \longrightarrow 2N_2\uparrow + 6H_2O$$ *[1]*

102. Write a balanced equation for a reaction in which ammonia is oxidised by *[2007]*
(i) a metal oxide. (ii) a gas which is not oxygen.

Sol. (i) $3CuO + 2NH_3 \longrightarrow 3Cu + N_2\uparrow + 3H_2O$

(ii) $2NH_3 + 3Cl_2 \longrightarrow 6HCl + N_2\uparrow$ *[1 × 2 = 2]*

103. Name the other ion formed when ammonia dissolves in water. Give one test that can be used to detect the presence of the ion produced. *[2014]*

Sol. Hydroxyl ion $[OH^-]$ other than ammonium ion. Red litmus turns blue or phenolphthalein indicator turns pink in this solution. *[2]*

104. Liquid ammonia is neutral to litmus paper. Give reason.

Sol. Ammonia is a covalent compound, no free ions are present that's why there is no effect of ammonia on litmus paper. *[2]*

105. Write the equations for the following reactions which result in the formation of ammonia
(i) A mixture of ammonium chloride and slaked lime is heated.
(ii) Aluminium nitride and water. *[2006]*

Sol. (i) $2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3$

(ii) $AlN + 3H_2O \longrightarrow Al(OH)_3 + NH_3$ *[2 × 1 = 2]*

106. What will you observe when ammonium hydroxide is added drop by drop to copper sulphate solution, then in excess. Explain with reactions involved.

Sol. When we add ammonium hydroxide drop by drop a pale blue precipitate is formed which gets dissolved in excess. *[1]*

$$CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Copper hydroxide (pale blue ppt)}}{Cu(OH)_2}\downarrow + (NH_4)_2SO_4$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Tetraamine copper sulphate [soluble deep blue complex in solution]}}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$ *[1]*

107. What is the difference between the chemical nature of an aqueous solution of hydrogen chloride and an aqueous solution of ammonia?

Sol. Aqueous solution of HCl is acidic and neutralises bases or alkalies and turns blue litmus to red.
Aqueous solution of ammonia is alkaline and turns red litmus to blue. *[2]*

108. (i) Of the two gases, ammonia and hydrogen chloride, which one is more denser? Name the method of collection of this gas.
(ii) Give one example of a reaction between the above two gases which produces a solid compound. *[2007]*

Sol. (i) HCl is more denser, it is collected by the upward displacement of air.
(ii) HCl and NH_3 gas react together to give solid ammonium chloride. *[2 × 1 = 2]*

109. In a laboratory two students Rakhi and Mukta just completed the fountain experiment. How will you be able to tell whether the gas used in the experiment was hydrogen chloride or ammonia?

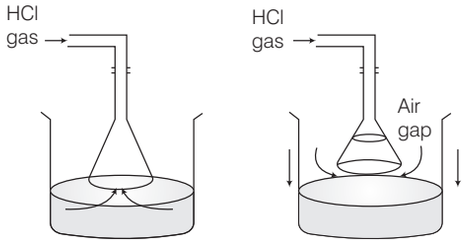
Sol. If in experiment, ammonia solution is used, the solution in the flask was blue, and if hydrogen chloride is used then the solution entering the flask was red. *[2]*

110. For the preparation of hydrochloric acid in the laboratory
(i) why is direct absorption of hydrogen chloride gas in water not feasible?
(ii) what arrangement is done to dissolve hydrogen chloride gas in water ?

Sol. (i) Hydrogen chloride gas is highly soluble in water. If delivery tube through which HCl gas is passed is directly immersed in water, then the partial vaccum is created in the tube because rate of absorption of

HCl gas is high. The pressure outside being higher causes the water to be pushed up into the delivery tube (back-suction). Thus, the direct absorption of hydrogen chloride gas in water is not feasible.

(ii) To dissolve hydrogen chloride gas in water, a special funnel arrangement is used as shown in the figure.



The funnel arrangement prevents or minimise back-suction of water and it also provides a large surface area for the absorption of gas.

111. (i) What is the special feature of the apparatus that is used in the laboratory preparation of nitric acid?

(ii) Why should the temperature of the reaction mixture of nitric acid not be allowed to rise above 200°C? ***[2011]***

Sol. (i) Entire apparatus should be made up of glass because nitric acid is highly corrosive in nature and will damage, wood, metal, rubber, plastic, etc.

(ii) Above 200°C, the nitric acid decomposes into H_2O, NO_2 and O_2 as it is very unstable to heat. Sodium sulphate or potassium sulphate will be formed which forms a crust over the mixture thus, restricting the release of nitric acid vapours. ***[2×1=2]***

112. What do you observe when

(i) nitric acid is kept in a reagent bottle for a long time?

(ii) dilute nitric acid is added to magnesium powder?

Sol. (i) The solution turns blue.

(ii) A hydrogen gas is liberated which catches flame as soon as it is formed. ***[1 × 2 = 2]***

113. Give the equations involved in brown ring test.

Sol. $6FeSO_4 + 3H_2SO_4 + 2HNO_3 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$ ***[1]***

$FeSO_4 + NO \longrightarrow \underset{\text{Nitroso ferrous sulphate}}{FeSO_4 \cdot NO}$ ***[1]***

114. Which concentrated acid will oxidise sulphur directly to sulphuric acid ? Write the equation involved.

Sol. Concentrated H_2SO_4 will oxidise sulphur directly to H_2SO_4.

$S + 6HNO_3 \longrightarrow H_2SO_4 + 2H_2O + 6NO_2$ ***[2]***

115. Draw the structure of H_2SO_4.

Sol. Refer to text on page 171.

116. Write the condition to maximise the yield of sulphuric acid by contact process.

Sol. The manufacturing of sulphuric acid by catalytic oxidation of SO_2 in the presence of V_2O_5 is favoured by low temperature (720K) and high pressure (2 bar). ***[2]***

117. Write the equations for sulphur combining directly with a metal and a non-metal.

Sol. $\underset{\text{Metal}}{Fe} + S \longrightarrow FeS$

$\underset{\text{(Non-metal)}}{H_2} + S \longrightarrow H_2S$ ***[2×1=2]***

118. In the preparation of H_2SO_4 by contact process, why is SO_3 not absorbed directly in water to form H_2SO_4?

Sol. In contact process, SO_3 is not absorbed directly in water to form H_2SO_4, because the reaction is highly exothermic. Hence, the reaction becomes difficult to handle. ***[2]***

119. Sulphur trioxide $\xrightarrow{A}$ Sulphuric acid

In manufacturing of sulphuric acid by contact process. Sulphur trioxide is not converted to sulphuric acid by reacting it with water. Instead a two step procedure is used. Write the equations for the two steps invloved in *A*.

Sol. $H_2SO_4 + SO_3 \longrightarrow \underset{\text{(Oleum)}}{H_2S_2O_7}$

$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$ ***[2 × 1 = 2]***

120. (i) What is the type of salt formed when the reactants are heated at a suitable temperature for the preparation of nitric acid?

(ii) State why for the preparation of nitric acid, the complete apparatus is made up of glass. ***[2018]***

Sol. (i) During the preparation of nitric acid at suitable temperature (<200°C), sodium and potassium bisulphates are formed.

$KNO_3 + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Potassium bisulphate}}{KHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$

$NaNO_3 + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{<200°C} \underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$

(ii) For the preparation of nitric acid, entire apparatus should be made up of glass. It is because nitric acid is highly corrosive in nature and will damage, rubber and cork of the apparatus. ***[2 × 1 = 2]***

121. Write balanced chemical equations to show how SO_3 is converted to sulphuric acid in the contact process. *[2017]*

Sol. Following steps are involved in the conversion of sulphur trioxide to sulphuric acid in the contact process.

(i) Absorption of sulphur trioxide in sulphuric acid

$$SO_3 + H_2SO_4 \longrightarrow \underset{\substack{\text{Oleum}\\(\text{Pyrosulphuric acdi})}}{H_2S_2O_7} \quad [1]$$

(ii) Dilution of oleum to sulphuric acid

$$H_2S_2O_7 + H_2O \longrightarrow \underset{\text{Sulphuric acid}}{2H_2SO_4} \quad [1]$$

122. Complete the following reactions.

(i) $MgCl_2 + H_2SO_4 \longrightarrow$

(ii) $CaO + HCl \longrightarrow$

(iii) $Fe + HCl \longrightarrow$

(iv) $Pb_3O_4 + HCl \xrightarrow{\Delta}$

Sol. (i) $MgCl_2 + H_2SO_4 \longrightarrow MgSO_4 + 2HCl\uparrow$

(ii) $CaO + 2HCl \longrightarrow CaCl_2 + H_2O$

(iii) $Fe + 2HCl \longrightarrow FeCl_2 + H_2\uparrow$

(iv) $Pb_3O_4 + 8HCl \longrightarrow 3PbCl_2 + 4H_2O + Cl_2\uparrow$

[4 × 1/2 = 2]

123. How will you distinguish between dilute hydrochloric acid and dilute sulphuric acid using lead nitrate solution? *[2017]*

Sol. Sulphuric acid gives white insoluble precipitate of lead sulphate, which remains insoluble on heating.

$$Pb(NO_3)_2 + H_2SO_4 \longrightarrow PbSO_4\downarrow + 2HNO_3$$

Lead nitrate react with HCl to give white ppt.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

The $PbCl_2$ get redissolve on heating. *[2]*

C 3 Marks Questions

124. Write the steps required to convert hydrogen chloride to anhydrous iron (III) chloride. Write the equations for the reactions which take place.

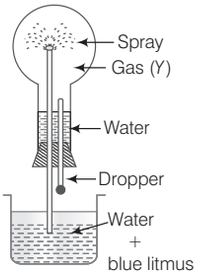
Sol. Prepare chlorine by reacting oxidising agents (like MnO_2, PbO_2, Pb_3O_4) with conc. HCl.

$$MnO_2 + 4HCl(\text{conc.}) \longrightarrow MnCl_2 + Cl_2 + 2H_2O$$

Now, pass the chlorine (prepared) over conc. H_2SO_4 for drying. Then the dry chlorine is heated over with iron to give anhydrous iron (III) chloride ($FeCl_3$).

$$\underset{\text{Heated}}{2Fe} + \underset{\text{Dry}}{3Cl_2} \longrightarrow \underset{\substack{\text{Anhydrous}\\\text{iron (III) chloride}}}{2FeCl_3} \quad [1½ × 2 = 3]$$

125. Study the figure given below and answer the questions that follows.



(i) Identify the gas *Y*.

(ii) What property of gas *Y* does this experiment demonstrate?

(iii) Name another gas which has the same property and can be demonstrated through this experiment.

Sol. (i) Hydrogen chloride gas (HCl)

(ii) Gas *Y i.e.,* HCl gas is highly soluble in water and acidic in nature.

(iii) Ammonia gas *[3 × 1 = 3]*

126. The following reactions are carried out.

(a) Nitrogen + Metal ⟶ Compound *X*

(b) *X* + Water ⟶ Ammonia + Another compound

(c) Ammonia + Metal oxide ⟶ Metal + Water + N_2

(i) Write the formula of the compound *X* (Metal = Mg).

(ii) Write the balanced equation for (b).

(iii) In (c) reaction ammonia shows ..... property.

Sol. (i) Mg_3N_2 *[1]*

(ii) $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2\downarrow + 2NH_3\uparrow$ *[1]*

(iii) reducing *[1]*

127. Complete the following table relating to important industrial process.

Name of the Process	Temperature	Catalyst	Equation for the Catalysed Reaction
Haber's process			

Sol. **Temperature** 450°C-500°C
Catalyst Finely divided iron
Equation $N_2 + 3H_2 \rightleftharpoons 2NH_3$ *[1 × 3 = 3]*

128. Write three chemical properties which show reducing property of ammonia.

Sol. (i) $2NH_3 + 3PbO \longrightarrow 3Pb + 3H_2O + N_2\uparrow$

(ii) $2NH_3 + 3CuO \longrightarrow 3Cu + 3H_2O + N_2\uparrow$

(iii) $NH_3 + 3Cl_2 \longrightarrow 3HCl + NCl_3$ *[3 × 1 = 3]*

129. Give reason.

(i) Liquid ammonia is used as a refrigerant in ice plants.

(ii) Ammonia solution is used as laboratory reagent.

(iii) Ammonium chloride is used to remove oil and grease stains from clothes.

Sol. (i) Refer to text on page 167.

(ii) Because ammonia solution, i.e. ammonium hydroxide can precipitate insoluble hydroxide of metals from their salt solutions (used in analytical chemistry).

(iii) Ammonium chloride when rubbed with metal, it releases ammonia and hydrogen chloride. Ammonia removes oil, grease, etc., and the HCl formed clean the metal surface by removing metal oxides of metals.

$$\underset{\text{Ammonium chloride}}{NH_4Cl(s)} \longrightarrow \underset{\text{Ammonia}}{NH_3(g)} + \underset{\text{Hydrogen chloride}}{HCl(g)}$$ ***[1 × 3 = 3]***

130. Write the complete equations.

(i) $NH_3 \xrightarrow{A} NH_4OH$

(ii) $NH_3 + B \longrightarrow NH_4Cl$

(iii) $NH_3 + 3\,Cl_2 \longrightarrow NCl_3 + C$

Sol. (i) $A = H_2O$ (ii) $B = HCl$

(iii) $C = 3HCl$ ***[3 × 1 = 3]***

131. Give the balanced chemical equations for each of the following. ***[2015]***

(i) Lab preparation of ammonia using an ammonium salt.

(ii) Reaction of ammonia with excess chlorine.

(iii) Reaction of ammonia with sulphuric acid.

Sol. (i) $\underset{\text{Slaked lime}}{Ca(OH)_2} + \underset{\text{Ammonium chloride}}{2NH_4Cl} \xrightarrow{\Delta} \underset{\text{Calcium chloride}}{CaCl_2} + \underset{\text{Water}}{2H_2O} + \underset{\text{Ammonia}}{2NH_3}\uparrow$

(ii) $\underset{\text{Ammonia}}{NH_3} + \underset{\text{Chloride (Excess)}}{3Cl_2} \longrightarrow \underset{\text{Nitrogen chloride}}{NCl_3} + \underset{\text{Hydrogen chloride}}{3HCl}$

(iii) $\underset{\text{Ammonia}}{2NH_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$ ***[3 × 1 = 3]***

132. (i) Which feature of the ammonia molecules lead to the formation of the ammonium ion when ammonia dissolves in water?

(ii) Name the other ion formed when ammonia dissolves in water.

(iii) Give one test that can be used to detect the presence of the ion produced in (ii).

Sol. (i) In ammonia molecule, there is one lone pair of electrons available on nitrogen atom. This lone pair of electron leads to the formation of ammonium ion. ***[1]***

(ii) Hydroxide ion (OH^-) ***[1]***

(iii) It will give reddish brown precipitate with aqueous $FeCl_3$. ***[1]***

133. Give one example of ammonia salt used in

(i) medicine. (ii) fertilisers.

(iii) explosive.

Sol. (i) $(NH_4)_2CO_3$ (ii) $(NH_4)_2SO_4$

(iii) $(NH_4)_2NO_3$ ***[3 × 1 = 3]***

134. Select from the list the gas that matches the description given in each case.

[ammonia, ethane, hydrogen chloride, hydrogen sulphides, ethyne]

(i) This gas is used as a reducing agent in reducing copper oxide to copper.

(ii) This gas produces dense white fumes with ammonia gas.

(iii) This gas has a characteristic rotten egg smell. ***[2015]***

Sol. (i) Ammonia

(ii) HCl

(iii) H_2S ***[3 × 1 = 3]***

135. (i) Explain, why only glass apparatus should be used for the preparation of nitric acid by heating concentrated sulphuric acid and potassium nitrate ? *[2006]*

(ii) Write a chemical equation to illustrate the acidic nature of nitric acid.

(iii) Name the product formed when ammonium nitrate is heated.

Sol. (i) Nitric acid is highly corrosive in nature and will damage rubber and cork of the apparatus.

(ii) $CaCO_3 + \underset{\text{Dil.}}{2HNO_3} \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

(iii) $NH_4NO_3 \xrightarrow{\Delta} N_2O(g) + \underset{\text{(Vaporisation)}}{2H_2O}$ ***[1 × 3 = 3]***

136. Explain the following.

(i) Dilute nitric acid is generally considered a typical acid but not so in its reaction with metals.

(ii) Concentrated nitric acid appears yellow when it is left standing in a glass bottle.

(iii) All glass apparatus is used in the laboratory preparation of nitric acid. ***[2015]***

Sol. (i) Nitric acid acts as an oxidising agent on reaction with metal instead of producing hydrogen gas and metal nitrate.

(ii) Concentrated nitric acid decomposes slightly in the presence of sunlight (even indirect sunlight) and produces NO_2 gas which gives yellowish appearance.

(iii) Nitric acid is highly reactive and corrosive which can react with even rubber corks of apparatus. ***[3 × 1 = 3]***

137. (i) Dilute nitric acid is generally considered a typical acid except for its reaction with metals. In what way dilute nitric acid is different from other acids when it reacts with metals?

(ii) Write the equation for the reaction of dilute nitric acid with copper.

(iii) Account for the yellow colour that appears in concentrated nitric acid when it is left standing in an ordinary glass bottle.

Sol. (i) Nitric acid is a strong oxidising agent, so, hydrogen gas is not liberated when metals react with nitric acid.

(ii) $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

(iii) Conc. HNO_3 is unstable to heat. So on standing in an ordinary glass bottle, it absorbs heat from the surrounding and gets decomposed liberating NO_2 gas which turns conc. HNO_3 yellow. ***[3×1=3]***

138. Give one equation each to show the following properties of sulphuric acid.

(i) Dehydrating property (ii) Acidic nature

(iii) As a non-volatile acid.

Sol. (i) $\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}(s)} \xrightarrow[\text{Dehydration}]{\text{Conc. } H_2SO_4} 12C + \underset{\text{Sugar charcoal}}{} 11H_2O$

(ii) **Acidic nature** It neutralises bases to form salts and water.

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

(iii) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$ ***[3 × 1 = 3]***

139. (a) (i) Write the balanced chemical equation to prepare ammonia gas in the laboratory by using an alkali.

(ii) State why concentrated sulphuric acid is not used for drying ammonia gas.

(iii) Why is ammonia gas not collected over water ? ***[3]***

(b) (i) Name the acid used for the preparation of hydrogen chloride gas in the laboratory. Why is this particular acid preferred to other acids?

(ii) Write the balanced chemical equation for the laboratory preparation of hydrogen chloride gas. ***[2018] [3]***

Sol. (i) Ammonia gas can be prepared by heating a mixture of ammonium salt (NH_4Cl) with an alkali [$Ca(OH)_2$].

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$$

(ii) Ammonia gas cannot be dried by passing it through concentrated sulphuric acid because ammonia being a basic gas reacts with conc. H_2SO_4 to form ammonium sulphate.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

(iii) Ammonia gas is not collected over water, since it is highly soluble in water.

(b) (i) Hydrogen chloride gas is prepared in the laboratory by the reaction of sodium chloride (common salt) with concentrated sulphuric acid. It is preferred over other acids because of its oxidising and dehydrating property.

(ii) *Balanced chemical equations for the preparation of HCl gas in laboratory are as follows*:

$$\underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Conc. sulphuric acid}}{H_2SO_4} \xrightarrow[200°C]{\text{Below}} \underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Hydrogen chloride gas}}{HCl\uparrow}$$

$$2NaCl + \underset{(\text{Conc.})}{H_2SO_4} \xrightarrow[200°C]{\text{Above}} \underset{\text{Sodium sulphate}}{Na_2SO_4} + 2HCl\uparrow$$

140. Write a balanced chemical equations to show

(i) the oxidising action of conc. sulphuric acid on carbon.

(ii) the behaviour of H_2SO_4 as an acid when it reacts with magnesium.

(iii) the dehydrating property of conc. sulphuric acid with sugar.

Sol. (i) Carbon on reaction with conc. H_2SO_4 gives CO_2, SO_2 and water.

$$\underset{\text{Carbon}}{C} + \underset{\text{Conc. Sulphuric acid}}{2H_2SO_4} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2\uparrow} + 2H_2O + \underset{\text{Sulphur dioxide}}{SO\uparrow}$$ ***[1]***

(ii) Dilute sulphuric acid reacts with metals, which are present above hydrogen in the activity series to form metallic sulphate ($MgSO_4$) and hydrogen gas at ordinary temperature.

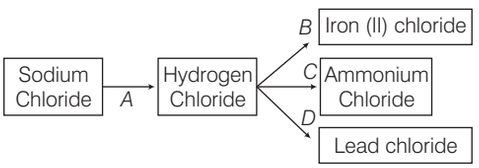
$$\underset{\text{Magnesium}}{Mg} + H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$$ ***[1]***

(iii) Carbohydrates (like sugar) are dehydrated by conc. H_2SO_4.

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}(s)} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Charcoal}}{12C(s)} + 11H_2O$$ *[1]*

d 4 Marks Questions

141. Refer to the flow chart diagram given and give the balanced equations with conditions, if any for the given conversions *A* to *D*. *[2012]*



Sol. $(A)NaCl + H_2SO_4 \xrightarrow{> 200^\circ C} NaHSO_4 + HCl$

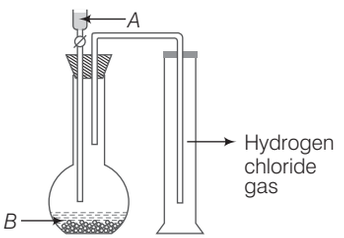
$(B)\ Fe + 2HCl \longrightarrow FeCl_2 + H_2$

$(C)\ NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$

$(D)\ PbO_2 + 4HCl \longrightarrow PbCl_2 + 2H_2O + Cl_2$

[4 × 1 = 4]

142. The diagram shows an apparatus for the laboratory preparation of hydrogen chloride.



(i) Identify *A* and *B*.

(ii) Write the equation for the reaction.

(iii) How would you check whether or not the gas jar is filled with hydrogen chloride?

(iv) What does the method of collection tell you about the density of hydrogen chloride?

Sol. (i) *A* is concentrated sulphuric acid.

B is sodium chloride.

(ii) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl\uparrow$

(iii) A glass rod dipped in NH_4OH solution if brought near the mouth of the gas jar, it evolves dense white fumes, it shows that the jar is full of HCl gas.

(iv) Since, the gas is collected by the upward displacement of air, it means it is heavier than air.

[1 × 4 = 4]

143. Certain blank spaces are left in the following table and these are labelled as *A, B, C, D* and *E*. Identify each of them.

Lab Protection	Reactant used	Products formed	Drying agent	Method of collection
(i) HCl gas	NaCl + H_2SO_4	*A*	conc. H_2SO_4	*B*
(ii) NH_3 gas	*C*	$Mg(OH)_2$ NH_2^+	*D*	*E*

Sol. (i) $A\text{-}\underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Hydrogen chloride}}{HCl}\uparrow$ *[2017]*

B- Upward displacement of air. *[2]*

(ii) $C\text{-}\underset{\text{Magnesium nitride}}{Mg_3N_2} + \underset{\text{water}}{H_2O},\quad D\text{-}\underset{\text{Quicklime}}{CaO}$

E. Downward displacement of air. *[2]*

144. The following questions are based on the preparation of ammonia gas in the laboratory. *[2012]*

(i) Explain, why ammonium nitrate is not used in the preparation of ammonia?

(ii) Name the compound normally used as a drying agent during the process.

(iii) How is ammonia gas collected?

(iv) Explain, why it is not collected over water?

Sol. (i) Ammonium nitrate is a highly explosive substance and cannot be heated, it may itself form nitrous oxide and water vapour.

(ii) Quick lime (CaO).

(iii) By the downward displacement of air or upward delivery as it is lighter than air.

(iv) Ammonia is highly soluble in water, so it cannot be collected over water. *[1 × 4 = 4]*

145. Ammonia is an extremely useful chemical. It is made industrially by the Haber's process.

(i) Write a balanced chemical equation with state symbols for the formation of ammonia.

(ii) State the sources of nitrogen and hydrogen.

(iii) It is known that the volumes of nitrogen and hydrogen are mixed in the ratio of 1 : 3. What is the reason for doing so ?

Sol. (i) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ *[1]*

(ii) Nitrogen is obtained by the fractional distillation of liquefied air while hydrogen is obtained by the catalytic cracking of long chain hydrocarbons. *[1]*

(iii) From the balanced chemical equation, one mole of nitrogen reacts with three moles of hydrogen, hence, a ratio of 1:3 is most efficient for the reaction to take place. *[2]*

146. (i) List two main uses of ammonia.

(ii) Give the balanced equations for the following conversions.

(a) Ammonia solution to an amphoteric hydroxide.

(b) Ammonia to brown gas.

Sol. (i) Uses of ammonia (NH_3)

(a) It is used as a laboratory reagent.

(b) It is used in the manufacture of nitric acid. *[2]*

(ii) (a) $ZnSO_4 + 2NH_4OH \longrightarrow \underset{\text{Amphoteric hydroxide}}{Zn(OH)_2} + (NH_4)_2SO_4$

(b) $4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + 6H_2O$ *[2×1=2]*

147. Write balanced chemical equations for each of the following.

(i) Action of warm water of AlN.

(ii) Action of hot and concentrated nitric acid on copper.

(iii) Action of hydrochloric acid on sodium bicarbonate.

(iv) Action of dilute sulphuric acid on sodium sulphite. *[2016]*

Sol. (i) $\underset{\text{(Aluminium nitride)}}{AlN} + \underset{\text{(Water)}}{3H_2O} \longrightarrow \underset{\text{(Aluminium hydroxide)}}{Al(OH)_3}\downarrow + \underset{\text{(Ammonia)}}{NH_3}\uparrow$

(ii) $Cu + \underset{\text{(Conc.)}}{4HNO_3} \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2\uparrow$

(iii) $\underset{\text{(Sodium hydrogen carbonate)}}{NaHCO_3} + \underset{\text{(dil)}}{HCl} \longrightarrow NaCl + H_2O + CO_2\uparrow$

(iv) $\underset{\text{(Sodium sulphite)}}{Na_2SO_3} + \underset{\text{(dil)}}{H_2SO_4} \longrightarrow Na_2SO_4 + H_2O + SO_2\uparrow$

[1 × 4 = 4]

148. (i) What happens when ammonia is passed over copper oxide?

(ii) Which colour of flame is obtained when ammonia burns with oxygen.

(iii) The first step in the manufacturing of nitric acid is the catalytic oxidation of ammonia. What is the name of the catalyst?

Sol. (i) $\underset{\text{Black}}{3CuO} + 2NH_3 \longrightarrow 3Cu + N_2\uparrow + 3H_2O$

On reacting copper oxide with ammonia a pinkish red metal with a colourless, odourless gas is obtained. The gas is neither combustible nor it supports combustion and does not turn lime water milky. *[2]*

(ii) Green flame *[1]*

(iii) Platinum *[1]*

149. State one relevant observation for each of the following.

(i) When crystals of copper nitrate are heated in a test tube.

(ii) When the gaseous product obtained by the dehydration of ethyl alcohol is passed through bromine water.

(iii) When hydrogen sulphide gas is passed through lead acetate solution.

(iv) When ammonia gas is burnt in an atmosphere of excess oxygen.

Sol. (i) When crystals of copper nitrate are heated in a test tube then reddish brown fumes of nitrogen dioxide gas (NO_2) are observed.

$2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + \underset{\substack{\text{Nitrogen dioxide}\\\text{(Reddish brown)}}}{4NO_2} + O_2$

(ii) Gaseous product obtained by the dehydration of ethyl alcohol is ethene. When ethene is passed through bromine water, then orange colour of bromine disappears due to the formation of colourless ethylene bromide.

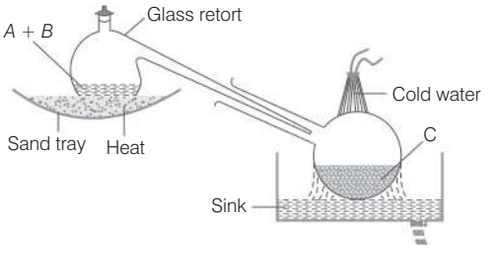
(iii) When hydrogen sulphide gas is passed through lead acetate solution, then black precipitate of lead sulphide is obtained.

$(CH_3COO)_2Pb + H_2S \longrightarrow \underset{\text{Black}}{PbS}\downarrow + 2CH_3COOH$

(iv) Ammonia gas burnt in an atmosphere of excess oxygen with yellowish green flame and produces water vapour and nitrogen.

$4NH_3 + 3O_2 \longrightarrow 2N_2\uparrow + 6H_2O$ *[4 × 1 = 4]*

150. The figure given below illustrates the apparatus used in the laboratory preparation of nitric acid.



(i) Name *A* (a liquid), *B* (a solid) and *C* (a liquid). (Do not give the formulae)

(ii) Write an equation to show how nitric acid undergoes decomposition.

(iii) Write the equation for the reaction in which copper is oxidised by concentrated nitric acid.

Sol. (i) *A* : Conc. sulphuric acid
B : Potassium nitrate
C : Nitric acid ***[2]***

(ii) $4HNO_3 \longrightarrow 2H_2O + 4NO_2 + O_2$ ***[1]***

(iii) $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$ ***[1]***

151. (i) Why nitric acid does not liberate hydrogen, when it reacts with metals?

(ii) Write the product formed when copper reacts with conc. and dilute acid respectively.

(iii) During the laboratory preparation of nitric acid, why the reaction mixture is not heated beyond 200°C ?

Sol. (i) Because it is a strong oxidising agent. ***[1]***

(ii) With dil. HNO_3 copper produces copper nitrates, water and nitric oxides. With conc. HNO_3, it gives copper nitrate, water and nitrogen dioxide. ***[1]***

(iii) During the laboratory preparation of nitric acid the reaction mixture is not heated beyond 200°C because high temperature may decompose nitric acid to nitrogen dioxide, water and oxygen and one of the reactant used *i.e.,* potassium sulphate changes into sticky mass and destroys the glass apparatus. ***[2]***

152. Write a balanced chemical equation for each of the following.

(i) Action of cold and dilute nitric acid on copper.

(ii) Reaction of ammonia with heated copper oxide.

(iii) Action of concentrated sulphuric acid on sulphur.

(iv) Laboratory preparation of ammonia from ammonium chloride. ***[2017]***

Sol. (i) Copper, on reaction which cold and dilute nitric acid gives copper nitrate and nitric oxide.

$$\underset{\text{Copper}}{3Cu} + \underset{\text{Cold and dilute}}{8HNO_3} \longrightarrow \underset{\text{Copper nitrate}}{3Cu(NO_3)_2} + 4H_2O + \underset{\text{Nitric oxide}}{2NO}$$ ***[1]***

(ii) Reaction of ammonia with heated copper oxide or copper metal and nitrogen gas.

$$\underset{\text{Ammonia}}{2NH_3} + \underset{\text{Copper oxide}}{3CuO} \xrightarrow{\Delta} \underset{\text{Copper metal}}{3Cu} + 3H_2O + \underset{\text{Nitrogen gas}}{N_2}\uparrow$$ ***[1]***

(iii) Concentrated sulphuric acid on reaction with sulphur gives sulphur dioxide as major product.

$$\underset{\text{Sulphur}}{S} + \underset{\text{Conc. Sulphuric acid}}{2H_2SO_4} \xrightarrow{\Delta} \underset{\text{Sulphur dioxide}}{3SO_2} + 2H_2O$$ ***[1]***

(iv) $2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$ ***[1]***

153. Give a balanced chemical equation for each of the following.

(i) Action of concentrated nitric acid on sulphur.

(ii) Catalytic oxidation of ammonia.

(iii) Laboratory preparation of nitric acid.

(iv) Reaction of ammonia with nitric acid. ***[2017]***

Sol. (i) Action of concentrated nitric acid on sulphur gives sulphuric acid as a major product.

$$\underset{\text{Sulphur}}{S} + \underset{\text{Conc. nitric acid}}{6HNO_3} \longrightarrow \underset{\text{Sulphuric acid}}{H_2SO_4} + 2H_2O + 6NO_2\uparrow$$

(ii) Cataltic oxidation of ammonia gives nitric oxide which on further oxidation gives brown fumes of nitrogen dioxide.

$$4NH_3 + 5O_2 \xrightarrow{\text{Pt, } 800\,^\circ C} 6H_2O + 4NO\uparrow + \text{Heat}$$

$$2NO + O_2 \longrightarrow NO_2 \text{ (Brown gas)}$$

(iii) A mixture of equal parts by weight of potassium/ sodium nitrate and concentrated sulphuric acid is heated gently to 180°C-200°C in a glass retort to give nitric acid.

$$\underset{\text{Potassium nitrate}}{KNO_3} + \underset{\text{Conc. Sulphuric acid}}{H_2SO_4} \xrightarrow{<200\,^\circ C} \underset{\text{Potassium bisulphate}}{KHSO_4} + \underset{\text{Nitric acid}}{HNO_3}\uparrow$$

$$\underset{\text{Sodium nitrate}}{NaNO_3} + \underset{\text{Conc. Sulphuric acid}}{H_2SO_4} \xrightarrow{<200^\circ C} \underset{\text{Sulphur bisulphate}}{NaHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$$

(iv) Ammonia on reaction with nitric acid give ammonium sulphate.

$$\underset{\text{Ammonia}}{2NH_3} + \underset{\text{Nitric acid}}{H_2SO_4} \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$$ ***[1 × 4 = 4]***

154. (i) Write the equations to show sulphuric acid is a dibasic acid.

(ii) Give one example of a substance that reacts with dilute or conc. H_2SO_4 to form

(a) CO_2 (b) H_2

(iii) Name one oxide of sulphur which on reacting with water gives sulphuric acid.

Sol. (i) $H_2SO_4 + NaOH \longrightarrow \underset{\text{Acidic}}{NaHSO_4} + H_2O$

$NaHSO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$

Sulphuric acid on reacting with sodium hydroxide (*i.e.,* alkali) gives two salts sodium bisulphate and sodium sulphate. *[1]*

(ii) (a) $Na_2CO_3 + \underset{\text{(dil.)}}{H_2SO_4} \longrightarrow Na_2SO_4 + H_2O + CO_2\uparrow$

(b) $Zn + \underset{\text{(dil.)}}{H_2SO_4} \longrightarrow ZnSO_4 + H_2\uparrow$ *[2]*

(iii) SO_3 *[1]*

155. (i) Give two reasons to show that the solution of ammonia in water contains hydroxide ions.

(ii) Give an example of ore which on roasting gives sulphur dioxide.

(iii) What property is shown by sulphuric acid when it reacts with potassium nitrate?

Sol. (i) (a) It reacts with an acid to form salt.

(b) It turns red litmus blue. *[2]*

(ii) Zinc blende or ZnS

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2\uparrow$ *[1]*

(iii) Non-volatile nature *[1]*

156. Copy and complete the following table relating to important industrial processes output refers to the product of the process not the intermediate steps. *[2008]*

Name of process	Input	Equation for catalysed reaction	Output
Haber's process	Hydrogen + Nitrogen		Ammonia
Contact process	Sulphur dioxide + Oxygen		

Sol.

Name of process	Input	Catalyst	Equation for catalysed reaction	Output
Haber's process	Hydrogen + Nitrogen	Finely divided iron	$N_2 + 3H_2 \longrightarrow 2NH_3$	Ammonia
Contact process	Sulphur dioxide + Oxygen	Vanadium pentaoxide	$2SO_2 + O_2 \longrightarrow 2SO_3$	Sulphuric acid

[4]

157. The following questions are pertaining to the laboratory preparation of hydrogen chloride gas.

(i) Write the equation for its preparation mentioning the condition required.

(ii) Name the drying agent used and justify your choice.

(iii) State a safety precaution you would take during the preparation of hydrochloric acid.

Sol. (i) HCl gas is prepared by the action of conc. sulphuric acid (H_2SO_4) on sodium chloride (NaCl) at below 200°C.

$NaCl + \underset{\text{(Conc.)}}{H_2SO_4} \xrightarrow{200°C} \underset{\text{Sod. bisulphate}}{NaHSO_4} + HCl\uparrow$ *[2]*

(ii) HCl gas is dried by using conc. H_2SO_4 as it does not react with HCl while drying. *[1]*

(iii) It should be maintained that lower end of the thistle funnel must dip into the acid level in the flask. *[1]*

158. State your observations when

(i) dilute hydrochloric acid is added to lead nitrate solution and the mixture is heated.

(ii) dilute hydrochloric acid is added to sodium thiosulphate.

(iii) Concentrated sulphuric acid is added to sugar crystals.

(iv) dilute hydrochloric acid is added to copper carbonate. *[2016]*

Sol. (i) Lead chloride ($PbCl_2$) is precipitated as per the reaction given below.

$\underset{\text{(Lead nitrate)}}{Pb(NO_3)_2} + 2HCl \xrightarrow{\Delta} \underset{\text{Lead chloride}}{PbCl_2}\downarrow + \underset{\text{Nitric acid}}{2HNO_3}$

(ii) Sulphur is precipitated as given in the following reaction.

$$\underset{\text{Sodium thiosulphate}}{Na_2S_2O_3} + 2HCl \longrightarrow \underset{\text{Sodium chloride}}{2NaCl} + H_2O + SO_2\uparrow + \underset{\text{Sulphur}}{S}\downarrow$$

(iii) Sulphuric acid acts as a dehydrating agent and reduces sugar to carbon.

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} + \underset{\text{conc}}{H_2SO_4} \xrightarrow{\text{Heat}} 12C + 11H_2O$$

(iv) Copper carbonate reacts with hydrochloric acid to produce the copper chloride salt and carbonic acid.

$$\underset{\text{Copper carbonate}}{CuCO_3(s)} + 2HCl(aq) \longrightarrow \underset{\text{Copper chloride}}{CuCl_2(aq)} + \underset{\text{Carbonic acid}}{H_2CO_3(aq)}$$

[1 × 4 = 4]

159. (i) What do you observe when

(a) nitric oxide come in contact with atmosphere?

(b) nitrogen dioxide is passed through acidified ferrous sulphate solution (fresh)?

(c) dilute sulphuric acid react with magnesium

(ii) Name a yellow non-metal formed when H_2S gas is passed through concentrated nitric acid.

Sol. (i) (a) Nitric acid changes into a reddish brown coloured gas. ***[1]***

(b) At the junction of two liquids a brown ring is formed. ***[1]***

(c) A colourless and odourless gas is evolved which burns with a poping sound. ***[1]***

(ii) Sulphur ***[1]***

160. (i) What do you observe when

(a) lead nitrate is added to dilute sulphuric acid?

(b) action of sulphuric acid on ferrous sulphate crystals?

(ii) Why, magnesium supports combustion in nitric oxide, while sulphur does not?

Sol. (i) (a) A white precipitate formed (insoluble in all the minerals acids). ***[1]***

(b) A white powder is formed. ***[1]***

(ii) When magnesium is burnt, heat is produced that is sufficient to decompose nitric oxide into nitrogen and oxygen. The oxygen formed support the combustion while sulphur is not able to decompose nitric oxide. ***[2]***

161. (i) Give the balanced chemical equations for the action of sulphuric acid on each of the following:

(a) Potassium hydrogen carbonate

(b) Sulphur

(ii) In the contact process for the manufacture of sulphuric acid, give the equations for the conversion of sulphur trioxide to sulphuric acid.

Sol. (i) (a) $\underset{\text{Potassium hydrogen carbonate}}{2KHCO_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Potassium sulphate}}{K_2SO_4} + \underset{\text{Water}}{2H_2O} + \underset{\text{Carbon dioxide}}{2CO_2}\uparrow$

(b) $\underset{\text{Sulphur}}{S} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Sulphur dioxide}}{3SO_2} + \underset{\text{Water}}{2H_2O}$ ***[2×1=2]***

(ii) Sulphur trioxide is converted into sulphuric acid as follow

$$\underset{\text{Sulphur trioxide}}{SO_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Oleum}}{H_2S_2O_7}$$

$$\underset{\text{Oleum}}{H_2S_2O_7} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sulphuric acid}}{2H_2SO_4}$$

[2× 1=2]

162. (i) Name the process used for the large scale manufacturing of sulphuric acid.

(ii) Which property of sulphuric acid accounts for its use as a dehydrating agent?

(iii) Concentrated sulphuric acid acts as both an oxidising agent and a non-volatile acid. Write one equation each to illustrate the above mentioned properties of sulphuric acid. ***[2006]***

Sol. (i) Contact process used for the large scale manufacturing of sulphuric acid. ***[1]***

(ii) Sulphuric acid has a great affinity for water. It readily removes elements of water from other compounds *i.e.*, it acts as a dehydrating agent. ***[1]***

(iii) As an oxidising agent.

$$S + \underset{\text{(Conc.)}}{2H_2SO_4} \longrightarrow 3SO_2 + 2H_2O$$ ***[1]***

As an non-volatile acid

$$2NaNO_3 + \underset{\text{Conc.}}{H_2SO_4} \longrightarrow Na_2SO_4 + 2HNO_3$$ ***[1]***

163. State one relevant observation for each of the following reactions.

(i) Action of dilute hydrochloric acid on iron (II) sulphide.

(ii) Burning of ammonia in air.

(iii) Action of concentrated sulphuric acid on hydrated copper sulphate. ***[2017]***

Sol. (i) Hydrochloric acid decomposes salts of weaker acids, (like carbonates), bicarbonates, sulphate, sulphides into metal chloride.

$$FeS + 2HCl \longrightarrow FeCl_2 + H_2S\uparrow$$ ***[1]***

(ii) Ammonia burns in air with yellowish green flame and produces water vapour and nitrogen.

$$4NH_3 + 3O_2 \longrightarrow 2N_2\uparrow + 6H_2O$$ *[1]*

(iii) Concentrated sulphuric acid removes water of crystallisation from salts. Due to which blue coloured salt changes into white colour.

$$\underset{\text{Blue}}{CuSO_4 \cdot 5H_2O} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Dirty white}}{CuSO_4(s)} + 5H_2O$$ *[2]*

e 5 Marks Questions

164. What happens when

(i) platinum is placed in aqua-regia?

(ii) magnesium is treated with dil. HCl?

(iii) hydrogen chloride gas comes in contact with ammonia solution?

(iv) lead nitrate solution is treated with dilute hydrochloric acid?

(v) copper oxide is treated with conc. HCl?

Sol. (i) Platinum will dissolve in aqua-regia.

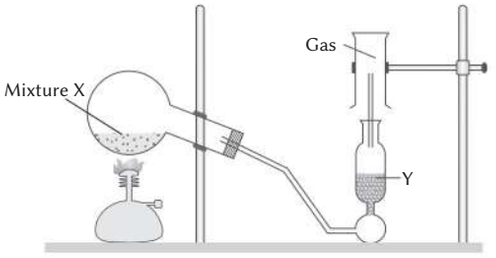
(ii) Magnesium strip burns with popping sound, and slowly dissolve with the evolution of a colourless and odourless gas.

(iii) Dense white fumes are observed.

(iv) $Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$

(v) It gives a blue colour solution with the evolution of greenish yellow coloured gas which turns moist blue litmus paper to red and moist starch iodine paper to blue-black. *[5 × 1 = 5]*

165. The diagram shows an experimental set up for the laboratory preparation of a pungent smelling gas. The gas is alkaline in nature



(i) Name the gas collected in the jar.

(ii) Write the balanced equation for the above preparation.

(iii) How is the gas being collected?

(iv) Name the drying agent used.

(v) How will you find that the jar is full of gas?

Sol. (i) Ammonia

(ii) $2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3\uparrow$

(iii) By the downward displacement of air.

(iv) Quick lime (CaO).

(v) Bring a moist red litmus paper to the mouth of the inverted jar if it immediately turns blue then it must contain ammonia gas. *[1 × 5 = 5]*

166. (i) What are the optimum conditions for the Haber's process?

(ii) A mixture of ammonia, nitrogen and hydrogen is obtained at the end of the reaction. Ammonia is then separated from nitrogen and hydrogen by cooling down the mixture to −45°C and changing gaseous ammonia into a liquid. Comment on the boiling points of ammonia and its reactants.

(iii) If the above process is carried out in the school laboratory, state a method other than cooling that can be used to separate ammonia from its reactants.

(iv) Write a simple test to detect ammonia gas.

Sol. (i) 450°C, 250 atm and finely divided iron catalyst. *[1]*

(ii) Ammonia has a higher boiling point than nitrogen and hydrogen gases. Ammonia should have a boiling point slightly higher than −45°C, so, that at that temperature, all the gaseous ammonia is converted into liquid. Nitrogen and hydrogen should have boiling points much lower than −45°C, so that they will remain as gases. *[1½]*

(iii) Fractional distillation. *[1]*

(iv) When a glass rod, dipped in HCl (*aq*) is taken into the NH_3 gas atmosphere, a dense white fume is formed along with the formation of powdery substance (NH_4Cl).

$$\underset{\text{Ammonia}}{NH_3(g)} + \underset{\text{Hydrochloric acid}}{HCl(aq)} \longrightarrow \underset{\text{Ammonium chloride}}{NH_4Cl(s)}$$ *[1½]*

167. (i) Nitrogen can be obtained in pure state by heating a mixture of ammonium chloride and a substance *A*. Name the substance *A*.

(ii) A gas *X* reacts with another gas *Y* in the presence of catalyst *Z* to give a colourless gas *C*. The gas *C* on reacting with air produces a brown gas *A*. The solution of *X* in water turns red litmus to blue. Explain the observation.

(iii) Why, nitrogen dioxide is called mixed anhydride?

Sol. (i) *A* = Sodium nitrate *[1]*

(ii) $A + B \xrightarrow{\text{Catalyst}} C$

The gas C when comes in contact with air (O_2) a brown gas D is produced which is due to nitrogen dioxide (NO_2), hence, C is NO.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g) \quad [1]$$

The solution of A in water turns red litmus blue, hence it is a base *i.e.,* NH_4OH.

$$NH_3 + H_2O \longrightarrow NH_4OH \quad \text{and } A \text{ is } NH_3$$

$$A + B \xrightarrow{\text{Catalyst}} C$$

$$4NH_3 + SO_2 \xrightarrow[800^\circ C]{Pt} 4NO\uparrow + 6H_2O + \text{Energy} \quad [2]$$

(iii) Because it dissolves in water forming two acids *i.e.,* nitrous acid (HNO_2) and nitric acid (HNO_3). [1]

168. (i) Why silver nitrate is dissolved in tap water?

(ii) A compound A when warmed with dilute sulphuric acid, gives a gas. Name that gas.

(iii) Complete and balance the following reaction.

$$NH_3 + O_2 \longrightarrow N_2 + H_2O$$

$$N_2 + H_2 \rightleftharpoons NH_3$$

$$Mg + N_2 \longrightarrow Mg_3N_2 \rightarrow Ma(OH)_2$$

Sol. (i) Because tap water contains sodium chloride thus, silver nitrate reacts with it to form a curdy white precipitate. [1]

(ii) Sulphite, SO_3^{2-} [1]

(iii) $4NH_3 + 3O_2 \longrightarrow 2N_2 + 6H_2O$ [1/2]

$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$ [1/2]

Catalyst – Iron

Promoter – Molybdenum

Temp. – 450-500°C

Pressure (atm) – 200-1000 atm [1]

$$3Mg + N_2 \longrightarrow Mg_3N_2 \xrightarrow{+6H_2O} 3Mg(OH)_2 + 2NH_3\uparrow \quad [1]$$

169. Complete and balance the following equations.

(i) $KNO_3 + H_2SO_4$ (conc.) $\xrightarrow{200^\circ C}$ ..... + ...

(ii) $2Cu(NO_3)_2 \xrightarrow{\Delta}$ ..... + ... + ...

(iii) $KOH + HNO_3 \longrightarrow$ ..... + ...

(iv) $P + 5HNO_3 \longrightarrow$ ..... + ... + ...

(v) $C + 4HNO_3 \longrightarrow$ ..... + ... + ...

Sol. (i) $KHSO_4 + HNO_3$

(ii) $2CuO + 4NO_2\uparrow + O_2\uparrow$

(iii) $KNO_3 + H_2O$

(iv) $H_3PO_4 + 5NO_2 + H_2O$

(v) $CO_2 + 4NO_2 + 2H_2O$ [5×1=5]

170. (i) $NH_4OH \xrightarrow{A} Cu(OH)_2 \xrightarrow{B} CuO$

$$+ C \longrightarrow Cu(NO_3)_2 + H_2O$$

$$\Big|_{D}$$

$$CuO + NO_2$$

Identify A, B, C and D in the above reaction sequence.

(ii) Name two drying agents of ammonia.

Sol. (i) $2NH_4OH + \underset{(A)}{CuSO_4} \longrightarrow Cu(OH)_2 + (NH_4)_2SO_4$

$$Cu(OH)_2 \xrightarrow{\Delta(B)} CuO + H_2O$$

$$CuO + \underset{(C)}{\text{Dil. } HNO_3} \longrightarrow Cu(NO_3)_2 + H_2O$$

$$2Cu(NO_3)_2 \xrightarrow{\Delta(D)} 2CuO + 4NO_2 + O_2$$

(ii) Quick lime or calcium oxide (CaO). [2½ × 2 = 5]

171. (i) How would you distinguish between ammonium sulphate and sodium sulphate, by using sodium hydroxide solution?

(ii) (a) What compounds are required for the laboratory preparation of nitric acid?

(b) Why does pure nitric acid take on a yellowish brown colour when exposed to light?

(iii) Write the equations for the following reactions.

(a) Copper and concentrated nitric acid.

(b) Copper oxide and dilute nitric acid.

Sol. (i) Only ammoniam sulphate on reacting with sodium hydroxide solution gives a colourless gas, which turns Nessler's reagent to brown whereas sodium sulphate not do so. [1]

(ii) (a) Nitre (potassium nitrate) and conc. H_2SO_4. [1]

(b) Because it decomposes at room temperature to form reddish brown nitrogen dioxide. [1]

(iii) (a) $Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$ [1]

(b) $CuO + \underset{\text{Dil.}}{2HNO_3} \longrightarrow Cu(NO_3)_2 + H_2O$ [1]

172. (i) Write the preparation of nitrous oxide from sodium nitrate.

(ii) Name the nitrate which on heating gives oxygen as the only gas.

(iii) Why sulphuric acid behaves as acid when dilute with water?

(iv) Give one reaction to show, conc. H_2SO_4 is least volatile acid.

Sol. (i) Nitrous oxide is prepared by heating sodium nitrate with ammonium sulphate.

$$(NH_4)_2SO_4 + 2\,NaNO_3 \xrightarrow{\Delta} Na_2SO_4 + 4H_2O + 2\,N_2O\uparrow \quad [1]$$

(ii) Sodium and potassium nitrate. [1]

(iii) The concentrated sulphuric acid has strong covalent bond, due to which less ions are present. But when sulphuric acid is diluted with water, it ionises to give hydrogen ions (H^+) and sulphate ions.

$$H_2SO_4 \rightleftharpoons \underset{}{H^+} + \underset{\text{Hydrogen sulphate ion}}{HSO_4^-}$$

$$HSO_4^- \rightleftharpoons H^+ + \underset{\text{Sulphate ion}}{SO_4^{2-}}$$

Due to the presence of H^+ ion by sulphuric acid in water it imparts acidic character. [2]

(iv) Conc. H_2SO_4 acts as least volatile acid when it is heated with sodium chloride, a volatile hydrogen chloride gas is produced.

$$NaCl + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HCl\uparrow \quad [1]$$

173. Some properties of sulphuric acid are listed below. Choose the role played by sulphuric acid as *A*, *B*, *C* or *D* which is responsible for the reactions (i) to (v).

Some role/s may be repeated.

(A) Dilute acid
(B) Dehydrating agent
(C) Non-volatile acid
(D) Oxidising agent

(i) $CuSO_4 \cdot 5H_2O \xrightarrow{\text{Conc. } H_2SO_4} CuSO_4 + 5H_2O$

(ii) $S + \underset{\text{(Conc.)}}{H_2SO_4} \longrightarrow 3SO_2 + 2H_2O$

(iii) $NaNO_3 + \underset{\text{(Conc.)}}{H_2SO_4} \xrightarrow{<200\,^\circ C} NaHSO_4 + HCl$

(iv) $MgO + H_2SO_4 \longrightarrow MgSO_4 + H_2O$

(v) $Zn + 2H_2SO_4 \longrightarrow ZnSO_4 + SO_2\uparrow + 2H_2O$

Sol. (i) (*B*) Dehydrating agent (ii) (*D*) Oxidising agent
(iii) (*C*) Non-volatile acid (iv) (*A*) Dilute acid
(v) (*D*) Oxidising agent ***[5 × 1 = 5]***

174. (i) Write balanced chemical equations for each of the following.

(a) When excess of ammonia is treated with chlorine.

(b) An equation to illustrate the reducing nature of ammonia.

(ii) *A*, *B*, *C* and *D* summarise the properties of sulphuric acid and depending on whether it is dilute or concentrated.

A = Typical acid property.
B = Non-volatile acid
C = Oxidising agent
D = Dehydrating agent.

Choose the property (*A*, *B*, *C* and *D*) depending on which is relevant to each of the following.

(a) Preparation of hydrogen chloride gas.

(b) Preparation of copper sulphate from copper oxide.

(c) Action of conc sulphuric acid on sulphur. ***[2016]***

Sol. (i) (a) $\underset{\text{Excess}}{8NH_3} + 3Cl_2 \longrightarrow N_2\uparrow + 6NH_4Cl$ [1]

(b) Pass ammonia gas over heated copper in a hard tube.

Copper oxide is reduced to copper.

$$\underset{\text{Black soil}}{2NH_3 + 3CuO} \longrightarrow \underset{\text{Reddish brown solid}}{3Cu} + 3H_2O + \underset{\text{Gas}}{N_2\uparrow}$$

[1]

(ii) (a) Preparation of hydrogen chloride gas from conc H_2SO_4 depicts its non-volatile nature (B).

$$\underset{\text{Salt of volatile acid}}{NaCl} + \underset{\text{Non volatile acid}}{H_2SO_4\,(conc)} \longrightarrow \underset{\text{Acid salt}}{NaHSO_4} + \underset{\text{Volatile salt}}{HCl}$$

[1]

(b) Preparation of copper sulphate from copper oxide s the property of dil H_2SO_4 and dipicts its acidic property (*A*).

$$\underset{\text{Copper oxide alkali}}{CuO} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Copper sulphate salt}}{CuSO_4} + \underset{\text{Water}}{H_2O} \quad [1]$$

(c) Action of conc sulphuric acid on sulphur depicts its oxidising nature (*C*).

$$S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O \quad [1]$$

CHAPTER EXERCISE

Fill in the Blanks

1. A greenish yellow coloured gas is produced when hydrochloric acid reacts with …… .
2. During the laboratory preparation of HCl gas, conc. H_2SO_4 is used as …… acid.
3. Sometime, sticky mass of …… is formed during the laboratory preparation of HCl acid.
4. Ammonia dissolves in water to give …… .
5. …… colour precipitate is formed when ammonium hydroxide is added to ferrous sulphate.
6. Ammonia acts as a …… agent.
7. Ammonia burns in oxygen with …… flame.
8. Industrial preparation of ammonia is done by (i)…… process. When a mixture of dry nitrogen and dry (ii) …… in the ratio (iii)…… … by volume is made to combine under suitable conditions. Optimum temperature of (iv) …… . Catalyst *i.e.,* finely divided (v) …… is mixed with (vi)…… as promoter. Pressure should be as (vii)……as possible *i.e.,* between (viii)……atm to (ix)……atm.
9. Nitric acid is a strong ..... agent.
10. Nitric acid becomes ..... when exposed to light.
11. ..... nitric acid contains 68% HNO_3 by weight.
12. Limestone on reacting with nitric acid gives ....., ...and ..... .
13. Nitric acid is prepared in the laboratory by distilling a mixture of (i)..... or (ii)..... with conc. sulphuric acid. The reactants (i) and (ii) is also called (iii)..... and (iv)..... respectively. The temperature of the reaction mixture should be kept below or near (v)..... °C. If the temperature is increased then, it causes (vi)..... .
14. …… sulphur is a bleaching agent.
15. Sulphuric acid is a …… acid.
16. …… oxide is formed when formic acid reacts with concentrated sulphuric acid.
17. …… gas is acidic in nature and cannot be derived by passing through concentrated H_2SO_4.
18. Molybdenum is used as …… (catalyst/promoter) during the preparation of …… .
19. …… gas dissolves in water to form an alkaline solution. (NH_3 / H_2SO_4 / HCl)
20. Sodium hydrogen carbonate on reacting with nitric acid produces ……, ... and ..... .
21. Corrosive action of H_2SO_4 on skin is due to …… .
22. Nitroglycerine and nitrotoluene are …… .
23. Tetraammine copper (II) sulphate dissolves in ammonia solution and gives …… colour.

Multiple Choice Questions

24. Hydrogen chloride gas being highly soluble in water is dried by ***[2011]***
    (a) anhydrous calcium chloride
    (b) phosphorous pentaoxide
    (c) quick lime
    (d) concentrated sulphuric acid
25. Ammonia is soluble in water because it is
    (a) an acid (b) a base
    (c) a simple covalent compound
    (d) a polar molecule
26. Ammonia is not dried by passing through
    (a) conc. HCl (b) conc. HNO_3
    (c) conc. H_2SO_4 (d) None of these
27. Ammonia gives a dense white fumes with
    (a) chlorine only
    (b) nitric acid
    (c) sulphuric acid
    (d) chlorine and hydrogen chloride gas
28. Ammonia is synthesised by
    (a) Haber's process (b) contact process
    (c) Ostwald's process (d) Both (a) and (c)
29. Ammonia can be obtained by adding water to
    (a) ammonium chloride (b) ammonium nitride
    (c) magnesium nitride (d) magnesium nitrate
30. The apparatus used for the manufacture of nitric acid is made up of
    (a) aluminium (b) all glass
    (c) flint glass (d) None of these
31. The brown ring formed on the junction is due to the formation of
    (a) $FeSO_4 \cdot OH$ (b) $FeSO_4 \cdot NO$
    (c) $FeSO_4$ (d) H_2SO_4

32. The formula of basic calcium nitrate is
(a) $CaO \cdot Ca(NO_3)_2$ (b) $CaNO_3$
(c) $Ca(NO_3)_2 \cdot OH$ (d) $CaNO_3 \cdot H_2O$

33. The salt of sulphuric acid is/are
(a) sulphate (b) sulphite
(c) bisulphate (d) both (a) and (c)

34. Sulphuric acid is a …… acid.
(a) dibasic (b) monobasic
(c) tribasic (d) None of these

35. Ammonia reacts with drying agent sulphuric acid to give
(a) ammonium sulphate
(b) ammonium phosphate
(c) sodium ammonium phosphate
(d) None of the above

36. On catalytic oxidation of ammonia, …… and …… is formed.
(a) NO , H_2O (b) NO_2, H_2O
(c) Cu , NO_2 (d) N_2, H_2O

37. Nitric acid is
(a) monobasic (b) diabasic
(c) reducing agent (d) None of these

38. Which of the following is used to dry hydrochloride gas?
(a) Quick lime
(b) Conc. sulphuric acid
(c) Phosphorous pentaoxide
(d) Anhydrous calcium chloride

39. The brown ring test is used for the detection of
(a) NO_3^{2-} (b) CO_3^{2-}
(c) Cl^- (d) None of these

40. Ammonium nitrate can be used in
(a) paints (b) vessels
(c) preparing explosives (d) None of these

41. The molecular formula of epsom salt is
(a) $MgSO_4 \cdot 6H_2O$ (b) $FeSO_4 \cdot 7\ H_2O$
(c) $MgSO_4 \cdot 5\ H_2O$ (d) None of these

Match the Following

42. Column I contains the gas evolved when hydrochloric acid is added to compound given in Column II. Match the gas evolved corresponding to their compounds.

	Column I (Gas evolved)		Column II (Compounds)
(i)	Chlorine	(a)	Sodium bicarbonate
(ii)	Carbon dioxide	(b)	Manganese (IV) oxide
(iii)	Sulphur dioxide	(c)	Sodium thiosulphate

43. Match the following columns.

	Column I		Column II
(i)	Ammonia + Carbon dioxide	(a)	Ammonium sulphate
(ii)	Ammonia + Oxygen in the presence of platinum	(b)	Nitric acid
(iii)	Ammonia + Sulphuric acid	(c)	Urea

44. Match the following columns.

	Column I		Column II
(i)	Nitrosoferrous sulphate	(a)	Reddish brown
(ii)	Nitric oxide	(b)	Brown black
(iii)	Conc. nitric acid comes in contact with skin.	(c)	Brown
(iv)	NO_2 gas passed through acidified freshly prepared ferrous sulphate.	(d)	Yellow

45. Match the following columns.

	Column I		Column II
(i)	A gas turns acidified potassium dichromate from orange to green.	(a)	Ethylene
(ii)	Gas obtained by the dehydration of ethanol.	(b)	SO_2
(iii)	Gas obtained by roasting galena.	(c)	CO_2

46. Match the following columns.

	Column I		Column II
(i)	Brown ring test	(a)	$FeSO_4 \cdot NO$
(ii)	Brown ring	(b)	NO_3^-
(iii)	Brown ring interfere	(c)	NO_2^- , I^-

1 Mark Questions

47. Give reason for the following.
Hydrogen chloride gas cannot be dried over quick lime.

48. How dil. HCl is used to distinguish between sodium sulphite and sodium thiosulphate?

49. Give reason, why conc. HCl is used for the preparation of aqua-regia?

50. Write the balanced equation for the following.
Action of dilute hydrochloric acid on sodium sulphide. *[2014]*

51. Name a solvent for noble metal.

52. Which experiment is used to demonstrate extreme solubility of hydrogen chloride gas?

53. What is the chemical nature of an aqueous solution of hydrogen chloride and an aqueous solution of ammonia?

54. Name two metals which directly combine with nitrogen on heating. *[2013]*

55. State the purpose of liquefying the ammonia produced in Haber's process.

56. Why quick lime is the only drying agent that is used for drying ammonia gas?

57. Give the balanced equations for the following.

Reduction of hot copper oxide to copper using ammonia gas. *[2013]*

58. Which property of ammonia is illustrated by the following reaction?

$2\ NH_3 + 3\ CuO \longrightarrow$

59. What is the full form of CFCs?

60. Give the balanced chemical equation.
Action of warm water on magnesium nitride.
[2014, 12, 09]

61. Name the fertilizer formed by carbon dioxide and ammonia.

62. State the conditions required for the following reaction to take place. Catalytic oxidation of ammonia to nitric oxide *[2014]*

63. During the thunderstorm, rain water contains nitric acid, why ?

64. Write the balanced chemical equation.
Reaction of concentrated sulphuric acid with carbon. *[2014]*

65. Give a balanced chemical equation.

Oxidation of carbon with concentrated nitric acid. *[2013]*

66. Give a balanced chemical equation.
Action of heat on a mixture of copper and concentrated nitric acid. *[2014, 2011, 2009]*

67. Write two main uses of nitric acid.

68. Name the solution which absorbs nitric oxide.

69. Write the importance of absorption tower.

70. Why commercial sample of nitric acid is pale yellow in colour?

71. Name the gas released when sodium carbonate is added to a solution of sulphur.

72. Name the industrial process that starts with the given reaction and name the catalyst used.

$$S + O_2 \rightarrow SO_2$$

73. Name the gas obtained when rock salt reacts with conc. sulphuric acid.

74. Complete the reaction.

$$\text{Sulphur dioxide} \xrightarrow{A} \text{Sodium sulphite}$$

75. Write the function of conc. H_2SO_4 in the preparation of CO from oxalic acid.

2 Marks Questions

76. Complete the following reactions.

(i) $MgCl_2 + H_2SO_4 \longrightarrow$ (ii) $CaO + HCl \longrightarrow$

(iii) $Fe + HCl \longrightarrow$ (iv) $Pb_3O_4 + HCl \xrightarrow{\Delta}$

77. (i) What are the products formed when ammonia is oxidised with copper oxide?

(ii) Name one lead compound that can be used to oxidise hydrogen chloride to chlorine.

78. (i) Why ammonia cannot be obtained in laboratory from ammonium nitrate and sodium hydroxide?

(ii) What do you mean by liquor ammonia?

79. Write the balanced chemical equation for the laboratory preparation of nitric acid from both potassium nitrate and sodium nitrate respectively.

80. Explain, how

(i) hydrated copper loses its colour?
[**Hint** (a) By heating
(b) By adding conc. H_2SO_4]

(ii) dilute sulphuric acid acts?
[**Hint** Typical acid]

81. Explain, why all ammonium salts, on heating do not decompose to give ammonia?

82. Complete the reaction.

$$NCl_3 \xleftarrow{B} NH_3 \xrightarrow{A} NH_4Cl$$

83. (i) Name one burning metal that combines directly with nitrogen.

(ii) State two ways by which fixation of nitrogen occur naturally.

84. Give a summary of contact process.

3 Marks Questions

85. Write the balanced chemical equations for the following reactions.
(i) Gold added to aqua-regia.
(ii) Hydrogen chloride gas mixed with ammonia.
(iii) Dilute hydrochloric acid is added to sodium thiosulphate solution.

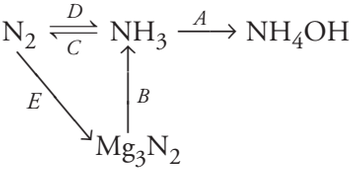
86. Write the balanced equation for the reaction of HCl with each of the following.
(i) Calcium sulphite
(ii) Marble chips
(iii) Lead nitrate solution

87. How ammonia is collected, tested and dried?

88. Write the chemical equations when
(i) lead nitrate is heated.
(ii) a mixture of ammonium chloride and slaked lime is heated.

89. Ammonia gas is evolved when ammonium salt is heated with sodium hydroxide solution. Give three ways by which this gas can be detected.

90. Complete the reaction.



91. How will you show that nitric acid contains hydrogen, nitrogen and oxygen?
[**Hint** $Mg + HNO_3 \longrightarrow$ show hydrogen
$4HNO_3 \xrightarrow{\Delta} 4NO_2 + 2H_2O + O_2$: show oxygen
brown NO_2 fumes show nitrogen]

92. Explain the following.
(i) Dilute nitric acid is generally considered a typical acid but not so in its reaction with metals.
(ii) Concentrated nitric acid appears yellow when it is left standing in a glass bottle.
(iii) All glass apparatus is used in the laboratory preparation of nitric acid.

93. The nitric acid is formed during the thunderstorm is a result of three chemical reactions. Write the balanced chemical equations involved.

94. What is the effect of nitric acid on
(i) Phenolphthalein?
(ii) Blue litmus solution?
(iii) Methyl orange?

95. State your observations for the following cases.
(i) Moist blue litmus is introduced into a gas jar of sulphur dioxide.
(ii) Dry red rose petals are placed in the jar of sulphur dioxide.
(iii) Paper soaked in potassium permanganate solution is introduced into a gas jar of sulphur dioxide.

96. Write the balanced chemical equation for the reaction of sulphuric acid with
(i) potassium bicarbonate.
(ii) sodium sulphate.
(iii) iron (II) sulphide.

4 Marks Questions

97. Complete and balance the following equations.
(i) $AgNO_3 + HCl \longrightarrow$ ..... + ...
(ii) $Na_2SO_3 + HCl \longrightarrow$ ..... + ... + ...
(iii) $NaHCO_3 + HCl \longrightarrow$ .....+.....+.....
(iv) $FeS + HCl \longrightarrow$ ..... + ...

98. Complete and balance the following equations.
(i) $N_2 + H_2 \longrightarrow$ .....
(ii) $NH_3 + Cl_2 \longrightarrow$ .....
(iii) $PbO + \overset{\text{Excess}}{NH_3} \longrightarrow$ ..... + ...+ H_2O
(iv) $NH_3 + O_2 \xrightarrow[800\,^\circ C]{Pt}$ ..... + ...

99. Write the chemical reaction and observation :
(i) ammonia is burnt in pure oxygen?
(ii) ammonia is passed through copper sulphate solution in excess?
(iii) ammonium hydroxide is added to ferric chloride solution?

100. (i) Why, during Ostwald's process excess of oxygen is taken?
(ii) Complete and balance the given reaction.
$Mg \xrightarrow{A} Mg(NO_3)_2 \xrightarrow{B} NO_2 \xrightarrow{C} HNO_3$

101. Write the reactions involved and procedure in brief to detect nitric acid by brown ring test.

102. (i) Write all the equations involved in the manufacture of sulphuric acid from sulphur.

5 Marks Questions

103. In the laboratory preparation of hydrochloric acid, HCl gas is dissolved in water. ***[2011]***
(i) Draw a diagram to show the arrangement used for the absorption of HCl in water.
(ii) Why is such an arrangement necessary?
Give two reasons.

(iii) Write the chemical equations for the laboratory preparation of HCl gas when the reactants are
(a) below 200°C (b) above 200°C

104. The questions given below are related to the manufacturing of ammonia. *[2010]*
(i) Name the process.
(ii) In what ratio must the reactants be taken?
(iii) Name the catalyst used.
(iv) Give the equation for the manufacturing of ammonia.
(v) Ammonia can act as a reducing agent, write a relevant equation for such a reaction.

105. With the reference to manufacture of ammonia.
(i) Name the process.
(ii) In what ratio must the reactants be taken?
(iii) Name the catalyst used.
(iv) Is ammonia a reducing or oxidising agent?
(v) Give the equation for the manufacture of ammonia.

106. Complete and balance the following equations.
(a) $S + 6HNO_3 \longrightarrow \ldots\ldots + \ldots\ldots + \ldots\ldots$
(b) $3Cu + 8HNO_3 \longrightarrow \ldots\ldots + \ldots\ldots + \ldots\ldots$
(c) $4NO_2 + 2H_2O + O_2 \longrightarrow \ldots\ldots$
(d) $2NO + O_2 \longrightarrow \ldots\ldots$
(e) $N_2 + O_2 \longrightarrow \ldots\ldots$

107. How will you prepare the following from nitric acid?
(i) Sulphuric acid (ii) Aqua-regia
(iii) Lead nitrate (iv) Zinc nitrate
(v) Ferric nitrate

108. Complete and balance the following equation
(i) $C + H_2SO_4 \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots + \ldots\ldots\ldots$
(ii) $Cu + H_2SO_4 \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots + \ldots\ldots\ldots$
(iii) $NaCl + H_2SO_4 \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots$
(iv) $K_2CO_3 + H_2SO_4 \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots$
(v) $ZnO + H_2SO_4 \longrightarrow \ldots\ldots\ldots + \ldots\ldots\ldots$

109. (i) With the help of equations, give an outline for the manufacturing of sulphuric acid by the contact process.
(ii) What property of sulphuric acid is shown by the reaction of concentrated sulphuric acid when heated with *[2011]*
(a) potassium nitrate?
(b) carbon?

110. Some properties of sulphuric acid are listed below. Choose the property *A*, *B*, *C* or *D* which is responsible for the reactions (i) to (v). Some properties may be repeated.
(A) Acid
(B) Dehydrating agent
(C) Non-volatile acid
(D) Oxidising agent
(i) $C_{12}H_{22}O_{11} + nH_2SO_4 \longrightarrow 12C$
(ii) $S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$
(iii) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$
(iv) $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$
(v) $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$

111. Identify the acid which matches the following description (i) to (v).
(i) The acid which is used in the preparation of a non-volatile acid.
(ii) The acid which produces sugar charcoal from sugar.
(iii) The acid which is prepared by the catalytic oxidation of ammonia.
(iv) The acid on mixing with lead nitrate solution produces a white precipitate which is insoluble even on heating.
(v) The acid on mixing with silver nitrate solution produces a white precipitate which is soluble in excess ammonium hydroxide.

ARCHIVES*

(Last 6 Years)

Collection of Questions Asked in Last 6 Years' (2018-2013) ICSE Class 10th Examinations

2018

1 Dry hydrogen chloride gas can be collected by ..... displacement of air. (downward/upward) *[1]*

2 Choose the correct answer from the options given below.
The catalyst used in the contact process is *[1]*

3 Write a balanced chemical equation for each of the following.

Action of dilute hydrochloric acid on magnesium sulphite. *[1]*

4 Lead nitrate solution is mixed with dilute hydrochloric acid and heated. *[1]*

5 Name the gas that is produced in each of the following cases.
(i) Sulphur is oxidised by concentrated nitric acid.
(ii) Action of dilute hydrochloric acid on sodium sulphide.
(iii) Action of cold and dilute nitric acid on copper. *[1]*

6 For the preparation of hydrochloric acid in the laboratory
(i) why is direct absorption of hydrogen chloride gas in water not feasible?
(ii) what arrangement is done to dissolve hydrogen chloride gas in water ? *[2]*

7 (i) What is the type of salt formed when the reactants are heated at a suitable temperature for the preparation of nitric acid?
(ii) State why for the preparation of nitric acid, the complete apparatus is made up of glass. *[2]*

8 (a) (i) Write the balanced chemical equation to prepare ammonia gas in the laboratory by using an alkali.
(ii) State why concentrated sulphuric acid is not used for drying ammonia gas.
(iii) Why is ammonia gas not collected over water ? *[3]*

(b) (i) Name the acid used for the preparation of hydrogen chloride gas in the laboratory. Why is this particular acid preferred to other acids?
(ii) Write the balanced chemical equation for the laboratory preparation of hydrogen chloride gas. *[3]*

2017

9 Potassium sulphite on reacting with hydrochloric acid releases …… gas. (Cl_2, SO_2, H_2S) *[1]*

10 Write a balanced chemical equation for each of the following.
(i) Action of cold and dilute nitric acid on copper.
(ii) Reaction of ammonia with heated copper oxide.
(iii) Action of concentrated sulphuric acid on sulphur.
(iv) Laboratory preparation of ammonia from ammonium chlorde. *[4]*

11 State one relevant observation for each of the following reaction.
(i) Action of dilute hydrochloric acid on iron (II) sulphide.
(ii) Burning of ammonia in air.
(iii) Action of concentrated sulphuric acid on hydrated copper sulphate. *[4]*

12 Certain blank spaces are left in the following table and these are labelled as A, B, C, D and E. Identify each of them.

	Lab preparation	Reactants used	Products formed	Drying agent	Method of collection
(i)	HCl gas	NaCl + H_2SO_4	*A*	conc. H_2SO_4	*B*
(ii)	NH_3 gas	*C*	$Mg(OH)_2$ NH_3	*D*	*E*

[4]

13 Write a balanced chemical equation to show
(i) the oxidising action of conc. sulphuric acid on carbon.
(ii) the behaviour of H_2SO_4 as an acid when it reacts with magnesium.
(iii) the dehydrating property of conc. sulphuric acid with sugar. *[3]*

14 Write balanced chemical equations to show how SO_3 is converted to sulphuric acid in the contact process. *[2]*

15 Give a balanced chemical equation for each of the following
(i) Action of concentrated nitric acid on sulphur.
(ii) Catalytic oxidation of ammonia.
(iii) Laboratory preparation of nitric acid.
(iv) Reaction of ammonia with nitric acid. *[4]*

2016

16 The aim of the fountain experiment is to prove that
(a) HCl turns blue litmus red
(b) HCl is denser than air
(c) HCl is highly soluble in water
(d) HCl fumes in moist air *[1]*

17 Write balanced chemical equation for each of the following.
(i) Action of warm water on AIN.
(ii) Action of hot and concentrated nitric acid on copper.
(iii) Action of hydrochloric acid on sodium bicarbonate.
(iv) Action of dilute sulphuric acid on sodium sulphite. *[4]*

18 State your observations when
(i) dilute hydrochloric acid is added to lead nitrate solution and the mixture is heated.
(ii) concentrated sulphuric acid is added to sugar crystals.
(iii) dilute hydrochloric acid is added to copper carbonate.
(iv) dilute hydrochloric acid is added to sodium thiosulphate. *[4]*

19 Fill in the blanks using the appropriate words give below.
(sulphur dioxide, nitrogen dioxide, nitric oxide, sulphuric acid)
(i) Cold, dilute nitric acid reacts with copper to given ..... .
(ii) Hot, concentrated nitric acid reacts with sulphur to form ..... . *[1]*

20 Name the gas evolved when the following mixtures are heated.
(i) Calcium hydroxide and ammonium chloride.
(ii) Sodium nitrite and ammonium chloride. *[2]*

21 (i) Write balanced chemical equation for each of the following.
(a) When excess of ammonia is treated with chlorine.
(b) An equation to illustrate the reducing nature of ammonia.
(ii) *A*, *B*, *C* and *D* summarise the properties of sulphuric acid depending on whether it is dilute or concentrated.
A = Typical acid property
B = Non-volatile acid
C = Oxidising agent
D = Dehydrating agent
Choose the property (*A*, *B*, *C* and *D*) depending on which is relevant to each of the followng.
(a) Preparation of hydrogen chloride gas.
(b) Preparation of copper sulphate from copper oxide.
(c) Action of conc. sulphuric acid on sulphur. *[5]*

2015

22 Select from the list the gas that matches the description given in each case.
[ammonia, ethane, hydrogen chloride, hydrogen sulphide, ethyne] *[3]*
(i) This gas is used as a reducing agent in reducing copper oxide to copper.
(ii) This gas produces dense white fumes with ammonia gas.
(iii) This gas has a characteristic rotten egg smell.

23 State one relevant observation for the given statement.
When ammonia gas burnt in an atmosphere of excess oxygen. *[1]*

24 Give the balanced chemical equations for each of the following. *[3]*
(i) Lab preparation of ammonia using ammonium salt.
(ii) Reaction of ammonia with excess chlorine.
(iii) Reaction of ammonia with sulphuric acid.

25 (i) Give the balanced chemical equations for the action of sulphuric acid on each of the following.
I. Potassium hydrogen carbonate
II. Sulphur
(ii) In the contact process for the manufacture of sulphuric acid, give the equations for the conversion of sulphur trioxide to sulphuric acid. *[4]*

26 Explain the following. *[3]*
(i) Dilute nitric acid is generally considered a typical acid but not so in its reaction with metals.
(ii) Concentrated nitric acid appears yellow when it is left standing in a glass bottle.
(iii) All glass apparatus is used in the laboratory preparation of nitric acid.

27 The following questions are pertaining to the laboratory preparation of hydrogen chloride gas.
(i) Write the equation for its preparation mentioning the condition required.
(ii) Name the drying agent used and justify your choice.
(iii) State a safety precaution you would take during the preparation of hydrochloric acid. ***[4]***

2014

28 Quicklime is not used to dry HCl gas because ..... (CaO is alkaline, CaO is acidic, CaO is neutral). ***[1]***

29 Write the balanced equation for the following.
Action of dilute hydrochloric acid on sodium sulphide. ***[1]***

30 Ammonia gas is collected by ..... (an upward displacement of air, a downward displacement of water, a downward displacement of air). ***[1]***

31 Give the balanced chemical equation.
Action of warm water on magnesium nitride. *[1]*

32 Name the other ion formed when ammonia dissolves in water. Give one test that can be used to detect the presence of the ion produced. ***[2]***

33 Cold and dilute nitric acid reacts with copper to form …… (hydrogen, nitrogen dioxide, nitric oxide). ***[1]***

34 Give a balanced chemical equation.
Action of heat on a mixture of copper and concentrated nitric acid. *[1]*

35 Write the balanced chemical equation. Reaction of concentrated sulphuric acid on carbon. *[1]*

36 Write any two conditions for the conversion of sulphur dioxide to sulphur trioxide. *[1]*

37 Give one equation each to show the following properties of sulphuric acid. ***[3]***
(i) Dehydrating property
(ii) cidic nature
(iii) As a non-volatile acid

2013

38 Identify the following substance which are underlined.
A gas which does not conduct electricity in the liquid state but conducts electricity when dissolved in water. ***[1]***

39 Which one of the following will not produce an acid when made to react with water?
(a) Carbon monoxide (b) Carbon dioxide
(c) Nitrogen dioxide (d) Sulphur trioxide ***[1]***

40 State the conditions required for the following reaction to take place.
Catalytic oxidation of ammonia to nitric oxide. ***[1]***

41 Identify the following substances which are underlined.
An alkaline gas which produces dense white fumes when reacted with hydrogen chloride gas. *[1]*

42 Give the balanced equations for the following.
Reduction of hot copper oxide to copper using ammonia gas. *[1]*

43 Nitrogen gas can be obtained by heating
(a) ammonium nitrate (b) ammonium nitrite
(c) magnesium nitride (d) ammonium chloride ***[1]***

44 Give a balanced chemical equation.
Oxidation of carbon with concentrated nitric acid. ***[1]***

45 Copy and complete the following table relating to important industrial process. ***[3]***

Name of the process	Temperature	Catalyst	Equation for the Catalysed Reaction
Haber's process			

46 In the given equation, identify the role played by concentrated sulphuric acid.

$$S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$$ ***[1]***

(a) non-volatile acid (b) oxidising agent
(c) dehydrating agent (d) None of the above

CHALLENGERS*

1 Lightning bolts in the atmosphere causes the formation of
(a) NH_3 (b) NO
(c) NH_4OH (d) NH_2OH

2 $NH_4Cl(s)$ is heated in a test tube. Vapours are brought in contact with red litmus paper, which changes to blue and then to red. It is because of
(a) formation of NH_4OH and HCl (b) formation of NH_3 and HCl
(c) greater diffusion of NH_3 than HCl (d) greater diffusion of HCl than NH_3

3 Which of the following statements is incorrect about ammonia?
(a) It is oxidised by oxygen at 700°C in the presence of platinum.
(b) It gives black precipitate with calomel
(c) It can be dried by P_2O_5, H_2SO_4 and $CaCl_2$.
(d) It gives white fumes with HCl

4 Which of the following reagents can separate nitric oxide from nitrous oxide?
(a) Sodium nitroprusside solution (b) Ferrous sulphate solution
(c) Nessler's reagent (d) Tollen's reagent

5 Copper on reduction with dilute HNO_3 produces a gas 'X'. This gas on reduction with $SnCl_2$/HCl forms 'Y', which on further oxidations gines z. Identify X, Y, Z.
(a) X = NO, Y = NH_2OH, Z = N_2O (b) X = NO, Y = $NH_2OH \cdot HCl$, Z = NO_2
(c) X = NO_2, Y = NH_2OH, Z = N_2O (d) X = NO, Y = $NH_2OH \cdot HCl$, Z = N_2O

6 HNO_3 in pure state is colourless but it is often of yellow colour. It is due of
(a) unstable structure of HNO_3 which immediately changes to NO_2^-
(b) photochemical decomposition in presence of sunlight.
(c) interaction of atmospheric gases with HNO_3.
(d) conversion of HNO_3 into NO_2^+

7 NH_3 cannot be obtained by
(a) heating of NH_4NO_3 or NH_4NO_2 (b) heating of NH_4Cl or $(NH_4)_2CO_3$
(c) heating of NH_4NO_3 with NaOH (d) reaction of AIN or Mg_3N_2 or $CaCN_2$ with H_2O

8 On photochemical decomposition of HNO_3, the products formed are
(a) NO and O (b) NO_2 and O_2
(c) N_2O_4 and NO_2 (d) N_2O_5 and NO_2

9 Liquid ammonia is used for refrigeration because it
(a) has a high dipole moment (b) has a high heat of vaporisation
(c) is basic (d) is a stable compound

10 It is recommended that ammonia bottles should be opened after cooling in ice for sometime. This is because
(a) it brings tears (b) it has high vapour pressure
(c) it is explosive liquid (d) none of these

Answers

1. (b) **2.** (c) **3.** (c) **4.** (b) **5.** (d) **6.** (b) **7.** (a) **8.** (b) **9.** (b) **10.** (b)

* These questions may or may not be asked in the examination, have been given just for additional practice

CHAPTER

9

General Organic Chemistry

Chapter Objective

- Versatile Nature of Carbon
- Structural Formula
- Functional Group
- Homologous Series
- Isomerism
- Nomenclature of Organic Compounds

The compounds of carbon (except oxides, carbonates and hydrogen carbonate salts) are organic compounds. The branch of chemistry dealing with organic compounds is called **organic chemistry.** Initially organic compounds were extracted from natural sources like plants and animals and it was thought that these compounds can only be formed within a living system. In 1828 German chemist Friedrich Wohler prepared urea in laboratory as shown in the reaction given below and discarded the theory that organic compounds can only be prepared in living system.

$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \xrightarrow{\text{Heat}} \underset{\text{Urea}}{CO(NH_2)_2}$$

The main points that differ inorganic compounds from organic compounds are tabulated below

Comparison between Organic and Inorganic Compounds

Organic Compounds	**Inorganic Compounds**
All organic compounds contain carbon as an essential element.	Inorganic compounds may or may not contain carbon. So, it is not an essential element in these compounds.
They have low boiling point and melting point.	They have high boiling point and melting point.
Their solubility in water is very low while in organic solvents such as alcohol, benzene and chloroform is high.	Their solubility in water is high and in organic solvents it is low.
They form covalent bonds *i.e.*, sharing of electrons occur.	They form ionic bond (strong bond between the elements.)
They are non-electrolytes *i.e.*, they do not conduct electricity.	They are good electrolytes *i.e.*, conduct electricity.
They are inflammable *i.e.*, they catch fire easily.	They do not burn easily.
Molecular reactions are slow due to high inter-linkages. These reactions do not come to an end.	Reactions are generally fast as they are ionic in nature (except with those which are covalent).

Versatile Nature of Carbon

The estimate number of carbon compounds known is about three million, the formation of such a large number of carbon compounds is due to some special properties of carbon.

Carbon shows special properties like tetravalency and catenation which makes carbon different from other elements.

These properties have been discussed below

1. Catenation

The property of self linking of elements mainly C-atoms through covalent bonds to form long, straight or branched chains and rings of different sizes is called *catenation*. Carbon shows maximum catenation in the periodic table due to its small size and high strength of C — C bonds.

Note Elements other than carbon like sulphur, silicon also have a tendency to show the property of self linking i.e., catenation but to a much lesser extent, due to less bond energy or strength.

2. Tetravalency of Carbon

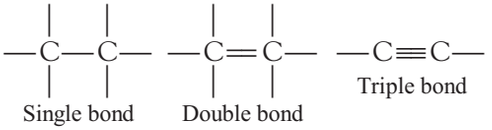
Carbon belongs to group 14 of the periodic table. Its atomic number is 6 and the electronic configuration is 2, 4. Thus, it has four electrons in the outermost shell. Hence, its valency is four *i.e.,* it is capable of bonding or pairing with four other carbon atoms or with the atoms of some other mono-valent elements like hydrogen, halogen (chlorine, bromine), etc.

3. Tendency to Form Multiple Bonds

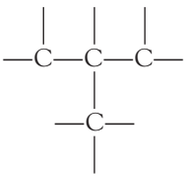
Due to its small size carbon has a strong tendency to form multiple bonds (double and triple bonds) by sharing more than one electron pair with its own atoms or with the atoms of elements like oxygen, nitrogen, sulphur, etc. As a result, it can form a variety of compounds that are exceptionally stable.

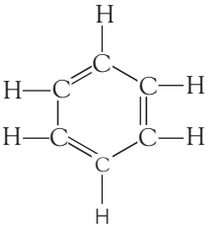
Formation of Straight (Single, Double and Triple Covalent Bonds) Branched and Cyclic Chains

Carbon is tetravalent *i.e.,* its valency is four. In order to complete its octet, carbon forms single, double and triple covalent bonds by sharing one, two or three pairs of electrons, respectively.



Catenation and tetravalency results in the formation of single, double or triple bonds. The combination of carbon atoms with one another also gives rise to branched or cyclic chains.


(Branched chain)


Cyclic compound
(Benzene)

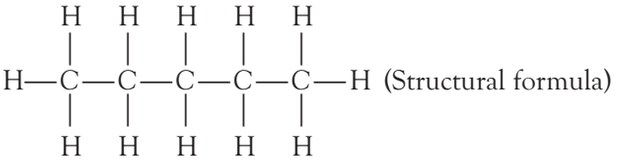
CHECK POINT 01

1. Is it possible to achieve organic compounds form inorganic compounds? If yes, give the chemical equation to justify your answer.
2. Name an element other than carbon which shows the property of self linking.
3. What do you mean by the tetravalency of carbon atom? Give your answer on the basis of electronic configuration.
4. Why does carbon forms a large number of compounds?
5. What are cyclic compounds and give examples?

Structural Formula

A formula which shows the arrangement of atoms in the molecule of a compound is called **structural formula**.

e.g., Pentane (C_5H_{12}) can be represented as


(Structural formula)

Similarly, it can also be written as

$CH_3—CH_2—CH_2—CH_2—CH_3$ (Condensed formula).

This is called as **abbreviated or condensed formula**. The above formula can be condensed further by writing only the carbons of the chain. Hence, it is called as carbon skeleton.

C—C—C—C—C (Carbon skeleton).

The carbon skeleton gives an idea for the linking of carbon atoms.

I. How to Draw the Structure of Compounds with Single, Double and Triple Bonds

Step I To draw the structure of carbon compound, first connect all the carbon atoms by a single bond.

Step II After that satisfy the tetravalency of carbon with available hydrogen atoms.

Step III If number of available H-atoms are less than that required, satisfy the remaining valency by using double or triple bond.

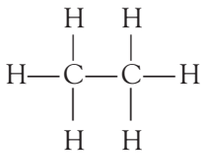
1. Structure of Ethane (C_2H_6)

Step I All the carbon atoms are connected by a single bond.

C—C

Here, only one valency of carbon is satisfied and the three remains unsatisfied. Each of these unsatisfied valencies are satisfied by hydrogen atoms.

Step II



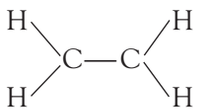
Now, the tetravalency of carbon in ethane is satisfied.

2. Structure of Ethene (C_2H_4)

Step I All the carbon atoms are connected by a single bond.

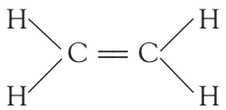
C—C

Step II The tetravalency of carbon is satisfied with available H-atoms



But in this case, even after linking the hydrogen atoms with carbon atoms, still one valency of each carbon remain unsatisfied. To satisfy it, a double bond is used between the two carbon atoms.

Step III



Now, all the four valencies of carbon are satisfied.

3. Structure of Ethyne (C_2H_2)

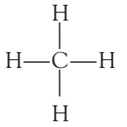
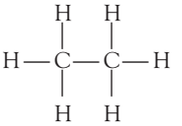
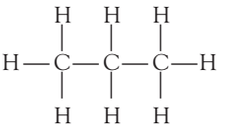
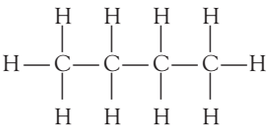
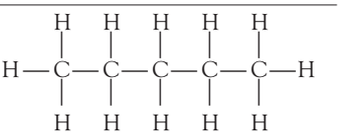
Step I All the carbon atoms are connected by a single bond.

C — C

Step II and III H—C ≡ C—H

In ethyne, the two carbon atoms share three pairs of electrons among themselves to form a carbon-carbon triple bond. Each carbon atom shares one electron with each hydrogen atom to form two carbon-hydrogen single bonds.

Structural Formulae of Hydrocarbons
(Upto Five Carbon Atoms)

Name	Molecular formula	Structural formula
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	

II. How to Draw Structure of Cyclic Compounds

Some carbon compounds also exist in cyclic or ring structure.

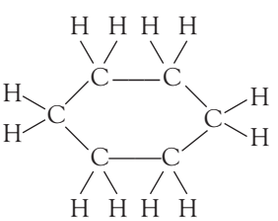
To draw the structure of cyclic or ring compounds, *follow these steps*

Step I First connect the available carbon atoms by a single bond in the cyclic form.

Step II Try to satisfy the tetravalency of each carbon with the available hydrogen atoms.

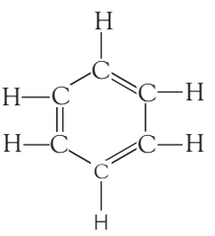
Step III Now check the valency of each carbon. If it is found unsatisfied, use double or triple bond to satisfy it.

e.g.,



Cyclochexane (C_6H_{12})

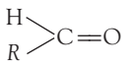
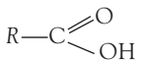
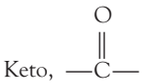
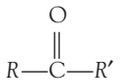
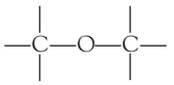
or



Benzene (C_6H_6)

Functional Group

An 'atom' or 'a group of atoms' which makes a carbon compound (or organic compound) reactive and decide its properties (or functions) is called a functional group *e.g.*, Alcohol group —OH present in ethanol (C_2H_5OH) is an example of a functional group.

Functional group	General formulae	Types of organic compound
Halide, X (F, Cl, Br, I)	R—X	Haloalkanes
Hydroxyl, — OH	R—OH	Alcohols
Aldehyde, —CHO		Aldehydes
Carboxyl, —COOH		Carboxylic acids
Keto, 		Ketones
Ethers, 	R—O—R'	Ethers

Characteristics of Functional Group

(i) Organic compounds containing the same functional group have similar chemical properties. Therefore, these compounds are identified using the same type of test.

(ii) The physical and chemical properties of the compounds of different functional groups are different.

Homologous Series

A homologous series is a group of organic compounds having similar structure and similar chemical properties in which the successive compounds differ by CH_2 groups.

Characteristics of Homologous Series

(i) All the members of homologous series can be represented by the same general formula.
e.g., General formula for alkane is C_nH_{2n+2}.

(ii) Any two adjacent homologue differs from its previous and successive member by CH_2 group in their molecular formula.

(iii) The difference in the molecular mass of any two adjacent homologous is 14 u.

(iv) All the compounds of homologous series show similar chemical properties. *e.g.*, All the compounds of alkane series show substitution reactions.
e.g., Methane reacts with chlorine to form methyl chloride.

$$CH_4 \xrightarrow{Cl_2} CH_3Cl + HCl$$

Similarly, ethane reacts with chlorine to form ethyl chloride

$$C_2H_6 + Cl_2 \longrightarrow C_2H_5Cl + HCl$$

(v) The members of homologous series show a gradual change in their physical properties such as melting point, etc., with increase in molecular mass.

(vi) All the members of homologous series can be prepared by the similar methods.
e.g., Alcohols are prepared by alkyl halides.

$$CH_3Br + \underset{(aq)}{KOH} \xrightarrow{Boil} CH_3OH + KBr$$

Examples of Homologous Series

1. Alkanes

General formula for alkanes is C_nH_{2n+2}.

(i) If we put $n = 1$, in general formula, C_nH_{2n+2}, we get $C_1H_{2\times1+2} = CH_4$.

It is the molecular formula of the first member of the homologous series of alkanes and is called **methane**.

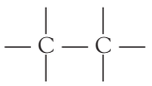
(ii) If we put $n = 2$, in general formula, C_nH_{2n+2}, we get $C_2H_{2\times2+2} = C_2H_6$ which is the molecular formula of the second member of the homologous series of alkanes and is called **ethane**.

(iii) Similarly, we can derive the molecular formula of the third, fourth and higher members of homologous series.

(iv) The molecular formula of any two successive members of a homologous series differ by a —CH_2— unit such as

- CH_4 and C_2H_6 –1st and 2nd member differ by a CH_2 unit.
- C_2H_6 and C_3H_8 –2nd and 3rd member differ by a CH_2 unit.
- C_3H_8 and C_4H_{10} –3rd and 4th member differ by a CH_2 unit.

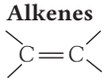
So, the homologous series will be

	General formula	Molecular formula	IUPAC name
Alkanes	C_nH_{2n+2}		
	$n=1$	CH_4	Methane
	$n=2$	C_2H_6	Ethane
	$n=3$	C_3H_8	Propane
	$n=4$	C_4H_{10}	Butane
	$n=5$	C_5H_{12}	Pentane

2. Alkenes

General formula for alkenes is C_nH_{2n}.

The homologous series for alkenes can be written as

	General formula	Molecular formula	IUPAC name
Alkenes	C_nH_{2n}		
	$n=1$	–	–
	$n=2$	C_2H_4	Ethene
	$n=3$	C_3H_6	Propene
	$n=4$	C_4H_8	Butene
	$n=5$	C_5H_{10}	Pentene

3. Alkynes

General formula for alkynes is C_nH_{2n-2}.

The homologous series for alkynes is as follows

	General formula	Molecular formula	IUPAC name
Alkynes	C_nH_{2n-2}		
—C≡C—	$n=1$	–	–
	$n=2$	C_2H_2	Ethyne
	$n=3$	C_3H_4	Propyne
	$n=4$	C_4H_6	Butyne
	$n=5$	C_5H_8	Pentyne

Significance of Homologous Series

The existence of homologous series of organic compounds has simplified the study of organic chemistry because instead of studying a large number of organic compounds separately, we have to study only a few homologous series.

Homologous series helps to predict the properties of even those members of the series that are yet to be prepared.

With the help of homologous series, the nature of any member of family of compounds can be ascertained.

CHECK POINT 02

1. Write the structural formula of propane (C_3H_8).
2. Write the name and structure of alkane, alkene and alkyne each having three carbon atoms.
3. Write the molecular formula and IUPAC names of the members of a homologous series of a hydrocarbon having general formula as C_nH_{2n-2}, for the following value of '*n*'.
   (a) 4 (b) 5 (c) 6
4. Do the compounds of alkane series show substitution reaction? Give examples to justify your answer.
5. Which of the following compounds belong to same homologous series C_2H_6O, $C_2H_6O_2$, C_2H_6,CH_4O?

Isomerism

Compounds having the same molecular formula but have different structure, properties or arrangement are called **isomers** and this phenomenon is called **isomerism**.

Types of Isomerism

There are two types of isomerism

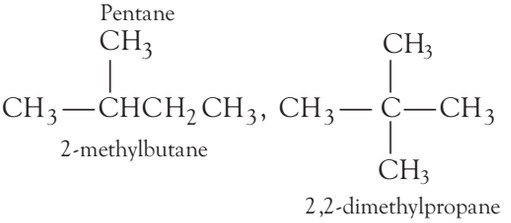
1. Structural Isomerism

Compounds having the same molecular formula but different structural formula (*i.e.*, way of linking) are called **structural isomers** and this phenomenon is called structural isomerism. It is also called **constitutional isomerism** *and further classified into following sub-types*

(i) **Chain Isomerism** Two or more compounds having similar molecular formula but different in the arrangement of carbon atoms in straight or branched chains are known as chain isomers and the phenomenon is termed as chain isomerism.

e.g., $CH_3CH_2CH_2CH_2CH_3$,

Pentane

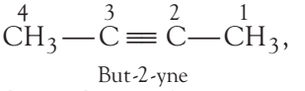


2-methylbutane

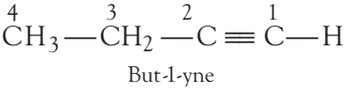
2,2-dimethylpropane

(ii) **Position Isomerism** Two or more compounds having similar molecular formula but differ in the position of substituent atom or functional group on the carbon atom are known as position isomers and the phenomenon is called position isomerism.

e.g.,

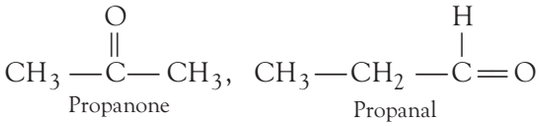


But-2-yne



But-1-yne

(iii) **Functional Group Isomerism** Compounds having the same molecular formula but different functional groups are called functional group isomers and the phenomenon is known as functional group isomerism *e.g.,* Following two functional isomers are possible for the molecular formula, C_3H_6O.



General Formula for Different Functional Groups

S. No.	General formula	Functional isomers
1.	C_nH_{2n}	Alkene and cycloalkane
2.	C_nH_{2n-2}	Alkyne, cycloalkene and alkadiene
3.	$C_nH_{2n+2}O$	Alcohol and ether
4.	$C_nH_{2n}O$	Aldehydes, ketones and epoxides
5.	$C_nH_{2n}O_2$	Acids, ester, hydroxy aldehyde and hydroxy ketone

2. Stereoisomerism

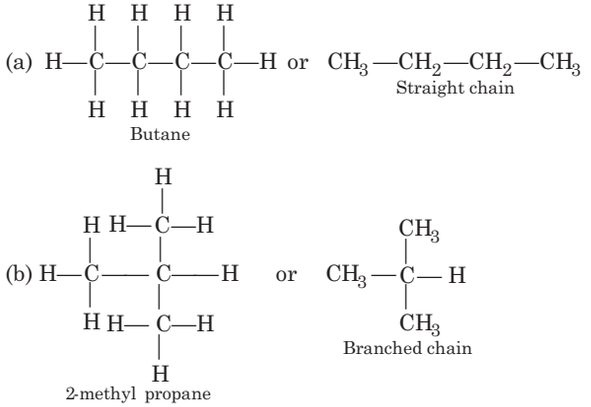
Compounds having the same molecular formula (constitution) and structural formula but different spatial arrangement of atoms are called stereoisomers and this phenomenon is called **stereoisomerism**. It is further classified into optical and geometrical isomerism.

Example 1. Draw all the positional isomers of an alcohol with molecular formula, C_3H_8O.

Sol. $CH_3CH_2CH_2OH$ and $CH_3CH(OH)CH_3$
Propan-1-ol Propan-2-ol

Example 2. Write all the possible isomers of C_4H_{10}.

Sol. C_4H_{10} have two isomers. Among these, only 2-methylpropane is the branched chain isomer.



Nomenclature of Organic Compounds

Organic compounds have generally two types of names. These are IUPAC names and common names. The IUPAC names have been adopted by the International Union of Pure and Applied Chemistry and are based on certain rules. The common names, also known as trivial names, have no proper system for naming.

In general, the IUPAC names of organic compounds are based on the name of basic carbon chain modified by a prefix (phrase before) or suffix (phrase after) indicating the name (or nature) of the functional group.

According to this system, *the name of an organic compound consist of three parts*

(i) Root word (ii) Suffix (iii) Prefix

Root Word It indicates the number of carbon atoms present in a hydrocarbon (or any other organic compound).

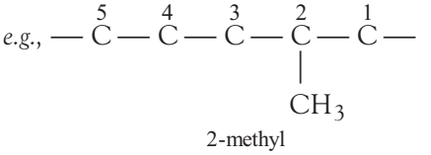
Some of the root words are tabulated below

Number of carbon atoms		Root word (Greek name)
One carbon atom	C_1	Meth
Two carbon atoms	C_2	Eth
Three carbon atoms	C_3	Prop
Four carbon atoms	C_4	But
Five carbon atoms	C_5	Pent
Six carbon atoms	C_6	Hex
Seven carbon atoms	C_7	Hept
Eight carbon atoms	C_8	Oct
Nine carbon atoms	C_9	Non
Ten carbon atoms	C_{10}	Dec

Suffix It is always added to the word root to indicate the functional groups present in the molecule.

Types of carbon chain	Suffix	General name
C— C (Single bond)	– ane	Alkane
C═C (Double bond)	– ene	Alkene
C≡C (Triple bond)	– yne	Alkyne
R— Group	yl	Alkyl

Prefix It denotes the substituent, alkyl or functional group and its position in the carbon chain.

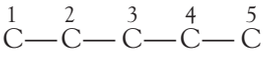


(Methyl group is attached to second C-atom)

Di, tri, tetra are used for two, three and four groups of the same type, respectively.

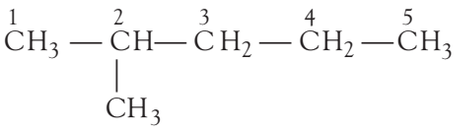
IUPAC Rules for Naming an Organic Compound

(i) The longest continuous chain of 'C' atoms, known as parent chain, is selected. The longest chain is not necessary to be straight.

e.g., 

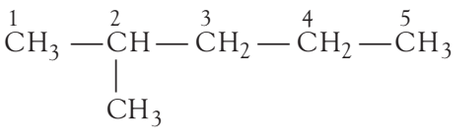
Longest chain have 5 carbon atoms, so word root is 'pent'.

(ii) The alkyl group present as side chains (branches) are considered as substituents and named separately as methyl ($—CH_3$) or ethyl ($—C_2H_5$) group.

e.g., 

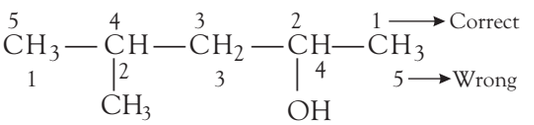
2- methylpentane

(iii) The carbon atoms of the longest carbon chain are numbered in such a way that the alkyl groups (substituents) get the lowest possible number.



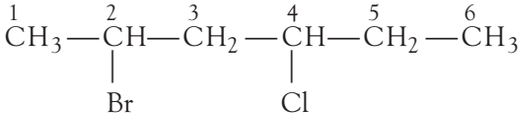
2-methylpentane

(iv) If the functional group is also present in the chain, then carbon atoms are numbered in such a way that the functional group gets the smallest possible number.



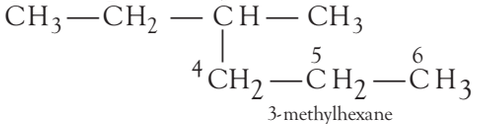
4-methylpentan-2-ol

(v) If different types of substituents are attached in the chain, they are named alphabetically.



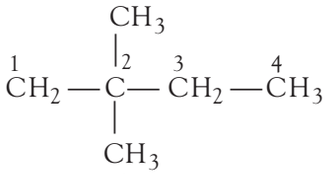
2 - bromo - 4 - chlorohexane

(vi) The IUPAC name of the compound is obtained by writing the position and name of alkyl group just before the name of parent 'hydrocarbon'.



3-methylhexane

(vii) Multiple alkyl groups are labelled as di for two, tri for three and tetra for four. If the two alkyl groups are on the same carbon atom, the numeral is repeated.

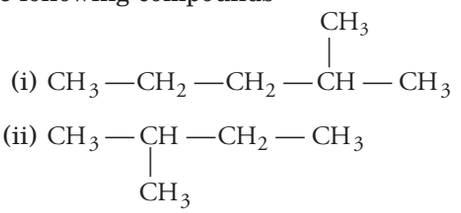


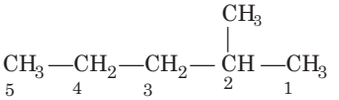
2, 2-dimethylbutane

Functional Groupwise Nomenclature

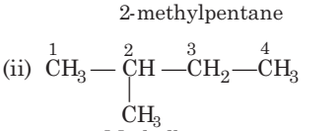
Functional group	General representation	Example
Hydrocarbon		
• Alkane	Rootword + – ane = alkane	$CH_3CH_2CH_2CH_3$ n-butane
• Alkene	Alkane – ane + ene = alkene	$CH_2=CH—CH_2—CH_3$ But-1-ene
• Alkyne	Alkane – ane + yne = alkyne	$CH_3—C\equiv C—CH_3$ But-2-ene
Alcohols	Alkane – e + ol = alkanol	$CH_3—CH(CH_3)—CH_2—CH(CH_3)—OH$ 1,3-dimethyl butanol
Aldehyde	Alkane – e + al = alkanal	CH_3CHO Ethanal
Ketone	Alkane – etone = alkanone	CH_3COCH_3 Propanone
Carboxylic group	Alkane – e + oic acid = alkanoic acid	CH_3CH_2COOH Propanoic acid

Example 3. Write down the IUPAC nomenclature of the following compounds



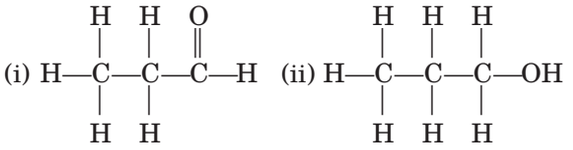
Sol. (i) 

2-methylpentane

(ii) 

Methylbutane

Example 4. Give the correct IUPAC names and the functional group for each of the compounds whose structural formulae are given below.



Sol.

	IUPAC name	Functional group
(i)	Propanal	—CHO (Aldehyde)
(ii)	Propanol	—OH (Alcohol)

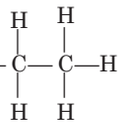
Example 5. Draw the structural formula of a compound with two carbon atoms in each of the following cases.

(i) An alkane with a carbon to carbon single bond.

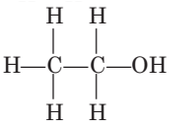
(ii) An alcohol containing two carbon atoms.

(iii) An unsaturated hydrocarbon with a carbon to carbon triple bond.

Sol. (i) Ethane (An alkane)



(ii) CH_3CH_2OH (Ethanol)



(iii) Ethyne $H-C\equiv C-H$

Example 6. Write the IUPAC name of the compounds whose structures are given below.

(i) $CH_3CH_2-\underset{\underset{OH}{|}}{CH}-CH_2-CH_2-\underset{\underset{CH_3}{|}}{CH}-CH_2CH_3$

(ii) $CH_3-CH_2-\overset{\overset{O}{||}}{C}-CH_2-\overset{\overset{O}{||}}{C}-CH_3$

(iii) $CH_3-\overset{\overset{O}{||}}{C}-CH_2-CH_2-CH_2-COOH$

(iv) $CH\equiv C-CH=CH-CH=CH_2$

Sol. *Follow the steps given below to solve such problems*

Step I Predict the principal functional group and suffix for the functional group.

$-OH$ (−ol), $>C=O$ (−one), $-COOH$ (− oic acid), $>C=C<$ (− ene)

Step II Predict substituent and their prefix

$-CH_3$ (methyl), $>C=O$ (oxo), $\equiv$

(suffix-yne as it has no prefix).

Step III Name the parent alkane according to the number of carbon atoms.

8 carbon (oct), 6 carbon (hex),

Step IV *Specify the substituent and principal functional group locations respectively as follows*

(i) 6 : methyl and 3 : OH,

(ii) 4 and 2: $>C=O$;

(iii) 1 : COOH and 5 : $>C=O$;

(iv) 1, 3 : ene and 5 : yne

Step V IUPAC name

(i) 6-methyloctan-3-ol.

(ii) Hexane-2,4-dione.

(iii) 5-oxohexanoic acid.

(iv) Hexa-1, 3-dien-5-yne.

CHECK POINT 03

1 Write the structural formula for all the possible isomers of pentane.

2 Write all the possible positional isomers of but-1-yne.

3 Define stereoisomerism and how are they classified?

4 Give an example with IUPAC name and chemical formula, for the following class.

Alcohols, aldehydes, ketones, carboxylic acid.

5 Write the IUPAC names for the following compounds.

(i) $H_3C-CH_2-\underset{\underset{Cl}{|}}{CH}-\underset{\underset{OH}{|}}{CH}-CH_3$

(ii) $H_3C-CH_2-\underset{\underset{C_2H_5}{|}}{CH}-CH_2-\underset{\underset{CH_3}{|}}{CH}-CH_3$

6 IUPAC names written below are incorrect. Rewrite the correct names after drawing their respective structures

(i) 4-methylpentane

(ii) 4-ethylpentan-1-ol

(iii) 3-chloropropan-2-ol

SUMMARY

- Organic chemistry is the branch of chemistry which deals with the study of organic compounds.
- In 1828, German chemist prepared urea in laboratory.
- Organic compounds essentially contains carbon atom. They have low melting and boiling point.
- The large variety of compounds is formed by carbon because of its tetravalency and the property of catenation that it exhibits.
- Rules for drawing structure
  (i) Connect all the C-atoms by single bond.
  (ii) Satisfy the tetravalency of each carbon by available H-atoms.
  (iii) Satisfy the remaining valency, if any, by multiple bonds.
- Functional groups are atoms or groups of atoms responsible for their chemical behaviors e.g., Alcohol group (— OH group).
- Homologous series is a series of compounds differing from its previous and successive member by —CH_2 unit e.g., Alkane (CH_4, C_2H_6).
- Isomerism This phenomenon arises when compounds have same molecular formula but differ in structures, atoms or spatial arrangement.
- Structural isomerism is a phenomenon arises when compounds have same molecular formula but differ in way of bonding.
  (i) Chain isomerism Differ in arrangement of carbon atoms.
  (ii) Position isomerism Differ in position of bond or functional group.
  (iii) Functional group isomerism Possessing different functional group.
  (iv) Metamerism Having different alkyl groups with same functional group.
- Stereo isomerism is a phenomenon arises when compounds having similar molecular formula but differ in their spatial arrangements. This can be optical or geometrical.
- Nomenclature In trivial system, organic compounds were named after their source or some properties. In IUPAC system compounds are named as prefix + root word + suffix.

EXAM PRACTICE

Fill in the Blanks

1. ..... was the first organic compound prepared in laboratory.

Sol. Urea

2. The name of organic compound consists of three types such as ....., ... and .....

Sol. root word, suffix, prefix

3. One carbon atom in a hydrocarbon contain the root word as ..... .

Sol. meth

4. A ..... is always added to the root word to indicate whether a carbon chain is single bonded, double or triple bonded.

Sol. suffix

5. Fill up the gaps.

	Compound	Trivial or Common Name
(i)	CH_4	.....
(ii)	.....	*n*-butane
(iii)	$(H_3C)_4C$	.....
(iv)	.....	Formaldehyde

Sol. Methane, $CH_3CH_2CH_2CH_3$, *neo*-pentane, HCHO.

Multiple Choice Questions

6. In which of the following compounds —OH is the functional group?

(a) Butanone (b) Butanol
(c) Butanoic acid (d) Butanal

Sol. (b)

7. The number of C—H bonds in ethane molecule are *[2011]*

(a) four (b) six
(c) eight (d) ten

Sol. (b)

8. Isomerism shown by pent-1-yne and 3-methylbut-1-yne is

(a) chain isomerism (b) position isomerism
(c) functional isomerism (d) stereo isomerism

Sol. (a)

9. Pentane has the molecular formula, C_5H_{12}. It has

(a) 5 covalent bonds (b) 12 covalent bonds
(c) 16 covalent bonds (d) 17 covalent bonds

Sol. (c)

10. The IUPAC name of dimethyl ether is *[2018]*

(a) ethoxy methane
(b) methoxy methane
(c) methoxy ethane
(d) ethoxy ethane

Sol. (b)

Match the Following

11. Match the following columns.

	Column I (IUPAC name)		Column II (Molecular formula)
(i)	Ethane	(a)	C_6H_{14}
(ii)	Propane	(b)	C_2H_6
(iii)	Pentane	(c)	C_3H_8
(iv)	Hexane	(d)	C_5H_{12}

Sol. (i) → b , (ii) → (c), (iii) → (d), (iv) → (a)

12. Match the following columns.

	Column I		Column II
(i)	Chain isomerism	(a)	Same molecular formula but different functional group.
(ii)	Position isomerism	(b)	Same molecular formula but different carbon skeleton.
(iii)	Functional group isomerism	(c)	Difference in the position of substituent atom or functional group.
(iv)	Metamerism	(d)	Same functional group but the alkyl group attached to the same functional group are different.

Sol. (i) → (b), (ii) → (c), (iii) → (a), (iv) → (d)

13. Match the following columns.

	Column I (Functional isomer)		Column II (General formula)
(i)	Cycloalkane	(a)	C_nH_{2n}
(ii)	Cycloalkene	(b)	$C_nH_{2n}O$
(iii)	Alcohol	(c)	C_nH_{2n-2}
(iv)	Aldehyde	(d)	$C_nH_{2n}O_2$
(v)	Acids and esters	(e)	$C_nH_{2n+2}O$

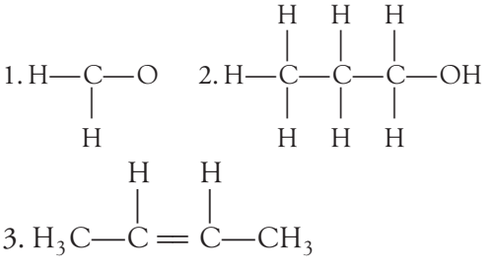
Sol. (i) → (a), (ii) → (c), (iii) → (e), (iv) → (b), (v) → (d)

a 1 Mark Questions

14. What is vital force theory?

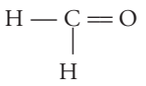
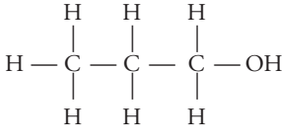
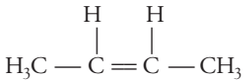
Sol. It states that organic compounds can be synthesised only inside a living body and a vital force is required for such synthesis.

15. (i) Give the IUPAC name for each of the following.

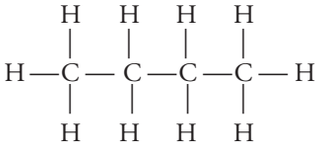


(ii) Write the structural formula of the two isomers of butane. *[2018]*

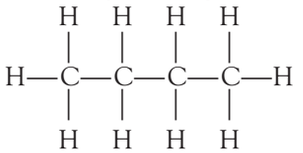
Sol. (i)

S. No.	Structure	IUPAC name
1.		Methanal
2.		Propan-1-ol
3.		But-2-ene

(ii) (a) *Structural formula of butane is*



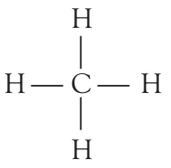
(b) *Structural formula of the two isomers of butane are*



n -butane

16. Write the general formula of alkane and give one example of alkane with this general formula.

Sol. General formula, C_nH_{2n+2} *e.g.,* Methane (CH_4).



17. Identify the substance underlined. *[2017]*

An <u>organic compound</u> containing — COOH functional group.

Sol. Carboxylic group

18. State one relevant observation for the reaction. The compound formed where two alkyl groups are linked by group. *[2017]*

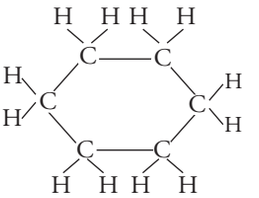
Sol. Ketone

19. Draw the structure of the cyclic compounds

(i) Cyclohexane (C_6H_{12})

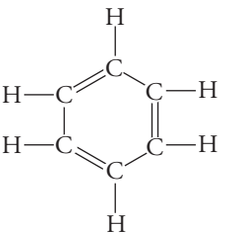
(ii) Benzene (C_6H_6)

Sol. (i) Cyclohexane



or

(ii) Benzene



or

20. Define isomerism. *[2009]*

Sol. Isomerism is the existence of two or more compounds having the same molecular formulae but different structural formulae.

b 2 Marks Questions

21. Discuss any two properties, which make carbon versatile in nature.

Sol. *The two properties are*

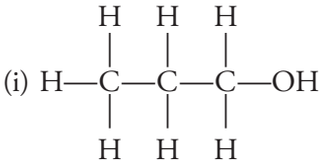
(i) **Tetravalency** The capacity of making four bonds that allow carbon to combine with different or similar atoms simultaneously and achieve a stable electronic arrangement. *[1]*

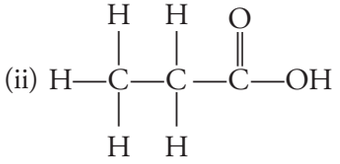
(ii) **Catenation** Unlike other elements, carbon atoms can self link with each other and can form long chain. This make carbon to form compounds of various chain lengths. *[1]*

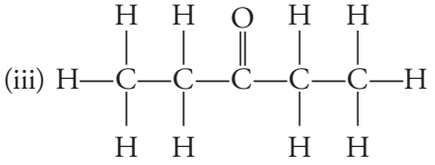
22. What is trivial system of nomenclature?

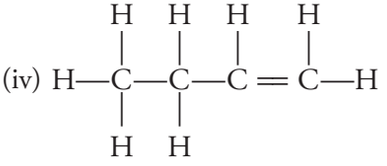
Sol. It is the oldest system of nomenclature in which the names of organic compound were assigned on the basis of their source or some properties *e.g.,* Acetic acid is named so because it is the chief constituent of vinegar (Latin *acetum*). The trivial names are also called common names. ***[2]***

23. Identify and name the functional groups present in the following compounds.

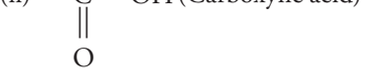
(i) 

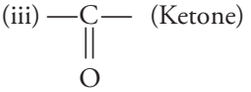
(ii) 

(iii) 

(iv) 

Sol. (i) —OH (Alcohol)

(ii)  (Carboxylic acid)

(iii)  (Ketone)

(iv) —C ═ C— (Alkene) ***[½ × 4 = 2]***

24. (i) Draw the structural formula of ethyne.

(ii) How is the structure of alkynes different from that of alkenes? ***[2006]***

Sol. (i) Ethyne H—C≡C—H ***[1]***

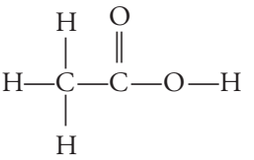
(ii) Alkynes possess a triple covalent bond between C—C atom whereas alkenes possess a double covalent bond between carbon-carbon atoms. ***[1]***

25. Draw the structural formula for each of the following.

(i) Ethanoic acid

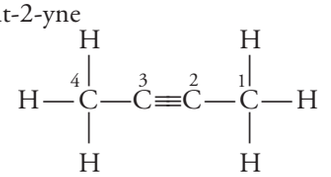
(ii) But-2-yne ***[2010]***

Sol. (i) Ethanoic acid



[1]

(ii) But-2-yne



[1]

26. An organic compound '*X*' is present in a beaker. How its physical and chemical properties can be determined?

Sol. The physical properties of organic compound is determined by the alkyl group whereas, the chemical properties of organic compound is determined by the presence of functional group. ***[2]***

C 3 Marks Questions

27. Give the common name of

(i) ethanol

(ii) ethoxyethane

(iii) ethanoic acid

Ans. (i) ethyl alcohol

(ii) diethyl ether

(iii) acetic acid ***[1 × 3 = 3]***

28. Which of the following represent the correct IUPAC name for the compounds concerned?

(i) 2,2-dimethylpentane or 2-dimethylpentane

(ii) 2,4,7-trimethyloctane or 2,5,7-trimethyl octane

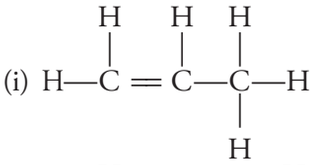
(iii) 2-chloro-4-methylpentane or 4-chloro-2-methylpentane

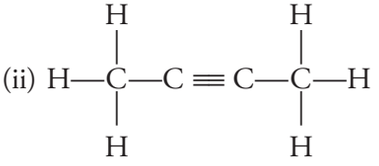
Sol. (i) 2,2-dimethyl pentane (because for the two alkyl groups on the same carbon, its locant is repeated twice). ***[1]***

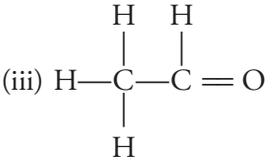
(ii) 2,4, 7-trimethyloctane (because 2, 4, 7-locant set is lower than 2, 5, 7). ***[1]***

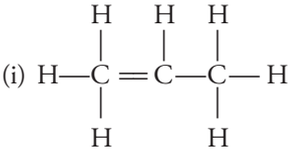
(iii) 2-chloro-4-methylpentane (alphabetical order of substituents) ***[1]***

29. Write the IUPAC names of each of the following. *[2016]*

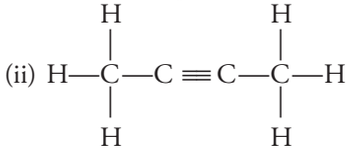
(i) 

(ii) 

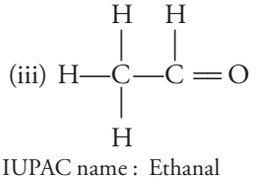
(iii) 

Sol. (i) 

IUPAC name : Prop-1-ene *[1]*

(ii) 

IUPAC name : But-2-yne

(iii) 

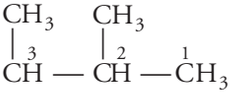
IUPAC name : Ethanal *[1]*

30. Draw the structural formula for each of the following. *[2017]*

(i) 2, 3-dimethylbutane

(ii) Diethyl ether

(iii) Propanoic acid

Sol. (i) 

2, 3-dimethylbutane *[1]*

(ii) $C_2H_5OC_2H_5$

Diethyl ether *[1]*

(iii) $^{3}CH_3\,^{2}CH_2\,^{1}COOH$

Propanoic acid *[1]*

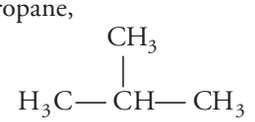
31. Give the structural formulae of each of the following. *[2016]*

(i) 2-methylpropane

(ii) Ethanoic acid

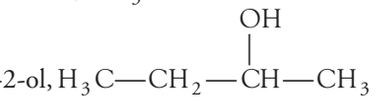
(iii) Butan-2-ol

Sol. (i) 2-methylpropane,



[1]

(ii) Ethanoic acid, CH_3COOH *[1]*

(iii) Butan-2-ol,  *[1]*

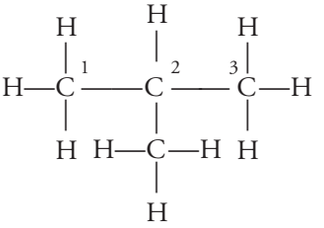
32. Give the structural formulae for the following.

(i) An isomer of *n*-butane

(ii) 2-propanol

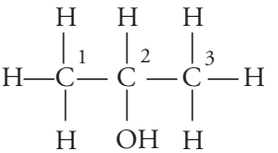
(iii) Diethyl ether *[2013]*

Sol. (i) An isomer of *n*-butane is isobutane (2-methylpropane)



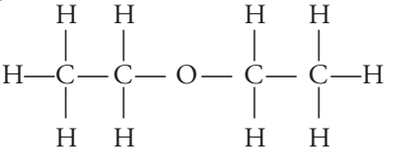
[1]

(ii) 2-propanol



[1]

(iii) Diethyl ether



[1]

33. (i) Using structural formulae of the given compound, identify the functional group by circling them.

(a) Dimethyl ether

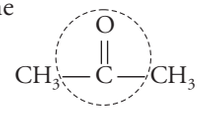
(b) Propanone

(ii) Name the property of elements by virtue of which atoms of the element can link to each other in the form of a long chain or ring structure. *[2015]*

Sol. (i) (a) Dimethyl ether

Functional group : —O— *[1]*

(b) Propanone

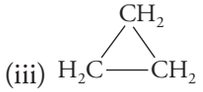


Functional group: $>C=O$ *[1]*

(ii) Catenation *[1]*

34. Write the name and structure of at least one isomer in each of the following.

(i) H_3COCH_3 (ii) $H_3C—CO—CH_3$

(iii) 

Sol. (i) C_2H_5OH : Ethyl alcohol *[1]*

(ii) C_2H_5CHO : Propanal *[1]*

(iii) $H_3C—CH=CH_2$: Propene *[1]*

d 4 Marks Questions

35. Define the following.

(i) Tetravalency of carbon (ii) Catenation

(iii) Homologous series (iv) Isomerism

Sol. (i) Refer to text on page 205.

(ii) Refer to text on page 205.

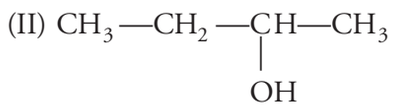
(iii) Refer to text on page 207.

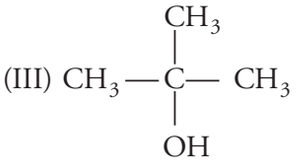
(iv) Refer to text on page 208.

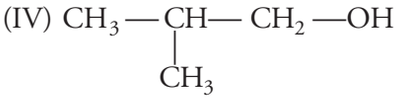
e 5 Marks Questions

36. Consider the structure I to VI and answer the following questions (i) to (iii).

(I) $CH_3—CH_2—CH_2—CH_2—OH$

(II) 

(III) 

(IV) 

(V) $CH_3—CH_2—O—CH_2—CH_3$

(VI) $CH_3—O—CH_2—CH_2—CH_3$

(i) Identify the pairs of compounds which are functional group isomers.

(ii) Identify the pairs of compounds that represent position isomerism.

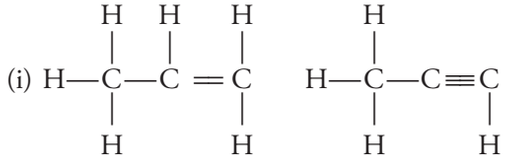
(iii) Identify the pairs of compounds that represent chain isomerism.

Sol. (i) I and V ; I and VI ; II and V ; II and VI ; III and V ; IV and V ; IV and VI are all functional group isomers. *[1½]*

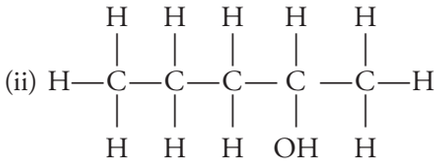
(ii) I and II ; III and IV ; V and VI represent position isomerism. *[1½]*

(iii) I and III ; I and IV ; II and III ; II and IV represent chain isomerism. *[2]*

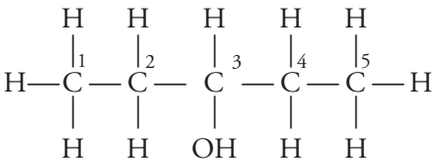
37. Give the IUPAC names of the following compounds numbered (i) to (v). The IUPAC names of the compounds on the left are to guide you into giving the correct IUPAC names of the compounds on the right.

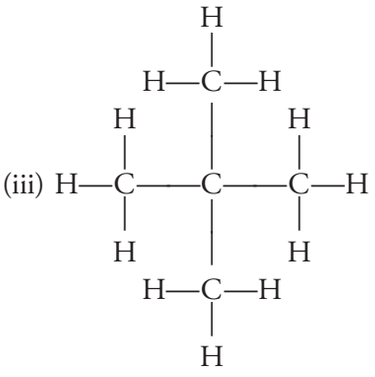
(i) 

Propene

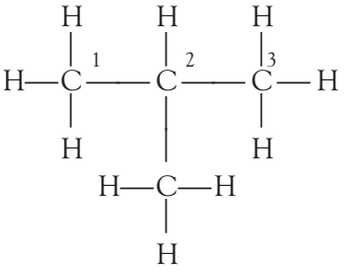
(ii) 

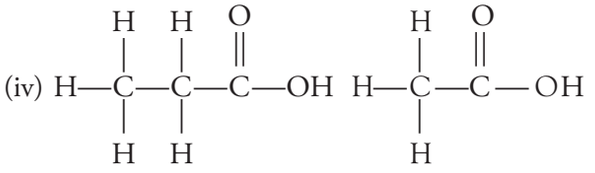
Pentan-2-ol



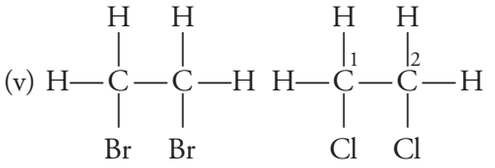
(iii) 

2, 2-dimethylpropane



(iv) 

Propanoic acid

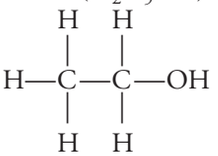
(v) 

1, 2 - dibromoethane *[2007]*

Sol. (i) Propyne
(ii) Pentan-3-ol
(iii) 2-methylpropane
(iv) Ethanoic acid
(v) 1, 2-dichloroethane *[1 × 5 = 5]*

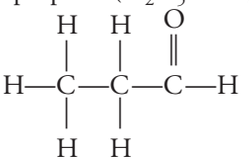
38. Give the structural formulae for the following.
(i) Ethanol (ii) 1- propan-al
(iii) Ethanoic acid (iv) 1, 2- dichloroethane
(v) 2-pentanone *[2014]*

Sol. (i) Ethanol (C_2H_5OH)



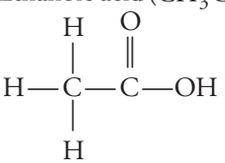
[1]

(ii) 1-propanal (C_2H_5CHO)



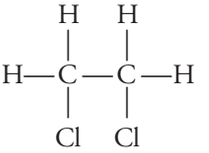
[1]

(iii) Ethanoic acid (CH_3COOH)



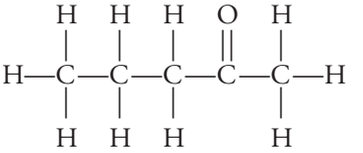
[1]

(iv) 1, 2-dichloro ethane



[1]

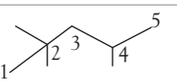
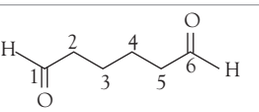
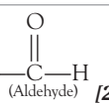
(v) 2-pentanone



[1]

39. Give condensed and bond line structural formulae and identify the functional group(s) other than alkyl group, present, if any, for
(i) 2, 2, 4-trimethyl pentane
(ii) Hexanedial.

Sol.

	Condensed formula	Bond Line Formula	Functional Groups	
(i)	$(CH_3)_3CCH_2CH(CH_3)_2$		—	*[2½]*
(ii)	$OHC(CH_2)_4CHO$		 (Aldehyde)	*[2½]*

40. (i) If the general formula of both alcohols and ethers is written as $C_nH_{2n+2}O$. Then write the name and structure of first two members of homologous series of each of these two classes.
(ii) Why first member of alcohols and ethers does not have same molecular formula?

Sol. (i) Alcohols ($C_nH_{2n+2}O$ or $C_nH_{2n+1}OH$)

Value of *n*	Structure	Name
1.	CH_3OH	Methanol
2.	C_2H_5OH	Ethanol

Ethers ($C_nH_{2n+2}O$ or $C_nH_{2n+1}OC_nH_{2n+1}$)

Value of *n*	Structure	Name
1.	H_3COCH_3	Methoxymethane
2.	$H_3COC_2H_5$	Ethoxymethane

[2½]

(ii) First member of alcohols has one carbon ($n = 1$) atom while that of ethers has two carbon atom ($n = 2$) hence the difference between their molecular formula *i.e.*, CH_4O and C_2H_6O, respectively is $—CH_2—$. *[2½]*

CHAPTER EXERCISE

Fill in the Blanks

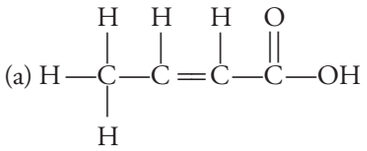
1. Catenation and tetravalency results in the formation of ……, …… or …… bonds.
2. On combining carbon atoms with one another, three types of chains are formed. They are ……, …… and …… . Their molecular formula is same but …… formula changes.
3. Choosing only words from the following list, write down the appropriate words to fill in the blanks from (i) to (v)

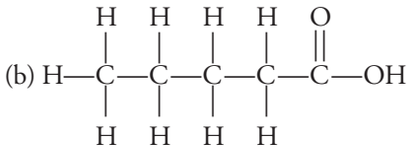
   Addition, carbohydrates, C_nH_{2n-2}, C_nH_{2n+2}, electrochemical, homologous, hydrocarbons, saturated, substitution, unsaturated.

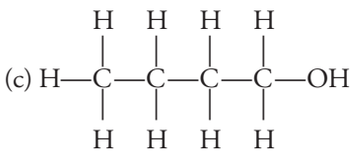
   The alkanes form an (i) ..... series with the general formula, (ii) ..... . The alkanes are (iii) ..... and (iv) ..... which generally undergo, (v) ..... reactions.

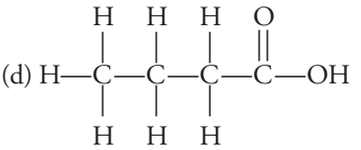
Multiple Choice Questions

4. Which of the following does not belong to the same homologous series?
   (a) CH_4 (b) C_2H_6
   (c) C_3H_8 (d) C_4H_8
5. Which of the following is an aldehyde?
   (a) CH_3CH_2OH (b) CH_3CHO
   (c) CH_3COCH_3 (d) CH_3COOH
6. The correct structural formula of butanoic acid is









7. Which of the following is the correct IUPAC name?
   (a) 3-ethyl, 4, 4-dimethylheptane
   (b) 4, 4-dimethyl-3-ethylheptane
   (c) 5-ethyl-4, 4-dimethylheptane
   (d) 4, 4-bis (methyl-3-ethylheptane)
8. The pair of compounds representing isomers is
   (a) methane and ethane
   (b) ethane and propane
   (c) but-1-ene and but-2-ene
   (d) propene and butene

Match the Following

9. Match the following columns.

Column I (Organic compounds)		Column II (IUPAC nomenclature)	
(i)	Ethanoic acid	(a)	$CH_3CH_2CH_2CH_2CH_2Br$
(ii)	Bromopentane	(b)	CH_3COOH
(iii)	Butanone	(c)	$CH_3CH_2CH_2CH_2CH_2CHO$
(iv)	Hexanal	(d)	$CH_3CH_2-C(=O)-CH_3$

1 Mark Questions

10. Draw the structure of simplest ketone. ***[2011]***
11. Give the IUPAC name of the isomer of C_4H_{10}, which has a branched chain. ***[2013]***

2 Marks Questions

12. What are organic compounds? Give its significance.
13. Draw the structures of the following compounds.
    (a) Ethanoic acid
    (b) Bromopentane
    (c) Butanone
    (d) Hexanal

    Are structural isomers possible for bromopentane?

3 Marks Question

14. Give the name and structure of each of the following type of hydrocarbon.

(i) Straight chain

(ii) Branched chain

(iii) Cyclic or closed chain

4 Marks Questions

15. Write the IUPAC name of the following compounds.

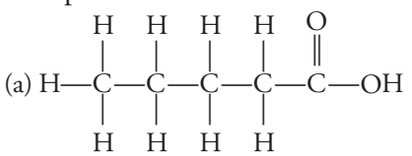
(i) $CH_3-\underset{\displaystyle CH_3}{\overset{|}{CH}}-CH_2-Br$

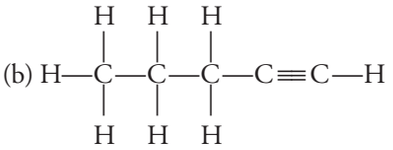
(ii) $CH_3-CH_2-\underset{\displaystyle Cl}{\overset{|}{CH}}-CH_2-CH_3$

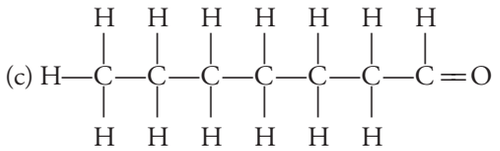
(iii) $CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$

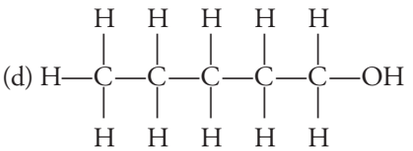
(iv) $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$

16. Write the IUPAC names of the following compounds.

(a) 

(b) 

(c) 

(d) 

5 Marks Questions

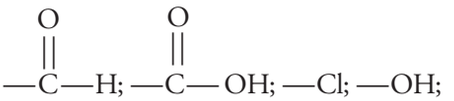
17. Give the structural formula for the following. ***[2008]***

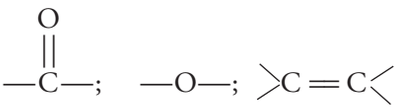
(i) Methanoic acid (ii) Ethanal

(iii) Ethyne (iv) Acetone

(v) 2-methylpropane

18. Using the functional groups, given below, draw five chemical structures each having atleast carbon atoms and two functional groups. Also name them.





ARCHIVES*

(Last 6 Years)

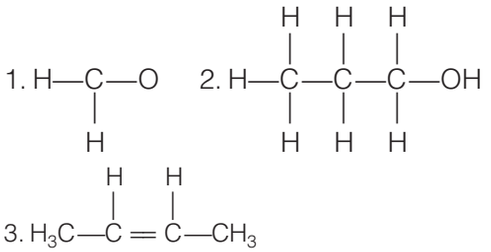
Collection of Questions Asked in Last 6 Years' (2018-2013) ICSE Class 10th Examinations

2018

1 The IUPAC name of dimethyl ether is *[1]*

(a) ethoxy methane
(b) methoxy methane
(c) methoxy ethane
(d) ethoxy ethane

2 (i) Give the IUPAC name for each of the following.



(ii) Write the structural formula of the two isomers of butane.

2017

1. Identify the substance underlined.

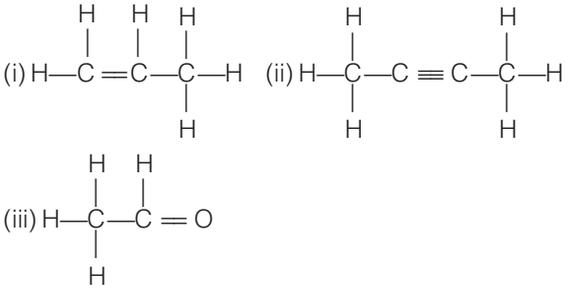
An <u>organic compound</u> containing —COOH functional group. *[1]*

2. State one relevant observation for the reaction.
The compound formed where two alkyl groups are linked by group. *[1]*

3. Draw the structural formula for each of the following
(i) 2, 3-dimethylbutane (ii) Diethylether
(iii) Propanoic acid *[3]*

2016

4. Write the IUPAC names of each of the following.



[3]

5. Give the structural formulae of each of the following.
(i) 2-methylpropane (ii) Ethanoic acid
(iii) Butan-2-ol *[3]*

2015

6. (i) Using structural formulae of the given compound, identify the functional group by circling them.
(a) Dimethyl ether (b) Propanone
(ii) Name the property of elements by virtue of which atoms of the element can link to each other in the form of a long chain or ring structure.

2014

7. Name the following,
Hydrocarbons containing a functional group. *[1]*

8. Give the structural formulae for the following.
(i) Ethanol (ii) 1-propanal
(iii) Ethanoic acid (iv) 1, 2-dichloroethane
(v) 2-pentanone *[5]*

9. The IUPAC name of acetylene is
(a) propane (b) propyne
(c) ethene (d) ethyne *[1]*

2013

10. Identify the statement that is incorrect about alkanes.
(a) They are hydrocarbons.
(b) There is a single covalent bond between carbon and hydrogen.
(c) They can undergo both substitution as well as addition reactions.
(d) On complete combustion, they produce carbon dioxide and water. *[1]*

11. Give reason for the following.
Hydrocarbons are excellent fuels. *[1]*

12. Give the IUPAC name of the isomer, C_4H_{10} which has a branched chain. *[2]*

13. Give the structural formulae for the following.
(i) An isomer of *n*-butane (ii) 2-propanol
(iii) Diethyl ether *[3]*

CHALLENGERS*

1 Which of the following forms a homologous series?
(a) Ethane, ethylene, acetylene (b) Ethane, propane, butanone
(c) Methanol, ethanol, propanoic acid (d) Butane, 2-methylbutane, 2, 3-dimethylbutane

2 The IUPAC name for isobutyl group is
(a) 2-methylethyl (b) 1, 1-dimethylethyl (c) 2-methylpropyl (d) 1-methylpropyl

3 The common name of $(CH_3)_3\,CC_2H_5$ is
(a) *Iso*-hexane (b) *Neo*-hexane (c) Trimethylpropane (d) None is correct

4 The family to which methoxy ethene belongs is
(a) hydrocarbon (b) ketone (c) unsaturated ether (d) ester

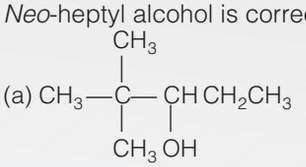
5 The correct IUPAC name of $CH_3CH_2CH(CH_3)\,CH(C_2H_5)_2$ is
(a) 4-ethyl-3-methylhexane (b) 3-ethyl-4-methylhexane
(c) 3-methyl-4-ethylhexane (d) 2-Isopentylbutane

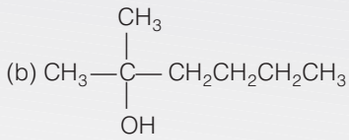
6 An example of alicyclic compound is
(a) benzene (b) hexane (c) cyclohexane (d) furan

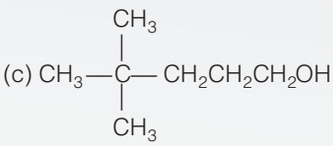
7 Which of the following structure represents 2, 2, 3-trimethylhexane?
(a) $CH_3C(CH_3)_2CH_2CH_2CH(CH_3)_2$
(b) $CH_3CH(CH_3)CH_2CH(CH_3)CH_2CH_3$
(c) $CH_3C(CH_3)_2CH(CH_3)CH_2CH_2CH_3$
(d) $CH_3C(CH_3)_2CH_2C(CH_3)_2CH_3$

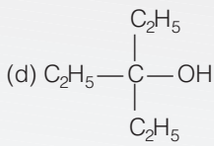
8 The compound which has one isopropyl group is
(a) 2, 2, 3, 3-tetramethylpentane (b) 2, 2-dimethylpentane
(c) 2, 2, 3-trimethylpentane (d) None of these

9 *Neo*-heptyl alcohol is correctly represented as

(a) 

(b) 

(c) 

(d) 

10 3-phenylprop-2-enoic acid is IUPAC name of
(a) Mendallic acid (b) Pivalic acid (c) Succinic acid (d) Cinnamic acid

Answers

1. (d) **2.** (c) **3.** (b) **4.** (c) **5.** (b) **6.** (c) **7.** (c) **8.** (d) **9.** (c) **10.** (d)

* These questions may or may not be asked in the examination, have been given just for additional practice.

CHAPTER

10

Hydrocarbons

Chapter Objective

- Classification of Hydrocarbons
- Alkanes
- Ethane
- Alkenes
- Alkynes

The organic compounds containing only carbon and hydrogen are called **hydrocarbons**.

e.g. CH_4, C_2H_6, C_2H_4 and C_2H_2. These are the simplest organic compounds and are regarded as parent organic compounds.

All other compounds are considered to be derived from them by the replacement of one or more hydrogen atoms by other atoms or groups of atoms. The major source of hydrocarbons is petroleum.

Classification of Hydrocarbons

Depending upon the types of carbon-carbon bonds present, hydrocarbons can be classified as follow

1. Saturated Hydrocarbons

The hydrocarbons in which all the carbon atoms are linked by only single bonds are called **saturated hydrocarbons** or **alkanes** or **paraffins**.

The general formula of these compounds is C_nH_{2n+2}, where, n = number of carbon atoms in one molecule of a hydrocarbon.

e.g., If there is only one carbon atom then its formula should be

$$C_1H_{2\times 1+2} = CH_4 \text{(methane)}.$$

Similarly, if there are two carbon atoms in the saturated hydrocarbon (alkane), its formula must be

$$C_2H_{2\times 2+2} = C_2H_6 \text{ (ethane)}$$

These compounds are chemically inert *i.e.,* less reactive and burn with blue and non-smoky flame due to their complete combustion. These compounds generally show substitution reactions.

2. Unsaturated Hydrocarbons

Those carbon compounds in which atleast one double or triple bond (or multiple bond) is present alongwith single bonds are called **unsaturated compounds.** These compounds generally burn with sooty or smoky flame due to their incomplete combustion. These are more reactive than saturated hydrocarbons and generally undergo addition reactions.

Unsaturated compounds are further divided into following two classes

(i) Alkenes

Those carbon compounds which have atleast one double bond alongwith single bonds are called alkenes. (A double bond is formed by the sharing of 2 pairs of electrons between the 2 carbon atoms).

General formula of these compounds is C_nH_{2n}.

e.g., If an alkene have 2 carbon atoms *i.e.*, $n = 2$, its formula is $C_2H_{2\times2} = C_2H_4$ (ethene).

(ii) Alkynes

Those unsaturated hydrocarbons which have one or more triple bonds alongwith the single bonds are called alkynes. (A **triple bond** is formed by the sharing of 3 pairs of electrons between 2 carbon atoms).

General formula of these compounds is C_nH_{2n-2}.

e.g., If an alkyne have 2 carbon atoms, then its formula is $C_2H_{2\times2-2} = C_2H_2$ (ethyne). If there are 3 carbon atoms in the alkyne, then its formula must be $C_3H_{2\times3-2} = C_3H_4$ (propyne).

Note The minimum number of carbon atoms present in an unsaturated compound is 2 because formation of double or triple bonds is possible only between 2 carbon atoms.

Alkanes

An alkane is a hydrocarbon in which the carbon atoms are connected through only single covalent bonds. These are also called **saturated hydrocarbons**. Their general formula is C_nH_{2n+2}, where n is the number of carbon atoms present in one molecule of alkane.

These are the simplest hydrocarbons and were earlier called 'paraffins' (Latin: parum-little: affinis-affinity) because of their inert (non-reactive) nature toward many acids, bases and other reagents.

Methane

Methane is also called as marsh gas, formed at the bottom of marshes due to the decomposition of cellulose by a special type of bacteria. Coal pockets also contain large amount of methane and are called fire damp (contain 90% methane). It is present in the air exhaled by animals whose food contain cellulose. It can be produced by the dry distillation of wood and peat (coal).

Note

- Methane is also called green house gas as it is the primary constituent of natural gas. It absorbs the heat radiation more effectively in comparison to carbon dioxide.
- Methane is emitted from landfills, natural gas, petroleum system, agricultural activities, coal mining, combustion, waste water treatment, certain industrial process, etc.

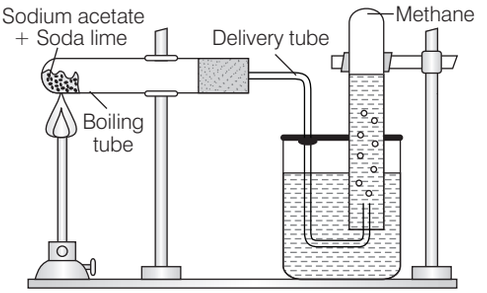
Preparation

The methods for the preparation of methane are given below

(i) Iodomethane is reduced by nascent hydrogen at room temperature to give methane gas. Nascent hydrogen is prepared by the action of Zn powder and dilute HCl.

$$\underset{\text{Iodomethane}}{CH_3I} + \underset{\substack{\text{Nascent}\\\text{hydrogen}}}{2[H]} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\substack{\text{Hydrogen}\\\text{iodide}}}{HI}$$

(ii) **Laboratory Preparation of Methane** In laboratory, methane is prepared by the reaction of sodium ethanoate (sodium acetate) and soda lime (a mixture of NaOH + CaO).



A mixture of sodium acetate and soda lime is taken in a hard glass test tube as shown in the figure and heated with the bunsen flame.

$$\underset{\text{Sodium acetate}}{CH_3CO\overset{-}{O}\overset{+}{N}a} + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + \underset{\text{Methane}}{CH_4}\uparrow$$

The gas evolved is collected over water by the downward displacement since, it is insoluble in water and is lighter than air. This reaction is known as a decarboxylation reaction because in this reaction, carbon dioxide molecule is eliminated from carboxylic acid in the form of carbonate.

Properties

Various physical and chemical properties of methane are as follow

1. Physical Properties

- It is a colourless and odourless gas.
- Its melting point is −183° C and boiling point is −162°C.
- It is insoluble in water but soluble in organic solvents.

2. Chemical Properties

(i) **Reaction with Halogens (substitution)** Alkane such as methane reacts with chlorine, bromine or iodine in the presence of sunlight to give substituted products *i.e.*, alkyl halides *e.g.*, Methane reacts with

chlorine in the presence of sunlight or heat to form chloromethane and hydrogen chloride.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Chloromethane}}{CH_3Cl} + \underset{\text{Hydrogen chloride}}{HCl}$$

In this reaction, one H-atom of methane has been substituted by a Cl-atom converting CH_4 into CH_3Cl. This type of reaction is known as **substitution reaction** and the product is called substituted product. By supplying more chlorine, it is possible to replace all the hydrogen atoms of methane by chlorine, one by one.

$$CH_3Cl + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Dichloromethane}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Trichloromethane}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Tetrachloromethane}}{CCl_4} + HCl$$

Note

- The substituted product formed can be separated by the fractional distillation as there is a difference in their respective boiling points.
- All alkanes react with chlorine, bromine and iodine in similar manner, to give their respective products.

(ii) **Reaction with Oxygen** (Combustion reaction) Methane burns in air with a bluish flame forming carbon dioxide and water vapour and a large amount of heat is produced.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$$

During insufficient supply of air alkane burns to give carbon monoxide and water.

$$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$$

$$CH_4 + O_2 \longrightarrow \underset{\text{(Soot)}}{C} + 2H_2O$$

Soot is used in the manufacture of printing inks and tyres.

Slow combustion

$$\underset{\text{Methane}}{CH_4} \xrightarrow[\text{or } K_2MnO_4]{[O],\ \text{Acidified } K_2Cr_2O_7} \underset{\text{Methyl alcohol}}{CH_3OH} \xrightarrow{[O]}$$

$$\underset{\text{Formaldehyde}}{HCHO} \xrightarrow{[O]} \underset{\text{Formic acid}}{HCOOH} \xrightarrow{[O]} CO_2 + H_2O$$

Uses of Methane

Some important uses of methane are as follow

- It is a source of carbon monoxide (CO) and hydrogen(H_2).
- It is used in the preparation of ethyne, methanol, methanal and carbon tetrachloride.
- It is also used as domestic fuel.

CHECK POINT 01

1. Write the structure and IUPAC names of all the possible isomers of an alkane consisting of five carbon atoms.
2. How would you prepare methane from
   (i) aluminium carbide?
   (ii) sodium ethanoate?
3. If chlorine is reacted with methane what product is formed?
4. Which types of reaction are known as substitution reaction?
5. Mention any two uses of methane gas.

Ethane

Ethane (C_2H_6) is a colourless, odourless gas, it can be isolated from natural gas, also obtained as petrochemical byproduct. It occurs upto the extent of 4% in natural gas along with methane and other gases.

Preparation

The methods of preparation of ethane are as follow

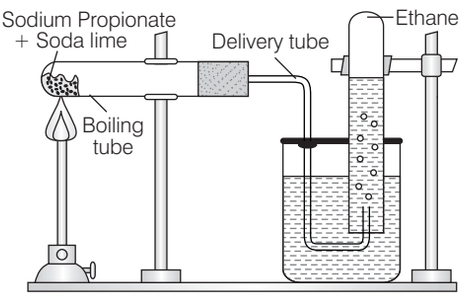
(i) Bromoethane is reduced by the nascent hydrogen at ordinary temperature.

$$\underset{\text{Bromoethane}}{C_2H_5Br} + 2[H] \longrightarrow \underset{\text{Ethane}}{C_2H_6} + HBr$$

(ii) **Laboratory Preparation of Ethane** In laboratory, ethane is prepared by the reaction of sodium propionate and soda lime. A mixture of sodium propionate and soda lime is taken in a hard glass test tube and heated with a bunsen burner (apparatus similar to as in the preparation of methane).

$$\underset{\text{Sodium propionate}}{C_2H_5CO\bar{O}\overset{+}{N}a} + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + C_2H_6\uparrow$$

[Decarboxylation reaction]



The gas evolved is collected by the downward displacement of water.

Ethane from Alkyl Halides (Wurtz reaction) Methyl iodide or methyl bromide reacts with sodium metal in the presence of dry ether, to give ethane gas.

$$2CH_3I + 2Na \xrightarrow[\text{ether}]{\text{Dry}} H_3C - CH_3 + 2NaI$$

Alkane with odd number of C-atoms is not prepared by this method. *e.g.*, Methane cannot be prepared by this method.

Properties

Various physical and chemical properties of ethane are as follow

1. Physical Properties

- It is a colourless and odourless gas.
- Its boiling point is −89° C and melting point is −172° C.
- It is insoluble in water but soluble in organic solvents like acetone, ether and alcohol.

2. Chemical Properties

(i) **Reaction with Halogens** (Substitution reactions) Ethane reacts with chlorine in the presence of sunlight or heated to form monochloroethane and hydrogen chloride.

$$\underset{\text{Ethane}}{C_2H_6} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Monochloroethane}}{C_2H_5Cl} + HCl$$

However, if chlorine is in excess, gradually all the atoms of hydrogen are replaced by the chlorine to form the following products.

$$\underset{\text{Chloroethane}}{C_2H_5Cl} + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Dichloroethane}}{C_2H_4Cl_2} + HCl$$

$$\underset{\text{Dichloroethane}}{C_2H_4Cl_2} + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Trichloroethane}}{C_2H_3Cl_3} + HCl$$

$$\underset{\text{Trichloroethane}}{C_2H_3Cl_3} + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Tetrachloroethane}}{C_2H_2Cl_4} + HCl$$

$$\underset{\text{Tetrachloroethane}}{C_2H_2Cl_4} + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Pentachloroethane}}{C_2HCl_5} + HCl$$

$$\underset{\text{Pentachloroethane}}{C_2HCl_5} + Cl_2 \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Hexachloroethane}}{C_2Cl_6} + HCl$$

(ii) **Reaction with Oxygen** (Combustion reaction) Ethane burns in air with a bluish flame forming carbon dioxide and water vapour and a large amount of heat is produced.

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O + \text{Heat}$$

During insufficient supply of air ethane burns to gives carbon monoxide and water.

$$2C_2H_6 + 5O_2 \longrightarrow 4CO + 6H_2O$$

Uses of Ethane

Some important uses of ethane are as follows

- Used in the preparation of ethene, ethanol, ethanal and ethanoic acid.
- It forms ethyl chloride, which is used to make tetra ethyl lead (anti-knocking agent).
- It is also a good fuel.

CHECK POINT 02

1. How would you bring out the following conversions?
   (i) Methane to methanol (ii) Ethane to ethanal
2. Give the reaction of chlorine with ethane and name the product formed.
3. Give the equation for laboratory preparation of ethane.
4. Complete the following. $2C_2H_6 + 7O_2 \longrightarrow$ ..... + ... + Heat
5. Name the hydrocarbon which is used to make tetra ethyl lead.

Alkenes

Hydrocarbons having at least one double bond are called alkenes. These are unsaturated hydrocarbons. Their general formula is C_nH_{2n} (where, $n = 2, 3, 4$) as they have two hydrogen atoms less than the alkanes.

Alkenes are also called **olefins** (oil forming) as the first member of this class *i.e.*, ethene forms oily liquid when treated with chlorine. These forms a homologous series having general formula C_nH_{2n}.

Ethene (Ethylene)

Ethene is the first member of alkene series. It is present in natural gas and in plants. It acts as a hormone responsible for the ripening of fruits.

Preparation

Various methods of preparation of ethene are given below

1. Laboratory Preparation

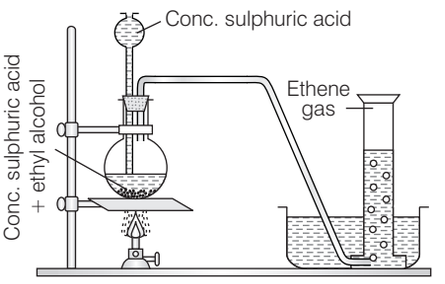
In laboratory, ethene is prepared by dehydration of ethyl alcohol, by reacting ethyl alcohol with sulphuric acid.

One part of ethyl alcohol and two parts of concentrated sulphuric acid in a flask and heat the mixture gradually at about 170°C. Ethylene gas is evolved which is collected by the downward displacement of water.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + \underset{\text{Conc.}}{H_2SO_4} \longrightarrow \underset{\text{Ethyl hydrogen sulphate}}{CH_3CH_2HSO_4} + H_2O$$

$$CH_3CH_2HSO_4 \xrightarrow[160°C]{\text{Excess } H_2SO_4} \underset{\text{Ethene}}{C_2H_4} + H_2SO_4$$

or $$\underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[170°C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{C_2H_4} + H_2O$$



Preparation of ethene from ethyl alcohol

2. Industrial Preparation

(i) **By Dehydration** Ethyl alcohol vapours passed through a tube containing alumina (Al_2O_3) at 300°C produces ethene.

$$\underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[300°C]{Al_2O_3} \underset{\text{Ethene}}{C_2H_4} + H_2O$$

Note
- Dehydration involves the elimination of water from alcohols.
- Al_2O_3 and H_2SO_4 act as dehydrating agents.

(ii) **By Dehydrohalogenation**

$$\underset{\text{Ethyl chloride}}{C_2H_5X} + \underset{\substack{\text{(Alcoholic,}\\ \text{hot and conc.)}}}{KOH} \longrightarrow \underset{\text{Ethene}}{C_2H_4} + KX + H_2O$$

(X = Cl, Br or I)

Properties

Various physical and chemical properties of ethene are as follow

1. Physical Properties

(i) It is a colourless and pleasant odour gas.

(ii) It is slightly soluble in water and highly soluble in organic solvents like alcohol, ether and chloroform.

(iii) It is slightly less denser than air.

(iv) Its melting and boiling points are – 169°C and – 102°C, respectively.

(v) It is an inflammable gas.

2. Chemical Properties

(i) **Addition of Hydrogen** (Hydrogenation) Vapours of ethene mixed with hydrogen are passed over a finely divided catalysts such as platinum or palladium or nickel at 200°C.

$$\underset{\text{Ethene}}{C_2H_4} + H_2 \xrightarrow[Ni]{200°C} \underset{\text{Ethane}}{C_2H_6}$$

(ii) **Addition of Halogens** (Halogenation) Chlorine, bromine and iodine are added to the double bond of ethene to form saturated ethylene chloride, ethylene bromide and ethylene iodide.

$$\underset{\text{Ethene}}{CH_2=CH_2} + Cl_2 \longrightarrow \begin{matrix} CH_2 & - & CH_2 \\ | & & | \\ Cl & & Cl \end{matrix}$$

$$\underset{\text{Ethene}}{CH_2=CH_2} + Br_2 \xrightarrow{CCl_4} \begin{matrix} CH_2 & - & CH_2 \\ | & & | \\ Br & & Br \end{matrix}$$

$$\underset{\text{Ethene}}{CH_2=CH_2} + I_2 \longrightarrow \begin{matrix} CH_2 & - & CH_2 \\ | & & | \\ I & & I \end{matrix}$$

Bromine solution in CCl_4 has an orange colour. When added dropwise to ethene, the orange colour of bromine disappears due to the formation of colourless ethylene bromide.

(iii) **Addition of Water** Alkenes react with water in the presence of acids to form alcohols.

$$CH_2=CH_2 + H_2O \xrightarrow{H^+} C_2H_5OH$$

(iv) **Addition of HCl** Ethene gas reacts with HCl to form chloroethane.

$$CH_2=CH_2 + HCl(aq) \longrightarrow \underset{\text{Chloroethane}}{CH_3CH_2Cl}$$

If ethyl chloride (ethene) or chloroethane is treated with aqueous potassium hydroxide then ethyl alcohol is formed.

$$CH_3CH_2Cl + aq.KOH \longrightarrow \underset{\text{Ethyl alcohol}}{CH_3CH_2OH} + KCl$$

(v) **Oxidation** Ethene is oxidised with $KMnO_4$ (alkaline potassium permanganate), at room temperature.

$$\underset{\text{Ethene}}{H_2C=CH_2} + H_2O + [O] \xrightarrow[\substack{\text{solution}\\ \text{(oxidising agent)}}]{\text{Alk. } KMnO_4}$$

$$\begin{matrix} CH_2 & - & CH_2 \\ | & & | \\ OH & & OH \end{matrix}$$

1,2-ethanediol

The purple colour of $KMnO_4$ decolourises.

(vi) **Combustion reaction** Ethene burns in air with a sooty flame, but if sufficient supply of air is present then it burns with a pale blue flame to produce CO_2 and water. A large amount of heat is also produced.

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O + \text{Heat}$$

Uses of Ethene

Some important uses of ethene are as follow

- Production of oxy-ethylene torch for welding and cutting metals.
- Used for artificial ripening and preservation of fruits.
- Used in manufacture of polythene.
- Used in hardening of oils.
- Used in manufacture of synthetic chemicals.

CHECK POINT 03

1 What is the nature of ethene gas?

2 Complete the following reactions.

(i) $C_2H_5OH \xrightarrow[170°C]{Conc.H_2SO_4} \ldots\ldots\ldots \xrightarrow{Cl_2} \ldots\ldots\ldots$

(ii) $C_2H_4 + H_2O \longrightarrow \ldots\ldots\ldots \xrightarrow[160°C]{Excess\ H_2SO_4} \ldots\ldots\ldots$

3 How is polythene produced?

4 How does ethylene undergo oxidation?

5 Write two uses of ethylene.

Alkynes

Hydrocarbons that contain a triple bond, (*i.e.*, — C ≡ C —, acetylenic bond) between two carbon atoms are called **alkynes**. It is an another class of unsaturated compounds having four carbon atoms less than alkanes. They form a homologous series, with the general formula C_nH_{2n-2} (where, $n = 2, 3, 4$.....). The first stable member of this series is ethyne (or acetylene).

Ethyne (Acetylene)

Its molecular formula is C_2H_2. It is the first member of the alkyne series. Traces of ethyne are present in coal gas. It is obtained by the cracking of alkanes from various fractions of petroleum.

Sources

- It is present in coal gas (in small amount).
- It is obtained by the cracking of alkanes from various fractions of petroleum.

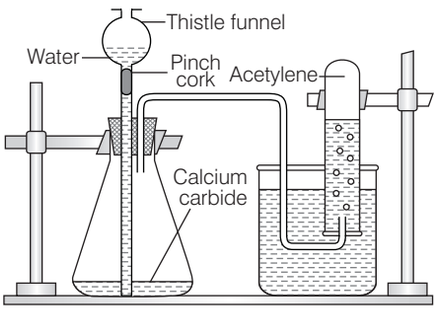
Preparation

The methods of preparation of ethyne are given below

1. Laboratory Preparation of Ethyne

In laboratory, ethyne is prepared by the reaction of calcium carbide and water.

Calcium carbide is taken in a conical flask and few drops of water are added through a thistle funnel as shown in the figure. Ethyne gas gets evolved and the reaction is exothermic.



Laboratory preparation of ethyne

$$\underset{\text{Calcium carbide}}{CaC_2} + 2H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Acetylene}}{C_2H_2}\uparrow$$

Gas is collected by the downward displacement of water, as it is insoluble in water.

In this reaction some impurities *i.e.*, phosphine, hydrogen sulphide, ammonia and arsenic are formed. Passing of ethyne through water absorbs all impurities (except phosphine which is absorbed in acidified $K_2Cr_2O_7$).

2. Preparation from 1, 2-dibromoethane (Ethylene dibromide)

When ethylene dibromide (1, 2-dibromoethane) is boiled with alcoholic potassium hydroxide, ethyne is formed.

$$\begin{array}{l}CH_2Br\\|\\CH_2Br\end{array} + 2KOH \xrightarrow[(alc.)]{\text{Boiling}} \underset{\text{Ethyne}}{CH \equiv CH} + 2KBr + 2H_2O$$

Properties

Various physical and chemical properties of ethyne are as follow

1. Physical Properties

(i) It is a gas at ordinary temperature. It is slightly lighter than air.

(ii) It is colourless.

(iii) It has Garlic like odour.

(iv) It is slightly soluble in water but highly soluble in organic solvents.

(v) Its melting point is 82° C and boiling point is 75°C.

2. Chemical Properties

Due to the presence of triple bond between two carbon atoms, ethyne is highly reactive and *give following chemical reactions*

(i) **Oxidation of Ethyne** (Combustion reaction) Ethyne burns in air with a sooty flame because it has high carbon content. All the carbons of ethyne does not burn completely in air. Some of the carbon particles escape unburnt and make flame sooty. Ethyne burns in excess of air with a brilliant white flame to produce CO_2 and H_2O.

$$\underset{\text{Ethyne}}{2CH \equiv CH} + 5O_2 \longrightarrow 4CO_2 + 2H_2O + \text{Heat}$$

Oxidation using oxidising agent such as alk. $KMnO_4$

$$HC \equiv CH + 4O \xrightarrow[\substack{\text{(Baeyer 's}\\\text{reagent)}}]{\text{Alk. } KMnO_4} \begin{array}{l}COOH\\|\\COOH\end{array}$$

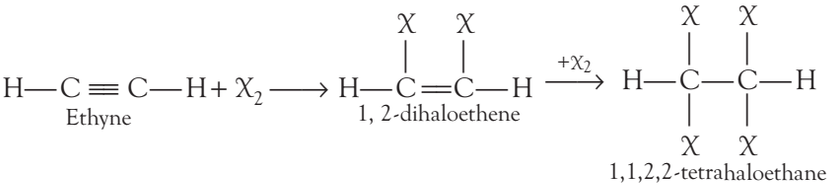
(Oxalic acid)

(ii) **Addition Reaction** Alkynes are unsaturated compounds, so they are associated with addition reaction, as triple bond breaks easily. *The addition of a reagent to ethyne takes place in two steps*

(a) **Addition of Hydrogen** (Catalytic hydrogenation) Ethyne reacts with hydrogen gas in the presence of nickel catalyst to form ethene and finally ethane.

$$\underset{\text{Ethyne}}{CH \equiv CH} \xrightarrow[Ni]{+H_2} \underset{\text{Ethene}}{CH_2 = CH_2} \xrightarrow[Ni]{+H_2} \underset{\text{Ethane}}{CH_3 - CH_3}$$

(b) **Addition of Halogens** If one molecule of halogen (chlorine, bromine, iodine, etc.) is added to ethyne it gives dihaloethene, which is still unsaturated compound and if one more molecule of halogen is added a saturated compound tetra haloethane is formed.

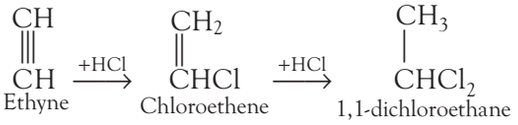


where, $X_2 = Cl_2, Br_2, I_2$

Ethyne reacts vigorously with chlorine gas in the presence of sunlight to give out flames.

$$\underset{\text{Ethyne}}{C_2H_2} + Cl_2 \longrightarrow 2C + 2HCl$$

(iii) **Reaction with HCl** Ethyne reacts with hydrochloric acid to form 1, 1- dichloroethane.



Uses of Ethyne

Some important uses of ethyne are as follow

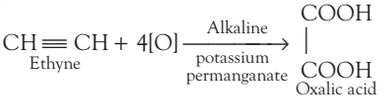
- Used for welding at very high temperature. Its mixture with oxygen is called oxyacetylene.

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O + \text{Heat}$$

The reaction is highly exothermic reaction.

- Used as an illuminant in oxy acetylene lamp.
- Used for artificial ripening and preservation of food.
- Used in the manufacturing of synthetic products like synthetic rubber, fibres, etc.
- Used in the manufacturing of organic compounds like acetic acid, plastic, rubber, etc.

Chemical Tests to Distinguish between Alkanes, Alkenes and Alkynes

Test	**Alkanes** (methane and ethane) **Saturated compound**	**Alkenes** (ethylene) **Unsaturated compound**	**Alkynes** (acetylene) **Unsaturated compound**
On adding a few drops of bromine solution in carbon tetrachloride to the hydrocarbon.	No change is observed.	The reddish brown colour of bromine solution gets decolourised.	The reddish brown colour gets decolourised.
On adding a few drops of alkaline potassium permanganate (purple colour) to the hydrocarbon.	No change is observed.	The purple colour fades.	The purple colour fades. (Baeyer's test) 
On adding a few drops of ammoniacal cuprous chloride to hydrocarbon.	No change is observed.	No change is observed.	Red precipitate of copper acetylide is formed.
On adding ammoniacal silver nitrate to the hydrocarbon .	No change is observed	No change is observed	White precipitate of silver acetylide is formed.

CHECK POINT 04

1. Compare the structures of ethyl acetylene and dimethyl acetylene. What similarities or differences do you notice? Do they fall in any special category of compounds?
2. Write the formation of 1, 1, 2, 2-tetrachloroethane from ethyne.
3. How is acetylene prepared in the laboratory?
4. Write the reaction of oxyacetylene that takes place during a welding process.
5. How does bromine solution in CCl_4 helps to distinguish alkanes and alkenes?

SUMMARY

- Hydrocarbons are the compounds of carbon and hydrogen only. Hydrocarbons are mainly obtained from coal and petroleum, which are the major sources of energy.
- Hydrocarbons are classified as saturated compounds (alkanes) and unsaturated compounds (alkenes and alkynes), cyclic (alicyclic) and aromatic, according to their structure.
- Methane can be obtained by following reactions

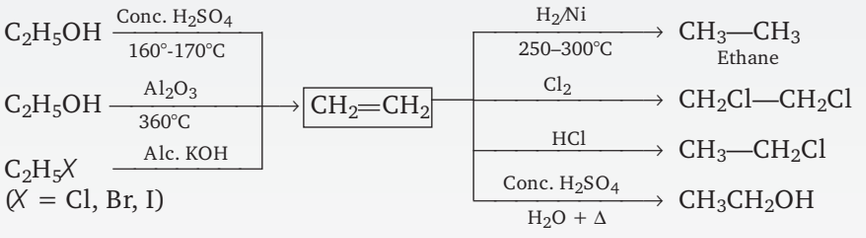
  (a) $CH_3I + 2[H] \longrightarrow CH_4 + HI$

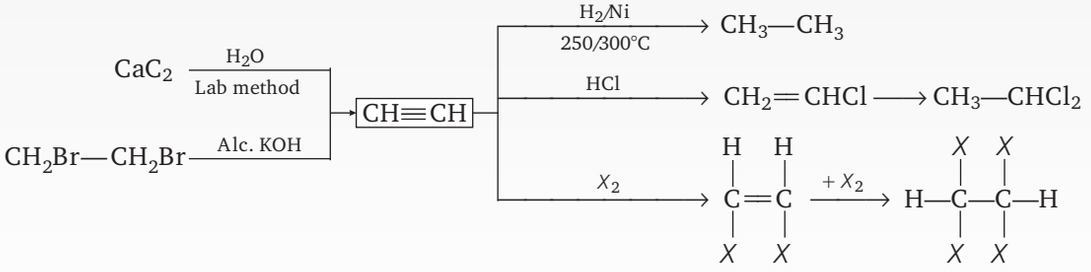
  (b) $CH_3COO^-Na^+ + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + CH_4\uparrow$
- Ethane can be obtained by following reactions

  (a) $C_2H_5Br + 2[H] \longrightarrow C_2H_6 + HBr$

  (b) $C_2H_5COO^-Na^+ + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + C_2H_6\uparrow$
- Alkanes (methane and ethane) react with halogens in the presence of sunlight and give alkyl halides.

Preparations and properties of alkenes may be summarised as





EXAM PRACTICE

Fill in the Blanks

1. ..... forms chloroform on halogenation in the presence of sunlight.

Sol. Methane

2. ..... and ..... is formed on complete combustion of ethane.

Sol. CO_2, H_2O

3. The alkane forms an (i) ..... series with the general formula (ii) ..... . The alkanes are (iii) ..... hydrocarbon which generally undergo (iv) ..... reactions.

Sol. (i) homologous
(ii) C_nH_{2n+2}
(iii) saturated
(iv) substituted

4. Alkenes are also called ..... .

Sol. olefins

5. ..... is a planar molecule.

Sol. Ethene

6. Choose the correct word/phrase from within the brackets to complete the following sentences
The catalyst used for the conversion of ethene to ethane is commonly ..... . (nickel/iron/cobalt) ***[2011]***

Sol. Nickel

7. ..... will give acetylene gas when treated with water.

Sol. CaC_2

8. ..... can be used for ripening of many raw fruits.

Sol. Ethene

9. Acetylene is a (i) ..... gas with an (ii) ..... like odour when it is in pure form. It is (iii) ..... soluble in water (iv) ..... soluble in organic solvent. It is (v) ..... than air.

Sol. (i) colourless (ii) ether
(iii) negligibly (iv) but highly
(v) lighter

10. Conversion of ethene to ethane is an example of ..... (hydration/hydrogenation).

Sol. hydrogenation

11. The compound formed when ethene reacts with hydrogen is ..... . (CH_4, C_2H_6, C_3H_8).

Sol. C_2H_6

Multiple Choice Questions

12. If the molecular formula of an organic compound is $C_{10}H_{18}$, it is ***[2017]***

(a) alkene
(b) alkane
(c) alkyne
(d) not a hydrocarbon

Sol. (c)

13. A gas which is also known as marsh gas.

(a) Ethane (b) Methane
(c) Ethene (d) None of these

Sol. (b)

14. Chlorine on reacting with methane gives ..... as the final product.

(a) chloromethane (b) hydrogen chloride
(c) carbon tetrachloride (d) None of these

Sol. (c)

15. The unsaturated hydrocarbons undergo ***[2011]***

(a) a substitution reaction (b) an oxidation reaction
(c) an addition reaction (d) None of these

Sol. (c)

16. The compound that should be heated with soda lime to obtain ethane gas in the laboratory is

(a) sodium propionate (b) ethene
(c) sulphuric acid (d) None of these

Sol. (a)

17. The organic compound which undergoes substitution reaction is. ***[2018]***

(a) C_2H_2 (b) C_2H_4
(c) $C_{10}H_{18}$ (d) C_2H_6

Sol. (d)

18. What will be the product formed for the following reaction?

$$C_2H_6 + O_2 \xrightarrow[\text{Cu tube, 475K}]{\text{120 atm}} A$$

(a) Acid (b) Alcohol
(c) Carbon dioxide (d) None of these

Sol. (b)

Match the Following

19. Match the following columns.

Column I	Column II
(i) $C_2H_5OH \xrightarrow[300°C]{Al_2O_3} C_2H_4 + H_2O$	(a) Dehydrohalogenation
(ii) $C_2H_4 + H_2 \xrightarrow[Ni]{200°C} \underset{\text{Ethane}}{C_2H_6}$	(b) Addition
(iii) $C_2H_5X + KOH \longrightarrow C_2H_4 + KX + H_2O$	(c) Dehydration
(iv) $CH_2{=}CH_2 + Cl_2 \longrightarrow$ $\underset{\vert\quad\vert}{CH_2{-}CH_2}$ (Cl, Cl)	(d) Hydrogenation

Sol. (i) → (c), (ii) → (d), (iii) → (a), (iv) → (b)

20. Match the following columns.

	Column I		Column II
(i)	Methane	(a)	Present in coal gas (trace amount).
(ii)	Ethane	(b)	Present in the air exhaled by animals whose food is made up of cellulose.
(iii)	Ethene	(c)	Occurs to the extent of 4% in natural gas, along with methane.
(iv)	Ethyne	(d)	Occurs as a plant hormone and responsible for the ripening of fruits.

Sol. (i) → (b), (ii) → (c), (iii) → (d), (iv) → (a)

a 1 Mark Questions

21. What are hydrocarbons?

Sol. Hydrocarbons are the covalent compounds of carbon and hydrogen.

22. What are the main types (groups) of aliphatic hydrocarbons?

Sol. (i) Saturated aliphatic hydrocarbons *e.g.,* Methane and ethane.
(ii) Unsaturated aliphatic hydrocarbons *e.g.,* Ethene and ethyne.

23. Write the equation for the preparation of carbon tetrachloride from methane. *[2006]*

Sol. $CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$

24. Write a balanced chemical equation for preparation of methane from iodomethane. *[2017]*

Sol. Iodomethane is reduced by nascent hydrogen at ordinary room temperature to give methane.

$$CH_3I + 2[H] \longrightarrow \underset{\text{Methane}}{CH_4} + HI$$

25. Write the balanced equation for the following reaction. Preparation of ethane from sodium propionate. *[2014, 2005]*

Sol. $\underset{\text{Sodium propionate}}{C_2H_5COO^-Na^+} + \underset{\text{Sodalime}}{NaOH} \xrightarrow[300°C]{CaO} Na_2CO_3 + C_2H_6\uparrow$

26. Write the balanced equation for the following. Ethane is burnt in air.

Sol. $2C_2H_6 + 7O_2 \xrightarrow{\Delta} 4CO_2 + 6H_2O + \text{Heat}$

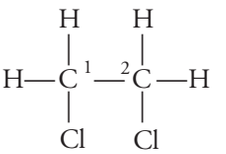
27. Give equation and condition under which ethane gets converted into ethyl alcohol.

Sol. Ethane into ethyl alcohol.

$$2C_2H_6 + O_2 \xrightarrow[\text{Cu tubes, 475K}]{\text{120 atm}} \underset{\text{Ethyl alcohol}}{2C_2H_5OH}$$

28. Ethylene forms an addition product with chlorine. Name this addition product and write its structural formula.

Sol.



1,2-dichloroethane

29. Name a compound that can be used to prepare ethylene by the dehydration of ethanol.

Sol. Concentrated sulphuric acid or Al_2O_3 (aluminium oxide).

30. State how the following conversion can be carried out? Ethyl chloride to ethene. *[2009]*

Sol. Ethyl chloride reacts with alcoholic potassium hydroxide solution to give ethene.

$$\underset{\text{Ethyl chloride}}{C_2H_5Cl} + \underset{\text{(Alc.)}}{KOH} \longrightarrow \underset{\text{Ethene}}{C_2H_4} + KBr + H_2O$$

31. From the given compounds:
Ethane, ethene, ethanoic acid, ethyne, ethanal
Homologue of homologous series with general formula C_nH_{2n}. ***[2005]***

Sol. Ethene.

32. Name the first member of alkyne.

Sol. Ethyne (acetylene)

33. Give an example of isomer shown by triple bond hydrocarbon and write its IUPAC name.

Sol. $CH_3—CH_2—C\equiv CH$, $CH_3—C\equiv C—CH_3$
(IUPAC name: But-1-yne) (IUPAC name: But-2-yne)

34. State one observation for the following.
Bromine vapours are passed into a solution of ethyne in carbon tetrachloride. ***[2012]***

Sol. Reddish brown colour of bromine water disappears.

35. Find out the odd one from the following.
$C_5H_{10}, C_2H_4, C_3H_6, C_4H_8, C_6H_{10}$

Sol. C_6H_{10}, is an alkyne (all others are alkene).

36. Why ethyne burns in oxygen with a sooty flame?

Sol. Ethyne (C_2H_2) is an hydrocarbon that contains carbon content. All the carbon particles do not oxidised completely. Thus, it burns with sooty flame.

37. Identify the term or substance based on the description given below.
Hydrocarbon containing a triple bond used for welding purposes. ***[2017]***

Sol. Ethyne

38. Distinguish between the following pair of compound. Ethane and ethene (using alkaline potassium permanganate solution). ***[2014, 2013]***

Sol. With ethane, the purple colour of potassium permanganate remains unfaded while with ethene, the purple colour gets decolourised or fades.

b 2 Marks Questions

39. Name ***[2015]***
(i) the process by which ethane is obtained from ethane.
(ii) a hydrocarbon which contributes toward the greenhouse effect.

Sol. (i) Hydrogenation (addition of hydrogen) ***[1]***
(ii) Methane (CH_4) ***[1]***

40. Why alkanes are known as
(i) paraffins?
(ii) saturated hydrocarbons?

Sol. (i) Paraffins means little affinity. Alkanes are relatively unreactive under ordinary conditions, so they are known as paraffins. ***[1]***
(ii) These compounds are also known as saturated hydrocarbons, since, all the four valencies of carbon are fully satisfied in the formula C_nH_{2n+2} by a single bond.
(C — C and C — H single bonds) ***[1]***

41. Write the balanced chemical equation for the following. ***[2011]***
(i) A mixture of soda lime and sodium acetate is heated.
(ii) Water is added to calcium carbide.

Sol. (i) $CH_3CO\overset{-}{O}\overset{+}{Na} + NaOH \xrightarrow[\Delta]{CaO} C_2H_6 + Na_2CO_3$ ***[1]***

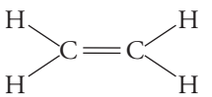
(ii) $CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$ ***[1]***

42. Equation for the reaction when compound *A* is bubbled through bromine dissolved in carbon tetrachloride is as follows.

$$A \xrightarrow{Br_2/CCl_4} \begin{matrix} CH_2Br \\ | \\ CH_2Br \end{matrix}$$

(i) Draw the structure of *A*.
(ii) State your observation during this reaction. ***[2016]***

Sol. (i)



[1]

(ii) Ethene undergo addition reaction to give 1,2-dibromoethane. ***[1]***

43. Give a balanced chemical equation for each of the following.
(i) Preparation of ethane from sodium propionate.
(ii) Action of alcoholic KOH on bromoethane. ***[2017]***

Sol. (i) $\underset{\text{Sodium propionate}}{C_2H_5COO^-\ Na^+} + NaOH \xrightarrow[300\,^\circ C]{CaO}$

$Na_2CO_3 + \underset{\text{Ethane}}{C_2H_6}\uparrow$ ***[1]***

(ii) Action of alcoholic KOH on bromoethane gives ethene as major product

$\underset{\text{Ethyl bromide}}{C_2H_5Br} + \underset{\text{Alcoholic}}{KOH} \longrightarrow \underset{\text{Ethene}}{C_2H_4} + KBr + H_2O$ ***[1]***

44. State the condition required for the following reactions to take place.
(i) Preparation of ethyne from ethylene dibromide.
(ii) Catalytic hydrogenation of ethyne. *[2014]*

Sol. (i) Refer to text on page 228. *[1]*
(ii) Refer to text on page 228. *[1]*

45. Select from the gases written below that matches the description that follows. *[2015]*
[Ethane, ethene, ethyne, propyne]
(i) This gas is used for welding purposes.
(ii) This gas is also a saturated hydrocarbon.

Sol. (i) Ethyne *[1]*
(ii) Ethane *[1]*

46. Give the balanced chemical equations for the following conversions. *[2015]*
(i) Calcium carbide to ethyne.
(ii) Sodium ethanoate to methane.

Sol. (i) $\underset{\text{Calcium carbide}}{CaC_2} + 2H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Acetylene}}{C_2H_2}\uparrow$ *[1]*

(ii) $\underset{\text{Sodium ethanoate}}{CH_3COO^-Na^+} + NaOH \xrightarrow[300\,^\circ C]{CaO} Na_2CO_3 + \underset{\text{Methane}}{CH_4}\uparrow$
Sodium carbonate *[1]*

47. Give the balanced equations for the laboratory preparation of the following organic compounds.
(i) A saturated hydrocarbon from iodomethane.
(ii) An unsaturated hydrocarbon from calcium carbide. *[2013]*

Sol. (i) $2CH_3I + 2Na \xrightarrow[\text{Ether}]{\text{Dry}} \underset{\text{Ethane}}{C_2H_6} + 2NaI$ *[1]*

(ii) $\underset{\text{Calcium carbide}}{CaC_2} + 2H_2O \longrightarrow Ca(OH)_2 + \underset{\text{Ethyne}}{C_2H_2}$ *[1]*

48. Give reasons for the following. *[2012]*
(i) Methane does not undergo addition reactions, but ethene does.
(ii) Ethyne is more reactive than ethane.

Sol. (i) Methane does not undergo addition reaction because it is single covalent bonded with four hydrogen atoms. While ethene has double covalent bond. Double bond in ethene breaks and provide site for addition. *[1]*
(ii) Ethyne (H—C≡C—H) has triple covalent bond which is less stable. Hence, it is more reactive than single covalent bond in ethane. *[1]*

49. Identify the term/substance in each of the following *[2016]*
(i) The catalyst used in the conversion of ethyne to ethane.
(ii) The type of reactions alkenes undergo.

Sol. (i) Nickel catalyst *[1]*
(ii) Addition reaction. *[1]*

50. Give a chemical test to distinguish between saturated and unsaturated compounds.

Sol.

Test	Saturated compounds	Unsaturated compounds
On adding a few drops of bromine solution in carbon tetrachloride to the hydrocarbon bond.	No change is observed.	The reddish brown colour of bromine gets decolourised.

[2]

C 3 Marks Questions

51. (i) How is ethene prepared by the dehydrohalogenation reaction?
(ii) Give the conditions and the main product formed by the hydrogenation of ethylene.

Sol. (i) When chloroethane reacts with alcoholic and concentrated potassium hydroxide solution, ethene is formed.

$\underset{\text{Chloroethane}}{C_2H_5Cl} + \underset{\text{(Alc.)}}{KOH} \longrightarrow \underset{\text{Ethene}}{C_2H_4} + KCl + H_2O$ *[1]*

(ii) **Conditions for Hydrogenation of Ethene** At ordinary temperature platinum or palladium catalyst is used.

At 200°C temperature, nickel catalyst is used. *[1]*

Reactions $\underset{\text{Ethene}}{C_2H_4} + H_2 \xrightarrow{\text{Pt/Pd}} \underset{\text{Ethane}}{C_2H_6}$

or $\underset{\text{Ethene}}{C_2H_4} + H_2 \xrightarrow[\text{Ni}]{200^\circ C} \underset{\text{Ethane}}{C_2H_6}$ *[1]*

52. Write a balanced chemical equation for each of the following.
(i) Burning of ethane in plentiful supply of air.
(ii) Action of water on calcium carbide.
(iii) Heating of ethanol at 170°C in the presence of conc. sulphuric acid. *[2016]*

Sol. (i) $\underset{\text{(Ethane)}}{2C_2H_6} + 7O_2 \longrightarrow 4CO_2 + 6H_2O$ *[1]*

(ii) $\underset{\text{(Calcium carbide)}}{CaC_2} + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2 \uparrow$ *[1]*

(iii) $CH_3CH_2OH \xrightarrow[170\,^\circ C]{\text{Conc. } H_2SO_4} \underset{\text{(Alkene)}}{CH_2 = CH_2} + H_2O$ *[1]*

d 4 Marks Questions

53. (i) How is methane prepared in laboratory?
(ii) Write the conversion of ethane from bromoethane.

Sol. (i) Refer to text on page 224. *[2]*

(ii) Bromoethane is reduced by nascent hydrogen at room temperature.

$$\underset{\text{Bromoethane}}{C_2H_5Br} + 2[H] \longrightarrow \underset{\text{Ethane}}{C_2H_6} + HBr$$

The nascent hydrogen is produced by the action of Zn powder and dilute HCl. *[2]*

54. (i) How can polychlorination of methane be minimised experimentally?
(ii) Write the name of all possible organic products in the reaction of methane with chlorine.
(iii) Why alkanes are insoluble in water?

Sol. (i) If excess of methane over chlorine is used, the reaction of chlorine with methane is increased. *[1]*

(ii) Methylchloride CH_3Cl
Dichloromethane CH_2Cl_2
Trichloromethane $CHCl_3$
Tetrachloromethane CCl_4 *[2]*

(iii) Because alkanes are hydrophobic hydrocarbons, they are insoluble in water and cannot make hydrogen bond with water molecule. *[1]*

55. (i) State how the following conversions can be carried out.
(a) Ethyl chloride to ethene
(b) Ethene to ethyl alcohol
(ii) Give one example of each
(a) addition reaction
(b) substitution reaction

Sol. (i) (a) $C_2H_5Cl + KOH(alc.) \longrightarrow C_2H_4 + KCl + H_2O$ *[1]*

(b) $C_2H_4 + H_2O \xrightarrow{H^+} C_2H_5OH$ *[1]*

(ii) (a) Addition reaction

$$\underset{\text{Ethene}}{C_2H_4} + Cl_2 \longrightarrow \underset{Cl}{\underset{|}{CH_2}} - \underset{Cl}{\underset{|}{CH_2}}$$ *[1]*

(b) Substitution reaction

$$\underset{\text{Methane}}{CH_4} + 3Cl_2 \xrightarrow[\text{sunlight}]{\text{Diffused}} CHCl_3 + 3HCl$$ *[1]*

56. (i) Give a chemical test to distinguish between ethene and ethyne.
(ii) What is the molecular formula of an alkyne, if there are six H-atoms in it?
(iii) Complete and balance the following equations.

(a) $CH_4 \xrightarrow[F]{Cl_2} A \xrightarrow[G]{Cl_2} B \xrightarrow[H]{Cl_2} C \xrightarrow[I]{Cl_2} D$

(b) $C_2H_4 + 3O_2 \longrightarrow$

Sol. (i) **Baeyer's test**
On adding few drops of alkaline potassium permanganate to ethyne. The purple colour of the solution fade away.

$$\underset{\text{Ethyne}}{CH \equiv CH} + 4[O] \xrightarrow[KMnO_4]{\text{Alkaline}} \underset{\text{Oxalic acid}}{\underset{COOH}{\underset{|}{COOH}}}$$ *[1]*

While no change in colour is observed in ethene

$$\underset{\text{Ethene}}{CH_2 = CH_2} + 4[O] \xrightarrow[KMnO_4]{\text{Alkaline}} \text{No change in colour.}$$

[1]

(ii) $H^1 - C \equiv C - \underset{H^2}{\underset{|}{\overset{6}{\overset{|}{C}}}} - \underset{H^3}{\underset{|}{\overset{5}{\overset{|}{C}}}} - H^4$

C_4H_6 – Butyne *[1]*

(iii) (a) $CH_4 \xrightarrow[-HCl]{Cl_2} CH_3Cl \xrightarrow[-HCl]{Cl_2} CH_2Cl_2 \xrightarrow[-HCl]{Cl_2} CHCl_3 \xrightarrow[-HCl]{Cl_2} CCl_4$

(b) $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O + \text{Heat}$ *[1]*

e 5 Marks Questions

57. (a) What do you observe

(i) when alkanes burn in an insufficient supply of oxygen?

(ii) alkane on heating at high temperature in the absence of air?

(iii) during the catalytic oxidation of alkanes?

(b) Write the two uses of ethane.

Sol. (a) (i) Carbon monoxide and water is formed. ***[1]***

(ii) Alkane on heating at high temperature (in the absence of air) broken down into lower alkanes, alkenes and hydrogen.

e.g., $\underset{\text{Ethane}}{H_3C-CH_3} \xrightarrow{500°C} \underset{\text{Ethene}}{H_2C=CH_2} + H_2$ ***[1]***

(iii) Alkanes on controlled oxidation or catalytic oxidation give alcohols, aldehyde or carboxylic acids, depending upon the reaction conditions. ***[1]***

(b) Refer to text on page 227. ***[2]***

58. Compound *A* is bubbled through bromine dissolved in carbon tetrachloride and the product is CH_2Br-CH_2Br.

$$A \xrightarrow{Br_2/CCl_4} CH_2Br-CH_2Br$$

(i) Draw the structural formula of *A*.

(ii) What type of reaction has *A* undergone?

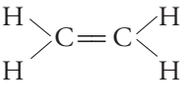
(iii) What is your observation?

(iv) Name (not formula) the compound formed when steam reacts with *A* in the presence of an acid.

(v) What is the procedure for converting the product of (iv) back to *A*? ***[2010]***

Sol. (i) *A* is ethene.

Structural formula is

 ***[1]***

(ii) Addition reaction. ***[1]***

(iii) Orange colour of bromine disappears due to the formation of the colourless ethylene bromide. ***[1]***

(iv) Ethanol (or ethyl alcohol)

$$CH_2=CH_2 + H_2O \xrightarrow{H^+} C_2H_5OH$$ ***[1]***

(v) Dehydration of ethanol by conc. H_2SO_4. ***[1]***

59. Complete the following table which relates to the homologous series of hydrocarbons.

General formula	IUPAC name of the homologous series	Characteristic bond type	IUPAC name of the first member of the series
C_nH_{2n-2}	(A)	(B)	(C) .....
C_nH_{2n+2}	(D)	(E)	(F) .....

Sol. (a) ***[2018] [5]***

General formula	IUPAC name of the homologous series	Characteristic bond type	IUPAC Name of the first member of the series
C_nH_{2n-2}	(A) Alkynes	(B) Triple bond	(C) Ethyne
C_nH_{2n+2}	(D) Alkane	(E) Single covalent bond	(F) Methane

CHAPTER EXERCISE

Fill in the Blanks

1. The formula of ethane is ..... .

2. Methane and ethane burn in air with (i) ..... and (ii) ..... flame to form (iii) ..... and (iv) ..... vapour. A large amount of (v) ..... is also produced. So, alkanes are (vi) ..... fuels.

3. ..... catalyst can be used for the conversion of ethene to ethane.

Multiple Choice Questions

4. The formula of methane is

(a) CH_4 (b) CH_3
(c) CH_2 (d) C_2H_6

5. The formula of 1, 1, 2, 2-tetrachloroethane is

(a) C_2Cl_6 (b) C_2HCl_5
(c) $C_2H_2Cl_4$ (d) None of these

6. An organic compound undergoes addition reaction and gives a red colour precipitate with ammoniacal cuprous chloride. Therefore, the organic compound could be *[2010]*

(a) ethane (b) ethene
(c) ethyne (d) ethanol

7. The formation of 1,2-dibromoethane from ethene and bromine is an example of

(a) substitution
(b) dehydration
(c) dehydrohalogenation
(d) addition

Match the Following

8. Match the following columns.

	Column I		Column II
(i)	$C_2H_5OH \xrightarrow[300°C]{Al_2O_3}$	(a)	Ethane
(ii)	$C_2H_4 + H_2 \xrightarrow[Ni]{200°C}$	(b)	Ethyne
(iii)	$Br—CH_2—CH_2—Br + \text{alc. KOH} \xrightarrow{Boil}$	(c)	Ethyl hydrogen sulphate
(iv)	$CH_3CH_2OH + H_2SO_4 \rightarrow$	(d)	Ethene

9. Match the following columns.

	Column I		Column II
(i)	Alkane	(a)	C_nH_{2n+2}
(ii)	Alkene	(b)	C_nH_{2n-2}
(iii)	Alkyne	(c)	C_nH_{2n}

1 Mark Questions

10. What is the ratio of methane and oxygen (mixture) required for the formation of methanol?

11. What happens when methane gas is burnt in air?

12. What is the special feature of the structure of ethyne?

13. Write the equation for the laboratory preparation of ethane from iodomethanes.

2 Marks Questions

14. (i) Write the equation for the complete combustion of ethane.

(ii) Using appropriate catalysts, ethane can be oxidised to an alcohol, an aldehyde and an acid. Name the alcohol, aldehyde and acid formed when ethane is oxidised.

15. Write the balanced chemical equations for the following reaction.

(i) Ethane and oxygen in the presence of molybdenum oxide.

(ii) Preparation of methane from anhydrous sodium ethanoate (sodium acetate).

16. (i) How is ethene prepared by the dehydration reaction?

(ii) How is gas collected during laboratory preparation of ethylene?

17. (i) Draw all the possible isomers of butene?

(ii) Draw the structure of C_3H_6 and write its IUPAC name.

18. Why ethene undergoes addition reaction with halogen whereas ethane undergoes substitution reaction?

19. (i) Write the molecular formula of alkane, which is composed of 16 H-atoms.

(ii) Name the compound that gives acetylene gas, when treated with water.

3 Marks Questions

20. The type of reaction between ethene and chlorine is different from ethane and chlorine.

(i) What features of the ethene structure makes such reaction possible?

(ii) What type of reaction occurs between ethene and chlorine?

(iii) Name the product of the reaction between ethene and chlorine.

21. Give the chemical equation for

(i) The laboratory preparation of methane from sodium acetate.

(ii) the reaction of one mole of ethene with one mole of chlorine gas.

(iii) the preparation of ethyne from 1,2-dibromoethane.

4 Marks Question

22. (i) A hydrocarbon *A* that decolourises potassium permanganate solution but does not form any precipitate with ammoniacal $AgNO_3$. Is the hydrocarbon saturated or unsaturated? What type of bonds formed between two carbon atoms?

(ii) What happens when a few drops of bromine is added to this hydrocarbon?

5 Marks Questions

23. (i) Why alkanes give substitution reaction but not addition reaction?

(ii) Explain Wurtz reaction.

24. What do you mean by

(i) hydrogenation?

(ii) halogenation?

(iii) substituted product?

25. Answer the following questions.

(i) Write reaction for preparation of ethene from iodoethane.

(ii) Name the product formed when water is added to calcium carbide. Also write its reaction.

(iii) Name a saturated hydrocarbon formed from iodomethane.

(iv) Name an unsaturated hydrocarbon formed from an alcohol.

$$C_2H_5OH + H_2SO_4 \xrightarrow{\Delta} C_2H_4 + H_2SO_4 + H_2O$$

(v) Name the catalyst used for conversion of ethene to ethane.

ARCHIVES*

(Last 5 Years)

Collection of Questions Asked in Last 5 Years' (2018-2014) ICSE Class 10th Examinations

2018

1 The organic compound which undergoes substitution reaction is.
(a) C_2H_2 (b) C_2H_4 (c) $C_{10}H_{18}$ (d) C_2H_6 *[1]*

2 Complete the following table which relates to the homologous series of hydrocarbons. *[5]*

General formula	IUPAC name of the homologous series	Characteristic bond type	IUPAC name of the first member of the series
C_nH_{2n-2}	(A)	(B)	(C) .....
C_nH_{2n+2}	(D)	(E)	(F) .....

2017

3 If the molecular formula of an organic compound is $C_{10}H_{18}$, it is *[1]*
(a) alkene (b) alkane
(c) alkyne (d) not a hydrocarbon

4 Identify the term or substance based on the description given below.
Hydrocarbon containing a triple bond used for welding purposes. *[1]*

5 Write a balanced chemical equation.
Preparation of methane from iodomethane. *[1]*

6 Give a balanced chemical equation for each of the following.
(i) Preparation of ethane from sodium propionate.
(ii) Action of alcoholic KOH on bromoethane. *[2]*

2016

7 Identify the term/substance in each of the following:
(i) The catalyst used in the conversion of ethyne to ethane.
(ii) The type of reactions alkenes undergo. *[2]*

8 Equation for the reaction when compound *A* is bubbled through bromine dissolved in carbon tetrachloride is as follows:

$$A \xrightarrow{Br_2/CCl_4} \begin{matrix} CH_2Br \\ | \\ CH_2Br \end{matrix}$$

(i) Draw the structure of *A*.
(ii) State your observation during this reaction. *[2]*

9 Write a balanced chemical equation for each of the following.
(i) Burning of ethane in plentiful supply of air.
(ii) Action of water on calcium carbide.
(iii) Heating of ethanol at 170°C in the presence of conc. sulphuric acid. *[3]*

2015

10 Name
(i) the process by which ethene is obtained from ethane.
(ii) a hydrocarbon which contributes towards the green house effect. *[2]*

11 Give the balanced chemical equations for the following conversions.
(i) Calcium carbide to ethyne.
(ii) Sodium ethanoate to methane. *[2]*

12 Select from the gases written below that matches the description that follows.
Ethane, ethene, ethyne, propyne
(i) This gas is used for welding purposes.
(ii) This gas is also a saturated hydrocarbon. *[2]*

2014

13 Write the balanced equation for the following reaction.
Preparation of ethane from sodium propionate. *[1]*

14 Distinguish between the following pair of compound.
Ethane and ethene (using alkaline potassium permanganate solution) *[1]*

15 State the conditions required for the following reactions to take place.
(i) Preparation of ethyne from ethylene dibromide
(ii) Catalytic hydrogenation of ethyne *[2]*

16 Match the following columns.

	Column I		Column II
(i)	Alkyne	(a)	C_nH_{2n+2}
(ii)	Alkane	(b)	C_nH_{2n-2}

[2]

CHALLENGERS*

1 Among the following, which alkane is expected to have lowest boiling point.
(a) Hexane (b) 2-methylpentane
(c) 3-methylpentane (d) 2,2-dimethyl butane

2 Which of the following reactions will not produce ethane?
(a) Reduction of CH_3COOH with HI/P_4 (b) Reduction of CH_3COCH_3 with HI/P_4
(c) Sodalime decarboxylation of sodium propionate (d) Hydrogenation of ethane in the presence of Ni

3 Which of the following alkane contains pri, sec, tert as well as quaternary C-atoms?
(a) $(CH_3)_3CH$ (b) $(C_2H_5)_3CH$
(c) $(CH_3)_3CCH_2CH(CH_3)_2$ (d) $(CH_3)_4C$

4 Oxidation of but-1-ene with hot $KMnO_4$ solution produces
(a) $CH_3CH_2COOH + HCOOH$ (b) $CH_3CH_2COOH + CO_2$
(c) $CH_3COOH + CO_2$ (d) $(CH_3)_2C{=}O + CO_2$

5 The treatment of *R* MgBr with *R*'C $\equiv$ CH produces
(a) *R*H (b) *R*'H (c) *R*—*R* (d) *R*—*R*'

6 Which isomer of C_5H_{12} gives four isomers of monoiodopentane?
(a) *Neo*-pentane (b) *n*-pentane (c) *Iso*-pentane (d) None of these

7 Which of the following decolourise bromine water as well as Baeyer's reagent?
(a) Propane (b) Cyclopropane (c) Propyne (d) Benzene

8 Which of the following compound has highest boiling point?
(a) *n*-hexane (b) *n*-pentane (c) 2-methylbutane (d) 2, 2-dimethyl propane

9 Which of the following will give only one monochloro derivative on halogenation?
(a) Isopentane (b) Neopentane (c) Isohexane (d) Isoheptane

10 The reagent required to convert but-1-yne to butan-2-one is
(a) dil. H_2SO_4 (b) $ZnCl_2 + HCl$ (c) $Hg^{2+} + H_2SO_4$(dil.) (d) alk. $KMnO_4$

Answers

1. (d) **2.** (b) **3.** (c) **4.** (b) **5.** (a) **6.** (c) **7.** (c) **8.** (a) **9.** (b) **10.** (c)

* These questions may or may not be asked in the examination, have been given just for additional practice

CHAPTER

11

Alcohols

Alcohol is formed when hydrogen atom in a hydrocarbon is replaced by hydroxyl group (—OH). General formula for an alcohol is $C_nH_{2n+1}OH$, where n stands for number of carbon atoms. Thus in an alcohol, the hydroxyl group (—OH) is bound to a saturated carbon atom. Alcohols find a wide application in industries as well as in day to day life.

Alcohols are classified as mono, di, tri or polyhydric compounds depending on whether they contain one, two, three or many hydroxyl groups in their structures.

Methanol, ethanol are monohydric alcohols. Glycol is dihydric and glycerol is trihydric alcohol.

IUPAC and common names of some alcohols

Molecular formula	Common name	IUPAC name
CH_3OH	Methyl alcohol	Methanol
C_2H_5OH	Ethyl alcohol	Ethanol
C_3H_7OH	Propyl alcohol	Propanol
C_4H_9OH	Butyl alcohol	Butanol

Chapter Objective

- Preparation of Ethanol
- Properties of Ethanol
- Different Commercial Forms of Ethanol
- Alcoholic Beverages
- Uses of Ethanol

Preparation of Ethanol

Ethanol can be prepared by the hydrolysis of alkyl halides. The reaction occurs with a hot dilute alkali like potassium hydroxide (KOH) or sodium hydroxide (NaOH).

$$\underset{\text{Ethyl bromide}}{C_2H_5Br} + NaOH\,(aq) \xrightarrow{\text{Boil}} \underset{\text{Ethanol}}{C_2H_5OH} + NaBr$$

$$\underset{\text{Ethyl chloride}}{C_2H_5Cl} + KOH(aq) \xrightarrow{\text{Boil}} \underset{\text{Ethanol}}{C_2H_5OH} + KCl$$

Properties of Ethanol

The physical and chemical properties of ethanol are as follow

Physical Properties

(i) Ethanol is colourless, have a faint odour and a burning taste.

(ii) **Nature** It is a flammable volatile liquid.

(iii) **Boiling Point** It increases with an increase in molecular weight that is the boiling point of alcohol increases with an increase in number of carbon atoms.

e.g., $CH_3OH\ [32] = 64.5°\,C$

$CH_3CH_2OH\ [46] = 78.3°\,C$

(iv) **Solubility** It is soluble in water.

(v) **Density** Ethanol is lighter than water as its density is 0.79 g cm^{-3} at 20° C.

Chemical Properties

(i) **Combustion** (Burning) Ethyl alcohol burns in air to produce carbon dioxide and water vapours with the generation of large amount of heat during the reaction.

$$\underset{\text{Ethanol}}{C_2H_5OH} + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

Ethanol burns with pale blue flame.

(ii) **Action with Sodium** When sodium reacts with ethanol, then hydrogen gas is evolved with the formation of sodium methoxide and sodium ethoxide, respectively.

$$\underset{\text{Ethanol}}{2C_2H_5OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2\uparrow$$

(iii) **Reaction with Acetic Acid** (Ester formation) Ethanol react with acetic acid in the presence of concentrated sulphuric acid to give ester and the process is known as **esterification**.

$$\underset{\text{Ethanol}}{C_2H_5OH} + \underset{\text{Ethanoic acid}}{CH_3COOH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\substack{\text{Ethyl acetate}\\(\text{Ester})}}{CH_3COOC_2H_5} + H_2O$$

(iv) **Dehydration with Concentrated Sulphuric Acid** When a mixture of ethyl alcohol and concentrated sulphuric acid is heated upto 170°C, dehydration of ethyl alcohol (ethanol) takes place and ethene is formed.

$$\underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[170°C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2{=}CH_2} + H_2O$$

At 140°C, conc. H_2SO_4 dehydrates alcohol to give its respective ethers.

$$\underset{\text{Ethanol}}{2C_2H_5OH} \xrightarrow[140°C]{\text{Conc. } H_2SO_4} \underset{\text{Diethyl ether}}{C_2H_5{-}O{-}C_2H_5} + H_2O$$

Different Commercial Forms of Ethanol

The different commercial forms of ethanol are as follow

Spurious Alcohol

It is an illicit liquor made by improper distillation and contains large proportion of methanol in a mixture of alcohols. It is used in paint industry as solvent.

Absolute Alcohol

It is 100% pure ethyl alcohol, which can be easily obtained by distilling moist alcohol with benzene.

A wide range of organic compounds are soluble in ethyl alcohol, it is the most common industrial solvent. To discourage its misuse as beverage, 5% methyl alcohol is added to it, thus making it unfit for drinking. This is called **denatured alcohol or methylated spirit**. Pyridine or copper sulphate is also used widely to denature the alcohol.

Alcoholic Beverages

These are those which are produced by the fermentation of grapes, maize, sugarcane, etc, and the amount of alcohol is different for different beverages. These beverages contain ethanol as their prime constituent.

Distilled beverage	Percentage of alcohol	Sources
Brandy	40-50%	Grapes
Gin	35-40%	Maize
Rum	45-55%	Sugarcane
Vodka	30-40%	Corn, wheat
Whisky	40-50%	Molasses

Uses of Ethanol

It is

(i) used in the manufacturing of chemicals and synthetic products such as dyes, perfumes, etc.

(ii) used in the alcoholic drinks like wine, beer and whisky, etc.

(iii) used in thermometers due to its low freezing point.

(iv) good solvent for gums and resins.

(v) used as an antiseptic in hospitals.

(vi) used as a thermometric liquid.

CHECK POINT

1 Give the reaction of sodium with ethanol.

2 What is esterification?

3 Write the uses of denatured and spurious alcohols, while discussing the differences between the two.

4 Give the percentage of alcohol in brandy, vodka and whisky.

SUMMARY

- Alcohols are formed when hydrogen atom in hydrocarbon is replaced by hydroxyl group (—OH) and have a general formula $C_nH_{2n+1}OH$.
- Alcohols are further classified as mono, di, tri or polyhydric compounds depending upon the number of hydroxyl groups.
- It is prepared by the hydrolysis of alkyl halides.

$$C_2H_5Br + NaOH(aq) \xrightarrow{\text{Boil}} \underset{\text{Ethanol}}{C_2H_5OH} + NaBr$$

- It is colourless, volatile in nature, possess high boiling point and are highly soluble in water.
- Chemical properties of ethanol are as follow
  (i) It burn in air to give carbon dioxide and water.
  (ii) On reaction with sodium it evolves hydrogen gas.
  (iii) It react with acetic acid to give ester.
  (iv) It undergoes dehydration to form alkene and dialkyl ether.
- Different commercial forms of ethanol are denatured alcohol, spurious alcohol and absolute alcohol.
- Ethanol is used in the manufacture of chemicals, alcoholic drinks, thermometers, preservatives, etc.
- Alcoholic beverages are those beverages which are produced by fermentation of grapes, maize, sugarcane, etc. These beverages contain ethanol as their prime constituent.

EXAM PRACTICE

Fill in the Blanks

1. The conversion of ethanol to ethene is an example of …… . (dehydration, esterification, dehydrogenation).

Sol. dehydration

2. Complete the following sentence. ***[2014]***

The compound formed when ethanol reacts with sodium is …… (sodium ethanoate, sodium ethoxide, sodium propanoate).

Sol. sodium ethoxide

3. 100% pure ethanol is called …… (denatured alcohol, absolute alcohol, spurious alcohol).

Sol. absolute alcohol

Multiple Choice Questions

4. The molecular formula of propyl alcohol is

(a) CH_3OH (b) C_2H_5OH

(c) C_3H_7OH (d) C_4H_9OH

Sol. (c)

5. The reaction of alcohol with acetic acid in the presence of concentrated sulphuric acid is known as

(a) distillation (b) saponification

(c) esterification (d) condensation

Sol. (c)

6. The reaction of ethanol with concentrated H_2SO_4 does not give

(a) ethene (b) diethyl ether

(c) ethyl hydrogen sulphate (d) acetylene

Sol. (d)

7. $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Alkaline } KMnO_4} CH_3COOH$

In the above reaction, alkaline $KMnO_4$ acts as

(a) reducing agent (b) oxidising agent

(c) catalyst (d) dehydrating agent

Sol. (b)

8. The organic compound mixed with ethanol to make it spurious is ***[2010]***

(a) methanol (b) methanoic acid

(c) methanal (d) ethanoic acid

Sol. (a)

Match the Following

9. Match the organic reaction in *X* with the type of reaction in *Y* and the product formed in *Z*.

	X	*Y*	*Z*
(i)	$C_2H_5OH + CH_3COOH$, conc. H_2SO_4	(a) Dehydration	(a_1) Ester
(ii)	$C_2H_5OH + O_2$	(b) Combustion	(b_1) Ethene
(iii)	Ethanol + Al_2O_3 at 350°C	(c) Esterification	(c_1) Carbon dioxide

Sol. (i) – (c) and (a_1) (ii) – (b) and (c_1) (iii) – (a) and (b_1)

a 1 Mark Questions

10. Write the formula for propan-2-ol.

Sol. The formula for propan-2-ol is $CH_3CH(OH)CH_3$

11. Name the gas that is produced in each of the following cases.

Reaction of ethanol and sodium. ***[2018]***

Sol. Hydrogen (H_2) gas

$$\underset{\text{Ethanol}}{2CH_3CH_2OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2CH_3CH_2ONa} + H_2$$

12. Give the balanced equation for the following.

Preparation of ethanol from monochloroethane and aqueous sodium hydroxide.

Sol. $C_2H_5Cl + NaOH(aq) \xrightarrow{\text{Boil}} C_2H_5OH + NaCl$

13. Write balanced chemical equation for the preparation of ethanol from ethyl chloride. ***[2016]***

Sol. $\underset{\text{(Ethyl Chloride)}}{C_2H_5Cl} + KOH(aq) \xrightarrow{\text{Boil}} \underset{\text{(Ethanol)}}{C_2H_5OH} + KCl$

14. Name the distinctive reaction that takes place when ethanol is treated with acetic acid. ***[2015]***

Sol. Esterification.

15. State one relevant observation for the addition of ethyl alcohol to acetic acid in the presence of concentrated sulphuric acid. ***[2017]***

Sol. An ester *i.e.,* ethyl acetate is formed and the process is called esterification.

$$\underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Ethyl alcohol}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + 2H_2O$$

b 2 Marks Questions

16. (i) Identify the following substance. Liquid (*E*) can be dehydrated to produce ethene.
(ii) Give the physical nature and boiling point of ethanol.

Sol. (i) Ethanol is the liquid (*E*) which can be dehydrated to produce ethene. *[1]*
(ii) Refer to text on page 242. *[1]*

17. Write the balanced chemical equation for the following.
(i) Reaction of ethyl alcohol with sodium.
(ii) Ethene from ethanol.

Sol. (i) When sodium reacts with ethyl alcohol, it gives sodium ethoxide and hydrogen.

$$2Na + 2C_2H_5OH \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2 \quad [1]$$

(ii) $CH_3-\underset{\underset{OH}{|}}{CH_2} \xrightarrow[160°C - 170°C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$

Ethylalcohol

[1]

18. (i) Define alcoholic beverages.
(ii) Give the reaction involved in the formation of methyl acetate (ester).

Sol. (i) Alcoholic beverages are those beverages which are produced by the fermentation of grapes, maize, sugarcane, etc. and the amount of alcohol is different for different beverages. *[1]*
(ii) The reaction involved in the formation of methyl acetate (ester) is

$$\underset{\text{Methanol}}{CH_3OH} + \underset{\text{Acetic acid}}{CH_3COOH} \xrightarrow{\text{Conc.}H_2SO_4} \underset{\text{Methyl acetate (Ester)}}{CH_3COOCH_3} + H_2O \quad [1]$$

c 3 Marks Questions

19. State how the following conversion can be carried out?
(i) Ethyl chloride to ethyl alcohol
(ii) Ethene to ethyl alcohol
(iii) Ethyl alcohol to ethene *[2009]*

Sol. (i) $C_2H_5Cl + KOH\,(aq) \xrightarrow{\text{Boil}} C_2H_5OH + KCl$ *[1]*

(ii) $C_2H_4 + H_2O \xrightarrow[80°C,\ 30\,atm]{H^+} C_2H_5OH$ *[1]*

(iii) $C_2H_5OH \xrightarrow[160–170°C]{\text{Conc. } H_2SO_4} C_2H_4 + H_2O$ *[1]*

20. Define the following.
(i) Denatured spirit
(ii) Spurious alcohol
(iii) Absolute alcohol

Sol. (i) A wide range of organic compounds are soluble in ethyl alcohol, it is the most common industrial solvent. To discourage its misuse as beverages, 5% of methyl alcohol is added to it, thus making it unfit for drinking. This is called denatured spirit. *[1]*
(ii) Spurious alcohol is an illicit liquor made by distillation and contains large proportion of methanol in a mixture of alcohols. *[1]*
(iii) Absolute alcohol is 100% pure ethyl alcohol which can be easily obtained by distilling moist alcohol with benzene. *[1]*

d 4 Marks Questions

21. Give two chemical and two physical properties of alcohols.

Sol. *Two chemical properties of alcohols are*
(i) **Reaction with Acetic Acid** Alcohols react with acetic acid in the presence of concentrated sulphuric acid to give ester and the process is known as esterification.

$$\underset{\text{Methanol}}{CH_3OH} + \underset{\text{Acetic acid}}{CH_3COOH} \xrightarrow{\text{Conc.}H_2SO_4} \underset{\text{Methyl acetate}}{CH_3COOCH_3} + H_2O \quad [1]$$

(ii) **Action with Sodium** When sodium reacts with methanol, then hydrogen gas is evolved with the formation of sodium methoxide.

$$\underset{\text{Methanol}}{2CH_3OH} + 2Na \longrightarrow \underset{\text{Sodium methoxide}}{2CH_3ONa} + \underset{\text{(Pop sound)}}{H_2}\uparrow \quad [1]$$

Two physical properties of alcohols are
(i) **Solubility** Alcohols are soluble in water. *[1]*
(ii) **Boiling point** Boiling point of alcohols increases with increase in the molecular weight that is the boiling point of alcohol increases with an increase in number of carbon atoms. *[1]*

22. Give four uses of ethyl alcohol.

Sol. *Four uses of ethyl alcohol*

(i) It is used as a solvent.
(ii) It is used in the manufacture of thermometers.
(iii) It is used in the manufacture of dyes, perfumes, antiseptics, etc.
(iv) It is used in alcoholic drinks. ***[4 × 1 = 4]***

e 5 Marks Questions

23. When an organic compound (*A*) is heated with concentrated H_2SO_4, it forms a compound (*B*) which is able to form compound (*C*), when one mole of hydrogen in the presence of Ni is added to it. When one mole of compound (*C*) undergoes combustion, it forms two moles of CO_2 and three moles of H_2O. Identify the compounds, *A*, *B* and *C* and also write the chemical equations involved in it.

Sol. Since, one mole of compound, *C* on combustion forms two moles of CO_2 and three moles of H_2O, the compound is a hydrocarbon with molecular formula, C_2H_6 which is ethane.

The compound *B* which forms C_2H_6 upon addition of hydrogen is ethene (C_2H_4). The organic compound *A* which forms ethene upon acidic dehydration is ethanol. *The chemical equations for the reactions involved are* ***[3]***

$$\underset{\text{Ethanol }(A)}{C_2H_5OH} \xrightarrow[\text{Heat}]{H_2SO_4} \underset{\text{Ethene }(B)}{CH_2=CH_2} \xrightarrow[\text{Heat}]{H_2/Ni} \underset{\text{Ethane }(C)}{CH_3-CH_3}$$

$$\underset{(C)}{C_2H_6} + 7/2\,O_2 \xrightarrow{\text{Combustion}} 2CO_2 + 3H_2O \quad \textbf{[2]}$$

CHAPTER EXERCISE

Fill in the Blanks

1. The product formed when ethene gas reacts with water in the presence of sulphuric acid is ..... (ethanol/ethanal/ethanoic acid). ***[2010]***

2. ..... is an organic compound which is called as "wood spirit".

Multiple Choice Question

3. The organic compound obtained as the end product by the hydrolysis of methyl bromide

(a) methanol (b) ethanol (c) ethane (d) methanoic acid

Match the Following

4. Match the following columns.

Column I (Beverages)		**Column II** (Percentage of alcohol)
(i) Brandy	(a)	45-55%
(ii) Vodka	(b)	40-50%
(iii) Rum	(c)	35-40%
(iv) Gin	(d)	30-40%

1 Mark Questions

5. Rewrite the statement in the correct form using the appropriate word.

Ethyl alcohol is dehydrated by sulphuric acid at a temperature of about 170°C. ***[2012]***

6. Write the equation for the following laboratory preparation.

Ethanol from iodoethane. ***[2005]***

2 Marks Question

7. (i) Give the laboratory preparation of ethyl alcohol

(ii) Give the product $C_2H_5Cl + KOH(aq) \xrightarrow{\text{Boil}}$ .....

3 Marks Question

8. Write the balanced chemical equations for the following.

(i) Monochloro ethane is hydrolysed with aqueous KOH.

(ii) Combustion of ethanol.

(iii) Ethanol reacts with sodium at room temperature.

4 Marks Question

9. Write the formulae of the products formed in the following reactions.

(i) Reaction of sodium with ethanol.

(ii) Reaction of concentrated sulphuric acid with ethanol.

ARCHIVES*

(Last 8 Years)

Collection of Questions Asked in Last 8 Years' (2018-2009) ICSE Class 10th Examinations

2018

1 Name the gas that is produced in each of the following cases.
Reaction of ethanol and sodium. *[1]*

2017

2 State one relevant observation for the addition of ethyl alcohol to acetic acid in the presence of concentrated sulphuric acid. *[1]*

2016

3 Write balanced chemical equation for the preparation of ethanol from ethyl chloride. *[1]*

2015

4 Name the distinctive reaction that takes place when ethanol is treated with acetic acid. *[1]*

2014

5 Give the balanced equations for the preparation of ethanol from monochloroethane and aqueous sodium hydroxide. *[2]*

6 Complete the following sentence.

The compound formed when ethanol reacts with sodium is …… (sodium ethanoate, sodium ethoxide, sodium propanoate). *[1]*

2012

7 Rewrite the statement in the correct form using the appropriate word.

Ethyl alcohol is dehydrated by sulphuric acid at a temperature of about 170°C. *[2]*

8 Name an organic compound which is used as a thermometric liquid. *[1]*

2010

9 Choose the correct word from the bracket.
The product formed when ethene gas reacts with water in the presence of sulphuric acid is……
(ethanol/ethanal/ethanoic acid). *[1]*

10 The organic compound mixed with ethanol to make it spurious is *[1]*

(a) methanol
(b) methanoic acid
(c) methanal
(d) ethanoic acid

2009

11 The organic compound obtained as the end product of the fermentation of sugar solution is *[1]*

(a) methanol
(b) ethanol
(c) ethane
(d) methanoic acid

CHALLENGERS*

1 $A \xrightarrow[H_2SO_4]{K_2Cr_2O_7} B \xrightarrow[\text{Vigorous oxidation}]{[O]} CH_3COOH$

Identify the reactant *A*.

(a) Ethyl alcohol (b) *Iso*-propyl alcohol (c) Propyl alcohol (d) *tert*-pentyl alcohol

2 Fermentation is an

(a) exothermic reaction (b) endothermic reaction (c) reversible reaction (d) None of these

3 The correct order of decreasing boiling point of following alcohols is

I. pentan-1-ol II. 2-methyl butan-2-ol III. 3-methyl butan-2-ol

(a) I > III > II (b) II > III > I (c) I > II > III (d) III > II > I

4 Wine (alcoholic beverage) mainly contains.

(a) CH_3OH (b) C_6H_6 (c) C_2H_5OH (d) CH_3COOH

5 Absolute alcohol can be obtained from rectified spirit by

(a) fractional distillation (b) azeotropic distillation (c) vacuum distillation (d) steam distillation

6 Compound *X* has the molecular formula, C_2H_6O.

X can be made by a fermentation process.

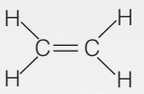
X can be oxidised to *Y*.

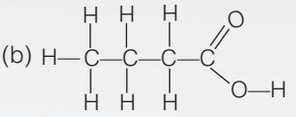
X can react with *Y* to form *Z* and water.

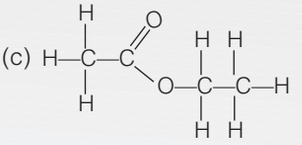
To which homologous series do *X*, *Y* and *Z* belong?

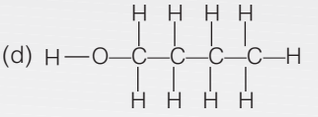
	X	*Y*	*Z*
(a)	Alcohols	Carboxylic acids	Esters
(b)	Alcohols	Esters	Carboxylic acids
(c)	Carboxylic acids	Alcohols	Esters
(d)	Carboxylic acids	Esters	Alcohols

7 Which structure shows a compound that reacts with ethanol to give a sweet smelling liquid?

(a) 

(b) 

(c) 

(d) 

8 Complete the following sentences related with ethanol by replacing *P*, *Q*, *R* and *S* from the appropriate set of words from the options given below the sentences. When consumed in large quantities, *P* tends to *Q* metabolic processes and *R* the central nervous system, which in turn, results in lack of coordination, drowsiness, mental confusion, etc. To avoid its misuse for drinking, it is mixed with some substances like pyridine. This process is called *S* of alcohol.

	P	*Q*	*R*	*S*
(a)	Methanol	Slow	Depress	Esterification
(b)	Ethanol	Fast	Depress	Saoponification
(c)	Methanol	Fast	Depress	Denaturation
(d)	Ethanol	Slow	Depress	Denaturation

Answers

1. (a) **2.** (a) **3.** (a) **4.** (c) **5.** (b) **6.** (a) **7.** (b) **8.** (d)

* These questions may or may not be asked in the examination, have been given just for additional practice

CHAPTER

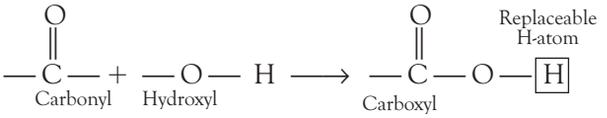
12

Carboxylic Acids

Chapter Objective

- Classification of Carboxylic Acids
- Acetic Acid (CH_3COOH)

The carbon compounds containing carboxyl (—COOH) functional group are known as **carboxylic acids**. Carboxyl group consists of a hydroxyl (— OH) group attached to a carbonyl (>C = O) group, hence it is called carboxyl. Carboxylic acids possess acidic properties due to the presence of the replaceable hydrogen atom in carboxylic group.



General Formula $R—COOH$ or $(C_nH_{2n+1}COOH)$

Functional Group $—\overset{\overset{O}{\|}}{C}—OH$

Carboxylic acids may be aliphatic or aromatic depending upon the groups attached to carboxylic group.

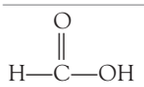
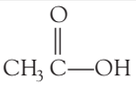
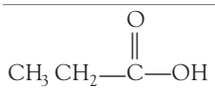
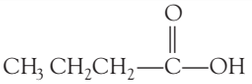
Classification of Carboxylic Acids

The carboxylic acids can be further classified as mono, di or tri carboxylic acids depending on the number of carboxylic (—COOH) group present in their respective molecule.

Formic acid and acetic acid are monocarboxylic acid. Oxalic acid is dicarboxylic acid.

Note Some higher members of monocarboxylic acids of aliphatic series ($C_{12} - C_{18}$) known as fatty acids, occur in natural fats as esters of glycerol e.g., Palmitic acid.

IUPAC and Common Names of Some Carboxylic Acids

Formula	Common name	IUPAC name
	Formic acid	Methanoic acid
	Acetic acid	Ethanoic acid
	Propionic acid	Propanoic acid
	Butyric acid	Butanoic acid

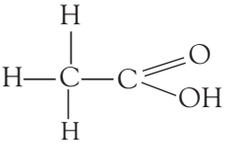
Acetic Acid (CH_3COOH)

It is a fatty acid and the name acetic acid comes from the Latin word '*acetum*' which means vinegar. Vinegar (or sirka) is a dilute (4–5%) solution of acetic acid.

In free state, it occurs in many fruit juices which becomes sour on fermentation. It is present as esters in a number of essential oils and also present in the combined state in plant extracts.

Structure of Acetic Acid

The structural formula of acetic acid is shown below



Preparation

These can be prepared in laboratory as well as in industries as follows

I. Laboratory Preparation

(a) **By the Oxidation of Ethyl Alcohol**

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + [O] \xrightarrow[\text{Acidified}]{K_2Cr_2O_7} \underset{\text{Ethanal or Acetaldehyde}}{CH_3CHO} + H_2O$$

$$\underset{\text{Acetaldehyde}}{CH_3CHO} + [O] \xrightarrow[\text{Acidified}]{K_2Cr_2O_7} \underset{\text{Acetic acid}}{CH_3COOH}$$

(b) **By the Hydrolysis of Ethyl Acetate**

$$\underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + H_2O \xrightarrow[\text{Conc. } H_2SO_4]{\text{Hydrolysis}} \underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Ethyl alcohol}}{C_2H_5OH}$$

II. Industrial Preparation

(a) **From Acetylene**

$$\underset{\text{Acetylene}}{C_2H_2} + H_2O \xrightarrow[HgSO_4]{H_2SO_4\,(dil)} \underset{\text{Acetaldehyde}}{CH_3CHO}$$

$$\underset{\text{Acetaldehyde}}{2CH_3CHO} + O_2 \xrightarrow[\text{Catalyst}]{\Delta} \underset{\text{Acetic acid}}{2CH_3COOH}$$

(b) **From Methanol**

$$\underset{\text{Methanol}}{CH_3OH} + \underset{\text{Carbon monoxide}}{CO} \xrightarrow{I_2\text{-}Rh} \underset{\text{Acetic acid}}{CH_3COOH}$$

(c) **From Ethanol**

$$\underset{\text{Ethyl alcohol}}{C_2H_5OH} + O_2 \xrightarrow[\text{Platinum}]{300^\circ C} \underset{\text{Acetic acid}}{CH_3COOH} + H_2O$$

CHECK POINT 01

1. Give the IUPAC name of $(CH_3)_2CHCH_2COOH$.
2. Draw the structure of acetic acid.
3. Write the reaction showing the oxidation of ethanol.
4. Complete the reaction,

$$CH_3CHO + O_2 \xrightarrow[\text{Catalyst}]{\Delta} \ldots\ldots\ldots$$

5. Name the catalyst which is used in the preparation of acetic acid from ethanol.

Properties

The physical and chemical properties of acetic acid are as follows

Physical Properties

(i) Acetic acid is a colourless pungent smelling liquid (like vinegar).
(ii) It is sour in taste.
(iii) It is hygroscopic liquid.
(iv) It has boiling point of 391 K.
(v) Pure ethanoic acid or acetic acid on cooling forms crystalline mass, which looks like a glacier. That is why, pure ethanoic acid is called glacial acetic acid.
(vi) It is miscible (soluble) with water, alcohol and ether in all proportions.
(vii) At room temperature pure acetic acid is corrosive.
(viii) Its density at 0°C is 1.08 g cm^{-3}.
(ix) It is a good solvent for iodine, phosphorus and for a number of organic solvents.

Chemical Properties

(i) **Acidic Nature** It ionises in water to give CH_3COO^- and H_3O^+ ions.

$$CH_3COOH + H_2O \longrightarrow CH_3COO^- + H_3O^+$$

(ii) **Reaction on Litmus** Ethanoic acid is a weak acid and turns blue litmus to red, through reaction involving complex organic compound called 7-hydroxyphenoxazone.

(iii) **Reaction with Metals** It reacts with active metals like Na, K, Mg and Al to form metal salts (metal ethanoate) and hydrogen gas.

e.g., $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2\uparrow$
Acetic acid — Sodium ethanoate

$2CH_3COOH + Zn \longrightarrow (CH_3COO)_2Zn + H_2\uparrow$
Acetic acid — Zinc acetate

$2CH_3COOH + Mg \longrightarrow (CH_3COO)_2Mg + H_2\uparrow$
Acetic acid — Magnesium acetate

(iv) **Reaction with Bases** It reacts with bases (alkalies) to form their respective salts and water.

$CH_3COOH + NaOH \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}a + H_2O$
Acetic acid — Sodium hydroxide — Sodium acetate

$CH_3COOH + NH_4OH \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}H_4 + H_2O$
Acetic acid — Ammonium hydroxide — Ammonium ethanoate

(v) **Reaction with Sodium Carbonate or Sodium Bicarbonate** Acetic acid reacts with sodium carbonate or sodium bicarbonate to give sodium ethanoate, water and effervescence of carbon dioxide gas.

$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3CO\overset{-}{O}\overset{+}{N}a + CO_2\uparrow + H_2O$
Acetic acid — Sodium carbonate — Sodium ethanoate

$CH_3COOH + NaHCO_3 \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}a + H_2O + CO_2\uparrow$
Acetic acid — Sodium bicarbonate — Sodium ethanoate

(vi) **Reaction with Alcohols** (Esterification) Acetic acid reacts with alcohols in the presence of concentrated sulphuric acid to form esters which are sweet fruity smelling compounds. This reaction is called esterification.

$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$
Acetic acid — Ethanol — Ethyl ethanoate (Ester)

Esters react in the presence of an acid or a base to give back the alcohol and carboxylic acid. This reaction is known as saponification because it is used in the preparation of soap.

$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COOH$

(vii) **Reduction** Acetic acid can be reduced to ethanol by using strong reducing agent. *e.g.*, $LiAlH_4$

$CH_3COOH + 4[H] \longrightarrow C_2H_5OH + H_2O$
Acetic acid — Ethanol

(viii) **Formation of Acetic Anhydride** Acetic acid on heating with phosphorous pentaoxide loses water and produces acetic anhydride.

$2CH_3COOH \xrightarrow[P_2O_5]{\Delta} (CH_3CO)_2O + H_2O$
Acetic acid — Acetic anhydride

(ix) **Reaction with PCl_5** When acetic acid reacts with phosphorous pentachloride, then it forms acetyl chloride and phosphoryl chloride.

$CH_3COOH + PCl_5 \longrightarrow CH_3COCl + POCl_3 + HCl$
Acetic acid — Acetyl chloride — Phosphoryl chloride

Tests for Acetic Acid

Some of the tests used to detect the presence of acetic acid are as follows

(i) When acetic acid reacts in the presence of concentrated sulphuric acid, a pleasant fruity smell of ester is produced.

(ii) On adding neutral $FeCl_3$, wine red colour is produced.

(iii) Effervescence of carbon dioxide is produced, when carbonate or bicarbonate is added.

Uses of Acetic Acid

(i) It is used as vinegar in cooking.

(ii) In the production of dyes, perfumes, esters, etc.

(iii) For coagulating rubber from latex.

(iv) It is used as a laboratory reagent.

(v) For the manufacture of cellulose acetate, which is used for packaging materials, varnishes, rayons, etc.

(vi) Used in medicines.

CHECK POINT 02

1 Give two physical properties of acetic acid.

2 Write the reaction of acetic acid with sodium.

3 Complete the reaction,

$\ldots\ldots \xrightarrow[P_2O_5]{\Delta} (CH_3CO)_2O + H_2O$

4 What is esterification?

5 Give any two uses of acetic acid.

SUMMARY

- Organic compounds containing carboxyl (—COOH) functional group are known as carboxylic acids.
- On the basis of number of carboxylic group present in the molecule, carboxylic acids are classified as mono, di or tricarboxylic acid.
- The word acetic acid comes from the Latin word 'acetum' which means vinegar.
- Acetic acid is prepared by the following methods
  - (i) By the oxidation of ethyl alcohol.
  - (ii) By the hydrolysis of ethyl acetate.
  - (iii) From acetylene.
  - (iv) From methanol and ethanol.
- Acetic acid is colourless, pungent smelling liquid, sour in taste, soluble in water.
- Pure ethanoic acid is called glacial acetic acid.
- Chemical properties of acetic acid are as follows
  - (i) Acidic Nature $CH_3COOH + H_2O \longrightarrow CH_3COO^- + H_3O^+$
  - (ii) Reaction with Metals $2CH_3COOH + 2Na \longrightarrow 2CH_3CO\overset{-}{O}\overset{+}{N}a + H_2 \uparrow$
  - (iii) Reaction with Bases $CH_3COOH + NaOH \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}a + H_2O$
  - (iv) Reaction with **Na_2CO_3 and $NaHCO_3$** $2CH_3COOH + Na_2CO_3 \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}a + H_2O + CO_2$

    $CH_3COOH + NaHCO_3 \longrightarrow CH_3CO\overset{-}{O}\overset{+}{N}a + H_2O + CO_2 \uparrow$
  - (v) Reaction with Alcohols $CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$
  - (vi) Reduction $CH_3COOH + 4[H] \longrightarrow C_2H_5OH + H_2O$
  - (vii) Formation of Acetic Anhydride $2CH_3COOH \xrightarrow[P_2O_5]{\Delta} (CH_3COO)_2O + H_2O$
  - (viii) Reaction with **PCl_5** $CH_3COOH + PCl_5 \longrightarrow CH_3COCl + POCl_3 + HCl$
- Acetic acid is used as vinegar, in production of dyes, perfumes, in medicines, etc.

EXAM PRACTICE

Fill in the Blanks

1. The carbon compounds containing ..... group are known as carbonylic acids.

Sol. carbonyl (—COOH)

2. The name of carboxylic acid is derived by the combination of ..... group and the ..... group.

Sol. carbonyl, hydroxyl

3. IUPAC name for formic acid is .....

Sol. methanoic acid

4. The structural formula of acetic acid is ..... .

Sol. CH_3COOH

5. In lab, acetic acid can be prepared by the oxidation of (i) ..... or (ii) ..... with acidified (iii) ..... or (iv) ..... .

$$A \xrightarrow{[O]} B \xrightarrow{[O]} C$$

Sol. (i) ethyl alcohol
(ii) acetaldehyde
(iii) potassium dichromate
(iv) sodium dichromate

Multiple Choice Questions

6. The functional group present in acetic acid is *[2011]*

(a) ketonic ($>C=O$)
(b) hydroxyl (— OH)
(c) aldehydic (— CHO)
(d) carboxyl (— COOH)

Sol. (d)

7. What will be the final oxidation product of ethyl alcohol?

(a) Acetaldehyde (b) Acetone
(c) Acetic acid (d) None of these

Sol. (c)

8. Ester is formed by

(a) two carboxylic acid
(b) two alcohol
(c) one carboxylic acid and one alcohol
(d) None of the above

Sol. (c)

Match the Following

9. Match the following columns.

Column I (Reaction of acetic acid)	Column II (Products)
(i) Esterification	(a) CH_3COONa
(ii) With metal	(b) $(CH_3CO)_2O$
(iii) Reduction	(c) $CH_3COOC_2H_5$
(iv) With PCl_5	(d) C_2H_5OH
(v) With P_2O_5	(e) CH_3COCl

Sol. (i) – (c), (ii) – (a), (iii) – (d), (iv) – (e), (v) – (b)

a 1 Mark Questions

10. Identify the substance underlined in the following case.

An <u>organic compound</u> containing —COOH functional group. *[2017]*

Sol. Carboxylic acid

11. Give one example of monocarboxylic acid.

Sol. Acetic acid or ethanoic acid.

12. Name an organic compound whose functional group is carboxyl. *[2012]*

Sol. Carboxylic acids containing carboxyl functional group is acetic acid (CH_3COOH).

13. Give the IUPAC name of CH_3COOH.

Sol. Ethanoic acid

b 2 Marks Questions

14. (i) Why is pure acetic acid known as glacial acetic acid?

(ii) Give a chemical equation for the reaction between ethyl alcohol and acetic acid. *[2012, 2009, 2008]*

Sol. (i) The pure acid *i.e.,* anhydrous acid on cooling forms crystalline mass resembling ice with melting point of 117°C and for this reason, it is called glacial acetic acid. *[1]*

(ii) $C_2H_5OH + CH_3COOH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$ *[1]*

15. (i) Name the distinctive reaction that takes place when ethanol is treated with acetic acid.
(ii) Give the balanced chemical equation for the above reaction. ***[2015]***

Sol. (i) Esterification ***[1]***

(ii) $\underset{\text{Ethyl alcohol}}{C_2H_5OH} + \underset{\text{Ethanoic acid}}{CH_3COOH} \xrightarrow{\text{Conc. } H_2SO_4}$

$\underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$ ***[1]***

c 3 Marks Questions

16. (i) Name the main constituent of acetic acid.
(ii) What is the effect of acetic acid on litmus paper?
(iii) Write the name of the compound present in litmus which is responsible for its colour changes.

Sol. (i) Vinegar ***[1]***
(ii) Being acidic in nature, it turns blue litmus to red. ***[1]***
(iii) 7-hydroxyphenoxazone. ***[1]***

17. (i) Which functional group is present in acetic acid?
(ii) Name the products obtained by the hydrolysis of ethyl acetate.
(iii) What are esters?

Sol. (i) Carboxyl group ***[1]***
(ii) Acetic acid and ethyl alcohol. ***[1]***
(iii) Esters are sweet fruity smelling compounds that are formed when acetic acid reacts with alcohols in the presence of concentrated sulphuric acid. ***[1]***

d 4 Marks Questions

18. (i) Define carboxylic acids?
(ii) Write the three important physical properties of acetic acid.
(iii) State the acidic nature of acetic acid with reference to reaction with base.

Sol. (i) Carboxylic acids are the organic compounds containing carboxyl (—COOH) functional group. ***[1]***
(ii) Refer to text on page 251. ***[1½]***
(iii) Refer to text on page 251. ***[1½]***

19. A compound X (having vinegar like smell) when treated with ethanol in the presence of the acid, Z, gives a compond Y which has a fruity smell.

The reaction is

$$C_2H_5OH + X \xrightarrow{Z} Y + H_2O$$

(i) Identify Y and Z.
(ii) Write the structural formula of X. ***[2018]***
(iii) Name the above reaction. ***[4]***

Sol. Since, compound X has vinegar like smell, thus it must be an acetic acid or ethanoic acid (CH_3COOH).

(i) Now, in the given reaction,

$C_2H_5OH + X \xrightarrow{Z} Y + H_2O\uparrow$

where, X is carboxylic acid.

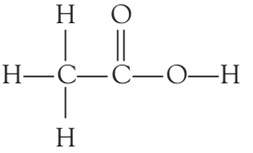
Therefore, Y must be an ester and Z can be conc. H_2SO_4.

This can be justified by the following reaction.

$\underset{\text{Ethyl alcohol}}{C_2H_5OH} + \underset{\substack{\text{Ethanoic acid}\\(X)}}{CH_3COOH} \xrightarrow{\text{Conc.}H_2SO_4(Z)}$

$\underset{\text{Ethyl ethanoate (Y)}}{CH_3COOC_2H_5} + H_2O\uparrow$

(ii) Structural formula of (X) is



Ethanoic acid

(iii) The above reaction is known as esterification.

20. (i) Give two tests to identify acetic acid.
(ii) How vinegar is prepared in industries?

Sol. (i) Refer to text on page 252.
(ii) Refer to text on page 251.

e 5 Marks Questions

21. (i) Write the balanced chemical equation for the preparation of the following.
Ethanoic acid from ethane.
(ii) What is the general formula of carboxylic acid?
(iii) How acetic acid is prepared in laboratory by using ethyl acetate?

Sol. (i) $C_2H_6 \xrightarrow[K_2Cr_2O_7]{[O]} C_2H_5OH \xrightarrow[K_2Cr_2O_7]{[O]} CH_3CHO \xrightarrow[K_2Cr_2O_7]{[O]} CH_3COOH$ ***[2]***

(ii) $C_nH_{2n+1}COOH$ (or $RCOOH$) ***[1]***

(iii) Refer to theory on page 251. ***[1]***

CHAPTER EXERCISE

Fill in the Blanks

1. When we treat sodium metal with acetic acid it produces ..... .

2. ..... is used for making pickles and preservatives.

Multiple Choice Questions

3. What will be the chemical formula of resulting mixture formed, when ethyl alcohol is added to acetic acid?

(a) CH_3COOCH_3 (b) $CH_3COOC_2H_5$

(c) $C_2H_5COOC_2H_5$ (d) None of the above

4. The reducing agent that reduces acetic acid to ethanol is

(a) $NaBH_4$

(b) $LiAlH_4$

(c) $Na_2Cr_2O_7$

(d) All of the above

Match the Following

5. Match the following columns.

	Column I		Column II
(i)	$(CH_3CO)_2O$	(a)	ethyl ethanoate
(ii)	CH_3COCl	(b)	acetic anlydride
(iii)	$CH_3COOC_2H_5$	(c)	acetyl chloride

1 Mark Questions

6. Name the compound formed when acetic acid and ethanol react together.

7. From the box given, answer the question.

Ethane, Ethene, Ethanoic acid, Ethyne, Ethanol

The compound with —COOH as the part of its structure. ***[2005]***

2 Marks Questions

8. What happens when

(i) ethanol is added to acetic acid?

(ii) methanol reacts with carbon monoxide?

9. Choose the correct word/phrase from within the brackets to complete the sentence. ***[2011]***

(i) When acetaldehyde is oxidised with acidified potassium dichromate, it forms (ester/ethanol/ acetic acid).

(ii) Ethanoic acid reacts with ethanol in the presence of concentrated H_2SO_4 to form a compound and water. The chemical reaction which takes place is called (dehydration/ hydrogenation/esterification).

3 Marks Questions

10. (i) What do you observe when acetic acid neutralise $FeCl_3$ solution?

(ii) Which compound is formed when acetic acid reacts with ammonium hydroxide? Also, write the equation.

4 Marks Questions

11. An organic compound *A* has the molecular formula $C_4H_8O_2$ on hydrolysis gives product *B* and *C* having molecular formula $C_2H_4O_2$ and C_2H_6O, respectively. *B* is used as vinegar in cooking. Identify *A*, *B* and *C*; and also write the chemical equation involved in the formation of *B* and *C*.

12. Write the chemical equations of the reactions of ethanoic acid with

(i) sodium hydroxide

(ii) sodium

(iii) sodium bicarbonate

(iv) ethanol in the presence of conc. H_2SO_4

ARCHIVES*

(Last 5 Years)

Collection of Questions Asked in Last 5 Years' (2018-2011) ICSE Class 10th Examinations

2018

1 A compound *X* (having vinegar like smell) when treated with ethanol in the presence of the acid, *Z*, gives a compond *Y* which has a fruity smell. ***[4]***

The reaction is

$$C_2H_5OH + X \xrightarrow{Z} Y + H_2O$$

(i) Identify *Y* and *Z*.

(ii) Write the structural formula of *X*.

(iii) Name the above reaction.

2017

2 Identify the substance underlined in the following case.

An organic compound containing —COOH functional group.

[1]

2015

3 (i) Name the distinctive reaction that takes place when ethanol is treated with acetic acid.

(ii) Give the balanced chemical equations for the above reaction. ***[2]***

2012

4 Name an organic compound whose functional group is carboxyl. ***[1]***

5 (i) Why is pure acetic acid known as glacial acetic acid?

(ii) Give a chemical equation for the reaction between ethyl alcohol and acetic acid. ***[2]***

2011

6 The functional group present in acetic acid is

(a) ketonic ($>C=O$) (b) hydroxyl (—OH)

(c) aldehydic (—CHO) (d) carboxyl (COOH) ***[1]***

7 Choose the correct word/phrase from within the brackets to complete the sentence.

(i) When acetaldehyde is oxidised with acidified potassium dichromate, it forms (ester/ethanol/acetic acid)

(ii) Ethanoic acid reacts with ethanol in the presence of concentrated H_2SO_4, so as to form a compound and water.

The chemical reaction which takes place is called (dehydration/hydrogenation/esterification).

[4]

CHALLENGERS*

1 The IUPAC name of $(CH_3)_2$ CHCOOH is

(a) propan-2-oic acid (b) *iso*-butanoic acid
(c) 2-methyl propanoic acid (d) 2-methyl butanoic acid

2 How many acids are possible for the compound with molecular formula, $C_4H_8O_2$?

(a) One acid (b) Two acids (c) Three acids (d) Four acids

3 Vinegar is a solution of ethanoic acid made by the reaction of ethanol with air. Which gas in air takes part in this reaction?

(a) Carbon dioxide (b) Nitrogen (c) Oxygen (d) Water vapour

4 Which statement about ethanoic acid is correct?

(a) It contains three carbon atom per molecule (b) It contains five hydrogen atoms per molecule
(c) It is insoluble in water (d) It reacts with ethanol to form a sweet smelling compound

5 Acetic acid reacts with PCl_5 to form

(a) acetyl chloride (b) methyl chloride
(c) carbon monoxide and hydrogen chloride (d) None of these

6 The reactivity of carboxylic acid towards esterification is highest in

(a) acetic acid (b) propionic acid (c) formic acid (d) *iso*-butyric acid

7 Which of the following is *iso*-butyric acid?

(a) $CH_3CH_2CH_2COOH$ (b) $CH_3(CH_2)_3COOH$ (c) $(CH_3)_2CH—COOH$ (d) $CH_3—\underset{\displaystyle COOH}{\underset{|}{C}}HCH_2CH_3$

8 $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Alkalive } KmNO_4} CH_3COOH$

It the above reaction, alkaline $KmNO_4$ acts as

(a) reducing agent (b) oxidising agent (c) catalyst (d) dehydrating agent

9 Which of the following is not classified as a derivative of carboxylic acid?

(a) Alcohol (b) Ester (c) Acid halide (d) Amide

10 Consider the following reaction.

Fat + Alkali $\xrightarrow{\Delta}$ Soap + Glycerol

What name is given to the reverse of above shown process?

(a) Saponification (b) Carbonylation (c) Esterification (d) Hydrogenation

Answers

1. (c) **2.** (b) **3.** (c) **4.** (d) **5.** (a) **6.** (c) **7.** (c) **8.** (b) **9.** (a) **10.** (c)

* These questions may or may not be asked in the examination, have been given just for additional practice

Explanations to Challengers

Chapter 1. Periodic Properties and Their Variations

1. (a) Atomic mass of an element is not a periodic property. It will not show regular trend (in periods).
e.g. Co (Atomic mass = 58.93) and ($Z = 27$)
Ni (Atomic mass = 58.69) and ($Z = 28$)

2. (b) Given (Z) = 24, thus its electronic configuration is

K	L	M	N
2	8	8	6

3. (a) Given atomic number (Z) = 38, has 5 shells and 2 electrons in its outermost shell, i.e. has electronic configuration 2, 8, 18, 8, 2
Thus, member of 5th period and II(A) group.

4. (d) Na, K and Li belongs to the same group and atomic radius increases down the group, thus Li has smallest radius. Also, Br belongs to 17th group but below the chlorine with ($Z = 35$). Hence, Li show smallest radius among the given options.
Li = 152 pm (atomic radius)
Br = 114 pm (atomic radius)
Na = 186 pm (atomic radius)
K = 231 pm (atomic radius)

5. (a) Anti-penultimate shells means the differentiating electrons enters in $(n-2)$ sub-shells.
$\because$ Differentiating electron (last electron) enters in f-block elements having general electronic configuration $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$.
Hence, (a) is the correct option.

6. (c) (i) Ionisation enthalpy $\propto$ effective nuclear charge and $\propto \frac{1}{\text{atomic size}}$
(ii) Atomic size decreases in period and increases in group.
(iii) Elements with fully-filled/half filled outermost sub-shell configuration are more stable.
Hence, ionisation enthalpy of beryllium (Be) is highest, as it has full-filled outermost electronic configuration
Be(4) = $\begin{matrix} \text{K} & \text{L} \\ 2 & 2 \end{matrix}$ or $1s^2 2s^2$

7. (b) Ionic size = (p/e) value can be calculated by
where, p = number of protons
e = number of electrons
and ionic size $\propto 1/p/e$ i.e. more be the value of $\frac{p}{e}$, smaller be the ionic size and *vice versa*.
Ionic size for $Na^+ = \frac{p}{e} = \frac{11}{10} = 1.1$
$Mg^{2+} = \frac{12}{10} = 1.2$
$F^- = \frac{9}{10} = 0.9$
$O^{2-} = \frac{8}{10} = 0.8$
Hence, correct order is $O^{2-} > F^- > Na^+ > Mg^{2+}$

8. (a) Electron affinity of Be is similar to He. i.e. −50 kJ/mol because, both have ful-filled outermost shells with two electrons in s-sub shell and are nearly of same size.

9. (c) (i) Ionisation energy (I.E.) increases from left to right in a period, but.
(ii) I.E. of elements having half or fully-filled outermost electronic configuration are more stable and show higher value of ionisation energy.
Thus, (c) is the correct order.

10. (a) (i) Electron affinities increases from left to right in a period and decreases down the group.
(ii) But, in case of oxygen and sulphur, sulphur has higher value of electron affinity due to larger size.
As oxygen is smaller in size with six valence electrons, which offer greater electron-electron repulsion as compared to sulphur (having six valence electrons).
Thus, has higher electron affinity.
Hence, correct order is N<O<S<Cl.

Chapter 2. Chemical Bonding

1. (b) HCl do not contain ionic bond between H and Cl. It is made by covalent bond between H and Cl, while all other i.e. NaOH, K_2S and LiH made by ionic bonds.

2. (a) Species made by ionic bonds are non-directional and of high melting point due to formation of bonds between ions (cation and anion). These bond can be made by all directions, thus are non-directional and offer strong attractive forces, thus are of high melting point.

3. (c) Given,
L has $\rightarrow$ 6 valence electrons

Q has → 7 valence electrons

P has → 1 valence electron

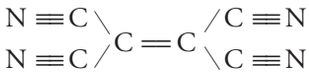
R has → 2 valence electrons

Thus, the ionic compounds formed between them are P_2L, RL,PQ and RQ_2.

Hence, option (c) is correct answer.

4. (c) As, there are three possible direction (X, Y and Z), thus the maximum three bond are possible to make between two atoms.

5. (c) Structure of $(CN)_2 \cdot C{=}{=} C(CN)_2$ is

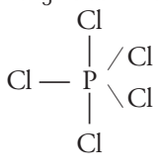


Thus, there are four (4) triple and one double bond is present in the given compound i.e., in total= 4+1=5

6. (a) In a covalent solid, atoms occupy the lattice points. Thus (a) is the correct option.

7. (b) PCl_5 is made by simple covalent bonds. All other contain at least one coordinate bond.

The structure of PCl_5 is as follow.



8. (c) Coordinate bond between two atoms will form in specific direction, thus are not non-directional.

Hence, option (c) is the correct answer.

9. (c) As, attractive force between ions in solid state are very strong and ions are not free to move, therefore they do not conduct electricity in solid state.

NaCl (solid) is an ionic solid hence, do not conduct electricity.

10. (c) As, N-atom in NH_3 contain lone pair of electrons and B atom in BF_3 contain an empty orbital, thus, they can form a coordinate bond to give an adduct.

Chapter 3. Acids, Basis and Salts

1. (a) When metal carbonates react with acids, they evolve $CO_2(g)$

e.g. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

2. (b) C_2H_5OH (ethyl alcohol) is a weak acid (weaker than water) thus, do not give H^+ ions in aqueous solution.

3. (b) Blue litmus paper when dipped in dil. HCl (acidic solution), it changes to red but when dipped in dil. NaOH (alkaline solution), it changes to blue.

Hence, option (b) is the correct answer.

4. (c) Aluminium (Al) metal when react with NaOH, it gives $H_2(g)$ as follows.

(i) $2Al + 6H_2O \longrightarrow Al(OH)_3 + 3H_2$

(ii) $Al(OH)_3 + NaOH \longrightarrow Na[Al(OH)_4]$

5. (b) Given, pH = 4

On dilution, the concentration of H^+ ions decreases, that results in increase in the pH value,

as $pH - \log[H^+]$

6. (a) When an acid reacts with a base, salt and water is formed.

In the given question 'X OH' is the base which gives OH^- ions and 'HY' is the acid (which gives H^+ ions)

Hence 'X' acts as a cation.

7. (b) We know that, $pH = -\log[H^+]$, means more be the value of pH, lesser be the concentration of H^+ ions.

Hence, pH = 8.6 is the correct answer.

8. (c) Bases are sour in taste. They do not turn blue litmus to red and their strength is given by $p(OH) = -\log[OH^-]$

option (b) is also incorrect.

Hence, (c) is the correct answer.

9. (b) $CuSO_4(aq) + 2NH_4OH(aq) \longrightarrow (NH_4)_2SO_4 + Cu(OH)_2$ (Pale blue ppt.)

10. (c) Given, Concentration of $HCl = 10^{-6}$ M

$$\text{After dilution conc. of HCl} = \frac{10^{-6}}{100} = 10^{-8} \text{ M}$$

$\therefore\ pH = -\log H^+]$

$\therefore\ pH = -\log[10^{-8}] = 8$

But this is not true because an acidic solution cannot have pH greater than 7. In this case, $[H^+]$ ions of water molecule cannot be neglacted.

Thus,

$$[H^+] = [H^+]_{HCl} + [H^+]_{H_2O} \quad ...(i)$$

As we know, ionic product

$$[H^+][OH^-] = 10^{-14}$$

$$\therefore \quad [H^+] = 10^{-7}$$

$$[H^+] \text{ total} = 10^{-8} + 10^{-7} \text{ (from Eq. (i))}$$

$$= 10^{-8}(1+10)$$

$$= 11 \times 10^{-8}$$

Now from, $pH = -\log[H^+] = -\log(11 \times 10^{-8})$

$$= -\log 11 - \log 10^{-8} = 6.958$$

Chapter 4. Analytical Chemistry: Uses of Sodium and Ammonium Hydroxides

1. $Cu(OH)_2$ is insoluble in excess of NaOH but soluble in excess of ammonium hydroxide and gives deep blue or prussian blue solution. The reaction is as follow

$$Cu(OH)_2 + (NH_4)_2SO_4 + \underset{\text{Excess}}{2NH_4OH} \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$$

2. (b) As, per the colours given in the table, the metal '*M*' is Cr.

K_2CrO_4 → Potassium chromate

$K_2Cr_2O_7$ → Potassium dichromate

3. (c) Zinc (Zn) shows amphoteric behaviour with dil,. HCl and dil. NaOH, as it reacts with both as follows.

(i) $Zn + HCl(dil.) \longrightarrow ZnCl_2 + H_2$

(ii) $Zn + 2NaOH(dil.) \longrightarrow Na_2ZnO_2 + H_2$

4. (c) When $Zn(OH)_2$ is added in excess of NaOH solution, it dissolved in that due to formation of soluble zincate ions.

$$Zn(OH)_2 + 2NaOH(aq) \longrightarrow \underset{\substack{\text{Sodium zincate}\\\text{(soluble salt)}}}{Na_2ZnO_2} + 2H_2O$$

$Zn(OH)_2$ is amphoteric, so it reacts as an acid with the base to give a soluble complex.

5. (b) Nessler's reagent is prepared by combining potassium iodide and mercuric chloride. It is used to test presence of NH_3 or NH_4^+ ions.

$$2K_2HgI_4 + NH_4Cl + 4KOH \longrightarrow \underset{\text{(iodide of millon base)}}{\begin{matrix} & & NH_2 \\ & Hg & \diagup \\ & & O \\ & Hg & \diagdown \\ & & I \end{matrix}} + 7KI + KCl + 3H_2O$$

Also, NH_3 when react with HCl (conc), it gives white fumes of NH_4Cl.

$$NH_3(g) + HCl \longrightarrow NH_4Cl$$

It has irritating odour also.

Hence, the given gas is NH_3.

6. (b) A + NaOH⟶ white ppt.

$\underset{\text{(Yellow)}}{B}$ + NaOH⟶ gives colourless solution

Thus, (i) (A) is $Ca(NO_3)_2$, because it gives white ppt. of $Ca(OH)_2$ and $NaNO_3$.

$$Ca(NO_3)_2 + 2NaOH \longrightarrow \underset{\text{White ppt.}}{Ca(OH)_2} + 2NaNO_3$$

(ii) (B) is $\underset{(B)}{Pb(NO_3)_2} + 2NaOH \longrightarrow \underset{\substack{\text{(gives colourless solution}\\\text{on shaking)}}}{Pb(OH)_2} + 2NaNO_3$

Hence, option (b) is the correct answer.

Chapter 5. Mole Concept and Stoichiometry

1. (a) $1\text{ g Au} = \frac{1}{197}$ mol - atoms of Au

$$= \frac{1}{197} \times 6.022 \times 10^{23} \text{ atoms of Au}$$

(b) $1\text{ g Na} = \frac{1}{23}$ mol - atoms of Na

$$= \frac{1}{23} \times 6.022 \times 10^{23} \text{ atoms of Na}$$

(c) $1\text{ g Li} = \frac{1}{7}$ mol - atoms of Li

$$= \frac{1}{7} \times 6.022 \times 10^{23} \text{ molecular of LI}$$

(d) $1\text{ g } Cl_2 = \frac{1}{71}$ mole-molecules of

$$Cl_2 = \frac{1}{71} \times 6.022 \times 10^{23} \text{ molecules of } Cl_2$$

$$= \frac{2}{71} \times 6.022 \times 10^{23} \text{ atoms of Cl}$$

(∵ 1 molecule of chlorine contains 2 atoms)

∴ 1 g of Li has largest number of atoms.

2. ∵ Molar mass of gas $= 2 \times V.D = 2 \times 11.2 = 22.4$

Also, number of moles of gas $(n) = \frac{\text{Weight } (w)}{\text{Molar mass } (M)}$

$$= \frac{1}{22.4}$$

Also, at NTP $n = \frac{V}{22.4\,(\text{L})}$

∴ $\frac{V}{22.4} = \frac{1}{22.4}$

Hence, $V = \frac{22.4}{22.4} = 1\text{ L}$

3. (c) Molar mass of CH_4 = 16 (Say = a)

and molar mass of C_2H_4 = 28 (say = b)

Thus, $\frac{16a + 28b}{a + b} = 20$ (given) ...(i)

On solving, we get $\frac{a}{b} = \frac{2}{1}$

Therefore, ratio = 2 : 1

i.e. $\frac{b}{a} = 1:2$ and

Putting the value in Eq (i), we get

$$= \frac{(16 \times 1) + (28 \times 2)}{3} = 24$$

Hence, molar mass of mixture = 24

4. (c) Given, $2H_2O \longrightarrow \underset{(2\times 22400\ mL)}{2H_2} + \underset{(22400\ mL)}{O_2}$

When 2×22400 ml of H_2 is produced we get
$= 22400$ ml of O_2

$\therefore$ 2500 ml of H_2 is produced, we get $= \dfrac{22400 \times 2500}{2 \times 22400}$

$= 1250$ mL of O_2 or $1250\,cm^3$ or O_2

5. Mass of $22400\ cm^3$ $CH_4 = 16g$

$\therefore$ Mass of $112\ cm^3$ CH_4

$= \dfrac{16 \times 112}{22400} = 0.08$ g

6. (c) Each oxygen atom in $O_2(g)$ bear two electrons.

Thus, 1 g equivalent of $O_2 = \dfrac{N_A}{2}$

Hence, 1 g equivalent of oxygen atom $= \dfrac{N_A}{4}$

7. (b)Let, atomic weight of metal $(M) = 50$

$\because$ It is 50% in the sample, and atomic weight of oxygen atom $= 16$

Also, ratio of metal (M) and oxygen in the given oxide $(MO_2) = 1:2$

Thus, $\dfrac{16}{M} = \dfrac{1}{2}$

or, atomic weight of $M = 2 \times 16 = 32$

In the second sample, $M = 40\%$ means,

oxygen $(O) = 60\%$

$\because$ moles of $M = \dfrac{40}{32} = 1.25 \approx 1.00$

and of oxygen $= \dfrac{60}{16} = 3.75 \approx 3.00$ (for simplicity)

Hence, formula $= MO_3$

(**Hint**, $1.25 \times 4 = 5, 3.75 \times 4 = 15$, means are in ratio of 1 : 3)

8. (b) Given $A = 4$ times $V.D$ of B

$\because$ Molar mass $(M) = 2 \times V \cdot D = 2 \times (4V \cdot D)$

Thus, molar mass of $A = 2B$

If M be the molar mass of B then,

Molar mass of $A = 2 \times 2B = 2 \times 2M = 4M$

9. (d) Given, mass of $C = 24g(w)$ for C

mass of $H = 4g(w)$ for H and mass of $O = 32g(w)$ for O ($\because n = w/m$)

$\therefore$ moles of $C = \dfrac{24}{12} = 2$, moles of $H = \dfrac{4}{1} = 1$

$\therefore$ moles of $O = \dfrac{32}{16} = 2$

Thus, simple ratio is $= 1:2:1$

Hence, empirical formula CH_2O.

10. (a) Each Na_2CO_3 contain $2 \times N_A$ Na^+ ion

$(N_A = 6.02 \times 10^{23})$

$\therefore$ When we have $2 \times N_A$ of Na^+ ions,

we have 1 mole of Na_2CO_3 i.e. 106 g of Na_2CO_3 (Molar mass $(M) = 106$)

Hence, when we have N_A ions of Na^+, the mass of

$Na_2CO_3 = \dfrac{M}{2} = \dfrac{106}{2} = 53$ g

Chapter 6. Electrolysis

1. (b) On using H_2SO_4 (dil.) as electrolytes and Mg and Cu as electrodes.

Mg being more reactive and Cu is less reactive than hydrogen. Thus, it will not give any gas at copper electrode. Hence, option (b) is the correct answer.

2. (b) One mole of electrons(e) are discharged by 1 Faraday charge.

One mole of Al ion $= Al^{3+} \rightarrow$ requires 3 moles of e^-

$\therefore$ 2 mol of $Al^{3+} \rightarrow$ requires 6 moles of e^-

Similarly, 5 mole of $OH^- \rightarrow$ requires 5 moles of e^-

3 moles of oxide ions i.e. $O^{2-} \rightarrow$ requires 6 moles of e^-, 6 moles of hydrogen ions i.e. $H^+ \rightarrow$ requires 6 moles of e^-.

Hence, hydroxide ions require least moles (numbers) of electrons.

3. (d) In the given reaction, $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Zn changes to Zn^{2+} i.e. itself get oxidise and act as reductant, while H^+ ions changes to $H_2(g)$ i.e. get reduced and act as an oxidant.

Hence, (d) is the correct answer.

Hint (c) is not correct, because HCl is a covalent compound.

4. (c) When Na_2SO_4 (aq) is electrolysed using Pt-electrodes. It gives Na^+ and H^+ ions (as cations) and OH^- ions and SO_4^{2-} ion (as anions)

$\because$ Discharge potential of H^+ and OH^- ions are less than of Na^+ and SO_4^{2-} ions. We get H_2 and O_2 at cathode and anode respectively.

5. (b) In an electrochemical cell, when electrode potential of both the half-cells becomes equal, the cell stops working.

$\because$ $\Delta E = 0$

Hence, (b) is the correct option

6. (a) Copper being less reactive than zinc cannot displace zinc from zincsulphate solution and thus we can store $ZnSO_4$ in a copper vessel.

$Cu + ZnSO_4 \rightarrow$ No reaction

7. (a) By convention, oxidation always occurs at anode.

∴ Process at anode is oxidation.

8. (b) Oxidation always occurs at anode and reduction always occurs at cathode.

Thus, we can not differentiate an electrochemical cell and an electrolytes cell by chemical reactions occurring at electrodes.

Chapter 7. Metallurgy

1. (a) The adsorption phenomenon is involved in the froth floatation process.

2. (a) Gravity separation method of concentration of the ore is based on the difference in specific gravities of the metallic ore and gangue particle. Generally metal ores are heavier than gangue associated with them.

3. (b) In the given equation, *M* is Au (gold) metal, which is extracted according to given equation.

$4Au + 8\,CN^- + 2H_2O + O_2 \rightarrow 4\,[Au(CN)_2]^- + 4OH^-$

$2\,[Au(CN)_2]^- + Zn \rightarrow [Zn(CN)_4]^{2-} + 2\,Au$

4. (c) For removing basic impurities present in the ore acidic flux like SiO_2 is used during smelting.

5. (d) Froth floatation depends on the selective adhesion of air bubble to mineral surfaces in a mineral/water slurry. The air bubble will attach to more hydrophobic particles. Hence, ore particles floats in concentration by froth floatation process.

6. (b) Argentite is a sulphide ore (Ag_2S) (silver glance) and cuprite (Cu_2O) (ruby copper) is an oxide.

7. (b)

Metal	Ore	Extraction methods	Reaction invoved in extraction
Tin (Sn)	SnO_2	Carbon reduction method	$2C + O_2 \rightarrow 2CO$ $2CO + SnO_2 \rightarrow Sn + 2CO_2$
Lead (Pb)	PbS	Self-reduction	$PbS + O_2 \rightarrow Pb + SO_2$ $PbS + 2PbO \xrightarrow{\text{Partial}} 3Pb + SO_2$

8. (b)

	Mg	Na	Cu	Al
	Carbonate	Chloride	Sulphide	Oxide
Ore	$MgCO_3$	NaCl	Cu_2S	$Al_2O_3.2H_2O$
	Magnesite	Common salt	Copper glance	Bauxite

9. (b) The method used to extract metals from the ore in which they are found depends on their reactivity. Reactive metals such as aluminium are extracted by electrolysis, while a less reactive metal such as iron may be extracted by reduction with carbon or carbon monooxide.

10. (d) Cinnabar is roasted in excess of air, then mercury is obtained.

$$\underset{\text{Cinnabar}}{2HgS} + 3O_2 \longrightarrow 2HgO + 2SO_2\uparrow$$

$$2HgO + HgS \longrightarrow 3Hg + SO_2\uparrow$$

$$2HgO \longrightarrow \underset{\text{(Mercury)}}{2Hg} + O_2\uparrow$$

In this process, no external reducing agent is used and hence, called as auto-reduction.

Chapter 8. Study of Compounds

1. (b) A natural source of nitrogen oxides occurs from a lightning stroke. The very high temperature in the vicinity of a lightning bolt causes the gases oxygen and nitrogen in the air to react to form nitric oxide.

$$N_2 + O_2 \longrightarrow NO$$

2. (c) Ammonium chloride decomposes to form ammonia and hydrogen chloride gas. Ammonia diffuses faster than hydrogen chloride because its light. Ammonia is basic and thus red litmus paper turns blue, while hydrogen chloride is acid, thus blue litmus turns red.

3. (c) Ammonia gas is basic and conc. H_2SO_4 is an acid thus it will react to form white fumes of $(NH_4)_2SO_4$. P_2O_5 and $CaCl_2$ also react with ammonia, hence cannot be used for drying it.

$$2\,NH_3 + H_2SO_4 \longrightarrow (NH_4)_2\,SO_4$$

$$P_2O_5 + 6NH_3 + 3H_2O \longrightarrow 2\,(NH_4)_3\,PO_4$$

$$CaCl_2 + 8\,NH_3 \longrightarrow CaCl_2.\,8NH_3$$

4. (b) Ferrous sulphate absorbs nitric oxide but N_2O remain undissolved.

5. (d) Cu produces NO gas when treated with dil. HNO_3. This gas is reduced by $SnCl_2$/HCl and then oxidised by HNO_2 to give N_2O. The reactions are as follows

$$Cu + \text{dil. } HNO_3 \longrightarrow \underset{(X)}{NO}$$

$$\underset{(X)}{NO} \xrightarrow{SnCl_2/HCl} \underset{(y)}{NH_2OH.HCl}$$

$$\underset{(Y)}{NH_2OH \cdot HCl} \xrightarrow{HNO_2} \underset{Z}{N_2O}$$

6. (b) The pure state of HNO_3 is colourless, but it is often of yellow colour due to photochemical decomposition into oxides of nitrogen and water.

7. (a) $NH_4NO_3 \longrightarrow N_2 + 2H_2O + 1/2\ O_2$

$NH_4NO_2(s) \longrightarrow N_2(g) + 2H_2O(l)$

(b) $NH_4Cl(s) \longrightarrow NH_3(g) + HCl(g)$

$(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3 + CO_2 + H_2O$

(c) $NH_4NO_3 + NaOH \longrightarrow NH_3(g) + NaNO_3 + H_2O(l)$

(d) $AlN + 3H_2O \longrightarrow Al(OH)_3 + NH_3(g)$

$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3(g)$

$CaCN_2 + 3H_2O \longrightarrow CaCO_3 + 2NH_3(g)$

8. (b) $4HNO_3 \longrightarrow 2H_2O + 4NO_2 + O_2$

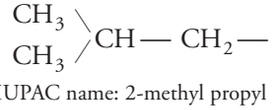
9. (b) Ammonia is a clear liquid that boils at a temperature of –28°F. In refrigeration, the liquid is stored in closed containers under pressure. When the pressure is released, the liquid evaporates rapidly, generally forming an invisible vapour or gas. This why ammonia is used in refrigeration.

10. (b) The vapour pressure of ammonia at room temperature is very high and hence the ammonia will evaporate unless the vapour pressure is decreased. Cooling decreases the vapour pressure so that the liquid remains in the same state. Hence, the bottle is cooled before opening.

Chapter 9. General Organic Chemistry

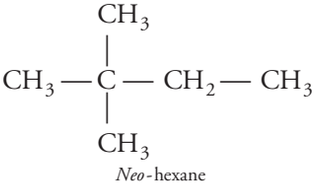
1. (d) A homologous series is a group of organic compounds (compounds that contain C atoms) that differ from each other by one methylene (CH_2) group. For e.g. butane, 2-methylbutane, 2, 3-dimethyl butane.

2. (c) Formula of isobutyl group



IUPAC name: 2-methyl propyl

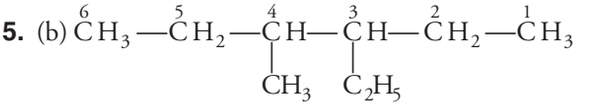
3. (b) IUPAC name of $(CH_3)_3C\,C_2H_5$ is *Neo*-hexane.



Neo-hexane

4. (c) The formula of methoxy ethene is $CH_3O\,CH_2 = CH_2$. It contains a double bond. So, it belongs to unsaturated ether.

5. (b)

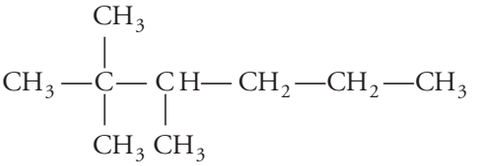


IUPAC name: 3-ethyl-4-methyl hexane

6. (c) Cyclohexane is an example of alicylic compound. An alicyclic compound is an organic compound that is both aliphatic and cyclic.

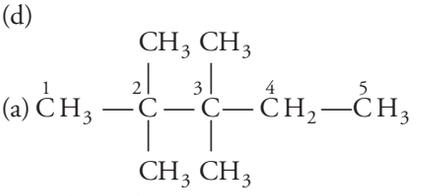
Cyclohexane

7. (c) $CH_3C(CH_3)_2\,CH\,(CH_3)\,CH_2\,CH_2\,CH_3$ represent 2,2,3- trimethylhexane



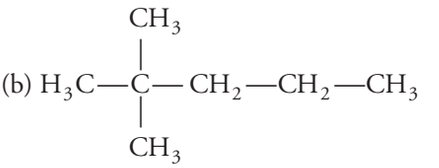
8. (d)

(a)



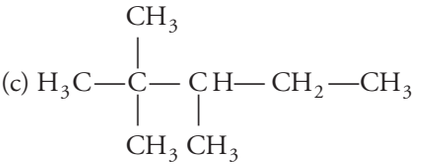
2, 2, 3, 3-tetramethyl pentane

(b)



2, 2-dimethyl pentane

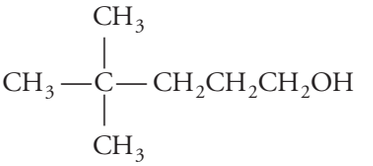
(c)



2, 2, 3-trimethyl pentane

From the above example, none of the compound have ispropyl group.

9. (c) *Neo*-heptyl alocohol is correctly represented by the following formula.



10. (d) 3-phenyl prop-2-enoic acid is IUPAC name of cinnamic acid.

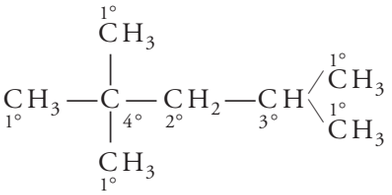
Chapter 10. Hydrocarbons

1. (d) A straight chain alkane will have a boiling point higher than a branched chain alkane, due to the greater surface area in contact, thus the greater van der waals' forces between adjacent molecules. Hence, 2,2-dimethyl butane have lowest boiling point.

2. (b) Reduction of CH_3COCH_3 with HI/P_4 does not produce ethane. It produce propane with HI/P_4.

$$CH_3COCH_3 \xrightarrow[2H]{HI/P_4} \underset{\text{Propane}}{CH_3CH_2CH_3}$$

3. (c) $(CH_3)_3CCH_2CH(CH_3)_2$ akane contains primary, secondary, tertiary as well as quaternary C-atoms.



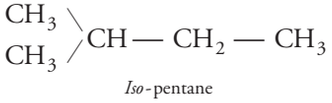
4. (b) Oxidation of but-1-ene with hot $KMnO_4$ solution produces propanoic acid and CO_2.

$$CH_3-CH_2-CH=CH_2 \xrightarrow{Hot+KMnO_4} CH_3CH_2COOH + CO_2$$

5. (a) $R'C\equiv CH$ on reaction with R MgBr forms alkane.

$$\underset{\text{Terminal alkyne}}{R'-C\equiv CH} + \underset{\text{Grignard reagent}}{\overset{-}{R}\overset{+}{M}gBr} \xrightarrow[\text{ether}]{\text{Dry}} \underset{\text{Alkynyl Grignard reagent}}{R'-C\equiv CMgBr} + \underset{\text{alkane}}{RH}$$

6. (c) *Iso*-pentane isomer of C_5H_{12} gives four isomers of monoiodopentane.

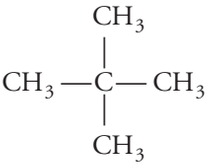


Iso-pentane

7. (c) Propyne decolourise bromine water as well as Baeyer's reagent.

8. (a) A straight chain alkane will have a boiling point higher than a branched chain alkane hence, *n*-hexane has highest boiling point.

9. (b) *Neo*-pentane will give only one monochloro derivative on halogenation.



Neo-pentane

10. (c) $Hg^{2+} + H_2SO_4$ (dil.) reagent convert but-1-yne to butan -2-one.

Chapter 11. Alcohols

1. (a) $\underset{A}{CH_3CH_2OH} \xrightarrow[H_2SO_4]{K_2Cr_2O_7} \underset{B}{CH_3CHO} \xrightarrow[\text{vigorous oxidations}]{[O]} CH_3COOH$

Here '*A*' is C_2H_5OH (ethanol).

2. (a) Fermentation is an exothermic reaction, it releases heat to surroundings.

3. (a) Amongst isomeric alcohols, the boiling points decrease with branching due to corresponding decrease in surface area, i.e. boiling point decreases in order : primary > secondary > tertiary.

4. (c) Wine mainly contains ethanol (C_2H_5OH).

5. (b) Absolute alcohol is named to 100% concentrated ethanol with chemical formula C_2H_5OH. To obtain absolute alcohol from rectified spirit (95% ethanol + 5% water) azeotropic distillation is used.

6. (a) Compound *X* has the molecular formula C_2H_6O.

X may be alcohol because, it can be made by a fermentation process. *X* (alcohol) can be oxidised to *Y* (acid). *X* can react with *Y* (acid) to form *Z* (ester) and water hence *X* is alcohol and *Y* and *Z* are carboxylic acid and ester respectively. So (a) option is correct.

7. (b) Compound (b) $CH_3CH_2CH_2COOH$ (acid) react with ethanol to forms ester (sweet smelling liquid)

$$CH_3CH_2CH_2COOH + C_2H_5OH \longrightarrow CH_3CH_2CH_2COOC_2H_5 + H_2O$$

8. (d) When ethanol is consumed in large quantities. It slows the metabolic processes and depress the central nervous system, which in turn results in lack of coordination, drowsiness, mental confusion etc. To avoid its misuse for drinking, it is mixed with some susbtances like pyridine, this process is called **denaturation of alcohol**.

Chapter 12. Carboxylic Acids

1. (c) $CH_3^{3}-CH^{2}(CH_3)-COOH^{1}$

IUPAC name: 2-methyl propanoic acid

2. (b) Two acids are possible for the compound with molecular formula, $C_4H_8O_2$

$CH_3CH_2CH_2COOH$ (n-butanoic acid) and $(CH_3)_2CH-COOH$ (2-methyl propanoic acid)

3. (c) Ethanoic acid is formed when ethanol is oxidised. Ethanol reacts with the oxygen in air. In the following reaction

$$C_2H_5OH\ (l) + O_2\ (g) \longrightarrow CH_3COOH\ (aq) + H_2O$$

Ethanoic acid is the active ingredient in vinegar.

4. (d) Ethanoic acid reacts with ethanol to form a sweet smelling compound (ester).

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \longrightarrow \underset{\text{Ethyl acetate (ester) sweet smelling}}{CH_3COOC_2H_5}$$

5. (a) $PCl_5 + CH_3COOH \longrightarrow POCl_3 + \underset{\text{Acetyl chloride}}{CH_3COCl} + HCl$

6. (c) The reactivity of carboxylic acid towards esterification is less due to presence of alkyl group hence, formic acid shows highest esterification reactivity.

7. (c) $CH_3-CH(CH_3)-COOH$ (Iso-butyric acid)

8. (b) Alkaline $KMnO_4$ is also known as Baeyer's reagent and acts as am oxidising agent

9. (a) Alcohol is not a derivative of carboxylic acid. Ester, acid halide and amide are derivative of carboxylic acid.

10. (c) The reverse of the following process is esterification.

Fat + alkali $\xrightarrow{\Delta}$ soap + glycerol

INTERNAL ASSESSMENT OF PRACTICAL WORK

Internal Assessment of Practical Work

Experiment 1

Detection of Gases

S. No.	Experiment	Observations	Inferences
Test for Hydrogen			
1.	Add dilute hydrochloric acid (HCl) or dilute sulphuric acid (H_2SO_4) to any reactive metal like zinc, iron, etc. (except lead). (**Note :** **Reactive metals** are the metals which are present above the hydrogen in activity series). **Reactions involved** Active metal + Dilute acid → Salt + Hydrogen $Zn + 2HCl \longrightarrow ZnCl_2 + H_2 \uparrow$ $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2 \uparrow$	A colourless, odourless gas evolves.	May be H_2, O_2, CO_2 and N_2 gas
2.	Bring moist blue/red litmus paper near to evolved gas.	No change appears.	May be H_2, O_2 and N_2 gas.
3.	Bring burning splint near to evolved gas.	• Gas burns with pale blue flame. • The splinter extinguishes and the gas burns with a pop sound.	• H_2 confirmed. • Gas supports combustion.
Test for Oxygen			
1.	Heat higher metal oxides (like HgO, PbO_2, Pb_3O_4) or nitrates. **Reactions involved** Heavy metal oxide $\xrightarrow{\Delta}$ Metal oxide or metal + Oxygen $2PbO_2 \xrightarrow{\Delta} 2PbO + O_2 \uparrow$ $2HgO \xrightarrow{\Delta} 2Hg + O_2 \uparrow$ Metal nitrates $\xrightarrow{\Delta}$ Metal oxides + Nitrogen dioxide + Oxygen $2Zn(NO_3)_2 \xrightarrow{\Delta} 2ZnO + 4NO_2 + O_2$ $2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + O_2$	A colourless, odourless gas evolves.	May be O_2, N_2, H_2 and CO_2 gas.
2.	Bring moist blue litmus paper near to evolved gas.	No change appears.	May be O_2, N_2 and H_2.
3.	Bring a glowing splinter near to evolved gas.	Splinter glows more brightly.	O_2 confirmed.

S. No.	Experiment	Observations	Inferences
Test for Carbon Dioxide			
1.	Add dilute mineral acid to carbonates or hydrogen carbonates of metals.	Colourless and odourless gas is evolved with brisk effervescence.	May be O_2, H_2, N_2, CO_2
	Reactions Metallic carbonate/hydrogen carbonate + Acid (dil.) $\longrightarrow$ Salt + Water + Carbon dioxide		
	Or, Heat metallic carbonate (**Note** Except, sodium carbonate and potassium carbonate) **Reactions involved** Metallic carbonate $\xrightarrow{\Delta}$ Metal oxide + Carbon dioxide $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$ $CuCO_3 \xrightarrow{\Delta} CuO + CO_2$		
2.	Bring moist blue litmus paper near to evolved gas.	Blue litmus paper turns red.	Acidic gas may be CO_2.
3.	• Bring burning wooden splint near to evolved gas. • When gas is passes through the lime water.	• Does not catch fire. • Lime water turns milky.	• Non-combustable gas and also does not support combustion. • CO_2 confirmed.
	(**Note** CO_2 has no effect on $K_2Cr_2O_7$ or $KMnO_4$ solution.)		
Test for Chlorine (Cl_2)			
1.	Add conc. HCl to oxidising agents like Pb_3O_4, PbO_2, MnO_2, $KMnO_4$ and $K_2Cr_2O_7$. **Reaction involved** Oxidising agent + conc. HCl $\longrightarrow$ Metal chloride + Chlorine + H_2O **Examples** $Pb_3O_4 + 8HCl \longrightarrow 3PbCl_2 + 4H_2O + Cl_2$ $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$	A greenish yellow coloured gas is evolved which have suffocating and irritating odour.	May be chlorine gas.
2.	Pass the gas through silver nitrate solution.	A white precipitate is formed.	May be chlorine gas.
3.	Bring moist blue litmus paper in contact with evolved gas and finally bleaches.	It turns red after bleach, it decolourises.	Acidic gas, bleaching agent, Cl is confirmed.
Test for Hydrogen Chloride (HCl)			
1.	Boil metallic chloride or ammonium chloride with conc. H_2SO_4. (except : $CaCl_2$, $BaCl_2$, $PbCl_2$) **Reactions involved** Metal chloride + conc. sulphuric acid $\longrightarrow$ Metal sulphate + Hydrogen chloride $KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$ $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$	Colourless gas evolves with a pungent chocking odour.	May be HCl, NH_3 or HNO_3 vapours.
2.	Bring a moist blue litmus paper near to gas.	Blue litmus paper turns red.	Acidic gas may be HCl or nitric acid vapour.
3.	When a glass rod dipped in ammonia near to gas. [**Note** When gas passes through silver nitrate solution white precipitate is formed.)	Dense white fumes or ammonium chloride are formed.	Hydrogen chloride gas (HCl) confirmed.

S. No.	Experiment	Observations	Inferences
Test for Sulphur Dioxide (SO_2)			
1.	Add dil. HCl or dil. H_2SO_4 to metal sulphite or hydrogen sulphite of metals (except : calcium sulphite and barium sulphite.) **Reaction involved** Metal sulphite/Hydrogen sulphite + dil. HCl $\longrightarrow$ Salt + Water + Sulphur dioxide **Examples** $\underset{\text{Sodium sulphite}}{Na_2SO_3} + H_2SO_4(dil) \longrightarrow$ $\underset{\text{Sodium sulphate}}{Na_2SO_4} + H_2O + \underset{\text{Sulphur dioxide}}{SO_2}\uparrow$	Colourless gas evolves with suffocating smell. (causes coughing.)	May be sulphur dioxide.
2.	When a moist blue litmus paper is brought near to evolved gas.	It turns red.	Acidic gas.
3.	When evolved gas is passes through lime water.	It turns milky.	May be SO_2.
4.	When gas is passed through $KMnO_4$ solution.	Pink colour changes to colourless.	Gas is reducing agent.
5.	When gas is passed through acidified potassium dichromate solution.	Orange colour changes to green.	SO_2 confirmed.
Test for Hydrogen Sulphide (H_2S)			
1.	Add dil. HCl or dil. H_2SO_4 in metallic sulphides. **Reactions involved** Metal sulphide + dil. Acid $\longrightarrow$ Salt + Hydrogen sulphide $FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S$ $ZnS + 2HCl \longrightarrow ZnCl_2 + H_2S$	Colourless gas evolves with rotten egg smell.	May be H_2S (Cl_2 and NO_2 are not present.)
2.	Bring moist blue litmus paper near to evolved gas.	It turns red.	Gas is acidic in nature.
3.	Pass evolved gas through lime water.	It turns milky.	May be H_2S or CO_2.
4.	Bring a paper dipped in lead acetate solution near to evolved gas.	It turns silvery black.	H_2S confirmed.
Test for Ammonia (NH_3)			
1.	Heat ammonium salts with alkali such as NaOH, $Ca(OH)_2$, etc.		
	Reactions involved Ammonium salt + Alkali $\longrightarrow$ Salt + Water + Ammonia $2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3$ $NH_4Cl + NaOH \xrightarrow{\Delta} NaCl + H_2O + NH_3$	A colourless gas evolves with a sharp pungent smell which brings tears to eyes.	Any other gas except Cl_2 and NO_2.
2.	Bring a moist red litmus paper near the evolved gas.	Red litmus turns blue.	Basic gas may be ammonia.
3.	Bring a glass rod dipped in conc. HCl near the gas.	Dense white fumes is formed.	Ammonia confirmed.

S. No.	Experiment	Observations	Inferences
Test for Water Vapour (H_2O)			
1.	Heat a salt containing water of crystallisation (like hydrated sodium carbonate or hydrated copper sulphate). **Reactions involved** Hydrated salt $\xrightarrow{\Delta}$ Anhydrous salts + Water vapour $CuSO_4 \cdot 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$ (Blue) (White) $Na_2CO_3 \cdot 10H_2O \xrightarrow{\Delta} Na_2CO_3 + 10H_2O$	Colourless and odourless gas evolves. A clear liquid droplets formed at cooler parts of the test tube.	May be O_2, H_2, CO_2 or water vapour.
2.	Dip blue/red litmus dipped in the liquid.	No change appears.	May be O_2, H_2 or water vapour.
3.	Bring burnt wooden splint in the presence of liquid.	Splint does not lighten.	Liquid may be water.
4.	Add the liquid droplets over anhydrous white copper sulphate.	The salt turns blue (salt absorbed water).	Water vapours confirmed.
Test for Nitrogen Dioxide (NO_2)			
1.	Heat metallic nitrate like copper nitrate, lead nitrate, etc. (except, $NaNO_3$ and KNO_3) **Reactions involved** Metal nitrate $\xrightarrow{\Delta}$ Metal oxide + Oxygen + Nitrogen dioxide $2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + O_2 + 4NO_2$ $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + O_2 + 4NO_2$	Reddish brown gas is evolved having an irritating pungent odour.	May be NO_2 gas.
2.	Bring moist blue litmus paper near to evolved gas.	It turns red.	Gas is acidic in nature.
3.	Bring moist potassium iodide paper near the evolved gas.	It turns into brown (oxidising agent).	NO_2 confirmed.

Viva-Voce *based* Questions

Identification of Gases

Q 1. Name the gas having rotten egg smell.
Ans. Hydrogen sulphide

Q 2. Name the gas having burning sulphur smell.
Ans. Sulphur dioxide

Q 3. When ammonia burns in an atmosphere of oxygen without presence of any catalyst, a gas is produced. Name the gas.
Ans. Nitrogen gas

Q 4. Which gas has a choking smell that usually causes coughing?
Ans. Ammonia gas

Q 5. Name the gas which is produced on reaction of dil. H_2SO_4 with a metallic sulphide.
Ans. Hydrogen sulphide gas

Q 6. Name two gases which react with ammonia to form dense white fumes.
Ans. HCl gas and chlorine (Cl_2) gas.

Q 7. When copper reacts with conc. HNO_3, then a gas is evolved. Name the gas.
Ans. Nitrogen dioxide

Q 8. Name the gas which is formed when zinc nitrate is heated.
Ans. Oxygen gas

Q 9. $CuSO_4 \cdot 5H_2O$ is blue in colour. After heating, it becomes white in colour. Why?
Ans. $CuSO_4 \cdot 5H_2O$ loses five molecules of water on heating as water vapour. The resulted anhydrous $CuSO_4$ is white in colour.

Experiment 2

Aim

To detect the anion present in a given sample.

Theory

An anion is an atom having a negative charge on it. The magnitude of the charge depends on the acid from where it has obtained. For example, CO_3^{2-}, SO_3^{2-}, S^{2-}, SO_4^{2}, Cl^- and NO_3^-.

Identification of anion present in a salt is done by performing various experiments known as tests. *These tests can be broadly divided into two types*

1. Action of heat
2. Action of reagent

On the basis of the reactions with sulphuric acid the anions can be devided into three group. These are as follows

(a) **Dilute sulphuric acid** (dil. H_2SO_4) **group includes**

(i) **Carbonate** CO_3^{2-} (ii) **Sulphite** SO_3^{2-} (iii) **Sulphide** S^{2-}

(b) **Concentrated sulphuric acid** (conc. H_2SO_4) **group includes**

(i) **Chloride** Cl^- (ii) **Nitrate** NO_3^-

(c) **Miscellaneous group** The anions which are not detected by using either dilute or concentrated sulphuric acid. *e.g.*, Sulphate (SO_4^{2-}).

Observation Table

Effect of Heat

Take about 0.5g of the salt in a clean and dry test tube. Hold the tube with a test tube holder. Heat the tube first gently and then strongly. Observe the changes.

Observations Evalution of gas on heating	Inferences
Colourless and odourless gas	CO_3^{2-}
Yellowish green gas with pungent smell	Cl^-
Brown colour gas	NO_3^-
Colourless gas with rotten egg smell	S^{2-}
White fumes with suffocating odour	SO_3^{2-}

Effect of Reagent

A. Dilute Sulphuric Acid Group

S.No.	Experiment	Observations	Inferences
I.	**Test for Carbonate** (CO_3^{2-})		
	(a) Add dil. H_2SO_4 to the salt (can be any metallic carbonate except barium carbonate, calcium carbonate and lead carbonate). Na_2CO_3 (Sodium carbonate) + dil. H_2SO_4 $\longrightarrow$ Na_2SO_4 (Sodium sulphate) + H_2O + $CO_2\uparrow$	A colourless and odourless gas evolves.	May be H_2, O_2, N_2, CO_2 gas.
	(b) Bring a moist blue litmus paper in contact with the evolved gas.	Blue litmus turns to red.	Evolved gas is acidic in nature.

S.No.	Experiment	Observations	Inferences
	(c) Pass the evolved gas through freshly prepared lime water. $Ca(OH)_2$ (Lime water) $+ CO_2 \longrightarrow CaCO_3$ (Milky) $+ H_2O$	Lime water turns milky.	CO_3^{2-} confirmed.
II.	**Test for Sulphite** (SO_3^{2-})		
	(a) Add dil. H_2SO_4 to the salt (can be any metallic sulphite except calcium and barium sulphite). Na_2SO_3 (Sodium sulphite) $+$ dil. $H_2SO_4 \longrightarrow Na_2SO_4$ (Sodium sulphate) $+ H_2O + SO_2\uparrow$	Colourless gas evolves having a smell of burning sulphur.	May be SO_2 gas
	(b) Bring a moist blue litmus paper in contact with the evolved gas.	Blue litmus changes red.	Evolved gas is acidic in nature.
	(c) Bring a paper dipped in $K_2Cr_2O_7$ in contact with the evolved gas.	Paper turns green.	SO_3^{2-} confirmed.
III.	**Test for Sulphide** (S^{2-})		
	(a) Add dil. H_2SO_4 to the salt. Na_2S (Sodium sulphide) $+$ dil. $H_2SO_4 \longrightarrow Na_2SO_4$ (Sodium sulphate) $+ H_2S\uparrow$ (Hydrogen sulphide)	Colourless gas having a smell of rotten eggs evolves.	May be H_2S gas
	(b) Bring moist blue litmus paper in contact with the evolved gas.	Blue litmus changes to red.	Evolved gas is acidic in nature.
	(c) Bring a lead acetate paper in contact with the evolved gas. $(CH_3COO)_2Pb$ (Lead acetate) $+ H_2S \longrightarrow 2CH_3COOH +$ PbS (Black ppt)	Paper turns black.	S^{2-} confirmed.

B. Concentrated Sulphuric Acid Group

S.No	Experiment	Observations	Inferences
I.	**Test for Cl^- Anion**		
	(a) Add conc. H_2SO_4 to the salt (any metallic chloride except : $CaCl_2$, $BaCl_2$, $PbCl_2$). $NaCl +$ conc. $H_2SO_4 \longrightarrow NaHSO_4 + HCl\uparrow$	Colourless pungent gas evolves.	May be HCl gas
	(b) Bring moist litmus paper in contact with the evolved gas.	Blue litmus changes to red	Gas is acidic in nature.
	(c) Bring a glass rod dipped in NH_4OH near the mouth of the test tube. $NH_4OH + HCl \longrightarrow NH_4Cl\uparrow$ (Dense white fumes) $+ H_2O$	Formation of dense white fumes.	May be HCl gas.
	(d) Pass the evolved gas through $AgNO_3$ solution.	White precipitate appears which dissolves in excess of NH_4OH.	HCl gas confirmed. Cl^- confirmed.
II.	**Test for Nitrate** (NO_3^-)		
	(a) Add conc. H_2SO_4 to the salt and heat the test tube. $NaNO_3 + H_2SO_4$ (conc.) $\longrightarrow NaHSO_4 + HNO_3$ $4HNO_3 \xrightarrow{\Delta} 4NO_2\uparrow + 2H_2O + O_2\uparrow$	Evolution of brown fumes.	May be NO_2 gas
	(c) To the fumes, add copper chips. $Cu + 4$ conc. $HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2\uparrow$	More brown dense fumes	May be NO_2 gas
	(d) To the evolved gas, add freshly prepared acidified $FeSO_4$ solution. $FeSO_4 + NO_2 \longrightarrow FeSO_4 \cdot NO$ (Nitroso ferrous sulphate)	Solution turns brown– black.	NO_2 confirmed.

Ring Test for NO_3^- Ion

Experiment	Observations	Inferences
Ring Test To a portion of the aqueous solution of the salt, add freshly prepared $FeSO_4$ solution and shake well. Then, add conc. H_2SO_4 along the side of the test tube.	Dark brown ring is formed at the junction of the two layers.	NO_3^- confirmed.

Reactions involved

$$NaNO_3 + \text{conc. } H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$

$$2HNO_3 + 3H_2SO_4 + 6FeSO_4 \longrightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

$$FeSO_4 + NO \longrightarrow \underset{\substack{\text{Nitrosoyl ferrous sulphate}\\ \text{(Brown ring)}}}{FeSO_4 \cdot NO}$$

C. Miscellaneous Group

The anion which is neither detected by dil. H_2SO_4 nor by conc. H_2SO_4.

S.No.	Experiment	Observations	Inferences
I.	**Test for Sulphate (SO_4^{2-})**		
(a)	Add $BaCl_2$ solution to the salt solution of any soluble sulphate (except : $PbSO_4$, $CaSO_4$ and $BaSO_4$). $Na_2SO_4 + BaCl_2 \longrightarrow \underset{\text{White ppt}}{BaSO_4\downarrow} + 2NaCl$	White precipitate appears.	May be SO_4^{2-} or SO_3^{2-}
(b)	To the white ppt., add conc. HCl.	Precipitate remains insoluble.	SO_4^{2-} confirmed.
II.	**Test for SO_4^{2-} using Lead Acetate Solution**		
(a)	Add lead acetate solution to acidified salt solution. $Na_2SO_4 + (CH_3COO)_2Pb \longrightarrow 2CH_3COO^-Na^+ + PbSO_4$	White precipitate appears.	May be SO_4^{2-}.
(b)	To the white ppt. add $CH_3COO^-NH_4^+$ solution. $PbSO_4 + 2CH_3COONH_4 \longrightarrow (NH_4)_2SO_4 + \underset{\text{Lead acetate}}{(CH_3COO)_2Pb}$	Precipitate dissolves.	SO_4^{2-} confirmed.

Viva-Voce *based* Questions

Detection of Anions

Q 1. What do you mean by qualitative analysis?

Ans. The detection of anions and cations present in a given inorganic substance is called qualitative analysis.

Q 2. What are anions and cations?

Ans. Atoms from which an electron is removed are called as cations and atoms in which an electron is added are called as anions.

Q 3. Name the anions detected by dil. H_2SO_4.

Ans. CO_3^{2-}, S^{2-} and SO_3^{2-} are the anions which are detected by dil. H_2SO_4.

Q 4. Why dil. H_2SO_4 is used instead of dil. HCl to perform the tests for acid radicals?

Ans. H_2SO_4 has higher boiling point (338°C) while boiling point of HCl is 110°C.

So, if the test is to be performed in cold, any dilute acid would be suitable but if the contents are to be heated, HCl may evolve along with other gases related to the acid radical to be tested.

The smell of the HCl gas will make the recognition of the other gases evolved is difficult, hence dil. H_2SO_4 is preferred over dil. HCl.

Q 5. Name the type of the salt which produces a pale brown gas on heating.

Ans. Nitrate or nitrite salts of metals.

Q 6. Which gas is evolved by the action of dil. acids on carbonates?

Ans. Carbon dioxide gas.

Q 7. What is ring (chemical form) in the test of nitrate?

Ans. It is due to the formation of $FeSO_4$.

Q 8. What are deliquescent salts?

Ans. Salts which absorb moisture from the atmosphere and dissolve in it are called deliquescent salts *e.g.,* $MgCl_2$, $FeCl_3$ and $ZnCl_2$.

Q 9. What are efflorescent salts?

Ans. Salts which give out water of crystallisation are termed as efflorescent salts. *e.g.,* $FeSO_4 \cdot 7H_2O$ or $Na_2CO_3 \cdot 10H_2O$ loses water of crystallisation to become $FeSO_4 \cdot xH_2O (3 < x < 7)$ and $Na_2CO_3 \cdot H_2O$ (loses 9 molecules of water of crystallisation).

Experiment 3

Aim

To detect the cation present in a given sample using NaOH (sodium hydroxide) and NH_4OH (ammonium hydroxide) solutions.

Theory

Qualitative analysis includes the identification of an unknown substance by chemical tests. The tests includes use of sodium and ammonium hydroxides on salt solution and observation of the colour and solubility of the precipitates formed. Sodium hydroxide is a strong alkali which dissociates completely to furnish OH^- ions while ammonium hydroxide is a weak alkali which dissociates partially to furnish sufficient OH^- ions and precipitate as **insoluble metal hydroxides** (colour). Due to the difference in colour, they are easily detected.

Procedure

Preparation of the Original Solution The first step in the detection of cation (except ammonium) is the preparation of original solution. To get the original solution, add distilled water to the given unknown salt, shake it well. If the salt dissolves completely, add some more salt in small quantity to obtain concentrated solution. This solution is known as original solution (OS). If the given salt does not dissolve in cold distilled water, heat the contents to prepare OS. If the given salt remains insoluble in both hot and cold distilled water, then add dil. HCl or conc. HCl to prepare OS.

Observation Table

S. No.	Experiment	Observations	Inferences
I.	**Action with NaOH Solution**		
	To the cation salt, add NaOH solution and then warm it gently.		
(i)	For NH_4^+ Cation,	• Colourless gas having pungent irritating odour evolves.	May be NH_3
	$NH_4Cl + NaOH \xrightarrow{\Delta} NaCl + H_2O + NH_3 \uparrow$		
	Bring glass rod dipped in conc. HCl in contact with the evolved gas.	• Dense white fumes formed.	NH_4^+ present
	$NH_3 + \text{conc. } HCl \longrightarrow \underset{\text{Ammonium chloride}}{NH_4Cl}$		

S. No.	Experiment	Observations	Inferences
(ii)	For Ca^{2+} Cation, NaOH + Ca^{2+} ions + Heat the solution **Reaction** $Ca(NO_3)_2 + 2NaOH \xrightarrow{\Delta} \underset{\text{White}}{Ca(OH)_2\downarrow} + 2NaNO_3$	White precipitate of $Ca(OH)_2$ which is insoluble in excess of NaOH solution.	Ca^{2+} present
(iii)	For Cu^{2+} Cation, NaOH + Cu^{2+} ions + Heat the solution **Reaction** $CuSO_4 + 2NaOH \xrightarrow{\Delta} \underset{\text{Blue}}{Cu(OH)_2\downarrow} + Na_2SO_4$	Pale blue precipitate of $Cu(OH)_2$ which is insoluble in excess of NaOH solution.	Cu^{2+} present
(iv)	For Fe^{2+} Cation, NaOH + Fe^{2+} ions + Heat the solution **Reaction** $FeCl_2 + 2NaOH \xrightarrow{\Delta} \underset{\text{Dirty green}}{Fe(OH)_2\downarrow} + 2NaCl$	Dirty green ppt. of $Fe(OH)_2$ insoluble in excess of NaOH solution	Fe^{2+} present
(v)	For Fe^{3+} Cation, NaOH + Fe^{3+} ions + Heat the solution **Reaction** $FeCl_3 + 3NaOH \xrightarrow{\Delta} \underset{\text{Reddish brown ppt.}}{Fe(OH)_3\downarrow} + 3NaCl$	Reddish brown ppt. of $Fe(OH)_3$ which is insoluble in excess of NaOH solution.	Fe^{3+} present
(vi)	For Pb^{2+} Cation, NaOH + Pb^{2+} ions + Heat the solution **Reaction** $Pb(NO_3)_2 + 2NaOH \xrightarrow{\Delta} \underset{\text{White}}{Pb(OH)_2\downarrow} + 2NaNO_3$	White colour precipitate of $Pb(OH)_2$ which is soluble in excess of NaOH solution.	Pb^{2+} present
(vii)	For Zn^{2+} Cation, NaOH + Zn^{2+} ions + Heat the solution **Reaction** $Zn(NO_3)_2 + 2NaOH \xrightarrow{\Delta} Zn(OH)_2\downarrow + 2NaNO_3$	White gelatinous precipitate of $Zn(OH)_2$ which is soluble in excess of NaOH solution.	Zn^{2+} present

II. Action with NH_4OH Solution

(i)	To the solution of Cu^{2+} ions, add little amount of NH_4OH solution followed by in excess. $CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Bluish white ppt.}}{Cu(OH)_2\downarrow} + (NH_4)_2SO_4$	Pale blue colour precipitate of $Cu(OH)_2$ which is soluble in excess of NH_4OH to give deep blue solution.	Cu^{2+} confirmed.
(ii)	To the solution of Fe^{2+} ions, add little amount of NH_4OH solution and then in excess. $FeCl_2 + 2NH_4OH \longrightarrow \underset{\text{Dirty green ppt}}{Fe(OH)_2\downarrow} + 2NH_4Cl$	Dirty green precipitate of $Fe(OH)_2$ which changes to reddish brown after some time and insoluble in excess of NH_4OH solution.	Fe^{2+} confirmed.

S. No.	Experiment	Observations	Inferences
(iii)	Similarly, with Fe^{3+}, Pb^{2+}, Zn^{2+}, Ca^{2+}		
(a)	Fe^{3+} ions + little NH_4OH solution + excess NH_4OH solution $FeCl_3 + 3NH_4OH \longrightarrow \underset{\text{Reddish brown}}{Fe(OH)_3\downarrow} + 3NH_4Cl$	Reddish brown precipitate which is insoluble in excess of NH_4OH solution.	Fe^{3+} confirmed.
(b)	Pb^{2+} ions + little NH_4OH solution + excess NH_4OH solution $Pb(NO_3)_2 + 2NH_4OH \longrightarrow \underset{\text{White ppt.}}{Pb(OH)_2\downarrow} + 2NH_4NO_3$	White precipitate which is insoluble in excess of NH_4OH solution.	Pb^{2+} confirmed.
(c)	Zn^{2+} ions + little NH_4OH solution + excess NH_4OH solution $Zn(OH)_2 + 4NH_4OH \longrightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$	White gelatinous precipitate which is soluble in excess of NH_4OH solution.	Zn^{2+} confirmed.
(d)	Ca^{2+} + little NH_4OH solution + excess NH_4OH solution $Ca(NO_3)_2 + 2NH_4OH \longrightarrow$ No visible reaction	No reaction	–

Viva-Voce *based* Questions

Detection of Cations

Q 1. Give one chemical test that would enable to distinguish between calcium nitrate solution and zinc nitrate solution.

Ans. When calcium nitrate solution and zinc nitrate solution is treated with dil. NaOH solution, then precipitates are formed.

$$Ca(NO_3)_2 + 2NaOH \longrightarrow \underset{\text{White ppt.}}{Ca(OH)_2\downarrow} + 2NaNO_3$$

$$Zn(NO_3)_2 + 2NaOH \longrightarrow \underset{\text{White gelatinous ppt.}}{Zn(OH)_2\downarrow} + 2NaNO_3$$

The two solutions can be easily differed by considering the different types of precipitates.

Q 2. The following shows the tests performed on two aqueous solutions, *A* and *B*. Write the observations obtained for the tests in each case (a) and (b).

(a) **Test** To solution *B* sodium hydroxide solution was added.
Conclusions *B* contains Fe^{3+} ions.

(b) **Test** To solution *C* ammonium hydroxide solution was added slowly then in excess.
Conclusions *C* contains Cu^{2+} ions.

Ans. (a) **Observations** Reddish brown ppt. of $Fe(OH)_3$ is formed which is insoluble in excess of NaOH solution.

(b) **Observations** Blue colour ppt. of $Cu(OH)_2$ is formed which is soluble in excess of NH_4OH to give deep blue solution.

Q 3. Name the gas released when ammonium salts are heated with alkali.

Ans. Ammonia (NH_3)

Q 4. What is the nature of ammonia gas?

Ans. Moist ammonia (NH_3) is basic in nature.

Q 5. When sodium hydroxide solution is added to copper sulphate solution first in little and then in excess. What is the colour of precipitate?

Ans. A pale blue or bluish white ppt. appears which is insoluble in excess of sodium hydroxide solution.

Q 6. Name a cation which is not a metal.

Ans. Ammonium (NH_4^+)

Q 7. Why NaOH and NH_4OH are made to react with metallic salt? Why other solutions are not used?

Ans. Sodium hydroxide is a strong alkali which dissociates completely to furnish OH^- ions while ammonium hydroxide is a weak alkali which dissociates partially to furnish sufficient OH^- ions which precipitate as insoluble hydroxides. water of crystallisation).

Experiment 4

Action of Heat on Given (Unknown) Substances

Heating causes both physical and chemical changes. Physical changes usually involve melting and evaporation while chemical changes involve decomposition of a substance, dehydration of hydrated crystals of substance. Change in colour during the heating helps to identify the heated substance.

S. No.	Experiment	Observations	Inferences
1.	**Identification of $CuCO_3$** (Copper Carbonate)		
(a)	Heat the given light, green amorphous powder. **Reactions involved** $\underset{\text{Hight green}}{CuCO_3} \xrightarrow{\Delta} \underset{\text{Black}}{CuO} + CO_2\uparrow$ $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$	• It turns black. • Colourless and odourless gas evolves.	• Black residue is CuO. • CO_2 evolved. • Given substance is $CuCO_3$.
2.	**Identification of $ZnCO_3$** (Zinc Carbonate)		
(a)	Heat the given white amorphous solid.	• It turns pale yellow solid. • Colourless and odourless gas evolves.	White residue is ZnO (turns white on cooling) • CO_2 confirmed.
(b)	Pass the evolved gas through lime water. **Reaction involved** $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$	Lime water turns milky.	• Given substance is $ZnCO_3$.
3.	**Identification of $Zn(NO_3)_2 \cdot 6H_2O$** (Zinc Nitrate Hexahydrate)		
(a)	Heat the given white, crystalline deliquescent solid.	Steamy vapours form that to give a white viscous liquid.	
(b)	Bring anhydrous $CuSO_4$ near to the mouth of the evolved vapers.	White anhydrous $CuSO_4$ turns to blue anhydrous $CuSO_4$.	
(c)	Strongly heat the residue.	Pale yellow residue forms along with reddish brown fumes.	• Residue is ZnO. • Reddish brown fumes is a mixture of NO_2 and O_2.
(d)	Bring a glowing wood splinter near the fumes. **Reactions involved** $Zn(NO_3)_2 \cdot 6H_2O \xrightarrow{\Delta} Zn(NO_3)_2 + 6H_2O$ $Zn(NO_3)_2 \xrightarrow{\Delta} 2ZnO + 4NO_2 + O_2\uparrow$	It inflames the splinter.	• Presence of oxygen in the fumes. • Steamy vapours is of H_2O. • Given substance is $Zn(NO_3)_2 \cdot 6H_2O$.

4. Identification of $Cu(NO_3)_2 \cdot 6H_2O$ (Copper nitrate hexahydrate)

(a)	Heat the given blush green crystalline solid.	Steamy vapour forms.	
(b)	Bring anhydrous $CuSO_4$ near to the evolved paper.	White anhydrous $CuSO_4$ turns blue hydrous $CuSO_4$.	
(c)	Strongly heat the residue.	Black residue forms along with reddish brown fumes.	• Residue is CuO. • Reddish brown fumes are mixture of NO_2 and O_2.

S. No.	Experiment	Observations	Inferences
(d)	Bring a glowing wood splinter near the fumes. **Reactions involved** $Cu(NO_3)_2 \cdot 6H_2O \xrightarrow{\Delta} Cu(NO_3)_2 + 6H_2O$ $2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + O_2 \uparrow$	It inflames the splinter.	• Presence of O_2. • Given substance is $Cu(NO_3)_2 \cdot 6H_2O$

5. Identification of $[Pb(NO_3)_2]$ Lead Nitrate

(a)	Heat the given white, crystalline solid.	• Reddish brown fumes and residue forms. • Residue changes to light yellow colour on cooling.	Residue is PbO.
(b)	Bring moist blue litmus paper near the evolved gas.	Blue litmus paper turns red.	
(c)	Bring a glowing wood splinter in the fumes. **Reactions involved** $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 \uparrow + O_2 \uparrow$	It inflames splinter.	• Presence of O_2 in the fumes. • Fume is amixture of NO_2 and O_2. • Given substance is $[(Pb(NO_3)_2]$.

Viva-Voce *based* Questions

Action of heat on given (unknown) substances

Q 1. Name the gas which is evolved on heating zinc carbonate ($ZnCO_3$).

Ans. Carbon dioxide (CO_2) gas.

Q 2. Name the residue which is left on heating lead nitrate $[(Pb(NO_3)_2]$.

Ans. Lead oxide (PbO).

Q 3. Which salt decripitates on heating?

Ans. Lead nitrate $[(Pb(NO_3)_2]$.

Q 4. What happens when zinc nitrate crystals are strongly heated?

Ans. Zinc nitrate crystals decompose to give off reddish brown coloured gas which turns prepared acidified ferrous sulphate solution brown black. A residue is left behind which is yellow when hot and white when cold.

Q 5. Name the bluish green crystals which form a black residue of copper oxide (CuO) on strong heating.

Ans. Copper nitrate crystals $[Cu(NO_3)_2 \cdot 6H_2O]$.

Experiment 5

Aim

To determine whether a given solution is acidic or basic.

Theory

Acids are the substances which have sour taste and bases are the substances which have bitter teste. To test whether a solution is acidic or basic, indicators are used which show one colour in the acidic medium and a different colour in the basic medium. *Some common indicators are as follows*

S. No.	Indicator Used	Colour Observed in Acid	Colour Observed in Base
(i)	Blue litmus	Red	No change
(ii)	Red litmus	No change	Blue
(iii)	Methyl orange	Red or pink	Yellow
(iv)	Phenolphthalein	Colourless	Pink

Observation Table

S. No.	Experiment	Observed in Dilute Acid	Observation in Alkali
(i)	Add a few drops of litmus solution	Blue litmus solution turns red	Red litmus solution turns blue
(ii)	Add a few drops of methyl orange	It turns red	It turns yellow
(iii)	Add a few drops of phenolphthalein.	It remains colourless	It turns pink

Viva-Voce *based* Questions

Determine Whether a given solution is acidic or basic

Q 1. Given two examples of acidic solution?

Ans. Lemon juice and coffee.

Q 2. Which type of solution turn red litmus blue?

Ans. Basic solutions

Q 3. What is the nature of aqueous solution of sodium carbonate?

Ans. Basic

Q 4. Why does dry HCl gas not change the colour of the dry litmus paper?

Ans. Dry HCl gas does not ionise to produce H^+ ions. Hence, it does not show acidic properties and therefore does not change the colour of dry litmus paper.

Q 5. Do basic solutions also have $H^+(aq)$ ions? If yes, then why are these basic?

Ans. Basic solutions also have H^+ ions in addition to H^- ions. They are basic because in these solutions H^- ion concentration is greater than H^+ ion concentration.

Experiment 6

Aim

To study the effect of adding concentrated hydrochloric acid to manganese (IV) oxide and copper oxide.

Observation Table

S. No.	Experiment	Observations	Inferences
Test between MnO_2 and conc. HCl			
(a)	Heat the conc. HCl and black powder of MnO_2.	A greenish yellow gas having pungent smell evolves.	Presence of chlorine gas.
(b)	Bring moist blue litmus paper in contact with the evolved gas.	Moist blue litmus paper changes to red and then bleach it to white.	The evolved gas is acidic in nature and is a bleaching agent.
(c)	Bring moist starch iodide paper in contact with the evolved gas.	Paper turns blue black.	Chlorine confirmed.
(d)	Filter the solution	Residue-black Filtrate-brown	
(e)	To the filtrate, add NH_4OH solution in excess.	No ppt.	MnO_2 which is a black powder confirmed.
	Chemical reactions $\underset{\text{Black}}{MnO_2} + \underset{\text{Conc.}}{4HCl} \longrightarrow \underset{\text{Light brown}}{MnCl_2} + 2H_2O + \underset{\text{Greenish yellow}}{Cl_2}$		
	$H_2O + Cl_2 \longrightarrow HCl + HClO$ (Blue litmus $\longrightarrow$ Red)		
	$HClO \longrightarrow HCl + [O]$		
	[O] + Hydrogen of the colouring matter $\longrightarrow$ Bleached product + H_2O		
	$2KI + Cl_2 \longrightarrow 2KCl + I_2$		
	I_2 + Starch $\longrightarrow$ Blue black		
Test between CuO and conc. HCl			
(a)	Heat the conc. HCl and black powder of CuO.	No gas is evolved.	
(b)	Filter the solution.	Residue-black Filtrate-blue	
(c)	To the filtrate obtained, add NH_4OH solution in excess.	Blue ppt is formed which is soluble in excess of NH_4OH to give a deep blue solution.	CuO is obtained.
	Chemical reactions $CuO + 2HCl\ (conc.) \xrightarrow{\Delta} CuCl_2 + H_2O$		
	$CuCl_2 + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + 2NH_4Cl$		
	$\underset{\text{Pale blue ppt.}}{Cu(OH)_2} + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow 4H_2O + \underset{\text{Deep blue solution}}{[Cu(NH_3)_4]^{2+}}$		

Viva-Voce *based* Questions

Effect of Adding conc. HCl to MnO_2 and CuO

Q 1. A compound (*A*) which is black in colour treated with conc.

HCl releases greenish yellow gas. Name the gas and compound (*A*).

Ans. The gas released is chlorine and compound (*A*) is MnO_2.

Q 2. Name two black coloured oxidising agents.

Ans. Copper oxide and manganese (IV) oxide.

Q 3. What is the colour of solutions formed when the oxidising agents CuO and MnO_2 are exposed to conc. HCl?

Ans. **Copper oxide** (CuO) Bluish green or blue solution.

Manganese (IV) **oxide** (MnO_2) : Light brown colour solution.

Q 4. How can we distinguish between MnO_2 and CuO?

Ans. Manganese dioxide (MnO_2) evolves chlorine gas on treatment with concentrated HCl whereas copper oxide (CuO) will not.

Q 5. Name the black metallic oxide which dissolves in nitric acid to give greenish blue solution.

Ans. Copper oxide

SAMPLE
QUESTION PAPERS (1-5)

SAMPLE QUESTION PAPER 1

A HIGHLY SIMULATED SAMPLE QUESTION PAPER FOR ICSE CLASS X

CHEMISTRY (FULLY SOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

FULLY SOLVED

Section-A

[40 *Marks*]

1. (a) Fill in the blanks from the choices given in brackets.

(i) An element with atomic number 17 belongs to ..... period. (first, third, seventh)

(ii) The electronic configuration of magnesium atom after loosing 2 electrons resembles to ..... gas. (neon, argon, helium)

(iii) Ammonium hydroxide is an example of ..... base. (weak/strong)

(iv) On reaction of H_2S gas with dil.HNO_3, the oxidised product obtained is ..... . (sulphur, nitrogen, oxygen)

(v) The molecular formula of the compound formed when ethyne reacts with chlorine is ..... . ($C_2H_4Cl_2$, $C_2H_2Cl_2$, C_2Cl_6) ***[5]***

(b) Choose the correct answer from the options given below.

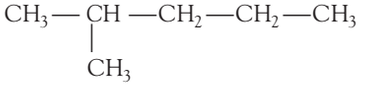
(i) Name the law that groups the elements in family of three.

(a) Law of triads
(b) Newland's law of octaves
(c) Mendeleev's periodic law
(d) None of the above

(ii) Among the following, which gas is a green house gas?

(a) Propane (b) Methane
(c) Phosgene (d) None of these

(iii) The IUPAC name for the following is



(a) 2-methyl pentane (b) hexane
(c) 4-methyl pentane (d) pentane

(iv) The reactions in which heat energy is evolved are

(a) enthalpy change reactions
(b) exothermic reactions
(c) endothermic reactions
(d) None of the above

(v) How many moles of HCl are present in 16.5 g of it?

(a) 0.45 mol (b) 2 mol
(c) 3.0 mol (d) 4 mol ***[5]***

(c) Identify the **substance** underlined, in each of the following cases.

(i) An alkene that shows both chain and position isomers.

(ii) Acid also known as aqua fortis.

(iii) An unsaturated hydrocarbon used for cutting and welding metals.

(iv) A gas is evolved when zinc metal reacts with dil. HCl.

(v) A gas is evolved when liquor ammonia is kept exposed to air. ***[5]***

(d) Write a balanced chemical equation for each of the following.

(i) When sodium carbonate reacts with calcium hydroxide.

(ii) When sodium reacts with ethyl alcohol.

(iii) When silver nitrate solution reacts with aqueous HCl.

(iv) When ammonium chloride is exposed to heat.

(v) When copper reacts with silver nitrate solution. ***[5]***

(e) State one relevant observation for each of the following
(i) Action of dilute hydrogen chloride on lead nitrate solution.
(ii) Reaction of ammonia with heated yellow lead oxide.
(iii) When ammonium hydroxide solution is added to a solution of Iron (III) chloride.
(iv) Action of dilute sulphuric acid on barium chloride.
(v) When acetic acid and ethyl alcohol reacts in presence of sulphuric acid. *[5]*

(f) (i) Draw the structural formula for each of the following.
(a) But-2-yne (b) Ethanal
(c) Propan-2-ol
(ii) From the list of term given, choose the most appropriate term to match the given description.
(smelting, calcination, galvanisation, roasting)
(a) Heating of ore above the melting point either along or with some flux.
(b) Process of heating ore in the presence of air to a high temperature. *[5]*

(g) (i) How many molecules are present in 2.2 g of carbon dioxide?
(ii) How many moles of sulphur and oxygen atoms are present in one mole each of H_2SO_4 and H_2SO_3?
(iii) Calculate the number of particles present in 0.01 mole of any substance. *[5]*

(h) Match the elements fluorine, hydrogen, chlorine, francium and sodium with each of the following.
(i) The second last element of the period 3.
(ii) The element which has the highest electronegativity.
(iii) The element which may be placed in group 1 but is not a metal.
(iv) The element which has the highest electropositivity.
(v) The most metallic element in period 3. *[5]*

Section-B [40 *Marks*]

2. (a) Arrange the following as per the instructions given in the brackets.
(i) Na, Mg, Al, Si, Cl (increasing order of non-metallic character).
(ii) Li, Be, C, O, F (decreasing order of metallic character).
(iii) Mg, Al, Na, Si (increasing order of atomic size).
(iv) Li, Be, B, C (decreasing order of atomic size). *[4]*

(b) An element A is present in the group 14 of the modern periodic table.
(i) What will be its valency?
(ii) What type of bond will it form? *[2]*

(c) Explain the following.
(i) Pure nitric acid takes a yellowish brown colour when exposed to light.
(ii) Colourless nitric oxide forms brown fumes in air. *[2]*

(d) Identify and name the salt on the basis of the following description.
(i) A salt prepared by the action of salt acid on metal.
(ii) A nitrate which does not decompose on heating. *[2]*

3. (a) Draw the structural formulae and identify the functional group.
(i) Ethanoic acid (ii) Ethanal *[4]*

(b) State the observations at the anode and at the cathode when the following are electrolysed.
(i) Aqueous copper sulphate between copper electrodes.
(ii) Water acidified with sulphuric acid using platinum electrodes. *[4]*

(c) Which of the following will get preferentially discharged at cathode and anode, respectively?
(i) Cu^{2+} or Zn^{2+} ion
(ii) OH^- or SO_4^{2-} ion *[2]*

4. (a) Complete the following table.

Name of the process	Reactants used	Products formed	Catalyst	Chemical reaction
A	Ammonia + Air	Nitric acid	*B*	*C*
Haber's process	*D*	Ammonia	*E*	$N_2 + 3H_2 \rightleftharpoons 2NH_3 + Heat$

[5]

(b) Write the balanced chemical equation for the following.
(i) Sodium nitrate and concentrated sulphuric acid.
(ii) Potassium hydrogen carbonate and sulphuric acid.
(iii) Zinc carbonate and dilute sulphuric acid. *[3]*

(c) Write the balanced equations for the three chemical reactions that take place during the conversion of sulphur dioxide to sulphuric acid in the contact process. *[2]*

5. (a) (i) An inorganic compound has the following percentage composition.
P = 22.4 %, Cl = 77.45%

FULLY SOLVED

Deduce the chemical formula

(P = 31, Cl = 35.5)

(ii) $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

How many gram of silver nitrate is required to precipitate 287 g of silver chloride?

(N = 14, O = 16, Cl = 35.5, Ag = 108) *[4]*

(b) Define Avogadro's number.

(i) Show that 100 g of water and 100 g of carbon dioxide are not equal in number of moles. Molecular masses of water and carbon dioxide are 18 u and 44 u, respectively.

(ii) Calculate the number of molecules present in the 100 g for both water and carbon dioxide. *[4]*

(c) Write a balanced chemical equation for each of the following.

(i) Magnesium reacts with dilute sulphuric acid.

(ii) When lead (II) oxide dissolved in dilute nitric acid. *[2]*

6. (a) Give the balanced chemical equations for the reaction of dilute hydrochloric acid with each of the following.

(i) Manganese dioxide

(ii) Sodium hydrogen sulphide

(iii) Ammonium hydroxide

(iv) Calcium carbonate *[4]*

(b) Name the following.

(i) A hydrocarbon used as an industrial fuel in chemical industries.

(ii) The next higher homologue of ethyl alcohol.

(iii) A compound which is used as an antifreeze agent.

(iv) An acid used for removing ink stains. *[4]*

(c) Write a balanced chemical equation for each of the following.

(i) Reaction of excess of chlorine with methane

(ii) Reaction of 1, 2-dibromoethane with alcoholic potassium hydroxide. *[2]*

7. (a) Name the following.

(i) Name the chief ore of aluminium.

(ii) Name the process used to concentrate the aluminium ore.

(iii) Name a process used for the concentration of zinc blende.

(iv) Name a bond that is formed between two atoms having significant difference in their electronegativities. *[4]*

(b) Answer the following questions with reference to Haber's process.

(i) Write the reactants.

(ii) Write the favourable conditions. *[3]*

(c) From the list given below, choose the answer that most appropriately fits the description given in the following.

[$FeSO_4$, NH_4OH, K_2HgI_4]

(i) Green vitriol is another name of this salt.

(ii) A complex salt solution used for testing a basic gas lighter than air.

(iii) A basic solution which does not contain a metallic element. *[3]*

EXPLANATIONS

Section-A

1. (a) (i) third (ii) neon
(iii) weak (iv) sulphur
(v) $C_2H_2Cl_2$

(b) (i) (a) Law of triads (ii) (b) Methane
(iii) (a) 2-methyl pentane (iv) (b) Exothermic reactions
(v) (a) 0.45 mol

(c) (i) Butene (ii) HNO_3
(iii) Ethyne (iv) H_2
(v) Ammonia

(d) (i) $Na_2CO_3 + Ca(OH)_2 \longrightarrow 2NaOH + CaCO_3 \downarrow$

(ii) $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2 \uparrow$

(iii) $AgNO_3 + HCl(aq) \longrightarrow AgCl \downarrow + HNO_3$

(iv) $NH_4Cl \xrightarrow{\text{Heat}} NH_3 + HCl$

(v) $\underset{\text{Copper}}{Cu} + 2\underset{\text{Silver nitrate}}{AgNO_3} \longrightarrow \underset{\text{Silver}}{2Ag} + \underset{\text{Copper nitrate}}{Cu(NO_3)_2}$

(e) (i) A white precipitate of lead chloride ($PbCl_2$) is obtained that is soluble in hot water but insoluble in cold water.

$$Pb(NO_3)_2(aq) + 2HCl(aq) \longrightarrow PbCl_2(s) + 2HNO_3(aq)$$

(ii) On passing ammonia through yellow lead oxide, it changes to silver white lead along with evolution of N_2 gas

$$\underset{\substack{\text{Lead oxide}\\\text{(Yellow)}}}{3PbO} + 2NH_3 \xrightarrow{\Delta} \underset{\substack{\text{Lead}\\\text{(Silver white)}}}{3Pb} + N_2 + 3H_2O$$

(iii) A reddish brown precipitate of ferric hydroxide is formed which is insoluble in excess of NH_4OH.

$$\underset{\text{(Yellow)}}{FeCl_3} + 3NH_4OH \longrightarrow \underset{\text{(Reddish brown ppt)}}{Fe(OH)_3 \downarrow} + 3NH_4Cl$$

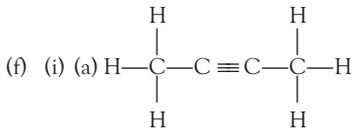
(iv) On action of dilute sulphuric acid with barium chloride solution, a thick white precipitate of barium sulphate which is insoluble in all mineral acids is formed. Hydrochloric acid is also obtained.

$$BaCl_{2(aq)} + \text{dil}\, H_2SO_4 \longrightarrow BaSO_4 \downarrow + 2HCl$$

(v) Process of esterification takes place and ethyl acetate is formed.

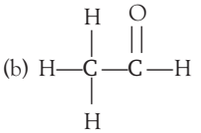
$$CH_3COOH + C_2H_3OH \underset{}{\overset{H_2SO_4}{\rightleftharpoons}} CH_3COOC_2H_5 + H_2O$$

(f) (i) (a)



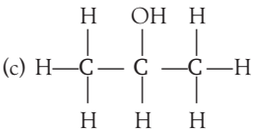
But-2-yne

(b)



Ethanal

(c)



Propan-2-ol

(ii) (a) Smelting
(b) Roasting

(g) (i) $\because$ 44 g of CO_2 contains 6×10^{23} molecules

$$\therefore \text{ 2.2 g of } CO_2 \text{ will contain} = \frac{6 \times 10^{23}}{44} \times 2.2$$
$$= 3 \times 10^{22} \text{ molecules}$$

(ii) One mole of H_2SO_4 contains 1 mole of sulphur atoms and 4 moles of oxygen atoms.
One mole of H_2SO_3 contains 1 mole of sulphur atom and 3 moles of oxygen atoms.

(iii) According to mole-concept, number of particles in 1 mole of any substance = 6.022×10^{23}

$\therefore$ Number of particles in 0.01 mole of any substance
$= 6.022 \times 10^{23} \times 0.01 = 6.022 \times 10^{21}$

(h) (i) Chlorine (17), (ii) Fluorine, (iii) Hydrogen,
(iv) Francium (v) Sodium

2. (a) (i) Na < Mg < Al < Si < Cl
(ii) Li > Be > C > O > F
(iii) Si < Al < Mg < Na
(iv) Li > Be > B > C

(b) (i) 4, (ii) Covalent bond

(c) (i) Pure nitric acid gets decomposed in the presence of light to give a reddish brown NO_2 gas, which dissolves in undecomposed nitric acid to give yellowish brown colour.

(ii) Nitric oxide is oxidised by the oxygen of air to form coloured nitrogen dioxide.

$$4HNO_3 \xrightarrow[\text{or heat}]{\text{Sunlight}} \underset{\substack{\text{Nitrogen}\\\text{dioxide}\\\text{(Brown fume)}}}{4NO_2} + 2H_2O + O_2$$

(d) (i) $MgSO_4$ (ii) KNO_3

3. (a) (i) Ethanoic acid $CH_3-\overset{\overset{O}{\|}}{C}-OH$

Functional group $-\overset{\overset{O}{\|}}{C}-OH$ (Carboxylic group)

(ii) Ethanal $CH_3-\overset{\overset{O}{\|}}{C}-H$

Functional group $-\overset{\overset{O}{\|}}{C}-H$ (Aldehyde group)

(b) (i) As the electrolysis is carried out, weight of cathode increases as copper metal deposits on the surface of cathode and weight of anode decreases as copper atoms would get oxidised to copper ions and enters into the solution.

At cathode $Cu^{2+} + 2e^- \longrightarrow Cu$

At anode $Cu + 2e^- \longrightarrow Cu^{2+}$

FULLY SOLVED

(ii) At cathode hydrogen gas is liberated while at anode oxygen gas is liberated.

At cathode

$$2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$$

At anode

$$4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$$

(c) (i) **At cathode** Cu^{2+} ion

(ii) **At anode** OH^- ion

4. (a) A. Ostwald's process

B. Platinum

C. $4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + 6H_2O + Heat$

D. Nitrogen and hydrogen

E. Finely divided iron

(b) (i) $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$ (Conc.)

(ii) $2KHCO_3 + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O + CO_2\uparrow$

(iii) $ZnCO_3 + H_2SO_4 \longrightarrow ZnSO_4 + H_2O + CO_2\uparrow$

(c) *The chemical reactions are summarised as below*

$$S + O_2 \longrightarrow SO_2$$

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

$$SO_3 + H_2SO_4 \longrightarrow \underset{(Oleum)}{H_2S_2O_7}$$

$$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$$

5. (a) (i)

Element	%	Atomic weight	Relative number of atoms	Simplest ratio
P	22.45	31	22.45 ÷ 31 = 0.72	0.72 ÷ 0.72 = 1
Cl	77.45	35.5	77.45 ÷ 35.5 = 2.18	2.18 ÷ 0.72 = 3

Hence, the formula of compound is PCl_3

(ii) Molar mass of $AgNO_3$ = 108 + 14 + 48 = 170 g

Molar mass of AgCl = 108 + 35.5 = 143.5 g

143.5 g of AgCl was precipitated by = 170 g of $AgNO_3$

287 g of AgCl will be precipitated by $= \frac{170}{143.5} \times 287$

= 340 g of $AgNO_3$

(b) The number of particles, atoms, molecules or ions present in one mole of any substance is fixed *i.e.*, 6.022×10^{23} and it is called Avogadro's number.

(i) Number of moles of water $= \frac{100\text{ g}}{18} = 5.5$ mol

Number of moles of $CO_2 = \frac{100}{44} = 2.27$ mol

(ii) 1 mol = 6.022×10^{23} molecules

5.5 moles of $H_2O = 5.5 \times 6.022 \times 10^{23}$ molecules

$= 3.31 \times 10^{24}$ molecules

2.2 moles of $CO_2 = 2.27 \times 6.022 \times 10^{23}$ molecules

$= 1.36 \times 10^{24}$ molecules

(c) (i) $Mg + H_2SO_4(dil) \longrightarrow MgSO_4 + H_2\uparrow$

(ii) $PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$

6. (a) (i) $\underset{\text{Manganese dioxide}}{MnO_2} + 4HCl \xrightarrow{Boiling} MnCl_2 + 2H_2O + \underset{\text{Chlorine gas}}{Cl_2\uparrow}$

(ii) $\underset{\text{Sodium hydrogen sulphide}}{NaHS} + HCl \longrightarrow NaCl + H_2S$

(iii) $\underset{\text{Ammonium hydroxide}}{NH_4OH} + HCl \longrightarrow NH_4Cl + H_2O$

(iv) $\underset{\text{Calcium carbonate}}{CaCO_3} + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

(b) (i) Ethane, (ii) Propyl alcohol, C_3H_7OH

(iii) Ethylene glycol, (iv) Oxalic acid

(c) (i) $CH_4 + 4Cl_2 \longrightarrow \underset{\text{Carbon tetrachloride}}{CCl_4} + 4HCl$

(ii) $CH_2BrCH_2Br + 2KOH \xrightarrow[\text{Alcoholic}]{} CH{\equiv}CH + 2KBr + 2H_2O$

Ethyne

7. (a) (i) Bauxite

(ii) Baeyer's process or Hall's process

(iii) Froth floatation

(iv) Polar covalent compound

(b) (i) *Sources of reactants*

Nitrogen gas Obtained by the fractional distillation of liquid air.

Hydrogen gas Obtained from water gas.

(ii) *Favourable conditions*

Temperature Optimum temperature is 450-500°C

Pressure Above 200 atm

Catalyst Finely divided iron

Promotor Al_2O_3 (or traces of molybdenum)

(c) (i) $FeSO_4$

(ii) Nessler's reagent, $K_2[HgI_4]$

(iii) Ammonium hydroxide (NH_4OH)

FULLY SOLVED

SAMPLE QUESTION PAPER 2

A HIGHLY SIMULATED SAMPLE QUESTION PAPER FOR ICSE CLASS X

CHEMISTRY (FULLY SOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

FULLY SOLVED

Section-A

[40 *Marks*]

1. (a) Fill in the blanks from the choices given in brackets.

(i) The neutral oxide which causes greenhouse effect. ..... .(water, methanol, CO_2)

(ii) A black metallic oxide which dissolves in nitric acid to give greenish blue solution is ..... . (copper oxide, zinc oxide, calcium oxide)

(iii) An organic gas which forms red precipitate with Fehling's solution is ..... . (propene, acetylene, ethene)

(iv) ..... is an example of non-polar covalent compound. (HCl, H_2O, N_2)

(v) A solution used for storing biological specimens is ..... . (formalin, CCl_4, $CHCl_3$) ***[5]***

(b) Choose the correct answer from the options given below.

(i) On moving from left to right across a period of the periodic table, the electron affinity of the electron in group 1 to 7

(a) increases
(b) decreases
(c) decreases and then increases
(d) increases and then decreases

(ii) The IUPAC name of acetylene is

(a) ethene (b) propyne
(c) ethyne (d) None of these

(iii) Oleum is also called

(a) gypsum
(b) white vitriol
(c) green vitriol
(d) pyrosulphuric acid

(iv) The molecule containing a triple covalent bond is

(a) methane (b) water
(c) ammonia (d) nitrogen

(v) The volume occupied by 7 g of nitrogen at STP is

(a) 4.6 L (b) 4.8 L
(c) 5.8 L (d) 5.6 L ***[5]***

(c) Identify the substance underlined in each of the following cases.

(i) <u>The substance</u> which conduct electric current in molten or aqueous state.

(ii) The <u>type of electrolyte</u> which allow large amount of electricity to flow through them.

(iii) The <u>electrode</u> connected to the positive terminal of the battery.

(iv) The <u>example</u> of saturated hydrocarbon.

(v) The <u>acid</u> which is a weak mineral acid. ***[5]***

(d) Write the balanced chemical equation for each of the following.

(i) When lead oxide is treated with ammonia.

(ii) When nitride of trivalent metal reacts with water.

(iii) When ammonium hydroxide solution is added to the zinc nitrite.

(iv) When ammonia reacts with excess of chlorine.

(v) When ammonia reacts with oxygen. ***[5]***

(e) State one relevant observation for each of the following reactions.

(i) On heating of conc. nitric acid.

(ii) On heating of metallic nitrate.

(iii) Addition of conc. sulphuric acid and nitric acid to freshly prepared saturated solution of iron [II] sulphate.

(iv) Burning of ammonia in oxygen.

(v) Catalytic oxidation of ammonia. *[5]*

(f) (i) Draw the structural formula for each of the following.

(a) 2, 2-dimethyl propane

(b) 2-methyl propene

(c) pentylene

(ii) From the list of term given, choose the most appropriate term to match the given description.

(NH_4Cl, CH_3COONa, NaCl, K_2SO_4)

(a) Acidic salt

(b) Basic salt *[5]*

(g) (i) What volume of propane is burnt for 50 cm^3 of oxygen in the reaction?

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

(ii) Calculate the mass of 2 atoms of oxygen.

(iii) Determine the empirical formula of the compounds with the following percentage compositions

Zn = 47.8, Cl = 52.2 *[5]*

(h) Match the following columns.

	Column I		Column II
(i)	A metal with atomic number 3	(a)	Boron
(ii)	A metal with electronic configuration 2,2	(b)	Lithium
(iii)	An element which has highest electronegativity	(c)	Beryllium
(iv)	A metal with the valency 3	(d)	Fluorine
(v)	A noble gas element	(e)	Neon

[5]

Section-A

[40 *Marks*]

2. (a) Arrange the following elements in the increasing order of their atomic size and ionisation potential.

(i) Chlorine, iodine, fluorine, bromine

(ii) Li, K, Rb, Cs *[4]*

(b) State the type of bonding in the following molecules.

(i) Magnesium chloride

(ii) Ammonia *[2]*

(c) How will you distinguish between the following?

(i) Magnesium dioxide and copper (II) oxide.

(ii) Dilute hydrochloric acid and dilute nitric acid. *[2]*

(d) The following table shows the tests which a student performed on four solutions *A*, *B*, *C* and *D*. Based on the observations provided, identify the cation present.

	Chemical Test	Observation	Conclusions
1.	To a solution *A*, NH_4OH is added in little amount.	A dirty green ppt. is formed.	(i)
2.	To a solution *B*, NH_4OH is added in little amount and then in excess amount.	A pale blue ppt. is formed.	(ii)

[2]

3. (a) Draw an electron dot diagram to show the formation of each of the following compounds.

(i) Sodium chloride (ii) Calcium oxide *[4]*

(b) State the ion produced at the anode and at the cathode during the electrolysis of

(i) sulphuric acid (ii) lead bromide *[4]*

(c) State the ion produced by the following case, from the aqueous mixture during the electrolysis of

(i) ammonium carbonate

(ii) lead acetate *[2]*

4. (a) Certain blank spaces are left in the following table and these are labelled as *A*, *B*, *C*, *D* and *E*. Identify each of them.

Reactants used	Products formed	Reaction condition/catalyst
A	$MnCl_2$	Δ
$CaOCl_2$ + 2HCl	*B*	Δ
$C_6H_{12}O_6$	C + H_2O	*C*
D	$CuSO_4$ + H_2O	H_2SO_4
E	C_2H_4 + H_2O	Conc. H_2SO_4 / 170°C

[5]

(b) Write the balanced chemical equation of the following.

(i) A mixture of methane and oxygen is heated in the presence of molybdenum oxide.

(ii) Preparation of ethanol from ethyl chloride.

(iii) Preparation of 1,1-dichloroethane from acetylene. *[3]*

(c) Write the balanced chemical equation for the reaction between sodium sulphite with dilute sulphuric acid. *[2]*

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5. (a) (i) 40 cm^3 of methane reacts with chlorine as per the following reaction.

$CH_4(g) + 2Cl_2(g) \longrightarrow CH_2Cl_2(g) + 2HCl(g)$

Find the volume of HCl and chlorine gas formed. *[2]*

(ii) Calculate the mass in grams for 2.5 moles of slaked lime, $[Ca(OH)_2]$. *[2]*

(b) The number of atoms in one mole is 6×10^{23}. Find out

(i) the number of molecules in 14 g of N_2 gas.

(ii) the total number of atoms in 18 g of water.

(iii) the number of chloride ions in 111 g of anhydrous calcium chloride.

(iv) state the concept that helped you to arrive at the above result. *[4]*

(c) Give a balanced chemical equation for the following.

(i) Concentrated sulphuric acid with potassium chloride.

(ii) Calcium reacts with cold water. *[2]*

6. (a) Write the balanced chemical equation for reaction between

(i) iron (II) oxide and carbon monoxide.

(ii) copper (II) oxide and hydrogen.

(iii) carbon and carbon dioxide.

(iv) ammonia reacts with carbon dioxide at 150°C. *[4]*

(b) Identify the term based on the descriptions given below.

(i) The liquor made by improper distillation.

(ii) Isomerism arises due to unequal distribution of alkyl groups on either side of the functional groups in the molecules.

(iii) Alcohol that affects the part of brain which controls muscular movements.

(iv) The characteristic of the carbon atom by virtue of which it forms four covalent bonds. *[4]*

(c) Give a balanced chemical equation for each of the following.

(i) Laboratory preparation of hydrogen chloride

(ii) Reaction of hydrogen chloride with metal carbonate *[2]*

7. (a) Name the following.

(i) The substance which effects oxidation.

(ii) Decomposition of a complex hydrocarbon into simpler hydrocarbons.

(iii) The process of breaking down a substance.

(iv) Reaction between acid and base. *[4]*

(b) During electrolysis of copper (II) sulphate solution.

(i) Name the cathode and anode. What do you observe at the cathode and at the anode?

(ii) What change is observed in the electrolyte? *[3]*

(c) Complete the following by selecting the correct option from the choices given.

(i) Ring test is used for the testing of ..... . (NO_3^-, NO_2^-, CO_3^{2-})

(ii) Tollen's reagent is the alkaline solution of ammonical silver ..... . (carbonate, nitrate, oxalate)

(iii) ..... has tendency to absorb moisture from the atmosphere, when exposed to it without dissolving in it. (H_2SO_4, H_2CO_3, HNO_3) *[3]*

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EXPLANATIONS

Section-A

1. (a) (i) water (ii) copper oxide
(iii) acetylene (iv) N_2
(v) formalin

(b) (i) (a) increases (ii) (c) ethyne
(iii) (d) pyrosulphuric acid
(iv) (d) nitrogen
(v) (d) 5.6 L

(c) (i) Electrolyte (ii) Strong electrolyte
(iii) Anode (iv) Butane
(v) Carbonic acid

(d) (i) $\underset{\text{Lead oxide}}{3PbO} + \underset{\text{Ammonia}}{2NH_3} \longrightarrow \underset{\text{Lead}}{3Pb} + 3H_2O + N_2\uparrow$

(ii) $\underset{\substack{\text{Aluminium}\\\text{nitride}}}{AlN} + 3H_2O \longrightarrow \underset{\substack{\text{Aluminium}\\\text{hydroxide}}}{Al(OH)_3} + NH_3\uparrow$

(iii) $\underset{\text{Zinc nitrite}}{Zn(NO_3)_2} + \underset{\substack{\text{Ammonium}\\\text{hydroxide}}}{2NH_4OH} \rightarrow \underset{\substack{\text{Amphoteric}\\\text{hydroxide}}}{Zn(OH)_2}\downarrow + 2NH_4NO_3$

(iv) $NH_3 + \underset{\text{Excess}}{3Cl_2} \longrightarrow \underset{\substack{\text{Nitrogen}\\\text{trichloride}}}{NCl_3} + 3HCl$

(v) $\underset{\text{Ammonia}}{4NH_3} + 5O_2 \xrightarrow{\text{Pt, 800°C}} 6H_2O + 4NO\uparrow + \text{Heat}$

$2NO + O_2 \longrightarrow \underset{\text{Brown gas}}{2NO_2}$

(e) (i) Conc. nitric acid gives brown fumes on heating.

$$4HNO_3 \xrightarrow{\Delta} 2H_2O + \underset{\substack{\text{Brown}\\\text{fumes}}}{4NO_2} + O_2$$

(ii) Metallic nitrate produce reddish brown fumes of nitrogen dioxide.

$$\text{Metallic nitrate} \xrightarrow{\Delta} \text{Metallic oxide} + NO_2 + O_2$$

(iii) A brown ring forms.

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$$

$$FeSO_4 + NO \longrightarrow \underset{\substack{\text{Nitroso ferrous sulphate}\\\text{[brown compound]}}}{FeSO_4 \cdot NO}$$

(iv) Ammonia burns in oxygen with yellowish green flame.

(v) Reddish brown vapour of nitrogen dioxide is produced.

$$4NH_3 + 5O_2 \xrightarrow{\text{Pt, 800°C}} 6H_2O + 4NO\uparrow + \text{Heat}$$

$$2NO + O_2 \longrightarrow 2NO_2 \text{ (Brown gas)}$$

(f) (i) (a) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-CH_3$ (b) $CH_2=\underset{\displaystyle CH_3}{\overset{}{\underset{|}{C}}}-CH_3$

(c) $CH_3-CH_2-CH_2-CH=CH_2$

(ii) (a) NH_4Cl (b) CH_3COONa

(g) (i) *The given reaction is*

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

It is clear that for every 5 volumes of oxygen, 1 volume of propane is burnt.

$\therefore$ Volume of propane burnt for every 50 cm^3 of oxygen

$$= \frac{1}{5} \times 50 = 10 \text{ cm}^3$$

(ii) Number of oxygen atoms in 16.0 g of atomic oxygen

$$= 6.022 \times 10^{-23} \text{ atoms}$$

$\therefore$ Mass of 2 atoms of oxygen

$$= \frac{16.0}{6.022 \times 10^{-23}} \times 2 = 5.31 \times 10^{-23} \text{g}$$

(iii)

Element	Percentage composition	Atomic mass	Atomic ratio	Simplest ratio
Zn	47.8	65	$\frac{47.8}{65} = 0.73$	$\frac{0.73}{0.73} = 1$
Cl	52.2	35.5	$\frac{52.2}{35.5} = 1.46$	$\frac{1.46}{0.73} = 2$

The empirical formula of the compound is $ZnCl_2$.

(h) (i) Lithium (b)
(ii) Beryllium (c)
(iii) Fluorine (d)
(iv) Boron (a)
(v) Neon (e)

2. (a) (i) *Increasing order of atomic size is*

Fluorine < chlorine < bromine < iodine

Increasing order of ionisation potential is

Iodine < bromine < chlorine < fluorine

(ii) *Increasing order of atomic size is*

Li < K < Rb < Cs

Increasing order of ionisation potential is

Cs < Rb < K < Li

(b) (i) Electrovalent (ii) Covalent

(c) (i) When magnesium dioxide is treated with conc. hydrogen chloride, greenish yellow gas (Cl_2) is liberated.

$$MnO_2 + \underset{\text{(Conc.)}}{4HCl} \longrightarrow MnCl_2 + 2H_2O + \underset{\substack{\text{Greenish}\\\text{yellow gas}}}{Cl_2}$$

When copper (II) oxide is treated with conc. hydrochloric acid,

$$CuO + \underset{\text{(Conc.)}}{2HCl} \longrightarrow CuCl_2 + H_2O$$

The solution turns to bluish colour due to the formation of copper chloride.

(ii) HCl reacts with $AgNO_3$, but HNO_3 does not.

$HCl(aq) + AgNO_3(aq) \longrightarrow AgCl(s) + HNO_3(aq)$

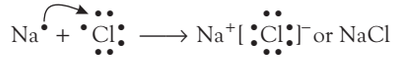
$HNO_3(aq) + AgNO_3(aq) \longrightarrow$ No reaction.

(d) (i) Fe (II) is present

(ii) Cu (II) is present

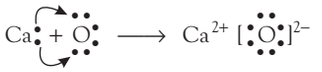
3. (a) (i) Na = 2, 8, 1

Cl = 2, 8, 7



(ii) Ca = 2, 8, 8, 2

O = 2, 6



(b) (i) $H_2SO_4 \rightleftharpoons \underset{\text{(Cathode)}}{2H^+} + \underset{\text{(Anode)}}{SO_4^{2-}}$

(ii) $PbBr_2 \rightleftharpoons \underset{\text{(Cathode)}}{Pb^{2+}} + \underset{\text{(Anode)}}{2Br^-}$

(c) (i) Ammonium carbonate

$(NH_4)_2CO_3 \rightleftharpoons 2NH_4^+ + CO_3^{2-}(aq)$

(ii) Lead acetate

$(CH_3COO)_2Pb \rightleftharpoons 2CH_3COO^- + Pb^{2+}(aq)$

4. (a) $A = MnO_2$ and HCl

$B = CaCl_2$ and H_2O

C = Conc. H_2SO_4

$D = CuSO_4 \cdot 5H_2O$

$E = C_2H_5OH$

(b) (i) $CH_4 + O_2 \xrightarrow[\Delta]{MO_2O_3} HCHO + H_2O$

(ii) $C_2H_5Cl + KOH \xrightarrow{\Delta} C_2H_5OH + KCl$

(iii) $\underset{\text{Acetylene}}{CH \equiv CH} \xrightarrow{HCl} CH_2 = CHCl \xrightarrow{HCl} \underset{\text{1,1-dichloroethane}}{CH_3 - CHCl_2}$

(c) Na_2SO_3 + dil. $H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2\uparrow$

5. (a) (i) By Gay-Lussac's law,

1 volume of CH_4 produces 2 volumes of HCl

$\therefore$ 40 cm^3 of CH_4 will produce

$= 2 \times 40 = 80\ cm^3$ of HCl

As, 1 volume of methane require 2 volumes of Cl_2

$\therefore$ 40 cm^3 of CH_4 will require

$= 2 \times 40 = 80\ cm^3$ of chlorine

Hence, for the formation of 80 cm^3 of HCl, 80 cm^3 of chlorine is required.

(ii) Mass of 1 mole of slaked lime, $Ca(OH)_2$

$= 40 + 2 \times (16 + 1)\ g = 74\ g$

Mass of 1 mole of $Ca(OH)_2 = 74\ g$

$\therefore$ 2.5 moles of $Ca(OH)_2$

$= 2.5 \times 74 = 185\ g$

(b) Molecular weight of any substance contain 6×10^{23} molecules.

(i) Mass of 1 mole of nitrogen = 28 g

$\because$ 28 g of N_2 gas contains $= 6 \times 10^{23}$ molecules

$\therefore$ 14 g of N_2 gas contains

$= \dfrac{6 \times 10^{23} \times 14}{28}$ molecules

$= 3 \times 10^{23}$ molecules

(ii) Mass of 1 mole of water = 18 g

$\because$ 18 g of H_2O contains $= 6 \times 10^{23}$ molecules

$\therefore$ 18 g of H_2O contains $= 3 \times 6 \times 10^{23}$ atoms

$= 18 \times 10^{23}$ atoms

(as H_2O contains 3 atoms)

(iii) Mass of 1 mole of anhydrous $CaCl_2 = 40 + 71$

$= 111\ g$

As, 1 molecule of $CaCl_2$ contains 2 chloride ions.

$\therefore$ 111 g of anhydrous $CaCl_2$ contains

$= 2 \times 6 \times 10^{23}$

$= 12 \times 10^{23}$ chloride ions

(iv) Mole concept and Avogadro's number .

(c) (i) KCl + Conc. $H_2SO_4 \longrightarrow KHSO_4 + HCl$

(ii) $Ca + \underset{\text{cold}}{2H_2O} \longrightarrow Ca(OH)_2 + H_2\uparrow$

6. (a) (i) $FeO + CO \xrightarrow{\Delta} Fe + CO_2$

(ii) $CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$

(iii) $C + CO_2 \xrightarrow{\Delta} 2CO$

(iv) $2NH_3 + CO_2 \xrightarrow{150°C} NH_2CONH_2 + H_2O$

(b) (i) Spurious alcohol.

(ii) Metamerism

(iii) Ethyl alcohol

(iv) Tetravalency of carbon

(c) (i) $NaCl + H_2SO_4 \xrightarrow{< 200°C} NaHSO_4 + HCl\uparrow$

(ii) $2Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2\uparrow$

7. (a) (i) Oxidising agent (ii) Cracking

(iii) Decomposition

(iv) Neutralisation

(b) (i) Cathode–Platinum

Anode –Carbon

At cathode –red shiny metal deposits

At anode–bubbles of a colourless, odourless gas are evolved.

(ii) Colour of electrolyte gradually fades from blue to colourless.

(c) (i) NO_3^-

(ii) nitrate

(iii) H_2SO_4

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SAMPLE QUESTION PAPER 3

A HIGHLY SIMULATED SAMPLE QUESTION PAPER FOR ICSE CLASS X

CHEMISTRY (FULLY SOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

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Section-A

[40 *Marks*]

1. (a) Fill in the blanks from the choices given in brackets.

(i) The smaller the atomic size, the ..... (greater, smaller, same) is the nuclear pull.

(ii) The symbolic representation of an element indicating their valence shell electrons is called ..... . (IUPAC names, electron dot structures, structural formula)

(iii) Decomposition of bicarbonates by acids releases ..... (CO_2 , SO_2, H_2) gas.

(iv) Zinc reacts with hot and concentrated KOH to give ..... . (zinc oxide, potassium zincate, potassium oxide)

(v) The compound formed when alkyne react with chlorine is ..... . (1, 2-dichloroethene, 1,1,2,2-tetrachloroethane, 1-chloroethene) ***[5]***

(b) Choose the correct answer from the options given below.

(i) In a periodic table, maximum electron affinity is possessed by

(a) halogens (b) alkali metals

(c) noble gases (d) alkaline earth metals

(ii) The acid which contains four hydrogen atoms is

(a) formic acid (b) sulphuric acid

(c) nitric acid (d) acetic acid

(iii) On reaction of magnesium nitride with water, the gas which liberated is

(a) NH_3

(b) HCl

(c) H_2

(d) N_2

(iv) The number of electrons lost or gained by an atom is called

(a) covalency (b) donation

(c) electrovalency (d) None of these

(v) How many times an atom of sulphur is heavier than an atom of carbon ? ***[5]***

(a) 3.20 times

(b) 2.66 times

(c) 1.20 times

(d) 1.33 times

(c) Identify the substance underlined in each of the following cases.

(i) Name <u>one lead compound</u> that can be used to oxidise HCl to chlorine.

(ii) A <u>compound</u> formed when iron reacts with hydrogen chloride.

(iii) The <u>common name</u> of phenol.

(iv) A <u>colourless gas</u> which becomes reddish brown when it comes in contact with atmosphere.

(v) Name a <u>compound</u> which used as catalyst in making sulphuric acid. ***[5]***

(d) Write a balanced chemical equation for each of the following.

(i) Action of dilute sulphuric acid on calcium.

(ii) Reaction of ammonia with CO_2 at 150°C.

(iii) Preparation of glyoxal from ethyne.

(iv) Action of H_2SO_4 on Na_2SO_3.

(v) Preparation of HNO_3 from Ostwald process. ***[5]***

(e) State one relevant observation for each of the following reactions.

(i) Addition of methyl alcohol in presence of conc. H_2SO_4 at 140°C.
(ii) Action of ammonia on copper oxide.
(iii) Action of calcium bicarbonate solution on nitric acid.
(iv) Action of copper sulphate on ammonium hydroxide.
(v) Action of heat on mercuric oxide. *[5]*

(f) (i) Draw the structural formula for each of the following.
(a) Diethyl ether (b) 3-methylpent-2-ene
(c) Pentanol *[3]*

(ii) From the list of terms given, choose the most appropriate term to match the given description (Baeyer's process, Hoope's process, thermite process, roasting).
(a) The ore is heated in excess of air.
(b) Conversion of bauxite into alumina. *[2]*

(g) (i) Define non-polar covalent compounds with example. *[2]*

(ii) What is the molecular mass of a substance, each molecule of which contains 9 atoms of carbon, 13 atoms of hydrogen and 2.33×10^{-23} g of other components? *[2]*

(iii) Calculate the number of moles in 1.46 metric ton of Al (1 metric ton = 10^3 kg). *[1]*

(h) Match the atomic number 11, 17, 9, 18, 7 with each of the following.
(i) Element which has the highest electron affinity in third period.
(ii) Element with the least ionisation potential in 3rd period.
(iii) Most active non - metal.
(iv) An element in period 3rd whose electron affinity is zero.
(v) The number of electrons present in the valence shell of halogen. *[5]*

Section-B [40 *Marks*]

2. (a) Arrange the following as per the instruction given in the brackets.

(i) F, Cl, Br, I, At (Decreasing order of electronegativity)
(ii) F, Cl, Br, I, At (Increasing order of ionisation potential)
(iii) F, Cl, Br, I, At (Increasing order of atomic size)
(iv) F, Cl, Br, I, At, (Increasing order of non-metallic character). *[4]*

(b) What are the terms defined below?
(i) A bond formed by a shared pair of electrons, each bonding atom contributing one electron to the pair.
(ii) A bond formed by a shared pair of electrons with both electrons coming from the same atom. *[2]*

(c) Answer the following questions.
(i) How will you distinguish between zinc nitrate solution and calcium nitrate solution using sodium hydroxide solution?
(ii) How will you distinguish between iron (II) chloride and iron (III) chloride using ammonium hydroxide? *[2]*

(d) Identify the substances *P* and *Q* from the observations given below.
(i) The deliquescent salt '*P*' turns yellow on dissolving in water and gives a reddish brown precipitate with sodium hydroxide solution.
(ii) The white crystalline solid '*Q*' is soluble in water. It liberates a pungent smelling gas when heated with sodium hydroxide solution. *[2]*

3. (a) Draw an electron dot diagram to show the formation of each of the following compounds.
(i) Ammonia
(ii) Carbon tetrachloride *[4]*

(b) With the reference of electrolysis of copper sulphate solution (with copper electrodes).
(i) What happens, when electrolysis of aqueous copper sulphate between platinum electrode occurs?
(ii) Compare the change in mass of the cathode with the change in mass of the anode. *[4]*

(c) Select the ion in each case, that would get selectively discharged from the aqueous mixture of the ions listed below.
(i) $\bar{O}H$, Cl^-, SO_4^{2-}
(ii) Ag^+, Cu^{2+}, Zn^{2+} *[2]*

4. (a) Certain blank spaces are left in the following table and these are labelled as *A*, *B*, *C*, *D* and *E*. Identify each of them.

	Preparation of	Reactants used	Products formed	Catalyst/ Temperature	Method of collection
(i)	HNO_3	$KNO_3 + H_2SO_4$	*A*	< 200°C	*B*
(ii)	H_2SO_4	*C*	SO_3, $H_2S_2O_7$, H_2SO_4	*D*	*E*

[5]

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(b) Write the balanced chemical equation to show the reaction of the following.
(i) Caustic soda solution and aluminium oxide.
(ii) Zinc is heated with sodium hydroxide solution.
(iii) Zinc oxide is treated with sodium hydroxide solution. *[3]*

(c) Write the balanced chemical equations to show how N_2 and H_2 converted to ammonia in Haber's process. *[2]*

5. (a) (i) Calculate the mass of iron which will be converted into its oxide (Fe_3O_4) by the action of 36 g of steam on it. *[2]*
(ii) Calculate the mass of limestone required to produce 112 kg of quick lime by burning it. *[2]*

(b) O_2 is evolved by heating $KClO_3$ using MnO_2 as catalyst,

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

(i) Calculate the mass of $KClO_3$ required to produce 6.72 L of O_2 at STP (atomic mass of K = 39, Cl = 35.5, O = 16].
(ii) Calculate the number of moles and the number of molecules of oxygen formed in the above volume.
(iii) Calculate the volume occupied by 0.01 mole of CO_2 at STP. *[4]*

(c) Write a balanced chemical equation for the preparation of each of the following.
(i) Ethane
(ii) Aldehyde (ethanal) *[2]*

6. (a) Give a balanced chemical equation for each of the following.
(i) Action of sodium hydroxide solution on ferric chloride solution.
(ii) Action of heat on zinc metal in presence of air at 500°C.
(iii) Action of heat on copper turnings in presence of conc. HNO_3.
(iv) Action of heat on concentrated HNO_3. *[4]*

(b) Identify the term or substance based on the description given below.
(i) The compounds having same molecular formula but different structural formula.
(ii) Name the chemical test used for the detection of hydrogen sulphide.
(iii) A nitrate which leaves behind no residue on heating.
(iv) An acid which is not an oxidising agent. *[4]*

(c) Give a balanced chemical equation for each of the following.
(i) Zinc reacts with conc. sulphuric acid.
(ii) Sodium bicarbonate reacts with dil. sulphuric acid. *[2]*

7. (a) Name the following.
(i) A substance which supplies oxygen or any other electronegative element.
(ii) The ore of zinc containing its sulphide.
(iii) Name the gas for which, ammonia fountain experiment can be used. This gas is covalent in nature but becomes electrovalent when dissolved in water.
(iv) The product obtained when hydrochloric acid reacts with lead nitrate. *[4]*

(b) Answer the following guestions.
(i) Copper though a good conductor of electricity is a non-electrolyte. Explain.
(ii) Name the gas released at the cathode when acidulated water is electrolysed. *[3]*

(c) Complete the following by selecting the correct option from the choices given.
(i) Ferrous salts are ..... (brown, light green, blue) in colour.
(ii) The mass of substance containing particles equal to Avogadro's number is called ..... . (mole, molecule, atoms)
(iii) Zinc chloride solution reacts with NH_4OH precipitate solution to give a ..... (white, black, blue) precipitate. *[3]*

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EXPLANATIONS

Section-A

1. (a) (i) greater

(ii) electron dot structures

(iii) CO_2

(iv) potassium zincate

(v) 1, 1, 2, 2-tetrachloroethane.

(b) (i) (a) halogens

(ii) (d) acetic acid

(iii) (a) NH_3

(iv) (c) electrovalency

(v) (b) 2.66 times

(c) (i) Lead oxide

(ii) Iron (II) chloride

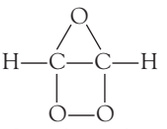
(iii) Carbolic acid

(iv) Nitric oxide

(v) Vanadium pentoxide

(d) (i) $Ca + H_2SO_4(dil.) \longrightarrow CaSO_4 + H_2\uparrow$

(ii) $2NH_3 + CO_2 \xrightarrow{150°C} \underset{\text{Urea}}{NH_2CONH_2} + H_2O$

(iii) $HC{\equiv}CH + O_3 \longrightarrow$ 

Ozonide acetylene

$\xrightarrow[H^+]{Zn/H_2O}$

Glyoxal

(iv) $Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2\uparrow$

(v) *Steps involved in the preparation of* HNO_3 *from ostwald process are as follows*

Oxidation of NH_3

$$4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + 6H_2O + \text{Heat}$$

Oxidation of nitric oxide

$$2NO + O_2(g) \xrightarrow{50°C} 2NO_2(g)$$

Absorption of NO_2 in water

$$4NO_2(g) + 2H_2O(l) + O_2(g) \longrightarrow 4HNO_3$$

(e) (i) At 140°C, conc. H_2SO_4 dehydrates alcohol to give ethers.

$$CH_3OH \xrightarrow[140°C]{\text{Conc. } H_2SO_4} \underset{\text{Dimethyl ether}}{CH_3{-}O{-}CH_3} + H_2O$$

(ii) Action of ammonia on copper oxide releases nitrogen gas with the formation of copper.

$$\underset{\text{Black solid}}{2NH_3 + 3CuO} \longrightarrow \underset{\text{Reddish brown solid}}{3Cu} + 3H_2O + \underset{\text{Gas}}{N_2\uparrow}$$

(iii) Action of calcium bicarbonate solution on nitric acid leads to the decomposition of bicarbonates.

$$\underset{\text{Calcium bicarbonate}}{Ca(HCO_3)_2} + 2HNO_3 \longrightarrow \underset{\text{Salt}}{Ca(NO_3)_2} + 2H_2O + 2CO_2\uparrow$$

(iv) Copper sulphate solution on reaction with ammonium hydroxide gives copper hydroxide and ammonium sulphate.

$$\underset{\substack{\text{Copper}\\\text{sulphate}\\\text{(blue)}}}{CuSO_4} + 2NH_4OH \longrightarrow \underset{\substack{\text{Pale blue}\\\text{ppt}}}{Cu(OH)_2\downarrow} + \underset{\substack{\text{Ammonium}\\\text{sulphate}\\\text{(colourless)}}}{(NH_4)_2SO_4}$$

(v) Oxides of mercury decomposes to give metal and oxygen.

$$2HgO \xrightarrow{\Delta} 2Hg + O_2$$

(f) (i)

(a)	$C_2H_5{-}O{-}C_2H_5$	(Diethyl ether)
(b)	$CH_3CH{=}\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}{-}CH_2CH_3$	(3-methylpent-2-ene)
(c)	$CH_3CH_2CH_2CH_2CH_2OH$	(Pentanol)

(ii) (a) In roasting, the ore is heated in excess of air.

(b) Conversion of bauxite into alumina is carried out by Baeyer's process.

(g) (i) When a covalent bond is formed between two atoms having almost same electronegativity, then the shared pair of electrons are equally shared by the two atoms and situated exactly between the two identical nuclei. This type of covalent bond is called non-polar covalent bonds. The compound which formed this type of bonds is called non-polar covalent compounds. *e.g.*, CH_4, H_2.

(ii) Mass of 9 atoms of carbon $= 9 \times 12\text{ u} = 108\text{ u}$

Mass of 13 atoms of hydrogen $= 13 \times 1\text{ u}$

$= 13\text{ u}$

Mass of 2.33×10^{-23} g of other components

$$= (1\text{u}) \times \frac{(2.33 \times 10^{-23}\text{ g})}{(1.66 \times 10^{-24}\text{ g})} = 14.04\text{ u}$$

Molecular mass of the substances

$= (108 + 13 + 14.04)\text{ u} = 135.04\text{ u}$

(iii) 1.46 metric ton of Al $= 1.46 \times 10^3 \times 10^3$ g of Al

$= 1.46 \times 10^6$ g

Atomic mass of Al = 27

$$\text{Moles of Al} = \frac{\text{Mass of Al}}{\text{Atomic mass}}$$

$$= \frac{1.46 \times 10^6}{27} = 5.41 \times 10^4\text{ mol}$$

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(h) (i) 17 (Chlorine)
(ii) 11 (Sodium)
(iii) 9 (Fluorine)
(iv) 18 (Argon)
(v) 7 (Valence electrons present in halogen)

2. (a) (i) F > Cl > Br > I > At
(ii) At < I < Br < Cl < F
(iii) F < Cl < Br < I < At
(iv) At < I < Br < Cl < F

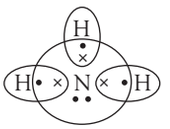
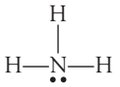
(b) (i) Covalent bond
(ii) Coordinate bond

(c) (i) Sodium hydroxide solution, when added to zinc nitrate solution, a white precipitate is formed which is soluble in excess of sodium hydroxide. On adding sodium hydroxide solution to calcium nitrate, a white precipitate is formed which is insoluble in excess of sodium hydroxide.

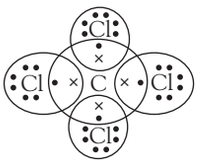
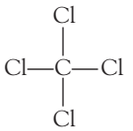
(ii) Iron (II) chloride, on reaction with ammonium hydroxide, a dirty green precipitate is formed which changes to reddish brown. Ammonium hydroxide, when reacts with iron (III) chloride, a reddish brown precipitate is formed.

(d) (i) Ferric chloride
(ii) Ammonium chloride

3. (a)

(i)  or 

Ammonia

(ii)  or 

Carbon tetrachloride

(b) (i) During the electrolysis of copper sulphate, Cu^{2+} ions are discharged at the cathode and deposited as pinkish copper metal, but OH^- ions are discharged at anode.

The electrolyte consists of hydrogen and sulphate ions which associate to form colourless sulphuric acid

(ii) The mass of cathode increases whereas that of anode decreases due to the deposition of pure copper on cathode.

(c) (i) $\bar{O}H$

(ii) Ag^+

4. (a) $A = KHSO_4 + HNO_3$

B = Distillation

$C = SO_2, O_2, H_2O$

$D = V_2O_5$ (45° C)

E = Downward displacement.

(b) (i) $Al_2O_3 + 2NaOH \longrightarrow \underset{\text{Sodium meta aluminate}}{2Na_2AlO_2} + H_2O$

(ii) $Zn + 2NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2\uparrow$

(iii) $ZnO + 2NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2O$

(c) $\underset{\text{Nitrogen}}{N_2} + \underset{\text{Hydrogen}}{3H_2} \underset{\text{Above 200 atm}}{\overset{450\text{-}500°C}{\rightleftharpoons}} \underset{\text{Ammonia}}{2NH_2}$
Fe and Mo

5. (a) (i) The balanced chemical equations representing the reaction is

$$\underset{3\times56=168\text{ g}}{3Fe} + \underset{4\times18=72\text{ g}}{4H_2O(g)} \longrightarrow Fe_3O_4 + 4H_2(g)$$

72 g of steam will react with 168 g of iron

$\therefore$ 36 g of steam will react with $= \frac{168}{72} \times 36$

$= 84$ g of iron

Mass of iron = 84 g

(ii) $\underset{\substack{40+12+48\\=100\text{kg}}}{CaCO_3} \xrightarrow{\Delta} \underset{40+16=56\text{ kg}}{CaO} + CO_2$

56 kg CaO is obtained from limestone = 100 kg

$\therefore$ 112 kg of CaO is obtained from lime stone

$$= \frac{100\times112}{56} = 200\text{ kg}$$

(b) $\underset{\substack{2\times(39+35.5+3\times16)\\2\times122.5=245}}{2KClO_3} \xrightarrow{MnO_2} \underset{\substack{2\times(39+35.5)\\2\times74.5=149\text{ g}}}{2KCl} + \underset{\substack{3\times22.4\\=67.2\text{ L}}}{3O_2}$

(i) 67.2 L of O_2 is produced by $KClO_3$ = 245 g

1 L of O_2 will be produced by $KClO_3 = \frac{245}{67.2}$

6.72 L of O_2 will be produced by $KClO_3$

$$= \frac{245\times6.72}{67.2} = 24.5\text{ g}$$

(ii) 245 g of $KClO_3$ produces = 3 moles of oxygen

24.5 of $KClO_3$ produces $= \frac{3\times24.5}{245} = 0.3$ mole

$\because$ 1 mole of oxygen produces

$= 6.022\times10^{23}$ molecules

$\therefore$ 0.3 mole of oxygen produces $= 6.022\times10^{23}\times0.3$

$= 1.8066\times10^{23}$ molecules

(iii) Since, 1 mole of CO_2 occupied = 22.4 L

$\therefore$ 0.01 mole of CO_2 occupied $= 22.4\times0.01$

$= 0.224$ L

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(c) (i) $\underset{\text{Sodium propionate}}{C_2H_5COONa} + NaOH \xrightarrow{CaO} \underset{\text{Ethane}}{C_2H_6} + \underset{\text{Sodium carbonate}}{Na_2CO_3}$

(ii) $\underset{\text{Ethanol}}{C_2H_5OH} + [O] \xrightarrow{K_2Cr_2O_7} \underset{\text{Ethanal}}{CH_3CHO} + H_2O$

6. (a) (i) When sodium hydroxide solution is added to ferric chloride, a reddish brown precipitate of ferric hydroxide is formed which is insoluble even in the excess of NaOH.

$$FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3NaCl$$

(ii) When zinc metal is heated in air at 500°C, the metal burns with bluish white flame and forms zinc oxide.

$$2Zn + O_2 \xrightarrow{500°C} \underset{\text{Zinc oxide}}{2ZnO}$$

(iii) When copper turnings are heated with conc. HNO_3, copper nitrate, water are formed with the evolution of NO_2 gas.

$$Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2H_2O + 2NO_2 \uparrow$$

(iv) When conc. HNO_3 is heated, it rapidly decomposes to reddish brown nitrogen dioxide gas alongwith the formation of H_2O and O_2 gas.

$$4HNO_3 \xrightarrow{\Delta} 2H_2O + 4NO_2 \uparrow + O_2 \uparrow$$

(b) (i) Isomer

(ii) Lead acetate test

(iii) Ammonium nitrate

(iv) Hydrogen chloride

(c) (i) $Zn + 2H_2SO_4(\text{conc.}) \longrightarrow ZnSO_4 + 2H_2O + SO_2$

(ii) $NaHCO_3 + H_2SO_4(\text{dil.}) \longrightarrow NaHSO_4 + H_2O + CO_2$

7. (a) (i) Oxidising agents

(ii) Zinc blende (ZnS)

(iii) Hydrogen chloride gas

(iv) Lead chloride

(b) (i) Copper is a good conductor of electricity but is a non-electrolyte because copper metal is solid element and does not have mobile ions to conduct electricity. It does not undergo chemical decomposition due to flow of electric current through it.

(ii) When acidulated water is electrolysed hydrogen (H_2) gas is evolved.

(c) (i) light green

(ii) mole

(iii) white

SAMPLE QUESTION PAPER 4

A HIGHLY SIMULATED SAMPLE QUESTION PAPER FOR ICSE CLASS X

CHEMISTRY (UNSOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

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Section-A

[40 *Marks*]

1. (a) Fill in the blanks from the choices given in brackets.

(i) The properties of elements are periodic function of ..... . (atomic number, atomic mass, atomic volume)

(ii) A ..... (single, double, triple) bond is formed by the sharing of two pairs of electrons between two atoms.

(iii) $ZnSO_4 \cdot 7H_2O$ is also known as ..... (white, blue, green) vitriol.

(iv) Manganese dioxide react with dil HCl to release ..... (Cl_2, O_2, H_2) gas.

(v) The compound form when ethyne react with I_2 is ..... . (1-iodoethene, 1, 2-diiodoethene, 1,1-di-iodoethene) ***[5]***

(b) Choose the correct answer from the options given below.

(i) In the periodic table halogens are placed in the group

(a) 1 (b) 11 (c) 17 (d) 18

(ii) Identify the saturated hydrocarbon from the following.

(a) Propane

(b) Propene

(c) Propyne

(d) None of these

(iii) Name of the catalyst that is used in Haber's process.

(a) Ni (b) Co

(c) Mo (d) Fe

(iv) Brass consists of

(a) Mg and Au

(b) Zn and Hg

(c) Zn and Cu

(d) Au and Sn

(v) A sample of $CaCO_3$ contains 3.0×10^{23} ions of Ca^{2+} and CO_3^{2-}. Calculate the mass of the sample. ***[5]***

(a) 50 g (b) 200 g

(c) 5 g (d) 100 g

(c) Identify the susbstance underlined in each of the following cases.

(i) The <u>substance</u> which is a proton donor.

(ii) The <u>base</u> which is used in the manufacturing of salts and soaps.

(iii) The <u>substances</u> that can remove water molecules even from compounds.

(iv) The <u>acid</u> which is known as king of chemicals.

(v) The <u>substance</u> prepared by mixing the solutions of calcium chloride and sodium carbonate. ***[5]***

(d) Write the complete balanced chemical equation of the following.

(i) $Cu + \text{conc. } H_2SO_4 \longrightarrow$

(ii) $H_2S + H_2SO_4 \longrightarrow$

(iii) $CH_3CH_2COO^-Na^+ + NaOH \xrightarrow{CaO}$

(iv) $2NH_3 + 3CuO \longrightarrow$

(v) $HCl + MgO \longrightarrow$ ***[5]***

(e) State one relevant observation for each of the following reactions.
(i) Ammonium Hydroxide solution is added to iron (III) chloride solution.
(ii) Sodium Hydroxide is slowly added and then in excess, to zinc sulphate solution.
(iii) Solution of Ammonium chloride and Sodium hydroxide are mixed and heated.
(iv) Nitric acid comes in contact with skin.
(v) Burning of Ethanol. *[5]*

(f) (i) Draw the structural formula for each of the following.
(a) Ethanoic acid (b) Acetylene
(c) 2, 2-dimethylpentane
(ii) From the list of terms given, choose the most appropriate term to match the given description (brass, bronze, cryolite, bauxite).
(a) Ore contains 60% Al_2O_3 and ferric oxide.
(b) An alloy composed of 60% Cu and 40% Zn. *[5]*

(g) (i) A crystalline salt when heated becomes anhydrous and losses 51.2% of its weight. The anhydrous salt on analysis gave the percentage composition as Mg = 20.0%, S = 26.66% and O = 53.33%. Write the molecular formula of the salt.
(ii) Arrange the following in the increasing order of number of atoms.
I. 1 g Au (s) II. 1 g Na (s)
III. 1 g Li (s) IV. 1 g of Cl_2 (g) *[5]*

(h) Match the following columns.

Column I		Column II
(i) Alkali metals	(a)	Group 16
(ii) Alkaline earth metals	(b)	Group 17
(iii) Halogens	(c)	Group 14
(iv) Chalcogens	(d)	Group 2
(v) Carbon	(e)	Group 1

[5]

Section-B [40 *Marks*]

2. (a) Arrange the following as per the instructions given in the brackets.
(i) Li, Na, K, Rb (increasing order of number of electron shells).
(ii) Be, Mg, Ca, Sr (increasing order of atomic size).
(iii) B, Al, Ga, In (increasing order of ionisation energy).
(iv) C, Si, Ge, Sn, (increasing order of electronegativity). *[4]*

(b) State the type of bonding present in the following molecules.
(i) Magnesium chloride
(ii) Sodium chloride *[2]*

(c) Answer the following questions.
(i) How can you distinguish $FeSO_4$ and $FeCl_3$ using ammonium hydroxide solution?
(ii) How does $Pb(NO_3)_2$ and $Hg_2(NO_3)_2$ react with HCl ? *[2]*

(d) Identify the salts *P* and *Q* from the observations given below.
(i) The insoluble salt '*P*' can be prepared by mixing $Pb(NO_3)_2$ with HCl.
(ii) When ammonium hydroxide is added to salt '*Q*' white, gelatinous precipitate with formation of NH_4Cl are obtained that are soluble in excess of NH_4OH. *[2]*

3. (a) Draw electron dot diagram to show the formation of each of the following compound.
(i) Propanoic acid (ii) Methane *[4]*

(b) State the observations using chemical equations.
(i) Electrolysis of acidified water using Pt electrode.
(ii) Electrolysis of $CuSO_4$ solution using Pt electrode. *[4]*

(c) In electrolysis of water, how does the addition of H_2SO_4 produce a conducting solution? *[2]*

4. (a) Certain blank spaces are left in the following tables and labelled as *A*, *B*, *C*, *D* and *E*. Identify each of them.

	Preparation	Reactants	Products
(i)	HNO_3	KNO_3 + conc. H_2SO_4	*A*
(ii)	*B*	$Pb(NO_3)_2 + 2HCl$	*C*
(iii)	*D*	*E*	$CaCO_3$ + 2NaCl

[5]

(b) Write balanced chemical equation to show
(i) decomposition of hypochlorous acid.
(ii) action of KOH on $Fe(SO_4)_3$.
(iii) action of $CuSO_4$ solution on zinc. *[3]*

(c) Write a balanced chemical equation to show formation of sodium sulphate crystal. *[2]*

5. (a) I. In three moles of ethane (C_2H_6), calculate the following.
(i) Number of moles of carbon atoms
(ii) Number of moles of hydrogen atoms.
(iii) Number of moles of ethane.
II. Calculate the total number of electrons present in 1.6 g of methane. *[4]*

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(b) A flask contains 3.2 g of SO_2. Calculate

(i) the moles of sulphur dioxide present in the flask.

(ii) when SO_2 present in flask reduce to 1.6 g, then moles of SO_2 present in the flask.

(iii) the number of molecules of SO_2 present in the flask.

(iv) the volume occupied by 3.2 g of SO_2 at STP. *[4]*

(c) Write a balanced chemical equation for the preparation of each of the following salts.

(i) Iron (II) sulphate (ii) Zinc sulphate *[2]*

6. (a) Give the balanced chemical equation for each of the following.

(i) Ferric hydroxide reacts with nitric acid.

(ii) Preparation of sodium sulphate from sodium carbonate.

(iii) Action of KOH on $ZnSO_4$.

(iv) Reduction of lead (II) oxide by carbon. *[4]*

(b) Identify the **term** or **substance** based on the descriptions given below.

(i) A non-metal which has three electrons in the outermost shell.

(ii) A chemical reaction in which electrons are lost by one substance and gained by another.

(iii) A compound which is deliquescent.

(iv) A formula which shows the simplest whole number ratio. *[4]*

(c) Write the balance chemical equation for the following.

(i) Water containing small amount of dil. H_2SO_4 is electrolysed.

(ii) Water containing small amount of dil. HCl, is electrolysed. *[2]*

7. (a) Name the following.

(i) The fusible compound formed by the combination of flux and gangue.

(ii) A **base** which is not an alkali.

(iii) A **salt** insoluble in cold water but soluble in hot water.

(iv) A **compound** that is polar covalent. *[4]*

(b) Answer the following questions, with respect to the electrolytic process.

(i) Why should water be acidified before proceeding with the electrolysis of water?

(ii) During electrolysis high voltage is not favoured. Why? *[3]*

(c) Complete the following by selecting the correct option from the choices given.

(i) Vinegar contains ..... . (methanoic, ethanoic, propanoic) acid

(ii) Solder is an alloy of ..... . (Sn and Pb, Mg and Pb, Zn and Cu)

(iii) The gas most difficult to liquify is ..... . (H_2, CO_2, SO_2) *[3]*

SAMPLE QUESTION PAPER 5

A HIGHLY SIMULATED SAMPLE QUESTION PAPER FOR ICSE CLASS X

CHEMISTRY (UNSOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

UNSOLVED

Section-A

[40 *Marks*]

1. (a) Fill in the blanks from the choices given in brackets.

(i) On moving down a group, the number of valence electrons ..... . (remains the same/increases/decreases)

(ii) Ionic compounds exist in ..... (solid / liquid/ gaseous) state.

(iii) The number of atoms present in one molecules of an element is called its ..... . (acidity / atomicity / basicity)

(iv) Reaction of metal sulphite with H_2SO_4 release ..... . (SO_2 , SO_3 , S)

(v) The catalyst used in the conversion of ethene to ethane is commonly ..... . (iron / cobalt / nickel) ***[5]***

(b) Choose the correct answer from the options given below.

(i) Among the following, which element has the highest ionisation potential?

(a) Chlorine (b) Carbon

(c) Fluorine (d) Helium

(ii) Identify the statement that is incorrect about alkanes.

(a) They are hydrocarbons.

(b) They can undergo both substitution as well as addition reaction.

(c) There is a single covalent bond between carbon and hydrogen.

(d) There is a double bond between carbon and hydrogen.

(iii) Which one is not an alloy of aluminium?

(a) Duralumin (b) Brass

(c) Alnico (d) Magnalium

(iv) A bond formed by a shared pair of electrons with both electrons coming from the same atom.

(a) Metallic bond (b) Covalent bond

(c) Ionic bond (d) Dative bond

(v) The mass of 2.0×10^{23} atoms of magnesium is about ***[5]***

(a) 24×10^{23} g (b) 4.0×10^{-23} g

(c) 2.4 g (d) 4.0 g

(c) Identify the substance underlined in each of the following cases.

(i) A solution of the <u>compound</u> is used as an electrolyte when copper is purified.

(ii) The <u>compound</u> burns in air with a blue flame to form sulphur oxide.

(iii) Although the <u>compound</u> is not a metal hydroxide, its aqueous solution is alkaline in nature.

(iv) Aqueous solution of the <u>compound</u> is used to get deposition of copper at cathode.

(v) The <u>compound</u> can be reduced to copper when heated with coke. ***[5]***

(d) Write a balanced chemical equation for each of the following.

(i) Calcium carbonate reacts with hydrochloric acid.

(ii) Copper oxide reacts with hydrochloric acid.

(iii) Sodium hydroxide reacts with sulphuric acid.

(iv) Ferric chloride reacts with sodium hydroxide.

(v) Ferrous sulphate reacts with ammonium hydroxide. *[5]*

(e) State one relevant observation for each of the following reactions.

(i) Addition of NH_4OH to $Zn(OH)_2$ in presence of $(NH_4)_2SO_4$.

(ii) Addition of alc. KOH to 1, 2-dibromo methane.

(iii) Action of HNO_3 on carbon.

(iv) Preparation of ethene from ethyl alcohol.

(v) Preparation of H_2SO_4 from contact process. *[5]*

(f) (i) Draw the structural formula for each of the following.

(a) 1, 1-dibromoethane

(b) Acetic acid

(c) Propanal *[3]*

(ii) From the list of terms given, choose the most appropriate term to match the given description.
(liquation, froth floatation, roasting, flux)

(a) For refining metal with low melting point.

(b) Separation of ore and gangue by preferential wetting. *[2]*

(g) (i) 560 ml of carbon monoxide is mixed with 400 mL of oxygen and ignited. The chemical equation for the reaction is as follows.

$$2CO + O_2 \longrightarrow 2CO_2$$

Calculate the volume of oxygen used and carbon dioxide formed in the above reaction.

(ii) A flask contains 3.2 g of SO_2. Calculate the moles of sulphur dioxide present in the flask.

(iii) Calculate the volume occupied at STP by 6.023×10^{23} molecules of a gas X. *[5]*

(h) Match the following.

(i)	Metal	(a)	Electronegative element
(ii)	Alkyne	(b)	C_nH_{2n+2}
(iii)	Alkene	(c)	Electropositive element
(iv)	Non-metal	(d)	C_nH_{2n}
(v)	Alkane	(e)	C_nH_{2n-2}

[5]

Section-B [40 *Marks*]

2. (a) Arrange the following as per the instructions given in the brackets.

(i) Li^+, Na^+, K^+ (increasing order of ionic radii).

(ii) F, Cl, Br (increasing order of ionisation energy).

(iii) Be, Mg, Ca (increasing order of the number of electron shells).

(iv) He, Ar, Ne (increasing order of atomic radii). *[4]*

(b) State the type of bonding in the following molecules.

(i) NaCl

(ii) MgO *[2]*

(c) Answer the following questions.

(i) Why graphite anode is used during electrolysis of fused lead bromide?

(ii) PCl_3 is called phosphorus trichloride but $AlCl_3$ is called aluminium chloride. Explain. *[2]*

(d) Identify the salt Y and Z from the observation given below.

(i) When a solution of compound Y is treated with $AgNO_3$ solution, a white precipitate is obtained which is soluble in excess of NH_4OH solution.

(ii) Compound Z which on reacting with dil. sulphuric acid liberates a gas which turns lime water milky, but the gas has no effect on acidified $K_2Cr_2O_7$ solution. *[2]*

3. (a) Draw an electron dot diagram to show the formation of each of the following compounds.

(i) Alkane (ii) Alkene *[4]*

(b) State the **observations** at the anode and at the cathode during the electrolysis of

(i) concentrated NaCl solution.

(ii) $CuSO_4$ solution using platinum anode and cathode. *[4]*

(c) Select the ions in each case, that would get selectively discharged from the aqueous mixture of the ions listed below.

(i) Cl^-, SO_4^{2-}, HCO_3^-

(ii) NH_4^+, Na^+, K^+ *[2]*

4. (a) Certain blank spaces are left in the following table and these are labelled as *A*, *B*, *C*, *D* and *E*. Identify each of them.

	Preparation of	Reactants used	Product forms	Method of collection
(i)	Nitric acid	KNO_3 + Conc. H_2SO_4	*A*	*B*
(ii)	*C*	$H_2S_2O_7$ + (*D*)	$2H_2SO_4$	*E*

[5]

(b) Write the balanced chemical equations for the reaction of dil. HCl with the following.

(i) Iron

(ii) Sodium sulphite *[3]*

(c) Write balanced chemical equations to show the laboratory preparation of hydrochloric acid. *[2]*

UNSOLVED

UNSOLVED

5. (a) When the reaction takes place between carbon dioxide and red hot carbon, then carbon monoxide is produced as given in the following reaction.

$$CO_2 + C \longrightarrow 2CO$$

(i) What volume of carbon monoxide at STP can be obtained from 3 g of carbon?

(ii) 30 cm^3 of oxygen was added to 12 cm^3 of carbon monoxide and mixture is ignited. Calculate the volume of oxygen used up and volume of carbon dioxide formed. ***[4]***

(b) 4.5 moles of calcium carbonate are reacted with dil. HCl.

(i) Write the equation for the reaction.

(ii) What is the mass of 4.5 moles of $CaCO_3$?

(iii) What is the volume of CO_2 liberated at STP?

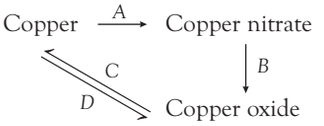
(iv) How many moles of HCl are used in this reaction? ***[4]***

(c) Write a balanced chemical equation for the preparation of each of the following salts.

(i) Iron (III) chloride

(ii) Calcium carbonate ***[2]***

6. (a) Write the balanced equation for the following conversions *A*, *B*, *C* and *D*.



[4]

(b) Identify the **term** or **substance** based on the description given below.

(i) A bond formed by a shared pair of electrons with two electrons coming from both the bond forming atoms.

(ii) A bond formed due to electrostatic force of attraction between cation and anion.

(iii) The law where every 8th element repeats properties.

(iv) Vertical arrangement of elements in the periodic table. ***[4]***

(c) Write the balanced chemical equation for each of the following.

(i) Preparation of nitric acid from potassium nitrate.

(ii) Preparation of soluble chloride salt from an insoluble carbonate. ***[2]***

7. (a) Name the following.

(i) An alloy made up of Al and Mg.

(ii) A black powdery substance used for the reduction of ZnO during extraction.

(iii) The oxide which acts as a flux in the blast furnace.

(iv) The ore used for the extraction of iron. ***[4]***

(b) Answer the following questions with respect to the electrolytic process in the extraction of copper.

(i) Name the electrolyte used for the refining of copper.

(ii) Give the equations for the reaction occur at cathode and anode, respectively. ***[3]***

(c) Complete the following by selecting the correct option from the choices given.

(i) Carbon atoms can link with one another by the property of ..... .(tetravalency, allotropy, catenation)

(ii) Role played by conc. H_2SO_4 on reaction with sulphur is ..... .(non-volatile acid, oxidising agent, dehydrating agent)

(iii) Ammonia can be obtained by adding water to ..... .(NH_4Cl, ammonium nitride, magnesium nitride) ***[3]***

Latest ICSE Specimen PAPER

Chemistry (Fully Solved)

General *Instructions*

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

Section-I

[40 *Marks*]

1. (A) Choose the correct answer from the options given below. (5)

(i) A strong electrolyte from the following is
- (a) acetic acid
- (b) oxalic acid
- (c) ammonium hydroxide
- (d) sodium hydroxide

(ii) Electron affinity is maximum in
- (a) alkali metals
- (b) alkaline earth metals
- (c) halogens
- (d) inert gases

(iii) The main components of brass are
- (a) copper and zinc
- (b) copper and lead
- (c) copper and tin
- (d) copper and iron

(iv) The drying agent used to dry NH_3 is
- (a) P_2O_5 (b) conc. H_2SO_4
- (c) $CaCl_2$ (b) CaO

(v) The general formula of alkynes is
- (a) C_nH_{2n-2} (b) C_nH_{2n+2}
- (c) C_nH_{2n} (d) $C_nH_{2n+2}O$

(B) Write balanced chemical equations for each of the following. (5)

(i) Catalytic oxidation of ammonia.

(ii) Action of concentrated nitric acid on sulphur.

(iii) Action of concentrated sodium hydroxide on zinc oxide.

(iv) Reaction between acid with ethanol in the presence of concentrated sulphuric acid.

(v) Action of dilute hydrochloric acid on iron.

(C) State any one observation for each of the following. (5)

(i) Dilute hydrochloric acid is added to silver nitrate solution.

(ii) Concentrated nitric acid is added to copper turnings.

(iii) Mixture of ammonium chloride and sodium hydroxide is heated.

(iv) Ammonium hydroxide solution is added in excess to copper sulphate solution.

(v) NaOH solution is added to calcium nitrate solution.

(D) Rewrite the following by inserting appropriate word / words. (5)

(i) Magnesium nitride reacts with water to liberate ammonia.

(ii) Lead bromide conducts electricity.

(iii) Starch iodide paper turns blue-black in the presence of chlorine.

(iv) Hydrogen chloride molecule contains a covalent bond.

(v) Acid salts are formed by replacement of the ionisable hydrogen ions of the acid by a metallic ion or ammonium ion.

FULLY SOLVED

(E) (i) Given, $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

2000 cc of O_2 was burnt with 400 cc of ethane. Calculate the volume of CO_2 formed and unused O_2. (5)

(ii) Find the number of moles and molecules present in 7.1 g of Cl_2.

(Atomic weight of Cl = 35.5)

(iii) Calculate the vapour density of ethene [C =12 , H = 1]

(F) Identify the terms: (5)

(i) The energy required to remove an electron from valance shell of a neutral isolated gaseous atom.

(ii) The method for the concentration of sulphide ores.

(iii) The property by which carbon bonds with itself to form a long chain.

(iv) A bond formed by a shared pair of electrons with both electrons coming from the same atom.

(v) A substance that conducts electricity in molten or aqueous state.

(G) Arrange the following as per the instruction given in the brackets. (5)

(i) Li, F, N [increasing order of electronegativity]

(ii) Na, Al , Cl [increasing order of ionisation potential]

(iii) O_2, N_2, Cl_2 [increasing order of number of covalent bonds]

(iv) Zn^{2+}, Na^+, Cu^{+2} [order of preference of discharge at the cathode]

(v) Br, F ,CI [decreasing order of atomic radius]

(H) (i) Draw the structural formula for each of the following: (5)

(a) But-1-ene (b) Propanoic acid

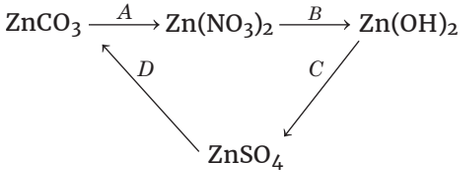
(c) Ethanol

(ii) Draw the structural isomers of C_4H_{10}.

Section-II

[40 *Marks*]

2. (A) Write balanced equations for following conversions: (4)



(B) Show the formation of H_3O^+ using the electron dot diagram. State the types of bonds present in it. (3)

(C) Distinguish between the following pairs of compounds using the test given within the brackets. (3)

(i) Calcium sulphite and calcium carbonate (using dil. HCI)

(ii) Calcium nitrate and potassium nitrate (using a flame test)

(iii) Lead nitrate solution and zinc nitrate solution (using an alkali)

3. (A) Study the table and answer the following questions: (6)

Atom	Atomic No.
A	11
B	17

(i) Compare the positions of *A* and *B* in the periodic table.

(ii) Which is more metallic?

(iii) Write equations for the formation of ions of *A* and *B*.

(iv) What type of bond is formed between *A* and *B*?

Mention its physical state and solubility in water.

(B) Identify the gas evolved in each of the following cases. (4)

(i) A colourless gas liberated on decomposition of nitric acid.

(ii) Water is added to calcium carbide.

(iii) Dilute hydrochloric acid is added to zinc sulphide.

(iv) Dilute nitric acid is added to copper.

4. (A) Write a balanced equation for the following. (4)

(i) C_2H_5Br + alcoholic KOH $\longrightarrow$

(ii) CH_3CH_2COONa + Soda lime $\longrightarrow$

(iii) $C_2H_4 + Br_2 \longrightarrow$

(iv) $C_2H_5OH + Na \longrightarrow$

(B) State how the following conversions can be carried out. (3)

(i) Ethyl chloride to ethyl alcohol

(ii) Ethyl alcohol to ethene.

(iii) Ethyl bromide to ethane.

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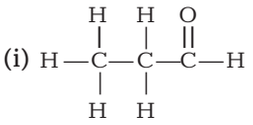
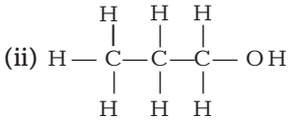
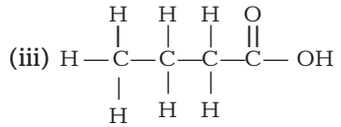
(C) Give the correct IUPAC name for each of the compounds whose structural formulae are given below. (3)

(i) 

(ii) 

(iii) 

5. (A) (i) Name the chief ore of aluminium and the process of concentration of the ore. (6)

(ii) Write balanced equations for the conversion of the above ore of aluminium to pure alumina.

(iii) Name one alloy of aluminium.

(B) A compound gave a following data. (4)

C = 57.82%, O = 38.58% and the rest hydrogen. Its relative molecular mass is 166.

Find its empirical formula and molecular formula. [C =12, O = 16, H = 1]

6. (A) (i) Copy and complete the following table (4)

Name of the process	Catalyst	Temperature	Equation for the reaction
Haber's process			

(ii) How is ammonia separated from unreacted nitrogen and hydrogen?

(B) Give appropriate scientific reasons for each of the following statements. (3)

(i) Electrolysis of molten lead bromide is considered to be a redox reaction.

(ii) Although copper is a good conductor of electricity it is a non-electrolyte.

(iii) Electrical conductivity of acetic acid is less in comparison to that of dil. sulphuric acid.

(C) Mention the property of conc. H_2SO_4 exhibited in each of the following reactions with (3)

(i) Suga (ii) Metallic chloride

(iii) Non-metal such as carbon.

7. (A) Answer the following questions pertaining to laboratory preparation of hydrogen chloride. (4)

(i) Write an equation for the laboratory preparation of hydrogen chloride .

(ii) Name the drying agent used.

(iii) Name the method of collecting hydrogen chloride gas.

(iv) Give a test to identify the gas.

(B) Give reasons for each of the following: (3)

(i) Direct absorption of HCl gas in water is not preferred.

(ii) All glass apparatus is used in the laboratory preparation of HNO_3.

(iii) NaCl has a high melting point.

(C) Give one point of difference between the following pairs of terms given. (3)

(i) Calcination and roasting.

(ii) Polar and non-polar covalent compounds.

(iii) Strong electrolyte and weak electrolyte.

FULLY SOLVED

SOLUTIONS

Section-I

1. (A) (i) (d) Sodium hydroxide is a strong electrolyte because it gets completely dissociated in aqueous solution.

(ii) (c) **Halogens** Electron affinity is maximum for halogens. It increases across a period and decreases down the group.

(iii) (a) Copper and zinc

Brass consists of 60-70% Cu and 40-30% Zn.

(iv) (d) **CaO** Quicklime, CaO is used as drying agent for drying ammonia. Being a basic gas ammonia can not be dried by passing it through concentrated sulphuric acid or phosphorus pentoxide.

(v) (a) C_nH_{2n-2}

Alkynes are unsaturated aliphatic hydrocarbons which contain a triple bond (— C ≡ C—). Alkynes have general formula C_nH_{2n-2}.

(B) (i) **Catalytic oxidation of ammonia**

Ammonia reacts with oxygen in the presence of platinum at 800° C to give nitric oxide and water vapour. Following reaction occurs :

$$4NH_3 + 5O_2 \xrightarrow{\text{Pt, } 800^\circ C} 6H_2O + 4NO\uparrow + \text{Heat}$$

(ii) Action of concentrated nitric acid on sulphur

Nitric acid oxidises sulphur to sulphuric acid.

$$\underset{\text{Sulphur}}{S} + 6HNO_3 \longrightarrow \underset{\text{Sulphuric acid}}{H_2SO_4} + 6NO_2 + 2H_2O$$
(Nitric acid)

(iii) Action of concentrated sodium hydroxide on zinc oxide

Zinc oxide is amphoteric in nature, it reacts with base, sodium hydroxide to give salt and water.

$$\underset{\text{Zinc oxide}}{ZnO} + 2NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2O$$
(Sodium hydroxide)

(iv) Reaction between acetic acid with ethanol in the presence of concentrated sulphuric acid

Alcohols react with acetic acid in the presence of concentrated sulphuric acid to give ester and the process is known as **esterification.**

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + H_2O$$

(v) Action of dilute hydrochloric acid on iron

On adding dilute HCl to iron I, iron II chloride in formed and H_2 gas is liberated.

$$Fe + 2HCl \xrightarrow{\Delta} FeCl_2 + H_2\uparrow$$

(C) (i) On adding dil. HCl to silver nitrate solution, a white precipitate of silver chloride is formed.

$$\underset{\text{Silver nitrate}}{AgNO_3} + \underset{\text{(Dil)}}{HCl} \longrightarrow \underset{\text{Silver chloride ppt.}}{AgCl\downarrow} + HNO_3$$

(ii) On adding conc. HNO_3 to copper turnings, it oxidises copper to copper nitrite.

$$\underset{\text{Copper}}{Cu} + 4\underset{\text{Conc.}}{HNO_3} \longrightarrow \underset{\text{Copper nitrite}}{Cu(NO_3)_2} + 2H_2O + 2NO_2$$

(iii) When sodium hydroxide solution (or any other alkali) is heated with ammonium chloride, ammonia gas is evolved.

$$\underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Caustic soda}}{NaOH} \xrightarrow{\Delta} \underset{\text{Sodium chloride}}{NaCl} + H_2O + \underset{\text{Ammonia gas}}{NH_3\uparrow}$$

(iv) On adding ammonium hydroxide to copper sulphate solution a pale-blue precipitate is formed which dissolves in excess of ammonium hydroxide to give deep blue or inky blue or prussian blue solution.

$$\underset{\substack{\text{Copper sulphate}\\\text{(Blue)}}}{CuSO_4} + 2NH_4OH \longrightarrow \underset{\text{Pale blue ppt.}}{Cu(OH)_2\downarrow} + \underset{\substack{\text{Ammonium sulphate}\\\text{(Colourless)}}}{(NH_4)_2SO_4}$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + \underset{\text{(Excess)}}{2NH_4OH} \longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$$

Tetraammine copper (II)sulphate (Deep blue solution)

(v) On adding sodium hydroxide to a solution of calcium nitrate a white precipitate is formed, which is sparingly soluble in excess of NaOH.

$$\underset{\substack{\text{Calcium nitrate}\\\text{(Colourless)}}}{Ca(NO_3)_2} + \underset{\substack{\text{Caustic soda}\\\text{(Colourless)}}}{2NaOH} \longrightarrow \underset{\substack{\text{Calcium hydroxide}\\\text{(White ppt.)}}}{Ca(OH)_2\downarrow} + \underset{\substack{\text{Sodium nitrate}\\\text{(Colourless)}}}{2NaNO_3}$$

(D) (i) Magnesium nitride reacts with warm water to liberate ammonia.

(ii) Lead bromide in molten state conducts electricity.

(iii) Moist starch iodide paper turns blue-black in presence of chlorine.

(iv) Hydrogen chloride molecule contains an ionic bond.

(v) Acids salts are formed by partial replacement of ionisable hydrogen ions of the acid by a metallic ion or ammonium ion.

(E) The reaction involved is given by

(i) $\underset{\text{2 vol}}{2C_2H_6} + \underset{\text{7 vol}}{7O_2} \longrightarrow \underset{\text{4 vol}}{4CO_2} + \underset{\text{6 vol}}{6H_2O}$

By Gay-Lussac's law,

2 volumes of C_2H_6 produces 4 volumes of Co_2

$\therefore$ 400 cc of C_2H_6 produces CO_2 in given by

$= 4/2 \times 400 = 800$ cc

$\therefore$ Volume of CO_2 produced = 800 cc

FULLY SOLVED

Now, 2 volumes of C_2H_6 reacts with 7 volume of O_2

$\therefore$ 400 cc of C_2H_6 will react with $\frac{7}{2} \times 400$

$= 1400$ cc of O_2

Hence, amount of unused O_2 is given by $(2000 - 1400)$ cc $= 600$ cc

(ii) Molecular weight of $Cl_2 = 35.5$ g mol^{-1}

$$\text{Number of moles} = \frac{\text{Given weight}}{\text{Molecular weight}}$$

$$n = \frac{7.1\ g}{35.5\ g\ mol^{-1}} \Rightarrow n = 0.2$$

Number of molecules in 1 mole $= 6.022 \times 10^{23}$

$\therefore$ Number of molecules in 0.2 moles

$= 6.02 \times 10^{23} \times 0.2 = 1.2044 \times 10^{23}$ Molecules

(iii) Molecular weight of ethene

$= 12 + 2 + 12 + 2 = 28$

$$\text{Vapour density} = \frac{\text{Molecular weight}}{2} = \frac{28}{2} = 14$$

(F) (i) Ionisation potential or ionisation energy

(ii) Roasting (iii) Catenation

(iv) Covalent bond (v) Electrolyte

(G) (i) Electronegativity increases across a period.

Hence, the order is Li < N < F.

(ii) Ionisation potential increases across a period due to increase in nuclear charge.

Hence, the order is Na < Al < Cl.

(iii) Covalent bond is formed by mutual sharing of valence electrons between two atoms so that each atom acquires stable electronic configuration of the noble gas.

Hence, in order to achieve noble gas electronic configuration, oxygen forms 2, nitrogen forms 3 covalent bonds and chlorine forms 1 covalent bond.

Therefore, the increasing order of number of covalent bonds follows the trend

$$Cl_2 < O_2 < N_2$$

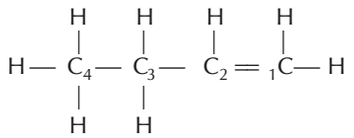
(iv) The tendency of cations to get reduced at cathode increases on descending the electrochemical series.

Hence, the order is $Na^+ < Zn^{2+} < Cu^{2+}$

(v) Atomic radius increases down the group due to increase in number of shells which over weighs the increased nuclear charge.

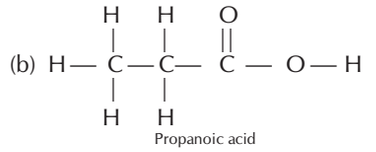
Hence the order is Br > Cl > F.

(H) (i) (a)



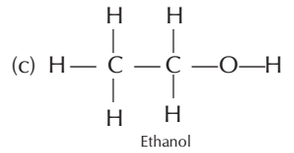
But-1-ene

(b)



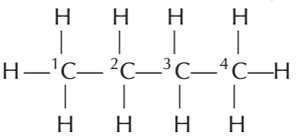
Propanoic acid

(c)

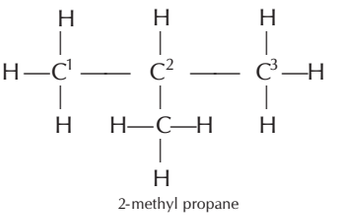


Ethanol

(ii) Structural isomers of C_4H_{10} are



n-butane



2-methyl propane

Section-II

2. (A) Balanced equations for the conversions are :

(i) $ZnCO_3 + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O + CO_2$

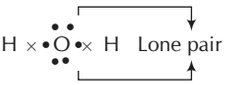
(ii) $Zn(NO_3)_2 + 2NaOH \longrightarrow Zn(OH)_2 + 2NaNO_3$

(iii) $Zn(OH)_2 \xrightarrow{\Delta} ZnO + H_2O$

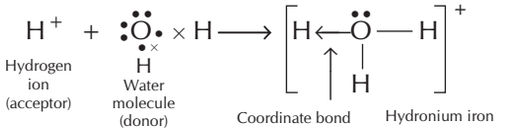
(iv) $ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4$

(v) $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

(B) Hydronium ion is formed from water molecule and hydrogen ion. The oxygen atom of a water molecule possesses two lone pair of electrons.



Out of these two lone pair of electrons, one lone pair is used to donate to hydrogen ion.



(C) (i) On adding dil. HCl to calcium sulphite and calcium carbonate, SO_2 and CO_2 gas evolves respectively.

$CaCO_3 + 2HCl \xrightarrow{\text{(Dil)}} CaCl_2 + H_2O + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$

$CaSO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + \underset{\text{Sulphur dioxide}}{SO_2\uparrow}$

FULLY SOLVED

(ii) On performing flame test calcium nitrate salt gives orange flame whereas potassium nitrate salt gives magenta flame.

(iii) On adding ammonium hydroxide to lead nitrate solution, a white precipitate is formed which is insoluble in excess of ammonium hydroxide.

$$\underset{\text{Lead nitrate (Colourless)}}{Pb(NO_3)_2} + 2NH_4OH \longrightarrow \underset{\text{Chalky white ppt.}}{Pb(OH)_2\downarrow} + \underset{\text{Ammonium nitrate}}{2NH_4NO_3}$$

Whereas, on adding ammonium hydroxide to zinc nitrate solution, a white ppt. so formed is soluble in excess of ammonium hydroxide and we get colourless solution.

$$Zn(NO_3)_2 + 2NH_4OH \longrightarrow \underset{\text{White ppt.}}{Zn(OH)_2\downarrow} + \underset{\text{Ammonium nitrate}}{2NH_4NO_3}$$

$$Zn(OH)_2 + \underset{\text{Excess}}{NH_4OH} \longrightarrow [Zn(NH_3)_4]^{2+}$$

3. (A) (i) Element '*A*' with atomic number 11 is Na. It is in third period and first group.

Element '*B*' with atomic number 17 is Cl. It is in third period and seventeenth group.

(ii) Metallic character decreases across a period. Hence *A* is more metallic.

(iii) *A* is electropositive in nature so it will loose an electron and forms cation.

$$A \longrightarrow A^+ + e^-$$

B is electronegative in nature, so it will gain an electron and forms anion.

$$B + e^- \longrightarrow B^-$$

(iv) Due to large electronegativity difference, ionic bond is formed between *A* and *B*. It is solid and soluble in water due to polar nature.

(B) (i) Concentrated nitric acid gives brown fumes on heating.

$$4HNO_3 \longrightarrow 2H_2O + \underset{\text{(Brown fumes)}}{4NO_2\downarrow} + O_2$$

But, at room temperature pure nitric acid dissociates to give N_2O_4, a colourless gas and O_2.

$$HNO_3 \longrightarrow N_2O_5 + H_2O$$

$$N_2O_5 \rightleftharpoons N_2O_4 + (1/2)O_2$$

(ii) When water is added to calcium carbide, acetylene gas is evolved.

$$CaC_2 + 2H_2O \longrightarrow \underset{\text{Acetylene}}{C_2H_2}\uparrow + Ca(OH)_2$$

(iii) On adding dil. HCl to zinc sulphide, H_2S gas is evolved.

$$ZnS + 2HCl \longrightarrow ZnCl_2 + \underset{\text{Hydrogen sulph}}{H_2S}\uparrow$$

(iv) On adding dilute nitric acid to copper NO gas is evolved.

$$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + \underset{\text{Nitric oxide}}{2NO}\uparrow$$

4. (A) (i) $C_2H_5Br + \text{Alc.KOH} \longrightarrow \underset{\text{Ethanol}}{CH_3CH_2OH} + KBr$

(ii) $CH_3CH_2COONa + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + \underset{\text{Methane}}{CH_4}\uparrow$

(iii) $C_2H_4 + Br_2 \longrightarrow \underset{\text{1, 2–dibromo ethane}}{CH_2Br{-}CH_2Br}$.

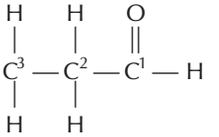
(iv) $2C_2H_5OH + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2\uparrow$

(B) (i) $\underset{\text{Ethyl chloride}}{C_2H_5Cl} + KOH\,(aq) \rightarrow \underset{\text{Ethyl alcohol}}{C_2H_5OH} + KCl$

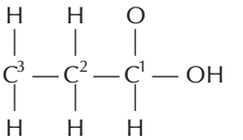
(ii) $\underset{\text{Ethyl alcohol}}{C_2H_5OH} \xrightarrow[160–170°C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{C_2H_4} + H_2O$

(iii) $\underset{\text{Ethyl bromide}}{C_2H_5Br} + 2[H] \longrightarrow \underset{\text{Ethane}}{C_2H_6} + HBr$

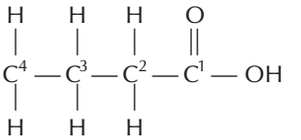
(C)

(i) 

Propan-1-ol

(ii) 

Propan-1-ol

(iii) 

Butan-1-oic acid

5. (A) (i) Chief ore of aluminium is bauxite. The ore is first purified and the metal is extracted from it by Baeyer's process.

(ii) Balanced chemical equations for conversion of bauxite ore to alumina are as follows:

$$\underset{\text{Impure bauxite}}{Al_2O_3.2H_2O} + \underset{\text{Conc. solution}}{2NaOH} \xrightarrow{150–200°C} \underset{\text{Sodium alumirate}}{2NaAlO_2} + 3H_2O$$

$$\underset{\text{Sodium aluminate}}{NaAlO_2} + 2H_2O \xrightarrow{50–60°C} \underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Aluminium hydroxide}}{Al(OH)_3}\downarrow$$

$$\underset{\text{Aluminium hydroxide}}{2AL(OH)_3} \xrightarrow{1100°C} \underset{\text{Pure alumina}}{Al_2O_3} + 3H_2O$$

(iii) Magnalium is an alloy of aluminium. It consists of 90-95% Al and 10-5 % Mg.

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(B) Calculation of empirical formula

Element	%	Atomic mass	Relative no. of atoms	Simplest molar ratio	Simplest whole no. molar ratio
C	57.82	12	57.82/12 = 4.81	$\frac{4.81}{2.41} = 1.99 \approx 2$	4
H	3.6	1	3.6 /1 = 3.6	$\frac{3.6}{2.41} = 1.49 \approx 1.5$	3
O	38.58	16	38.58/16 = 2.41	$\frac{2.41}{2.41} = 1$	2

Empirical formula of compound = $C_4H_3O_2$

Empirical formula weight $= 12\times4 + 1\times3 + 16\times2 = 83$

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}},\quad n = \frac{166}{83} = 2$$

$\therefore$ Molecular formula $= (C_4H_3O_2)_2 = C_8H_6O_4$

6. (A) (i)

Name of the process	Catalyst	Temperature	Equation for the reaction
Haber's process	Fe and Mo	450-500°C	$N_2 + 3H_2 \overset{450-500^\circ C}{\rightleftharpoons} 2NH_3$ + Heat

(ii) Ammonia is separated from uncombined nitrogen and hydrogen by liquefaction. In this process the mixture of gases is allowed to expand under pressure, on sudden expansion, ammonia gas liquefies and collected.

(b) (i) Electrolysis of molten lead bromide is considered to be redox reaction because both oxidation and reduction occurs in this process as follows:

At cathode, $Pb^{2+} + 2e^- \longrightarrow Pb$

At anode, $Br^- \longrightarrow Br + e^-$

$Br + Br \longrightarrow Br_2$

Overall reaction, $PbBr_2(l) \xrightarrow{380^\circ C} Pb(s) + Br_2(g)$

(ii) Copper being a metal contains free electrons and conduction of electricity is carried out by the movement of free electrons, but copper does not dissociate into ions and hence, is a non-electrolyte.

(iii) Electrical conductivity of acetic acid is less in comparison to dil. sulphuric acid because acetic acid is a weak electrolyte. It is only partially dissociated, whereas sulphuric acid is a strong electrolyte and it is completely dissociated.

(C) (i) **Dehydrating agent**

With sugar conc. H_2SO_4 reacts to give black spongy mass of carbon, called sugar charcoal.

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}(S)} \xrightarrow{\text{Cone.}H_2SO_4} \underset{\text{Sugar charcoal}}{12C(S)} + 11H_2O$$

(ii) **Preparation of insoluble salt** On reaction with metallic chlorides sulphuric acid precipitates the insoluble sulphates of metals.

e.g. $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4\downarrow + 2HCl$

(iii) **Oxidising property Sulphuric acid oxidises non-metals e.g.**

$$\underset{\text{Carbon}}{C} + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2\uparrow$$

7. (A) (i) Common salt is added to conc. H_2SO_4, this mixture on heating liberates HCl gas.

$$\underset{\text{[Reactants]}}{NaCl} + H_2SO_4 \xrightarrow[200^\circ C]{\text{Below}} \underset{\text{Sodium bisulphate}}{NaHSO_4} + \underset{\text{Hydrogen chloride (gas)}}{HCl}$$

(ii) HCl is dried by passing conc. H_2SO_4.

Drying agent like P_2O_5, CaO can't be used, since, they react with HCl.

(iii) LHCl gas is collected by upward displacement of water.

(iv) *Identification* A glass rod dipped in NH_3 (ammonia) solution is brought near the mouth of gas jar containing HCl gas. If HCl gas is present then white dense fumes of ammonium chloride are formed.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

(B) (i) Direct absorption of HCl gas in water is not preferred because it is soluble in water.

(ii) Entire apparatus should be made up of glass because nitric acid is highly corrosive in nature and will damage wood, metal rubber, plastic, etc.

(iii) NaCl is an ionic compound. It has high melting point due to the presence of strong electrostatic forces of attraction which requires a large amount of energy to break this forces of attraction.

(C) (i)

Calcination	Rrrrroasting
Ore is heated in absence or limited supply of air.	Ore is heated in the excess of air.

(ii)

Polar covalent compounds	Non-polar covalent compounds
In these types of compounds, the electrons are not equally shared between atoms due to more electronegativity difference in them e.g. HCl, NaCl	In these types of compounds electrons are equally shared between atoms because the electronegativity of atoms are nearly equal. e.g. I_2, CH_4

(iii)

Strong electrolyte	Weak electrolyte
These are completely dissociated in fused state or in aqueous solution e.g. Dil. HCl, NaOH etc.	These are partially dissociated in fused state or in aqueous solution. e.g. NH_4OH, CH_3COOH etc.

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ICSE EXAMINATION PAPER 2019

General Instructions

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section A** and any 4 questions from **Section B**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Section I [40 Marks]

1. (a) Choose the correct answer from the options given below: ***(5)***

(i) An *electrolyte* which completely dissociates into ions is
(a) alcohol (b) carbonic acid
(c) sucrose (d) sodium hydroxide

(ii) The most *electronegative* element from the following elements is
(a) magnesium (b) chlorine
(c) aluminium (d) sulphur

(iii) The reason for using *aluminium* in the alloy duralumin is
(a) aluminium is brittle
(b) aluminium gives strength
(c) aluminium brings lightness.
(d) aluminium lowers melting point.

(iv) The *drying agent* used to dry HCl gas is
(a) conc.H_2SO_4 (b) ZnO
(c) Al_2O_3 (d) CaO

(v) A *hydrocarbon* which is a greenhouse gas is
(a) acetylene (b) ethylene
(c) ethane (d) methane

(b) Fill in the blanks with the choices given in brackets ***(5)***

(i) Conversion of ethanol to ethene by the action of concentrated sulphuric acid is an example of ..... (dehydration / dehydrogenation / dehydrohalogenation)

(ii) When sodium chloride is heated with concentrated sulphuric acid below 200°C, one of the products formed is ..... . (sodium hydrogen sulphate / sodium sulphate / chlorine).

(iii) Ammonia reacts with excess chlorine to form ..... . (nitrogen / nitrogen trichloride / ammonium chloride)

(iv) Substitution reactions are characteristic reactions of ..... . (alkynes / alkenes / alkanes)

(v) In period 3, the most metallic element is ..... . (sodium / magnesium / aluminium).

(c) Write a balanced chemical equation for each of the following reactions ***(5)***

(i) Reduction of copper (II) oxide by hydrogen.

(ii) Action of dilute sulphuric acid on sodium hydroxide.

(iii) Action of dilute sulphuric acid on zinc sulphide.

(iv) Ammonium hydroxide is added to ferrous sulphate solution.

(v) Chlorine gas is reacted with ethene.

(d) State one observation for each of the following: ***(5)***

(i) Concentrated nitric acid is reacted with sulphur.

(ii) Ammonia gas is passed over heated copper (II) oxide.

(iii) Copper sulphate solution is electrolysed using copper electrodes.

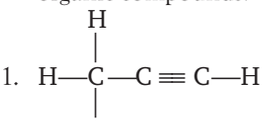
(iv) A small piece of zinc is added to dilute hydrochloric acid.

(v) Lead nitrate is heated strongly in a test tube.

(e) (i) Calculate

1. The number of moles in 12 g of oxygen gas. [O = 16]
2. The weight of 10^{22} atoms of carbon. [C = 12, Avogadro's number = 6×10^{23}]
3. Molecular formula of a compound is $C_6H_{18}O_3$. Find its empirical formula.

(f) (i) Give the IUPAC name of the following organic compounds. ***(5)***

1.


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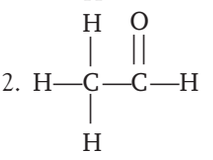


(ii) What is the special feature of the structure of ethyne?

(iii) Name the saturated hydrocarbon containing two carbon atoms.
(iv) Give the structural formula of acetic acid.

(g) Give the appropriate term defined by the statements given below: *(5)*
(i) The formula that represents the simplest ratio of the various elements present in one molecule of the compound.
(ii) The substance that releases hydronium ion as the only positive ion when dissolved in water.
(iii) The tendency of an atom to attract electrons towards itself when combined in a covalent compound.
(iv) The process by which certain ores, specially carbonates, are converted to oxides in the absence of air.
(v) The covalent bond in which the electrons are shared equally between the combining atoms.

(h) Arrange the following according to the instructions given in brackets *(5)*
(i) K, Pb, Ca, Zn (In the increasing order of the reactivity)
(ii) Mg^{2+}, Cu^{2+}, Na^{+}, H^{3+} (In the order of preferential discharge at the cathode)
(iii) Li, K, Na, H (In the decreasing order of their ionisation potential)
(iv) F, B, N, O (In the increasing order of electron affinity)
(v) Ethane, methane, ethene, ethyne. (In the increasing order of the molecular weight) [H = 1, C = 12]

Section II *[40 Marks]*

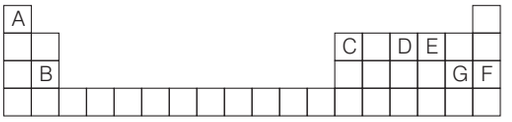
2. (a) Draw the electron dot structure of *(3)*
(i) Nitrogen molecule [N = 7]
(ii) Sodium chloride [Na = 11, Cl = 17]
(iii) Ammonium ion [N = 7, H = 1]

(b) The pH values of three solutions *A*, *B* and C are given in the table. Answer the following questions *(3)*

Solution	pH value
A	12
B	2
C	7

(i) Which solution will have no effect on litmus solution?
(ii) Which solution will liberate CO_2 when reacted with sodium carbonate ?
(iii) Which solution will turn red litmus solution blue?

(c) Study the extract of the Periodic Table given below and answer the questions that follow. Give the alphabet corresponding to the element in question. Do not repeat an element. *(4)*



(i) Which element forms electrovalent compound with G?
(ii) The ion of which element will migrate towards the cathode during electrolysis?
(iii) Which non-metallic element has the valency of 2 ?
(iv) Which is an inert gas?

3. (a) Name the particles present in *(3)*
(i) strong electrolyte
(ii) non-electrolyte
(iii) weak electrolyte

(b) Distinguish between the following pairs of compounds using the reagent given in the bracket. *(3)*
(i) Manganese dioxide and copper (II) oxide. (using concentrated HCl)
(ii) Ferrous sulphate solution and ferric sulphate solution. (using sodium hydroxide solution)
(iii) Dilute hydrochloric acid and dilute sulphuric acid, (using lead nitrate solution).

(c) Choose the method of preparation of the following salts, from the methods given in the list. *(4)*
[**List** A. Neutralisation B. Precipitation C. Direct combination D. Substitution]
(i) Lead chloride
(ii) Iron (II) sulphate
(iii) Sodium nitrate
(iv) Iron (III) chloride

4. (a) Complete the following equations *(3)*
(i) S + conc. HNO_3 →
(ii) C + conc. H_2SO_4 →
(iii) Cu + dil. HNO_3 →

(b) Write a balanced chemical equation for the preparation of *(3)*
(i) ethene from bromoethane
(ii) ethyne using calcium carbide
(iii) methane from sodium acetate.

(c) Name the following organic compounds: *(4)*
(i) The compound with 3 carbon atoms whose functional group is a carboxyl.
(ii) The first homologue whose general formula is C_nH_{2n}.

(iii) The compound that reacts with acetic acid to form ethyl ethanoate.

(iv) The compound formed by complete chlorination of ethyne.

5. (a) Give the chemical formula of *(3)*

(i) bauxite (ii) cryolite

(iii) sodium aluminate

(b) Answer the following questions based on the extraction of aluminium from alumina by **Hall-Heroult's process**. *(3)*

(i) What is the function of cryolite used along with alumina as the electrolyte?

(ii) Why is powdered coke sprinkled on top of the electrolyte?

(iii) Name the electrode, from which aluminium is collected.

(c) Match the alloys given in column I to the uses given in column II. *(4)*

	Column I		Column II
(i)	Duralumin	A.	Electrical fuse
(ii)	Solder	B.	Surgical instruments
(iii)	Brass	C.	Aircraft body
(iv)	Stainless steel	D.	Decorative articles

6. (a) Identify the substances underlined *(3)*

(i) The catalyst used to oxidise ammonia.

(ii) The organic compound which when solidified, forms an ice like mass.

(iii) The dilute acid which is an oxidizing agent.

(b) Copper sulphate solution reacts with sodium hydroxide solution to form a precipitate of copper hydroxide according to the equation *(3)*

$$2NaOH + CuSO_4 \longrightarrow Na_2SO_4 + Cu(OH)_2 \downarrow$$

(i) What mass of copper hydroxide is precipitated by using 200 gm of sodium hydroxide?
[H = 1, O = 16, Na = 23, S = 32, Cu = 64]

(ii) What is the colour of the precipitate formed?

(c) Find the **empirical formula and the molecular formula** of an organic compound from the data given below *(4)*
C = 75.92%, H = 6.32% and N = 17.76%
The vapour density of the compound is 39.5.
[C = 12, H = 1, N = 14]

7. (a) Name the gas evolved in each of the following cases *(3)*

(i) Alumina undergoes electrolytic reduction.

(ii) Ethene undergoes hydrogenation reaction.

(iii) Ammonia reacts with heated copper oxide.

(b) Study the flow chart given and give balanced equations to represent the reactions A, B and C.

$$\boxed{Mg_3N_2} \xrightarrow{A} \boxed{NH_3} \underset{C}{\overset{B}{\rightleftharpoons}} \boxed{NH_4Cl}$$

(3)

(c) Copy and complete the following table which refers to the **industrial method for the preparation** of ammonia and sulphuric acid. *(4)*

Name of the compound	**Name of the process**	**Catalytic equation** (with the catalyst)
Ammonia	(i)	(ii) .....
Sulphuric acid	(iii)	(iv) .....

EXAMINATION PAPER 2019

SOLUTIONS

Section I

1. (a) (i) (d) Sodium hydroxide is a strong electrolyte, therefore it dissociates completely into ions.

(ii) (b) Among the given options, chlorine (Cl) is the most elecronegative element because it has the maximum tendency to attract the shared pair of electrons towards itself.

(iii) (b) Duralumin is an alloy in which, aluminium is one of its component and is used because of similar size as that of other components. It gives strength to the alloy.

(iv) (a) Only conc. H_2SO_4 can be used to dry HCl gas because all other are metal-oxides which can react with HCl.

(v) (d) Methane (CH_4) is the hydrocarbon gas, which causes green house effect. Hence, it is a greenhouse gas.

(b) (i) Conversion of ethanol to ethene by the action concentrated sulphuric acid is an example of **dehydration.** When a mixture of ethyl alcohol and concentrated sulphuric acid is heated upto 170°C, dehydration of ethyl alcohol (ethanol) takes place and ethene is formed.

$$\underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[170°C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

(ii) When sodium chloride is heated with concentrated sulphuric acid below 200°C, one of the products formed is **sodium sulphate**. The following reaction occurs between H_2SO_4(conc.) and NaCl.

$$2NaCl + H_2SO_4\,(\text{conc.}) \xrightarrow{\text{Below } 200°C} \underset{\text{Sodium sulphate}}{Na_2SO_4} + 2HCl$$

(iii) Ammonia reacts with excess chlorine to form **nitrogen trichloride**. The reaction occurs as follows:

$$NH_3 + \underset{\text{Excess}}{3Cl_2} \longrightarrow 3HCl + \underset{\text{Explosive}}{NCl_3}$$

(iv) Substitution reactions are characteristic reactions of **alkanes.** e.g.

Reaction with halogens (substitution)

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{or } 400°C]{\text{Sunlight}} \underset{\text{Chloromethane}}{CH_3Cl} + \underset{\substack{\text{Hydrogen}\\\text{chloride}}}{HCl}$$

In this reaction, one H-atom of methane has been substituted by a Cl-atom converting CH_4 into CH_3Cl.

(v) In period 3, the most metallic element is sodium. On moving left to right in a period, nuclear pull increases due to the increase in atomic number and thus, the atomic size decreases. Hence, metallic character also decreases.

(c) (i) Reduction of copper (II) oxide by hydrogen:

$$CuO + H_2 \longrightarrow Cu + H_2O$$

(ii) Action of dilute sulphuric acid on sodium hydroxide:

$$2NaOH + H_2SO_4\,(\text{dil.}) \longrightarrow Na_2SO_4 + 2H_2O$$

If there is insufficient amount of NaOH, sodium bi-sulphate is formed.

$$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$$

(iii) Action of dilute sulphuric acid on zinc sulphide evolves hydrogen sulphide gas from metal sulphide.

$$ZnS + H_2SO_4\,(\text{dil.}) \longrightarrow ZnSO_4 + H_2S\uparrow$$

(iv) When ammonium hydroxide is added to ferrous sulphate solution, it gives insoluble precipitates of ferrous hydroxide that are dirty green in colour, thus, NH_4OH is used in qualitative analysis for identification of cations.

Metallic Salt Solution	Ammonium Hydroxide	Ammonium Salt	Metallic Hydroxide [ppt.]
$FeSO_4$ +	$2NH_4OH \longrightarrow$	$(NH_4)_2SO_4$ +	$\underset{\text{Dirty green}}{Fe(OH)_2}\downarrow$
			(Insoluble in excess of NH_4OH)

(v) Chlorine on reaction with ethene at room temperature form saturated ethylene chloride.

$$\underset{\text{Ethene}}{CH_2=CH_2} + Cl_2 \longrightarrow \underset{\substack{\text{1,2-dichloroethane}\\\text{(ethylene chloride)}}}{\begin{matrix} CH_2 & - & CH_2 \\ | & & | \\ Cl & & Cl \end{matrix}}$$

(d) (i) When (conc.) HNO_3 react with sulphur, H_2SO_4, H_2O and NO_2 is formed as follows:

$$\underset{\text{Sulphur}}{S} + 6HNO_3 \longrightarrow H_2SO_4 + 2H_2O + 6NO_2$$

The above reaction shows the oxidising property of HNO_3(conc.).

(ii) When ammonia gas is passed over heated copper (II) oxide, it gives reddish brown copper.

In fact, ammonia reduces oxide to give metals, water vapour and N_2.

Reaction

$$2NH_3 + \underset{\substack{\text{Black}\\\text{solid}}}{3CuO} \longrightarrow \underset{\substack{\text{Reddish brown}\\\text{solid}}}{3Cu} + 3H_2O + \underset{\text{Gas}}{N_2}\uparrow$$

(iii) When copper sulphate solution is electrolysed using copper elecrodes, reddish brown copper is deposited at cathode.

During electrolysis, ions present in the solution are Cu^{2+}, H^+, SO_4^{2-}, OH^-.

Reaction at cathode

$$Cu^{2+} + 2e^- \longrightarrow \underset{\text{Reddish brown}}{Cu} \text{ (reduction reaction)}$$

Reaction at anode

$$Cu \longrightarrow Cu^{2+} + 2e^- \text{ (oxidation reaction)}$$

(iv) Dilute hydrochloric acid reacts with zinc (placed above hydrogen in the activity series 1 and forms zinc chloride and evolve hydrogen gas.

Zinc + Hydrogen chloride gas $\xrightarrow{\Delta}$ Zinc chloride + Hydrogen gas

$$Zn + 2HCl \xrightarrow{\Delta} ZnCl_2 + H_2\uparrow$$

(v) On heating lead-nitrate $[Pb(NO_3)_2]$ strongly in a test tube, we get lead-oxide (PbO), NO_2 and O_2 (g) as decomposition products.

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$$

(e) (i) Given, mass of oxygen (w) = 12 g

Molar mass of oxygen gas M = 32

$\because$ No. of moles (n) $= \frac{w}{M}$

$\therefore \quad n = \frac{12}{32} = 0.375$ mol.

(ii) Given,

Number of carbon-atoms (N) $= 10^{22}$ atoms

Avogadro's number (N_A) $= 6 \times 10^{23}$

Molar mass of carbon (M) = 12

$\therefore$ Mass of carbon atoms (w)

$\frac{w}{M} = \frac{N}{N_A}$ or $w = \frac{N \times M}{N_A}$, $w = \frac{10^{22} \times 12}{6 \times 10^{23}}$

$= 2 \times 10^{-1}$

Weight of carbon atoms = 0.2 g

(iii) **Given** :

Molecular formula = $C_6H_{18}O_3$.

To find empirical formula; we calculate the simplest whole number ratio of $C_6H_{18}O_3$

$\therefore$ Ratio of C, H and O is 6 : 18 : 3

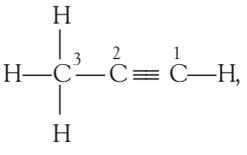
As '3' is the common diviser;

On dividing by (3), we get C_2H_6O.

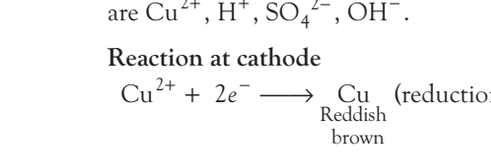
Simplest ratio is 2 : 6 : 1

Hence, the empirical formula of $C_6H_{18}O_3$ is C_2H_6O.

(f) (i) 1. IUPAC name of



i.e. $CH_3—C \equiv CH$ or C_3H_4 is propyne,



2. H—C(H)—C(=O)—H, i.e. CH_3 — CHO is ethanal.

(ii) **Structure of ethyne**

In ethyne, each carbon atom is attached to one hydrogen atom by single covalent bond and to another carbon atom by a triple covalent bond. The shape of ethyne is linear as it has no branch atom.

H—C $\equiv$ C—H (Linear structure)

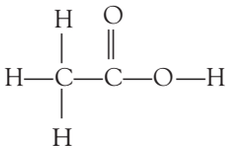
Ethyne

(iii) The name of saturated hydrocarbon containing two carbons is 'ethane', as, 'eth' is used for two-carbons and suffix-ane for saturated hydrocarbon (alkane).

Structure of ethane $H_3C—CH_3$.

(iv) **Structural Formula of Acetic acid**

Acetic acid is also known as ethanoic acid



(g) (i) **Emperical formula** is the formula that represent the simplest ratio of the various elements present in one molecule of the compound.

(ii) **Anacid** is a substance that releases hydronium ion as the only positive ion when dissolved in water.

(iii) **Electronegativity** is the tendency of an atom in a molecule to attract the shared pair of electrons toward itself.

(iv) **Calcination** is the process of heating the concentrated ore in the absence or limited supply of air at a temperature not sufficient to melt the ore.

(v) **Non-polar covalent bond** is formed between two atoms having almost same electronegativity, and electrons are equally shared by the two atoms situated exactly between the two identical nuclei.

(h) (i) The metals at the top of the reactivity series are highly reactive and the metals placed at the bottom are least reactive. Potassium (K) resides at top of the series followed by Ca, Zn and Pb.

Hence, correct order is Pb < Zn < Ca < K.

(ii) **Electropositive Series** Order of preferential discharge at the cathode can be predicted by electrochemical series. A metal with a higher position in the series displaces the one with a lower position.

Electropositive Series of Cations

Metal	Cation		
Na	Na^+	Increasing ease of reduction ↓	Discharge with most difficulty. The cations are dicharged at cathode by gain of electrons.The tendency of cation to reduce, increases on moving from top to bottom in the series.
Mg	Mg^{2+}		
H	H^+		
Cu	Cu^{2+}		Discharge most easily

Hence, the correct order of preferential discharge at cathode is.

$$Na^+ < Mg^{2+} < H^+ < Cu^{2+}$$

(iii) **Ionisation potential (or ionisation energy)** It is defined as the energy required to remove an electron from the outermost shell of an atom in its isolated gaseous state.

$$M(g) + IE \longrightarrow M^+(g) + e^-$$

[where, 'M' is any Group-I element]

Value of ionisation energy decreases with the increase in atomic size. Therefore, correct order is;

$$H < Li < Na < K.$$

(iv) Electron affinity is defined as the amount of energy released while converting a neutral gaseous isolated atom into a negatively charged gaseous ion by the addition of electron.

Trends in Electron Affinity Across a Period As we move from left to right, the atomic size decreases and nuclear charge increases. Hence, electron affinity increases.

Therefore correct order is

$$B < N < O < F$$

Nitrogen has lower electron affinity due to half-filled stable configuration.

(v) More is the number of carbon atoms present in the hydrocarbon molecule, more is its molecular weight. In case of equal number of carbon atoms, more is the number of hydrogen atoms in the molecule, more is its molecular weight.

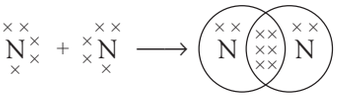
	Number of C and H-atoms
Formula of methane	$= CH_4$ [C = 1, H = 4]
Formula of ethane	$= C_2H_6$ [C = 2, H = 6]
Formula of ethene	$= C_2H_4$ [C = 2, H = 4]
Formula of ethyne	$= C_2H_2$ [C = 2, H = 2]

Therefore, correct order is methane (CH_4) < ethyne (C_2H_2) < ethene (C_2H_4) < ethane (C_2H_6).

Section II

2. (a) (i) Nitrogen Molecule (N_2)

Electronic configuration of N is 2, 5. To complete its octet, nitrogen needs three electrons. Hence, two N-atoms share three pair of electrons to form N_2 molecule. e.g.

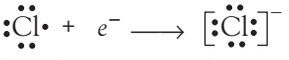


N_2 molecule

(ii) **Sodium Chloride (NaCl)** The electronic configuration of sodium (atomic number is 11) is 2, 8, 1. It loses one electron from its outermost shell and acquires the inert gas configuration of nearest noble gas (i.e., neon), thus, cation is formed.

$$\underset{(2,8,1)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + e^-$$

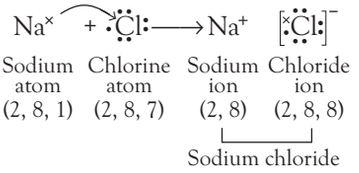
The electronic configuration of chlorine (atomic number is 17) is 2, 8, 7. It accepts one electron (which was released by sodium) and, thus anion is formed.



(2, 8, 7) (2, 8, 8)

The above two oppositely charged ions (i.e. chloride and sodium ions) approach each other. They are held together by the strong electrostatic force of attraction. In this way, formation of sodium chloride takes place.

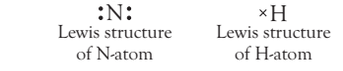
Electron Dot Structure of NaCl



Sodium atom (2, 8, 1) | Chlorine atom (2, 8, 7) | Sodium ion (2, 8) | Chloride ion (2, 8, 8)

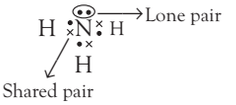
Sodium chloride

(iii) **Formation of Ammonium Ion (NH_4^+)** Formation of ammonium ion (NH_4^+) involves ammonia molecule and hydrogen ion. Ammonia contains one nitrogen atom and three hydrogen atoms. Nitrogen atom has five and hydrogen atom has one valence electron, respectively.



Lewis structure of N-atom | Lewis structure of H-atom

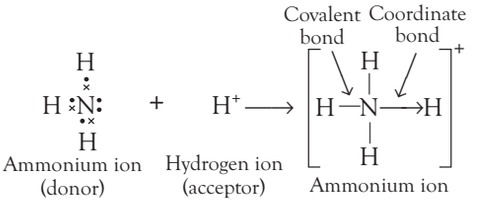
In ammonia, covalent bond formation takes place in which each of three hydrogen atoms are bonded to nitrogen atom by sharing a pair of electrons and one lone pair of electrons present on N-atom of ammonia after completing its octet.



Lone pair

Shared pair

The hydronium ions, from water, accepts this lone pair of electrons of nitrogen atom of ammonia molecule leading to the formation of a coordinate bond (and hydronium ion acquires helium configuration).



Ammonium ion (donor) | Hydrogen ion (acceptor) | Ammonium ion

Covalent bond | Coordinate bond

EXAMINATION PAPER 2019

(b) (i) The solution with pH value 7, shows no effect on litmus solution as it has equal number of $[H^+]$ and $[OH^-]$ ions.

Notes pH less than 7 — acidic, i.e. $[H^+ (aq)]$ more than $[OH^-]$

- pH more than 7 — basic, i.e. $[OH^-]$ more than $[H^+ (aq)]$

(ii) Acids liberate carbon dioxide on reaction with metallic carbonates (sodium carbonate)

Therefore, pH = 2, i.e. solution [*B*] is acidic in nature and will react with Na_2CO_3 to give CO_2.

(iii) Bases turn red litmus to blue,

Therefore, solution with pH > 7, is basic hence, solution [*A*] will turn the red litmus solution blue.

(c) (i) As element G belongs to group-17 (Halogen family), it will form electrovalent compound with the element of group-2, i.e. [*B*]. It forms BG_2 compound.

(ii) During electrolysis, (+)ve ions move towards cathode and get reduced.

As, ion of [*A*], i.e. $[A^+]$ is highly electropositive, in solution, it will migrate towards cathode during electrolysis.

(iii) '*E*' is the non-metallic element having a valency of 2. '*E*' element belongs to group 16 having 6 valence electrons. So, valency is $8 - 6 = 2$.

(iv) Element with completely filled outermost valence shell is known as inert gas. In the given table, element (*F*) belongs to group-18 and has completely filled valence shell, thus is an inert gas.

3. (a) (i) **Strong Electrolyte** The electrolytes, which completely dissociate into its ions are called strong electrolytes. The (+) ve and (–) ve particles (ions) of strong acids/bases and ions of salts of strong acid or base are present in strong electrolyte. e.g. dil. HCl has H^+ and $Cl^{\ominus}$ ions.

(ii) **Non-electrolyte** Chemical compounds which do not conduct electricity in the fused state or in aqueous solution are called non-electrolytes, The particles present are molecules e.g. Pure or distilled water, alcohol, kerosene etc.

(iii) **Weak-Electrolyte** Weak electrolytes are partially dissociated in fused state or in aqueous solution. These electrolytes contain ions as well as molecules.

Acids Carbonic acid (H_2CO_3), acetic acid (CH_3COOH).

Bases NH_4OH. **Salts** Na_2CO_3, $NaHCO_3$.

(b) (i) When hydrochloric acid is heated with **manganese dioxide**, then greenish yellow gas, i.e. chlorine is evolved which turns moist starch iodide paper blue black.

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2 \uparrow$$

Copper (II) oxide on reaction with HCl gives $CuCl_2$ and H_2O

$$CuO + 2HCl \longrightarrow CuCl_2 + H_2O$$

(ii) **For Ferrous Sulphate ($FeSO_4$) Ferrous [Fe^{2+} ion or iron (II) salts]** On adding sodium hydroxide drop by drop to a solution of ferrous salt, a dirty green precipitate is formed. After sometime it turns into reddish brown colour and is **insoluble** in excess of sodium hydroxide.

$$\underset{\substack{\text{Ferrous}\\\text{sulphate}\\\text{(Pale green)}}}{FeSO_4} + \underset{\substack{\text{Caustic}\\\text{soda}\\\text{(Colourless)}}}{2NaOH} \longrightarrow \underset{\substack{\text{Ferrous}\\\text{hydroxide}\\\text{(Dirty green ppt.)}}}{Fe(OH)_2 \downarrow} + \underset{\substack{\text{Sodium}\\\text{sulphate}\\\text{(Colourless)}}}{Na_2SO_4}$$

For ferric sulphate [$Fe_2(SO_4)_3$], i.e. **Ferric [Fe^{3+} ion or iron (III) salts]** On adding sodium hydroxide (NaOH) drop by drop to a ferric salt solution, a reddish brown precipitate is formed which is **insoluble** in excess of sodium hydroxide.

$$Fe_2(SO_4)_3 + 6NaOH \longrightarrow 3Na_2SO_4 + \underset{\substack{\text{(Ferric-hydroxide}\\\text{reddish brown ppt.)}}}{2Fe(OH)_3}$$

(iii) **For Dilute Hydrochloric Acid** Lead nitrate reacts with hydrochloric acid to give white precipitate of lead chloride, respectively.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 \downarrow + 2HNO_3$$

For Dilute Sulphuric Acid Sulphuric acid precipitates the insoluble sulphates of lead from the solution of their salt $Pb(NO_3)_2$,

$$Pb(NO_3)_2 + H_2SO_4 \longrightarrow \underset{\text{(Insoluble)}}{PbSO_4} \downarrow + 2HNO_3$$

(c) (i) **Lead chloride** ($PbCl_2$) →

Method of preparation : Precipitation

Chemical reaction involved :

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 \downarrow + 2HNO_3$$

$$Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2 \downarrow + 2NaNO_3$$

(ii) **Iron (II) sulphate ($FeSO_4$)** ⟶ Substitution. e.g. chemical reaction involved :

$$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S \uparrow$$

$$FeSO_4 + 7H_2O \longrightarrow FeSO_4 \cdot 7H_2O$$

(iii) **Sodium Nitrate** ($NaNO_3$) : This is salt of strong acid (HNO_3) and strong base (NaOH), thus is an example of neutralisation.

$$NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$$

(iv) **Iron (III) Chloride** ($FeCl_3$)

It is prepared by direct combination of Fe and $Cl_2(g)$.

$$Fe + 3Cl_2 \xrightarrow{\Delta} 2FeCl_3$$

4. (i) $S + 6HNO_3 \longrightarrow H_2SO_4 + 6NO_2 + 2H_2O$

(ii) $\underset{\text{Carbon}}{C} + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2\uparrow$

(iii) $\underset{\text{Copper}}{3Cu} + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

(b) (i) **By Dehydrohalogenation**

$$\underset{\text{Bromo ethane}}{C_2H_5Br} + \underset{\text{Alcoholic}}{KOH} \longrightarrow \underset{\text{Ethene}}{C_2H_4} + KBr + H_2O$$

(ii) $\underset{\text{Calcium carbide}}{CaC_2} + 2H_2O \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Ethyne}}{C_2H_2}\uparrow$

Gas is collected by the downward displacement of water, as it is insoluble in water.

(iii) $\underset{\text{Sodium acetate}}{CH_3CO\overset{-}{O}\overset{+}{N}a} + NaOH \xrightarrow[300°C]{CaO} Na_2CO_3 + \underset{\text{Methane}}{CH_4}\uparrow$

(c) (i) Compound with 3 carbon atoms whose functional group is a carboxyl is propanoic acid

The structural formula is

$$CH_3—CH_2—COOH$$

(ii) First homologue, whose general formula is C_nH_{2n} is C_2H_4.

The name includes eth (word root) and suffix (ene), i.e. **ethene.**

(iii) The compound that reacts with acetic acid (CH_3COOH) to form ethyl ethanoate, i.e. ($CH_3COOC_2H_5$) is ethanol (C_2H_5OH).

The reaction involved is

$$CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4\ (conc.)} CH_3COOC_2H_5$$

This is an esterification reaction in which alcohol reacts with acid to give ester having fruity smell.

(iv) The compound formed by complete chlorination of ethyne is 1,1,2,2-tetrachloroethane.

Chemical reaction involved is

$$\underset{\text{Ethane}}{CH \equiv CH} \xrightarrow{Cl_2} \underset{Cl}{\overset{H}{\overset{|}{C}}} = \underset{Cl}{\overset{H}{\overset{|}{C}}} \xrightarrow{Cl_2} H—\underset{Cl}{\overset{Cl}{\overset{|}{C}}}—\underset{Cl}{\overset{Cl}{\overset{|}{C}}}—H$$

i.e.

Hence, the name of product is 1,1,2,2-tetrachloroethane ($C_2H_2Cl_4$)

5. (a) (i) The chemical formula of bauxite is $Al_2O_3 \cdot 3H_2O$

(ii) The chemical formula is **cryolite** is Na_3AlF_6

(iii) The chemical formula is **sodium aluminate** is $NaAlO_2$.

(b) (i) Cryolite is added to lower the fusion temperature from 2050°C to 950°C and also to increase the conductivity.

(ii) Powdered coke is sprinkled alongwith alumina over the surface of electrolyte to reduces heat (cause by the radiation) and it prevents the burning of anode.

(iii) Aluminium is collected at cathode.

(c) (i) → (C), (ii) → (A), (iii) → (D), (iv) → (B)

(i) Duralumin → (C) Aircraft body.

(ii) Solder → (A) Electrical fuse.

(iii) Brass → (D) Decorative articles.

(iv) Stainless steel → (B) Surgical instruments.

6. (a) (i) The **catalyst** used to oxidise ammonia : Pt (Platinum).

In Ostwald process, oxidation of ammonia into nitrogen monoxide occur in presence of platinum.

$$4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + 6H_2O + Heat$$

(ii) The **organic compound** which when solidified, forms an ice like mass is pure ethanoic-acid. Pure ethanoic acid or acetic acid on cooling forms crystalline mass, which looks like a glacier. That is why, pure ethanoic acid is called glacial acetic acid.

(iii) The **dilute acid**, which is an oxidising - agent is HNO_3(dil.). Oxidising properties of HNO_3 are due to nascent oxygen which it gives on decomposition.

$$2HNO_3\ (conc.) \longrightarrow 2NO_2 + H_2O + [O]$$

$$2HNO_3\ (dil.) \longrightarrow 2NO + H_2O + 3[O]$$

(b) (i) Given:

$2NaOH + CuSO_4 \longrightarrow Na_2SO_4 + Cu(OH)_2$

Molar mass of $Cu(OH)_2 = 64 + 2(16 + 1)$

$= 64 + 32 + 2 = 98$

Molar mass of NaOH = 23 + 16 + 1 = 40

According to given equation:

2 moles of NaOH ≡ 1 mol of $Cu(OH)_2$

i.e.

$\because 2 \times 40$ g of NaOH, gives 98 g of $Cu(OH)_2$

$\therefore$ 200 g of NaOH give $\frac{98 \times 200}{80}$ g of $Cu(OH)_2$

$= 245$ g of $Cu(OH)_2$

(ii) $Cu(OH)_2$ precipitate is of pale greenish-blue colour.

(c) Given,

C = 75.92%

H = 6.32 %

N = 17.76%

Vapour density of compound = 39.5

$\because$ Molecular mass (M) = 2 × Vapour density

= 2 × 39.5

= 79

To find empirical formula

	% in 100 g of sample (*w*)	Molar-mass of element (*M'*)	$\left(n = \frac{w}{M'}\right)$	Simple ratio of atoms
Carbon	75.92	12	$n = \frac{75.92}{12} = 6.32$	$\frac{6.32}{1.268} \approx 5$
Hydrogen	6.32	1	$n = \frac{6.32}{1} = 6.32$	$\frac{6.32}{1.268} \approx 5$
Nitrogen	17.76	14	$n = \frac{17.76}{14} = 1.268$	$\frac{1.268}{1.268} = 1$

(On dividing 6.32, 6.32 and 1.265 respectively by 1.268, we get :)

C = 5, H = 5, N = 1

Hence, simple ratio i.e., empirical formula is = C_5H_5N

Also, empirical formula weight

= mass of 5C + 5H + N

= 5 × 12 + 5 × 1 + 14 = 79

and molecular weight = n' × empirical formula weight.

Where $n' = \frac{\text{molecular weight}}{\text{empirical formula weight}}$

$= \frac{79}{79} = 1$

Hence molecular formula = 1 × (C_5H_5N)

= C_5H_5N

7. (a) (i) When alumina undergoes electrolytic reduction, it evolves CO and CO_2 gases.

At cathode Carbon lining (gas carbon) of the cell.

$4Al^{3+} + 12e^- \longrightarrow 4Al$

At anode Thick rods of graphite are suspended into the fused electrolyte.

$6O^{2-} - 12e^- \longrightarrow 6[O]$

$6[O] \longrightarrow 3O_2$

Anode oxidises carbon to carbon monoxide and then to carbon dioxide.

$2C + O_2 \longrightarrow 2CO$

$2CO + O_2 \longrightarrow 2CO_2$

The oxygen evolved at the anode escapes as a gas or reacts with carbon anode. The carbon anode is thus, oxidised.

(ii) Ethene on hydrogenation gives ethane. It is as follows.

$$\underset{\text{Ethene}}{C_2H_4} + H_2 \xrightarrow[\text{Ni}]{200^\circ C} \underset{\text{Ethane}}{C_2H_6}$$

(iii) When ammonia reacts with heated copper-oxide (CuO), it gives copper (Cu), $N_2(g)$ and H_2O.

$$2NH_3 + 3CuO \xrightarrow{\Delta} N_2(g) + 3Cu + 3H_2O$$

(b) $Mg_3N_2 \xrightarrow{(A)} NH_3 \underset{(C)}{\overset{(B)}{\rightleftharpoons}} NH_4Cl$

In above reaction.

(A) is H_2O.

$\because Mg_3N_2 + \underset{(A)}{6H_2O} \xrightarrow[-\,3Mg(OH)_2]{} NH_3$

and (B) is HCl

$\because NH_3 + \underset{(B)}{HCl} \longrightarrow NH_4Cl$

and (C) is $Ca(OH)_2$

$\because 2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3\uparrow$

(c)

Name of the Compound	Name of Process	Catalytic equation (With the catalyst)
Ammonia	(i) Haber's process	(ii) $\underset{[1\text{ vol}]}{N_2} + \underset{[3\text{ vol}]}{3H_2} \underset{\text{Above 200 atm (Fe and Mo)}}{\overset{450\text{-}500^\circ C}{\rightleftharpoons}} \underset{[2\text{ vol}]}{2NH_3} + \text{Heat}$
Sulphuric acid	(iii) Contact process	(iv) $2SO_2 + O_2 \underset{450^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3$

(Here, V_2O_5 is a catalyst in contact process)

ICSE EXAMINATION PAPER 2020

CHEMISTRY (SOLVED)

GENERAL INSTRUCTIONS

1. You will not be allowed to write during the first 15 minutes. This time is to be spent in reading the question paper.
2. The time given at the head of this paper is the time allowed for writing the answers.
3. Attempt all questions from **Section I** and any 4 questions from **Section II**.
4. The intended marks for questions or parts of questions are given in brackets [ ].

Time : 2 Hrs **Max. Marks : 80**

Section-I

[40 *Marks*]

1. (a) Choose the correct answer from the options given below: ***[5]***

(i) The element with highest ionisation potential is

(a) hydrogen (b) caesium

(c) radon (d) helium

(ii) The inert electrode used in the electrolysis of acidified water is

(a) nickel (b) platinum

(c) copper (d) silver

(iii) A compound with low boiling point is

(a) sodium chloride

(b) calcium chloride

(c) potassium chloride

(d) carbon tetrachloride

(iv) The acid which can produce carbon from cane sugar is

(a) concentrated hydrochloric acid

(b) concentrated nitric acid

(c) concentrated sulphuric acid

(d) concentrated acetic acid

(v) The organic compound having a triple carbon-carbon covalent bond is

(a) C_3H_4 (b) C_3H_6

(c) C_3H_8 (d) C_4H_{10}

(b) State one relevant observation for each of the following reactions: ***[5]***

(i) Action of concentrated nitric acid on copper.

(ii) Addition of excess ammonium hydroxide into copper sulphate solution.

(iii) A piece of sodium metal is put into ethanol at room temperature.

(iv) Zinc carbonate is heated strongly.

(v) Sulphide ore is added to a tank containing oil and water, and then stirred or agitated with air.

(c) Write a balanced chemical equation for each of the following: ***[5]***

(i) Reaction of carbon powder and conc. nitric acid.

(ii) Reaction of excess ammonia with chloride.

(iii) Reaction of lead nitrate solution with ammonium hydroxide.

(iv) Producing ethane from bromo ethane using Zn/Cu couple in alcohol.

(v) Complete combustion of ethane.

(d) (i) Draw the structural formula for each of the following: ***[5]***

1. 2, 2-dimethyl pentane
2. Methanol
3. Iso propane

(ii) Write the IUPAC name for the following compounds:

1. Acetaldehyde
2. Acetylene

(e) State one relevant reason for each of the following: ***[5]***

(i) Graphite anode is preferred to platinum in the electrolysis of molten lead bromide.

(ii) Soda lime is preferred to sodium hydroxide in the laboratory preparation of methane.

(iii) Hydrated copper sulphate crystals turn white on heating.

(iv) Concentrated nitric acid appears yellow, when it is left for a while in a glass bottle.

(v) Hydrogen chloride gas fumes in moist air.

(f) Calculate: ***[5]***

(i) The amount of each reactant required to produce 750 mL of carbon dioxide, when two volumes of carbon monoxide combine with one volume of oxygen to produce two volumes of carbon dioxide.

$$2CO + O_2 \longrightarrow 2CO_2$$

(ii) The volume occupied by 80 g of carbon dioxide at STP.

(iii) Calculate the number of molecules in 4.4 g of CO_2.
[Atomic mass of C = 12, O = 16]

(iv) State the law associated in question no. (f) (i) above.

(g) Give one word or a phrase for the following statements: ***[5]***

(i) The chemical bond formed by a shared pair of electrons, each bonding atom contributing one electron to the pair.

(ii) Electrode used as cathode in electrorefining of impure copper.

(iii) The substance prepared by adding other metals to a base metal in appropriate proportions to obtain certain desirable properties.

(iv) The tendency of an atom to attract electrons to itself when combined in a compound.

(v) The reaction in which carboxylic acid reacts with alcohol in the presence of conc. H_2SO_4 to form a substance having a fruity smell.

(h) Fill in the blanks from the choices given in brackets: ***[5]***

(i) The polar covalent compound in gaseous state that does not conduct electricity is .....
(carbon tetra chloride, ammonia, methane)

(ii) A salt prepared by displacement reaction is .....
(ferric chloride, ferrous chloride, silver chloride)

(iii) The number of moles in 11 g of nitrogen gas is .....
(0.39, 0.49, 0.29) [atomic mass of N = 14]

(iv) An alkali which completely dissociates into ions is ..... . (ammonium hydroxide, calcium hydroxide, lithium hydroxide)

(v) An alloy used to make statues is .....
(bronze, brass, fuse metal)

EXAMINATION PAPER 2020

Section-II

[40 *Marks*]

2. (a) The following table represent the elements and the atomic number. ***[3]***
With reference to this, answer the following using only the alphabets given in the table.

Elements	Atomic number
P	13
Q	7
R	10

(i) Which element combines with hydrogen to form a basic gas ?

(ii) Which element has an electron affinity zero ?

(iii) Name the element, which forms an ionic compound with chlorine.

(b) Draw the electron dot diagram for the compounds given below. Represent the electrons by (.) and (x) in the diagram. ***[3]***
[**Atomic number** Ca = 20, O = 8, Cl = 17, H = 1]

(i) Calcium oxide

(ii) Chlorine molecule

(iii) Water molecule

(c) Choose the correct word which refers to the process of electrolysis from *A* to *E*, to match the description (i) to (iv): ***[4]***

A : Oxidation *B* : Cathode C : Anode *D* : An electrolyte E : Reduction

(i) Conducts electricity in aqueous or in molten state.

(ii) Loss of electron takes place at anode.

(iii) A reducing electrode.

(iv) Electrode connected to the positive end or terminal of the battery.

3. (a) Baeyer's process is used to concentrate bauxite ore to alumina.

Give balanced chemical equations for the reaction taking place for its conversion from bauxite to alumina. ***[3]***

(b) Complete the following by selecting the correct option from the choice given: ***[3]***

(i) pH of acetic acid is greater than dilute sulphuric acid. So, acetic acid contains ..... concentration of H^+ ions. (greater, same, low)

(ii) The indicator which does not change colour on passage of HCl gas is ..... (methyl orange, moist blue litmus, phenolphthalein)

(iii) The acid which cannot act as an oxidising agent is ..... (conc. H_2SO_4, conc. HNO_3, conc. HCl)

(c) Match the gases given in Column I to the identification of the gases mentioned in column II: ***[4]***

Column I	Column II
(i) Hydrogen sulphide	A. Turns acidified potassium dichromate solution green.
(ii) Nitric oxide	B. Turns lime water milky.
(iii) Carbon dioxide	C. Turns reddish brown when it reacts with oxygen.
(iv) Sulphur dioxide	D. Turns moist lead acetate paper silvery black.

4. (a) Differentiate between the following pairs based on the information given in the brackets. ***[3]***

(i) Conductor and electrolyte (conducting particles).

(ii) Cations and anions (formation from an atom).

(iii) Acid and alkali (formation of type of ions).

(b) Draw the structure of isomers of pentane. *[3]*

(c) Hydrogen chloride gas is prepared in the laboratory using conc. sulphuric acid and sodium chloride. Answer the questions that follow based on this reaction : *[4]*

(i) Give the balanced chemical equation for the reaction with suitable condition(s) if any.

(ii) Why is concentrated sulphuric acid used instead of concentrated nitric acid?

(iii) How is the gas collected?

(iv) Name the drying agent not used for drying the gas.

5. (a) Distinguish between the following pairs of compounds using a reagent as a chemical test: *[3]*

(i) Calcium nitrate and zinc nitrate solution.

(ii) Ammonium sulphate crystals and sodium sulphate crystals.

(iii) Magnesium chloride and magnesium nitrate solution.

(b) Calculate the percentage of *[3]*

(i) fluorine

(ii) sodium and

(iii) aluminium

in sodium aluminium fluoride [Na_3AlF_6], to the nearest whole number.

[Atomic mass: Na = 23, Al = 27, F = 19]

(c) (i) State the volume occupied by 40 g of methane at STP, if its vapour density (V.D.) is 8.

(ii) Calculate the number of moles present in 160 g of NaOH.

[Atomic mass Na = 23, H = 1, O = 16] *[4]*

6. (a) Identify the salts *P*, *Q*, *R* from the following observations: *[3]*

(i) Salt *P* has light bluish green colour. On heating, it produces a black coloured residue. Salt *P* produces brisk effervescence with dil. HCl and the gas evolved turns lime water milky, but no action with acidified potassium dichromate solution.

(ii) Salt *Q* is white in colour. On strong heating, it produces buff yellow residue and liberates reddish brown gas. Solution of salt *Q* produces chalky white insoluble precipitate with excess of ammonium hydroxide.

(iii) Salt *R* is black in colour. On reacting with concentrated HCl, it liberates a pungent greenish yellow gas which turns moist starch iodide paper blue black.

(b) Identify the substance underlined in each of the following: *[3]*

(i) The electrode that increases in mass during the electro-refining of silver.

(ii) The acid that is a dehydrating as well as a drying agent.

(iii) The catalyst used to oxidise ammonia into nitric oxide.

(c) Copy and complete the following paragraph using the options given in brackets: *[4]*

Alkenes are a homologous series of (i) ..... (saturated/unsaturated) hydrocarbons characterised by the general formula (ii) ..... (C_nH_{2n+2} / C_nH_{2n}). Alkenes undergo (iii) ..... (addition/substitution) reactions and also undergo (iv) ..... hydrogenation/dehydrogenation) to form alkanes.

7. (a) Write balanced chemical equations, for the preparation of the given salts *[3]*

(i) to (iii) by using the methods *A* to *C* respectively:

A : Neutralisation B : Precipitation C : Titration

(i) Copper sulphate

(ii) Zinc carbonate

(iii) Ammonium sulphate

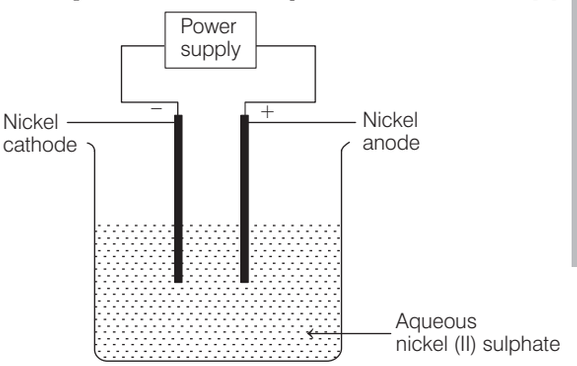
(b) Name the following elements: *[3]*

(i) An alkaline earth metal present in group 2 and period 3.

(ii) A trivalent metal used to make light tools.

(iii) A monovalent non-metal present in fluorspar.

(c) An aqueous solution of nickel (II) sulphate was electrolysed using nickel electrodes. Observe the diagram and answer the questions that follows: *[4]*



(i) What do you observe at the cathode and anode respectively?

(ii) Name the cation that remains as a spectator ion in the solution.

(iii) Which equation for the reaction at the anode is correct?

1. $Ni \longrightarrow Ni^{2+} + 2e^-$
2. $Ni + 2e^- \longrightarrow Ni^{2+}$
3. $Ni^{2+} \longrightarrow Ni + 2e^-$
4. $Ni^{2+} + 2e^- \longrightarrow Ni$

ANSWERS

Section-I

1. (a) (i) *(d)* The element with highest ionisation potential is helium. Its atomic size is smaller than H, Cs, Ra due to an increase in the nuclear charge and thus more energy is required to remove the electron.

(ii) *(b)* Platinum is used as an inert electrode in the electrolysis of acidified water as platinum does not react with H^+ or OH^-.

(iii) *(d)* Carbon tetrachloride has low boiling point. Out of the four options given, only carbon tetrachloride is covalent while the other three are ionic compound.

(iv) *(c)* Conc. sulphuric acid can produce carbon from cane sugar.

$$\underset{\text{Conc. sugar}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Carbon}}{12C(s)} + 11H_2O$$

(v) *(a)* C_3H_4 is the organic compound having a triple carbon-carbon covalent bond. The general formula of triple C—C bond is $C_nH_{2n-2} \Rightarrow C_3H_{3\times2-2} = C_3H_4$

(b) (i) When conc. nitric acid reacts with copper, copper nitrate alongwith water and nitrogen oxide is formed as per following reaction :

$$\underset{\text{Copper}}{3Cu} + \underset{\text{Nitric acid}}{8HNO_3\,(\text{conc.})} \longrightarrow \underset{\text{Copper nitrate}}{3Cu(NO_3)_2} + \underset{\text{Nitrogen oxide}}{2NO} + \underset{\text{Water}}{4H_2O}$$

(ii) When copper sulphate solution reacts with excess ammonium hydroxide, ammonium sulphate and copper hydroxide are produced.

$$\underset{\text{Copper sulphate}}{CuSO_4(aq)} + \underset{\text{Ammonium hydroxide}}{2NH_4OH} \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + \underset{\substack{\text{Coppper Hydroxide}\\\text{(pale blue colour)}}}{Cu(OH)_2}$$

(iii) When a piece of sodium metal is put into ethanol at room temperature, sodium ethoxide is formed alongwith liberation of hydrogen gas.

$$2CH_3OH + 2Na \longrightarrow \underset{\text{Sodium methoxide}}{2CH_3\overset{-}{O}\overset{+}{N}a} + H_2\uparrow$$

(iv) When zinc carbonate is heated, it gets decomposed to zinc oxide and carbon dioxide.

$$\underset{\text{Zinc carbonate}}{ZnCO_3} \xrightarrow{\Delta} \underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Carbon dioxide}}{CO_2}\uparrow$$

(v) When sulphide ore is added to a tanle containing oil and water, then stirred or agitated with air, froth is produced and this froth carries sulphide ore particles which are transferred to an adjacent container for obtaining concentrated sulphide ore.

(c) (i) Reaction of carbon with conc. nitric acid.

$$\underset{\text{Carbon powder}}{C} + \underset{\text{Nitric acid}}{4HNO_3\,(\text{conc.})} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2}\uparrow + \underset{\text{Water}}{2H_2O} + \underset{\text{Nitrogen dioxide}}{4NO_2}\uparrow$$

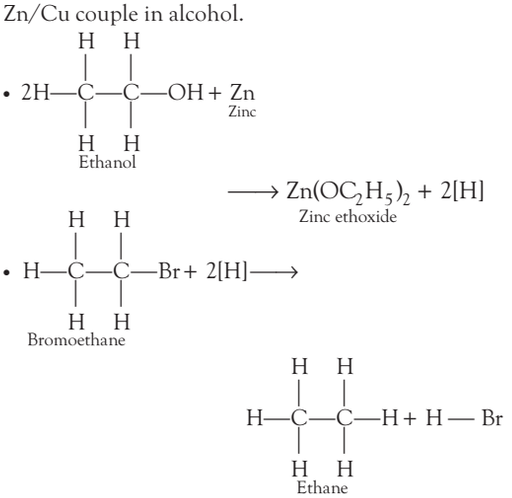
(ii) Reaction of excess ammonia with chlorine

$$\underset{\substack{\text{Ammonia}\\\text{in excess}}}{8NH_3\,(g)} + \underset{\text{Chlorine}}{3Cl_2} \longrightarrow \underset{\text{Ammonium chloride}}{6NH_4Cl} + \underset{\text{Nitrogen gas}}{N_2}\uparrow$$

(iii) Reaction of lead nitrate solution with ammonium hydroxide.

$$\underset{\text{Lead nitrate}}{Pb(NO_3)_2} + \underset{\text{Ammonium hydroxide}}{2NH_4OH} \longrightarrow \underset{\text{Ammonium nitrate}}{2NH_4NO_3} + \underset{\text{Lead hydroxide}}{Pb(OH)_2}\downarrow$$

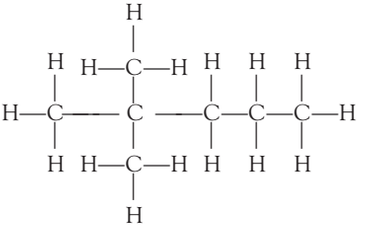
(iv) Preparation of ethane from bromoethane by using Zn/Cu couple in alcohol.



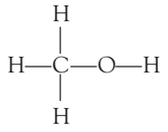
(v) Complete combustion of ethane takes place as under

$$\underset{\text{Ethane}}{2C_2H_6} + \underset{\substack{\text{(In sufficient}\\\text{supply of}\\\text{oxygen)}}}{7O_2} \longrightarrow \underset{\text{Carbon dioxide}}{4CO_2}\uparrow + \underset{\text{Water}}{6H_2O} + \text{Heat}$$

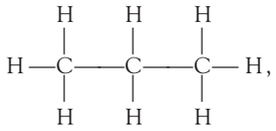
(d) (i) 1. Structural formula of 2, 2 dimethyl pentane is



2. Structural formula of methanol is

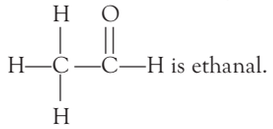


3. Structural formula of *iso*-propane is

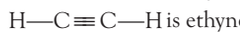


i.e. *iso*-propane is similar to propane.

(ii) 1. IUPAC name of acetaldehyde :



2. IUPAC name of acetylene :



(e) (i) Graphite anode is preferred to platinum in electrolysis of molten lead bromide as graphite is an inert electrode which does not react with bromine liberated at anode while platinum may react with bromine.

(ii) Soda lime is preferred to sodium hydroxide in laboratory preparation of methane as lime (CaO) does not participate in the reaction but helps in fusion of the reaction mixture.

(iii) Hydrated copper sulphate crystals turn white on heating because of vaporisation of its water of crystallisation.

$$\underset{\text{(Blue)}}{CuSO_4 \cdot 5H_2O} \longrightarrow \underset{\text{(White)}}{CuSO_4} + 5H_2O$$

(iv) Conc. nitric acid appears yellow, when kept for a while in glass bottles, because concentrated nitric acid undergoes decomposition as it is very unstable to heat. On decompostion, they from reddish brown nitrogen dioxide gas which when dissolved in the acid appears yellow in colour.

$$4HNO_3 \xrightarrow[\text{Sunlight}]{} 4NO_2 + 2H_2O + O_2$$

(v) Refer to page no. 159 (Physical properties).

(f) (i) $\underset{\substack{2\text{ mol}\\1\text{ mol}}}{2CO(g)} + \underset{\substack{1\text{ mol}\\0.5\text{ mol}}}{O_2(g)} \longrightarrow \underset{\substack{2\text{ mol}\\1\text{ mol}}}{2CO_2(g)}$

At STP, 22400 mL CO_2 production requires 1 mol of CO and 0.5 mol of O_2.

For 750 mL CO_2 production $= \frac{750}{22400} \times 1$ mol CO

and $\frac{750}{22400} \times 0.5$ mol oxygen is required, i.e. 0.334 mol CO and 0.0167 mol O_2, 0.536g oxygen and 9.352 g CO.

(ii) Volume occupied by 44g (1 mole) of CO_2 at STP = 22400 mL

Volume occupied by 80g (1 mole) of CO_2 at STP

$$= \frac{22400}{44} \times 80$$

$$= 40600 \text{ mL} = 40.60 \text{ L}$$

(iii) Number of molecules in 44 g (1 mole) of $CO_2 = 6.022 \times 10^{23}$

No of molecules in 4.4 g (1 mole) of CO_2

$$= \frac{6.022 \times 10^{23}}{44} \times 4.4$$

$$= 6.022 \times 10^{22}$$

(iv) The law associated with (i) above is Gay Lussac's law.

(g) (i) Covalent bond

(ii) Pure thin sheet of copper

(iii) Alloy

(iv) Electronegativity

(v) Esterification

(h) (i) Ammonia

(ii) Ferrous chloride

(iii) 0.39 (28 g nitrogen gas = 1 mole

11 g nitrogen gas $= \frac{1}{28} \times 11 = 0.39$)

(iv) Calcium hydroxide- $Ca(OH)_2$

(v) Brass (Brass is alloy of copper and zinc.)

2. (a) (i) Q ($N_2 + 3H_2 \longrightarrow 2NH_3$, ammonia is a basic gas).

(ii) *R* (Because neon with atomic number 10 has zero electron affinity). It has fully filled electronic configuration.

(iii) *P* (Al with atomic number 13 forms ionic compound $2Al + 3Cl_2 \longrightarrow 2AlCl_3$).

(b) (i) Refer to page no. 28 (Calcium oxide)

(ii) Refer to page no. 30 (Chlorine molecule).

(iii) Refer to page no. 30 (Water molecule).

(c) (i) Electrolyte (ii) Oxidation

(iii) Cathode (iv) Anode

3. (a) Refer to page no. 140 (Baeyer's process).

(b) (i) **low** (Because acetic acid is a weaker acid than sulphuric acid and also $pH = -\log[H^+]$)
So, lower the $[H^+]$ value higher will be the pH.

(ii) **phenolphthalein** (Moist blue litmus turns red on passage of HCl gas and methyl orange turns pink on passage of HCl gas. But phenolphthalein does not change its colour in acidic medium).

(iii) **conc. HCl** (Conc. H_2SO_4 as well as conc. HNO_3 are good oxidising agents).

(c) (i) D (H_2Sturns moist lead acetate paper black).

(ii) C (Nitric oxide turns reddish brown, when it reacts with oxygen).

(iii) B (Carbon dioxide turns lime water milky due to the formation of calcium carbonate).

$$CO_2 + Ca(OH)_2 \longrightarrow \underset{\text{Milkiness appears}}{CaCO_3 \downarrow}$$

(iv) A (SO_2 turns acidified potassium dichromate solution green).

4. (a) (i) Refer to page no. 111 (Conductors, electrolyte).

(ii) Cations are formed, when one or more electrons are removed from an atom or ion.

$$Na \longrightarrow \underset{\text{Sodium cation}}{Na^+} + e^-$$

Anions are formed, when one or more electrons are added to an atom or ion :

$$Cl + e^- \longrightarrow \underset{\text{Chloride anion}}{Cl^-}$$

(iii) Refer to pages no. 47-49 (Acids and Bases).

(b) Refer to page no. 208 (Chain isomerism).

(c) (i) Refer to page no. 159 (Laboratory preparation, reactions).

(ii) Because concentrated sulphuric acid has high boiling point and does not volatilise out easily. Whereas concentrated nitric acid is volatile and may volatilise out along with HCl gas.

(iii) Refer to page no. 159 (Precautions).

(iv) Refer to page no. 159 (Purification of HCl gas).

5. (a) (i) Refer to page no. 75 (Summary).

(ii) On heating ammonium sulphate with calcium oxide, smell of ammonia comes out which can be confirmed by contacting it with a rod of HCl and white fumes of NH_4Cl forms. In case of sodium sulphate no such reaction takes place.

(iii) Magnesium chloride on reacting with silver nitrate will generate ppt. of AgCl while in case of magnesium nitrate no such ppt. shall be produced.

(b) (i) Fluorine % in $[Na_3AlF_6]$

$$= \frac{19\times6}{23\times3+27+6\times19}\times100 = \frac{11400}{210} = 54.29\%$$

(ii) Na % In $[Na_3AlF_6]$

$$= \frac{23\times3}{210}\times100 = \frac{6900}{210} = 32.86\%$$

(iii) Al % in $[Na_3AlF_6]$

$$\frac{27}{210}\times100 = \frac{2700}{210} = 12.85\%$$

(c) (i) Molecular mass of methane at STP

$$= 2\times\text{vapour density} = 2\times8 = 16\,g$$

So, 16g methane occupies volume = 22.4 L

40g methane occupies volume

$$= \frac{22.4}{16}\times40 = 56\,L$$

(ii) Molecular mass of NaOH

$$= 23+16+1 = 40\ g$$

So, number of moles of NaOH in 40 g $= \frac{40}{40} = 1$

6. (a) (i) The reaction involved are following :

Copper carbonate

$$\underset{\substack{(P)\\(\text{Blush green colour})}}{CuCO_3} \xrightarrow{\Delta} \underset{\text{(Black coloured residue)}}{CuO} + CO_2$$

$$\downarrow \text{Dil. HCl}$$

$$CuCl_2 + H_2O + \underset{\substack{\text{Brisk}\\\text{effervescence}}}{CO_2\uparrow} \longrightarrow \text{Turns lime water milky}$$

$$\downarrow \text{Passed though acidified } K_2Cr_2O_7$$

No reaction

(ii) The reactions involved are following :

***Q*= Lead nitrate**

$$\underset{\substack{(Q)\\(\text{White})}}{2Pb(NO_3)_2} \xrightarrow{\Delta} \underset{\text{(Buff yellow residue)}}{2PbO} + \underset{\text{(Redish brown gas)}}{4NO_2\uparrow} + O_2\uparrow$$

$$\downarrow 4NH_4OH$$

$$\underset{\text{(Chalky white ppt.)}}{2Pb(OH)_2} + 4NH_4NO_3$$

(iii) The reactions involved are following :

***R* = Manganese dioxide**

$$\underset{\text{(Black)}}{MnO_2} + 4HCl\ (\text{conc.}) \longrightarrow \underset{\substack{\text{(Greensih}\\\text{yellow gas)}}}{Cl_2} + MnCl_2 + 2H_2O$$

$$\downarrow$$

Turns moist starch iodide paper black

(b) (i) Cathode (ii) Conc. sulphuric acid

(iii) Platinum

(c) (i) Unsaturated (ii) C_nH_{2n}

(iii) Addition (iv) Hydrogenation

7. (a) (i) $\underset{\substack{\text{Base}\\\text{(Neutralisation)}}}{CuO} + \underset{\text{Acid}}{H_2SO_4} \longrightarrow \underset{\text{(Salt)}}{CuSO_4} + H_2O$

(ii) $\underset{\text{Precipitation}}{ZnSO_4} + Na_2CO_3 \longrightarrow ZnCO_3\downarrow + Na_2SO_4$

(iii) $\underset{\text{Titration}}{2NH_4OH} + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + 2H_2O$

(b) (i) Magnesium (ii) Aluminium

(iii) Fluorine

(c) (i) At anode, oxidation or loss of e^- of Ni shall take place. At cathode, reduction or gain of e^- shall take place.

(ii) Ni^{2+}

(iii) 1. $Ni \longrightarrow Ni^{2+} + 2e^-$

LATEST ICSE SPECIMEN PAPER

Latest Specimen Paper Issued by CISCE for Class X

CHEMISTRY (Semester-I)

Maximum Marks : 40
Time allowed : One hour (inclusive of reading time)
ALL QUESTIONS ARE COMPULSORY
The marks intended for questions are given in brackets [ ]

Select the correct option for each of the following questions.

1. The trend in metallic nature of metals as we go from top to bottom in a group *[1]*
(a) increases
(b) decreases
(c) neither increases nor decreases
(d) None of the above

2. The colour change observed when the solution of magnesium hydroxide is tested with the following indicators. *[1]*
(a) Phenolphthalein turns colourless to pink
(b) Methyl orange remains orange
(c) Phenolphthalein remains colourless
(d) Blue litmus solution turns red

3. The compound which is a non-electrolyte *[1]*
(a) KCl (*aq*) (b) H_2SO_4 (dil.)
(c) CCl_4 (*l*) (d) CH_3COOH(*aq*)

4. Twice the vapour density gives *[1]*
(a) actual vapour density
(b) relative vapour density
(c) molecular mass
(d) molar volume

5. The number of lone pair of electrons in the nitrogen atom in ammonia molecule *[1]*
(a) one (b) two
(c) three (d) four

6. Elements with similar valence shell configuration in a periodic table are placed in
(a) different groups (b) same period
(c) different period (d) same group

7. The gas liberated when sodium sulphite reacts with dilute sulphuric acid *[1]*
(a) carbon dioxide (b) hydrogen
(c) hydrogen sulphide (d) sulphur dioxide

8. Thickness of metal coating during electroplating depends on *[1]*
(a) duration of current passage
(b) a low current
(c) nature of cathode
(d) purity of anode

9. Ionic bonding is seen in *[1]*
(a) methane (b) hydrogen
(c) ammonia (d) sodium oxide

10. The molecular formula of an organic compound is $C_6H_{12}O_6$ and the empirical formula is CH_2O, the value of n is *[1]*
(a) 2 (b) 6 (c) 1 (d) 12

11. When an electron is added in the valence shell *[1]*
(a) energy is released (b) energy is absorbed
(c) energy remains same (d) None of these

12. The most electronegative element is *[1]*
(a) sodium (b) aluminium
(c) bromine (d) fluorine

13. The bond in carbon tetrachloride is *[1]*
(a) single covalent bond
(b) double covalent bond
(c) ionic bond
(d) triple covalent bond

14. The type of bonding present in the nitrogen molecule *[1]*
(a) single covalent bond (b) double covalent bond
(c) polar covalent bond (d) triple covalent bond

15. A compound with empirical formula XY_2, has the vapour density equal to its empirical formula weight, its molecular formula is *[1]*
(a) X_2Y_4 (b) X_2Y_2
(c) XY (d) X_4Y_2

16. Identify one statement that does not hold true for electrorefining of copper. *[1]*
(a) Electrolyte is acidified $CuSO_4$ solution.
(b) Cathode is a thin strip of impure copper.
(c) Anode dissolves in the electrolyte.
(d) Anode gets thicker.

17. The observation when ammonium chloride reacts with potassium hydroxide. *[1]*
(a) A reddish brown gas.
(b) A colourless gas which turns moist red litmus blue.
(c) A green coloured gas which turns moist blue litmus paper red.
(d) A colourless gas which turns lime water milky.

18. The colour of the precipitate formed when ferrous ions react with ammonium hydroxide solution. *[1]*
(a) Blue (b) Reddish brown
(c) Dirty green (d) White

19. During ionisation, metals lose electrons. This change can be called *['1]*
(a) oxidation (b) reduction
(c) redox (d) displacement

20. The oxide of a metal that reacts both with acid and alkali to form salt and water *[1]*
(a) sodium oxide (b) magnesium oxide
(c) aluminium oxide (d) ferrous oxide

21. The property which decreases from left to right across the periodic table *[1]*
(a) electron affinity
(b) electronegativity
(c) ionisation energy
(d) metallic character

22. On the basis of electronic configuration the period and groiup of B_5^9 is *[1]*
(a) 2 and IIIA (b) 3 and IIA
(c) 4 and VIA (d) 5 and VIIA

23. Select the ion that would get selectively discharged from the aqueous mixture of the ions listed below *[1]*
(a) SO_4^{-2} (b) NO_3^{-1}
(c) OH^{-1} (d) Cl^{-1}

24. Hydronium ion is formed when a molecule of water combines with *[1]*
(a) hydrogen atom (b) proton
(c) Hydrogen molecule (d) oxygen atom

25. The condition that is most appropriate for electroplating with nickel *[1]*
(a) electrolyte is molten copper sulphate
(b) anode should be made of impure nickel plate
(c) alternating current is used
(d) periodic replacement of cathode is needed

26. The hydroxide which is soluble in excess ammonium hydroxide. *[1]*
(a) Lead hydroxide (b) Ferrous hydroxide
(c) Zinc hydroxide (d) Ferric hydroxide

27. Which statement is not true for electrolysis? *[1]*
(a) Cations migrate towards cathode
(b) Anions discharge at anode
(c) Anions get reduced during electrolysis
(d) Cations get reduced during electrolysis

28. H_2Y is the formula of a compound. What is the valency exhibited by Y? *[1]*
(a) 1
(b) 2
(c) 3
(d) None of the above

29. The particles which attract one another to form electrovalent compounds are *[1]*
(a) electrons (b) protons
(c) ions (d) molecules

30. Which one of the following statements is not correct? *[1]*
(a) Pure water does not allow a current to flow through it.
(b) The electrolyte only conducts when in the molten state.
(c) Electrodes that react with the electrolytes are said to be 'active'.
(d) Ions must be present in the electrolyte in order that it conducts electricity.

31. The salt formed by partial replacement of hydrogen ion of an acid by a basic radical. *[1]*
(a) Sodium sulphite
(b) Magnesium hydroxide
(c) Potassium sulphate
(d) Zinc hydrogen sulphite

32. Alkali which dissociates only partially in aqueous solution *[1]*
(a) lithium hydroxide
(b) calcium hydroxide
(c) potassium hydroxide
(d) sodium hydroxide

33. The property that matches with elements of the halogen family are *[1]*
(a) they are chemically highly reactive.
(b) they are metallic in nature.
(c) they are monoatomic in their molecular form.
(d) they have one electron in the valence shell

34. Cathode is a reducing electrode because *[1]*
(a) it has less number of electrons
(b) it has deficiency of electrons
(c) cations gain electrons from cathode
(d) anions lose electrons to cathode

35. The simplest ratio of the atoms of carbon and hydrogen is 1 : 1. Identify the possible molecular formula. *[1]*
(a) C_6H_6 (b) C_2H_4
(c) C_6H_2 (d) C_3H_4

36. The empirical formula of the compound is CH_2O, the possible molecular formula can be *[1]*
(a) $C_3H_6O_3$ (b) C_2H_4O
(c) $C_4H_3O_2$ (d) $C_4H_6O_2$

37. Observe the periodic table to answer the questions.

Group no.	1-1A	2-IIA	13-IIIA	14-IVA	15-VA	16-VIA	17-VIIA	18-0
2nd period	Li		*D*			*O*	*J*	Ne
3rd period	*A*	Mg	*E*	Si		*X*	*M*	
4th period	*R*	*T*	*G*		*Q*	*Y*		*Z*

In the above table some elemens are mentioned with their own symbol and position of the periodic table while others are shown with a letter. Answer the following questions pertaining to the same.

(i) Identify the most electronegative element
(a) Li (b) Ne
(c) Z (d) J

(ii) How many valence electrons are present in *Q* ?
(a) 3 (b) 5
(c) 15 (d) 4

(iii) The formula of the compound formed between *E* and O is
(a) *EO* (b) E_3O_2 (c) E_2O_3 (d) EO_3

(iv) The type of bond formed between A and X
(a) ionic bond (b) metallic bond
(c) covalent bond (d) coordinate bond

ANSWERS

1. (a)	2. (a)	3. (c)	4. (c)	5. (a)	6. (d)	7. (d)	8. (a)	9. (d)	10. (b)
11. (a)	12. (d)	13. (a)	14. (d)	15. (a)	16. (b, d)	17. (b)	18. (c)	19. (a)	20. (c)
21. (d)	22. (a)	23. (c)	24. (b)	25. (b)	26. (c)	27. (c)	28. (b)	29. (c)	30. (b)
31. (d)	32. (b)	33. (a)	34. (c)	35. (a)	36. (a)	37. (i) (d)	(ii) (b)	(iii) (c)	(iv) (a)

LATEST ICSE SPECIMEN PAPER

Latest Specimen Paper Issued by CISCE for Class X

CHEMISTRY (Semester-II)

Instructions

- *Answers to this paper must be written on the paper provided separately.*
- *You will not be allowed to write during the first 10 minutes.*
- *This time is to be spent in reading the question paper.*
- *The time given at the head of this paper is the time allowed for writing the answers.*
- *Attempt **All** questions from **Section A** and **any three** questions from **Section B**.*
- *The intended marks for questions or parts of questions are given in brackets [ ].*

Time : 90 min. **Max. Marks : 40**

Section A

*(Attempt **all** questions)*

1. Choose the correct answers to the questions from the given options. (Do not copy the question, write the correct answer only.) ***[10]***

(i) The IUPAC name of ethylene is
(a) propane (b) propyne
(c) ethene (d) ethyne

(ii) Carbon to carbon double bond is found in
(a) 2-butylene (b) acetaldehyde
(c) acetic acid (d) ethyl alcohol

(iii) Fused alumina is reduced to aluminium by electrolytic reduction, since
(a) alumina is highly stable
(b) alumina is least stable
(c) alumina is not reduced by drying agents
(d) alumina is not reduced by reducing agents

(iv) The catalyst preferred in the conversion of sulphur dioxide to sulphur trioxide is
(a) finely divided iron
(b) graphite
(c) vanadium pentaoxide
(d) platinum

(v) Substitution reaction is a characteristic property of
(a) alcohols (b) alkanes
(c) alkenes (d) alkynes

(vi) The gas evolved when dilute sulphuric acid reacts with iron sulphide
(a) sulphur dioxide (b) carbon dioxide
(c) hydrogen sulphide (d) nitrogen dioxide

(vii) An acid obtained from concentrated nitric acid on reaction with sulphur
(a) carbonic acid (b) sulphuric acid
(c) nitric acid (d) hydrochloric acid

(viii) The hydroxide soluble in excess of ammonium hydroxide is
(a) zinc hydroxide
(b) lead hydroxide
(c) magnesium hydroxide
(d) ferrous hydroxide

(ix) The chemical name of the principal ore of aluminium
(a) sodium aluminium fluoride
(b) aluminium oxide
(c) hydrated aluminium fluoride
(d) hydrated aluminium oxide

(x) A hydrocarbon which is a greenhouse gas.
(a) Acetylene
(b) Ethylene
(c) Ethane
(d) Methane

Section B

*(Attempt **any three** questions from this Section)*

2. (i) Define **[2]**

(a) Catenation

(b) Alloy

(ii) Name the compound formed when **[2]**

(a) Ethene reacts with hydrogen in the presence of a catalyst.

(b) Bauxite reacts with sodium hydroxide.

(iii) Draw the structural diagram of **[3]**

(a) Propanal

(b) Ethanoic acid

(c) 1,2-dichloroethane

(iv) Complete and balance the following chemical equations. **[3]**

(a) $C_2H_6 + O_2 \longrightarrow$

(b) $C_2H_2 + I_2 \longrightarrow$

(c) $NH_3 + HCl \longrightarrow$

3. (i) Identify the anion present in the following compounds. **[2]**

(a) Compound Z which on reacting with dilute sulphuric acid liberates a gas which has no effect on acidified potassium dichromate but turns lime water milky.

(b) The solution of compound *L* on reacting with freshly prepared ferrous sulphate solution followed by addition of few drops of concentrated sulphuric acid to the reactants along the sides of a test tube forms a brown ring at the junction of the two liquids.

(ii) State the following. **[2]**

(a) The drying agent used in the laboratory preparation of HCl gas.

(b) Products formed when ammonia is burnt in excess of oxygen.

(iii) State the observation for the following, when **[3]**

(a) Manganese dioxide reacts with concentrated HCl.

(b) A glass rod dipped in concentrated HCl acid is brought near ammonia gas.

(c) Concentrated sulphuric acid is added to carbon.

(iv) Write balanced equation for the following conversions. **[3]**

(a) Lead sulphate from lead nitrate and sulphuric acid.

(b) Nitrogen trichloride from ammonia.

(c) Sodium chloride from sodium sulphite and dilute hydrochloric acid.

4. (i) State the relevant reason for the following. **[2]**

(a) A layer of powered coke is used over the electrolytic mixture in Hall-Heroult's process.

(b) Graphite anodes are continuously replaced during the electrolysis of alumina.

(ii) Name the alloys for the given composition. **[2]**

(a) Magnesium and aluminium

(b) Magnesium + Manganese + Aluminium + Copper

(iii) Identify the terms for the following. **[3]**

(a) The experiment which demonstrates high solubility of ammonia gas.

(b) A method used to collect HCl gas.

(c) The electrode where reduction takes place.

(iv) Complete the table given below. **[3]**

Name of the process	Reactants	Acid product formed
(a) _____	Nitrogen dioxide + water + oxygen	(b) _____
(c) _____	Oleum + water	Sulphuric acid

5. (i) Write the balanced chemical equation to show the concentration of ore in Baeyer's process. **[2]**

(a) Sodium aluminate to aluminium hydroxide

(b) Aluminium hydroxide to alumina

(ii) Select the correct answer from the brackets to complete the following statements. **[2]**

(a) The catalyst used in the oxidation of ammonia is _____ [zinc / platinum].

(b) The product formed when ammonia reacts with oxygen is _____ [nitric oxide / nitrous oxide].

(iii) Name the following organic compound. *[3]*

(a) The compound with 3 carbon atoms whose functional group is a carboxylic acid.

(b) The first homologue whose general formula is C_nH_{2n}.

(c) The compound formed by complete chlorination of ethyne.

(iv) Answer the following questions related to the laboratory preparation of the hydrogen chloride gas. *[3]*

(a) Why is sodium chloride preferred to other metallic chlorides?

(b) State the temperature required in the preparation.

(c) Write the chemical equation.

6. (i) Distinguish between the following. *[2]*

(a) Dilute HCl and dilute HNO_3 [using silver nitrate solution]

(b) Dilute HCl and dilute H_2SO_4 [using lead nitrate solution]

(ii) Give one word for the following statements. *[2]*

(a) Naturally occurring minerals from which metals are extracted.

(b) Organic compounds having the same molecular formula but different structural formula.

(iii) *A*, *B* and C are the chemical properties of sulphuric acid. *[3]*

A. Oxidising agent

B. Dehydrating agent

C. Non-volatile acid

Match the following equations 1 to 3 to the above chemical properties of sulphuric acid.

1. $KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3$

2. $C_{12}H_{22}O_{11} \longrightarrow 12C + 11H_2O$

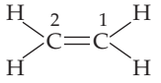
3. $S + 2\,H_2SO_4 \longrightarrow 2H_2O + 2SO_2$

(iv) Study and complete the following table. *[3]*

Homologous series	Alkane	Alkyne
General formula	C_nH_{2n+2}	1. _____
IUPAC name	2. _____	Ethyne
Common name	Marsh gas	3. _____

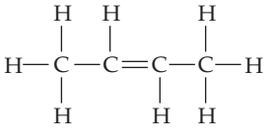
SOLUTIONS

1. (i) (*c*) **Ethylene**



IUPAC name : Ethene

(ii) (*a*) **2-butylene**



(iii) (*d*) Fused alumina is highly stable. It has very high enthalpy of formation.

Therefore, reducing agents cannot be used to reduce it to aluminium.

Hence, it is reduced by electrolytic reduction only.

(iv) (*c*) Vanadium pentaoxide is preferred as a catalyst in the conversion of sulphur dioxide to sulphur trioxide.

$$2\,SO_2 + O_2 \xrightarrow{V_2O_5} 2\,SO_3$$

(v) (*b*) Substitution reaction is a characteristic property of alkanes. The H-atom of alkanes is substituted by some other atom.

(vi) (c) Dilute sulphuric acid reacts with iron sulphide to produce hydrogen sulphide gas.

$$\underset{\text{Iron sulphide}}{FeS} + \underset{\text{Sulphuric acid (dil.)}}{H_2SO_4} \longrightarrow \underset{\text{Ferrous sulphate}}{FeSO_4} + \underset{\text{Hydrogen sulphide}}{H_2S\uparrow}$$

(vii) (*b*) Sulphur is oxidised to sulphuric acid when treated with concentrated nitric acid.

$$\underset{\text{Sulphur}}{S} + \underset{\substack{\text{Nitric acid}\\\text{(conc. hot)}}}{6HNO_3} \longrightarrow \underset{\text{Sulphuric acid}}{H_2SO_4} + \underset{\text{Nitrogen dioxide}}{6NO_2} + \underset{\text{Water}}{2H_2O}$$

(viii) (*a*) Zinc hydroxide [$Zn(OH)_2$] is soluble in excess of ammonium hydroxide.

$$\underset{\text{Zinc hydroxide}}{Zn(OH)_2} + \underset{\substack{\text{Hydroxide ion}\\\text{(from ammonium hydroxide)}}}{2OH^-} \longrightarrow \underset{\substack{\text{Zinc}\\\text{hydroxide ion}}}{Zn(OH)_4^{2-}}$$

(ix) (*d*) Hydrate aluminium oxide is the chemical name of the principal ore of aluminium. It is commonly known as bauxite having chemical formula $Al_2O_3 \cdot 2H_2O$.

(x) (*d*) Methane is a greenhouse gas which affects the temperature of earth and climate system. It produces greenhouse effect.

2. (i) (a) **Catenation** The property of self-linking of atoms of an element through covalent bonds to form long chains is called catenation.

(b) **Alloy** An alloy is a homogeneous mixture of two or more metals or of one or more metals with certain non-metallic elements.

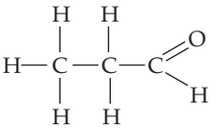
(ii) (a) Ethene reacts with hydrogen in presence of catalysts such as platinum or palladium at ordinary temperature or nickel at 200°C to form ethane.

$$\underset{\text{Ethene}}{C_2H_4} + H_2 \xrightarrow{Pt} \underset{\text{Ethane}}{C_2H_6}$$

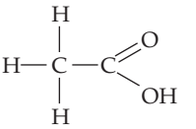
(b) Bauxite reacts with sodium hydroxide to forms sodium meta-aluminate due to amphoteric nature of aluminium.

$$\underset{\text{Bauxite}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\substack{\text{Sodium}\\\text{meta-aluminate}}}{2NaAlO_2} + \underset{\text{Water}}{2H_2O}$$

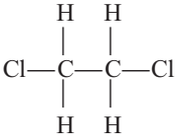
(iii) (a) Propanal :



(b) Ethanoic acid :

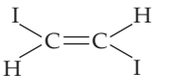


(c) 1, 2-dichloroethane :

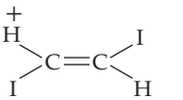


(iv) (a) $\underset{\text{Ethane}}{2C_2H_6} + \underset{\text{Oxygen}}{7O_2} \longrightarrow \underset{\text{Carbon dioxide}}{4CO_2} + \underset{\text{Water}}{6H_2O}$

(b) $\underset{\text{Ethyne}}{C_2H_2} + \underset{\text{Iodine}}{I_2} \longrightarrow$



trans-1, 2-di-iodoethene



cis-1, 2-di-iodoethene

(c) $\underset{\text{Ammonia}}{NH_3} + \underset{\text{Hydrochloric acid}}{HCl} \longrightarrow \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl}$

3. (i) (a) Compound *Z* is Na_2CO_3.

The gas liberated is carbon dioxide (CO_2).

$$\underset{\substack{\text{Sodium}\\\text{carbonate}}}{Na_2CO_3} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{H_2SO_4} \longrightarrow \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2\uparrow} + \underset{\text{Water}}{H_2O}$$

Anion → Carbonate (CO_3^{2-})

(b) Compound *L* is NO_3^- (Anion).

Freshly prepared $FeSO_4$ solution is added to the aqueous solution of NO_3 followed by addition of conc. H_2SO_4 results in the formation of a complex $[Fe(H_2O)_3NO]^+$ which appears as brown right at the function.

(ii) (a) Concentrated sulphuric acid is used as a drying agent for purifying hydrogen chloride gas in its laboratory preparation.

(b) When ammonia is burnt in excess of oxygen, nitric oxide and water is produced.

$$\underset{\text{Ammonia}}{4NH_3} + \underset{\text{Oxygen}}{5O_2} \xrightarrow[\Delta]{Pt} \underset{\text{Nitric oxide}}{4NO} + \underset{\text{Water}}{6H_2O}$$

(iii) (a) Black coloured manganese dioxide reacts with conc. HCl to given light brown coloured $MnCl_2$ with the evolution of greenish yellow chlorine gas.

$$\underset{\substack{\text{Manganese}\\\text{dioxide (black)}}}{MnO_2} + \underset{\substack{\text{Hydrochloric}\\\text{acid}}}{4HCl} \xrightarrow{\Delta} \underset{\substack{\text{Manganese}\\\text{chloride}\\\text{(light brown)}}}{MnCl_2} + \underset{\text{Water}}{2H_2O} + \underset{\substack{\text{(Chlorine)}\\\text{(greenish yellow)}}}{Cl_2}$$

(b) When a glass rod dipped in concentrated HCl acid brought near ammonia gas, a dense white fumes of ammonium chloride is observed.

$$\underset{\text{Ammonia}}{NH_3} + \underset{\substack{\text{Hydrochloric}\\\text{acid}}}{HCl} \longrightarrow \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl}$$

(c) Concentrated sulphuric acid reacts with carbon to form colourless carbon dioxide and sulphur dioxide gas.

$$\underset{\text{Carbon}}{C} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{2H_2SO_4} \xrightarrow{\Delta} \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{2SO_2} + \underset{\text{Water}}{2H_2O}$$

(iv) (a) Lead nitrate reacts with sulphuric acid to form white precipitate of lead sulphate and nitric acid.

$$\underset{\text{Lead nitrate}}{Pb(NO_3)_2} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{H_2SO_4} \longrightarrow \underset{\substack{\text{Lead}\\\text{sulphate}}}{PbSO_4}\downarrow + \underset{\text{Nitric acid}}{2HNO_3}$$

(b) Ammonia reacts with chlorine to form nitrogen trichloride.

$$\underset{\text{Ammonia}}{NH_3} + \underset{\text{Chlorine}}{3Cl_2} \longrightarrow \underset{\substack{\text{Hydrochloric}\\\text{acid}}}{3HCl} + \underset{\substack{\text{Nitrogen}\\\text{trichloride}}}{NCl_3}$$

(c) Sodium sulphite and dilute hydrochloric acid combines to form sodium chloride, sulphur dioxide and water.

$$\underset{\substack{\text{Hydrochloric}\\\text{acid}}}{2HCl} + \underset{\substack{\text{Sodium}\\\text{sulphite}}}{Na_2SO_3} \longrightarrow \underset{\substack{\text{Sodium}\\\text{chloride}}}{2NaCl} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{SO_2} + \underset{\text{Water}}{H_2O}$$

4. (i) (a) A layer of powdered coke is sprinkled over the surface of the electrolytic mixture in Hall-Heroult's process because

- it reduces heat loss by radiation.
- it prevents the burning of anode.

(b) The graphite anode is continuously replaced time to time during the electrolysis of alumina, as it gets oxidised by the oxygen evolved at the anode.

(ii) (a) Magnalium alloy consist of aluminium (90-95%) and magnesium (10-5%). It is light and strong as well as resist corrosion.

(b) Duralumin is an alloy which consist of 95% aluminium, 4% copper, 0.5%, magnesium and 0.5% manganese. It is highly ductile.

(iii) (a) High solubility of ammonia gas is demonstrated by fountain experiment.

(b) HCl gas is collected by upward displacement of air as it is 1.28 times heavier than air.

(c) The cathode is the electrode where reduction takes place.

(iv) (a) Ostwald process (b) Nitric acid

(c) Contact process

5. (i) (a) Sodium aluminate reacts with water to form sodium hydroxide and aluminium hydroxide.

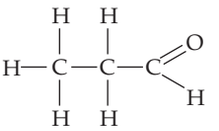
$$\underset{\substack{\text{Sodium}\\\text{aluminate}}}{NaAlO_2} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\substack{\text{Sodium}\\\text{hydroxide}}}{NaOH} + \underset{\substack{\text{Aluminium}\\\text{hydroxide}}}{Al(OH)_3}\downarrow$$

(b) The precipitate of aluminium hydroxide is filtered, washed, dried and ignited at 1000°C to get alumina (Al_2O_3).

$$2Al(OH)_3 \xrightarrow[1000°C]{\text{Heat}} \underset{\text{Alumina}}{Al_2O_3} + 3H_2O$$

(ii) (a) platinum (b) nitric oxide

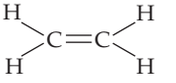
(iii) (a)



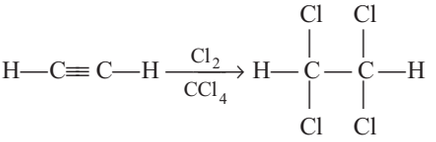
Propanoic acid

(b) Ethene, C_nH_{2n}

$n = 2$ C_2H_4



(c) Complete chlorination of ethyne gives 1, 1, 2, 2-tetrachloroethane.



(iv) (a) Sodium chloride is cheap and therefore, it is preferred for preparation of HCl over other metal chlorides.

(b) The reaction can occur upto the stage of formation of sodium sulphate on heating above 200°C.

(c) $\underset{\text{Sodium chloride}}{2NaCl} + \underset{\text{Sulphuric acid (conc.)}}{H_2SO_4} \xrightarrow[200°C]{\text{Above}} \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Hydrochloric acid}}{2HCl}$

6. (i) (a) Using silver nitrate solution dilute HCl and dilute HNO_3 can be distinguished as follows

Dil. HCl	Dil. HCl
It forms a thick curdy white precipitate of silver chloride.	It does not reacts with silver nitrate solution.
$\underset{\text{Hydrochloric acid}}{HCl} + \underset{\text{Silver nitrate}}{AgNO_3} \longrightarrow \underset{\text{Silver chloride}}{AgCl} + \underset{\text{Nitric acid}}{HNO_3}$	$\underset{\text{Nitric acid}}{HNO_3} + \underset{\text{Silver nitrate}}{AgNO_3} \longrightarrow$ No reaction

(b) Using lead nitrate solution dilute HCl and dilute H_2SO_4 can be distinguished as follows

Dil. HCl	Dil. H_2SO_4
It forms precipitate of $PbCl_2$ which redissolves on heating.	It forms white precipitate of $PbSO_4$ which remains insoluble even on heating.
$\underset{\text{Lead nitrate}}{Pb(NO_3)_2} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Lead chloride}}{PbCl_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Nitrogen dioxide}}{NO_2}$	$\underset{\text{Lead nitrate}}{Pb(NO_3)_2} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Lead sulphate}}{PbSO_4}\downarrow + \underset{\text{Water}}{H_2O} + \underset{\text{Nitrogen dioxide}}{NO_2}$

(ii) (a) Ores are the naturally occurring minerals from which metals are extracted.

(b) Isomers are the organic compounds having the same molecular formula but different structural formula.

(iii) A → (3), B → (2), C → (1)

A. **Oxidising agent**

$$\underset{\text{Sulphur}}{S} + \underset{\text{Sulphuric acid}}{2H_2SO_4} \longrightarrow \underset{\text{Water}}{2H_2O} + \underset{\text{Sulphur dioxide}}{2SO_2}\uparrow$$

In the given equation, sulphuric acid acts as an oxidising agent as sulphur is getting oxidised by H_2SO_4.

B. **Dehydrating agent**

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} \xrightarrow{H_2SO_4} \underset{\text{Carbon}}{12C} + \underset{\text{Water}}{11H_2O}$$

In this equation, sulphuric acid is acting as dehydrating agent as it removes water from the sugar compound.

C. **Non-volatile acid**

$$\underset{\text{Potassium nitrate}}{KNO_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Potassium hydrogen sulphate}}{KHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$$

Here, sulphuric acid acts as non-volatile due to which it is used to prepare volatile acids like HNO_3.

(iv) 1. C_nH_{2n} 2. Methane 3. Acetylene

ICSE EXAMINATION PAPER 2021-22

CHEMISTRY (Semester-I)

Maximum Marks : 40
Time allowed : One hour
You will not be allowed to write during the first 10 minutes.
This time is to be spent in reading the question paper.
ALL QUESTIONS ARE COMPULSORY
The intended marks for questions or part of questions are given in brackets [ ]

Select the correct option for each of the following questions.

1. In a periodic table, the element of period 3 are arranged in the increasing order of ionisation potential as *[1]*
(a) B, N,Cl, Ar (b) Mg, Si, S, Ar
(c) Ar, Si, S, Mg (d) Si, Ar, Cl, Mg

2. If relative molecular mass of butane (C_4H_{10}) is 58 then its vapour density will be *[1]*
(a) 58 (b) 29 (c) 32 (d) 16

3. Identify one statement that holds true for electrolysis of molten lead bromide. *[1]*
(a) Silver grey metal deposits at the anode.
(b) Temperature is not maintained during electrolysis.
(c) Brown vapours of bromine are obtained at the anode.
(d) Electrolyte contains H^+ ions along with Pb^{2+} ions.

4. The tendency of an atom to attract shared pair of electrons to itself when forming a chemical bond is known as *[1[*
(a) electron affinity (b) electronegativity
(c) ionisation potential (d) nuclear charge

5. Solid sodium chloride does not conduct electricity as *[1]*
(a) the strength of the bond is weak
(b) it contains free ions
(c) it does not contain any free ion
(d) it contains free ions as well as molecules

6. Elements *A* and *B* have electronic configurations 8 and 13 respectively. The chemical formula formed between *A* and *B* will be *[1]*
(a) *AB* (b) B_3A_3
(c) A_2B_3 (d) B_2A_3

7. The percentage of hydrogen present in NaOH is (Relative molecular mass of NaOH = 40) (At. wt. of H = 1). *[1]*
(a) 2.5 (b) 25 (c) 0.25 (d) 0.025

8. A salt formed by incomplete neutralisation of an acid by a base *[1]*
(a) basic salt (b) acid salt
(c) normal salt (d) complex salt

9. The colour of the precipitate formed after the addition of a small amount of sodium hydroxide solution to an aqueous solution of ferric chloride is *[1]*
(a) gelatinous white (b) pale blue
(c) reddish brown (d) dirty green

10. Alkaline earth metals have the same *[1]*
(a) number of valence electrons
(b) number of shells
(c) metallic property
(d) ionisation potential

11. Which of the following compounds neither dissociate nor ionise in water? *[1]*
(a) Hydrochloric acid (b) Sodium hydroxide
(c) Potassium nitrite (d) Carbon tetrachloride

12. The table shows the electronic configuration of four elements. *[1]*

Element	Electronic configuration
W	2, 6
X	2, 8
Y	2, 8, 1
Z	2, 8, 7

Which pair of atoms will form a covalent compound?
(a) Two atoms of W
(b) Two atoms of *X*
(c) An atom of *W* and atom of *X*
(d) An atom of *Y* and an atom of *Z*

13. Element with an atomic number 19 will *[1]*
(a) accept an electron and get oxidised
(b) accept an electron and get reduced
(c) lose an electron and get oxidised
(d) lose an electron and get reduced

14. Which of the following has two sets of lone pair of electron in them? *[1]*
(a) Ammonia (b) Methane
(c) Water (d) Ammonium ion

15. If the empirical mass of the formula PQ_2 is 10 and the relative molecular mass is 30, then the molecular formula will be *[1]*
(a) PQ_2 (b) P_3Q_2
(c) P_6Q_3 (d) P_3Q_6

16. Which of the following is a tribasic acid? *[1]*
(a) H_2SO_4 (b) $Al(OH)_3$
(c) H_3PO_4 (d) $Ca(OH)_2$

17. If a solution of an electrolytic mixture has calcium ions, cupric ions, zinc ions and magnesium ions. Which of these ions would you see preferentially discharged at the cathode? *[1]*
(a) Calcium ions
(b) Zinc ions
(c) Cupric ions
(d) Magnesium ions

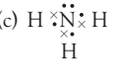
18. Which of the following ions will readily discharge at the anode during the electrolysis of acidulated water? *[1]*
(a) OH^- (b) SO_4^{2-}
(c) Cl^- (d) H^+

19. If the empirical formula of a compound is CH and its vapour density is 13, then its molecular formula will be (At. wt. C = 12, H = 1) *[1]*
(a) CH (b) C_2H_2
(c) C_4H_4 (d) C_3H_3

20. Aqueous solution of cupric chloride forms a deep blue solution on addition of *[1]*
(a) dropwise sodium hydroxide
(b) excess sodium hydroxide
(c) dropwise ammonium hydroxide
(d) excess ammonium hydroxide

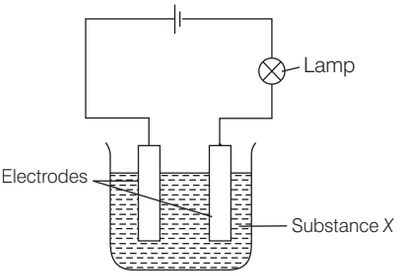
21. Which statement about conduction of electricity is correct? *[1]*
(a) Electricity is conducted in aqueous solution by electrons.
(b) Electricity is conducted in a metal wire by ions.
(c) Electricity is conducted in a molten electrolyte by electrons.
(d) Electricity is conducted in an acid solution by ions.

22. If an element has low ionisation potential, then it is likely to be a *[1]*
(a) metal (b) metalloid
(c) non-metal (d) inert gas

23. Which electron arrangement for the outer shell electrons in a covalent compound is correct? *[1]*
(a) (b)
(c)  (d)

24. The products formed when an acid reacts with a base is *[1]*
(a) salt and hydrogen (b) salt and oxygen
(c) salt and water (d) salt and carbon dioxide

25. In a circuit below, the lamp lights up



What could *X* be ? *[1]*
(a) A solution of alcohol and water
(b) A solution of sodium chloride in water
(c) Sugar solution
(d) Solid potassium chloride

26. Which one of the following is a non-metallic cation? *[1]*
(a) K^+ (b) NH_4^+
(c) Cu^{2+} (d) Na^+

27. Type of bonding present in hydrogen chloride. *[1]*
(a) metallic (b) ionic
(c) covalent (d) coordinate

28. The non-metallic properties of elements from left to right in a periodic table *[1]*
(a) increases
(b) decreases
(c) remains same
(d) first increases and then decreases

29. The aqueous solution that contains both ions and molecules *[1]*
(a) sulphuric acid (b) nitric acid
(c) acetic acid (d) hydrochloric acid

30. The basic oxide which is an alkali *[1]*
(a) copper oxide (b) sodium oxide
(c) ferric oxide (d) zinc oxide

31. If the pH of a solution is '2', then the solution is a *[1]*
(a) strong acid (b) strong alkali
(c) weak acid (d) weak alkali

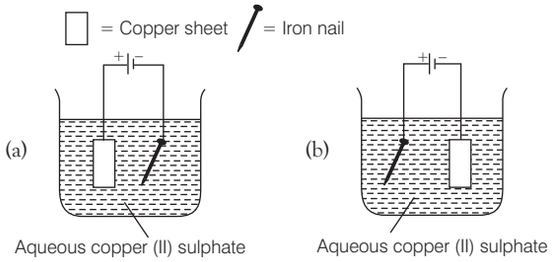
32. The acidity of aluminium hydroxide is *[1]*
(a) 3 (b) 1
(c) 4 (d) 2

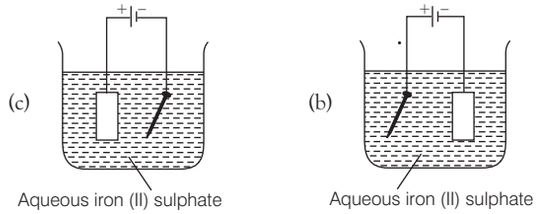
33. Hydracids are those acids which contain *[1]*
(a) hydrogen with any meal
(b) hydrogen, a non-metal and oxygen
(c) hydrogen and a non-metal other than oxygen
(d) hydrogen and oxygen only

34. The oxidation reaction among the following is *[1]*
(a) $Fe^{3+} + 3e^- \longrightarrow Fe$ (b) $Fe^{2+} - 1e^- \longrightarrow Fe^{3+}$
(c) $Cl_2 + 2e^- \longrightarrow 2Cl^{1-}$ (d) $Cu^{2+} + 2e^- \longrightarrow Cu$

35. A student added excess of sodium hydroxide solution to each of the salt solution. An insoluble precipitate formed was observed in *[1]*
(a) calcium nitrate (b) zinc nitrate
(c) lead nitrate (d) sodium nitrate

36. Which apparatus could electroplate and iron nail with copper?





37. The table below shows the electronic arrangements of six atoms, *A* to *F*.

Atom	*A*	*B*	*C*	*D*	*E*	*F*
Electronic configuration	2, 5	2	2, 6	2, 8, 6	2, 8, 8	2, 8, 3

With respect to the table select the following.
(i) Two atoms from the same group of the periodic table *[1]*
(a) *D* and *E* (b) C and *D*
(c) *E* and *F* (d) C and *E*
(ii) Two noble gases *[1]*
(a) *A* and *B* (b) *E* and *F*
(c) *B* and *E* (d) *D* and *E*
(iii) The atom which is the most electronegative *[1]*
(a) *A* (b) *B*
(c) C (d) *F*
(iv) The atom which has the highest ionisation potential
(a) *A* (b) *B* *[1]*
(c) *E* (d) *F*

ANSWERS

1. *(b)*	**2.** *(b)*	**3.** *(c)*	**4.** *(b)*	**5.** *(c)*	**6.** *(d)*	**7.** *(a)*	**8.** *(b)*	**9.** *(c)*	**10.** *(a)*
11. *(d)*	**12.** *(a)*	**13.** *(c)*	**14.** *(c)*	**15.** *(d)*	**16.** *(c)*	**17.** *(c)*	**18.** *(a)*	**19.** *(b)*	**20.** *(d)*
21. *(d)*	**22.** *(a)*	**23.** *(c)*	**24.** *(c)*	**25.** *(b)*	**26.** *(b)*	**27.** *(c)*	**28.** *(a)*	**29.** *(c)*	**30.** *(b)*
31. *(a)*	**32.** *(a)*	**33.** *(c)*	**34.** *(b)*	**35.** *(a)*	**36.** *(a)*	**37.** *(i) (b)*	*(ii) (c)*	*(iii) (c)*	*(iv) (c)*