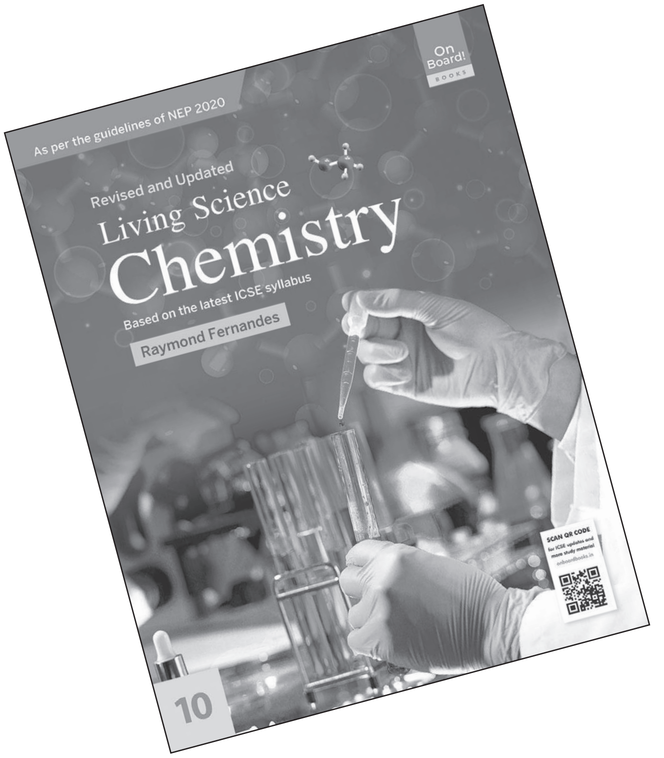
TEACHER'S HANDBOOK

ICSE Living Science
CHEMISTRY
Book 10



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Contents

CHAPTER – 1
THE PERIODIC CLASSIFICATION AND PERIODIC PROPERTIES OF ELEMENTS

P. 10 CHECK YOUR PROGRESS 1

1. **a.** Sixth
   b. 30
   c. electrons
   d. group
2. **a.** 2
   b. Representative or Normal elements
   c. Groups
   d. Periods
   e. i. 7 elements
   ii. 18 elements
3. **a.** There are 2 elements in period 1 and 8 elements each in period 2 and period 3 of the periodic table.
   b. Group 6
   c. Common feature of the electronic configurations of the elements at the end of period 2 and period 3 is that both have their octet complete or have 8e$^-$ in outermost shell.
   Period 2 → Ne (10) → 2, 8
   Period 3 → Ar (18) → 2, 8, 8

P. 16 CHECK YOUR PROGRESS 2

1. **a.** period, non-metallic
   b. more
   c. number of outer electrons
2. **a.** Li > Be > B > C > N > O > F (increasing order of atomic size)
   b. Be > Mg > Ca > Sr > Ba (increasing order of metallic character)
   c. I < Br < Cl < F (increasing order of electronegativity)
   d. F > S > Si > Al > Mg (increasing order of ionization energy)
3. **a.** iv, **b.** ii, **c.** i, **d.** ii, **e.** ii
4. **a.** The metallic character depends upon atomic size and ionization potential. As we move along a period from left to right, the effective nuclear charge increases, thus decreasing the atomic radius. This favours the increase in electronegativity and therefore the tendency to lose electrons is low. This accounts for the decrease in the metallic character along a period.
   b. Noble gases have zero electron affinity as they do not accept electrons due to their fully filled valence shells. Electron affinity is highest for halogens while it is least for alkali metals.
   c. As we move down a group, the number of shells goes on increasing, and therefore, the atomic size increases. Therefore, the electronegativity decreases.
   d. Along a period, the effective nuclear charge increases. This is due to the fact that the number of electrons increases (in the same shell) along with the increase in the number of protons in the nucleus. The nucleus thus pulls the valence shell of electrons in the atom towards it, thereby bringing the valence shell closer to the nucleus, and thus decreasing the atomic radius.

   As we move down a group, the number of shells goes on increasing along with the number of electrons, and subsequently, the number of protons (or nuclear charge) also increases. But the increase in the number of shells outweighs the increased nuclear charge. Therefore, due to the increase in the number of shells down the group, the distance of the outermost shell from the nucleus increases, and hence, the atomic radius (or size) increases.
   e. As we move down a group, the number of shells increases and so does the atomic size. As the distance from the nucleus to the outermost electrons increases, the attraction between them lessens, which makes the electron easier to be removed. Thus, less energy is required to remove electrons from the valence shell. As a result the ionization potential decreases down a group. Therefore, lithium (Li) has the highest ionization potential while caesium (Cs) has the least ionization potential in the first group.
5. **a.** True
   b. True
   c. True
   d. True
   e. True
6. **a.** Element B is more non-metallic as the non-metallic character decreases down the group.
   b. Element C, as it belongs to 16th group with six valence electrons and –2 valency.

- **c.** Element E has highest ionization potential.
- **d.** Element D of 17th group, with 7 valence electrons.
- **e.** Element F is bigger than A as the atomic size increases down the group.
- **f.** Element E has zero electron affinity as it has a stable electronic configuration.

P. 18 CHECK YOUR PROGRESS 3

1. **a.** largest

b. Francium

c. decrease

2. **a.** Group 17 elements need one electron to complete their octet while group 1 elements lose one electron to complete their octet.

b. Halogens have seven electrons in their outermost shell. These elements, therefore, have a tendency to accept an electron and form negatively charged ion. So, halogens have high electron affinity.

c. The metallic character depends on atomic size. So, larger the atomic size, more metallic is the element. Larger the atomic size, easier it is for the element to lose its electrons, so more metallic is the element.

P. 20–21 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. c **2.** a **3.** d **4.** b **5.** c
6. a **7.** b **8.** a **9.** d **10.** c
11. a **12.** a **13.** a **14.** a **15.** a
16. b 17. a **18.** a **19.** d **20.** b

B. Fill in the blanks

1. atomic number
2. groups, periods
3. non-metallic, atomic size
4. metallic, electron affinity
5. lose, gain
6. electronegativity, atomic size
7. 3, 13
8. non-metallic, metallic
9. ionization potential, increases
10. decrease, increase

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Alkali
2. Halogens
3. Valence electrons
4. Ionization potential
5. Electronegativity
6. Electron affinity
7. Nuclear charge
8. Cation
9. Anion
10. Modern Periodic Law

B. Give one example/member for each of the following.

1. Ionization potential
2. Electron affinity
3. Ionization potential or electron affinity
4. Magnesium
5. Nitrogen or phosphorus

C. Match the following.

1. e **2.** d **3.** c **4.** b **5.** a

D. Match the given word(s) with its appropriate description.

1. b **2.** e **3.** d **4.** c **5.** a

E. Name each of the following.

1. Hydrogen
2. Any noble gas, like neon, argon, helium
3. Helium
4. Fluorine
5. Aluminium

F. Choose the odd one out.

1. Hydrogen, as rest are halogens,
2. Calcium, as rest belong to alkali group,
3. Sodium, as rest are inert gases
4. atomic size, as rest follow a general trend opposite to atomic size.
5. Sulphur, as rest are from the second period.

G. Identify the element for each of the following statements.

	Statement	Element
1.	The most non-metallic element	Fluorine
2.	The most electronegative element	Fluorine
3.	The most electropositive element	Hydrogen
4.	The element with only 2 electrons	Helium
5.	The lightest metal	Lithium
6.	An element with Latin name and symbol Na	Sodium

7.	An element with Latin name and symbol K	Potassium
8.	The first element of the periodic table	Hydrogen
9.	An element with zero neutron	Hydrogen
10.	An element having twice the atomic number as atomic mass	Carbon, nitrogen, oxygen, helium, argon, neon

III. Short Answer Type Questions

A. Give reasons for the following.

1. Ionization potential depends inversely on atomic size and directly on nuclear charge. The atomic size increases down the group due to the addition of a shell and there is an increase in the number of protons in the nucleus. Therefore, less energy is required to draw an electron from its shell. So, ionization potential decreases down the group.

   Across the period, ionization potential increases, because on moving across the period, the nuclear charge increases and atomic size decreases. This makes it difficult to remove electrons from the valence shell.

2. Electron affinity like ionization potential depends inversely on atomic size and directly on nuclear charge. We know, the atomic size increases down the group due to the addition of a shell, and nuclear charge also increases due to increased number of protons and neutrons in the nucleus. However, the increased nuclear charge becomes less effective due to increase in atomic size. Therefore, down the group electron affinity decreases.

   Across the period, electron affinity increases as on moving from left to right in a period, the atomic size decreases and nuclear charge increases. Smaller the atomic radius, greater is the tendency of the atom to attract electrons. This increases the electron affinity along a period.

3. Atomic size and nuclear charge affect the electronegativity. With an increase in nuclear charge across the period, the attraction for electrons increases. Also, the decrease in atomic size further increases the power of the nuclear pull. Thus, electronegativity increases across the period.

4. Metallic character depends on low ionization potential, low electron affinity and low electronegativity. Thus, while moving down the group electron affinity, ionization potential and electronegativity decrease leading to increase in metallic character. Vice-versa happens for non-metallic character.

5. Noble gases have their octet complete, thus have attained stable electronic configuration. Hence, they cannot accept electrons.

B. Differentiate between the following pairs by giving at least one difference.

1.	**Ionization potential**	**Electron affinity**
	Energy required to remove an electron from valence shell of an isolated gaseous atom in its ground state to form a gaseous positive ion.	Energy released when an electron is added to the valence shell of an isolated gaseous atom to form gaseous negative ion.
2.	**Atomic number**	**Mass number**
	It is the number of protons present in the nucleus of an atom.	Sum of protons and neutrons present in the nucleus of an atom.
3.	**Period**	**Group**
	The seven horizontal rows in the Modern Periodic Table are periods.	The eighteen vertical columns in the Modern Periodic Table are groups.
4.	**Halogens**	**Alkali metals**
	a. The members of Group 17 – fluorine, chlorine, bromine, iodine, astatine and tennessine. **b.** Have 7 valence electrons.	**a.** The members of Group 1 – hydrogen, lithium, sodium, potassium, rubidium, caesium and Francium. **b.** Have 1 electron in their valence shell.
5.	**Metals**	**Non-metals**
	a. Low ionization potential, low electron affinity and low electronegativity. **b.** Have 1, 2 or 3 valence electrons. **c.** Form cation by losing electron.	High ionization potential, high electron affinity and high electronegativity. Have 4, 5, 6, or 7 valence electrons. Form anion by gaining electron.

C. Complete the following table.

S. No	Element name	Element symbol	Atomic number	Mass Number	Electrons	Electronic configuration
1.	Lithium	Li	3	6.94	3	2, 1
2.	Boron	B	5	10.81	5	2, 3
3.	Chlorine	Cl	17	35.45	17	2, 8, 7
4.	Argon	Ar	18	39.95	18	2, 8, 8
5.	Calcium	Ca	20	40.07	20	2, 8, 8, 2

D. Problems/Calculations-based Questions.

We know

Atomic number Z = number of protons

And number of protons = number of electrons

Therefore, Z = number of protons = number of electrons

Also, Mass number A = number of protons + number of neutrons

Or Mass number A = number of electrons + number of neutrons

Or Mass number A = atomic number + number of neutrons

1. Atomic number or Z = 10 = number of protons = number of electrons = 10

   Electronic configuration 10 = 2, 8; valency: 0

   Position: second period and group 18

   It is an inert gas, Neon.
2. Atomic number or Z = 13 = number of protons = number of electrons = 13

   Electronic configuration 13 = 2, 8, 3; valency: 3

   Position: third period and group 13

   It is a metal, Aluminium.
3. Atomic number or Z = 15 = number of protons = number of electrons = 15

   Mass number = $p + n = 15 + 16 = 31$

   Electronic configuration 15 = 2, 8, 5; valency: –3, +5

   Position: third period and group 15

   It is a non-metal, Phosphorus.
4. Atomic number or Z = 11 = number of protons = number of electrons = 11

   Mass number = $p + n = 11 + 12 = 23$

   Electronic configuration 11 = 2, 8, 1; valency: 1

   Position: third period and group 1

   It is a metal, Sodium.
5. Atomic number or Z = 16 = number of protons = number of electrons = 16

   Mass number = $p + n = 16 + 16 = 32$

   Electronic configuration 15 = 2, 8, 6; valency: –2 +6

   Position: third period and group 16

   It is a non-metal, Sulphur.

E. Define each of the following.

1. Ionization potential: The amount of energy required to remove an electron from an isolated gaseous atom in its ground state to form a gaseous positive ion.
2. Electron affinity: The amount of energy released when an isolated gaseous atom accepts an electron to form gaseous negative ion.
3. Electronegativity: It is the tendency of an atom in a molecule to attract the shared pair of electrons towards itself when combined in a compound.
4. The repetition of similar properties of elements after regular intervals of atomic number is called periodicity of elements.

F. Explain why.

1. As ionization potential decreases down the group, the power of losing electron increases. Hence, reducing power increases.
2. Metals have low ionization potential, so they easily lose electron(s) and get oxidized. On the other hand, non-metals have high ionization potential and high electron affinity; therefore, they gain electron(s) and get reduced. Thus, metals are reducing agents and non-metals are oxidizing agents.

G. Answer the following questions.

1. First period is the shortest period with two elements - Hydrogen and Helium.
2. We know that as we move down the group, atomic size increases and across the period atomic size decreases. Therefore, the atomic size of calcium is bigger than magnesium as it is below magnesium in the third period. Aluminium has smaller size than magnesium as it occupies next group in the same period.
3. The noble gases or group 18 members have zero electron affinity as they have stable electronic configuration.
4. Some elements of groups 1, 2, and 13, 14 show diagonal relation with third period elements. This happens because of certain similarities in properties like atomic size and electronegativity. Example – Lithium and magnesium, beryllium and aluminium, boron and silicon.
5. Electron volt (eV) is the measuring unit for ionization potential and electron affinity.

IV. Knowledge-based Questions

1. Modern Periodic Law states that the properties of the elements are the periodic function of their atomic numbers.

   Characteristics of the Modern Periodic Table:

   a. It has 7 horizontal rows as periods and 18 vertical columns as groups.

   b. Groups 1, 2, and 13–17 elements are called normal elements or representative elements. Group 3–12 are transition elements.

   c. There are 2 elements in the first period, 8 elements in the second and third periods, 18 each in fourth and fifth periods, and 32 elements in the sixth and seventh periods.

d. Group 1 elements are known as alkali metals. Group 2 elements are called alkaline earth metals. Elements belonging to group 17 are called halogens and those in group 18 are known as noble gases.

2. First twenty elements

S. No	Elemen name with symbol	Atomic number = p = e	Electronic configuration
1.	Hydrogen, H	1	1
2.	Helium, He	2	2
3.	Lithium, Li	3	2, 1
4.	Beryllium, Be	4	2, 2
5.	Boron, B	5	2, 3
6.	Carbon, C	6	2, 4
7.	Nitrogen, N	7	2, 5
8.	Oxygen, O	8	2, 6
9.	Fluorine, F	9	2, 7
10.	Neon, Ne	10	2, 8
11.	Sodium, Na	11	2, 8, 1
12.	Magnesium, Mg	12	2, 8, 2
13.	Aluminium, Al	13	2, 8, 3
14.	Silicon, Si	14	2, 8, 4
15.	Phosphorus, P	15	2, 8, 5
16.	Sulphur, S	16	2, 8, 6
17.	Chlorine, Cl	17	2, 8, 7
18.	Argon, Ar	18	2, 8, 8
19.	Potassium, K	19	2, 8, 8, 1
20.	Calcium, Ca	20	2, 8, 8, 2

3. Nuclear charge: It is the total positive charge on the nucleus of an atom. It is equal to the number of protons present within the nucleus of an atom.

Nuclear charge increases with a decrease in atomic size.

Nuclear charge increases across the period and it increases down the group also, but down the group, its pull is overcome by the increase in atomic size.

Both nuclear charge and atomic size are the main factors that affect the periodicity or trend of properties like atomic size, ionization potential, electron affinity, electronegativity, metallic and non-metallic character.

4. Group 1 or alkali metals: Lithium, sodium, potassium, rubidium, caesium, francium, are univalent (positive), highly reactive, and highly electropositive. They have low ionization potential, low electron affinity and very low electronegativity. The members are light and soft metals, good conductors and strong reducing agents.

Group 17 or halogens: Fluorine, chlorine, bromine, iodine, astatine, and tennessine are univalent (negative) and highly reactive. They have high ionization potential, high electron affinity and are highly electronegative, non-metals, bad conductors and strong oxidizing agents.

5. Trends in the periodic properties:

a. Atomic size decreases across the period (left to right).

b. Nuclear charge, atomic density, ionization potential, electron affinity, electronegativity, and non-metallic character increase across the period (left to right).

c. Atomic size, atomic radii, atomic volume, and metallic character increase down the group.

d. Ionization potential, electron affinity, electronegativity, and non-metallic character decrease down the group.

V. Application and Skill-based Questions

Element	A	B	C	D	E	F
Atomic number	3	5	2	11	19	14
Electronic configuration	2, 1	2, 3	2	2, 8, 1	2, 8, 8, 1	2,8,4

1. A, D and E Group 1

2. A, B – Second period; D, F – Third period

3. A, B, D, E – metals; F – non-metal; C – inert gas

4. D < F < A

5. F

VI. Reasoning/Observation-based Questions

1. Metals have low ionization energy therefore, ascending order - Q < T < R < P < U < S.

2. Most metallic is Q and least metallic is S.

On moving Down, the group, atomic size increases; therefore, the order will be U < T < S < R < Q < P.

Down the group electron affinity decreases; therefore, U will have the highest electron affinity.

3. Li < B < C < O < F; across the period electronegativity increases.

H < Li < Na < K; down the group metallic character increases.

4. Z

a. X

b. Z_2X

c. CY_4

5. **a.** F, as metallic character increases down the group.
   b. C
   c. E due to stable configuration.

P. 21–23 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. **a.** increases
   b. decreases
2. **a. i.** 1
   b. iii. They are metallic in nature.
3. Third group, third period
4. The oxidizing power of elements increases on moving from left to right along a period in the periodic table because the electron affinity of elements increases.

2012

1. **a. iii.** Sodium
   b. ii. Calcium
2. **a.** Ionization potential of elements increases across a period because across a period atomic size decreases and nuclear charge increases, so more energy is required to remove a valence electron.
   b. Alkali metals are good reducing agents because they have low ionization potential.
3. **a.** $_{19}E$ is a metal
   $_{8}F$ and $_{17}G$ are non-metals.
   b. Molecular formula – EG
   Type of bond –Ionic Bond
4. Sodium

2013

1. **a. iv.** fluorine.
2. **a.** J
   b. R
   c. M
   d. 5
   e. T
   f. Y Krypton
   g. Covalent bond, molecular formula = A_2H

2014

1. **a. iv.** atomic radius decreases and nuclear charge increases.
2. **a.** 3 shells and 2 valence electrons.
3. **a. i.** 3rd period, 16 Group
   ii. Z is a non-metal.
   iii. H_2Z
   iv. Covalent compound
   b. i. Electrovalent bond exists between M and O.
   ii. One electron is there in the outermost shell.
   iii. M belongs to first group or alkali metals.

2015

1. **a. i.**
2. **a. i.** Barium will form ions most readily because its ionization potential is lowest in the group. So removal of electrons is easy.
   ii. All these elements have two electrons in their valence shells.
3. **a.** Li < Na < K < Rb < Cs (increasing order of metallic character)
   b. Na > Mg > Si > S > Cl (decreasing order of atomic size)
   c. K < Na < Si < S < Cl (increasing order of ionization energy)
   d. I < Br < Cl < F (increasing order of electron affinity)

2016

1. **a. i.**
2. **a.** less than (<)
   b. less than (<)
3. **a. i.** Five valence electrons
   ii. M
   iii. T
   iv. T
   b. i. metallic
   ii. Smallest
   c. i. I. Ionic bond II. Covalent bond
   ii. I. ZX II. WX

2017

1. **a.** ionization potential
2. **a.** atomic number 15; 2, 8, 5 phosphorus
   b. atomic number 19; 2, 8, 8, 1 potassium
   c. atomic number 8; 2, 6 Oxygen
   d. atomic number 4; 2, 2 Beryllium
   e. atomic number 2; Helium - rare gas
3. **a.** i. Increasing order of the number of electron shells, He < Ne < Ar.

ii. Ionization potential decreases down the group; therefore, K < Na < Li.

iii. Electronegativity decreases down the group; therefore, Br < Cl < F.

iv. Atomic size increases down the group; therefore, Li < Na < K.

2018

1. **a.** Electron affinity
2. **a.** Inert gases have stable configuration. Their valence shell has octet condition

   b. Ionization potential depends upon two factors – atomic size and nuclear charge. Higher the nuclear charge, greater is the ionization potential. Smaller the atomic size greater is the ionization potential. Therefore, on moving across the period, atomic size decreases and nuclear charge increases. So, ionization potential increases across the period.

   c. Alkali metals have low ionization potential; hence, they lose electron and get oxidized easily. So, they act as good reducing agents.
3. **a.** The element B would have higher higher metallic character than A.

   b. The element A would probably have higher electron affinity than B.

   c. The element A would have smaller atomic size than B.

2019

1. **b.** Chlorine
2. sodium
3. **a.** Electronegativity
4. **a.** In the decreasing order of ionization potential: Ionization potential decreases down the group; therefore, the order will be

   H > Li > Na > K

   b. increasing electron affinity: electron affinity increases across the periods as the atomic size decreases. Therefore, the order will be

   B < N < O < F
5. **a.** G is a non-metal from Group 17; therefore, G will combine with B to form an electrovalent compound BG_2.

   b. H will form cation.

   c. Group 16 element E.

   d. Element F from Group 18.

2020

1. **a.** iv. helium
2. **a.** Q with atomic number 7.

   b. R with atomic number 10.

   c. P with atomic number 13.
3. **a.** Magnesium with atomic number 12; Electronic configuration 2, 8, 2

2022 Semester 1 (Conducted in the year 2021)

1. b **2.** b **3.** d, **4.** a
5. a **6.** c **7.** a **8.** a,
9. a. ii b. iii c. iii d. iii

CHAPTER – 2

CHEMICAL BONDING

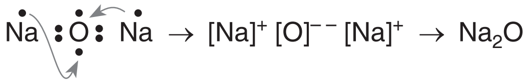
P. 31 CHECK YOUR PROGRESS 1

1. **a.** metallic
   b. Larger
   c. Halogens
   d. lose
   e. electrons
2. Ionic bond formation of potassium chloride

Metal: **Potassium**	Non-metal: **Chlorine**
Atomic number: 19	Atomic number: 17
E.C. 2, 8, 8, 1	E.C. 2, 8, 7
Valence electrons: 1	Valence electrons: 7
Electron dot structure: 	Electron dot structure: 
Potassium has one electron to donate to achieve stable octet configuration	Chlorine atom can accept one electron to achieve stable octet configuration

Ionic bond formation of sodium oxide

Metal: **Sodium**	Non-metal: **Oxygen**
Atomic number: 11	Atomic number: 8
E.C. 2, 8, 1	E.C. 2, 6
Electron dot structure: 	Electron dot structure: 



3. **a.** Two conditions favouring the formation of an ionic bond are
   - **i.** Low ionization potential of the metallic element that forms a cation. If the ionization potential is low, a cation will be formed easily.
   - **ii.** Large electron affinity of the non-metallic element that forms an anion. If the electron affinity is high, an anion will be formed easily.

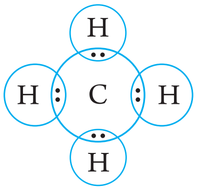
   b. Ionic compounds conduct electricity in molten or aqueous state because these contain free electrons that can move only in aqueous state.

   c. Chloride ion is stable as it contains an extra electron and thus achieves stable [2, 8, 8] configuration.

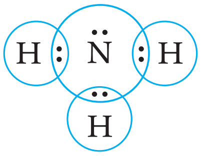
4. **a.** i.
   b. i
   c. iii
   d. i
   e. ii

P. 36 CHECK YOUR PROGRESS 2

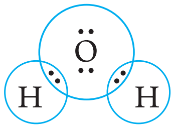
1. **a. i.** non-volatile
   b. ii. non-polar covalent compound.
   c. If X is a covalent compound, it is likely to have a
   i. low melting point.
   d. ii
   e. iii
   f. ii
2. **a.** Methane.



   b. Ammonia.



   c. Water.



3. **a.** Give two examples in each case.
   - **i.** Solid covalent compounds – Iodine, Sugar
   - **ii.** Gaseous polar compounds – Ammonia, hydrogen sulphide
   - **iii.** Gaseous non-polar compounds – Oxygen and nitrogen
   - **iv.** Liquid non-polar compounds – Toluene and benzene

   b. Give reasons for the following.
   - **i.** Methane does not conduct electricity in its molten or aqueous state because it contains neither the ions nor free electrons required for conduction.
   - **ii.** If there is a difference in electronegativities then the bond is a polar bond. If there is no difference in electronegativities, in

covalent compounds then the bond is non-polar. So, covalent compounds can be polar as well as non-polar in nature.

iii. The molecules of carbon tetrachloride (a covalent compound) are held together by relatively weaker forces as compared to that in ionic compounds. The melting and boiling points of covalent compounds are generally low. So, carbon tetrachloride has a low boiling point.

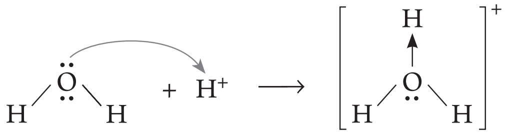
iv. In polar covalent compounds, shared pair of electrons is not at equal distance between the two atoms and lies closely to the more electronegative atom. So, there is charge separation and these compounds ionize in water.

4. **a.** ionize
- **b.** Covalent compounds
- **c.** Covalent compounds
- **d.** non-polar
- **e.** non-metals

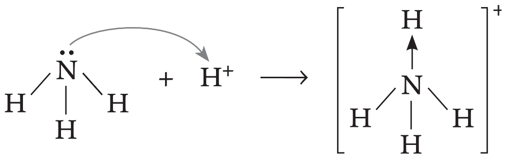
P. 37-38 CHECK YOUR PROGRESS 3

1. **a.** Hydroxyl ion
- **b.** Lone pair of electrons
- **c.** Single covalent bond
- **d.** Hydronium ion
- **e.** Two

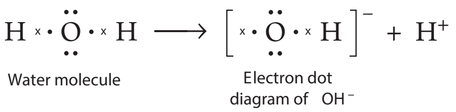
2. **a.** Hydronium ion



b. Ammonium ion

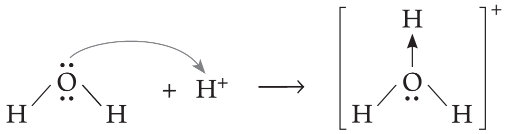


c. Hydroxyl ion



3. A chemical bond formed by the sharing of a pair of electrons between two atoms, both of which are provided by only one of the combining atoms is called coordinate bond. The atom which provides the electron pair for the formation of coordinate bond is called donor and the atom or ion sharing donated electron pair is called acceptor.

Example:



4. **a.** Hydronium,
- **b.** Donor,
- **c.** acceptor,
- **d.** lone,
- **e.** Ammonium chloride,
- **f.** ionic.

P. 38–42 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. d **2.** b **3.** b **4.** a **5.** b
6. c **7.** a **8.** b **9.** b **10.** d
11. b **12.** a **13.** d **14.** c **15.** c
16. c **17.** a **18.** b **19.** c **20.** b

B. Fill in the blanks.

1. electrons, orbit
2. valence, reactions
3. transfer, ionic
4. sharing, covalent
5. cation, anion
6. Electrovalency, electrovalent
7. Covalency, covalent
8. ammonia, methane
8. ammonium chloride, coordinate
10. two, one

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Orbit
2. Valence shell
3. Electrovalent compounds
4. Covalent bond
5. Coordinate bond

B. Give one example for each of the following.

1. Hydrogen chloride, ammonia, water, etc.
2. Hydrogen, oxygen, methane, carbon tetrachloride, etc.
3. Ammonium chloride, ammonium bromide, ammonium sulphate, etc.
4. Sodium chloride, magnesium oxide, calcium sulphide, etc.
5. Helium

C. Match the following.

1. b **2.** d **3.** e **4.** a **5.** c

D. Match the given word(s) with its appropriate description.

1. e **2.** b **3.** a **4.** c **5.** d

E. Name each of the following.

1. Dipole,
2. Coordinate bond,
3. Weak Van der Waal's force,
4. Ionic/Electrovalent bond,
5. Hydrogen, oxygen, nitrogen, etc.

F. Choose the odd one out.

1. H_2O - being polar
2. CH_4 - being non-polar
3. H_2O - no coordinate bond
4. CCl_4 - covalent compound
5. NaCl - electrovalent compound

G. Answer the following questions.

1. The cation possesses a positive charge. It is formed by losing an electron.
2. The charge of an anion is negative. It is formed by gaining an electron.
3. Na^+ – 2, 8 and Cl^- – 2, 8 ,8
4. Ca^{2+} – 2, 8, 8 and O^{2-} – 2, 8
5. Electrovalent bond has the highest strength as it is an electrostatic force of attraction between a cation and an anion.
6. Hydrogen, chlorine, fluorine molecules, etc.
7. Nitrogen molecule has triple covalent bond.
8. Hydronium ion is formed.
9. Hydronium ion has one unit positive charge and one lone pair of electrons.
10. Ammonium ion is formed. It does not have any lone pair of electrons.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Due to strong electrostatic force of attraction, the ionic solids like sodium chloride do not conduct electricity in solid state.
2. In methane, the shared pairs of electrons are equally distributed between carbon and all the four hydrogen atoms as well as equally attracted. So there is no charge separation. So methane is a non-polar covalent compound.
3. Since HCl is a polar covalent compound, it will ionize or form hydrogen ion and chloride ion in water, unlike sodium chloride, in which sodium and chloride are already present as ions. So, in water, they just break or dissociate.
4. Since cations are formed by the loss of electrons and anions are formed by the gain of electrons, anions will always be bigger than their cations because of additional electrons.
5. Ionic compounds are generally hard solids with high melting and boiling points due to the strong electrostatic force of attraction between cations and anions present in them.
6. Covalent compounds are generally soft solids, or liquids, or gases with low melting and boiling points as they are formed by equal sharing of electrons. So there is no strong electrostatic force of attraction between the compounds.
7. Non polar compounds like methane are water-insoluble compounds as like dissolves in like. Meaning, water is a polar solvent and methane is a non-polar covalent compound; hence, it does not dissolve.
8. The polar covalent compounds like HCl will ionize or form hydrogen ion and chloride ion in water, unlike ionic solids like sodium chloride, in which sodium and chloride are already present as ions. So in water, they just break or dissociate.

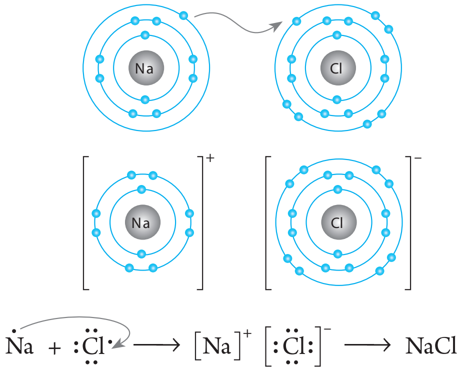
B. Differentiate between the following pairs.

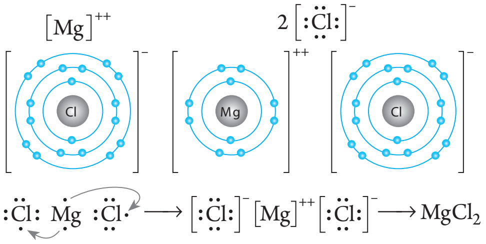
1. Electrovalent bond	**Covalent bond**
a. Bond formed by the transfer of electron from metal to non-metal.	**a.** Bond formed by the equal sharing of electron(s).
b. Strongest bond	**b.** Weaker than electrovalent bond.
2. Polar covalent bond	**Non-polar covalent bond**
a. It ionizes in water	**a.** It does not ionize in water.
b. Shared pair of electrons is not at equal distance between the two atoms and lies closely to the more electronegative atom.	**b.** The shared pair of electrons is equally distributed between the two atoms as well as equally attracted by them.

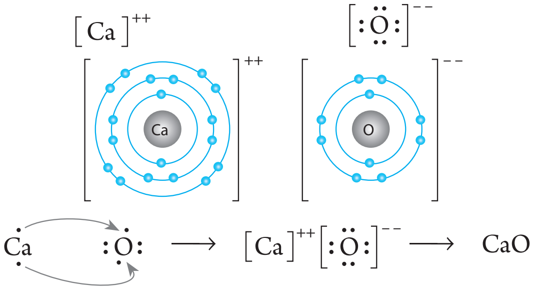
c. There is charge separation.	**c.** These compounds show no charge separation and are equally neutral.
3. Coordinate bond	**Electrovalent bond**
a. It is formed by a shared pair of electrons, with both electrons coming from the same atom.	**a.** It is formed by the transfer of electron(s).
b. Weaker than electrovalent bond.	**b.** Strongest bond due to electrostatic force of attraction.
4. Coordinate bond	**Covalent bond**
a. It is formed by a shared pair of electrons, with both electrons coming from the same atom.	**a.** It is formed by equal sharing of electrons
b. Stronger than covalent bond.	**b.** Weaker than coordinate bond.
5. Cation	**Anion**
a. Formed by the loss of an electron.	**a.** Formed by the gain of an electron.
b. The size of cations is less than that of their atom.	**b.** The size of anions is more than that of their atom

C. Draw as indicated.

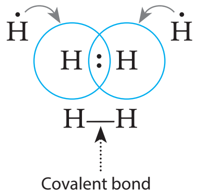
1.

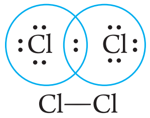




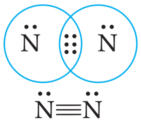


2.

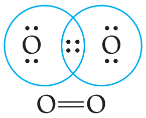




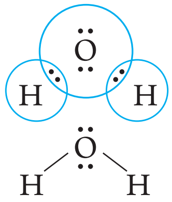
Chlorine



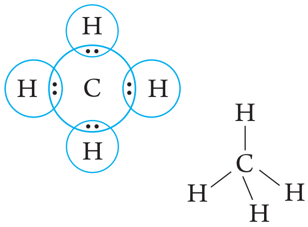
Nitrogen



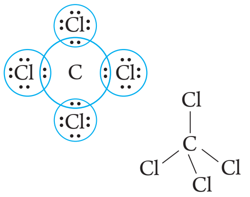
Oxygen



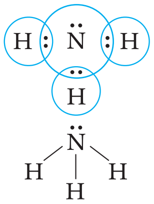
Water



Methane

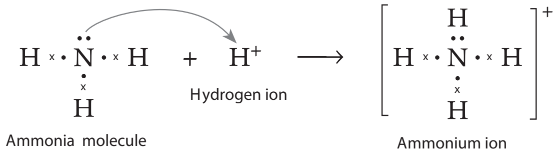


Carbon tetrachloride



Ammonia

3.



D. Complete the following table.

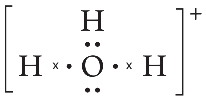
	Compound	Type of bond
1.	Sodium chloride	Ionic bond
2.	Carbon tetrachloride	Non-polar covalent bond
3.	Methane	Non-polar covalent bond
4.	Nitrogen molecule	Non-polar triple covalent bond
5.	Hydrogen chloride	Polar single covalent bond
6.	Calcium oxide	Ionic bond
7.	Magnesium chloride	Ionic bond
8.	Water	Polar covalent bond
9.	Ammonia	Polar covalent bond
10.	Chlorine molecule	Non-polar covalent bond

E. Define each of the following.

1. Electrovalency: The number of electrons that an atom donates or accepts to form an electrovalent bond.
2. Electrovalent or ionic bond: The bond formed between compounds as a result of the transfer of electrons from a metal to a non-metal atom.
3. Covalent bond: The bond formed between compounds formed by sharing of electrons.
4. Coordinate bond: A chemical bond formed by the sharing of a pair of electrons between two atoms, both of which are provided by only one of the combining atoms.
5. Non-polar covalent bond: When the difference in electronegativity is zero, a non-polar bond is formed because the shared pair of electrons is equally distributed between the shared atoms as well as equally attracted by them.
6. Polar covalent bond: When there is a slight difference in electronegativity between the atoms forming the bond, then the shared pair of electrons is shifted closer to the more electronegative element, thus giving it a partial negative charge and the other element a partial positive charge. The bond, therefore, as a whole develops polarity and is known as polar covalent bond.

F. Answer the following questions.

1. Lone pair of electrons is the pair of electrons that does not take part in bond formation. Water has two lone pairs of electrons present on the oxygen atom and ammonia has one lone pair of electrons present on nitrogen atom.
2. **a.** Electrovalent bond,
   b. Electrovalent bond
   c. Covalent bond
   d. A_2B_3
3. **a.** H_2, N_2
   b. HCl, H_2O
   c. NH_4^+, H_3O^+
   d. NaCl, CaO
4. Hydronium ion is formed as cation.



Hydronium ion

5. Chemical bond: A strong attractive force that holds atoms or ions or molecules together.
6.

Property	Electrovalent compound A	Polar covalent compound B
Melting point and boiling point	High	Low
Conducting of the electricity	Conducts good electricity in molten or aqueous state.	Only polar covalent compounds in aqueous state conduct mild electricity.
Formation of ions – dissociation or ionization	Undergoes dissociation	Undergoes ionization

7. Need for chemical bond formation: To attain a stable electronic configuration (nearest to a noble gas). Noble gases are chemically less reactive and have eight electrons (except helium) in their valence shell. So all combining atoms strive to get noble gas configuration by bonding.
8. There are mainly three types of chemical bonds. These are ionic or electrovalent bonds, covalent bonds and coordinate or dative bonds.
9. It is the pair of electrons shared between two atoms.
10. Type of covalent bonds: There are three types of covalent bonds. These are single, double and triple bonds that are formed by the mutual sharing of one, two and three electron pairs between two atoms, respectively. Covalent bonds are also polar covalent bonds and non-polar covalent bonds.

IV. Knowledge-based Questions

1. Ionic or electrovalent bond is formed between a metal and a non-metal atoms. Metals tend to transfer their valence electrons to non-metals, and non-metals tend to accept electrons from metals to achieve their octets. A metal atom loses its electron(s) readily and forms a positively charged ion and thus becomes electropositive in nature. A non-metal atom readily accepts electron(s) in its valence shell and forms a negatively charged ion and thus becomes electronegative in nature.

   The conditions which favour the formation of ionic bonds between a cation and an anion are as follows:

   a. Low ionization potential of the metallic element that forms a cation. If the ionization potential is low, a cation will be formed easily.

b. Large electron affinity of the non-metallic element that forms an anion. If the electron affinity is high, an anion will be formed easily.

c. Large electronegativity difference between the combining atoms. If the difference in the electronegativities of two elements is high, then the transfer of electrons will be easier.

2. Characteristic properties of ionic compounds

a. Melting and boiling points: They have high melting and boiling points due to the presence of strong electrostatic forces of attraction, and to break these forces of attraction, a large amount of energy is required.

b. Conduction of heat and electricity: These compounds are good conductors of heat and conduct electricity only in molten (fused) or aqueous state. They do not conduct electricity in solid state as constituent ions are not free to move as they are bonded by strong electrostatic forces of attraction. In aqueous or molten state, constituent ions are free to move.

c. Solubility: They are generally soluble in water but do not dissolve in organic solvents. Water is polar covalent and shows charge separation. So, water molecules can easily break the ionic bonds of the ionic compounds. Thus, ionic compounds dissolve in water. Organic solvents being non-polar cannot break ionic bonds. Thus, ionic compounds do not dissolve in organic solvents.

3. The covalent bonds are of the following types:

a. Single covalent bond

b. Double covalent bond

c. Triple covalent bond

A covalent bond formed by the sharing of one pair of electrons is called single covalent bond. It is denoted by a single dash (—) between the two atoms. For example, the two hydrogen atoms in H_2 molecule (H—H).

The covalent bond formed by the sharing of two pairs of electrons between the two atoms is called double covalent bond. It is denoted by a set of two dashes (═). For example, oxygen molecule O_2 (O═O), where the two oxygen atoms share two pairs of electrons.

The triple covalent bond is formed by sharing of three pairs of electrons. It is denoted by a set of three dashes (≡). For example, two nitrogen atoms share three pairs of electrons to form a molecule of nitrogen (N≡N).

The covalent compounds possessing polar covalent bonds are called polar covalent compounds. In such compounds, shared pair of electrons is not at equal distance between the two atoms and lies closely to the more electronegative atom.

The covalent compounds possessing non-polar covalent bonds are called non-polar covalent compounds. In such compounds, the shared pair of electrons is equally distributed between the two atoms as well as equally attracted by the two atoms.

4. Conditions favouring the formation of a covalent bond:

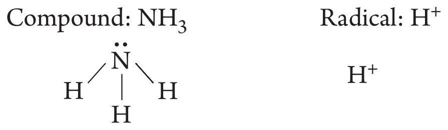
a. A covalent bond is formed between two non-metals.

b. The difference in electronegativities between the combining atoms of the two non-metals must be sufficiently low or zero. When the difference in electronegativities is zero, a non-polar bond is formed because the shared pair of electrons is placed exactly between the shared atoms. When there is a slight difference in electronegativities between the atoms forming the bond, then a polar covalent bond is formed. This is because the shared pair of electrons is shifted closer to the more electronegative element, thus giving it a partial negative charge and the other element a partial positive charge. The bond therefore as a whole develops polarity.

c. The two combining atoms should have high ionization energy.

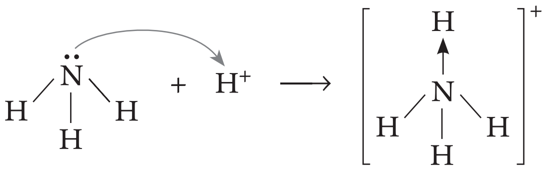
5. A chemical bond formed by the sharing of a pair of electrons between two atoms, both of which are provided by only one of the combining atoms is called coordinate bond. The atom which provides the electron pair for the formation of coordinate bond is called donor and the atom or ion sharing donated electron pair is called acceptor.

Ammonium ion

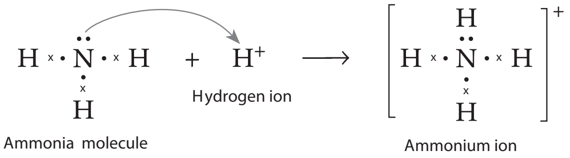


In the molecule of ammonia, the nitrogen atom contains a lone pair of electrons. An ammonium ion is formed when the lone pair of electrons on the nitrogen atom of the ammonia molecule is shared with the hydrogen ion. In this combination, the hydrogen ion accepts the lone pair of electrons and distributes the charge across the entire ammonium radical. The entire system therefore becomes stable.

The formation of ammonium radical and the hydronium ion involves coordinate bonds, where the lone pair of electrons is shared with the hydrogen ion.

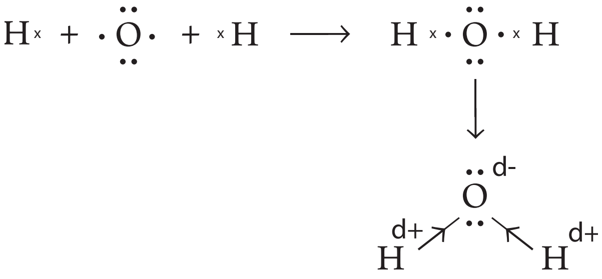


This ammonium ion formation can be represented by the help of electron dot structure as:



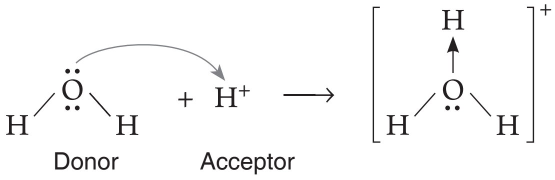
V. Application and Skill-based Questions

1. **a.** Water will form hydronium ion.

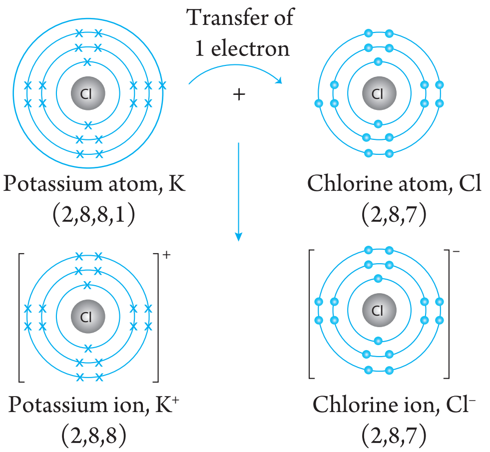


b. A coordinate bond is formed.

c. Lone pair of water acts as donor and hydrogen ion acts as acceptor.

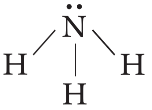


2.



Formation of potasium chloride KCl

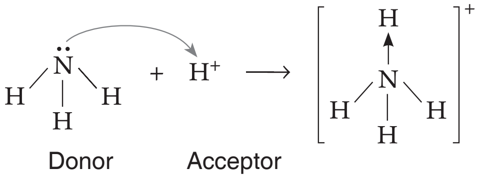
3. Compound: NH_3



a. Ammonium ion is formed.

b. Coordinate bond.

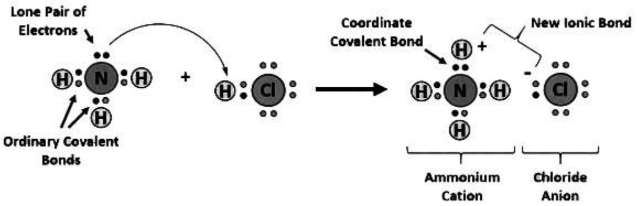
c. Ammonia is a donor and hydrogen ion is an acceptor .



4.

Compound	Type of covalent bonds
Hydrogen H_2	H-H single covalent bond
Nitrogen N_2	N ≡ N triple covalent bond
Carbon dioxide CO_2	O=C=O double covalent bond
Oxygen O_2	O=O double covalent bond
Chlorine Cl_2	Cl–Cl single covalent bond

5.



VI. Reasoning/Observation-based Questions

1.

Ionize	Dissociate	Unionized
NH_3, HCl, H_2O	NaCl, CaO, NH_4Cl, $MgCl_2$	N_2, CH_4, CCl_4

2.

Compounds - aqueous solution	Ions/molecules/both ions and molecules
1. $MgCl_2$	Ions
2. CH_4	Molecules
3. NH_4Cl	Ions and molecules both
4. NaCl	Ions
5. HCl	Ions and molecules both
6. CaO	Ions
7. O_2	Molecules
8. CCl_4	Molecules
9. N_2	Molecules
10. NH_3	Ions and molecules both

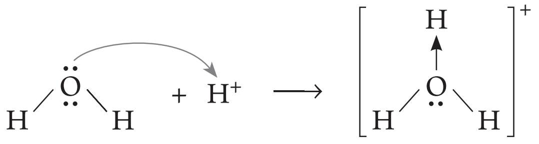
P. 42–44 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. Because there is a big difference between electronegativities of H and Cl.
2. **a.** sharing
   b. high
   c. nitrogen

2012

1.



Coordinate bond formation in hydronium ion

2013

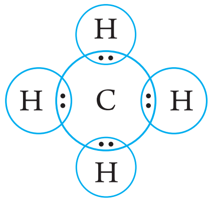
1. Coordinate bond
2. **a. ii.** Ammonium chloride
   b. iii. They are insoluble in water.
3. Sodium chloride is soluble in water whereas carbon tetrachloride is insoluble in water. Electrical conductivity : Sodium chloride conducts electricity in the molten and in the aqueous solution state, whereas carbon tetrachloride being non-polar covalent compound does not conduct electricity.

2014

1. **a. ii.** a low melting point and low boiling point.
   b. iv. nitrogen.
2. Ionization

2015

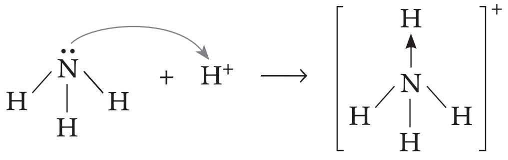
1. **b.** Ammonium chloride
2. **a.** Carbon tetrachloride is a covalent compound. It does not have free electrons in it, so it does not conduct electricity.
3. Methane is an organic compound and its formula is CH_4. The hydrogen atom and carbon atom contribute one electron each to the shared pair of electrons for the formation of each C-H bond. In the process, each hydrogen atom attains duplet of electrons and the carbon atom attains the octet of electrons.



4. **a.** $Y + 3e^- \rightarrow Y^{3-}$
   b. $3X + Y_2 \rightarrow X_3Y_2$
5. **a.** Covalent bonding (as it is L molecule).
   b. Rearrangement of molecules.

2016

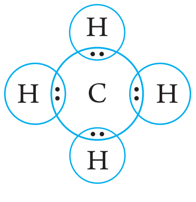
1. **a.** high
2. **a.** 17
3. **a. i.** Ionic bond
   ii. Covalent bond
   b. i. ZX
   ii. WX
4.

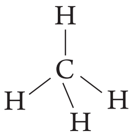


Coordinate bond formation in ammonium ion

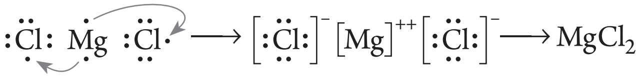
2017

1. **a.** carbon tetrachloride
   b. OH–
2. **b.** Consists of molecules
3. **a.** Covalent bonding
   b. Ionic bonding
4. **a.**



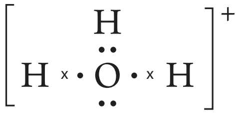


b.



2018

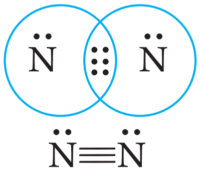
1. **a.** Ionization
2. **a.** Due to the strong electrostatic force of attraction between cation and anion, high energy is required to break the ions apart. Therefore, ionic compounds have high melting point.
   b. Inert gases have a stable electronic configuration, with 8 electrons (octet) in the valence shell except helium (2 electrons in the valence shell). They are extremely stable. Hence, these gases neither lose nor gain electrons.
   c. Dilute HCl is a strong acid, with highly polar covalent bond which ionizes in water (being polar) into hydrogen ions and chloride ions. These ions show good conductivity. On the other hand, acetic acid is a mild acid with very low polarity; hence, its conductivity is less.
3. **a.** solid
4. **a.** Lone pair of electrons: The unshared pair of electrons which usually do not participate in a chemical reaction.
   b.



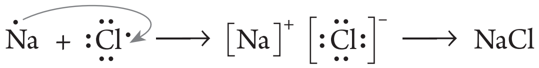
Hydronium ion

2019

1. **a.** Non-polar covalent bond
2. **a.**



b.



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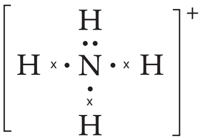
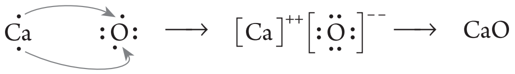


Ammonium ion

2020

1. **a.** **iv.** carbon tetrachloride
2. **a.** Covalent bond
3. **a.** ammonia
4. **a.**



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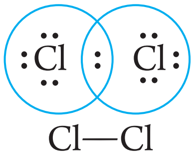

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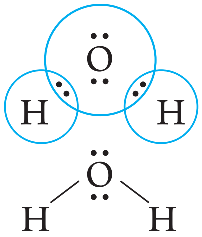

2022

Semester 1 (Conducted in the year 2021)

1. **c.** it does not contain any free ions.
2. **d.** Carbon tetrachloride
3. **a.** Two atoms of W
4. **c.** Water
5. **c.**
6. **c.** Covalent

Chapter – 3

ACIDS, BASES AND SALTS

P. 51 Check Your Progress 1

1. **a.** Oxyacids
   b. Phosphorous acid, H_3PO_3
   c. Citric acid.
   d. Tartaric acid
   e. Water
2. **a.** $SO_3 + H_2O \rightarrow H_2SO_4$
   b. $P + 5HNO_3 \rightarrow H_3PO_4 + H_2O + 5NO_2$
   c. $NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$
   d. $CuO + 2HCl \rightarrow CuCl_2 + H_2O$
   e. $ZnS + HCl \rightarrow ZnCl_2 + H_2S$
3. **a.** Sulphuric acid and nitric acid
   b. Burning of fossil fuels - coal and petroleum
   c. Carbon dioxide
   d. Carbon dioxide is released in both the cases
   e. Any sulphide salt
4. **a.** Colourless CO_2 gas evolves with a fizz sound.
   $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$
   b. Colourless CO_2 gas evolves with a fizz sound.
   $NaHCO_3 + HNO_3 \rightarrow NaNO_3 + H_2O + CO_2\uparrow$
   c. Colourless hydrogen sulphide gas with rotten egg like smell is evolved.
   $ZnS + 2HCl \rightarrow ZnCl_2 + H_2S\uparrow$
   d. Colourless hydrogen sulphide gas with rotten egg like smell is evolved.
   $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S\uparrow$
   e. Potassium nitrate on heating with concentrated sulphuric acid produces more volatile nitric acid.
   $2KNO_3 + H_2SO_4 \rightarrow K_2SO_4 + 2HNO_3$
5. **a.** Carbonic acid – In carbonated beverages
   b. Nitric acid – In jewellery
   c. Lactic acid – In making pickles
   d. Salicylic acid – In skin ointments
   e. Formic acid – In soft drinks

P. 56 CHECK YOUR PROGRESS 2

1. **a.** purple
   b. yellow
   c. acidity
   d. ammonia.
   e. Calcium hydroxide
2. **a.** CaO
   b. NaOH
   c. $Mg(OH)_2$
   d. Ammonium hydroxide
   e. $Mg(OH)_2$
3. **a.** $2Mg + O_2 \rightarrow 2MgO$
   b. $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$
   c. $FeSO_4 + 2NaOH \rightarrow Fe(OH)_2\downarrow + Na_2SO_4$
   d. $Fe(OH)_2 + 2HCl \rightarrow FeCl_2 + 2H_2O$
   e. $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$
4. **a.** The bases which are soluble in water are called alkalis. All alkalis are bases, but all bases are not alkalis. For example, KOH (base) is an alkali since it is soluble in water, but $Cu(OH)_2$ (base) is not an alkali since it is not soluble in water. All bases do not dissolve in water.
   b. Pure water is neutral and contains equal number of H^+ and OH^- ions; hence, it has a pH of 7.
   c. In order to know the pH values over a wider range, a universal indicator is used. It is a mixture of many specific indicators, each of which gives a sharp colour change at specific intervals of pH. It gives different colours at different pH values of the solution. Therefore, it can be used to differentiate between acidic or basic solutions of different pH values.
   d. To get relief from pain and acidity, antacids like milk of magnesia containing mild bases like $Mg(OH)_2$ and $Al(OH)_3$ are taken which neutralize the excess hydrochloric acid released by stomach walls.
   e. Bee sting leaves acid (mainly formic or methanoic acid) on the skin that causes pain and swelling. To get relief from pain, baking soda, a base, is applied on the stung area which neutralizes the acid.
5. **a.** 0.1M HCl – pH 0
   b. Gastric juice – pH 1.0–2.0
   c. Saliva – pH 6.2–7.6
   d. Blood – pH 7.36–7.42
   e. Urine – pH 5.5–7.8

P. 60-61 Check Your Progress 3

1. **a.** acidic, metal
   b. acidic
   c. $BaSO_4$
   d. greater
   e. normal
2. **a.** Ammonium chloride will dissociate in water to form ammonium ions and chloride ions.
   $NH_4Cl \rightarrow NH_4^+ + Cl^-$
   b. A metal and a non-metal combine to give a salt on heating.
   Metal + Non-metal $\xrightarrow{\text{heat}}$ salt
   c. Active metals like Zn, Fe and Mg on reaction with dilute acids displace hydrogen from acids and form their corresponding salts.
   Metal + Dilute acids $\rightarrow$ Metal salt + $H_2\uparrow$
3.

Salt	Neutralization
Zinc sulphate	Neutralization
Barium sulphate	Precipitation
Ferric sulphate	Displacement
Ferrous sulphide	Synthesis

4. **a.** Chloride salt – lead chloride ($PbCl_2$)
   b. Sulphate salt – barium sulphate ($BaSO_4$)
   c. Carbonate salt – calcium carbonate ($CaCO_3$)
   d. Oxide salt – lead oxide (PbO)
   e. Hydroxide salt – magnesium hydroxide ($Mg(OH)_2$)
5. **a.** True
   b. False
   c. False
   d. True
   e. False

P. 63–67 Exercises

I. Objective Type Questions

A. Choose the correct option

1. a **2.** b **3.** b **4.** c
5. d **6.** a **7.** d **8.** c
9. b **10.** c **11.** b **12.** b
13. a **14.** a **15.** c **16.** b
17. c **18.** a **19.** d **20.** c

B. Fill in the blanks

1. indicator
2. weak
3. phenolphthalein
4. universal
5. normal
6. basic
7. acid
8. acids
9. neutralization
10. Acids

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Neutralization **2.** Alkali
3. Acid rain **4.** Phenolphthalein
5. Methyl orange **6.** Universal indicator
7. Concentrated acid **8.** Dilute acid
9. Mineral acids **10.** Strong acids

B. Give one example for each of the following.

1. Basic lead nitrate - $Pb(OH)NO_3$
2. acetic acid CH_3COOH
3. H_2SO_4
4. HCl
5. H_3PO_4
6. KOH
7. $Ca(OH)_2$
8. Phenolphthalein, red litmus
9. Methyl orange, blue litmus
10. $NaHCO_3$

C. Match the following

1. e **2.** c **3.** d **4.** b **5.** a

D. Match the given word(s) with its appropriate description.

1. b **2.** c **3.** d **4.** e **5.** a

E. Choose the odd one out.

1. HCOOH being organic acid
2. Carbonic acid, being mineral acid
3. NH_4OH being weak alkali
4. KOH being alkali
5. KNO_3 being normal salt

F. Answer the following questions.

1. Phosphoric acid H_3PO_4
2. Sulphuric acid H_2SO_4
3. pH = $-\log [H^+]$
4. Sodium nitrate
5. Hydrogen sulphide gas

III. Short Answer Type Questions

A. Give reasons for the following.

1. A normal salt formed by the complete replacement of ionizable hydrogen ions of an acid by a cation is called normal salt. NaCl is a product of

$$HCl + NaOH \rightarrow NaCl + H_2O$$

2. Since an acid salt liberates hydrogen ion or hydronium ion, it exhibits all the properties of an acid. An acid salt reacts with bases to form normal salts.

$$NaHCO_3 + NaOH \rightarrow \underset{\text{normal salt}}{Na_2CO_3} + H_2O$$

3. As copper hydroxide is a water insoluble hydroxide, it is a base.

4. As aluminium oxide reacts with both acids and bases to form salts.

With acid: $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$

With base: $Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

5. All acid salts are not acidic in solution. The acid salts such as $NaHSO_4$ and $KHSO_4$ are acidic in solution because they are formed by the neutralization of a strong acid (H_2SO_4) and a strong base (NaOH/KOH) and they contain one ionizable hydrogen ion. The acid salts $NaHCO_3$, NaH_2PO_4, Na_2HPO_4 and $KHCO_3$ are slightly alkaline in solution because they are formed by the neutralization of a weak acid and a strong base.

B. Differentiate between the following pairs.

1.	**Mineral acid**	**Organic acid**
a.	Acids obtained from minerals.	Acids obtained from plants and animals and microbes.
b.	They are strong acids and ionize completely in solution. e.g., HCl, HNO_3	They are weak acids and do not ionize completely in solution. e.g., HCOOH, citric acid
2.	**Concentrated acid**	**Dilute acid**
	Contains high percentage of acid in its aqueous solution; e.g., conc. HCl	Contains less percentage of acid in its aqueous solution; e.g., dil. HCl
3.	**Base**	**Alkali**
a.	Bases are substances (insoluble or water soluble) which combine with hydronium ion of acid to form salt and water. e.g., copper hydroxide	Alkalis are water soluble bases which combine with hydronium ion of acid to form salt and water. e.g., sodium hydroxide
b.	All bases are not alkalis.	All alkalis are bases.
4.	**Normal salt**	**Acidic salt**
a.	A salt formed by complete replacement of ionizable hydrogen ions of an acid by a cation.	A salt formed by the partial replacement of the ionizable hydrogen ions of an acid by a metal ion.
b.	Does not have any replaceable hydrogen ion. e.g., Na_2CO_3	Has at least one replaceable hydrogen ion. e.g., $NaHCO_3$
5.	**Acid**	**Base**
	An acid is a compound which when dissolved in water yields hydronium ion [H_3O^+] as the only positive ion. e.g., sulphuric acid	A base is a substance which combines with a hydronium ion obtained from an acid to form salt and water only. e.g. sodium hydroxide

C. Diagram-based questions

1. pH scale with different gradient.
2. Less than 7, between 0 and 6.4
3. It is a base.
4. Highly basic or alkaline or strong base
5. pH = 7

D. Equations-based questions

1. Complete and balance the following equations.
   - **a.** $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
   - **b.** $2NaNO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2HNO_3$
   - **c.** $ZnCO_3 + 2HCl \rightarrow ZnCl_2 + H_2O + CO_2$
   - **d.** $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$
   - **e.** $Pb(OH)_2 + 2HNO_3 \rightarrow Pb(NO_3)_2 + 2H_2O$
2. **a.** As dibasic acids have two ionizable H-atoms per molecule, they form two types of salts – an acid salt and a normal salt.

   $KOH + H_2SO_4 \rightarrow KHSO_4$ (acid salt) $+ H_2O$

   $2KOH + H_2SO_4 \rightarrow \underset{\text{(normal salt)}}{K_2SO_4} + 2H_2O$

   b. H_3PO_4 is an acid which produces three hydronium ions by the ionization of its one molecule, in 3 steps.

   $$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$$
   $$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$$
   $$HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^+$$

   c. If the salt of a strong base and a strong acid combine, a neutral salt is produced.

   NaOH (strong base) + HCl (strong acid) → NaCl (neutral salt) + H_2O

d. $H^+ + OH^- \rightarrow H_2O$

e. A basic salt reacts with acids to form normal salt.

$Cu(OH)Cl + HCl \rightarrow CuCl_2$ (normal salt) + H_2O

E. Define each of the following.

1. Basicity is the number of hydronium ions produced by the ionization of one molecule of an acid in its solution.
2. Acidity is the number of hydroxyl ions produced by the ionization of one molecule of a base in its solution.
3. Alkalis are water-soluble bases like KOH, NaOH and NH_4OH.
4. pH is defined as the negative logarithm of the hydrogen ion concentration in solution.
5. Acidic salt is formed when H^+ ions of an acid are partially replaced by a metal cation or ammonium ion.
6. Basic salt is formed when OH^- ions of a base are partially replaced by an anion.
7. Normal salt is formed by the complete replacement of ionizable hydrogen ions of an acid by a metal cation or ammonium ion.
8. The interaction of an acid and a base invariably results in the formation of salt and water as the only products and is called neutralization.
9. The rain containing acids like H_2SO_4, HNO_3 is called acid rain.
10. An indicator is a chemical compound used to detect the acidic or basic nature of a solution by a sharp change in its colour.

F. Explain why.

1. Acid rain contains acids like H_2SO_4 and HNO_3.
   - **a.** Acid rain is harmful for agriculture, trees and plants as it dissolves and washes away nutrients needed for their growth.
   - **b.** It causes respiratory ailments in human beings.
   - **c.** It corrodes water pipes resulting in dissolving of metals like iron, copper and lead into the drinking water.
   - **d.** It damages buildings and other structures made of stone or marble or metal as it reacts with them.
2. Acids change the colour of indicators. They turn blue litmus red, methyl orange solution from orange to red
3. Bases change the red litmus blue and colourless phenolphthalein solution pink.
4. One of the constituents of our gastric juice is hydrochloric acid, required to digest our food and to activate certain enzymes that aid in digestion. If the acid content is excessively high, it causes burning sensation or acidity. To temporarily reduce the acidity in the stomach, we have to take an antacid. The primary function of the antacid is to neutralize the excess hydrochloric acid in the gastric juice.

G. Answer the following questions.

1. **a.** $NaHSO_4$

   b. KH_2PO_4 or K_2HPO_4
2. Acidic salt as it liberates CO_2, pH will be less than 7.

   $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$
3. **a.** A with pH 14

   b. C with pH 2

   c. B with pH 5 weak acid

   d. D with pH 7
4. Strong acids undergo complete dissociation in aqueous solution producing a high concentration of hydronium ions For example, HCl, H_2SO_4, HNO_3, etc. These acids are good conductors of electricity. Strong acids contain ions in their aqueous solution.

   Weak acids do not dissociate completely in aqueous solution thereby producing a low concentration of hydronium ions. For example, H_2CO_3, HCOOH, CH_3COOH, etc. Weak acids exist largely as unionized molecules in solutions. This means that weak acids contain ions as well as molecules in their aqueous solution.
5. We can explain the concept using the example of acetic acid. CH_3COOH possesses four hydrogen atoms in its molecule, but it does not mean that it has a basicity of four. In reality, it is a monobasic acid with a basicity of one because it has only one ionizable H atom and gives only one hydronium ion. Hence, it is a monobasic acid. Likewise, H_3PO_3 possesses three hydrogen atoms but shows a basicity of two because it has two ionizable H atoms (that are attached to O atoms). The remaining H atom is attached directly to phosphorus atom, hence, it is not ionizable.
6. **a.** $Zn(HCO_3)_2 + 2HCl \rightarrow ZnCl_2 + 2H_2O + 2CO_2\uparrow$

   b. $ZnCO_3 + 2HCl \rightarrow ZnCl_2 + H_2O + CO_2\uparrow$

   c. $ZnSO_3 + 2HCl \rightarrow ZnCl_2 + H_2O + SO_2\uparrow$

   d. $ZnS + 2HCl \rightarrow ZnCl_2 + H_2S\uparrow$

7. $Fe(HCO_3)_2 + H_2SO_4 \rightarrow FeSO_4 + 2H_2O + 2CO_2$

$FeCO_3 + H_2SO_4 \rightarrow FeSO_4 + H_2O + CO_2$

$FeSO_3 + H_2SO_4 \rightarrow FeSO_4 + H_2O + SO_2$

$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S\uparrow$

8. Burning of fossil fuels (containing nitrogenous and sulphur matter) such as coal and oil in power plants and petrol or diesel in vehicles releases sulphur dioxide and nitrogen oxides into the air. Polluted air contains many oxidizing agents that catalyse the oxidation of sulphur and nitrogen oxides. The oxidised sulphur and nitrogen oxides further react with water to form acids that are washed down to the earth with rain water.

9. **a.** Uses of acids:

- **i.** Acids are used in the manufacture of drugs, dyes and paints.
- **ii.** Acids are very important laboratory reagents. Acids like HCl, H_2SO_4 and HNO_3 are used in dilute as well as concentrated forms.

b. Uses of bases:

- **i.** Alkalis are used in the manufacture of soaps.
- **ii.** Alkalis such as ammonium hydroxide are used to remove grease stains from clothes.

10. The notation pH means ‘power of hydrogen’. pH is defined as the negative logarithm to the base 10 of the hydrogen ion concentration in solution.

A Danish biochemist, S P Sorenson, proposed the acidity of a solution to be expressed in terms of a parameter called pH.

The strength of an acid or an alkali is expressed in terms of pH value or hydrogen ion concentration.

Mathematically, $pH = -\log [H^+]$

IV. Knowledge Based Questions

1. **a.** $NaHSO_4$

b. AgCl

c. $Pb(NO_3)_2$

d. $CuSO_4$

2. Sodium hydrogen sulphate, $NaHSO_4$

3. **a.** pH < 7 (acidic solution)

b. **i.** R **ii.** R **iii.** Q

4. **a.** $ZnS + 2HCl \rightarrow ZnCl_2 + H_2S$

$ZnCl_2 + Na_2CO_3 \rightarrow ZnCO_3 + 2NaCl$

b. Precipitation

$$Na_2CO_3 + 2HCl \xrightarrow{\text{Neutralisation}} 2NaCl + H_2O + CO_2$$

c. Neutralisation

$$BaCO_3 + H_2SO_4 \xrightarrow{\text{Neutralisation}} BaSO_4 + H_2O + CO_2$$

OR

$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$

Precipitation

$BaCl_2 + H_2SO_4 \rightarrow BaSO_4\downarrow + 2HCl$

d. $2NH_4OH + H_2SO_4 \rightarrow 2H_2O + (NH_4)2SO_4$

Neutralisation

5. **a.** Salt prepared by precipitation

Insoluble salt (double decomposition)

Example – Barium sulphate ($BaSO_4$)

b. Sodium nitrate

Reaction

$$\underset{\text{sodium hydroxide}}{NaOH} + \underset{\text{nitric acid}}{HNO_3} \rightarrow NaNO_3 + \underset{\text{water}}{H_2O}$$

c. Precipitation reaction

$$\underset{\text{barium chloride}}{BaCl_2} + \underset{\text{sodium sulphate}}{Na_2SO_4} \rightarrow \underset{\text{(white ppt)}}{BaSO_4} + \underset{\text{sodium chloride}}{2NaCl}$$

6. **a.** **Iron (III) Chloride:** Iron chloride is formed by direct combination of elements.

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

b. **Potassium sulphate:** By neutralization of KOH with dilute sulphuric acid.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

c. **Iron (II) sulphate:** Iron sulphate is prepared by the action of dilute acid on an active metal.

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

d. **Potassium zincate:** By the action of metals with alkalis.

$Zn + 2KOH \rightarrow K_2ZnO_2 + H_2$

e. **Potassium chloride:** By the neutralization reaction of strong acid with strong base.

$KOH + HCl \rightarrow KCl + H_2O$

V. Application/Skill-based Questions

1. **a.** B, with pH 5.0

b. D with pH 13.2

c. A with pH 1.3

d. C with pH 7.0

2. Acids with replaceable hydrogen

Acidic salts: $NaHSO_4$, $NaHCO_3$, K_2HPO_4, KH_2PO_4

3. The basic salt is formed by the partial replacement of hydroxyl ion (OH^-) of a base by an acidic radical (or anion).

$Cu(OH)Cl$, $Cu(OH)NO_3$, $Pb(OH)Cl$, $Pb(OH)NO_3$

VI. Reasoning/Observation-based Questions

1. a. Brisk effervescence of CO_2 is obtained.

b. A brisk effervescence of CO_2 is obtained.

c. A rotten egg smelling hydrogen sulphide gas is evolved.

d. A burning sulphur like sulphur dioxide gas is evolved.

2.

Salt	Gas evolved with dil. acid
Carbonate	CO_2
Hydrogen carbonate	CO_2
Sulphide	SO_2
Sulphide	H_2S

P. 67–69 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. a. ii. hydrogen sulphide

2. a. Simple displacement: Zinc sulphate

b. Neutralization: Sodium nitrate

c. Decomposition by acid: Sodium hydrogen sulphate

d. Double decomposition: Lead chloride

e. Direct Synthesis: Iron (III) chloride

3. $Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_2 + 2NaNO_3$

2012

1. The blue colour of the copper sulphate solution disappears due to the formation of colourless zinc sulphate.

2.

a. Acid salt	**iii.** Sodium hydrogen sulphate
b. Double salt	**i.** Ferrous ammonium sulphate
c. Ammonium hydroxide solution	**v.** Contains ions and molecules
d. Dilute hydrochloric acid	**ii.** Contains only ions
e. Carbon tetrachloride	**iv.** Contains only molecules

2013

1. a. i. hydronium

ii. hydroxide

b. iii. Salt

iv. Water

c. v. Hydrogen

2. Pungent smelling or rotten eggs like smelling hydrogen sulphide gas is liberated when copper sulphide is treated with dilute hydrochloric acid.

3. Acidic salt

4. a. i. Carbon monoxide

b. iii. Zinc oxide

5. a. Sodium + Dilute Sulphuric Acid to obtain Sodium Sulphate

$2Na + H_2SO_4 \rightarrow Na_2SO_4 + H_2\uparrow$

b. Copper(II) carbonate + Zinc nitrate to obtain Zinc Carbonate

$Zn(NO_3)_2 + Na_2CO_3 \rightarrow ZnCO_3 + 2NaNO_3$

c. Copper(II) carbonate + Dilute Sulphuric acid to obtain Copper(II) Sulphate

$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + CO_2 + H_2O$

d. Iron + Dilute Sulphuric acid to obtain Iron(II) Sulphate

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2\uparrow$

2014

1. a. 1

2. Barium chloride solution after reaction with dilute sulphuric acid forms white precipitate barium sulphate and hydrochloric acid while no effect is seen on dilute hydrochloric acid.

Reaction

$$BaCl_2 + H_2SO_4 \rightarrow \underset{\text{(white ppt.)}}{BaSO_4} + 2HCl$$

3. a. $PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2\uparrow$

$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4\downarrow + 2HNO_3$

b. $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2\uparrow$

c. $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2\uparrow$

2015

1. **a.** Conc. Nitric acid

   b. Sulphuric acid is a strong acid compared to acetic acid. A strong acid has more ionisable hydrogen ions in it. It completely dissociates and produces more free ions in the solution. Acetic acid being a weak acid partially dissociates and produces less ions in the solution. So, electrical conductivity of acetic acid is less compared to sulphuric acid.

   c. i. $2Fe + \underset{\substack{A\\ \text{dry chlorine}\\ \text{gas}}}{3Cl_2} \rightarrow \underset{\substack{\text{iron(III)}\\ \text{chloride}}}{2FeCl_3}$

   ii. $2FeCl_3 + \underset{\substack{B\\ \text{Sodium Carbonate}\\ \text{Solution}}}{3Na_2CO_3} \rightarrow Fe_2(CO_3)_3 + 6NaCl$

   iii. $FeCO_3 + 2HNO_3 \rightarrow Fe(NO_3)_2 + H_2O + CO_2$

2. **a.** Na_2O, MgO

   b. SO_2

   c. Al_2O_3

   d. SiO_2

3. **a.** $ZnCO_3$

   b. $Ca(NO_3)_2$

2016

1. **a. i.** alkaline

   b. i. $Cu + 4HNO_3 \rightarrow Cu(NO_3) + 2\ NO_2\uparrow + 2H_2O$

   ii. $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2\uparrow$

   iii. $H_2SO_4 + \underset{\text{sodium sulphite}}{Na_2SO_3} \rightarrow Na_2SO_4 + H_2O + SO_2\uparrow$

   c. i. When dilute hydrochloric acid is added to lead nitrate solution, insoluble white precipitate of lead chloride is formed. When the mixture is heated, the precipitate dissolves because lead chloride is soluble in water.

   $Pb(NO_3)_2 + 2HCl \rightarrow \underset{\substack{\text{white precipitate}\\ \text{(insoluble salt)}}}{PbCl_2\downarrow} + 2HNO_3$

   ii. $\underset{\substack{\text{barium}\\ \text{chloride}}}{BaCl_2} + \underset{\substack{\text{sodium}\\ \text{sulphate}}}{Na_2SO_4} \rightarrow \underset{\substack{\text{barium}\\ \text{sulphate}\\ \text{(white ppt.)}}}{BaSO_4\downarrow} + \underset{\substack{\text{sodium}\\ \text{chloride}}}{2NaCl}$

   iii. $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2CO_3 \rightarrow CuCl_2 + H_2O + CO_2\uparrow$

   d. i. $Pb(NO_3)_2$ from PbO **3.** Neutralization

   ii. $MgCl_2$ from Mg **1.** Simple displacement

   iii. $FeCl_3$ from Fe **5.** Combination

   iv. $NaNO_3$ from NaOH **2.** Titration

   v. $ZnCO_3$ from $ZnSO_4$ **4.** Precipitation

2017

1. **a.** SO_2

   b. OH^-

2. **c.** an alkali

3. **a.** Rotten egg like smelling hydrogen sulphide gas is evolved.

4. **a.** Zinc carbonate

5. **a.** direct combination

2018

1. **a.** $MgSO_3 + 2HCl \rightarrow MgCl_2 + H_2O + SO_2\uparrow$

2. **a.** Conductivity of dilute hydrochloric acid is greater than that of acetic acid because hydrochloric acid is a strong acid and it dissociates completely in aqueous solution to form H^+ and Cl^- ions (a higher concentration of ions). Acetic acid, on the other hand, is a weak acid and it partially dissociates forming H^+ and CH_3COO^- ions (concentration of ions is low).

3. **a.** Hydrogen sulphide

4. **a.** Solution Q is a weak acid as its pH is 5.2.

   b. Solution R is a strong alkali as its pH is 12.2.

5. **a.** iron(III) chloride

2019

1. **a.** $2NaOH + H_2S0_4 \rightarrow Na_2SO_4 + 2H_2O$

   b. $ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S$

2. **a.** Acid

3. **a.** C (Because pH 7 is neutral).

   b. B (Because acids liberate CO_2 gas when treated with carbonates and acids have pH less than 7).

   c. A (Bases turn red litmus blue and they have pH more than 7).

4. **i. b.** Lead chloride can be prepared by precipitation.

   $Pb(NO_3)_2\ (aq) + 2NaCl\ (aq) \rightarrow PbCl_2\ (s) + 2NaNO^3\ (aq)$

   ii. d. Iron(II) sulphate can be prepared by substitution.

iii. **a.** Sodium nitrate can be prepared by neutralization.

$$2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$$

iv. **c.** Iron(III) chloride can be prepared ny direct combination.

$$2Fe + 3Cl_2 \rightarrow 2FeCl_3$$

2020

1. **a.** low, b. phenolphthalein
2. **a.** Ferric chloride
3. An acid dissociates to furnish H^+ ions and the conjugate base which is negatively charged and a base dissociates to give OH^- ions and a conjugate acid which is positively charged.
4. **i.** Copper sulphate by neutralization.

$$Cu(OH)_2 + H_2SO_4 \rightarrow CuSO_4\downarrow + 2H_2O$$

Copper hydroxide Sulphuric acid Copper sulphate

ii. Zinc carbonate by precipitation.

$$Zn(NO_3)_2\ (aq) + 2NaCO_3\ (aq) \rightarrow Zn(CO_3)_2 + 2NaNO_3\ (aq)$$

Zinc nitrate Sodium carbonate Zinc carbonate

iii. Ammonium sulphate can be prepared by titration of NH_3 solution with dil. H_2SO_4 solution.

$$2NH_4OH\ (aq) + H_2SO_4\ (aq) \rightarrow \underset{\text{white powder}}{(NH_4)_2SO_4} + 2H_2O\ (l)$$

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1. **b.** acid salt
2. **d.** Carbon tetrachloride
3. **c.** H_3PO_4 phosphoric acid
4. **c.** salt and water
5. **c.** Acetic acid
6. **b.** Sodium oxide
7. **a.** strong acid
8. **a.** 3
9. **c.** hydrogen, and a non-metal other than oxygen

CHAPTER – 4

Analytical Chemistry

P. 74 Check Your Progress 1

1. **a.** transition

b. orange

c. $FeCl_2$

d. NH_4OH

e. $Zn(OH)_2$

2. **a.** Cu^{2+} ($CuSO_4$)

b. Pb^{2+} $Pb(NO_3)_2$

c. Fe^{3+} ($FeCl_3$)

3. **a.** $Pb(NO_3)_2 + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2NaNO_3$

b. $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$

c. $2Al + 2KOH + H_2O \rightarrow 2KAlO_2 + 3H_2\uparrow$

d. $Pb(OH)_2 + 2NaOH \rightarrow Na_2PbO_2 + 2H_2O$

e. $Cu(OH)_2 + 4NH_4OH \rightarrow [Cu(NH_3)_4](OH)_2 + 4H_2O$

f. $Zn(OH)_2 + 2KOH \rightarrow\Delta\ K_2ZnO_2 + 2H_2O$

4. **a.** $Pb + \underset{\text{(conc.)}}{2KOH} \rightarrow \underset{\text{potassium plumbite}}{K_2PbO_2} + H_2\uparrow$

b. $Zn(OH)_2 + 2HCl \rightarrow ZnCl_2 + 2H_2O$

c. $2Al + \underset{\text{(conc.)}}{2KOH} + 2H_2O \rightarrow \underset{\text{potassium aluminate.}}{2KAlO_2} + 3H_2\uparrow$

d. $CaCl_2 + 2NH_4OH = Ca(OH)_2 + 2NH_4Cl$

5. If a **light blue** precipitate is formed which is insoluble in excess sodium hydroxide, then the metal cation in the salt solution is copper(II) or cupric.

If a **white gelatinous** precipitate is formed which dissolves in excess sodium hydroxide, then the metal cation in the salt solution can be zinc (Zn^{2+}).

6. If a **white** precipitate is formed which does not dissolve in excess ammonium hydroxide, then the metal cation in the salt solution is lead(II).

$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

$Pb^{2+} + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4^+$

P. 76–80 Exercises

I. Objective Type Questions

A. Choose the correct option.

1. b **2.** b **3.** d **4.** c **5.** c

6. b **7.** a **8.** b **9.** a **10.** c

11. a **12.** b **13.** b **14.** a **15.** d

16. c **17.** d **18.** b **19.** a **20.** b

B. Fill in the blanks.

1. iron(III) or ferric ions

2. light blue

3. inky blue

4. zinc (Zn^{2+})

5. ammonium hydroxide

6. iron(III) or ferrous ion

7. white

8. calcium

9. hydrogen

10. sodium hychoxide

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Hot and concentrated

2. Sodium zincate and hydrogen

3. Sodium plumbite and hydrogen

4. Hydrogen

5. Inky blue

B. Give one example for each of the following.

1. ZnO or PbO or Al_2O_3

2. CaO, K_2O or Na_2O

3. Cu^{2+}

4. NaOH or KOH

5. Cu or Zn

C. Match the following.

1. e **2.** d **3.** b **4.** c **5.** a.

D. Match the given word(s) with its appropriate description.

1. d **2.** c **3.** e **4.** b **5.** a

E. Name each of the following.

1. Sodium hydroxide or potassium hydroxide

2. Ammonium hydroxide

3. Aluminium hydroxide

4. Calcium

5. Lead

6. Ammonium hydroxide and strong alkali - potassium hydroxide

7. Ferrous ion

F. Choose the odd one out.

1. NH_4OH, a weak alkali

2. CaO, a metal oxide; rest are amphoteric oxides

3. $NaPbO_2$

4. Na, rest are amphoteric metals

G. Answer the following questions.

1. Analytical chemistry is a branch of chemistry that deals with the analysis of compounds.
2. Aluminium, zinc and lead hydroxides.
3. Aluminium, zinc and lead as they are amphoteric metals.
4. Inky blue solution of tetraaminecopper(II) ions is formed.
5. Colourless solution of tetraaminezinc(II) ions is formed.
6. With sodium hydroxide, copper forms light blue ppt, which is insoluble in excess NaOH, whereas with excess ammonium hydroxide, copper salt solution forms an inky blue solution of tetraaminecopper (II) ions.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Aluminium, zinc and lead are amphoteric metals.
2. Ferrous ions form dirty green precipitate and ferric ions form reddish-brown precipitate with ammonium hydroxide.
3. As zinc is an amphoteric hydroxide.
4. As it forms water-soluble complex tetraamine-copper(II) ions.
5. Due to the formation of water-soluble complex - tetraaminezinc(II) ions.

B. Differentiate between the following pairs.

1. Ferrous ions form dirty green precipitate whereas ferric ions form reddish-brown precipitate with ammonium hydroxide solution.
2. Copper ions form light blue precipitate with ammonium hydroxide which dissolves when excess of ammonium hydroxide is added, to form inky blue solution whereas zinc forms gelatinous white precipitate which dissolves and forms colourless tetraaminezinc solution with excess of ammonium hydroxide.
3. Lead forms white precipitate with ammonium hydroxide whereas calcium does not form any precipitate with ammonium hydroxide.
4. Zinc forms gelatinous white precipitate with ammonium hydroxide which dissolves and forms colourless solution with excess of ammonium hydroxide whereas lead ions form white precipitate with ammonium hydroxide which does not dissolve on further adding excess of ammonium hydroxide.
5. The blue copper sulphate crystals will form light blue precipitate with sodium hydroxide which does not dissolve in excess sodium hydroxide but with ammonium hydroxide it will form light blue precipitate which further forms inky blue solution on adding ammonium hydroxide in excess.

C. Complete the following tables.

1.

Cation	Solubility in little ammonium hydroxide	Solubility in excess ammonium hydroxide
Fe^{2+}	Dirty green ppt	Insoluble
Fe^{3+}	Reddish brown ppt	Insoluble
Cu^{2+}	Bluish white ppt	Soluble
Zn^{2+}	Gelatinous white ppt	Soluble
Pb^{2+}	White ppt	Insoluble
Ca^{2+}	No ppt	Clear solution

2.

Cation	Solubility in little sodium hydroxide	Solubility in excess sodium hydroxide
Fe^{2+}	Dirty green ppt	Insoluble
Fe^{3+}	Reddish brown ppt	Insoluble
Cu^{2+}	Bluish white ppt	Insoluble
Zn^{2+}	White gelatinous ppt	Soluble
Pb^{2+}	Chalky white ppt	Soluble
Ca^{2+}	white	Insoluble

3.

Cation	Colour	Colour with sodium hydroxide
Copper ions- Cu^{2+}	Blue to green	Light blue insoluble ppt
Ferrous ions - Fe^{2+}	Light green	Dirty green insoluble ppt
Ferrous ions Fe^{3+}	Yellowish brown	Reddish brown insoluble ppt
Zinc ions - Zn^{2+}	Colourless	Gelatinous white ppt, soluble in excess of sodium hydroxide
Lead ions- Pb^{2+}	Colourless	Chalky white ppt, soluble in excess of sodium hydroxide
Calcium ions - Ca^{2+}	Colourless	White ppt, sparingly soluble in excess of sodium hydroxide

D. Write complete and balanced reactions for the following.

1. $ZnO + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2O$
2. $2Al + 2KOH + 2H_2O \xrightarrow{\Delta} 2KAlO_2 + 3H_2\uparrow$
3. $Pb(OH)_2 + 2NaOH \xrightarrow{\Delta} Na_2PbO_2 + 2H_2O$
4. $Pb + 2KOH \xrightarrow{\Delta} K_2PbO_2 + H_2\uparrow$

5. $Al(OH)_3 + NaOH \xrightarrow{\Delta} NaAlO_2 + 2H_2O$

6. $Ca^{2+} + 2NaOH \rightarrow Ca(OH)_2$ (white ppt) + $2Na^+$

7. $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3$ (reddish brown ppt) + $3NaCl$

8. $FeSO_4 + 2NaOH \rightarrow Fe(OH)_2$ (dirty green ppt) + Na_2SO_4

9. $Zn^{2+} + 2NaOH \rightarrow Zn(OH)_2 + 2Na^+$; $Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2(sol) + 2H_2O$

10. $CuSO_4 + NaOH \rightarrow Cu(OH)_2$ (bluish white ppt) + Na_2SO_4

E. Complete and balance the following reactions.

1. $FeSO_4 + 2NH_4OH \rightarrow Fe(OH)_2\downarrow + (NH_4)_2SO_4$
2. $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$
3. $CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$
4. $ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$

F. Answer the following questions.

1. The oxides and hydroxides of certain metals like zinc and aluminium exhibit both basic and acidic behaviour and are called amphoteric oxides.

2. With base: $2Al + 2KOH + 2H_2O \rightarrow 2KAlO_2 + 3H_2\uparrow$

   With acid : $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2\uparrow$

3. With base: $Pb + 2NaOH \rightarrow Na_2PbO_2 + H_2\uparrow$

   With acid : $Pb + H_2SO_4 \rightarrow PbSO_4 + H_2\uparrow$

4. Zincate: ZnO_2^{2-}

   Plumbite: PbO_2^{2-}

   Aluminate: AlO_2^{1-}

5. P - Lead ions, $PbCO_3$ lead carbonate

   R - Ferric ions, $Fe_2(CO_3)_3$ ferric carbonate

6. $Pb(NO_3)_2 + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2NaNO_3$; $Pb^{2+} + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2Na^+$

   Lead(II) hydroxide dissolves in excess sodium hydroxide because it is an amphoteric hydroxide and therefore reacts to form soluble sodium plumbite.

   $Pb(OH)_2 + 2NaOH \rightarrow Na_2PbO_2 + 2H_2O$

7. If on adding sodium hydroxide no precipitate is formed, but a gas is evolved which turns moist red litmus blue and gives dense white fumes with a rod dipped in concentrated hydrochloric acid, then the gas is ammonia and the positive radical in the salt solution is the ammonium radical.

8. Zinc sulphate is colourless and copper sulphate is blue in colour. On adding sodium hydroxide, copper will form light blue ppt whereas zinc will form white gelatinous ppt

IV. Knowledge based questions

1. It is silver chloride [AgCl] dissolves in excess of NH_4OH.

   Product formed is $[Ag(NH_3)_2]Cl$ [Soluble colourless Diamine Argentous(I) chloride]

2. $PbCO_3 + 3NaOH \rightarrow Na[Pb(OH)_3] + Na_2CO_3$

   $ZnCO_3 + 4NaOH \rightarrow Na_2[Zn(OH)_4] + Na_2CO_3$

   $CaCO_3(s) + 2NaOH(aq) \rightarrow Ca(OH)_2(aq) + Na_2CO_3(aq)$

   If chalky white precipitate is formed it would be Pb^{2+}, if white gelatinous precipitate is formed, it would be Zn^{2+} cation and if white precipitate is formed, it would be Ca^{2+} cation.

3. **a.** $CuSO_4$

   i. Dropwise manner

   $CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$

   Light blue

   ii. Excess

   $Cu(OH)_2 + 4NH_4OH \rightarrow [Cu(NH_3)_4](OH)_2 + 4H_2O$

   Inky blue

   b. $FeCl_3$

   i. Dropwise manner

   $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$

   Reddish brown

   ii. Excess

   $Fe^{3+} + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 2NH_4^+$

   Insoluble

   c. $ZnSO_4$

   i. Dropwise manner

   $ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$

   White gelatinous ppt.

   ii. Excess

   $Zn(OH)_2 + 4NH_4OH \rightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$

   colourless solution

4. **a.** Not soluble

   b. Sodium hydroxide

   c. Ammonium hydroxide

5. **a.** Zinc.

   b. Hydrogen

   c. sodium zincate

6. **a.** NaOH

   b. NaOH

   c. KOH

7. **a.** Cu

b. $CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$

8. **a.** PbO [Lead monoxide]

b. Al_2O_3 [Aluminium oxide]

c. Na_2ZnO_2 [Sodium zincate]

9. **a.** $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$

b. $Pb + \underset{\text{(conc.)}}{2KOH} \xrightarrow{\Delta} \underset{\text{potassium plumbite}}{K_2PbO_2} + H_2\downarrow$

c. $Cu(OH)_2 + 4NH_4OH \rightarrow [Cu(NH_3)_4](OH)_2 + 4H_2O$

V. Application and Skill-based Questions

1. Reagent

a.	Ammonium hydroxide	Lead nitrate White insoluble ppt	Zinc nitrate White gelatinous ppt which dissolves on adding excess
b.	Sodium hydroxide	Ferrous nitrate Dirty green ppt	Ferric nitrate Reddish brown ppt
c.	Ammonium hydroxide On adding in excess	Copper sulphate Deep inky blue solution	Zinc sulphate Colourless solution
d.	Sodium hydroxide	Lead nitrate Chalky white ppt which dissolves on adding excess	Calcium nitrate White ppt, sparingly soluble on adding excess
e.	Ammonium hydroxide	Zinc chloride White gelatinous ppt on adding little ammonium hydroxide	Calcium chloride No ppt

2. **1.** Zn^{2+}

2. Mn^{2+}

3. Cr^{3+}

4. Ti^{3+}

5. Fe^{3+}

3. **1.** Pale green lustrous crystals

2. Pale green crystals

3. Yellowish brown powder

4. Pale green powder

4. Complete the table given below.

Cation	Colour
Cu^{2+}	Light (pale) blue to green
Fe^{2+}	Dirty green
Fe^{3+}	Reddish brown
Pb^{2+}	Chalky white
Ca^{2+}	Colourless
Zn^{2+}	White gelatinous

VI. Reasoning/Observation-based Questions

1. **a.** Chalky white ppt is formed which dissolves on adding excess NaOH.

b. Pale blue ppt formed which turns to inky blue solution on adding excess NH_4OH.

c. White gelatinous ppt, is formed which dissolves on adding excess NH_4OH.

d. No ppt formed.

e. Soluble sodium aluminate is formed with bubbles of hydrogen gas, which burns with pop sound.

2. **a.** Zinc

$Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2$ (sodium zincate) + $H_2\uparrow$

b. Lead(II) hydroxide

$Pb(OH)_2 + 2NaOH \xrightarrow{\Delta} Na_2PbO_2$ (sodium plumbite) + $2H_2$

c. Aluminium oxide

$Al_2O_3 + 2NaOH \xrightarrow{\Delta} 2NaAlO_2$ (sodium meta aluminate) + H_2O

d. Tin

$Sn + 2NaOH \xrightarrow{\Delta} Na_2SnO_2$ (sodium stannite) + H_2

e. Zinc oxide

$ZnO + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2$ (sodium zincate) + H_2O

3. **a.** Light blue ppt is formed which is insoluble in excess NaOH.

b. Inky blue solution is formed.

c. Dirty green ppt is formed.

d. White gelatinous ppt is formed which dissolves to a colourless solution in excess NH_4OH.

4. Reddish brown ppt is formed which is insoluble in excess NH_4OH.

P. 80–82 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. **a.** When ammonium hydroxide is first added in a small quantity and then in excess to copper sulphate solution then first a light blue precipitate appears, then the solution turns inky blue.

2. **a.** **ii.** Lead

3. **a.** $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

   b. $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

4.

List X	List Y
a. Pb^{2+}	**iv.** White soluble in excess
b. Fe^{2+}	**iii.** Dirty green
c. Zn^{2+}	**v.** White soluble in excess
d. Fe^{3+}	**i.** Reddish brown
e. Cu^{2+}	**vi.** Blue
f. Ca^{2+}	**ii.** White insoluble in excess.

2012

1. Hydrogen gas evolved
2. State one observation for each of the following.
   - **a.** A white ppt of lead hydroxide is formed which does not dissolve in excess ammonium hychoxide
   - **b.** A reddish-brown ppt of ferric hychoxide is formed which remains insoluble in excess of sodium hydroxide
3. **a.** Cl^- ion

   b. Aqueous ferrous nitrate when treated with NaOH solution gives a dirty green ppt. Which is insoluble in excess sodium hychoxide.

   Aqueous lead nitrate when treated with NaOH solution gives a white ppt which dissolves in excess NaOH.

2013

1. When NaOH solution is added in excess to both the solutions, white precipitate is formed in $Zn(NO_3)_2$ which dissolves in NaOH solution and no such precipitate is formed with $Ca(NO_3)_2$.
2. State two relevant observations for each of the following:
   - **a.** **i.** When NH_4OH is added in small quantity, a bluish white precipitate of copper hydroxide is formed.
     - **ii.** When NH_4OH is added in excess, an inky blue solution of tetraamine copper sulphate is formed.
   - **b.** **i.** When NH_4OH is added in minimum quantities, a white soluble ppt. of $Zn(OH)_2$ is formed.
     - **ii.** When NH_4OH is added in excess, a colourless solution of tetraamine zinc sulphate is formed.

2014

1. Distinguish between the following pairs of compounds using test given within brackets.
   - **a.** Using ammonium hydroxide:

Iron(II) Sulphate	Iron(III) Sulphate
Dirty green precipitate of $Fe(OH)_3$ is formed	Reddish brown precipitate of $Fe(OH)_3$ is formed

   - **b.** Using excess ammonium hydroxide:

Lead Salt	Zinc Salt
White precipitate of $Pb(OH)_2$, insoluble in excess NH_4OH solution, is formed	White gelatinous ppt. of $Zn(OH)_2$, soluble in excess of NH_4OH solution, is formed

2. A white precipitate is obtained which is insoluble in excess of sodium hydroxide.

2015

1. **i.** Zn^{2+} **ii.** Cu^{2+} **iii.** Pb^{2+} **iv.** NH_4^+

2016

1. AgCl
2. **a.** A light blue precipitate is formed and the precipitate dissolves when excess of ammonium hydroxide is added

   $$\underset{\text{Light blue}}{CuSO_4} + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$$

   $$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow Cu(NH_3)_4]SO_4 + 4H_2O$$

   (Excess) Inky blue solution

   b. White gelatinous precipitate of $Zn(OH)_2$ is formed and it dissolves in excess of ammonium hydroxide forming tetraaminezinc complex.

   $$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$$

   $$Zn(OH)_2 + 4NH_4OH \rightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$$

3. **a.** Fe^{3+}

   b. $Pb^{2+.}$

   c. Ca^{2+}

2017

1. **iv.** Copper chloride
2. **a.** Copper
3. **a.** Dirty green precipitate of ferrous hydroxide is formed.

4. a. The blue copper sulphate crystals will form pale blue precipitate with sodium hydroxide and with ammonium hydroxide it will form inky blue solution on adding excess of NH_4OH.

5. a. $ZnCO_3$

2018

1. a. i. calcium nitrate

2. a. $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$

b. $Zn + 2KOH \rightarrow K_2ZnO_2 + H_2$

3. a. $Pb(NO_3)_2 + 2NaOH \longrightarrow Pb(OH)_2\downarrow + 2NaNO_3$

$Pb(OH)_2 + 2NaOH \longrightarrow Na_2PbO_2 + 2H_2O$

4. a. Lead nitrate with ammonium hydroxide will form chalky white ppt which will not dissolve even on adding excess of ammonium hydroxide. Whereas zinc nitrate will form a white gelatinous ppt which will dissolve on adding excess of ammonium hydroxide.

2019

1. a. $FeSO_4 + 2NH_40H \rightarrow (NH_4)SO4 + Fe(OH)_2\downarrow$

2. $FeSO_4 + 2NaOH \rightarrow Fe(OH)_2\downarrow$ (dirty green ppt) + Na_2SO_4 $Fe_2(SO_4)_3 + 6NaOH \rightarrow 2Fe(OH)_3\downarrow$ (reddish brown ppt) + $3Na_2SO_4$

3. Light blue

2020

1. a. The light blue ppt formed will dissolve to form inky blue solution of tetraamminecopper (II) ions.

2. a. A chalky white ppt is formed which remains insoluble:

$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

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1. c. reddish brown

2. d. excess of ammonium hydroxide

3. b. NH^{4+}

4. a. calcium nitrate

Chapter – 5

Mole Concept and Stoichiometry

P. 87 Check Your Progress 1

1. $2NO + O_2 \rightarrow 2NO_2$

$2NO = 2NO_2$

$2 : 2$ ratio

$100\ cm^3 = 100\ cm^3$

Since NO and NO_2 are in 2 : 2 ratio.

$\therefore$ Volume of NO_2 formed will be $100\ cm^3$.

Alternatively

$O_2 = 2NO_2$

$1 = 2$

$50\ cm^3 = 100\ cm^3$

Same answer because O_2 and NO_2 are in 1 : 2 ratio.

2. $2CO + O_2 \rightarrow 2CO_2$

$2CO = 2CO_2$

$2 : 2$

$\therefore \quad 200\ cm^3 = x$

$$x = \frac{200 \times 2}{2}$$

$x = 200\ cm^3$

Volume of CO_2 formed = $200\ cm^3$

$2CO = O_2$

$2 : 1$

$200\ cm^3 = x$

$$x = \frac{200 \times 1}{2}$$

$x = 100\ cm^3$

Only $100\ cm^3$ of O_2 is used, so volume of oxygen left = $100\ cm^3$

3. a. $2H_2 + O_2 \rightarrow 2H_2O$ (steam)

$2H_2 = 2H_2O$

$2 : 2$

$22.4\ L = x$

$$x = \frac{2 \times 22.4}{2}$$

$x = 22.4\ L$

Volume of steam = 22.4 L

b. $2H_2 = O_2$

$2 : 1$

$22.4\ L = x$

$$x = \frac{22.4}{2}$$

$x = 11.2\ L$

Volume of oxygen used up = 11.2 L

Volume of unused oxygen = 22.4 – 11.2 = 11.2 L

Steam at room temperature changes to liquid.

4. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

C_3H_8 (propane) $= 5O_2$

$22400\ cm^3 = 5 \times 22400\ cm^3$

$x = 100\ cm^3$

$$x = \frac{22400 \times 100}{5 \times 22400}$$

$x = 20\ cm^3$

Volume of propane used = $20\ cm^3$

P. 94 Check Your Progress 2

1. Number of moles = $\dfrac{\text{weight in gram (mass)}}{\text{M wt}}$

Mass = moles × M wt

$= 0.2 \times 18$

$= 3.6$ g ($H_2O = 2 + 16 = 18$)

Mass of water = 3.6 g

2. $7\ L\ O_2 = 10\ g$

$22.4\ L\ O_2 = x$

$$x = \frac{22.4 \times 10}{7} = 32\ g$$

Molecular mass of O_2 = 32 g

3. $N_2 = 2N$

$= 2 \times 14$

$= 28$

$28\ g\ N_2 = 22.4\ L$

$2.8\ g = x$

$$x = \frac{2.8 \times 22.4}{28 \times 100} = 22.4\ L$$

Volume of N_2 = 2.24 L

4. a. 22.4 L

b. $Cl_2 = 2 \times (Cl)$

$= 2 \times 35.5$

$= 71\ g$

P. 97 Check Your Progress 3

1. 32
2. It means that carbon dioxide is 22 times heavier than an atom of hydrogen.
3. 35.5
4. Molecular mass of gas A = 4 and the molecular mass of gas B = 10
5. 22 kg

P. 98 CHECK YOUR PROGRESS 4

1. Percentage of Aluminium in cryolite (Na_3AlF_6) = ?

Relative molecular mass

$= 3 (Na) + Al + 6 (F)$

$= 3 \times 23 + 27 + 6 \times 19$

$= 69 + 27 + 114 = 210$

$$\text{Percentage of Aluminum} = \frac{\text{Mass of Al}}{\text{Relative mol. mass}} \times 100$$

$$= \frac{27}{210} \times 100$$

$$= \frac{270}{21}$$

$= 12.857\%$

2. Percentage of oxygen in ethanol (C_2H_5OH) = ?

Relative molecular mass of C_2H_5OH

$= 2 (C) + 5 (H) + O + H$

$= 2 \times 12 + 5 \times 1 + 16 + 1$

$= 24 + 5 + 16 + 1$

$= 46$

$$\text{Percentage of oxygen} = \frac{\text{Mass of oxygen}}{\text{Relative mol. mass}} \times 100$$

$$= \frac{16}{46} \times 100$$

$$= \frac{1600}{46}$$

$= 34.78\%$

3. Percentage of nickel in nickel sulphate ($NiSO_4$) = ?

Relative molecular mass

$= Ni + S + (4) O$

$= 59 + 32 + 4 \times 16$

$= 59 + 32 + 64$

$= 155$

$$\text{Percentage of Nickel} = \frac{\text{Mass of Nickel}}{\text{Relative mol. mass}} \times 100$$

$$= \frac{59}{155} \times 100$$

$$= \frac{5900}{155}$$

$= 38.06\%$

4. Percentage of water of crystallization in green vitriol ($FeSO_4 \cdot 7H_2O$) = ?

Relative molecular mass

$= Fe + S + 4 (O) + 7 (H_2O)$

$= 56 + 32 + 4 \times 16 + 7 \times 18$

$= 56 + 32 + 64 + 126$

$= 278$

$$\text{Percentage of water} = \frac{\text{Mass of water of crystallisation}}{\text{Relative mol. mass}} \times 100$$

$$= \frac{126}{278} \times 100$$

$$= \frac{12600}{278}$$

$= 45.32\%$

5. Percentage of water of crystallization in alum ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$) = ?

Relative molecular mass

$= 2\,K + S + 4 \times O + 2 \times Al + 3\,(S + 4 \times O) + 24\,(H_2O)$

$= 2 \times 39 + 32 + 4 \times 16 + 2 \times 27 + 3\,(32 + 4 \times 16) + 24 \times 18$

$= 78 + 32 + 64 + 54 + 3\,(32 + 4 \times 16) + 432$

$= 228 + 288 + 432$

$= 948$

$$\text{Percentage of water} = \frac{\text{Mass of water of crystallisation}}{\text{Relative mol. mass}} \times 100$$

$$= \frac{432}{948} \times 100$$

$$= \frac{43200}{948}$$

$= 45.57\%$

6. 62.94% (use the similar method as done above)

P. 100 CHECK YOUR PROGRESS 5

1.

Element	%	At. wt.	Relative ratio	Simplest ratio
Na	14.13	23	$\frac{14.13}{23} = 0.62$	$\frac{0.614}{0.311} = 2$
S	9.97	32	$\frac{9.97}{32} = 0.311$	$\frac{0.311}{.311} = 1$
H	6.22	1	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.311} = 20$
O	69.5	16	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.311} = 14$

∴ E.F. = Na : S : H : O

= 2 : 1 : 20 : 14

= $Na_2SH_{20}O_{14}$

Since all hydrogen is present as water of crystallisation.

∴ There are $10H_2O$ molecules.

Atoms of O left 14 – 10 = 4.

Thus molecular formula = $Na_2SO_4 \cdot 10H_2O$

2.

Element	%	At. wt.	Relative ratio	Simplest ratio
N	35	14	$\frac{35}{14} = 2.5$	$\frac{2.5}{2.5} = 1 \times 2 = 2$
H	5	1	$\frac{5}{1} = 5$	$\frac{5}{2.5} = 2 \times 2 = 4$
O	60	16	$\frac{60}{16} = 3.75$	$\frac{3.75}{2.5} = 1.5 \times 2 = 3$

∴ E.F. = N : H : O

= 2 : 4 : 3

(A) = $N_2H_4O_3$

Element	%	At. wt.	Relative ratio	Simplest ratio
N	63.63	14	$\frac{63.63}{14} = 4.54$	$\frac{4.54}{2.27} = 2$
O	36.37	16	$\frac{36.37}{16} = 2.27$	$\frac{2.27}{2.27} = 1$

∴ E.F. = N : O

= 2 : 1

(B) = N_2O

The compound A is ammonium nitrate because it forms nitrous oxide. NH_4NO_3

3.

Element	At. wt.	Relative ratio	Simplest ratio
C	12	9	9/12 = 0.75 = 3
H	1	1	1/1 1 = 4
N	14	3.5	3.5/14 0.25 = 1

Empirical Formula = C_3H_4N

Empirical Weight = 36 + 4 + 14 = 54.

Atomic Weight = 108

Multiplication factor = n

$$= \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

$$= \frac{108}{54} = 2$$

Molecular formula = (Empirical formula) n

$= (C_3H_4N)_2$

$= (C_6H_8N_2)$

4.

Element	%	At. wt.	Relative ratio	Simplest ratio
C	12.8	12	$\frac{12.8}{12} = 1.06$	$\frac{1.06}{1.06} = 1$
H	2.1	1	$\frac{2.1}{1} = 2.1$	$\frac{2.1}{1.06} = 1.98$
Br	85.1	80	$\frac{85.1}{80} = 1.06$	$\frac{1.06}{1.06} = 1$

∴ E.F. = C : H : Br

= 1 : 2 : 1

= CH_2Br

119 cc occupies 1g

$$\therefore \text{ 22400 cc occupies } = \frac{1}{119} \times 22400 = 188$$

∴ M wt = 188

E.F. wt = CH_2Br = 12 + 2 + 80 = 94

$$\therefore \quad \eta = \frac{\text{E.F. wt}}{\text{M wt}} = \frac{188}{94} = 2$$

∴ M.F. = $\eta \times$ E.F.

= 2 × CH_2Br = $C_2H_4Br_2$

5. Wt of the carbohydrate = 310

Wt of carbon left = 124

∴ Wt of H_2O vap. = 310 – 124 = 186

18 g H_2O = 1 mole of H_2O

186 g = x

$$x = \frac{186}{18} = 10 \text{ moles}$$

$10H_2O$ moles represent H & O in 20 : 10 ratio.

Residue left 124 (carbon)

12 g = 1 C mole

124 g = x

$$x = \frac{124}{12} = 10$$

∴ Relative ratio of C, H & O is 10 : 20 : 10 = 1 : 2 : 1

∴ E.F. = CH_2O

P. 103 CHECK YOUR PROGRESS 6

1. a. $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

M wt = 164 g

$2Ca(NO_3)_2 = 4NO_2$

2 × 164 g = 4 × 22.4 L

16.4 g = x

$$x = \frac{16.4 \times 4 \times 22.4}{164 \times 2 \times 100} = \frac{448}{100}$$

x = 4.48 L

Volume of liberated NO_2 = 4.48 L

b. $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

$2 \times 164\ g = 2 \times 56\ g$

$16.4\ g = x$

$x = \frac{16.4 \times 2 \times 56}{2 \times 64 \times 10} = \frac{56}{10}$

$x = 5.6\ g$

Weight of cal. oxide (CaO) obtained = 5.6 g

2. a. $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$

M wt of $NH_4Cl = N + 4H + Cl$

$= 14 + 4 \times 1 + 35.5$

$= 14 + 4 + 35.5$

$= 53.5\ g$

M wt of $CaCl_2 = Ca + 2Cl$

$= 40 + 2 \times 35.5$

$= 40 + 71$

$= 111\ g$

$2NH_4Cl = CaCl_2$

$2 \times 53.5 = 111$

$53.5 = x$

$x = \frac{111 \times 5.35}{2 \times 53.5} = 5.5\ g$

$x = 5.5\ g$

Amount of $CaCl_2$ formed = 5.5 g

b. $2NH_4Cl = 2NH_3$

$2 \times 53.5\ g = 2 \times 22.4\ L$

$53.5\ g = x$

$x = \frac{5.35 \times 2 \times 22.4}{2 \times 53.5 \times 100} = \frac{220}{100}$

$x = 2.24\ L$

Volume of ammonia liberated = 2.24 L

3. $Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$

M wt of $Al_4C_3 = 4Al + 3C$

$= 4 \times 27 + 3 \times 12$

$= 108 + 36 = 144$

$Al_4C_3 = 3CH_4$

$144 = 3 \times 22.4\ L$

$14.4 = x$

$x = \frac{3 \times 22.4 \times 14.4}{144 \times 100} = \frac{672}{100}$

$x = 6.72\ L$

Volume of methane liberated = 6.72 L

4. a. $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

M wt of $FeS_2 = Fe + 2S$

$= 56 + 2 \times 32$

$= 56 + 64$

$= 120\ g$

$FeS_2 = 2S$

$120\ g = 64\ g$

$30\ g = x$

$x = \frac{30 \times 64}{120}$

$x = 16\ g$

30 g of FeS_2 has 16 g of S.

b. $4FeS_2 = 8SO_2$

$4 \times 120 = 8 \times 22.4\ L$

$30\ g = x$

$x = \frac{30 \times 8 \times 22.4}{2 \times 120} = \frac{22.4}{2}$

$x = 11.2\ L$

30 g of FeS_2 will form 11.2 L of SO_2 at STP.

5. a. $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

$2H_2S = 2SO_2$

[M wt of $SO_2 = S + 2(O) = 32 + 2 \times 16 = 32 + 32 = 64$]

$2 \times 22.4\ L = 2 \times 64\ g$

$x = 12.8\ g$

$x = \frac{2 \times 22.4 \times 12.8}{2 \times 64 \times 100} = \frac{448}{100}$

$x = 4.48\ L$

Volume of H_2S needed is 4.48 L.

b. $2H_2S = 3O_2$

$2 \times 22.4\ L = 3 \times 22.4\ L$

$4.48\ L = x$

$x = \frac{4.48 \times 3 \times 22.4}{2 \times 22.4}$

$x = 6.72\ L$

Volume of oxygen needed = 6.72 L

6. $(NH_4)_2Cr_2O_7 \rightarrow N2 + Cr_2O_3 + 4H_2O$

M wt of $(NH_4)2Cr_2O_7 = 2(N) + 8H + 2Cr + 7(O)$

$= 2 \times 14 + 8 \times 1 + 2 \times 52 + 7 \times 16$

$= 28 + 8 + 104 + 112$

$= 252$

$(NH_4)_2Cr_2O_7 = N_2$

$252 = 22.4\ L$

$63 = x$

$x = \frac{22.4 \times 63}{252} = \frac{22.4}{4}$

$x = 5.6$ L

Volume of N_2 liberated = 5.6 L

EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. d	**2.** a	**3.** b	**4.** d	**5.** a
6. c	**7.** a	**8.** b	**9.** a	**10.** c
11. d	**12.** c	**13.** d	**14.** b	**15.** a
16. d	**17.** c	**18.** a	**19.** b	**20.** b

B. Fill in the blanks.

1. empirical
2. empirical
3. molecular
4. element
5. similar
6. heavier
7. mass
8. volumes
9. changes
10. are not

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Vapour density
2. Relative atomic mass
3. Relative molecular mass
4. Gram atomic mass
5. Gram molecular mass

B. Give one example for each of the following.

1. O^{17}, O^{18}
2. Cl^{35}, C^{l3}
3. Kelvin
4. 10^5 Pa
5. 0 °C or 273.15K

C. Match the following.

1. e **2.** d **3.** b **4.** a **5.** c

D. Match the given word(s) with its appropriate description.

1. d **2.** e **3.** a **4.** b **5.** c

E. Choose the odd one out.

1. O^8 **2.** Pa

3. K **4.** temperature

F. Answer the following questions.

1. 2:7:4:6
2. Gay Lussac
3. Molecular mass = 2 × VD
4. Ionic compounds
5. Molecular formula = $n \times$ empirical formula

III. Short Answer Type Questions

A. Give reasons for the following.

1. Due to change in temperature, gaseous state changes to liquid or gas.
2. The relative atomic mass is a ratio and therefore it has no unit.
3. For the substances containing ions, i.e. for ionic compounds, the term formula unit mass is used instead of molecular mass as ionic compounds exist as a cluster of ions and not as molecules.
4. Atomic mass of an element may be fractional. This is due to the presence of isotopes of the element. The isotopes of a particular element differ in their atomic masses
5. The mass of an atom is actually very small because atoms are extremely small. Numbers are so small that it is difficult to use. Therefore, instead of using actual masses, relative atomic masses are used.

B. Differentiate between the following pairs.

1. Relative atomic mass	**Relative molecular mass**
It is the mass of the atoms heavier than 1/12th C-12 atom. e.g., Relative atomic mass for oxygen atom is 8	It is the mass of the molecules heavier than 1/12th C-12 atom. e.g., Relative molecular mass of oxygen molecule O_2 is 32.
2. Empirical formula	**Molecular formula**
The simplest formula of a substance which gives the relative number of atoms of each element present in a molecule of the substance. e.g., for molecular formula C_2H_4, empirical formula is CH_2.	A symbolic representation of a molecule of a compound in terms of symbol and actual number of atoms of each element present in one molecule of the compound. e.g., C_2H_4 is a molecular formula.
3. Vapour density	**Molecular mass**
The ratio between the mass of a certain volume of the gas to the mass of the same volume of hydrogen gas under similar conditions of temperature and pressure. It is half of molecular mass. Molecular mass = 2 x VD	Molecular weight is the ratio of the mass of one molecule of a gaseous substance to the weight of one atom of hydrogen.
4. Gram atomic mass	**Gram molecular mass**
It is relative atomic mass expressed in grams.	It is relative molecular mass expressed in grams.

C. Complete the following table using the given information: Atomic mass

H = 1, C = 12, O = 16, N = 14, S = 32, Cl = 35.5, Na = 23, Al = 27

S. No	Molecular formula	Relative molecular mass
1.	H_2O	18
2.	SO_2	64
3.	H_2S	34
4.	H_2SO_4	98
5.	NO_2	46
6.	HCl	36.5
7.	HNO_3	63
8.	CO_2	44
9.	H_2CO_3	62
10.	$Al(OH)_3$	78

D. Numerical questions

Based on Gay-Lussac's Law of combining volumes

1. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1: 2: 1 : 2

1 × 400 mL methane forms 1× 400 mL CO_2 and 2 × 400 mL water vapour.

Thus, 800 mL water vapour is formed.

2. $C + O_2 \rightarrow CO_2$

1: 1: 1

Thus, 1 × 225 mL of gas carbon will form 1 × 225 mL of CO_2.

3. $H_2 + Cl_2 \rightarrow 2HCl$

1 : 1 : 2

18 L 17.6 L

17.6 L of chlorine will form 2 × 17.6 L of HCl.

18.0 – 17.6 L of hydrogen will be left behind.

Thus, resulting mixture will be:

0.4 L hydrogen and 35.2 L of HCl.

4. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

2 : 5 : 4 : 2

2 vol of ethyne will produce 4 vol of CO_2.

Thus, 2 L of ethyne will produce 4 L CO_2.

5. $H_2 + Cl_2 \rightarrow 2HCl$

1 vol : 1 vol : 2 vol

6 L : 4 L : will form 2 × 4 = 8 L of HCl.

6 – 4 = 2 L of hydrogen will be left behind.

Based on vapour density, empirical formula and relative molecular mass

6.

Element	Percentage	Relative ratio	Simplest ratio
C = 12	20	20/12 = 1.67	1.67/1.66 =1
H = 1	6.7	6.7/1 = 6.7	6.7/1.66 = 4
N = 14	46.67	46.47/14 = 3.33	3.33/1.66 = 2
O = 16	26.63	26.63/16	1.66/1.66 = 1

Empirical formula = $C_1H_4N_2O_1$

Empirical formula mass = C + 4(H) + 2(N) + O = 12 + 4 + 28 + 16 = 60

Molecular mass = 2 × V.D. = 2 × 60 = 120

Multiplication factor = n = Molecular mass/ Empirical formula mass

= 120/60 = 2

Thus, molecular formula = $C_2H_8N_4O_2$

7.

Element	Percentage	Relative ratio	Simplest ratio
C = 12	54.55	54.55/12= 4.54	4.54/2.27=2
H = 1	9.09	9.09/1 = 9.09	9.09/2.27 = 4
O = 16	36.36	36.36/16= 2.27	2.27/2.27 = 1

Empirical formula = $C_2H_4O_1$

Empirical formula mass = 2C + 4(H) + 1O = 24 + 4 + 16 = 44

Molecular mass = 2 × V.D. = 2 × 44 = 88

Multiplication factor = n = Molecular mass/

Empirical formula mass = 88/44 = 2

Thus, molecular formula is $C_4H_8O_2$

8. VD = 60

Molecular weight = 2 × V.D.

= 2 × 60 =120

Empirical formula = CH_3

Empirical formula mass = C + 3(H) = 12 + 3 = 15

Molecular mass = 2 × V.D. = 2 × 60 = 120

Multiplication factor = n = Molecular mass/ Empirical formula mass = 120/15 = 8

Thus, molecular formula will be 8 x CH_3 = C_8H_{24}

9.

Element	Percentage	Relative ratio	Simplest ratio
Na = 23	14.13	14.13/23 = 0.614	0.614/0.311 = 2
H = 1	6.22	6.22/1 = 6.22	6.22/0.311 = 20
S = 32	9.97	9.97/32 = 0.311	0.311/0.311 = 1
O = 16	69.50	69.50/16 = 4.34	4.34/0.311 = 13.95 = 14

Empirical formula = $Na_2H_{20}S_1O_{14}$

10.

Element	Percentage	Relative ratio	Simplest ratio
C = 12	68.84	68.84/12 = 5.74	5.74/1.64 = 3.5
H = 1	4.92	4.92/1=4.92	4.92/1.64 = 3
O = 16	100 – (68.84 + 4.92) = 26.24	26.24/16 = 1.64	1.64/1.64 = 1

Since the empirical formula is in whole number, multiply the values by 2.

Empirical formula = $2(C_{3.5}H_3O_1)$

= $C_7H_6O_2$

Based on percentage composition

11. Molecular mass of $CaCO_3$ = 40 + 12 + 48 = 100

%age of Ca = (40/100) × 100; 40%

12. Molecular mass of H_2SO_4 = 2 + 32 + 64 = 98

%age of S = (32/98) × 100; 32.65%

13. Molecular mass of CO_2 = 12 + 32 = 44

%age of carbon = 12/44 × 100 = 27.27%

14. Molecular mass of $Mg_3(PO_4)_2$ = 3 × 24 + 2(31 + 64) = 262 % of Mg = 72/262 ×100 = 27.48%

15. Molecular mass of $CuSO_4.5H_2O$ = 63.5 + 32 + 64 + 5 x 18 = 249.5 = 90/249.5 x 100 = 36.07%

Based on mole concept

16. 32 g of sulphur contains 6.022×10^{23} atoms of sulphur. 50 g of sulphur contains $6.022 \times 10^{23} \times 50/32$ atoms = 9.409×10^{23} atoms. 8 atoms of sulphur are present in 1 molecule of sulphur. 9.409×10^{23} atoms of sulphur are present in $9.409 \times 10^{23}/8$ molecules = 1.176×10^{23} molecules of sulphur.

17. 100 g of chlorophyll contains 2.7 g of magnesium. 1 g of chlorophyll contains 0.027 g of magnesium. 1 mole of Mg = 24 g of magnesium = 6.022×10^{23} atoms of magnesium. 2.7×10^{-2} g of magnesium contains $6.022 \times 10^{23} \times 2.7 \times 10^{-2}/24 = 6.77 \text{ x } 10^{20}$ atoms of magnesium.

18. Number of moles of CO_2 in 88 g of CO_2 = Mass of CO_2/Molar mass of CO_2

= 88 g/44 g mol^{-1}

= 2 mol

Since 1 mole of CO_2 contains two moles of oxygen atoms, two moles of CO_2 contain four moles of oxygen atoms.

Hence, 1 mole of oxygen atoms contains $6.022 \text{ x } 10^{23}$ oxygen atoms.

4 moles of oxygen atoms contain

$6.022 \times 10^{23} \times 4 = 2.4088 \times 10^{24}$ oxygen atoms. Since 1 mole of oxygen atoms is present in 1 mole of CO 4 moles of oxygen atoms are present in 4 moles of CO.

Mass of 4 moles of CO = Number of moles of CO × gram-molecular mass of CO

= 4 × (12 + 16)g = 112 g

19. **a.** Given: Mass of oxygen gas = 12 g

Molar mass of oxygen gas = 2 × 16 g mol^{-1} = 32 g mol^{-1}

No. of moles of oxygen gas = Mass of oxygen gas/Molar mass of oxygen gas = 12 g/32 g mol^{-1}

= 12/32 mol

= 0.375 mol of oxygen gas. Hence, 12 g of oxygen gas is equal to 0.375 mole of oxygen gas.

b. Given: Mass of water = 20 g

Molar mass of water (H_2O) = (2 × 1 g mol^{-1} + 1 × 16 g mol^{-1}) = 18 g mol^{-1}

No. of moles of water = Mass of water/Molar mass of water = 20 g /18 g mol^{-1} = 1.11 mol.

Hence, 20 g of water is equal to 1.11 moles of water.

c. Given: Mass of carbon dioxide = 22 g

Molar mass of CO_2 = (1 × 12 g mol^{-1} + 2 × 16 g mol^{-1}) = 44 g mol^{-1}

No. of moles of carbon dioxide = Mass of carbon dioxide/Molar mass of carbon dioxide

= 22 g/44 g mol^{-1}

= 0.5 mole

Hence, 22 g of carbon dioxide is equal to 0.5 mole of carbon dioxide.

20. 1 mole of oxygen atoms = 6.022×10^{23} oxygen atoms.

2.6×10^{24} oxygen atoms contain

= $1/6.022 \times 10^{23} \times 2.6 \times 10^{24}$ = 4.32 moles

21. Number of moles = mass of substance/molecular mass of substance

a. Mol. mass of NaOH = 23 + 1 + 16 = 40

Moles = 160/40 = 4 moles of NaOH

b. Mol. mass of CO_2 = 12 + 2 × 16 = 44

Moles = 88/44 = 2 moles of CO_2

c. Mol. mass of CH_4 = 12 + 4 × 1 = 16

Moles = 3.2/16 =0.2 moles of CH_4

d. Mol. mass of NH_3 = 14 + 3 × 1 = 17

Moles = 340/17 = 20 moles of NH_3

22. Number of molecules = moles × 6.022 × 10^{23} Therefore, 10 × 6.022 × 10^{23} = 6.022 × 10^{24}

23. Number of molecules = moles × 6.022 × 10^{23} Number of molecules = mass/mol. mass × 6.022 × 10^{23}

Mol. mass of NaOH = 40

= 320/40 × 6.022 ×10^{23}

= 48.176 × 10^{23}

24. Volume occupied: 44 g of CO_2 occupies

22.4 L vol

1 g will occupy 22.4/44 L vol

4.4 g will occupy 22.4/44 x 4.4 = 2.24 L vol.

25. Vapour density x 2 = mol. wt

Therefore, Mol. mass = 2 x 22 = 44 g

Now, 44 g of substance A occupies 22.4 L volume

1 g will occupy 22.4/44

2.2 g will occupy 22.4/44 x 2.2 = 1.12 L volume.

E. Define each of the following.

1. Atomicity: Atomicity is defined as the number of atoms in one molecule of an element.
2. Vapour density: It is the ratio of the mass of a certain volume of a gas or vapour to the mass of an equal volume of hydrogen; all measurements made under the same conditions of temperature and pressure.
3. Empirical formula: It is the simplest formula of a substance which gives the relative number of atoms of each element present in a molecule of the substance.
4. Relative atomic mass: It is the ratio of the mass of an atom of an element to 1/12th the mass of an atom of carbon-12.
5. Relative molecular mass: It is the ratio of the mass of one molecule of a substance to 1/12th the mass of an atom of carbon-12.

F. Questions on masses of combining elements

1. Molar mass of KNO_3 = 39 + 14 + 3 × 16 = 101

K% = (mass of K/total mass of KNO_3) x 100

= (39 × 100)/101 = 38.61%

K_3PO_4 molar mass = 3 × 39 + 31+ 4 × 16 = 212

K% =(mass of K/total mass of K_3PO_4) × 100

= (3 × 39/212)× 100 = 55.18%

Thus, K_3PO_4 is a better fertilizer for potassium as it has 55.18% of potassium.

2. Molar mass of NH_2CONH_2 = 14 + 2 + 12 + !6 +14 + 2 = 60

N% = (2 × 14/60)100 = 46.66%

Molar mass of NH_4NO_3 = 14 × 2 + 1 × 4 + 3 × 16 = 80

N% = 28/80 × 100 = 35%

Molar mass of $(NH_4)_3PO_4$ = 3(14 + 4)+ 31 + 4 × 16 = 149

N% = 42/149×100 = 28.81%

Thus, urea is a better fertilizer for nitrogen as it has 46.66% nitrogen.

3. Molar mass of CO = 12 + 16 = 28

Molar mass of CO_2 = 12 + 2 × 16 = 44

O% = mass of O/total mass of substance CO × 100

O% = 16/28 × 100 = 57.14%

O% in CO_2 = 32/44 × 100 = 72.27%

4. Molar mass

a. H_2SO_4 = 2 + 32 + 64 = 98

b. H_2S = 2 + 32 = 34

c. $Na_2CO_3.10H_2O$ = 23 × 2 + 12 + 3 × 16 + 10(2 + 16) = 288

d. CH_4 = 12 + 4 = 16

5. $CaCO_3 \rightarrow CaO + CO_2$

Mol. mass of $CaCO_3$ = 40 + 12 + 3 × 16

= 40 + 60 = 100

Mol. mass of CaO = 40 + 16 = 56

By unitary method: 100 g of $CaCo_3$ will burn to give 56 g CaO

1 g of $CaCo_3$ will burn to give $\frac{56}{100}$g CaO

200 g of $CaCo_3$ will produce $\frac{56}{100} \times 200$ = 112 g of CaO.

G. Answer the following questions.

1. When gases react, they do so in volumes which bear a simple whole number ratio to one another and to the volume of the product if gaseous, provided all the volumes are measured at the same temperature and pressure.
2. The volume of a gas changes with change in temperature and pressure. In order to compare the volume of gases, standard conditions of temperature and pressure are employed. Standard temperature = 0°C or 273 K and Standard pressure = 10^5 Pa.

3. This law is applicable only to gases and therefore solid and liquid reactants and products are not considered for chemical calculations even if they are a part of the reaction.
4. The relative mass of sodium is 23 amu which means that one atom of sodium is 23 times heavier than an atom of hydrogen.
5. The atomicity of an element is the number of atoms present in a molecule of a gas.
   - The molecules of noble gases contain only one atom. So noble gases are termed monoatomic.
   - The molecules of gases like oxygen and hydrogen contain two atoms. Therefore, oxygen and nitrogen molecules are termed diatomic.
   - The molecules of ozone contain three atoms. Hence, it is triatomic.
6. The volume occupied by one mole of gas at STP is the molar volume.
7. 6.022×10^{23}
8. Avogadro's law: Equal volumes of all gases at the same temperature and pressure contain the same number of molecules.
9. The mole is the standard chemical unit used to measure the quantity of a substance in terms of number and mass. In general, one mole is amount of a substance which contains as many entities (atoms, ions or molecules) as there are atoms in 0.012 kg or 12 g of carbon-12 isotope. The mole is equal to 6.022×10^{23} particles (atoms, molecules, or ions) of a substance.
10. Number of moles = mass of substance/ molecular mass of substance

IV. Knowledge-based Questions

1. The term 'stoichiometry' is derived from two Greek words 'Stoicheion' meaning element and 'metron' meaning to measure. The term is generally used for referring to the calculation of quantities of substances involved in chemical reactions.
2. According to the law of combining volumes, 2 parts by volume of hydrogen combine with 1 part by volume of oxygen to form 2 parts by volume of steam.

   $2H_2 + 1O_2 \rightarrow 2H_2O$

   2 : 1 : 2
3. Limiting reagent Substances that are totally consumed during the course of a chemical reaction are known as limiting reagents. They're also called limiting reactants or limiting agents.
4. The mass percentage of each constituent element present in any compound is called its percentage composition. Percentage of an element in a compound = (Total mass of the element in one molecule of a compound/Gram molecular mass of the compound) ×100
5. **Steps:**
   - **a.** Write down the molecular formula of the compound and calculate its gram molecular mass.
   - **b.** Calculate the mass of each element present in the molecule of the compound by multiplying the atomic mass of that element by the number of atoms in the molecule.
   - **c.** Calculate the percentage of each element by using the formula:

     %age of an element = (Total mass of element in one molecule of a compound/ Gram molecular mass of the compound) × 100

V. Application and Skill-based Questions

1. Mol. wt = 2 × vapour density

   Mol. wt of $CO_2 = 12 + 2 \times 16 = 44$

   44/2 = V.D. Or

   V.D. = 22
2. V.D. of H_2S = 17, then its molecular mass will be 2 × V.D. or 2 × 17 = 34
3. The volume of air and that of hydrogen must be equal.

   Using Unitary method: 0.525 L of air weighs 0.678 g.

   Let 22.40 L of air weigh x.

   $\therefore$ x = (22.40 × 0.678)/0.525 × = 28.92 g

   V.D. = Mass of air/Mass of equal volume of hydrogen

   V.D. = 28.92/1 or V.D. = 28.92
4. V.D. = Mass of a certain volume of gas/Mass of the same volume of hydrogen

   V.D. = 135/4.22

   V.D. = 31.99

   Molecular weight = 2 × V.D.

   = 2 × 31.99 = 63.98 g

5.

Element	Percentage	Relative ratio	Simplest ratio
M	70	70/56 = 1.25	1.25/1.25 = 1
O	30	30/16 = 1.875	1.875/1.25 = 1.5

On multiplying by 2

M 1 × 2;

O = 1.5 × 2

Empirical formula is M_2O_3

VI. Reasoning/Observation-based Questions

1.

Element	Na	C	O
Percentage	43.3	11.3	45.4
Atomic mass	23	12	16
Relative ratio	43.3/23	11.3/12	45.4/16 = 2.84
Simplest ratio	1.88	0.94	2.84
Empirical formula	1.88/0.94	0.94/0.94	2.84/0.94
	2	1	**3**

Thus, $Na_2C_1O_3 = Na_2CO_3$

2. Fe = 0.2014 g means 0.2014/56 = 0.0036

S = 0.1153 g means 0.1153/32 = 0.0036

O = 0.2302 g means 0.2302/16 = 0.01438

H_2O = 0.4532 g means 0.4532/18 = 0.02517

The relative ratio can be converted to simplest ratio by dividing with 0.0036. We get $FeSO_4.7H_2O$ Hence, from these values, an empirical formula can be deduced.

3. a. $2H_2 + O_2 \rightarrow 2H_2O$

b. Reversible reaction

c. Law of combing volumes: When gases react, they do so in volumes which bear a simple whole number ratio to one another and to the volume of the product if gaseous, provided all the volumes are measured at the same temperature and pressure.

d. At or above 373 K, the water will be in vapour form, thus, Gay-Lussac's law will be applicable, but if the temperature is below 373, then water will remain in liquid state and the law will not be applicable.

4.

NaOH	+ HCl →	NaCl +	H_2O
23 + 16 + 1	1 + 35.5	23 + 36.5	2(1) + 16
40 g	36.5 g	59.5 g	18 g

We know from the equation 40 g of NaOH neutralizes 36.5 g of HCl

2.5 g of NaOH will neutralize

= (36.5 × 2.5)/40 = 2.28 g of HCl

5. a. one volume of hydrogen combines with one volume of chlorine and form 2 volumes of hydrogen chloride gas.

b. $H_2 + Cl_2 \rightarrow 2HCl$

c. Law of combining volumes

d. Joseph Louis Gay-Lussac, a French chemist

P. 109-111 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. Gram molar mass of $SO_2 = 32 + (16 \times 2) = 64$ g

$\therefore$ No. of moles in 320 g of $SO_2 = \dfrac{320}{64} = 5$ moles

1 mole of SO_2 occupies 22.4 dm^3 at STP.

$\therefore$ 5 moles of SO_2 will occupy = $5 \times 22.4 = 112\ dm^3$

2. *Gay-Lussac's law of combining volumes:* when gases react they do so in volumes which bear a simple whole number ratio to one another and to the volume of the product if gaseous, provided all the volumes are measured at the same temperature and pressure.

3. The equation is as following:

$C_3H_8 \quad + \quad 5O_2 \quad \rightarrow \quad 3\ CO_2 \quad + \quad 4H_2O$

1 5

mole moles

1 mole 5 × 22.4 L

at STP

12 × 3 + 1 × 8 = 44 g = 5 × 22.4 L at STP.

$\therefore$ For 8.8 g of propane = $\dfrac{5 \times 22.4 \times 8.8}{44}$

= 22.4 L of O_2 at STP.

4. a. 1 mole of sulphur = 6×10^{23} atoms = 32 g of sulphur

$\therefore$ 10^{22} atoms of sulphur = $\dfrac{32 \times 10^{22}}{6 \times 10^{23}} = \dfrac{32}{60}$

= 0.53 g

b. 1 mole of $CO_2 = 12 + (2 \times 16) = 44$ g

$\therefore$ 0.1 mole of $CO_2 = 0.1 \times 44 = 4.4$ g.

5.

Element	Percent ratio	Atomic mass	Relative no. of atom	Simplest ratio
C	12.67	12	$\frac{12.67}{12} = 1.055$	$\frac{1.055}{1.055} = 1$
H	2.13	1	$\frac{2.13}{1} = 2.13$	$\frac{2.13}{1.055} \cong 2$
Br	85.11	80	$\frac{85.11}{80} = 1.063$	$\frac{1.063}{1.055} \cong 1$

$\therefore$ Empirical formula of the compound = CH_2Br

Molecular formula = (Empirical formula)$_n$

$$n = \frac{\text{Molecular weight}}{\text{E.F. weight}}$$

$$= \frac{2 \times VD}{\text{E.F. weight}} = \frac{2 \times 94}{(12+2+80)} = \frac{2 \times 94}{94} = 2$$

$\therefore$ Molecular formula = $(CH_2Br)_2 = C_2H_4Br_2$

2012

1. **a. iv.** 22

2. **a.** Number of moles

$$= \frac{\text{Given weight}}{\text{Molecular wt. of substance}}$$

$$= \frac{9.3}{31} = 0.3$$

0.3 moles of phosphorus are taken.

b. Molecular weight of H_3PO_4

$= (1 \times 3) + (31) + (4 \times 16)$

$= 3 + 31 + 64 = 98$

$\because$ 31 g of phosphorus gives 98 g of phosphoric acid

$$\therefore \quad 9.3 \text{ g} \quad " \quad = \frac{98 \times 9.3}{31}$$

= 29.4 g of phosphoric acid

c. From the equation:

1 mole of phosphorus liberates 5 moles of nitrogen dioxide

0.3 moles of phosphorus liberates = 5 × 0.3 = 1.5 moles of NO_2

Now, at STP 1 mole of NO_2 occupies 22.4 L.

$\therefore$ 1.5 moles = 22.4 × 1.5 = 33.6 L

2013

1. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

   2 v 13 v

$\therefore$ 2 volumes of C_4H_{10} require 13 volumes of O_2

$\therefore$ 1 volume of C_4H_{10} require $\frac{13}{2}$ volumes of O_2

$\therefore$ 90 dm^3 of C_4H_{10} will require = $\frac{13}{2} \times 90$

= 585 dm^3 of O_2

2. The molecular weight of

   the gas = 2 × V.D.

   = 2 × 8 = 16 g

   As we know that molar mass/weight of a gas occupies 22.4 liters.

$\therefore$ 16 g of gas occupies 22.4 litres at STP

$\therefore$ 24 g of gas will occupy $\frac{22.4}{16} \times 24$

= 11.2 × 3 = 33.6 litres.

3. As Avogadro's law states – Equal volume of all gases at the same temperature and pressure contain the same number of molecules – So, nitrogen gas molecules present in the same container = X.

4. **a.** $\underset{\text{2 volumes}}{2KClO_3} \xrightarrow{MnO_2} \underset{\text{2 volumes}}{2KCl} + \underset{\text{3 volumes}}{3O_2}$

   Now,

$\therefore$ 3 volumes of oxygen require 2 volumes of $KClO_3$

$\therefore$ 6.72 litres of O_2 require = $\frac{2}{3} \times 6.72 = 4.48$ L

$KClO_3 = 39 + 35.5 + 16 \times 3$

= 122.5 g

$\because$ 22.4 litres of $KClO_3$ has mass = 122.5 g

$\therefore$ 4.48 L of $KClO_3$ has mass = $\frac{122.5}{22.4} \times 4.48$ = 24.5 g

b. $\therefore$ 22.4 litres of oxygen = 1 mole

$\therefore$ 6.72 litres of oxygen = $\frac{1}{22.4} \times 6.72 = 0.3$ mole

No. of molecules in 0.3 mole of oxygen

= 0.3 × 6.023 × 10^{23}

= 1.8069 × 10^{23} molecules

c. $\therefore$ 1 mole of CO_2 occupy 22.4 litres at STP

$\because$ 0.01 mole of CO_2 will occupy = 22.4 × 0.01

= 0.224 litres.

2014

1. Di. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

   2 vol 4 vol

$\therefore$ 1 vol 2 vol

According to Gay Lussac's law

2 volume of CO_2 is produced from 1 volume of C_2H_2

$\therefore$ 8.4 dm^3 of CO_2 at STP is produced from

$$= \frac{1\times 8.4}{2} = 4.2\ dm^3 \text{ of } C_2H_2$$

Therefore, at STP 4.2 dm^3 of ethyne is required.

2. Molecular formula = (empirical formula)$_n$

$$n = \frac{\text{Molecular formula weight}}{\text{Empirical formula weight}}$$

$$= \frac{2\times \text{V.D.}}{(2\times 10+5)}$$

(V.D. = vapour density)

$$= \frac{2\times 25}{25} = 2$$

$\therefore$ Molecular formula = $(X_2Y)_2 = X_4Y_2$

3. **Avogadro's Law:** Equal volumes of all gases at the same temperature and pressure contain the same number of molecules.

4. Molecular weight of NH_3 = (14 + 3 × 1) = 17 g

Number of moles of NH_3 in 68 g = $\frac{\text{wt.}}{\text{mol. wt.}}$

$= \frac{68}{17}$ = 4 moles

i. Volume occupied by the gas = 4 × 22.4 L

= 89.6 L at STP

ii. 4 moles of ammonia are present in the cylinder.

iii. Number of molecules = No. of moles × N_A

$= 4 \times 6.023 \times 10^{23}$

$= 24.092 \times 10^{23}$ molecules

2015

1. d. 6.02×10^{23} atoms of carbon

2. a. Given: Mass of sulphur = 3.2 g

32 g of sulphur contain = 6.023×10^{23} atoms

3.2 g of sulphur contain = $\frac{6.023\times 10^{23}}{32\text{ g}} \times 3.2\text{ g} = 6.023 \times 10^{22}$ atoms

Now,

6.023×10^{23} atoms of calcium = 40 g

$\therefore$ 6.023×10^{22} atoms of calcium = $\frac{40\text{ g}}{6.023\times 10^{23}} \times 6.023 \times 10^{22}$ = 4 g

Hence, the mass of calcium = 4 g

b. $H_2 + Cl_2 \rightarrow 2HCl$

1 vol 1 vol 2 vols

In this reaction, 1 volume of H_2 reacts with 1 volume of chlorine. So, 4 volumes of chlorine will react with 4 volumes of hydrogen only. (6 – 4 = 2) 2 volumes of hydrogen will be left.

Total 8 litres of HCl gas is produced. Therefore, the volume of residual gas will be 2 litres (hydrogen).

c. Given:

Empirical formula = CH

Vapour density = 13

Empirical formula mass = $12\times 1+1\times 1=13$

Molecular mass = 2 × vapour density

= 2 × 13 = 26

$$n = \frac{\text{Molecular formula mass}}{\text{Empirical formula mass}}$$

$$= \frac{26}{13} = 2$$

Molecular formula = n × Empirical formula

= 2 × CH

= C_2H_2

Hence, the molecular formula of the compound is C_2H_2.

3. $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2(g) + 4H_2O(g) + Cr_2O_3$

Mass of $(NH_4)_2Cr_2O_7$ = 63 g (given)

Molar mass of $(NH_4)2Cr_2O_7$ = 2(14 + 4) + 52 × 2 + 16 × 7 = 252 g

Molar mass of Cr_2O_3 = 2 × 52 + 16 × 3

= 104 + 48 = 152 g

a. 252 g of $(NH_4)_2Cr_2O_7$ = 1 mole

63 g of $(NH_4)_2Cr_2O_7$ = $\frac{63}{252} = \frac{1}{4} = 0.25$ mole

Hence, 0.25 mole of $(NH_4)_2Cr_2O_7$ is heated.

b. 252 g $(NH_4)_2Cr_2O_7$ gives = 28 g N_2

$\therefore$ 63 g $(NH_4)_2Cr_2O_7$ gives = $\frac{28\times 63}{252}$ = 7 g N_2

28 g N_2 = 1 mole of N_2

$\therefore$ 7 g N_2 = $\frac{1}{28}\times 7 = \frac{1}{4} = 0.25$ mole

Hence, 0.25 mole N_2 is formed.

c. One mole of an ideal gas at STP occupies 22.4 litres or 22.4 dm^3

So, 0.25 mole of N_2 will occupy = 22.4 × 0.25

= 5.6 litres or 5.6 dm^3

d. 252 g of $(NH_4)_2Cr_2O_7$ gives = 152 g of Cr_2O_3

$\therefore$ 63 g of $(NH_4)_2Cr_2O_7$ gives = $\frac{152}{252} \times 63$

= 38 g of Cr_2O_3

Hence, the mass of Cr_2O_3 formed is 38 g.

2016

1. a. iii.

2. a. 20 L at STP has mass = 32 g

So, 1 L at STP has mass = $\frac{32}{20}$ g

$\therefore$ 22.4 L has mass = $\frac{32}{20} \times 22.4$ g = 35.84 g

b. We have,

$$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$$

$\Rightarrow$ 328 g of $Ca(NO_3)_2 \rightarrow$ 112 g of CaO

$\Rightarrow$ 1 g of $Ca(NO_3)_2 \rightarrow \frac{112 \text{ g}}{338}$ of CaO

Thus, 82 g of $Ca(NO_3)_2 \rightarrow \frac{112}{328} \times 82$ g of CaO

= 28 g of CaO

Hence, 28 g of calcium oxide is formed when 82 g of calcium nitrate is heated.

Now, 328 g of $Ca(NO_3)_2 \rightarrow 4 \times 22.4$ g of NO_2

$\Rightarrow$ 1 g of $Ca(NO_3)_2 \rightarrow \frac{4 \times 22.4}{328}$ g of NO_2

Thus, 82 g of $Ca(NO_3)_2 \rightarrow \frac{4 \times 22.4 \times 82}{328}$ L of NO_2 = 22.4 L of NO_2

Hence, 22.4 L of NO_2 is evolved.

3. a. i. 6×10^{23} molecules of oxygen gas = 1 mole of oxygen gas

So, 12×10^{24} molecules of oxygen gas

$= \frac{1}{6 \times 10^{23}} \times 12 \times 10^{24}$ moles of oxygen gas

= 20 moles of oxygen gas

Now, mass of one mole of oxygen gas = 32 g

Hence, mass of 20 moles of oxygen gas = 20 × 32 g = 640 g

Thus, 640 g of oxygen gas is present in the cylinder.

ii. 1 mole of oxygen gas at STP = 22.4 L

So, 20 moles of oxygen gas at STP = 22.4 × 20 = 448 L

Thus, volume of oxygen at STP present in the cylinder is 448 L.

b.

Element	%	Relative number of moles	Simplest ratio
C	82.7	82.7/12 = 6.9	$\frac{6.9}{6.9} = 1$
H	17.3	17.3/1 = 17.3	$\frac{17.3}{6.9} = 2.5$

Since the ratio of carbon and hydrogen atoms is 1 : 2.5, therefore the simplest whole number ratio will be 2 : 5.

So empirical formula of compound = C_2H_5

Empirical formula mass = 24 + 5 = 29

Vapour density = 29

Mass = Vapour density × 2 = 29 × 2 = 58g

$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{58}{29} = 2$

$\therefore$ 22.4 L has mass = $\frac{32}{20} \times 22.4$ g = 35.84 g

$\therefore$ Molecular formula = 2 × C_2H_5 = C_4H_{10}

c. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Ammonia used = 100 cm^3

Now, 4 × 22400 cm^3 of NH_3 requires 5 × 22400 cm^3 of O_2 [$\because$ 22.4 L = 22400 cm^3]

or 4 × 22400 cm^3 of $NH_3 \rightarrow$ 5 × 22400 cm^3 of O_2

1 cm^3 of $NH_3 \rightarrow \frac{5 \times 22400}{4 \times 22400}$ cm^3 of O_2

So, 100 cm^3 of $NH_3 \rightarrow \frac{5}{4} \times 100$ cm^3 of O_2 = 125 cm^3 of O_2

Thus, 100 cm^3 of NH_3 would require 125 cm^3 of O_2.

2017

1. 1 mole of Na = 23 g atom of Na

23 g of Na = 1 mole of Na

4.6 g of Na = 4.6 × 1/23 = 0.2 mole

So, number of gram atoms = 0.2 × 6.022 × 10^{23} atoms = 1.204 × 10^{23} atoms

2. Molecular mass of $CuSO_4.5H_2O$

= [64 + 32 + 4 × 16] + 5[18] = [64 + 32 + 64] + [90] = 160 + 90 = 250

% of water of crystallization = 90/250 × 100 = 36%

3. Empirical formula = XY_2

Empirical formula weight = V.D.

Molecular weight = 2 × V.D.

Molecular weight = 2 × [Empirical formula weight]

So, molecular formula = $(XY_2)_2 = X_2Y_4$

4. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$.

1 : 5 : 3 : 4

if air is 100, then oxygen is 20%.

If air is 1000 cm^3, then oxygen is 20/100 × 1000 = 200 cm^3

If 5 vol. of oxygen is used, then propane is 1 vol.

1 vol. of oxygen is used, then propane is 1/5 vol.

5. 11.2 litres of a certain gas at STP is 24 g

1 litre of a certain gas at STP. Is 24/11.2 g

22.4 litres of a certain gas at STP is 24/11.2 × 22.4 L= 48 g

6. a. Weight of hydrogen = 2 × 1 g = 2 g

2 g of hydrogen corresponds to 1 mole of hydrogen.

1 g of hydrogen corresponds to 1/2 mole of hydrogen.

1000 g of hydrogen corresponds to 1/2 × 1000 g mole of H_2 = 500 moles

b. 1 mole of H2 occupies 22.4 L

500 mole of H2 will occupy = 22.4 x 500 L

By Avogadro's law, the volume occupied by CO_2 will be same. Weight of CO_2 = 12 + 2 x 16 = 44 g 22.4 L will weigh 44 g

1 L will weigh 44/22.4 g

22.4 x 500 L will weigh 44/22.4×22.4 × 500 = 22000 g = 22 kg

c. X (Because of Avogadro's law)

d. Avogadro's law

2018

1.

Element	%mass	Atomic	Relative ratio	Simplest ratio
Nitrogen	82.35	14	82.35/12 = 5.88	5.88/5.88 = 1
Hydrogen	17.64	1	17.64/1 = 17.64	17.64/5.88 = 3

Empirical formula $N_1H_3 = NH_3$

2. a. Mol. mass of Al_4C_3 = 4 x 27 + 3 x 12 = 144

Mol. mass of $Al(OH)_3$ = 27 + 3(16 + 1 = 78 144 g of Al4C3 produce 4 x 78 g of Al(OH)3 1 g of Al4C3 produces 312/144 g

12 g of Al_4C_3 gives 312/144 x 12 = 26 g of $Al(OH)_3$

b. $Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$

1 : 12 : 4 : 3

1 mole at STP occupies 22.4 L of volume.

3 moles will occupy 3 × 22.4 = 67.2 L

144 g of Al_4C_3 will produce 67.2 L of methane.

1 g of Al_4C_3 will produce 67.2/144 L of methane.

12 g of $A_{l4}C_3$ will produce (67.2/144) x 12 = 5.6 L of methane.

3. a. 2 vol. of ethane forms 4 volumes of carbon dioxide.

1 vol. of ethane will form 4/2 volumes of carbon dioxide.

So, 300 cc of ethane would give 600 cc of carbon dioxide.

b. 2 vol. of ethane requires 7 volumes of oxygen.

1 vol. of ethane requires 7/2 volumes of oxygen. 300 cc of ethane requires 7/2 × 300 = 1050 cc

Total volume of oxygen = 1250 cc

Volume of oxygen used = 1050 cc

Unused oxygen = (1250 – 1050) cc = 200 cc

4. a. 150 cc of gas A contains X molecules.

150 cc of gas B will also contain X molecules.

75 cc of gas B will contain *X*/2 molecules under the same conditions of temperature and pressure.

b. Avogadro's law

2019

1. Molecular formula = $C_6H_{18}O_3$

Take the common multiple

Molecular formula = $(C_2H_60)_3$

Molecular formula = (Empirical formula)n

Thus, empirical formula = C_2H_6O

2. $2NaOH + CuSO_4 \rightarrow Na_2SO_4 + Cu(OH)_2\downarrow$

2[23 + 16 + 1] [64 + 32 + 2]

80 98

80 g of NaOH is used to precipate 98 g of $Cu(OH)_2$.

Hence, 200 g of NaOH will be used to precipitate (98/80) × 200 = 245 g of $Cu(OH)_2$.

3.

Symbol	Percentage	At. weight	Relative ratio	Simplest ratio
C	75.92%	12	$\frac{75.92}{12} = 6.32$	$\frac{6.32}{1.26} = 5$
H	6.32%	1	$\frac{6.32}{1} = 6.32$	$\frac{6.32}{1.26} = 5$
N	17.76%	14	$\frac{17.76}{14} = 1.26$	$\frac{1.26}{1.26} = 1$

Empirical formula ⇒ C_5H_5N

Vapour density = 39.5

Molecular Mass = 2 × V.D.= 2 × 39.5 = 79

Empirical formula mass = 12 × 5 + 5 × 1 + 1 × 14

= 60 + 5 + 14 = 79

n = Molecular formula mass/Empirical formula mass = 79/79

Thus, both empirical formula and molecular formula are C_3H_5N.

4. a. Oxygen gas (O_2)

Molecular mass = 16 x 2 = 32 g

32 g of oxygen gas → 1 mole

1 g of oxygen gas → 1/32 mole

12 g of oxygen gas → 1/32 × 12 mole = 0.375 mole

b. 6.022 × 1023 atoms of carbon weighs → 12 g

1 atom of carbon weighs → $12/6 \times 10^{23}$

10^{22} atoms of carbon will weigh → $12/6 \times 10^{23} \times 10^{22} = 12/60 = 1/5 = 0.2$ g

2020

1. a. $2CO + O_2 \rightarrow 2CO_2$

2 : 1 2

2 moles of co react with 1 mole of O_2

At STP, 1 mole of an ideal gas takes up 22.4 L

So, 44.8 L of CO reacts with 22.46 L O_2 to give 44.8 L of CO_2.

So, 750 mL of CO_2 production will need 750 mL of CO and 375 mL of O_2.

b. From equation we know 44 g of CO_2 occupies 22.4 L 1 g CO_2 will occupy 22.4/44 L 80 g CO_2 will occupy 22.4/44 × 80 = 40.72 L

c. Number of molecules = moles of CO_2 × NA

Moles = mass of CO_2/Mol. mass of CO_2

Moles = 4.4/44 = 0.1 moles

Avogadro's number = 6.023×10^{23}

Therefore, molecules = $0.1 \times 6.023 \times 10^{23} = 6.023 \times 10^{22}$

d. Gay Lussac's Law

2. a. Moles = mass of nitrogen/mol. mass of nitrogen Mol. mass of nitrogen = 2 × 14 = 28

Moles = 11/28 = 0.39 Thus, 0.39 is the correct option.

3. Mol. mass = $Na_3AlF_6 = 3 \times 23 + 27 + 6 \times 19$

= 69 + 27 + 114 = 210

F% = 114/210 × 100 = 54.28

Na% = 69/210 × 100 = 32.85

Al% = 27/210 × 100 = 12.85

4. a. Mol. wt = 2 × V.D. = 2 × 8 =16

16 g occupies 22.4 L vol at STP

1 g will occupy 22.4/16

40 g will occupy 22.4/16 × 40 = 56 L

b. Number of moles = Mass of NaOH/Molar mass of NaOH

Mol. mass of NaOH = 23 + 1 + 16 = 40

Therefore, moles = 160/40 = 4 moles of NaOH

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1. Mol. wt = 2 × V.D. option b, 29

2. H% = 1/40 × 100 = 2.5 option a

3. *n* = mol mass/emp mass = 30/10 = 3

therefore, mol. formula = *n* × emp. formula

$= 3 (PQ_2) = P_3Q_6$

option d

4. Mol. wt = 2 × V.D. = 2 × 13 = 26, option b C_2H_2

Chapter – 6

Electrolysis

P. 117 Check Your Progress 1

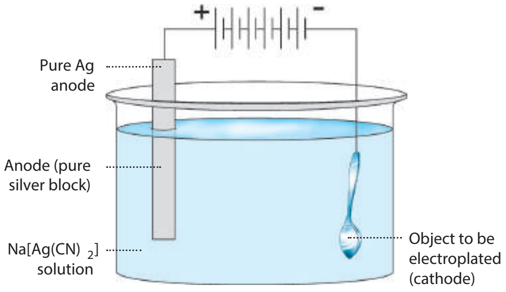
1. **a.** electricity, anode, Deficiency
   b. Current, cathode. excess
   c. lose, cation
   d. electrolyte. ions, ions. Positively, negatively
2. **a. i.** Ions and molecules together
   ii. Because during electrolysis cathode receives electrons, so reduction takes place at cathode and anode releases electrons, and oxidation takes place at anode. Oxidation and reduction processes occur simultaneously.
   b. i. If the compound is formed between A and B and an electric current passed through the molten compound, the element A will be obtained at the cathode and B at the anode of the electrolytic cell.
   ii. For conducting electricity, there are two conditions: 1. Compound dissociating into ions 2. Movement of ions (so they have to be in solution or molten form). Solid sodium bromide is in a solid state and has no ions. So it does not conduct electricity,
   c. 1. Cu^{2+} ion
   2. Chlorine gas is produced at the anode.

P. 122-123 CHECK YOUR PROGRESS 2

1. **a.** cathode, anode
   b. reduced
   c. More
2. **a.** The electrolysis of molten lead bromide liberates lead at cathode and bromine at anode.
   b. Electrolysis of water gives 2 volumes of hydrogen and 1 volume of oxygen.
   c. The blue colour of electrolytic solution of copper sulphate remains same during electrolysis.

P. 125 CHECK YOUR PROGRESS 3

1. (a) electrolyte (b) silver (c) cathode (d) anode (e) anions.
2. **a.** Cathode: article like spoon or tong to be plated and anode: pure silver metal block
   b. Sodium argento cyanide
   c. The metal that should be electroplated must be pure.
   d.



Electroplating of an object with silver

3. **a.** Silver
   b. Aqueous nickel sulphate
   c. Sodium argentocyanide
   d. Electrorefining or electrmetallurgy
4. **a.** Silver, nickel, lead, zinc and copper
   b. Sodium, potassium, calcium, magnesium and aluminium
   c. Graphite, platinum
   d. Silver, nickel
5. Anode mud is found in electrorefining of copper. It contains water insoluble impurities of gold and silver which settle under the anode during electrorefining process.

P. 126–130 Exercises

I. Objective Type Questions

A. Choose the correct option.

1. a **2.** c **3.** b **4.** d
5. c **6.** b **7.** a **8.** d
9. b **10.** a **11.** b **12.** c
13. a **14.** b **15.** c **16.** c
17. a **18.** b **19.** a **20.** d

B. Fill in the blanks.

1. electrolytes
2. non-electrolyte
3. molecules
4. low
5. Anode
6. Anions
7. Cations
8. Electrolytic refining
9. electropositive
10. depends

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Anion
2. Cation
3. Electrochemical series
4. Selective discharge
5. Inert electrodes
6. Cathode
7. Anode
8. Faraday's law of electrolysis
9. DC (direct current)
10. Electroplating

B. Give one example for each of the following.

1. Silver plating on inferior metal like iron.
2. Purification of copper metal.
3. Extraction of potassium metal from its salt KCl.
4. Graphite electrode.

C. Match the following.

1. d **2.** e **3.** a **4.** b **5.** c

D. Match the given word(s) with its appropriate description.

1. c **2.** d **3.** e **4.** a **5.** b

E. Name each of the following.

1. Sulphate anion
2. Hydroxide anion
3. Potassium
4. Silver
5. Platinum or graphite

F. Choose the odd one out.

1. Silver
2. Potassium
3. Hydroxide
4. Sulphate

G. Answer the following questions.

1. The electropositive elements like metals and hydrogen are liberated at cathode.
2. The electronegative non-metals are liberated at anode.
3. Electrodes are the conducting rods, which allow the electric current to enter and leave the electrolytic solution.
4. In electrolysis, oxidation and reduction both occur simultaneously.
5. **a.** Concentration of ions
   b. Nature of electrodes.

III. Short Answer Type Questions

A. Give reasons for the following.

1. As sulphate occupies top position in the electrochemical series of anions.
2. As impurities present in water ionize water to hydrogen and hydroxyl ions.
3. The hydroxyl ions OH^- will get discharged in preference to SO_4^{2-} as OH^- is placed lower in the electrochemical series.
4. When electrodes made up of metals like copper, silver, nickel and mercury are used, then such electrodes being active in nature participate in electrolytic reaction and interfere in the discharge of preferential ions.
5. In solid state, being an ionic compound, the ions of lead bromide are held together by electrostatic forces and are not free to move. In molten state it ionizes and thus conducts electricity.

B. Differentiate between the following pairs.

1. Anion	**Cation**
a. It is a negatively charged ion.	It is a positively charged ion.
b. It moves towards anode during electrolysis.	It moves towards cathode during electrolysis.
2. Anode	**Cathode**
a. It is a positively charged electrode.	It is a negatively charged electrode.
b. Oxidation occurs at anode.	Reduction occurs at cathode.
3. Electrorefining	**Electroplating**
it is a process by which metals containing impurities are purified electrically to give pure metal.	It is an electrolytic process of depositing a superior metal on the surface of another metal.
4. Strong electrolyte	**Weak electrolyte**
a. It is a chemical compound which dissociates completely into ions in its aqueous solution or in fused state.	It is a chemical compound which dissociates partially into ions in its aqueous or fused state.
b. It allows a large amount of electricity to flow through it, and hence, is a good conductor of electricity.	It allows a small amount of electricity to flow through it, and hence, is a poor conductor of electricity.

C. Complete the following table.

	Electrolyte and electrode	Anode	Anode reaction	Cathode	Cathode reaction
1.	Molten lead bromide	Graphite	$Br^- \rightarrow Br + e^-$ $2Br \rightarrow Br_2\uparrow$	Graphite	$Pb^{2+} + 2e^- \rightarrow$ Pb (as grey metal)
2.	Acidified water	Platinum	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$	Platinum	$H^+ + e^- \rightarrow H$ $H + H \rightarrow H_2\uparrow$
3.	Copper sulphate solution using copper electrodes	Impure copper	$Cu \rightarrow Cu^{2+} + 2e^-$	Pure copper	$Cu^{2}+ + 2e^- \rightarrow Cu$
4.	Copper sulphate solution using graphite electrodes	Graphite	$OH^- \rightarrow OH + e^-$ $4OH \rightarrow 2H_2O + O_2(g)$	Graphite	$Cu^{2+} + 2e^- \rightarrow Cu\downarrow$

D. Diagram-based questions.

1. a. Acidulated water (water with few drops of dilute sulphuric acid)

b. Pure water will not get ionized.

c. At anode: $4OH^- \rightarrow 2H_2O + 4e^- + O_2$

At cathode: $H^+ + e^- \rightarrow H$ (atom); $H + H \rightarrow H_2$

d. Water is made up of two hydrogen and an oxygen atom.

2. a. As graphite remains unaffected with bromine vapours or lead metal.

b. At cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

At anode: $Br^- \rightarrow Br + e^-$

$Br + Br \rightarrow Br_2$ (vapours)

(a) Anode: thick reddish-brown vapours of bromine

Cathode: grey layer of lead metal

E. Define each of the following.

1. The substances that in their fused or aqueous state conduct electricity in molten or aqueous state are called electrolytes.
2. Electrodes are the conducting rods, which allow the electric current to enter and leave the electrolytic solution.
3. Electrorefining is a process by which metals containing impurities are purified electrically to give pure metal.
4. The extraction of metals by electrolysis is called electrometallurgy.
5. The electrolytic process of depositing a superior metal on the surface of another metal is called electroplating.

F. Explain why

1. The oxides of these metals are very stable and cannot be reduced by conventional reducing agents like coke, carbon monoxide and hydrogen. Such metals are extracted from their halides like chlorides and bromides by electrolysis using graphite and iron electrodes. These cannot be extracted from their aqueous salt solutions by electrolysis as they can react with water.
2. To improve the appearance and prevent from corrosion, the electroplating is performed.
3. Pure water is a poor conductor of electricity. To electrolyse water, a few drops of dilute sulphuric acid are added. The addition of dilute sulphuric acid initiates the ionization of water. Water ionizes to form hydronium and hydroxyl ions which conduct electricity.
4. Dilute sulphuric acid is preferred over dilute nitric acid. This is because nitric acid is volatile and may decompose. The nitrate radical thus formed may interfere with the electrolytic reaction.
5. Graphite rods being inert or unreactive do not react with bromine vapours or lead metal. Hence, these are preferred over other inert electrodes like platinum.

G. Answer the following questions.

1. SO_4^{2-} ions have a lesser tendency to get oxidized and discharged at anode whereas OH^- ions have a greater tendency to get oxidized and discharged at anode.
2. When sodium chloride is electrolysed in its aqueous state, the electrolytic solution will contain four different ions, namely, Na^+, Cl^-, H^+ (H_3O^+) and OH^-.
3. When aqueous sodium chloride solution is dilute, hydronium ions will be discharged at the cathode (first factor) and hydroxyl ions will be discharged at the anode. However, chlorine gas will be liberated at the anode if the solution is concentrated.
4. When copper sulphate is electrolysed using inert electrodes like platinum, copper ions get discharged at the cathode and are deposited at the cathode as reddish-brown copper metal. At the anode, colourless oxygen gas is liberated. The colour of the electrolytic solution slowly fades because the effective concentration of copper ions in solution decreases.

5. **Nickel plating**
    - **a.** Electrolyte: Aqueous solution of nickel sulphate ($NiSO_4$)
    - **b.** Cathode: Article to be plated

      Anode: Active electrode (plate or block of nickel metal)
    - **c.** Electrolytic equations: $NiSO_4 \rightarrow Ni^{2+} + SO_4^{2-}$; $H_2O \rightarrow H^+ + OH^-$

      At the anode: $Ni \rightarrow Ni^{2+} + 2e^-$

      At the cathode: $Ni^{2+} + 2e^- \rightarrow Ni$ (deposited)

IV. Knowledge-based Questions

1. The copper metal from copper anode loses electrons readily than sulphate and hydrogen ions. Therefore, the atoms of copper change to copper ions that go into the solution. Thus, the copper anode undergoes a loss in mass. For every copper ion discharged at the cathode, an ion of copper is formed at the anode which goes into the solution. Hence, the number of copper ions in the solution remains the same. The cathode, therefore, increases in mass and the anode decreases in mass. The colour of the electrolytic solution remains blue.
2. Conditions for electroplating:
    - **a.** The article to be electroplated should be made the cathode and the anode must be made of the pure metal.
    - **b.** The metal to be electroplated should be replaced periodically because when electric current is passed, the metal from the anode dissolves by forming the metal ions which migrate towards the cathode.
    - **c.** The electrolyte should contain the ions of the metal which is to be electroplated on the article.
    - **d.** For effective electroplating, a low direct current is passed at a constant rate through the electrolyte for avoiding uneven deposition of the metal which takes place when high or alternating current is used.
3. Purpose for electroplating:
    - **a.** Improving appearance: Electroplating makes the object look more attractive by imparting a better look to an inferior metal. For example, an article made of brass is electroplated with silver or gold to impart a shiny appearance to it.
    - **b.** Prevention of corrosion: Iron equipment and objects are electroplated with zinc or chromium or nickel for preventing them from corrosion as these get corroded easily in the presence of humid atmosphere.
4. Silver plating is plating silver on an inferior metal article. Articles like spoon or tong to be plated are taken as cathode. The anode is pure silver metal block.

    Electrolytic equations: $Na[Ag(CN)_2] \rightarrow Na^+ + Ag^+ + 2(CN)^-$; $H_2O \rightarrow H^+ + OH^-$; $HCN \rightarrow H^+ + CN^-$

    At cathode: Ag^+ (from electrolyte) + $e^- \rightarrow Ag$ (deposited on the article)

    At anode: $Ag \rightarrow Ag^+ + e^-$

    Both CN^- and OH^- migrate to the anode but neither is discharged. Instead, silver from anode loses electrons to give Ag^+ ions in solution. Hence, concentration of silver at anode decreases.
5. Electrolytic refining of copper: The electrolyte used is acidified copper sulphate solution. Impure blocks of copper are connected to the anode of the electrolytic cell whereas the cathode is made of pure strips of copper.

    Cathode: Pure thin sheet of copper

    Anode: Impure block of copper

    $CuSO_4 \rightarrow Cu^{2+} + SO_4^{2-}$

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

    $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

    At anode: $Cu \rightarrow Cu^{2+} + 2e^-$

    At the cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

    Cu^{2+} ions are discharged at cathode as copper atoms that are deposited on the thin sheet of pure copper placed at the cathode.

V. Application and Skill-based Questions

1. **a.** The concentrated sulphuric acid helps in increasing the electrical conductivity. So, the conductivity will decrease and process will slow down if acid is not added to the electrolyte.
    - **b.** Copper metal will get deposited on cathode, that is, on silver. But the process is electrorefining.
    - **c.** To speed up the reaction.
2. **a.** To generate silver ions which will accept electron and will get deposited on the article to be coated.
    - **b.** Copper ions will be released. However, CN^- and OH^- will also be generated in the electrolyte dissociation and will migrate to anode. Depending upon the concentration of ions and preference, deposition will occur.
    - **c.** No, as it is an electroplating process.

3. a. Electrolysis of molten sodium chloride

Electrolytic equation: $NaCl \rightarrow Na^+ + Cl^-$

At the cathode $Na^+ + e^- \rightarrow Na$

At the anode $Cl^- \rightarrow Cl + e^-$; $Cl + Cl \rightarrow Cl_2$

b. Nickel plating

Electrolytic equations: $NiSO_4 \rightarrow Ni^{2+} + SO_4^{2-}$; $H_2O \rightarrow H^+ + OH^-$

At the cathode: $Ni^{2+} + 2e^- \rightarrow Ni$

At the anode: $Ni \rightarrow Ni^{2+} + 2e^-$

4. Graphite rods being inert or unreactive do not react with bromine vapours or lead metal during the electrolysis of molten lead bromide. Hence, these are preferred over other inert electrodes like platinum.

5.

Strong electrolyte	Weak electrolyte
Molten $CaCl_2$, aqueous NaCl, hydrochloric acid, copper sulphate solution,	NH_4OH

VI. Reasoning/Observation-based Questions

1. Hydrogen gas at cathode and oxygen gas at anode.

2. The blue colour of the solution will remain unchanged. The anode will diminish and reddish brown shining copper metal will deposit at cathode.

3. At anode $Cu \rightarrow Cu^{2+} + 2e^-$; the copper metal ionizes to copper ions, which dissolve in the electrolyte. This is because the copper metal from copper anode loses electrons readily than sulphate and hydrogen ions. Therefore, the atoms of copper change to copper ions that go into the solution. Thus, anode loses mass.

4. The anode is converted into copper ions and diminishes.

5. During electrolysis of molten lead bromide, lead ions being positively charged migrate towards cathode where they accept two electrons from the cathode and change to lead atom. Thus, Pb^{2+} undergoes reduction. Bromide ions being negatively charged migrate towards anode where they lose their extra electron and get oxidized to bromine. Thus, both oxidation and reduction occur simultaneously.

Sodium argentocyanide is preferred over $AgNO_3$ because migration of Ag^+ ions from the given complex is slow compared to $AgNO_3$. Hence, an even deposition of silver is obtained on the article.

P. 105–106 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1.

Copper Sulphate Solution	Copper metal
Electric current is produced by flow of ions	Electric current is produced by flow of electrons.
It is the aqueous solution of ionic compound.	It is a metal in solid state.
Copper sulphate undergoes a chemical change.	Copper metal remains unchanged chemically

2. a. Reddish-brown copper metal deposits at cathode. Bubbles of a colourless-odourless gas is seen at anode.

b. At cathode

$$Cu^{2+} + 2e^- \rightarrow Cu$$

At anode

$$OH^- - e^- \rightarrow OH$$

$$4OH \rightarrow 2H_2O + O_2\uparrow$$

c. The colour of electrolyte gradually fades from blue to colourless.

2012

1. a. Cations migrate to cathode during electrolysis.

2. d. Aqueous acetic acid

3. a. Because in an aqueous solution of sodium chloride, Na^+ and Cl^- ions become free and mobile.

4. a. Cu^{2+}

b. Pt

c. Cu^{2+} at cathode

d. H^+

e. Ag

2013

1. Dark reddish-brown vapour of bromine are liberated at anode and greyish lead is produced on the cathode.

2. a. i. Liquid carbon tetrachloride

3. a. Right electrode is the oxidising electrode because here copper anode itself ionizes to give Cu^{2+} ions.

b. $Cu - 2e^- \rightarrow Cu^{2+}$

c.
- In the above electrolytic reaction, copper ions get discharged at the cathode and are deposited at the cathode as reddish-brown copper metal.
- The colour of the electrolytic solution remains blue because the effective concentration of copper ions in solution remains the same.

2014

1. a. i. (c)

ii. (c)

b. i. Ionization

ii. Electroplating

2. Cathode becomes thick due to deposition of red copper metal.

2015

1. a. The copper of the anode ionises and deposits at the cathode. The colour of the solution does not fade.

b. i. During electrolysis of molten lead bromide, graphite anode is preferred to other electrodes because graphite rod is unaffected by the reactive bromine vapours.

ii. $PbBr_2 \rightleftharpoons Pb^{2+} + 2Br^-$

During electrolysis of molten lead bromide, both reduction (at cathode) and oxidation (at anode) take place simultaneously. So, it is a redox reaction.

At the cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

At the anode: $2Br^- - 2e^- \rightarrow 2Br$

$2Br \rightarrow Br_2\uparrow$

c. Using ammonium hydroxide:

Strong electrolyte	Weak electrolyte
These are chemical compounds, which dissociate completely into their aqueous or fused state.	These are chemical compounds, which do not dissociate completely into their aqueous or fused state.
They allow a large amount of electricity to flow through them and hence, are considered good conductors of electricity.	They allow a small amount of electricity to flow through them and hence, are poor conductors of electricity.
Example: Hydrochloric acid, sodium chloride	Example: Acetic acid, phosphoric acid

2. a.

	Anode	Electrolyte
Purification of copper	Impure metal acidified aqueous	$CuSO_4$ solution

b. At anode:

$Cu \rightarrow Cu^{2+} + 2e^-$

2016

1. a. ii. mainly ions

2. a. i. Cathode:

$Cu^{2+} + 2e^- \rightarrow Cu$; Anode: $Cu - 2e^- \rightarrow Cu^{2+}$.

ii. Cathode:

$Pb^{2+} + 2e^- \rightarrow Pb$; Anode: $2Br^- - 2e^- \rightarrow 2Br$

$Br + Br \rightarrow Br_2$ (Reddish-brown).

3. a. O_2 (oxygen)

b. Ag^+

4. a. In solid state, sodium and chloride ions are held together by electrostatic forces of attraction. Thus, they are not free to move about and do not conduct electricity in the solid state. But in fused or aqueous state, the crystal lattice breaks down and the ions become free to move, which allows electricity to be conducted.

b. In electroplating of an article with silver, if silver nitrate solution is used as an electrolyte, the deposition of silver will be very fast and uneven. However, if silver argento-cyanide solution is used as an electrolyte, then silver will be deposited slowly in a uniform manner.

c. Electrolytes on being dissolved in water or in molten state dissociate into positively and negatively charged ions. The movement of these ions results in conduction of electricity. Copper is a solid metal in which there are no free ions, but free electrons which conduct electricity. Therefore, copper is a non-electrolyte even though it is a good conductor of electricity.

2017

1. a. Sodium argentocyanide

b. Molecules only

2. a. At anode:

Dark reddish-brown fumes of bromine evolve at the anode.

At cathode:

Greyish white metal lead is formed on the cathode.

b. At anode:

Anode decreases in size due to the formation of copper ions.

At cathode:

Reddish brown copper metal is deposited.

3. a. OH^-

b. Ag^+

2018

1. a. iii. Redox reaction

2. a. Ionization

3. a. The bromine atoms combine to give molecules of bromine that escape as reddish-brown vapours at anode.

Electrolytic equation:

$PbBr_2 \rightarrow Pb^{2+} + 2Br^-$

At the cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

At the anode: $Br^- \rightarrow Br + e^-$; $Br + Br \rightarrow Br_2\uparrow$

4. Hydrochloric acid is a strong acid. It ionizes to give more hydrogen ions as compared to acetic acid. Hence, conductivity of dilute hydrochloric acid is more than that of acetic acid.

5. a. solid **b.** sodium metal

6. a. Cathode is made up of thin sheets of pure copper connected in parallel.

b. $Cu \rightarrow Cu^{2+} + 2e^-$

Copper anode undergoes oxidation forming Cu^{2+} ions which pass into the solution.

2019

1. a. iv. Sodium hydroxide

2. a. When copper sulphate solution is electrolysed using copper electrodes, reddish brown or pink deposit of copper metal takes place on cathode.

3. a. Only ions

b. Molecules

c. Ions as well as molecules

2020

1. a. ii. Platinum

2. a. As graphite do not react with bromine vapours or lead metal.

3. a. Pure strips of copper metal

4. i. d. An electrolyte

ii. a. Oxidation,

iii. b. Cathode

iv. c. Anode

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1. c **2.** c **3.** d **4.** c **5.** c

6. c **7.** d **8.** c **9.** a.

Chapter – 7

Metallurgy

P. 139 Check Your Progress 1

1. a. ZnS (zinc blende)

b. Roasting

c. The Baeyer's process

d. Aluminium

e. Copper and silver.

2. a. Aluminium oxide cannot be reduced by carbon because carbon is less reactive than aluminium so it cannot displace aluminium present in aluminium oxide.

b. Minerals are those substance that occur naturally in the earth's crust whereas those minerals which have high percentage of a particular metal and from which metal can be extracted profitably are called ores. Hence, All ores are called minerals. But, metals cannot be extracted from all minerals profitably. Only some minerals have a high concentration of the metal. Therefore all minerals are not ores.

c. It is so because pine oil selectively wets the sulphide ore and hence brings it to the froath. The concept used in this technique is to alter the surface of the particles of the ore in such a way that they are attracted to the air bubbles produced by blowing air in the mixture of oil and ore and then float with froth on the surface.

d. This method is based upon the difference in the densities of the ore and the gangue particles. The powdered ore is spread on tables having grooves on the top. The powdered ore is then washed with upward stream of water. The lighter gangue particles are washed away and the heavier ore particles are left behind.

P. 143 Check Your Progress 2

1. a. Bauxite

b. Solder

c. Molten cryolite and fluorspar

d. Baeyer's process

e. Duralumin

2. a. Bauxite is used as main ore from which aluminium is extracted.

b. Sodium hydroxide is mixed to get $NaAlO_2$ after reaction.

c. Cryolite is used to lower the melting point of Aluminium oxide

d. Graphite is used as anode.

P. 144–148 Exercises

I. Objective Type Questions

A. Choose the correct option

1. a **2.** d **3.** b **4.** c
5. c **6.** b **7.** a **8.** b
9. c **10.** d **11.** a **12.** b
13. c **14.** d **15.** a **16.** d
17. c **18.** a **19.** d **20.** b

B. Fill in the blanks.

1. minerals
2. gangue
3. metallurgy
4. concentration
5. gravity separation
6. froth floatation
7. pulverisation
8. Magnetic separation
9. Leaching
10. Magnetic separation

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Metallurgy
2. Ore
3. Minerals
4. Gangue
5. Baeyer's Process

B. Give one example for each of the following.

1. Bauxite
2. Sodium hydroxide
3. Alloy
4. Amalgam
5. Hoope's electrolytic method

C. Match the following.

1. g **2.** f **3.** d **4.** e
5. a **6.** b **7.** c

D. Match the given word(s) with its appropriate description.

1. e **2.** d **3.** b **4.** c **5.** a

E. Name each of the following.

1. Haematite, Siderite
2. Bauxite, Corundum
3. Zinc blende, Calamine
4. Froth floatation, Gravity separation
5. Calcination, Roasting

F. Choose the odd one out.

1. brass
2. sulphur steel
3. solde
4. galena
5. cryolite

G. Answer the following questions.

1. Carbon dioxide
2. 950 degree Celsius
3. Powered coke
4. Alumina : cryolite : fluorspar is 1:3:1
5. Fluorspar enhances the conductivity of the mixture since alumina is almost a non-conductor of electricity.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Pine oil is used to wet the ore particles; being light it floats as froth over the surface and thus, helps in separating the ore from the gangue.
2. The precipitation process is speeded by adding crystals of $Al(OH)_3$. The process is called seeding.
3. A layer of powdered coke is sprinkled over the electrolytic mixture to reduce heat loss due to radiation. It also prevents the carbon anode from burning in air at the point above the electrolyte.
4. Number of graphite rods are used as oxygen released oxidizes the graphite rod. So multiple electrodes are used so that they last long.

B. Differentiate between the following pairs.

1.	**Gangue**	**Flux**
	Earthy materials associated with minerals like dust.	Chemical used to remove gangue.
2.	**Mineral**	**Ore**
	The elements or compounds, which occur naturally in the earth's crust are known as minerals.	The naturally occurring minerals from which metals can be extracted profitably are called ores.
3.	**Calcination**	**Roasting**
	The process of heating the concentrated ore below its melting point in the absence or limited supply of air.	The process in which the concentrated ore is heated strongly below its melting point in the presence of excess of air.
4.	**Leaching**	**Froth flotation**
	It is based on the difference in the chemical reactivity of the ore and the gangue towards a particular reagent.	It is based on the principle that the ore particles are preferentially wetted by oil while the gangue particles are wetted by water.

C. Complete the following table

Alloy	Composition	Property	Uses
Duralumin	Aluminium (95%) + Magnesium (0.5%) + Manganese (0.5%) + Copper (4%)	• Light • Hard • Resistant to corrosion • Strong as steel • Highly ductile	• Aircraft and its parts • Speed boats
Magnalium	Aluminium (90–95%) + Magnesium (5–10%)	• Light • Strong • Resistant to corrosion	• Light scientific instruments like beam balance • Metal mirrors
Stainless steel	Iron (75%) + Nickel (8-10%) + Chromium (15–18%) + Carbon (0.5–1%)	• Hard • High tensile strength • Lustrous • Resistant to corrosion	• Utensils • Surgical and scientific instruments • Automobile bodies • Ornamental pieces
Manganese steel	Iron (85%) + Carbon (1%) + Manganese (14%)	• Durable • Tough • Hard	• Safes • Rock drills • Armour plates
Brass	Copper (55–95%) + Zinc (5–45%)	• Malleable • Ductile • Lustrous • Hard • Resistant to corrosion	• Jewellery • Decorative metal items • Medals • Musical instruments
German silver	Copper (50%) + Zinc (30%) + Nickel (20%)	• Silver in colour • Malleable and ductile • Gives good polish • Harder than silver	• Ornaments • Decorative items

D. Diagram-based questions.

1. **a.** Froth flotation process

   b. The concept used in this technique is to alter the surface of the particles of the ore in such a way that the ore particles are attracted to the air bubbles and then float with the froth on the surface.

   c. The ore particles are preferentially wetted by oil while the gangue particles are wetted by water. Being light the mixture of oil and ore floats as froth over the surface and thus, helps in separating the ore from the gangue.

   d. This method is used for the concentration of sulphide ores such as zinc blende (ZnS), galena (PbS) and copper pyrites ($CuFeS_2$).

2. **a.** Refining of aluminium by Hoope's electrolytic method.

   b. The upper layer of pure aluminium acts as a cathode. The middle layer consists of a mixture of fluorides of Al, Ba and Na. The lowest layer consists of impure aluminium which acts as anode.

   c. At cathode: $Al^{3+} + 3e^- \rightarrow Al$

   At anode: $Al \rightarrow Al^{3+} + 3e^-$

   d. The three metals can be sodium, calcium and magnesium.

E. Equations-based questions

1. **a.** $Al_2O_3{\cdot}2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

   b. $NaAlO_2 + 2H_2O \rightarrow NaOH + Al(OH)_3\downarrow$

   c. $2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$

   d. $Fe_2O_3(s) + 3C(s) \xrightarrow{heat} 2Fe(s) + 3CO(g)$

   e. $ZnO(s) + C(s) \xrightarrow{heat} Zn(s) + CO(g)$

2. **a.** $\underset{\text{Calamine}}{ZnCO_3} \rightarrow ZnO + CO_2$

   b. $CuO + H_2 \rightarrow Cu + H_2O$

   c. $Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$

   d. $Fe_2O_3(s) + 3CO(g) \xrightarrow{heat} 2Fe(s) + 3CO_2(g)$

   e. $PbO + C \rightarrow Pb + CO$

F. Define each of the following.

1. Metallurgy is the process of extracting metals from their ores.
2. Minerals are compounds or elements that occur naturally in the earth's crust.
3. An ore is a mineral from which the metal can be extracted profitably.
4. Gangue is the impurity associated with the minerals; these impurities are usually clay and silicates.
5. Flux is the chemical used to remove the associated earthy impurities - gangue from the ore.
7. The combination of flux with gangue is known as slag.
8. Calcination is the heating of a carbonate ore in the absence of air.
9. Roasting is heating a sulphide ore in the presence of air.
10. Alloy is a homogeneous mixture of two or more metals or metals and non-metals.
11. Amalgam is an alloy of a metal with mercury.

G. Explain why.

1. Alloys are prepared to enhance the properties of the metal. The properties of alloys are entirely different from the constituent metals. This makes them more useful than the pure metals.
2. Crystals of aluminium hydroxide are added to sodium aluminate during its hydrolysis, to speed up the process of conversion of aluminium into aluminium hydroxide through seeding.
3. Alumina obtained is very stable and is impossible to reduce using conventional reducing agents. Moreover, alumina has a very high melting point which makes it difficult to electrolyse. It is important to reduce the melting point of alumina if it has to be reduced by electrolysis.
4. The elements or compounds, which occur naturally in the earth's crust are known as minerals. All minerals are not suitable for the extraction of metals profitably. The naturally occurring minerals from which metals can be extracted profitably are called ores.
5. The concept used in this technique is to alter the surface of the particles of the ore in such a way that they are attracted to the air bubbles formed by the mixture of oil and powdered ore and then it floats with the froth on the surface. The particles of the ore can then be easily removed.
6. Magnetic separation method is used where either the ore or the impurities are magnetic in nature.

H. Answer the following questions.

1. It is a method based on the difference in the chemical reactivity of the ore and the gangue towards a particular reagent. The powdered ore is treated with a suitable chemical reagent. The reagent selectively dissolves the desired metallic component of the ore to form a soluble product. On filtration, impurities are left behind. The filtrate is treated with suitable chemical reagent which precipitates the ore.

2. It is a method based on the principle that the ore particles are preferentially wetted by oil while the gangue particles are wetted by water. The surface of the particles of the ore is altered in such a way that they are attracted to the air bubbles formed by the mixture of oil and powdered ore and then it floats with the froth on the surface.
3. Baeyer's process is a chemical method used for concentration of bauxite ore, as bauxite is not concentrated by conventional physical methods.
4. Seeding is used to speed up the precipitation process of conversion of sodium aluminate to aluminium hydroxide by adding crystals of aluminium hydroxide.
5. The different concentration methods are:
   - **a.** Gravity separation method
   - **b.** Froth floatation method
   - **c.** Magnetic separation method
   - **d.** Leaching or Chemical method.
6. Methods for refining are: liquation, distillation, oxidation, and electrorefining.

IV. Knowledge-based Questions

1. Baeyer's process

Step 1: The ore is crushed and heated to remove volatile impurities. It is then mixed with concentrated NaOH solution and heated under pressure for 2 hours in a digester.

$$Al_2O_3{\cdot}2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$$

Step 2: The solution is filtered and cooled; it is then diluted with water where it undergoes hydrolysis.

$$NaAlO_2 + 2H_2O \xrightarrow{50\text{–}60°C} NaOH + Al(OH)_3\downarrow$$

The precipitation process is speeded by adding crystals of $Al(OH)_3$. The process is called seeding.

Step 3: The $Al(OH)_3$ is washed, dried and heated to about 1300 °C.

$$2Al(OH)_3 \xrightarrow{1100\text{–}1300°C} Al_2O_3 + 3H_2O$$

2. Refining of aluminium by Hoope's electrolytic method:

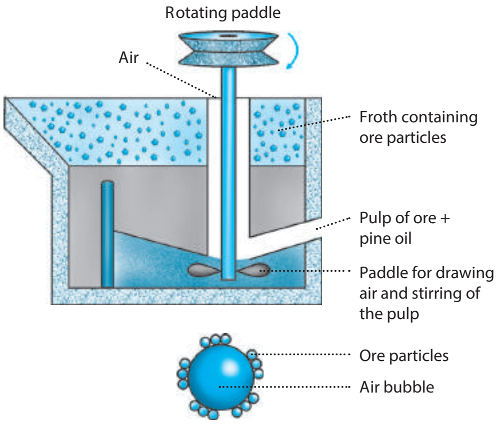
The electrolytic cell consists of iron box lined inside with carbon. The cell consists of three layers of fused mass which differ in specific gravities. The upper layer of pure aluminium acts as a cathode. The middle layer consists of a mixture of fluorides of Al, Ba and Na. The lowest layer consists of impure aluminium which acts as anode. On passing electric current, aluminium is deposited at cathode from the middle layer and an equivalent amount of aluminium is taken up by the middle layer from the bottom layer.

Electrolytic reactions:

At cathode: $Al^{3+} + 3e^- \rightarrow Al$ (Pure Al ion)

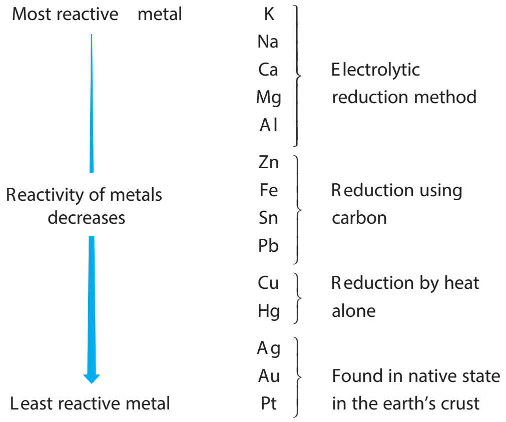
At anode: $Al \rightarrow Al^{3+} + 3e^-$ (Impure Al from lower layer enters the middle layer)

3. The process of metallurgy consists of the following steps: a. Concentration of ore, b. Conversion of concentrated ore into metal oxide, c. Extraction of the metal by the reduction of metal oxide, d. Refining of impure metals.
4. It is a method based on the principle that the ore particles are preferentially wetted by oil while the gangue particles are wetted by water. The powdered ore is taken in a tank containing water and a little pine oil. The mixture is agitated by means of a rotating shaft and the air is blown through the mixture to create froth. The concept used in this technique is to alter the surface of the particles of the ore in such a way that they are attracted to the air bubbles and then float with the froth on the surface.



Enlarged view of air bubble showing the ore particles attached to it.

5.



V. Application and Skill-based Questions

1. **a.** Haematite,

   b. Cryolite

   c. Bauxite

   d. Iron tank lined with carbon

   e. Zinc blende

2. **A** = Electrolytic reduction

   B = Calcination

   C = Roasting

   D = Reduction of metal

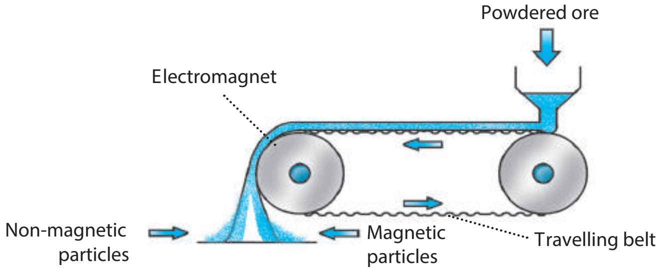
3. **A.** Froth floatation

   B. Magnetic separation and gravity separation

   C. Magnetic separation

   D. Gravity separation

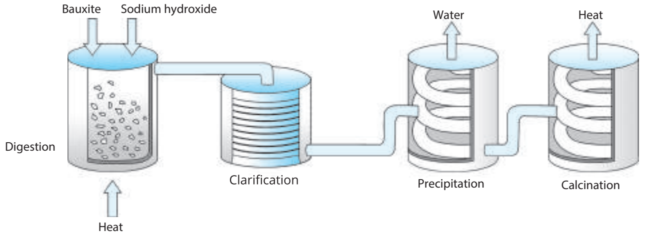
4. **a.**



   b. The purpose of this process is to concentrate the ore wherein either the ore or the impurities are magnetic in nature.

VI. Reasoning/Observation-based Questions

1. **a.**



   b. To dissolve the aluminium from bauxite ore to form soluble sodium aluminate.

   c. Equations:

   Digestion: $Al_2O_3 \cdot 2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

   Precipitation: $NaAlO_2 + 2H_2O \xrightarrow{50\text{–}60°C} NaOH + Al(OH)_3\downarrow$

   Calcination: $2Al(OH)_3 \xrightarrow{1100\text{–}1300°C} Al_2O_3 + 3H_2O$

2. **a.** 1 part molten alumina, 3 parts cryolite and 1 part fluorspar.

   b. Cryolite and fluorspar act as a solvent for the alumina and also lower the fusion temperature; the mixture melts at 950°C instead of 2050°C, thereby saving electrical energy. Also, addition of fluorspar enhances the conductivity of the mixture since alumina is almost a non-conductor of electricity.

   c. A layer of powdered coke is sprinkled over the electrolytic mixture to reduce heat loss due to radiation. It also prevents the carbon anode from burning in air at the point above the electrolyte.

   d. The reaction temperature will then be 2050°C.

   e. Reaction at the cathode: $2Al^{3+} + 6e^- \rightarrow 2Al$

   Reaction at the anode: $3O^{2-} \rightarrow 3O_2 + 6e^-$; $C + O_2 \rightarrow CO_2$

3. **a.** Aluminium is deposited at the cathode.

   b. Specific gravity of the fused mass classifies it into the three layers.

   c. The lowest layer consists of impure aluminium which acts as anode and the upper layer of pure aluminium acts as a cathode.

   d. At cathode: $Al^{3+} + 3e^- \rightarrow Al$ (Pure Al ion)

   At anode: $Al \rightarrow Al^{3+} + 3e^-$

4. **a.** When copper and aluminium are alloyed, aluminium bronze is formed which has a beautiful yellow colour. It is used for interior decoration.

   b. Iron rusts in moist air. However, stainless steel made of iron, chromium, nickel and carbon does not rust easily.

5. Depending upon the nature of the metal and the nature of the impurities present within the metal, the refining process is decided. For metals like aluminium and copper, the anode is taken as a thick block of impure metal and the cathode is a thin sheet of pure metal. The electrolyte is an aqueous solution of a salt of the metal to be refined. On electrolysis, pure metal is deposited at the cathode while impurities settle down at the bottom of anode.

P. 148–151 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. **a.** Coke

   b. Bronze

2. When carbon monoxide is passed over heated copper oxide, black powdery copper oxide changes to red shiny copper metal.

3. a. Aluminium

   b. Calcination is the process of heating the ore in the absence or limited supply of air at a temperature not sufficient to melt it. Calcination is generally used for carbonate and hydrated ores. Roasting is the process in which concentrated ore is heated to a high temperature in excess of air. This removes the volatile impurities and the ore changes to its oxide. It is generally used for sulphide ores.

   c. Froth floatation process

   d. **Main ore of Iron:** Haematite (Fe_2O_3)

   Main ore of Aluminium: Bauxite ($Al_2O_3.2H_2O$)

   e. Molten Alumina of Cryolite + Fiuorspar.

2012

1. a. i. Magnesium oxide

2. 1. The alloy contains Cu and Zn, is hard and is used in decorative articles. – **b.** Brass

   2. It is stronger than aluminium, light and is used in making light tools. – **a.** Duralumin

   3. It is lustrous, hard, corrosion-resistant and used in surgical instruments. – **d.** Stainless Steel

   4. Tin lowers the melting point of the alloy and is used for soldering purpose. – **e.** Solder

   5. The alloy is hard, brittle, takes up polish and is used for making statues. – **c.** Bronze

3. aluminium

4. a. Caustic alkali dissolves aluminium oxide forming soluble sodium aluminate while impurities remain insoluble and precipitate as red mud.

   b. $Al_2O_3 \cdot 2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

   c. Substance is fluorspar (CaF_2) and it increases the conductivity of the electrolyte.

2013

1. c. Bronze

2. a. Cryolite (Na_3AlF_6) is added to alumina, it acts as a solvent for the alumina and lowers the fusion temperature. The mixture melts at 950 °C instead of 2050 °C thereby saving electrical energy.

   b. $2Al^{3+} + 6e^- \rightarrow 2Al$

   c. The carbon anode has to be renewed periodically as the oxygen released oxidises it.

2014

1. a. **iii.** calcination

2. a. **Brass:** Copper and zinc.

   b. **Duralumin:** Aluminium, Copper, Magnesium and manganese

   c. **Bronze:** Copper and Zinc.

3. Name the following:

   a. Cryolite

   b. Zinc blende

2015

1. a. Solder

2. Aluminium oxide has great affinity towards oxygen and thus oxides are very stable; so it cannot be reduced by reducing agents like carbon monoxide. Zinc is moderately reactive, so it gets reduced by carbon.

3. a. i. **Cryolite:** Cryolite acts as a solvent for the alumina and also lowers the fusion temperature; the mixture melts at 950 °C instead of 2050 °C thereby saving electrical energy.

   ii. **Sodium hydroxide:** Sodium hydroxide is used to remove volatile impurities from the ore.

   iii. **Graphite:** Graphite has a high melting point and it is a good conductor of electricity; so it is used as an electrode in the extraction of aluminium.

   b. To reduce heat loss by radiation and to prevent the burning of the anode.

2016

1. reducing agents, donors

2. a. **iv.** copper and tin

3. Froth flotation

4. a. NaOH (Sodium hydroxide)

   b. $2Al(OH)_3 \xrightarrow[\Delta]{1000\ °C} Al_2O_3 + 3H_2O$

   c. Cryolite

   d. At cathode: $2Al^{3+} + 6e^- \rightarrow 2Al$

   e. During electrolysis, aluminium is deposited at the cathode and oxygen is liberated at the anode. Some of the oxygen reacts with the carbon in graphite to form carbon dioxide, thereby slowly burning away the anodes. Thus, the anodes have to be replaced periodically or a number of graphite electrodes have to be used as anodes.

2017

1. a. Galvanisation

b. Solder

c. Zinc blende

d. Copper oxide

2. a. Alumina (Al_2O_3): It is the main compound yielding aluminium.

Cryolite (Na_3AlF_6): It acts as a solvent and lowers the fusion temperature from 2050°C to 950°C, thereby saving electrical energy.

Fluorspar (CaF_2): It increases the conductivity of electrolytic mixture, since alumina is almost a non-conductor of electricity.

b. Layer of powdered coke is sprinkled over the surface of the electrolytic mixture to prevent the heat loss by radiation and prevents carbon anode from burning in air.

3. a. Cu

b. Pb

c. Mg

2018

1. a. Froth floatation process

2. a. $2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$

3. a. haematite

4. a. Brass → Copper and zinc

b. Duralumin → Aluminium, copper, magnesium and manganese

5. a. Bauxite ($Al_2O_3.2H_2O$)

b. Baeyer's process

c. $Al_2O_3 \rightleftharpoons \underset{\substack{\text{Cation} \\ \downarrow \\ \text{Cathode}}}{2Al^{3+}} + \underset{\text{Anion}}{3O^{2-}}$

Cathode

$$2Al^{3+} + 6e^{-} \longrightarrow 2Al$$

2019

1. a. iii. aluminium brings lightness.

2. a. $CuO + H_2 \rightarrow Cu + H_2O$

3. a. Calcination

4. a. $Al_2O_3.2H_2O$

b. Na_3AlF_6

c. $NaAlO_2$

5. a. Cryolite acts as a solvent and lower the fusion temperature from 2050°C to 950°C thus saving electricity.

b. A layer of powdered coke is sprinkled over the surface of the electrolyte to reduce the heat loss by radiation and prevent the carbon rod from burning in air.

c. Cathode

6. a. Duralumin → iii. Aircraft body

b. Solder → i. Electrical fuse

c. Brass → iv. Decorative articles

d. Stainless steel → ii. Surgical instruments

7. a. Oxygen gas is released.

2020

1. a. Sulphide ore floats on the surface of water as froth and the process is froth floatation process.

2. a. Alloy

3. a. bronze

4. Digestion: $Al_2O_3{\cdot}2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

Precipitation: $NaAlO_2 + 2H_2O \xrightarrow{50-60°C} NaOH + Al(OH)_3\downarrow$

Calcination: $2Al(OH)_3 \xrightarrow{1100-1300°C} Al_2O_3 + 3H_2O$

2022 Semester 2

1. a. iv. cryolite

b. ii. Fluorspar

2. a. An ore is a mineral from which the metal can be extracted profitably.

3. a. Aluminium is very reactive due to which its oxide is quite stable and it cannot be reduced by a reducing agent like coke and CO. Therefore, it can be reduced only by electrolytic reduction.

4. a. Magnalium – Light scientific instruments like beam balance, metal mirrors

b. Duralumin – Aircraft and its parts, speed boats

5. a. Hoope's Process

6. a. graphite, aluminium

7. a. Minerals

b. An alloy

Chapter – 8

Study of Compounds – Hydrogen Chloride

P. 155 Check Your Progress 1

1. **a.** Concentrated H_2SO_4
   b. $NaHSO_4$
   c. NH_4Cl
   d. Hydrogen gas
   e. Fountain experiment
2. **a.** $P_4O_{10} + 3HCl \rightarrow \underset{\text{phosphorus oxychloride}}{POCl_3} + \underset{\text{metaphosphoric acid}}{3HPO_3}$
   b. $HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$

P. 159 Check Your Progress 2

1. **a.** iron(II) sulphide
   b. lead(IV) oxide, oxidizing agent.
   c. oxidizes
   d. Lead nitrate, hot
2. **a.** SO_2
   b. CO_2
   c. H_2S
   d. $NO_2 + NO$

P. 160–164 EXERCISES

I. Objective Type Questions

A. Choose the correct option

1. b **2.** c **3.** d **4.** a **5.** a
6. d **7.** b **8.** c **9.** a **10.** b
11. c **12.** d **13.** c **14.** a **15.** b
16. a **17.** a **18.** c **19.** c **20.** d

B. Fill in the blanks

1. single
2. chlorides
3. upward
4. moist
5. HCl
6. does not ionize
7. dissociates
8. ammonia
9. ferrous
10. constant

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. HCl
2. HCl
3. Fountain experiment
4. CO_2
5. Sulphide salt

B. Match the following.

1. c **2.** d **3.** a **4.** e **5.** b

C. Match the given word(s) with its appropriate description.

1. c **2.** d **3.** e **4.** b **5.** a

D. Name each of the following.

1. SO_2
2. Gold chloride
3. $3HCl + 1HNO_3$
4. Moist NH_3
5. AgCl

E. Answer the following questions.

1. NaCl and conc. H_2SO_4
2. Below 200°C
3. HCl acid
4. It forms nascent chlorine which dissolves noble metals like gold, platinum.
5. Gold and platinum

III. Short Answer Type Questions

A. Give reasons for the following.

1. Concentrated sulphuric acid is used because it is less volatile in nature amd therefore can displace a more volatile acid from its corresponding salt..
2. When HCl is dissolved in water, it releases hydronium ions. The formation of hydronium ions by HCl is responsible for the acidic character.
3. Platinum combines with nascent chlorine atoms released from aqua regia and forms platinum tetrachloride.
4. As platinum dissolves in aqua regia and forms new chemical, platinum chloride.
5. The metals are placed in a mixture of hydrochloric acid and sulphuric acid so that the acid dissolves the metal oxide coating present on the metal surface.

B. Differentiate between the following pair.

1.

HCl gas	**Hydrochloric acid**
It is a gas.	It is a gas dissolved in water.
It is prepared in the lab by the action of conc. Sulphuric acid on sodium chloride.	It is prepared by dissolving hydrogen chloride gas in water.

C. Diagram-based questions

1. **a.** It contains water.
   b. No
   c. Red
   d. Because the entire hydrogen chloride gas dissolves rapidly in water entering the flask.
2. **a.** The burning candle extinguishes.
   b. It will turn red.
   c. To show that hydrogen chloride gas is heavier than air.

D. Equations-based questions

1. **a.** $H_2 + Cl_2 \rightarrow 2HCl$
   b. $NaCl + H_2SO_4 \xrightarrow{<200^\circ C} NaHSO_4 + HCl(g)$
   c. $CaO + 2HCl \rightarrow CaCl_2 + H_2O$
   d. $HCl(g) + NH_4OH(aq) \rightarrow NH_4Cl(g) + H_2O(l)$
   e. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$
2. **a.** $Ca(s) + 2HCl(g) \rightarrow CaCl_2(s) + H_2(g)\uparrow$
   b. $Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) + H_2(g)\uparrow$
   c. $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$
   d. $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2\uparrow$
   e. $KHCO_3 + HCl \rightarrow KCl + H_2O + CO_2\uparrow$
   f. $K_2SO_3 + 2HCl \rightarrow 2KCl + H2O + SO_2\uparrow$
   g. $NaHSO_3 + HCl \rightarrow NaCl + H_2O + SO_2\uparrow$
   h. $FeS + 2HCl \rightarrow FeCl_2 + H_2S\uparrow$
   i. $CuS + 2HCl \rightarrow CuCl_2 + H_2S\uparrow$
   j. $Pb(NO_3)_2 + 2HCl \rightarrow PbCl_2\downarrow + 2HNO_3$
3. $AgNO_3 + HCl \rightarrow AgCl\downarrow + HNO_3$

   Curdy white ppt of silver chloride is formed.
4. $Pb(NO_3)_2 + 2HCl \rightarrow PbCl_2\downarrow + 2HNO_3$

   White precipitate of lead chloride is formed.
5.

Chemicals combine with HCl acid	**Gas evolved**
Carbonate	CO_2
Sulphite	SO_2
Sulphide	H_2S
Bicarbonate	CO_2
Hydrogen sulphite	SO_2

E. Define the following.

Azeotropic mixtures are mixtures of two or more liquids with similar boiling points and a similar composition in their vapour phase.

F. Answer the following questions.

1. It will form curdy white precipitate of silver chloride with clear silver nitrate solution.
2. It is used for pickling of metals before electroplating or galvanising.
3. To avoid back suction.
4. 3 Parts conc. HCl and 1 part conc. HNO_3.
5. Dense white fumes of ammonium chloride are obtained.

IV. Knowledge-based Questions

1. In the laboratory, hydrogen chloride gas is prepared by the action of concentrated sulphuric acid on common salt, sodium chloride.

   Reaction: The reaction takes place at a temperature of 200 °C as follows:

   $NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4 + HCl$

   The gas obtained is dried and purified by passing it through concentrated H_2SO_4 which acts as a dehydrating and drying agent. In the laboratory preparation, dry HCl gas is collected by the upward displacement of air.
2. Fountain experiment: to demonstrate high solubility of hydrogen chloride gas.

   Procedure: A round bottom flask is filled with hydrogen chloride gas and is placed in an inverted position. A rubber stopper with two holes in its base is fitted in this flask. Through one hole, a delivery tube with a jet is passed and through the other, a syringe filled with water. The delivery tube is put in a trough containing blue litmus solution. When the syringe is squeezed, the water entering the flask dissolves almost the entire hydrogen chloride gas, thus creating a partial vacuum.

   The vacuum draws up the litmus solution, which spurts into the round bottom flask and turns red when it comes in contact with the undissolved hydrogen chloride gas.
3. To show hydrogen chloride gas is heavier than air, place a burning candle in jar B. Place jar A containing dry HCl gas over jar B. The burning candle gets extinguished because HCl gas being heavier than air displaces air from jar B.

Inference: Hydrogen chloride (HCl) gas is heavier than air.

4. Reaction with active metals: HCl reacts with active metals which are placed above hydrogen in the metal reactivity series. Hydrochloric acid reacts with active metals to form metal chlorides and liberates hydrogen gas.

   $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

   Reaction with bases, i.e. oxides and hydroxides of metals: Hydrochloric acid neutralizes oxides and hydroxides of metals to form their corresponding salts and water.

   $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

   Since hydrochloric acid is a monobasic acid, it forms only normal salts.

5. Chemical tests:
   - **a.** A glass rod dipped in ammonia solution gives dense white fumes with hydrochloric acid. $NH_3 + HCl \rightarrow NH_4Cl$
   - **b.** Hydrochloric acid forms a curdy white precipitate with silver nitrate solution. The precipitate is insoluble in nitric acid but soluble in ammonium hydroxide.

     $AgNO_3 + HCl \rightarrow AgCl\downarrow + HNO_3$
   - **c.** Concentrated hydrochloric acid when reacts with manganese dioxide liberates greenish-yellow chlorine gas.

     $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

     The liberated gas turns starch iodide paper blue-black.
   - **d.** Hydrogen chloride gas is highly soluble in water. When the delivery tube containing hydrogen chloride gas is directly immersed in water, its rate of dissolution in water is higher than its rate of formation. This creates a partial vacuum inside the delivery tube resulting in low pressure. To balance this low pressure, the air from outside exerts pressure on the water in a beaker and hence, forces it up through the delivery tube in the flask. As a result, water is sucked back. This effect is called back suction.

V. Application and Skill-based Questions

1. When concentrated hydrochloric acid is mixed with concentrated nitric acid in the ratio of 3 : 1, it forms a mixture called aqua regia.

   $3HCl + HNO_3 \rightarrow NOCl_2 + 2H_2O + [Cl]$.

   The nascent chlorine, released by this reaction, reacts with noble metals to form their respective soluble chlorides. Aqua regia is, therefore, used to dissolve noble metals like platinum and gold.

   $Au + 3[Cl] \rightarrow AuCl_3$

   $Pt + 4[Cl] \rightarrow PtCl_4$

2. To prove that the HCl gas is highly soluble in water and acidic in nature.
3. Pink fountain will be obtained.
4. Concentrated hydrochloric acid is a strong reducing agent as it reduces strong oxidizing agents like oxides of lead, manganese, permanganate and dichromates.

   $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$

   $PbO_2 + 4HCl \rightarrow PbCl_2 + 2H_2O + Cl_2$

5. Concentrated HCl will react with violet potassium permanganate solution, and decolourise it whereas dilute hydrochloric acid will not.

   $2KMnO_4 + 16HCl \text{ (conc.)} \rightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

   KMnO4 + HCl (dil.) → no reaction

VI. Reasoning/Observation-based Questions

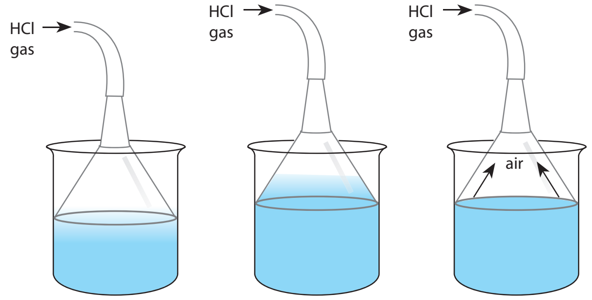
1. **a.** Curdy white ppt of silver chloride is formed.
   - **b.** White ppt of lead nitrate is formed.
   - **c.** Greenish yellow chlorine gas is evolved.
   - **d.** Rotten egg like smelling gas hydrogen sulphide is formed.
   - **e.** Dense white fumes of ammonium chloride are formed.
   - **f.** It fumes in moist air as it is soluble in water.
2. **a.** No effect on blue litmus paper.
   - **b.** Solution becomes pale green.
   - **c.** White fumes are formed.
   - **d.** It liberates greenish yellow gas.
   - **e.** White precipitation occurs which disappears on warming.
3. **a.** A salt soluble in hot water but insoluble in cold water, obtained on heating an oxidizing agent with conc. HCl. – **R:** $PbCl_2$
   - **b.** A salt obtained on reaction of an active metal with hydrogen chloride gas. – **S:** $FeCl_2$
   - **c.** A soluble salt obtained on reaction of a metallic chloride with liquor ammonia. – **T:** $Ag(NH_3)_2Cl$
   - **d.** A salt which is insoluble in dilute nitric acid but soluble in ammonium hydroxide. – **Q:** AgCl
   - **e.** A salt obtained when basic gas reacts with hydrogen chloride gas. – **P:** NH_4Cl

P. 164–166 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. **a. iv.** conc. sulphuric acid.
2. **a.** $Na_2S_2O_3 + \underset{\text{dil}}{2HCl} \rightarrow 2NaCl + SO_2 + H_2O + S\uparrow$

   b. $Ca(HCO_3)_2 + \underset{\text{dil}}{2HCl} \rightarrow CaCl_2 + 2H_2O + 2CO_2\uparrow$
3. **a.**



The funnel rim is in contact with the water surface

As the water level rises, it raises the funnel

The funnel rim loses contact with water surface. Air from the outside enters in and equalizes the pressure

b. To check back suction
To check escape in air.

c. i. $NaCl + \underset{\text{conc.}}{H_2SO_4} \xrightarrow[\Delta]{<200\,°C} NaHSO_4 + HCl\uparrow$

ii. $2NaCl + \underset{\text{conc.}}{H_2SO_4} \xrightarrow[\Delta]{>200\,°C} \underset{\text{aq}}{Na_2SO_4} + 2HCl\uparrow$

2012

1. Aqua regia contains a mixture of one part by volume of concentrated nitric acid and three parts by volume of concentrated hydrochloric acid.
2. Because quick lime is basic in nature and combines with moist hydrogen chloride gas forming calcium chloride.
3. **a.** $2KMnO_4 + 16HCl \rightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

   b. $AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$
4. SO_4^{-2} ion
5. $NaCl + \underset{\text{conc. A}}{H_2SO_4} \xrightarrow{\Delta<200°C} NaHSO_4 + \underset{\text{Hydrogen chloride}}{HCl\uparrow}$

   $2HCl + \underset{\text{B}}{Fe} \rightarrow \underset{\text{Iron (II) chloride}}{FeCl_2} + H_2$

   $\underset{(g)}{HCl} + \underset{\text{C}(g)}{NH_3} \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl}$

   $\underset{\text{(dil)}}{2HCl} + \underset{\text{(aq) D}}{Pb(NO_3)_2} \rightarrow \underset{\text{Lead chloride}}{PbCl_2\downarrow} + 2HNO_3$

2013

1. **a.** Sulphur dioxide (SO_2) gas is evolved.

   b. Chlorine (Cl_2) gas is released.
2. When dilute HCl acid is added to $AgNO_3$, first AgCl is formed, which reacts with NH_4OH and soluble diamine sliver chloride $[Ag(NH_3)_2Cl]$ is formed.
3. **a.** Add H_2SO_4 to NaCl. It forms HCl. When HCl is added to sodium nitrate, there is no reaction.

   b. Ammonia gives dense white fumes with a rod dipped in concentrated hydrochloric acid while hydrogen sulphide gas does not give any fumes with ammonia.
4. Hydrogen chloride gas

2014

1. CaO is alkaline
2. $Na_2S + 2HCl \rightarrow 2NaCl + H_2S\uparrow$
3. A colourless odourless gas is liberated with brisk effervesence.
4. **a.** Y is hydrogen chloride (HCl) gas.

   b. Gas Y is highly soluble in water.

   c. Ammonia gas

2015

1. Hydrogen chloride
2. Hydrochloric acid.
3. **a.** $NaCl + H_2SO_4 \xrightarrow{<200\,°C} NaHSO_4 + HCl(g)$

   If the temperature increases beyond 200 °C, sodium sulphate is formed.

   $NaCl + NaHSO_4 \xrightarrow{<200\,°C} Na_2SO_4(aq) + HCl(g)$

   b. It is dried by passing through concentrated sulphuric acid because it does not react with H_2SO_4.

   c. Wear goggles, gloves and maintain the temperature below 200 °C to avoid the formation of Na_2SO_4. Sodium sulphate sticks to the glass and is difficult to remove.

2016

1. **a. iii.** HCl is highly soluble in water
2. **a.** $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$.
3. **a.** When dilute hydrochloric acid is added to lead nitrate, insoluble white precipitate of lead chloride is formed.

   $Pb(NO_3)_2 + 2HCl \rightarrow 2HNO_3 + \underset{\text{(white ppt)}}{PbCl_2\downarrow}$

When the mixture is heated, the precipitate dissolves because lead chloride is soluble in hot water.

b. When dilute hydrochloric acid is added to copper carbonate, copper chloride and carbonic acid are formed, which further decompose into water and carbon dioxide.

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2CO_3 \rightarrow CuCl_2 + H_2O + CO_2\uparrow$$

c. Dilute hydrochloric acid reacts with sodium thiosulphate to form sodium chloride, liberate sulphur dioxide gas and sulphur.

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2\uparrow + S\downarrow$$

4. a. Gas evolved: SO_2 (Sulphur dioxide)

Chemical test: It changes orange acidified potassium dichromate green.

b. Gas evolved: H_2S (Hydrogen sulphide)

Chemical test: Turns lead nitrate solution black

2017

1. a. SO_2

2. b. Ammonium chloride

3. c. Rotten egg smelling hydrogen sulphide gas is evolved.

4. A - below 200°C: $NaHSO_4 + HCl$

above 200°C: $Na_2SO_4 + 2HCl$

B - Upward displacement of air.

2018

1. a. $MgSO_3 + 2HCl \rightarrow MgCl_2 + H_2O + SO_2\uparrow$

2. a. White precipitate of lead chloride is formed which is soluble in hot water and insoluble in cold water.

3. a. upward

4. a. Sulphuric acid

[It is preferred over other acids because it is a less volatile in nature.]

b. $NaCl + H_2SO_4 \xrightarrow{\text{below } 200°C} NaHSO_4 + HCl\uparrow$

5. a. Direct absorption of hydrogen chloride gas in water is not feasible as it leads to back suction.

b. Funnel arrangement" is done to dissolve hydrogen chloride gas in water.

6. a. H_2S (Hydrogen sulphide)

2019

1. a. i. Conc. H_2SO_4

2. a. sodium bisulphate

3. a. $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

Zinc metal dissolves forming solution with the liberation of hydrogen gas which bums with a blue flame and a pop sound.

4. a. $\underset{\text{(black)}}{MnO_2} + 4HCl \rightarrow \underset{\text{(colourless)}}{MnCl_2} + 2H_2O + \underset{\text{(greenish yellow gas)}}{Cl2\uparrow}$

b. $CuO + 2HCl \rightarrow CuCl_2 + H_2O$

$Pb(NO_3)_2 + 2HCl \rightarrow \underset{\text{(white ppt.)}}{PbCl_2\downarrow} + 2HNO_3$

(Insoluble in cold water but dissolves in warm water)

$Pb(NO_3)_2 + H_2SO_4 \rightarrow \underset{\text{(white ppt.)}}{PbSO_4} + 2HNO_3$

(Insoluble both in cold water and warm water)

2020

1. a. As HCl is highly soluble in water.

2. a. $NaCl + H_2SO_4 \xrightarrow{< 200°C} NaHSO_4 + HCl(g)$

b. In place of concentrated sulphuric acid, concentrated nitric acid cannot be used. This is because concentrated nitric acid is volatile and may evaporate along with hydrogen chloride.

c. By upward displacement of air.

d. CaO and P_2O_5

2022 Semester 2

1. a. i. it is highly soluble in water

b. iv. Sodium oxide

2. a. $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

b. $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

CHAPTER – 9

STUDY OF COMPOUNDS – AMMONIA

P. 171 CHECK YOUR PROGRESS

1. a. Ammonium chloride

b. Quicklime (Calcium oxide)

c. Haber Bosch Process

d. Finely divided iron in the presence of molybdenum.

2. a. $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3\uparrow$

b. $NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$

c. $AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3\uparrow$

d. $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

3. a. Ammonia cannot be collected over water because ammonia is highly soluble in water.

b. Ammonia is manufactured by Haber Bosch process.

i. Dry nitrogen and hydrogen gas taken in the ratio of 1 : 3 in the presence of finely divided iron and molybdenum at a temperature of 500 °C and under a pressure of 200 atmospheres react to give ammonia.

$$\underset{\text{1 vol}}{N_2(g)} + \underset{\text{3 vol}}{3H_2(g)} \rightleftharpoons \underset{\text{2 vol}}{2NH_3(g)} + \text{heat}$$

ii. In Haber's process, ammonia is prepared from nitrogen and hydrogen taken in the ratio of 1:3 by volume.

iii.
- Nitrogen is obtained by the fractional distillation of air.
- Hydrogen is obtained either from water gas through Bosch process or from natural gas.

c. As ammonium nitrate (NH_4NO_3) is explosive in nature and decomposes on heating, it is not used for the preparation of ammonia.

$NH_4NO_3 \rightarrow N_2O + 2H_2O$

P. 176–177 CHECK YOUR PROGRESS

1. a. hydroxide **b.** ammonium chloride

c. neutral **d.** white

e. Ammonium chloride

2. a. AgCl **b.** Ammonia

c. NCl_3 **d.** NO_2

e. $Cu(OH)_2$

3. a. The yellow-green colour of gaseous chlorine disappears and dense white fumes of ammonium chloride are formed.

b. $3PbO + 2NH_3 \rightarrow 3Pb + 3H_2O + N_2\uparrow$

Observation: A yellow coloured lead(II) oxide is reduced to grey coloured lead metal.

c. When ammonia is passed through phenolphthalein solution, it turns pink.

d. $\underset{\text{lead nitrate}}{Pb(NO_3)_2} + 2NH_4OH \rightarrow \underset{\text{precipitate is white insoluble in excess}}{Pb(OH)_2\downarrow} + 2NH_4NO_3$

P. 178-182 EXERCISES

I. Objective Type Questions

A. Choose the correct option

1. c **2.** d **3.** a **4.** b **5.** b

6. c **7.** d **8.** a **9.** b **10.** b

11. c **12.** b **13.** c **14.** a **15.** b

16. a **17.** c **18.** d **19.** b **20.** d

B. Fill in the blanks.

1. Red, blue
2. water
3. acids
4. Ammonia
5. white
6. ammonia
7. Ammonia
8. excess, nitrogen
9. nitrogen
10. reduces, oxidized

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Ammonia
2. Haber-Bosch process
3. Nitrogen
4. Ammonia
5. Platinum

B. Give one example for each of the following.

1. When ammonia is passed over heated copper oxide or lead oxide.
2. Ammonium nitrate
3. Ammonium chloride - Sal ammoniac
4. Nessler's reagent
5. Phenolphthalein or red litmus

C. Match the following.

1. e **2.** d **3.** a **4.** b **5.** c

D. Match the given reaction with its product.

1. e **2.** d **3.** a **4.** b **5.** c

E. Name each of the following.

1. Ammonia

2. Nessler's reagent

3. Urea

4. Ammonium chloride

5. Ammonium chloride

F. Choose the odd one out.

1. Methyl orange being acidic indicator.

G. Answer the following questions.

1. Urea

2. Brown ppt is formed.

3. Ammonium chloride and calcium hydroxide

4. To avoid back suction.

5. Ammonia in liquid state. It is also known as liquefied ammonia.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Slaked lime is used instead of sodium hydroxide and potassium hydroxide because slaked lime is cheap and is not deliquescent like these caustic alkalis.

2. It is lighter than air and highly soluble in water.

3. This is because CaO is basic in nature and it reacts with other drying agents like concentrated sulphuric acid, phosphorus penta oxide and fused calcium chloride.

4. As dry ammonia does not generate hydroxyl ion in dry state. But when ammonia is dissolved in water, it generates hydroxyl ions and thus is an akali.

5. In order to make the reaction irreversible.

B. Differentiate between the following pair.

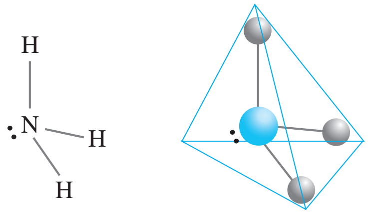
1. Liquor ammonia is ammonia in water whereas liquid ammonia is ammonia in liquid state.

C. Complete the following table.

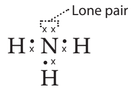
Cation	Solubility in little ammonium hydroxide	Solubility in excess ammonium hydroxide
Fe^{2+}	Dirty green ppt	Insoluble
Cu^{2+}	Pale blue ppt	Insoluble
Zn^{2+}	Gelatinous white ppt	Soluble
Pb^{2+}	Chalky white ppt	Insoluble
Ca^{2+}	No ppt	No ppt

D. Diagram-based questions.

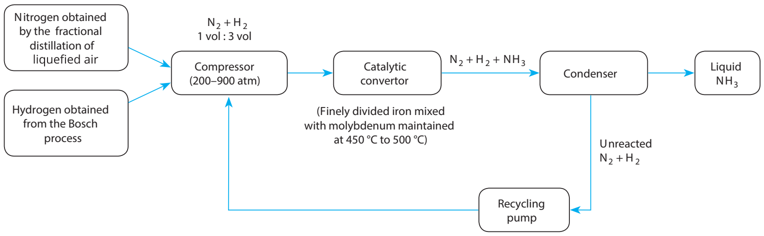
1.



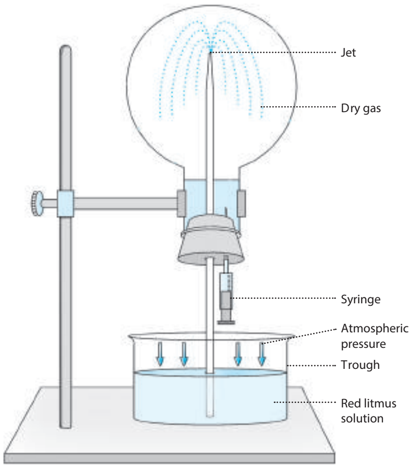
Lewis diagram:



2.



3.



4. **a.** Water

b. No

c. Blue

d. As the ammonia gas is basic or alkaline in nature when dissolved in water.

5. **a.** It acts as a drying agent.

b. $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

c. On bringing a glass rod dipped in concentrated hydrochloric acid, dense white fumes of ammonium chloride will be obtained.

d. Calcium chloride formed will be left behind as residue.

E. Equations-based questions

1. **a.** $NH_3 + HCl \rightarrow NH_4Cl$

b. $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

c. $4NH_3 + 5O_2 \xrightarrow{\text{Pt at 800°C}} 4NO + 6H_2O + \text{heat}$

d. $8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$

e. $NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$

f. $3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2\uparrow$

g. $3PbO + 2NH_3 \rightarrow 3Pb + 3H_2O + N_2\uparrow$

h. $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

i. $2NH_3 + CO_2 \rightarrow NH_2CONH_2 + H_2O$

j. $N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{heat}$

2. **a.** $AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3$

b. $2NH_3 + CO_2 \xrightarrow[\text{200 atm}]{\text{150 °C}} NH_2CONH_2 + H_2O$

c. $2NH_3 + 3CuO \xrightarrow{\Delta} N_2 + 3Cu + 3H_2O$

d. $6NH_3 + 3H_2O + P_2O_5 \rightarrow 2(NH_4)_3PO_4$

e. $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

3. **a.** $Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

lead nitrate

precipitate is white insoluble in excess

b. $CuSO_4 + 2NH_4OH \longrightarrow (NH_4)_2SO_4 + Cu(OH)_2\downarrow$

c. $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

d. $Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

F. Answer the following questions.

1. Ammonia is manufactured by Haber-Bosch process. Favourable conditions are: Low temperature: 500 °C

High pressure: 900 atmosphere

Catalyst : Iron Promoter: Molybdenum

$N_2 + 3H_2 \rightarrow 2NH_3$

2. Aqueous solution of ammonia is basic in nature and hence, gives following tests:

a. It turns red litmus blue.

b. It turns colourless phenolphthalein solution pink.

c. It gives white dense fumes with HCl.

3. Ammonia gas is used in the preparation of fertilizers, washing soda, baking soda and nitric acid. Liquid ammonia is used as a refrigerant.

4. Neutralization of ammonium hydroxide takes place.

$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

$NH_4OH + HNO_3 \rightarrow NH_4NO_3 + H_2O$

5. $CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2\downarrow$

Pale blue precipitate of $Cu(OH)_2$ is soluble in excess of NH_4OH and gives deep blue coloured solution due to the formation of a complex.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

IV. Knowledge-based Questions

1. To prepare ammonia fortis, ammonia is dissolved in water. The difficulty encountered in doing so is that ammonia dissolves rapidly in water, thus causing back suction. Back suction is prevented by using the funnel arrangement. The funnel provides a large surface area, which aids in preventing back suction.

2. **a.** Turns moist red litmus blue.

b. Gives dense white fumes with a rod dipped in conc. HCl.

c. Turns colourless Nessler's reagent $[K_2HgI_4]$ brown. On passing excess ammonia through Nessler's reagent, a brown precipitate is formed.

d. Turns moist turmeric paper brown and phenolphthalein solution pink.

e. Gives a bluish-white precipitate when bubbled through aqueous copper sulphate solution. This precipitate dissolves if excess ammonia is passed through the solution, forming a deep blue solution.

3. Ammonia reacts with moist carbon dioxide to form ammonium carbonate.

$$2NH_3 + H_2O + CO_2 \rightarrow (NH_4)2CO_3$$

Dry ammonia and carbon dioxide when reacted at about 150 °C and 200 atm pressure form urea, a nitrogenous fertilizer.

$2NH_3 + CO_2 \rightarrow NH_2CONH_2 + H_2O$

4. **a.** Oxidation of ammonia: Ammonia is neither combustible nor does it support combustion. It extinguishes a burning splinter. However, ammonia burns in oxygen with a greenish yellow flame forming nitrogen and water vapour.

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

b. Catalytic oxidation of ammonia:

Ammonia reacts with oxygen in the presence of platinum catalyst to form nitric oxide and water.

$4NH_3 + 5O_2 \xrightarrow{\text{Pt at 800°C}} 4NO + 6H_2O + \text{heat}$

$2NO + O_2 \rightarrow 2NO_2$

The catalyst is heated to about 800 °C and the heating is discontinued once the reaction is initiated, yet the catalyst glows red hot because the reaction is exothermic.

5. Lab preparation from ammonium chloride

Reactants: Ammonium chloride (sal ammoniac) and dry calcium hydroxide in the ratio of 2 : 3 by weight.

Reaction: Dry ammonium chloride reacts with calcium hydroxide when heated gently to form ammonia.

$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

Condition and reactions: Excess of calcium hydroxide is used to counter the loss of ammonium chloride due to sublimation. Slaked lime is used instead of sodium hydroxide and potassium hydroxide because slaked lime is cheap and is not deliquescent like these caustic alkalis.

Reactants should be in a grounded state so as to provide maximum surface area for reaction.

V. Application and Skill-based Questions

1. Metals like magnesium, calcium and aluminium when burnt in nitrogen gas form their respective metal nitrides. When warm water is added in a dropwise manner to these nitrides, these nitrides undergo hydrolysis to liberate ammonia.

$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3\uparrow$

$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3\uparrow$

$AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3\uparrow$

2. This is because ammonia reacts with these compounds.

Reaction with conc. sulphuric acid:

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Reaction with phosphorus pentoxide:

$6NH_3 + P_2O_5 + 3H_2O \rightarrow 2(NH_4)_3PO_4$

Reaction with fused calcium chloride:

$8NH_3 + CaCl_2 \rightarrow CaCl_2{\cdot}8NH_3$

3. Dry ammonia gas is neutral in nature. It does not give test with dry red litmus paper. But when ammonia is dissolved in water, it generates hydroxyl ions and thus behaves like an alkali.

$NH_3 + H_2O \rightarrow NH_4OH \rightarrow NH_4^+ + OH^-$

Therefore, it turns moist red litmus paper blue, methyl orange to yellow and colourless phenolphthalein solution to pink.

4. When chlorine is in excess:

$NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$ (excess)

A yellow coloured liquid (NCl_3) is formed which is highly explosive in nature.

When ammonia is in excess:

$8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$

The yellow-green colour of gaseous chlorine disappears and dense white fumes of ammonium chloride are formed.

5. Reduction of copper oxide:

Reaction: $3CuO + 2NH_3 \rightarrow \underset{\text{reddish brown}}{3Cu} + 3H_2O + N_2\uparrow$

Observation: The black coloured copper oxide turns to reddish brown copper metal.

Reduction of lead oxide: $3PbO + 2NH_3 \rightarrow 3Pb + 3H_2O + N_2\uparrow$

Observation: A yellow coloured lead(II) oxide is reduced to grey coloured lead metal.

VI. Reasoning/Observation-based Questions

1. a. Ammonium hydroxide

b. NH_4OH

c. $CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$

Bluish white precipitate is obtained.

When excess ammonium hydroxide is added to the above mixture an inky blue solution of tetraamine copper sulphate is formed.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

2. As it helps in the identification of certain positive radicals. Like:

$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

precipitate is white nitrate insoluble in excess.

$Zn(NO_3)_2 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + 2NH_4NO_3$

precipitate is white soluble in excess.

$FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$

precipitate is gelatinous brown insoluble in excess.

$FeSO_4 + 2NH_4OH \rightarrow Fe(OH)_2\downarrow + (NH_4)_2SO_4$

precipitate is dirty green insoluble in excess.

$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$

precipitate is bluish white sulphate soluble in excess.

When excess ammonium hydroxide is added to the above mixture, an inky blue solution of tetraamine copper sulphate is formed.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

3. On vaporizing 1 mole (or 17 g) of liquid ammonia, 5.7 kcals of heat from the surroundings is absorbed and the water is converted into ice. Hence, ammonia is used as a refrigerant as well as in the manufacture of ice.

4. Ammonium hydroxide dissociates **partially** in solution to form the hydroxyl ions.

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

5. Ammonia reacts with oxygen in the presence of platinum catalyst to form nitric oxide and water.

$4NH_3 + 5O_2 \xrightarrow{\text{Pt at 800°C}} 4NO + 6H_2O + \text{heat}$

Formation of NO is the initial reaction for the large-scale manufacturing of nitric acid by the Ostwald's process.

P. 144–145 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. A colourless gas with characteristic pungent smell of ammonia forms.
2. **a.** Ammonia

   b. $Ca(OH)_2 + 2NH_4Cl \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3\uparrow$

   c. By downward displcement of air

   d. Quicklime (CaO)

   e. When a wet red litmus paper is brought near the mouth of the jar, it turns blue.
3. $3Cl_2 + 8NH_3 \rightarrow 6NH_4Cl + N_2$
4. ammonia, alkaline, ammonium, hydroxyl, dirty green

2012

1. Nitrogen gas
2. Magnesium nitride reacts with warm water to liberate ammonia.
3. $4NH_3 + 5O_2 \xrightarrow{\text{Pt at 800 °C}} 4NO + 6H_2O + \text{heat}$
4. **a.** Because ammonium nitrate is explosive in nature and dissociate into nitrous oxide and water on heating.

   b. Quick lime

   c. By downward displacement of air

   d. Because it is highly soluble in water.

2013

1. Ammonia reacts with excess chlorine to form nitrogen trichloride and hydrogen chloride gas.
2. **a.** ammonium nitrate.
3. $3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2\uparrow$
4.

Name of the process	Temperature	Catalyst	Equation for the catalyzed reaction
Haber Bosch process	450 °C to 500 °C	heated iron and molybdenum	$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$

2014

1. a downward displacement of air
2. $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3\uparrow$
3. A colourless gas with characteristic smell of ammonia is evolved.
4. **a.** Hydroxyl ion.

   b. It will give dirty green precipitate with iron(II) sulphate solution.

2015

1. Ammonia
2. Ammonia burns in excess oxygen with a greenish-yellow flame forming nitrogen and water vapour.

   $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
3. Nitric acid
4. **a.** $\underset{\text{Ammonium salt}}{2NH_4Cl(s)} + \underset{\text{Slaked lime}}{Ca(OH)_2(s)} \xrightarrow{\text{heat}} \underset{\text{Calcium chloride}}{CaCl_2(s)} + 2H_2O(l) + \underset{\text{Ammonia gas}}{2NH_3\uparrow(g)}$

   b. $NH_3 + 3Cl_2 \rightarrow 3HCl + \underset{\text{Nitrogen chloride}}{NCl_3}$

   c. $2NH_3 + H_2SO_4 \rightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$

2016

1. $AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3\uparrow$
2. **a.** **i.** Ammonia gas

   $2NH_4Cl + \underset{\text{slaked lime}}{Ca(OH)_2} \rightarrow CaCl_2 + 2H_2O + 2NH_3$

   ii. Nitrogen gas

   $NaNO_2 + NH_4Cl \xrightarrow{\text{heat}} NaCl + NH_4NO_2$

   $NH_4NO_2 \xrightarrow{\text{heat}} N_2 + 2H_2O$

   b. **i.** $8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$

   ii. $2NH_3 + 3CuO \rightarrow 3Cu + 3H_2O + N_2\uparrow$

2017

1. **a.** Ammonium chloride
2. **a.** $3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2\uparrow$

   b. $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O$

3. A - $Mg_3N_2 + 6H_2O$

B - CaO

C - Downward displacement of air.

4. a. $4NH_3 + 5O_2 \xrightarrow{\text{Pt at } 800°C} 4NO + 6H_2O + \text{heat}$

b. $NH_3 + HNO_3 \rightarrow NH_4NO_3$

5. Ammonia burns in air to form greenish-yellow flame forming nitrogen and water vapour.

2018

1. a. $NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$

b. Concentrated sulphuric acid is not used for drying ammonia gas because it reacts with ammonia.

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

c. Ammonia is a highly soluble gas. One volume of water can dissolve 702 volumes of ammonia at 20°C and at 1 atmospheric pressure. Hence it is not collected over water.

2019

1. a. Nitrogen trichloride

2. a. Platinum

3. a. Nitrogen

4. A - $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

B - $NH_3 + HCl \rightarrow NH_4Cl$

C - $2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + 2H_2O + CaCl_2$

5. (i) Haber Bosch process

(ii) $\underset{1 \text{ vol}}{N_2(g)} + \underset{3 \text{ vol}}{3H_2(g)} \rightleftharpoons \underset{2 \text{ vol}}{2NH_3(g)} + \text{heat}$

Catalyst: Finely divided iron in the presence of molybdenum

2020

1. a. $8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$

2. a. Ammonia

3. a. Platinum

2022 Semester 2

1. a. iii. basic

2. a. Ammonia and chlorine gas react to form ammonium chloride and nitrogen gas.

3. a. Nitric oxide and water are formed. Nitric oxide further reacts to form nitrogen dioxide.

b. A yellow coloured liquid nitrogen trichloride, which is an explosive, is formed.

4. a. $2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$

5. A - Ammonium chloride and calcium hydroxide

B - Fresh quick lime

C - Downward displacement of air

CHAPTER – 10

STUDY OF COMPOUNDS – NITRIC ACID

P. 188 CHECK YOUR PROGRESS 1

1. **a.** HNO_3 vapours

b. NO

c. NO_2

2. **a.** The reaction mixture is not heated beyond 200 °C because of the following reasons:

i. At high temperature, nitric acid decomposes to form nitrogen dioxide gas.

ii. The residue of Na_2SO_4 and K_2SO_4 forms a hard crust and sticks to the glass walls and is difficult to remove thus leading to wastage of fuel.

iii. Glass apparatus may break.

b. When excess of water is added, it dissolves nitrogen dioxide in water and thus, the yellow colour of the acid is removed.

c. Nitric acid cannot be concentrated by simple distillation beyond 68% because it forms a constant boiling mixture with water. A constant boiling mixture boils without change in composition.

P. 192 CHECK YOUR PROGRESS

1. **a.** conc. nitric acid

b. nitrogen dioxide

c. sulphur

d. iron

e. nascent chlorine

2. **a.** Carbon dioxide

b. Ferric sulphate

c. Copper nitrate

d. Orthophosphoric acid

P. 193–196 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. c **2.** b **3.** a **4.** b **5.** d
6. a **7.** b **8.** c **9.** b **10.** c
11. d **12.** a **13.** b **14.** a **15.** c
16. b **17.** c **18.** c **19.** d **20.** b

B. Fill in the blanks.

1. gold,

2. oxidizes, reduced

3. oxidizes, reduced

4. chlorine

5. nitrogen dioxide

6. oxygen

7. normal

8. proteins

9. distilling

10. yellow

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. Yellow

2. Saltpetre or chile saltpetre

3. Concentrated

4. Vapour form

5. Distillation

B. Give one example for each of the following.

1. Dropping active metal like magnesium in dilute nitric acid:

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$

2. Thermal decomposition of nitric acid:

$4HNO_3 \rightarrow 2H_2O + 4NO_2 + O_2$

3. Nitric acid reacts with metallic carbonates and bicarbonates to liberate carbon dioxide.

$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O + CO_2\uparrow$

$KHCO_3 + HNO_3 \rightarrow KNO_3 + H_2O + CO_2\uparrow$

4. Oxidizes hydroiodic acid to iodine:

$2HNO_3 + 2HI \rightarrow 2H_2O + 2NO_2\uparrow + I_2\uparrow$

5. $Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$

C. Match the following.

1. e **2.** d **3.** b **4.** c **5.** a

D. Match the given word(s) with its appropriate description.

1. c **2.** d **3.** e **4.** b **5.** a

E. Name each of the following.

1. Water or bubbling carbon dioxide or air through the acid.

2. Concentrated nitric acid

3. Nitrogen dioxide

4. Platinum

5. Concentrated sulphuric acid

F. Answer the following questions

1. CO_2 or air is passed through the acid which drives out nitrogen dioxide gas from the acid and further oxidizes remaining nitrogen dioxide to nitric acid.

2. Adding excess of water dissolves nitrogen dioxide in water, and thus, the yellow colour of the acid is removed.

3. Nitric acid is concentrated by distilling the acid over concentrated nitric acid.

4. Copper turnings

5. Ostwald's process

III. Short Answer Type Questions

A. Give reasons for the following.

1. With fuming HNO_3, iron becomes passive (or inert) as a thin protective film of Fe_3O_4 is formed.

2. The passivity (or inertness) of iron can be removed by rubbing the surface layer with sand paper or by treating with strong reducing agents.

3. Commercial fuming nitric acid is yellow in colour due to the presence of dissolved NO_2.

4. The quartz stones are acid resistant and slow down the movement of gaseous nitrogen dioxide and initiate better dissolution of nitrogen dioxide in water.

5. Pure nitric acid is a colourless liquid but commercial nitric acid is usually yellow in colour due to the dissolution of nitrogen dioxide.

B. Differentiate between the following pair.

1.

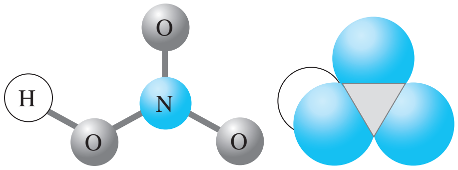
Dilute nitric acid	Concentrated nitric acid
The dilute acid oxidizes compounds and reduces to nitric oxide (NO).	The concentrated acid is usually reduced to nitrogen dioxide (NO_2).
No action on non-metals.	Oxidizes non-metals to their corresponding oxy acids.
Strongly ionized.	Poorly ionized.
Oxidizing agent.	Comparatively, stronger oxidizing agent.

C. Complete the following table.

Nitric acid	Catalytic chamber	Oxidation chamber	Absorption chamber
Equations:	$4NH_3 + 5O_2 \xrightarrow[800°C]{Platinum} 4NO + 6H_2O$ + Heat	$2NO + O_2 \xrightarrow{50°C} 2NO_2$	$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$

D. Diagram-based questions

1.



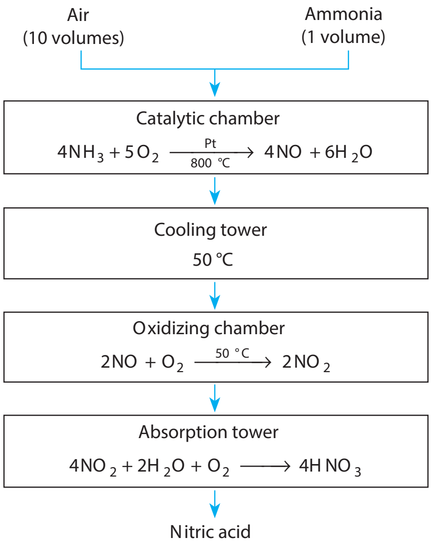
2. a. Nitric acid

b. $KNO_3 + H_2SO_4 \xrightarrow{200°C} KHSO_4 + HNO_3$

c. In vapour form.

d. Due to dissolved nitrogen dioxide.

3.



4. a. NO_3^-

b. As on exposure to atmosphere, it oxidizes to ferric sulphate (iron(III) sulphate), which does not form the brown ring.

c. Sulphuric acid and nitric acid

E. Equations-based questions

1. $2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$
2. $NaNO_3 + H_2SO_4 \xrightarrow{200°C} NaHSO_4 + HNO_3$
3. $4HNO_3 \rightarrow 4NO_2 + 2H_2O + O_2$
4. $4NH_3 + 5O_2 \xrightarrow[800°C]{Platinum} 4NO + 6H_2O + Heat$
5. $2NO + O_2 \xrightarrow{50°C} 2NO_2$
6. $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$
7. $Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$
8. $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$
9. $K_2SO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + SO_2\uparrow$
10. $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O + CO_2\uparrow$
11. $FeS + 2HNO_3 \rightarrow Fe(NO_3)_2 + H_2S$
12. $CaOCl_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + Cl_2$
13. $S + 6HNO_3 \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$
14. $C + 4HNO_3 \rightarrow CO_2 + 4NO_2 + 2H_2O$
15. $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO\uparrow$

F.

1. Constant boiling of nitric acid yields 68% nitric acid by weight.

2. Concentrated nitric acid is a better oxidizing agent than dilute nitric acid.

3. Methyl orange turns pink when it is added to dilute nitric acid.
4. Hydrogen is released when nitric acid is added to manganese.

G. Answer the following questions.

1. Freshly prepared solution of ferrous sulphate is added to dilute nitric acid taken in a test tube. Concentrated sulphuric acid is carefully poured along the sides of the test tube. A dark brown ring of hydrated nitroso ferrous sulphate is formed at the junction of the two acid layers.
2. Concentrated nitric acid on heating with copper turnings gives reddish brown fumes of nitrogen dioxide.

   $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
3. Nitric acid has a dual action on metals. It acts as an acid as well as an oxidizing agent.
4. The passivity (or inertness) of iron can be removed by rubbing the surface layer with sand paper or by treating with strong reducing agents.
5. The reaction is highly violent when nitric acid reacts with sodium, potassium and calcium.

IV. Knowledge-based Questions

1. HNO_3 oxidizes acidified ferrous sulphate to ferric sulphate:

   With concentrated nitric acid:

   $2HNO_3 + 2FeSO_4 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 2H_2O + 2NO_2\uparrow$

   With dilute nitric acid:

   $2HNO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO\uparrow$
2. Dilute nitric acid gives ring test. Freshly prepared solution of ferrous sulphate is added to dilute nitric acid taken in a test tube. Concentrated sulphuric acid is carefully poured along the sides of the test tube. A dark brown ring is formed at the junction of the two layers.

   $6FeSO_4 + 3H_2SO_4 + 2HNO_3 \rightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$

   $FeSO_4 + NO + 5H_2O \rightarrow \underset{\text{hydrated nitroso ferrous sulphate (brown ring)}}{[Fe(NO)(H_2O)_5]SO_4}$

   In the brown ring test, the concentrated sulphuric acid being heavier settles down and iron(III) sulphate layer remains above it, resulting in the formation of the brown ring at the junction.
3. Organic compounds undergo nitration when reacted with nitric acid. In nitration, hydrogen atoms of the organic compound are substituted by the $-NO_2$ group. Nitration generally takes place in the presence of concentrated sulphuric acid.

   $C_6H_6 + HNO_3 \xrightarrow[\text{concentrated}]{H_2So_4} C_6H_5NO_2 + H_2O$
4. When concentrated nitric acid is mixed with concentrated hydrochloric acid in the ratio of 1 : 3, it forms a mixture called aqua regia.

   $3HCl + HNO_3 \rightarrow \underset{\text{nitrosyl chloride}}{NOCl_2} + 2H_2O + [Cl]$

   The nascent chlorine released by the reaction reacts with noble metals to form their respective soluble chlorides. Aqua regia is, therefore, used to dissolve noble metals like platinum and gold.

   $Au + 3[Cl] \rightarrow \underset{\text{gold(III) chloride}}{AuCl_3}$
5. With fuming HNO_3, iron becomes passive (or inert) as a thin protective film of Fe_3O_4 is formed. The passivity (or inertness) can be removed by rubbing the surface layer with sand paper or by treating with strong reducing agents.

V. Application and Skill-based Questions

1. With cold dilute nitric acid, ammonium nitrate is formed.

   $4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$

   With hot dilute nitric acid, nitric oxide is formed.

   $4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$

   With concentrated nitric acid, nitrogen dioxide is formed.

   $Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$
2. Concentrated: $2HNO_3 \rightarrow H_2O + 2NO_2 + [O]$

   Dilute: $2HNO_3 \rightarrow H_2O + 2NO + 3[O]$

   Concentrated nitric acid is poorly ionized. So, its oxidizing properties predominate. Therefore, reddish brown NO_2 gas is released whereas dilute acid decomposes to form NO.
3. With dilute nitric acid, sulphur is deposited: $3H_2S + 2HNO_3 \rightarrow 4H_2O + 2NO + 3S\downarrow$
4. With conc. nitric acid:

   $$H_2S + 2HNO_3 \rightarrow 2H_2O + 2NO_2 + S\downarrow$$

   With dilute nitric acid:

   $$3H_2S + 2HNO_3 \rightarrow 4H_2O + 2NO + 3S\downarrow$$
5. Dilute nitric acid reacts with bleaching powder to liberate chlorine.

   $CaOCl_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + Cl_2$

   Chlorine is a greenish-yellow gas. It turns moist blue litmus paper initially red because it is acidic in nature and then white because it is a strong bleaching agent.

VI. Reasoning/Observation-based Questions

1. The flask is heated gently to about 200°C to initiate the reaction. The reaction mixture is not heated beyond 200°C because of the following reasons:
   - **a.** At high temperature, nitric acid decomposes to form nitrogen dioxide gas.

     $4HNO_3 \rightarrow 4NO_2 + 2H_2O + O_2$
   - **b.** The residue of Na_2SO_4 and K_2SO4 forms a hard crust and sticks to glass walls and it is difficult to remove thus, leading to wastage of fuel.
   - **c.** Glass apparatus may break
2. The apparatus is made of glass because vapours of nitric acid are corrosive and destroy materials like cork and rubber.
3. Only concentrated sulphuric acid should be used in the preparation of nitric acid because it is a strong as well as non-volatile acid. Therefore, it is capable of displacing more volatile nitric acid from sodium or potassium nitrate on heating the reaction mixture.
4. Concentrated hydrochloric acid is volatile in nature and nitric acid will carry the vapours of HCl also. Therefore, it is not used to displace another volatile acid.
5. **a.** Dust-free air and excess of air is used in the initial reaction. All stages of the reaction require oxygen.
   - **b.** All three reactions are reversible, therefore an increase in the concentration of the reactants favours the forward reactions.
   - **c.** The gases entering the catalytic chamber must be pure as impurity poisons the catalyst which then loses its efficiency.
   - **d.** Nitric oxide formed in the catalytic chamber must be cooled because low temperature favours the oxidation of nitric oxide.

P. 155–156 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. platinum
2. **a.** Brown fumes of nitrogen dioxide are formed.
3. **a.** A glass retort
   - **b. i.** At high temperature, nitric acid decomposes to form nitrogen dioxide gas.
     - **ii.** The residue of Na_2SO_4 and K_2SO_4 forms a hard crust and sticks to the glass walls and is difficult to remove, thus leading to the wastage of fuel.
     - **iii.** Glass apparatus may break.
4. $Fe(OH)_3 + 3HNO_3 \rightarrow Fe(NO_3)_3 + 3H_2O$

2012

1. Nitrogen dioxide gas
2. **a.** A reddish-brown nitrogen dioxide gas is liberated.
3. **a.** Magnesium reacts with 1% dilute and cold nitric acid to liberate hydrogen gas.

2013

1. Nitrogen dioxide (NO_2) gas is liberated.
2. **a.** $C + 4HNO_3 \rightarrow CO_2 + 4NO_2 + 2H_2O$

2014

1. **a.** nitric oxide
2. **a.** $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$
3. **a.** Platinum gauze catalyst at 800 °C in the presence of oxygen.
4. **a.** $NaNO_3 + H_2SO_4 \xrightarrow{200\ °C} NaHSO_4 + HNO_3$
   - **b.** $Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$
5. $CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O + CO_2\uparrow$

2015

1. **a.** When crystals of copper nitrate are heated in a test tube, nitrogen dioxide gas is formed and a black residue of copper oxide is left behind.

   $$2Cu(NO_3)_2 \rightarrow 2CuO + O_2 + 4NO_2$$
2. **a.** Nitric acid reacts with all metals except gold and platinum. It has a dual action on metals. It acts as an acid as well as an oxidizing agent. It reacts with metals on the basis of reactivity.
   - **b.** Pure HNO_3 is colourless but it appears yellow due to the dissolution of reddish-brown nitrogen dioxide in the acid. NO_2 is produced due to the decomposition of HNO_3.
   - **c.** As nitric acid vapours are corrosive they may corrode rubber, cork or metal. So glass apparatus is used in the laboratory preparation of nitric acid.

2016

1. **a.** $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
   - **b. i.** Nitric oxide **ii.** Sulphuric acid.

2017

1. **a.** $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO\uparrow$
2. $2NH_4Cl + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2HCl$
3. **a.** $S + 6HNO_3 \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$

   b. $4NH_3 + 5O_2 \xrightarrow[800°C]{Pt} 4NO + 6H_2O + Heat$

   c. $NaNO_3 + H_2SO_4 \xrightarrow{200°C} NaHSO_4 + HNO_3$

   d. $NH_3 + HNO_3 \rightarrow NH_4NO_3$

2018

1. **a.** Nitrogen dioxide

   b. Nitric oxide or nitrogen monoxide
2. **a.** Acid salt

   b. Glass apparatus is used because nitric acid vapours are corrosive and may destroy rubber, cork or metal.

2019

1. **a.** Dense reddish brown fumes of nitrogen dioxide are obtained.
2. **a.** $S + \underset{\text{conc.}}{6HNO_3} \rightarrow H_2SO_4 + 6NO_2 + 2H_2O$

   b. $3Cu + \underset{\text{dil.}}{8HNO_3} \rightarrow 3Cu(NO_3)_2 + 2NO\uparrow + 4H_2O$

2020

1. **a.** Dense reddish brown fumes of nitrogen dioxide are obtained.
2. **a.** $C + 4HNO_3 \rightarrow CO_2 + 4NO_2 + 2H_2O$
3. **a.** Due to the decomposition of nitric acid and emission of dark brown NO_2 gas.

2022 (Semester 2)

1. **a.** **c.** Sulphur dioxide
2. **a.** It forms CO_2 and NO_2 (reddish-brown) gas.
3. **a.** $Fe(OH)_3 + 3HNO_3 \rightarrow Fe(NO_3)_3 + 3H_2O$
4. **a.** Nitrate ion (NO_3^-)

   b. As it oxidizes readily in the atmosphere to ferric sulphate (iron(III) sulphate), which does not form the brown ring.

   c. Sulphuric acid and nitric acid.

CHAPTER – 11

STUDY OF COMPOUNDS – SULPHURIC ACID

P. 202 CHECK YOUR PROGRESS 1

1. a. Sulphur trioxide is not directly dissolved in water to get H_2SO_4 because it is an exothermic reaction as with water a large amount of heat is released. This results in the formation of a dense fog of H_2SO_4 which does not condense easily.

b. At high temperature sulphur trioxide may decompose back to SO_2 and O_2 so an optimum temperature of 400-500 °C is generally used. Also, the oxidation of sulphur dioxide is exothermic and the required temperature is maintained without external heating. Low temperature slows down the rate of reaction.

c. Of all acids, sulphuric acid is the most important. It is used directly or indirectly in all industries. Hence it is called “king of chemicals”.

d. Sulphuric acid is called oil of vitriol because it was first prepared by the dry distillation of green vitriol ($FeSO_4·7H_2O$) and obtained as an oily viscous liquid.

$2FeSO_4·7H_2O \rightarrow Fe_2O_3 + SO_2 + SO_3 + 14H_2O$

2. a. When sulphur trioxide reacts with water, it forms sulphuric acid. This reaction is highly exothermic and very dangerous because the heat of reaction vaporises the sulphuric acid forming a dense fog.

$$SO_3 + H_2O \rightarrow H_2SO_4$$

b. After passing through converters, sulphur trioxide is cooled and passed into an absorption tower where it is absorbed in concentrated sulphuric acid to form oleum ($H_2S_2O_7$).

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

c. Oleum is diluted by adding a calculated amount of water to obtain H_2SO_4 of the desired strength.

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

3. a. The main purpose of the Contact process is manufacturing of sulphuric acid.

b. S and O_2

c. Platinum or vanadium pentoxide

d. $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

P. 206 CHECK YOUR PROGRESS 2

1. a. Copper sulphate crystals are dehydrated by concentrated sulphuric acid.

b. Oxalic acid reacts with concentrated sulphuric acid to produce a mixture of carbon dioxide and carbon monoxide.

c. Concentrated sulphuric acid on reaction with sodium chloride gives hydrogen chloride gas.

d. Concentrated sulphuric acid releases sulphur dioxide gas, carbon dioxide gas and water on reaction with non-metals.

2. a. Dilute sulphuric acid is a dibasic acid,so it forms normal salts and acid salts.

b. When oil of vitriol is added to sodium carbonate, a brisk effervescence is observed due to the production of CO_2 gas.

c. Concentrated sulphuric acid is used to prepare nitric acid because it is a strong as well as nonvolatile acid, therefore, it is capable of displacing more volatile nitric acid from sodium or potassium nitrate on heating the reaction mixture.

d. Sulphuric acid cannot be used to dry hydrogen sulphide gas as the gas reacts with the acid.

3. a. sugar charcoal

b. SO_2 and CO_2 gases

c. $ZnSO_4$ and SO_2

d. Iodine and Sulphur dioxide gas

P. 207–210 EXERCISES

I. Objective Type Questions

A. Choose the correct option

1. a **2.** b **3.** a **4.** b **5.** c
6. d **7.** a **8.** b **9.** c **10.** d
11. c **12.** c **13.** c **14.** b **15.** d
16. a **17.** d **18.** c **19.** a **20.** c
21. d

B. Fill in the blanks.

1. hygroscopic
2. sulphuric
3. Contact
4. oleum
5. Concentrated
6. dibasic

7. acidic
8. sulphuric acid
9. sulphites
10. hydrogen sulphide

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. CO_2
2. H_2S
3. Platinum or V_2O_5
4. Contact process
5. Conc. sulphuric acid

B. Give one example for each of the following.

1. **a.** Sulphuric acid dehydrates white crystalline sugar and turns it into black spongy carbon.

   $C_{12}H_{22}O_{11} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O$

   This black spongy carbon is very pure and is called sugar charcoal.

   b. Any active metal with dilute sulphuric acid releases hydrogen gas, showing its acidic nature.

   $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

   c. Concentrated sulphuric acid has a high boiling point and is therefore a non-volatile acid. Hence, when salts of more volatile acids are heated with sulphuric acid, it displaces the acids from the salt.

   $KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

   d. Sulphuric acid is used in the laboratory as a drying agent for gases such as N_2, O_2, HCl, etc.

   e. $C + 2H_2SO_4 \rightarrow 2SO_2 + 2H_2O + CO_2$

C. Match the following.

1. c **2.** a **3.** b **4.** e **5.** d

D. State one relevant observation for each of the following.

1. Black spongy carbon is obtained, which is very pure and is called sugar charcoal.
2. Thick white precipitate of barium sulphate is formed.
3. Sulphuric acid gets reduced to burning sulphur like smelling SO_2.
4. It oxidizes carbon to carbon dioxide and produces SO_2.
5. Hydrogen sulphide gas with rotten egg like smell evolves.

E. Choose the odd one out.

$H_2S_2O_8$ as rest participate in Contact process.

F. Answer the following questions.

1. CO_2
2. Colourless, odourless and oily liquid.
3. Sulphuric acid
4. No, as pure sulphuric acid does not ionize.
5. Changes from pink colour to colourless.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Pure sulphuric acid is a poor conductor of electricity as it does not ionize.
2. High pressure may give a higher yield of sulphur trioxide but damages or corrodes the lead pipes and acid resisting towers containing gases as these gases are acidic in nature.
3. Sulphuric acid is a dibasic acid as it ionizes completely in solution and forms two series of salts, i.e., sulphates, and bisulphates.
4. Concentrated sulphuric acid is a powerful dehydrating agent. It removes water from organic compounds and also water of crystallization from hydrated salts.
5. Concentrated sulphuric acid when heated undergoes decomposition giving out nascent oxygen that oxidizes the substances and it itself gets reduced to sulphur dioxide.

B. Differentiate between the following pair.

Dilute sulphuric acid	Concentrated sulphuric acid
Very volatile in nature.	Non-volatile in nature.
Not a dehydrating agent and does not remove water of crystallization.	Powerful dehydrating agent and removes water of crystallization.
Dilute sulphuric acid gives a white precipitate of barium sulphate ($BaSO_4$) when added to barium chloride solution which is insoluble in dilute HCl or HNO_3.	Concentrated sulphuric acid has no effect on $BaCl_2$ solution.
Dilute sulphuric acid has no effect on copper.	Concentrated sulphuric acid when heated with copper gives SO_2 gas which turns acidified potassium dichromate solution green.
Reacts with metal carbonates and bicarbonates to liberate CO_2.	Has no effect on metal carbonates and bicarbonates.

C. Equations-based questions.

1. **a.** $C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$

   b. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2\uparrow$

   c. $C_{12}H_{22}O_{11} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O$

d. $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

2. **a.** $KOH + H_2SO_4 \rightarrow KHSO_4 + H_2O$

b. $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2\uparrow$

c. $ZnSO_3 + H_2SO_4 \rightarrow ZnSO_4 + H_2O + SO_2$

d. $2NaHSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2SO_2$

e. $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$

3. **a.** $C + 2H_2SO_4 \rightarrow 2SO_2 + 2H_2O + CO_2$

b. $S + 2H_2SO_4 \rightarrow 3SO_2 + 2H_2O$

c. $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$

d. $KOH + H_2SO_4 \rightarrow KHSO_4 + H_2O$

e. $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2\uparrow$

f. $ZnSO_3 + H_2SO_4 \rightarrow ZnSO_4 + H_2O + SO_2$

g. $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$

h. $BaCl_2 + H_2SO_4 \rightarrow BaSO_4\downarrow + 2HCl$

i. $CuSO_4{\cdot}5H_2O \xrightarrow{\text{Conc. } H_2SO_4} CuSO_4$ (colourless) $+ 5H_2O$

j. $C_2H_5OH \xrightarrow{\text{Conc. } H_2So_4} C_2H_4 + H_2O$

As oxidizing agent: Equations a, b, c,

Neutralization: Equation d,

As dilute acid: Equations e, f, g, h

As dehydrating agent: Equations: i, j

D. Explain why

1. As it reacts with H_2S and oxidizes it to form sulphur.

   $H_2S + H_2SO_4 \rightarrow SO_2 + 2H_2O + S$

2. As it produces CO_2 gas with a fizz:

   $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2\uparrow$

3. Sulphuric acid is hygroscopic in nature. It readily absorbs water vapour from the atmosphere and increases in volume. Therefore, it is kept in airtight bottles to prevent it from getting diluted.

4. Water must not be added to the concentrated acid as it is a highly exothermic reaction (the solution attains a temperature of 120 °C), which can cause splashing of the acid. This can result in severe burn injuries. Hence, the acid should be diluted by pouring it slowly into the water with continuous stirring. The acid being denser will sink to the bottom and the heat evolved is distributed uniformly.

E. With the help of chemical reactions, prove that sulphuric acid shows the following properties.

1. Dehydrating property: $HCOOH \xrightarrow{\text{Conc. } H_2So_4} CO + H_2O$

2. Acidic nature: $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$

3. As a non-volatile acid: $KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

4. As an oxidizing agent: $H_2S + H_2SO_4 \rightarrow SO_2 + 2H_2O + S$

F. Answer the following questions.

1. Dilute sulphuric acid gives a white precipitate of barium sulphate ($BaSO_4$) when added to barium chloride solution which is insoluble in dilute HCl or HNO_3. Concentrated sulphuric acid has no effect on $BaCl_2$ solution.

   $BaCl_2 + H_2SO_4(\text{dil.}) \rightarrow 2HCl + \underset{\text{(White ppt)}}{BaSO_4\downarrow}$

2. Concentrated sulphuric acid is a dehydrating agent. It turns blue copper sulphate hydrated crystals into white amorphous copper sulphate powder.

   $CuSO_4 \cdot 5H_2O \xrightarrow[\text{conc.}]{H_2SO_4} CuSO_4 + 5H_2O$

3. Contact process is an industrial method for the preparation of sulphuric acid from sulphur trioxide which is formed by oxidizing sulphur dioxide. The sulphur trioxide is converted to oleum and finally to sulphuric acid.

4. It is called oil of vitriol because it was first prepared by the dry distillation of green vitriol ($FeSO_4{\cdot}7H_2O$) and obtained as an oily viscous liquid.

5. Of all acids, sulphuric acid is the most important. It is used directly or indirectly in all industries.

6. Sulphuric acid; it is formed by the atmospheric oxidation of sulphur dioxide in the presence of moisture.

7. Dried and purified sulphur dioxide and oxygen are passed over preheated catalytic converters (V_2O_5), which then form sulphur trioxide.

   $2SO_2 + O_2 \rightleftharpoons 2SO_3 + \text{heat}$

   Catalyst: vanadium pentoxide (V_2O_5); Temperature: 450 °C – 500 °C; Pressure: 1-2 atm.

8. Vanadium pentoxide (V_2O_5) is preferred over platinum as a catalyst since it is less susceptible to poisoning by impurities such as arsenic. It is also much cheaper than platinum.

IV. Knowledge-based Questions

1. When barium chloride solution is added to dilute sulphuric acid, a white precipitate of barium sulphate is obtained which is insoluble in dilute nitric acid and dilute hydrochloric acid. No white precipitate is obtained when barium chloride reacts with dil. HCl or dil. HNO_3.
2. **a.** It is used in lead storage batteries as H_2SO_4 undergoes electrolysis.

   b. It is used in the manufacture of dyes, drugs and disinfectants.

   c. It is used in the manufacture of explosives like nitroglycerine.
3. Concentrated sulphuric acid when heated with sodium chloride gives hydrogen chloride gas which forms dense white fumes with a rod dipped in ammonia solution.

   $NaCl + H_2SO_4\ (conc.) \xrightarrow{\Delta} NaHSO_4 + HCl\uparrow$

   $NH_3 + HCl \rightarrow NH_4Cl\uparrow$ (white dense fumes)
4. When an acid reacts with base, it neutralizes the base and forms salt and water. Likewise, sulphuric acid reacts with base like sodium hydroxide and forms salt of sodium sulphate along with water molecule.

   Acid + base → salt + water

   $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
5. When SO_2 is produced through roasting, it needs to be purified as it contains impurities like fly ash, dust particles and some arsenic compounds such as arsenous oxide. These impurities reduce the efficiency of the catalyst or poison the catalyst, and can even destroy it. In order to remove impurities, the gaseous mixture of sulphur dioxide and oxygen is passed through a series of converters:

   a. The gaseous mixture is passed through electrostatic precipitator where strong electric field is applied. Most of the fly ash and dust particles are attracted by electric charge and are removed.

   b. After the removal of most of the dust particles, the gaseous mixture is passed through the water scrubber which removes the remaining dust particles and fly ash.

   c. The gaseous mixture after cooling is then passed through a washing tower. Water is sprayed to remove any other solid particles.

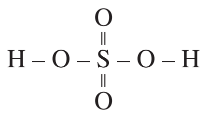
   d. The gaseous mixture is then dried by passing through drying tower where concentrated sulphuric acid, a dehydrating agent, is sprayed to remove water from SO_2 and O_2 mixture.

   e. The gaseous mixture is still not completely free from impurities. It contains arsenic oxide as an impurity which can be removed by passing the gas over ferric hydroxide.

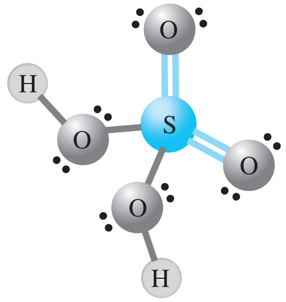
   $As_2O_3 + 2Fe(OH)_3 \rightarrow 2FeAsO_3 + 3H_2O$

V. Application and Skill-based Questions

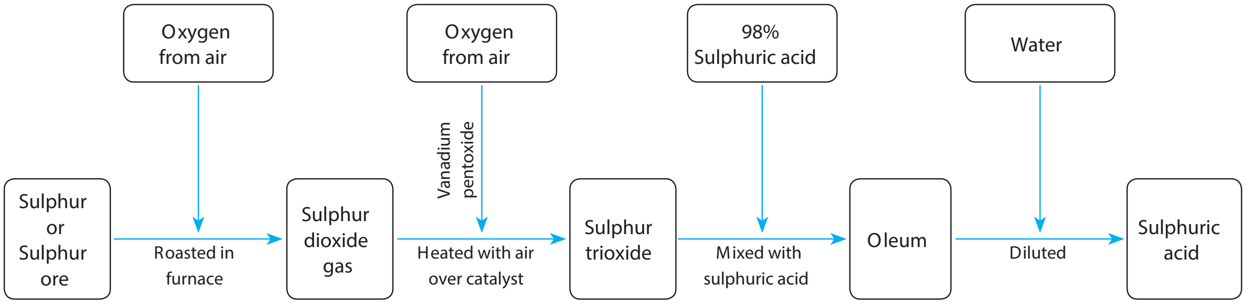
1.



$$H-O-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-O-H$$



2.



3. **a.** Sulphuric acid

   b. Sulphur dioxide: $Zn + 2H_2SO_4 \rightarrow ZnSO_4 + 2H_2O + SO_2$

4. Drying agents only cause a physical change in the compound. There is no alteration in the composition of the compound. On the other hand, dehydrating agents cause a chemical change by changing the composition of a compound.

5. Dilute sulphuric can be distinguished from dilute hydrochloric acid and dilute nitric acid using barium chloride solution. White ppt of barium sulphate formed in the reaction of barium chloride with dilute sulphuric acid is insoluble in dilute hydrochloric acid and dilute nitric acid.

VI. Reasoning/Observation-based Questions

1. Concentrated sulphuric acid is highly corrosive and hygroscopic in nature. When exposed to air, it absorbs moisture and increases in volume. So, it should be kept in stoppered bottles.

2. Oleum is diluted by adding a calculated amount of water to obtain H_2SO_4 of the desired strength.
$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

3. Sulphur trioxide is not absorbed into water directly as the reaction is highly exothermic. The heat of the reaction vaporizes the thus produced sulphuric acid and results in the formation of a dense fog of sulphuric acid particles, which is difficult to condense.

4. The temperature should be maintained between 450°C and 500 °C for catalytic conversion of sulphur dioxide to sulphur trioxide. If the temperature is above 500 °C (or high), sulphur trioxide may decompose to give sulphur dioxide and oxygen. Also, the low temperature slows down the rate of reaction.

5. High pressure may give a higher yield of sulphur trioxide but damages or corrodes the lead pipes and acid resisting towers containing gases as these gases are acidic in nature.

6. **a. i.** $Zn + \underset{(dil)}{H_2SO_4} \rightarrow ZnSO_4 + H_2\uparrow$

   ii. $Zn + \underset{(Conc)}{2H_2SO_4} \rightarrow ZnSO_4 + 2H_2O + SO_2$

   b. Charring occurs.

   c. Splashing followed by liberation of heat occurs.

   d. Concentrated sulphuric acid dehydrates blue crystalline hydrated copper sulphate (blue vitriol) and turns it into white amorphous copper sulphate powder.

   e. White precipitate of $CaSO_4$ is formed.

P. 211–212 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. Sugar crystals first turn brown, then to black spongy mass called sugar charcoal, which is very pure. Steam also evolves.

2. **a. i.** Hydrogen sulphide

3. $Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2\uparrow$

4. **a.** $2SO_2 + O_2 \xrightleftharpoons[V_2O_5]{} 2SO_3 + \text{heat}$

   $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

   $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

   b. i. Non-volatile nature

   ii. Oxidizing property

2012

1. Hydrogen sulphide gas

2. **i.** b
   ii. d
   iii. c
   iv. a
   v. d

3. $ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S\uparrow$

2013

1. It dehydrates blue crystalline hydrated copper sulphate and turns it into white amorphous copper sulphate powder.

2. **b.** Oxidizing agent

3. $C_{12}H_{22}O_{11} \xrightarrow[\text{concentrated}]{H_2SO_4} 12C + 11H_2O$

4. Dilute sulphuric acid

2014

1. $C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$

2. Using barium chloride solution:

Dil H_2SO_4	**Dil HCl**
$BaSO_4$ and HCl is formed	No effect

3. Platinum vanadium pentoxide (V_2O_5) as catalyst and temperature of 450 °C – 500 °C.

4. **a.** $CuSO_4{\cdot}5H_2O \xrightarrow[\text{concentrated}]{H_2SO_4} CuSO_4 + 5H_2O$

   b. $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2\uparrow + H_2O$

   c. $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl\uparrow$

2015

1. **a.** Nitric acid

   b. Conc. sulphuric acid

   c. Sulphuric acid

2. **a.** $\underset{\text{Potassium hydrogen carbonate}}{KHCO_3} + \underset{\text{Dil. sulphuric acid}}{H_2SO_4} \rightarrow \underset{\text{Potassium hydrogen sulphate}}{KHSO_4} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$

b. $\underset{\text{Sulphur}}{S} + \underset{\text{Conc. sulphuric acid}}{2H_2SO_4} \rightarrow \underset{\text{Sulphur dioxide}}{3SO_2} + \underset{\text{Water}}{2H_2O}$

3. Conversion of sulphur trioxide into sulphuric acid

$$\underset{\text{Sulphur trioxide}}{SO_3} + H_2SO_4 \rightarrow \underset{\text{oleum}}{H_2S_2O_7}$$

Dilution of oleum

$$H_2S_2O_7 + H_2O \rightarrow \underset{\text{Sulphuric acid}}{2H_2SO_4}$$

2016

1. $H_2SO_4 + Na_2SO_3 \rightarrow Na_2SO_4 + H_2O + SO_2$

2. **a.** When barium chloride solution is mixed with sodium sulphate solution, then an insoluble white precipitate of barium sulphate and solution of sodium chloride is formed.

$BaCl_2 + Na_2SO_4 \rightarrow \underset{\text{(white ppt)}}{BaSO_4\downarrow} + 2NaCl$

b. When concentrated sulphuric acid is added to sugar crystals it dehydrates sugar and turns it into black spongy carbon called sugar charcoal which is very pure.

$C_{12}H_{22}O_{11} \xrightarrow[\text{concentrated}]{H_2SO_4} 12C + 11H_2O$

3. **a.** **ii** = Non-volatile acid

b. **i** = Typical acid property

c. **iii** = Oxidizing agent

2017

1. **a.** $S + \underset{\text{(conc.)}}{2H_2SO_4} \rightarrow 3SO_2 + 2H_2O$

2. Blue crystal loses its crystalline shape and becomes white amorphous.

3. **a.** $C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$

b. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

c. $C_{12}H_{22}O_{11} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O$

4. $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

5. **a.** Cu

2018

1. **c.** Vanadium pentoxide

2. **a.** $C + 2H_2SO_4 \rightarrow 2H_2O + 2SO_2\uparrow + CO_2\uparrow$

3. **a.** Dehydrating agent: $C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} C_2H_4 + H_2O$

b. Oxidizing agent: $C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$

2019

1. **a.** dehydration

b. sodium bisulphate

2. **a.** $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

b. $ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S\uparrow$

3. **a.** $C + \text{conc. } 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2\uparrow$

4. **Name of the process** - Contact process

Catalytic equations

Stage 1: $S + O_2 \rightarrow SO_2$

$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

Stage 2: Removal of dust, fly ash and arsenic impurities. If not removed, these impurities will poison the catalyst used in the next stage.

Stage 3:

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + \text{heat}$$

Catalyst: V_2O_5

Stage 4: $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

Stage 5: $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

2020

1. **a.** **iii.** concentrated sulphuric acid

2. **a.** Concentrated sulphuric acid

2022 (Semester 2)

1. **a.** **iv.** concentrated sulphuric acid

b. **iii.** sulphur trioxide gas.

2. **a.** $C_{12}H_{22}O_{11} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O$

3. **a.** Sulphuric acid

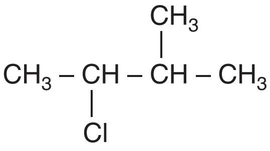
Chapter – 12

Organic Chemistry–I

P. 223 Check Your Progress

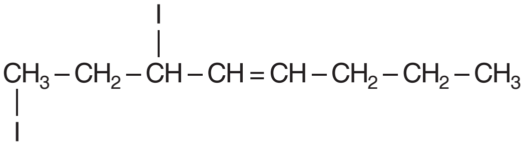
1. **a.** Hept-3-yne
   b. Butan-2-ol
   c. Pent-2-ene
   d. 3-chloro-4-methyl hexane
   e. 2, 4 dimethyl hexane
   f. 3 chloro butanal
   g. 5, 5-dimethylhexanal
   h. 4-ethyl pentanoic acid
   i. 5-iodo 5-methyl hex-2-one
   j. 4, 4-dimethyl-2 chloro pentanoic acid

2. **a.**



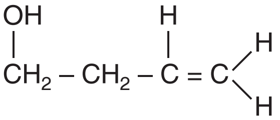
$CH_3-\underset{Cl}{\underset{|}{CH}}-\overset{CH_3}{\overset{|}{CH}}-CH_3$

b.

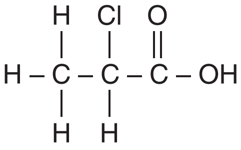


$\underset{I}{\underset{|}{CH_3}}-CH_2-\overset{I}{\overset{|}{CH}}-CH=CH-CH_2-CH_2-CH_3$

c.



d.



$H-\underset{H}{\underset{|}{\overset{H}{\overset{|}{C}}}}-\underset{H}{\underset{|}{\overset{Cl}{\overset{|}{C}}}}-\overset{O}{\overset{\|}{C}}-OH$

P. 226–229 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. a **2.** c **3.** d **4.** d **5.** a
6. b **7.** d **8.** b **9.** a **10.** c
11. a **12.** b **13.** c **14.** c **15.** d
16. b **17.** d **18.** a **19.** d **20.** b

B. Fill in the blanks.

1. low
2. homologue
3. Organic
4. Tautomers
5. Chain
6. Positional
7. Functional
8. maximum
9. nature
10. chemical

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. -ene
2. Alkyne
3. prop-
4. Hydrocarbon
5. Alkane
6. Aromatic
7. Alkanes
8. Olefins
9. Alkyne
10. -al.

B. Give one example for each of the following homologous series.

1. Methanol
2. Methanal
3. Propanone
4. Methane
5. Ethene
6. Ethyne
7. Methanoic acid
8. Benzene

C. Match the following.

1. c **2.** d **3.** e **4.** b **5.** a

D. Match the given word(s) with its appropriate description.

1. e **2.** d **3.** a **4.** b **5.** c

E. Choose the odd one out.

1. Ethyne, being an alkyne member
2. Pentene, being an alkene member
3. Methene, being a non-halogen derivative
4. Butene, being unsaturated
5. Butyne, all others are ketones

F. Answer the following questions.

1. International Union of Pure and Applied Chemistry
2. Alkene and alkyne
3. Root word, prefix and suffix
4. Positional isomerism

5. Chain isomerism

6. Functional isomerism

III. Short Answer Type Questions

A. Give reasons for the following.

1. As carbon is tetravalent, it shows maximum catenation and forms isomers.

2. Due to catenation, carbon forms large number of compounds with many carbon atoms linked to each other.

3. As it is unsaturated and its valency is not satisfied $(= CH_2)$.

4. There are three carbon atoms, so the root word is Prop. -OH is attached to it which means it is an alcohol. If we count from the side which is nearest to the functional group, we get propan-1-ol.

5. Isomerism arises due to the difference in the mode of linking of atoms and difference in the arrangement of atoms or groups in space. This happens because of the directional properties of covalent bond due to which organic compounds with same molecular can be arranged in various structure.

B. Differentiate between the following pairs.

1.	**Alkanes**	**Alkenes**
a.	Alkanes are saturated hydrocarbon with C-C single bond.	Alkenes are unsaturated hydrocarbon with C=C double bond.
b.	Represented with suffix -ane.	Represented suffix -ene.
2.	**Chain isomers**	**Position isomers**
a.	Formed due to change in the size of the carbon skeleton chain.	Formed due to change in the position of functional group.
b.	Root word changes.	Root word remains the same.
3.	**Alkanes**	**Cycloalkanes**
a.	These are open chain saturated hydrocarbons.	These are closed chain saturated hydrocarbons.
b.	Word cyclo is not used as a prefix.	Word cyclo is used as a prefix.
4.	**Open chain compounds**	**Closed chain compounds**
a.	These are also known as aliphatic compounds.	These are also known as cyclic compounds.
b.	These are classified further into saturated and unsaturated compounds.	These are classified further into homocyclic and heterocyclic compounds.
5.	**IUPAC system**	**Trivial system**
	he IUPAC system assigns only one name to the compound. A systematic name of an organic compound may consist of root word, suffix and prefix.	The organic compounds are named on the basis of their source, properties and their Latin or Greek origin.

C. Complete the following table.

S. No	Homologous series name	General formula	IUPAC name
1.	Alkane	CnH_{2n+2}	Alkane
2.	Alkene	CnH_{2n}	Alkene
3.	Alkyne	CnH_{2n-2}	Alkyne
4.	alcohol	CnH_{2n+1}-OH	Alkanol
5.	Aldehyde	CnH_{2n+1}-CHO	Alkanal
6.	Ketone	CnH_{2n+2}-CO	Alkanone
7.	Carboxylic acid	$CnH_{2n+1}COOH$	Alkanoic acid
8.	Halogen derivatives	CnH_{2n+1}-X X – F, Cl, Br or I	Halo alkane

D. Define each of the following.

1. Organic compounds having the same molecular formula but different structural formulae are called isomers and the phenomenon is called isomerism.

2. A homocyclic or carbocyclic compound is a compound in which the ring comprises only carbon atoms.

3. A heterocyclic compound contains other elements besides carbon in the ring.

4. Hydrocarbons are organic compounds containing only carbon and hydrogen.

5. In the Trivial system of nomenclature, the organic compounds are named on the basis of their source, properties and their Latin or Greek origin.

E. Answer the following questions.

1. Alkane - C_nH_{2n+2}; Alkene - C_nH_{2n}; Alkyne - C_nH_{2n-2}

2. **a.** Methanal

b. Ethanoic acid

c. Ethanol

d. Chloromethane

e. Bromoethane.

3. The IUPAC system assigns only one name to the compound. A systematic name of an organic compound may consist of root word, suffix and prefix.

a. Root word: This depends upon the number of carbon atoms selected present in the longest carbon chain.

b. Suffix: The suffix is added to the appropriate root word. The suffix represents the nature of the functional group.

c. Prefix: This denotes the substituent (alkyl group or functional group) if present in the carbon chain.

4. A functional group is a chemically reactive atom or group of atoms present within the molecule of an organic compound which is responsible for its characteristic chemical properties. All the compounds with the same functional group show similar chemical properties.

5. A homologous series is a series of organic compounds each containing a characteristic functional group. The successive members of the series are called homologues.

IV. Knowledge-based Questions

1. Hydrocarbons are organic compounds containing only carbon and hydrogen. They are divided into aliphatic (open chain) and cyclic (closed chain) compounds. Hydrocarbons can either be saturated or unsaturated.

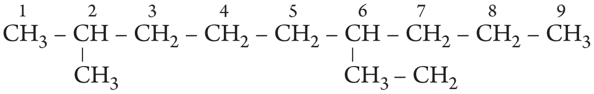
   Saturated hydrocarbons contain only single covalent bonds between carbon atoms. Saturated hydrocarbons are called alkanes or paraffins. Unsaturated hydrocarbons contain at least one carbon-carbon double bond or carbon-carbon triple bond. Unsaturated hydrocarbons are of two types: alkenes or olefins and alkynes or acetylenes.

   First five alkanes are methane, ethane, propane, butane and pentane.

2. Characteristics of homologous series:
   - **a.** Different members of a homologous series can be assigned the same general formula. For example, the alkanes are represented by C_nH_{2n+2}.
   - **b.** Every member of a homologous series differs from its successive member by a CH_2 group.
   - **c.** All homologues have the same chemical properties.
   - **d.** Different homologues can be prepared by the same general method of preparation.
   - **e.** The root names of all homologues depend on the number of carbon atoms.
   - **f.** An increase in molecular mass of members within a homologous series shows a regular gradation of the physical properties, such as physical state, melting point and boiling point. Melting and boiling points of compounds in a homologous series increase with an increase in molecular mass.

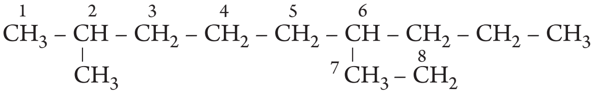
3. Organic compounds can be classified as: a. Open chain compounds and b. Closed chain compounds. Open chain compounds are also called aliphatic compounds (or acyclic compounds) and closed chain compounds are called cyclic compounds. Cyclic compounds can be classified further into heterocyclic compounds and homocyclic or carbocyclic compounds. Homocyclic or carbocyclic compound is a compound in which the ring comprises only carbon atoms. A heterocyclic compound contains other elements besides carbon in the ring. Homocyclic compounds then can be subdivided into alicyclic compounds and aromatic compounds

4. The longest possible chain of carbon atoms is to be selected as the parent chain. The compound is named as derivative of the selected parent chain.



$$\overset{1}{CH_3}-\underset{\displaystyle CH_3}{\overset{2}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_2}-\underset{\displaystyle CH_3-CH_2}{\overset{6}{CH}}-\overset{7}{CH_2}-\overset{8}{CH_2}-\overset{9}{CH_3}$$

(I) Correct



$$\overset{1}{CH_3}-\underset{\displaystyle CH_3}{\overset{2}{CH}}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_2}-\underset{\displaystyle {}^{7}CH_3-\overset{8}{CH_2}}{\overset{6}{CH}}-CH_2-CH_2-CH_3$$

(II) Incorrect

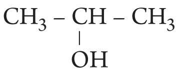
   In the above molecule, selection of parent chain in (I) is correct but incorrect in (II) as (II) has only eight carbon atoms. Therefore, the longest chain contains nine carbon atoms. The remaining two alkyl groups (that are not numbered) are considered as substituents. The word root for the selected chain is 'non'.

5. Positional isomers are compounds that have the same molecular formula but differ in the position of particular atoms or groups. The phenomenon is termed positional isomerism.

   For example,

   Propan-1-ol $CH_3-CH_2-CH_2-OH$

   Propan-2-ol



$$CH_3-\underset{\displaystyle OH}{CH}-CH_3$$

V. Application and Skill-based Questions

1. C_0H_8O-Functional isomers:

$CH_3OC_2H_5$	methoxy ethane	(ether)
$CH_3CH_2CH_2OH$	propanol	(alcohol)

2. $C_4H_{10}O$

   Chain isomers: $CH_3CH_2CH_2CH_2OH$; $CH_3CH(CH_3)CH_2OH$

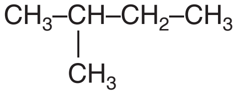
   Position isomers: $CH_3CH_2CH_2CH_2OH$; $CH_3CH_2CH(OH)CH_3$

   Functional isomers: $CH_3CH_2CH_2CH_2OH$; $CH_3CH_2OCH_2CH_3$

3. Chain isomerism, Chain isomers are compounds that have the same molecular formula but different carbon skeleton.

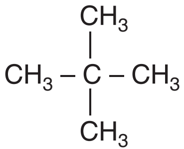
4. Pentane: $CH_3–CH_2–CH_2–CH_2–CH_3$

Iso-pentane:



$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3$

Neo-pentane:



$CH_3-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}}-CH_3$

5. C_4H_9Br

a. $CH_3–CH_2–CH_2–CH_2Br$ **1**-Bromobutane

b. $CH_3–CH_2–CHBr–CH_3$ **2**-Bromobutane

VI. Reasoning/Observation-based Questions

1. **a.** OH
   b. –CHO
   c. –COOH
   d. –O–
   e. –Cl

2. Functional isomers, as ethanol -OH and methoxy methane ether are compounds that have the same molecular formula but different functional groups – alcohol and ether. Therefore, both the compounds belong to different homologous series.

3. $n = 1$ -methan
   $n = 2$ -ethan
   $n = 3$ -prop
   $n = 4$ -butan
   $n = 5$ -pentan

4. $n = 2$ eth, $n = 3$ prop, $n = 4$ but, $n = 5$ pent and $n = 6$ hex

5. **a.** The homologous series formed is alcohol.
   b. Ketone series is formed.
   c. Carboxylic acid series is formed.
   d. Halogen derivative series is formed.

Chapter – 13

Organic Chemistry–II

P. 237 Check Your Progress

1. **a.** C_2H_5COONa

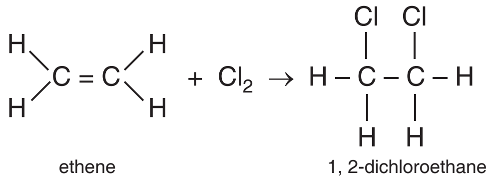
   b. CaC_2 (calcium carbide)

   c. HCHO (formaldehyde)

   d. CH_4

   e. The Wurtz reaction

2. **a.**



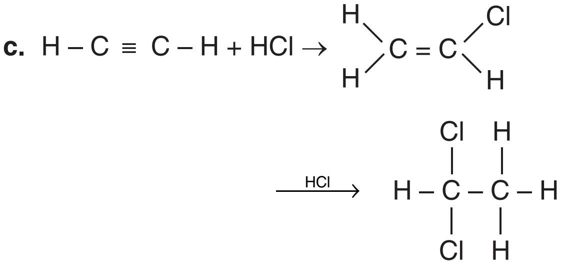
   b. $2CH_4 + O_2 \xrightarrow[\text{120 atm}]{\text{Cu tube at 200 °C}} 2CH_3OH$

   Methane Methanol

   $2C_2H_6 + O_2 \xrightarrow[\text{120 atm}]{\text{Cu tube at 200 °C}} 2C_2H_5OH$

   Ethane Ethanol

   c.



1, 1 – dichloroethane

3. **a.** Bromine is reddish brown in colour. When ethene is added to bromine solution, ethene decolourises bromine water forming dibromoethane.

   b. Cabon monoxide and water are formed.

   c. Ethene decolourises cold alkaline potassium permanganate solution (Baeyer's reagent). The purple colour of alkaline potassium permanganate is discharged.

P. 240 CHECK YOUR PROGRESS

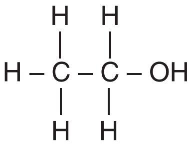
1. **a.** dehydration

   b. concentrated sulphuric acid

   c. hydrogenation

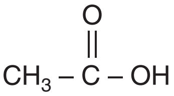
   d. nickel

2. **a.**



$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & - & C & -OH \\ & | & & | & \\ & H & & H & \end{array}$$

   b.



$$CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH$$

3. **a.** $C_2H_4 + H_2SO_4 \xrightarrow[\text{30 atm}]{\text{80 °C}} C_2H_5HSO_4$

   ethyl hydrogensulphate

   $C_2H_5HSO_4 + H_2O \xrightarrow{\text{boiling}} C_2H_5OH + H_2SO_4$

   b. $H_2C = CH_2 + H_2O \xrightarrow{H^+} H_3C - CH_2 - OH$

   $H_3C - CH_2 - OH \xrightarrow{KMnO_4} H_3C - COOH$

   c.

   $C_2H_5OH \xrightarrow{[O]} CH_3CHO \xrightarrow{[O]} CH_3COOH + H_2O$

   ethanol acetaldehyde acetic acid

   d.

   $C_2H_5OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

   ethyl acetate

P. 241–244 Exercises

I. Objective Type Questions

A. Choose the correct option

1. b	**2.** a	**3.** c	**4.** a	**5.** b
6. c	**7.** a	**8.** b	**9.** c	**10.** d
11. d	**12.** c	**13.** b	**14.** c	**15.** d
16. b	**17.** b	**18.** a	**19.** d	**20.** c

B. Fill in the blanks.

1. Carboxylic
2. Wurtz
3. Methane
4. ester
5. denaturing
6. hydrogen
7. ethene
8. hydrogenation
9. sodium ethoxide
10. nickel

II. Very Short Answer Type Questions

A. Give one word for each of the following

1. Methane
2. Zinc and HCl
3. Wurtz reaction
4. Decarboxylation
5. Sodium metal

B. Give one example for each of the following.

1. $CH_3COONa + NaOH \xrightarrow[300°C]{CaO} CH_4 + Na_2CO_3$

2. $2CH_3I + 2Na \xrightarrow{\text{dry ether}} C_2H_6 + 2NaI$

3. $CH_2{=}CH_2 + H_2 \xrightarrow{\text{Ni/300°C}} CH_3 - CH_3$

4. $C_2H_6 \xrightarrow{\text{850°C}} C_2H_4 + H_2$

5. $C_2H_5OH + CH3COOH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

C. Match the following.

1. e **2.** d **3.** a **4.** b **5.** c

D. Match the given word(s) with its appropriate description

1. c **2.** e **3.** d **4.** b **5.** a

E. Name each of the following.

1. Methane
2. Methane
3. Ethene
4. Ethyne
5. Ethanol

F. Answer the following questions

1. Fermentation
2. Ethanol and sodium iodide
3. Ethyl hydrogensulphate and then ethanol
4. Ethyne
5. A salt metal alkanoate is formed

III. Short Answer Type Questions

A. Give reasons for the following.

1. Methane gas is collected by downward displacement of water as it is insoluble in water and lighter than air.
2. The minimum carbon number alkane obtained by Wurtz reaction is ethane.
3. This is because when alkyl halide is treated with metallic sodium in the presence of dry ether, an alkane with double the number of carbon atoms present in the alkyl group is formed. Also a mixture of alkanes is produced which is difficult to separate.
4. Methane does not allow the long wave infrared radiations radiating from the earth's surface to escape from the atmosphere. Thus, the heat of the earth is trapped in the atmosphere. This is called greenhouse effect. The resultant increase in earth's temperature is called global warming
5. As these homologous series of alkenes and alkynes are unsaturated and have double and triple bonds, respectively.

B. With the help of a chemical test, differentiate between the following pair

1.	**Ethane**	**Ethene**
	No change on adding bromine water.	On adding bromine water the reddish brown colour of bromine water gets decolourised.
2.	**Ethane**	**Ethyne**
	On adding ammoniacal cuprous chloride solution, there is not effect.	On adding ammoniacal cuprous chloride solution, crimson precipitate of cuprous acetylide is formed.
3.	**Ethanol**	**Ethanoic acid**
	On adding sodium carbonate solution, there is no gas evolved or no effect.	On adding sodium carbonate solution, carbon dioxide gas is released with brisk effervescence.

C. Diagram-based questions.

1. **a.** Methane
   b. It is insoluble in water.
   c. $CH_3COONa + NaOH \xrightarrow[\text{300°C}]{\text{CaO}} CH_4 + Na_2CO_3$
2. **a.** Ethene
   b. It is insoluble in water.
   c. $C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4 \text{ at 170°C}} H_2C{=}CH_2 + H_2O$

D. Equations-based questions

1. $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
2. $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$
3. $CH_3COOH + 4[H] \xrightarrow{LiAlH_4} C_2H_5OH + H_2O$
4. $C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4 \text{ at 170°C}} H_2C{=}CH_2 + H_2O$
5. $2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2\uparrow$
6. $C_2H_4 + H_2 \rightarrow C_2H_6$
7. $C_2H_5Br + H_2 \rightarrow C_2H_6 + HBr$
8. $C_2H_6 + O_2 \xrightarrow{\text{molybdenum oxide at 350°C – 500°C}} CH_3CHO + H_2O$

E. Explain why

1. Calcium oxide is added to sodium hydroxide because sodium hydroxide is deliquescent.
2. Alkenes are more reactive than alkanes due to the presence of a carbon-carbon double bond.
3. Bromine is reddish brown in colour. When ethene is added to bromine solution, ethene decolourises bromine water forming dibromoethane.

   $H_2C = CH_2 + Br_2 \rightarrow \underset{\text{1,2-dibromoethane (colourless)}}{Br - CH_2 - CH_2 - Br}$

The decolourisation of reddish-brown colour of bromine water by ethene is a test for the presence of unsaturation (double bond) in its molecule.

4. Alkanes like methane and ethane will not decolourise bromine dissolved in carbon tetrachloride, whereas alkenes like ethene and alkynes like ethyne will decolourise bromine dissolved in carbon tetrachloride. This is because alkanes have single covalent bond and alkenes and alkynes have double and triple covalent bonds respectively. The alkenes and alkynes are unsaturated hydrocarbons. Therefore, by this reaction, unsaturated compounds can be distinguished from saturated compounds like methane and ethane as the latter do not show any change with bromine water.

F. Answer the following questions.

1. **a.** The reddish brown water gets decolourised.
   b. Crimson precipitate of cuprous acetylide is formed.
   c. Sweet smelling ester is formed.
2. Decarboxylation is the removal of carboxyl group with the help of soda lime.

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[300°C]{CaO} CH_4 + Na_2CO_3$$

3. Ethyl alcohol when reacts with acetic acid in the presence of concentrated sulphuric acid, a new type of organic compound called ester is formed.

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

This reaction is called esterification.

4. In the presence of nickel as a catalyst, ethyne is heated to about 200 °C. It first adds on hydrogen to form ethene or ethylene and then goes on to form ethane on further addition of hydrogen.

$$H - C \equiv C - H + H_2 \rightarrow H_2C = CH_2$$

$$CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$$

Addition of hydrogen to an unsaturated compound like alkene or alkyne is called hydrogenation.

5. Ethene decolourises cold alkaline potassium permanganate solution (Baeyer's reagent).

$$H_2C = CH_2 + H{-}OH + [O] \rightarrow \underset{\text{1,2-ethanediol (ethylene glycol)}}{H_2(OH)C - C(OH)H_2}$$

The purple colour of the alkaline potassium permanganate is discharged.

IV. Knowledge-based Questions

1. In laboratory, acetic acid is prepared by the controlled oxidation of ethyl alcohol by concentrated sulphuric acid and potassium dichromate or sodium dichromate.

$$C_2H_5OH + [O] \rightarrow CH_3CHO + H_2O$$

$$CH_3CHO + [O] \rightarrow CH_3COOH$$

2. Ethyl alcohol is a good industrial solvent. It is also consumable. To prevent the misuse of commercial alcohol, it is mixed with poisonous substances like methanol and pyridine. This process is called denaturing alcohol. Denatured alcohol is also called methylated alcohol.
3. Methylated spirit or denatured alcohol is ethyl alcohol with 5% methyl alcohol, a coloured dye and some pyridine.
4. When concentrated sulphuric acid is added to ethene at 80 °C and 30 atmospheric pressure, ethyl hydrogensulphate is formed which on hydrolysis with boiling water forms ethanol.

$$C_2H_4 + H_2SO_4 \rightarrow C_2H_5HSO_4$$

$$C_2H_5HSO_4 + H_2O \rightarrow C_2H_5OH + H_2SO_4$$

5. Ethyne reacts with bromine in carbon tetrachloride to first form dibromoethene and then tetrabromoethane. During the addition of bromine to ethyne, the reddish-brown colour of bromine gets decolourised.

$$CH \equiv CH + Br_2 \rightarrow \underset{\text{1,2-dibromoethene}}{CHBr = CHBr}$$

$$CHBr{=}CHBr + Br_2 \rightarrow \underset{\text{1,1,2,2-tetrabromoethane}}{CHBr_2 - CHBr_2}$$

V. Application and Skill-based Questions

1. Bromination
2. Hydrogenation
3. Dehydrohalogenation
4. Neutralization
5. Deacarboxylation

VI. Reasoning/Observation-based Questions

1. Ethyne
2. Ethene
3. Ethene
4. Ethanol
5. Acetic acid

P. 244–248 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

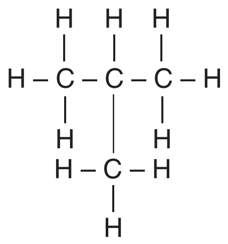
1. **a.** Acetylene
2. **a. iii.** Carboxyl – COOH
   b. i. Addition reaction
   c. ii. 6
3. **a. i.** nickel
   ii. esterification
   iii. acetic acid
   iv. ethanol
   b. $CH_2Br.\ CH_2Br + 2KOH \rightarrow CH \equiv CH + 2KBr + 2H_2O$
4. **a.** Because 90% compounds contain C and H and are present in plants and animals.
   b. In insufficient supply of air, methane burns to give carbon monoxide which is poisonous in nature and water.
5. **a.** $CH_3Cl + \underset{(aq)}{KOH} \rightarrow CH_3OH + KCl$
   b. $CH_3COONa + NaOH \xrightarrow[\text{(sodalime)}]{CaO} CH_4 + Na_2CO_3$
   c. $CH_3CH_2OH + 2[O] \xrightarrow[K_2Cr_2O_7]{} CH_3COOH + H_2O\uparrow$
   d. $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2\uparrow$
   e. $2C_2H_5OH + 2Na \rightarrow 2C_2H_5Na + H_2\uparrow$

2012

1. A colourless solution is obtained and red-brown colour of bromine vapours disappear.
2. **a.** Ethyne
   b. acetic acid
   c. Ethene
   d. Ethanol
3. **a.** Because on cooling below its melting point (17 °C) it solidifies and forms little ice-like crystals.
   b. $\underset{\text{acetic acid}}{CH_3COOH} + \underset{\text{ethyl alcohol}}{C_2H_5OH} \rightarrow CH_3COOC_2H_5 + H_2O$

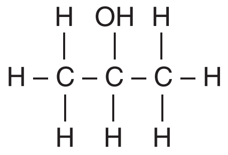
2013

1. Ethane gas evolves when sodium propionate is heated with soda lime.
2. Halogenation
3. Ethene decolourises alkaline potassium permaganate solution ($KMnO_4$) (oxidation) while ethane does not decolourise $KMnO_4$ solution
4. **c.** They can undergo both substitution as well as addition reactions.
5. **a.** $\underset{\text{Iodomethane}}{CH_3I} + 2H \xrightarrow[C_2H_5OH]{Zn/Hg} \underset{\text{Methane}}{CH_4} + HI$
   b. $\underset{\text{Ethyl alcohol}}{C_2H_5OH} \xrightarrow[\text{at } 170\ °C]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{H_2C = CH_2} + H_2O$
   c. $\underset{\text{Carbon carbide}}{CaC_2} + 2H_2O \rightarrow \underset{\text{Ethyne}}{C_2H_2} + Ca(OH)_2$
   d. $\underset{\text{Ethyl bromide}}{C_2H_5Br} + NaOH \rightarrow \underset{\text{Ethyl alcohol}}{C_2H_5OH} + NaBr$
6. **a.** an isomer of *n*-butane.



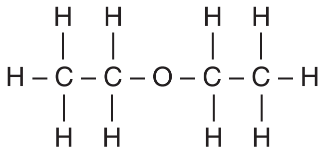
$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \\ & & H & & | & & H & & \\ & & H & - & C & - & H & & \\ & & & & | & & & & \\ & & & & H & & & & \end{array}$$

   b. 2-Propanol.



$$\begin{array}{ccccccccc} & & H & & OH & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \\ & & H & & H & & H & & \end{array}$$

   c. diethyl ether.



$$\begin{array}{ccccccccccccc} & & H & & H & & & & H & & H & & \\ & & | & & | & & & & | & & | & & \\ H & - & C & - & C & - & O & - & C & - & C & - & H \\ & & | & & | & & & & | & & | & & \\ & & H & & H & & & & H & & H & & \end{array}$$

7. **a.** Methane is a saturated hydrocarbon, and no electron is available for addition reaction. Ethene is an unsaturated hydrocarbon, and due to the availability of electrons, it takes part in addition reaction.
   b. Ethyne is a highly reactive compound due to the presence of a triple bond between C–C atom. Ethane has a single bond between C–C atom and is saturated. So it is not reactive.
   c. Hydrocarbons produce a lot of energy, when burnt in air; so they are excellent fuels.

2014

1. **a.** ethyne
2. sodium ethoxide

3. Ketone

4. a. $C_2H_5COONa + NaOH \xrightarrow[300\ °C]{CaO} C_2H_6 + Na_2CO_3$

b. $C_2H_5Cl + NaOH \rightarrow C_2H_5OH + NaCl$

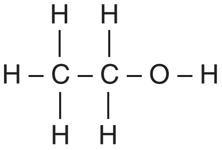
5. Using alkaline potassium permanganate solution:

Ethane	Ethene
No effect.	Solution of cold alkaline potassium permanganate solution (Baeyer's reagent) gets decolourised.

6. a. In presence of nickel as a catalyst and heating to about 200 °C

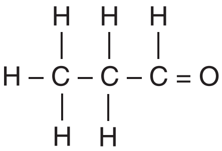
b. Dropping ethylene dibromide into a boiling ethanoic solution of potassium hydroxide.

7. a. Ethanol



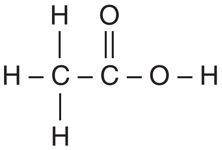
$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$$

b. 1-propanal



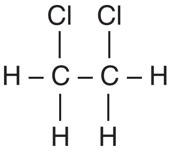
$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{C}=O$$

c. Ethanoic acid



$$H-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-O-H$$

d. 1, 2-dichloroethane



$$H-\overset{Cl}{\underset{H}{C}}-\overset{Cl}{\underset{H}{C}}-H$$

8. a. Alkynes **ii.** C_nH_{2n-2}

b. Alkanes **i.** C_nH_{2n+2}

2015

1. a. Ethyne

b. Ethane

2. d. They undergo combustion with oxygen forming carbon dioxide and water.

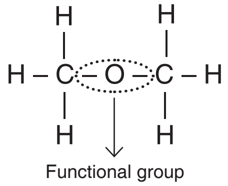
3. The red-brown colour of bromine gets decolourised.

4. a. $\underset{\text{Ethanoic acid}}{CH_3COOH(l)} + \underset{\text{Ethanol}}{C_2H_5OH(l)} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5(l)} + \underset{\text{Water}}{H_2O(l)}$

b. $\underset{\text{Calcium carbide}}{CaC_2(s)} + \underset{\text{Water}}{2H_2O} \rightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2(s)} + \underset{\text{Ethyne}}{C_2H_2(g)}\uparrow$

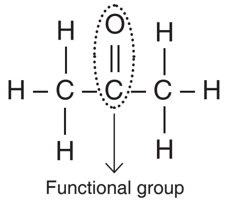
c. $\underset{\text{Sodium ethanoate}}{CH_3COONa(s)} + \underset{\text{Sodium hydroxide}}{NaOH(s)} \xrightarrow[300\ °C]{CaO} \underset{\text{Sodium carbonate}}{Na_2CO_3(s)} + \underset{\text{Methane}}{CH_4(g)}\uparrow$

5. a. Dimethyl ether



$$H-\overset{H}{\underset{H}{C}}-O-\overset{H}{\underset{H}{C}}-H$$

b. Propanone



$$H-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-\overset{H}{\underset{H}{C}}-H$$

6. a. Hydrogenation

b. Methane

c. Esterification

d. Catenation

e. Dehydrohalogenation

2016

1. a. hydrogenation

2. $C_2H_5Cl + KOH(aq) \rightarrow C_2H_5OH + KCl$

3. a. Nickel

b. Addition reaction

4. a. Prop - 2 - ene

b. 2-Butyne

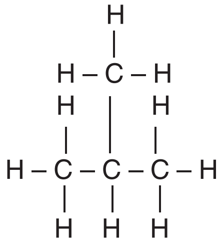
c. Ethanal

5. a. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

b. $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

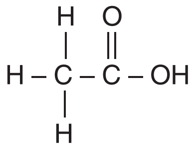
c. $C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4 \text{ at } 170\ °C} C_2H_4 + H_2O$

6. a.



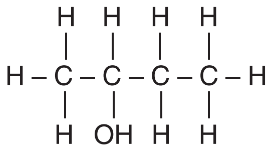
$$H-\overset{H}{\underset{H}{C}}-\overset{\overset{H}{H-C-H}}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$$

b.



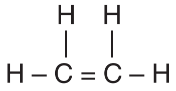
$$\begin{array}{ccccccc} & & H & & O & & \\ & & | & & \| & & \\ H & - & C & - & C & - & OH \\ & & | & & & & \\ & & H & & & & \end{array}$$

c.



$$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & \\ & & H & & OH & & H & & H & & \end{array}$$

7. a.



$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & = & C & - & H \end{array}$$

b. Bromine in CCl_4 has orange colour. When added dropwise to ethene, the orange colour of bromine disappears as ethene undergoes addition reaction to form colourless ethylene bromide.

2017

1. a. C_2H_6

2. a. iii. alkyne

3. a. Fruity smelling ester is formed.

4. a. Glacial acetic acid

b. Acetylene

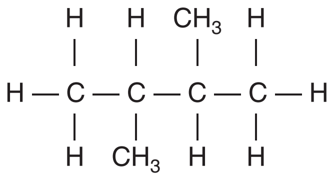
c. Isomerism

d. Ketone

5. a. $C_2H_5COONa + NaOH \xrightarrow[300°C]{CaO} C_2H_6 + Na_2CO_3$

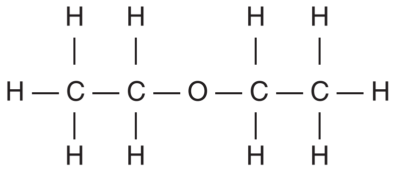
b. $C_2H_5Br + KOH \rightarrow C_2H_4 + KBr + H_2O$

6. i.



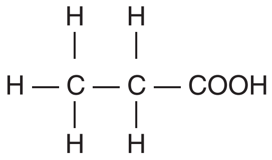
$$\begin{array}{ccccccccccc} & & H & & H & & CH_3 & & H & & \\ & & | & & | & & | & & | & & \\ H & — & C & — & C & — & C & — & C & — & H \\ & & | & & | & & | & & | & & \\ & & H & & CH_3 & & H & & H & & \end{array}$$

ii.



$$\begin{array}{ccccccccccccc} & & H & & H & & & & H & & H & & \\ & & | & & | & & & & | & & | & & \\ H & — & C & — & C & — & O & — & C & — & C & — & H \\ & & | & & | & & & & | & & | & & \\ & & H & & H & & & & H & & H & & \end{array}$$

iii.



$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & — & C & — & C & — & COOH \\ & & | & & | & & \\ & & H & & H & & \end{array}$$

2018

1. a. iv. C_2H_6

b. iii. methoxy methane

2. a. Catenation

3. a. Y – ethyl ethanoate (ester) and

Z – concentrated sulphuric acid

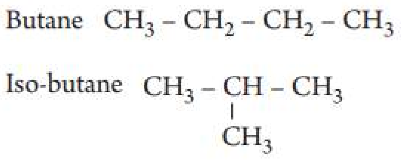
b. CH_3COOH

c. Esterification

$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$

4. a. Methanal **b.** Propanol **c.** But-2-ene

5.



Butane $CH_3 - CH_2 - CH_2 - CH_3$

Iso-butane

$$\begin{array}{ccccc} CH_3 & - & CH & - & CH_3 \\ & & | & & \\ & & CH_3 & & \end{array}$$

2019

1. a. dehydration

b. alkanes

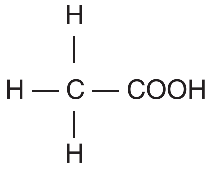
2. a. iv. Methane

3. a. i. Propyne **ii.** Ethanal

b. Triple bond $C \equiv C$

c. Ethane

d.



$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & — & C & — & COOH \\ & & | & & \\ & & H & & \end{array}$$

4. a. i. $C_2H_5Br + KOH \rightarrow C_2H_4 + KBr + H_2O$

ii. $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

iii. $CH_3COONa + NaOH \rightarrow CH_4 + Na_2CO_3$

b. i. Propanoic acid CH_3CH_2COOH

ii. Ethene C_2H_4

iii. Ethanol C_2H_5OH

iv. 1,1,2,2-tetrachloroethane

5. a. Ethane

2020

1. a. i. C_3H_4

2. a. $C_2H_5Br + 2[H] \xrightarrow{Zn/Cu} C_2H_6 + HBr$

b. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ + Energy

3. a. When a piece of sodium metal is put into ethanol at room temperature, it gives off hydrogen gas with bubbles and a colourless solution of sodium ethoxide is formed :

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2\uparrow$

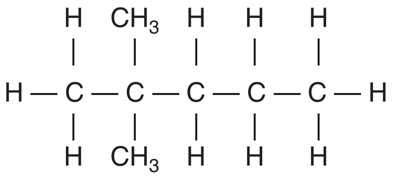
4. a. Esterification

5. a. Soda lime is preferred to sodium hydroxide in the laboratory preparation of methane because sodium hydroxide absorbs water being deliquescent in nature, from the atmosphere while soda lime (NaOH + CaO) is stable and CaO absorbs water so that NaOH can participate in the reaction.

6. a. unsaturated **b.** C_nH_{2n}

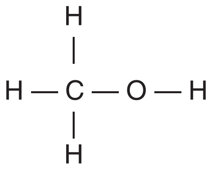
c. addition **d.** hydrogenation

7. a.



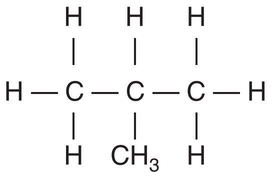
$$\begin{array}{ccccccccccccc} & & H & & CH_3 & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & CH_3 & & H & & H & & H & & \end{array}$$

b.



$$\begin{array}{ccccccc} & & H & & & & \\ & & \mid & & & & \\ H & - & C & - & O & - & H \\ & & \mid & & & & \\ & & H & & & & \end{array}$$

C.



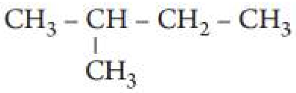
$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & H \\ & & \mid & & \mid & & \mid & & \\ & & H & & CH_3 & & H & & \end{array}$$

8. a. Ethanal

b. Ethyne

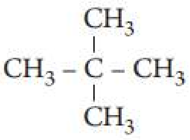
9. Pentane $CH_3-CH_2-CH_2-CH_2-CH_3$

Iso-pentane



$$\begin{array}{l} CH_3-\underset{\displaystyle CH_3}{\underset{\mid}{CH}}-CH_2-CH_3 \end{array}$$

Neo-pentane



$$CH_3-\underset{\displaystyle CH_3}{\underset{\mid}{\overset{\displaystyle CH_3}{\overset{\mid}{C}}}}-CH_3$$

2022 (Semester 2)

1. a. ii. Nickel

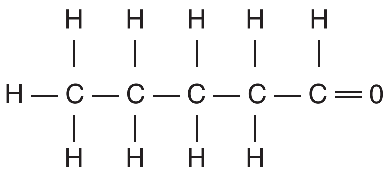
2. The compounds that have the same molecular formula but different molecular structures (structural formulae) are called isomers and the phenomenon is called isomerism.

3. a. Ethene

b. Propanal

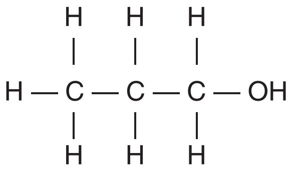
c. 3-methylpentane

4. a.



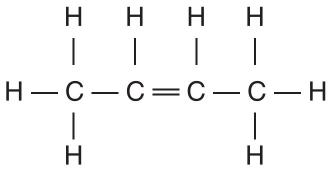
$$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & H \\ & & \mid & & \mid & & \mid & & \mid & & \mid \\ H & - & C & - & C & - & C & - & C & - & C = 0 \\ & & \mid & & \mid & & \mid & & \mid & & \\ & & H & & H & & H & & H & & \end{array}$$

b.



$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & - & C & - & OH \\ & & \mid & & \mid & & \mid & & \\ & & H & & H & & H & & \end{array}$$

C.



$$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & \\ & & \mid & & \mid & & \mid & & \mid & & \\ H & - & C & - & C & = & C & - & C & - & H \\ & & \mid & & & & & & \mid & & \\ & & H & & & & & & H & & \end{array}$$

5. a. Catenation **b.** Alkyne

6. a. $CH_2=CH_2 + Cl_2 \xrightarrow[\text{inert solvent}]{CCl_4} CH_2Cl–CH_2Cl$

b. $2C_2H_6 + 7O_2$ (excess) $\rightarrow 4CO_2 + 6H_2O$

c. $CH_4 + 2O_2$ (excess) $\rightarrow CO_2 + 2H_2O$

CHAPTER – 14

Practical Chemistry

P. 255 Check Your Progress

1. **a.** White
   b. Yellow
   c. Black
2. **a.** NH_4OH
   b. dil. HCl
   c. $MgCl_2$
3. **a.** The salt solution reacts with $Ba(NO_3)$ solution to give a white precipitate soluble in dilute HNO_3 but insoluble in dilute H_2SO_4. **iii.** SO_4^{2-}
   b. The salt reacts with conc. H_2SO_4 on heating evolving a coloured gas which turns potassium iodide paper brown. **ii.** NO_3^-
   c. The salt solution reacts with $AgNO_3$ solution to give a white precipitate insoluble in dilute HNO_3. **iv.** Cl^-
   d. The salt solution reacts with $Ba(NO_3)_2$ solution to give a white precipitate insoluble in dilute HNO_3. **i.** CO_3^{2-}
4. **a.** CO_2
   b. HCl
   c. Nitrogen dioxide
   d. SO_2

P. 256-258 Exercises

I. Objective Type Questions

A. Choose the correct option.

1. c **2.** b **3.** d **4.** a **5.** c
6. b **7.** a **8.** b **9.** c **10.** b
11. a **12.** b **13.** d **14.** c **15.** c
16. b **17.** a **18.** d **19.** c **20.** b

B. Fill in the blanks.

1. $CO_{2,}$
2. $SO_{2,}$
3. HCl
4. H_2S
5. Chlorine
6. NH_3
7. Lime
8. reddish brown, brown
9. Neutral
10. Soluble

II. Very Short Answer Type Questions

A. Give one word for each of the following.

1. CO_2 **2.** SO_2 **3.** H_2S **4.** NH_3 **5.** Cl_2

B. Match the following.

1. e **2.** c **3.** d **4.** b **5.** a

C. Match the precipitate to its correct ion

1. e, **2.** c, **3.** d, **4.** b, **5.** a

D. Name the following.

1. Red litmus paper or its solution
2. Blue litmus paper or its solution
3. Nessler's reagent
4. $K_2Cr_2O_7$ or $KMnO_4$
5. Hydrogen and oxygen

E. Choose the odd one out

1. NH_3, a being basic gas.
2. NH_3, being a basic gas.
3. Cu^{2+} forming coloured ppt, not white.

F. Identify the gas in each of the following.

1. H_2S **2.** SO_2 **3.** CO_2 **4.** NH_3 **5.** Cl_2

G. Identify the anion in each of the following.

1. Sulphate
2. Carbonate
3. Sulphite
4. Sulphide
5. Nitrate

III. Short Answer Type Questions

A. Give reasons for the following.

1. Due to the formation of white insoluble silver chloride ppt.
2. Due to the formation of insoluble black lead sulphide solution.

B. Differentiate between the following pairs.

1. Potassium carbonate and Potassium sulphate

   Add HCl (dil.) to both the compounds and pass the gas liberated through acidified potassium dichromate solution

   Potassium carbonate on treating with HCl forms carbonate radical. When water extract or the acid extract is treated with barium chloride, a white ppt is formed. If HCl is added to this white ppt, it dissolves with effervescence.

   It has no effect on potassium dichromate solution.

Potassium sulphate on treating with HCl forms sulphite radical and sulphur dioxide. When water extract or the acid extract is treated with barium chloride, a white ppt is formed. If dilute HCl is added to this white ppt,it does not dissolve.

The gas liberated turns potassium dichromate solution green.

2. Ferrous nitrate and Lead nitrate

When ammonium hydroxide is added to both the solutions, the following reactions take place.

$Fe(NO_3)_2 + 2NH_4OH \rightarrow Fe(OH)_2^- + 2NH_4NO_3$

It forms dirty green precipitate.

$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2^- + 2NH_4NO_3$

It forms chalky white precipitate.

3. Manganese dioxide and Copper oxide

To both the compounds add conc. HCl and heat. Following are the observations.

Manganese dioxide reacts with concentrated hydrochloric acid to liberate greenish yellow chlorine gas. The gas turns moist blue litmus red and then bleaches it

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

Copper oxide reacts with concentrated hydrochloric acid to form copper(II) chloride and water. The solution turns light green if water is added to the reaction.

$CuO + HCl \rightarrow CuCl_2 + H_2O$

C. Complete the following table.

Ion	Test	Observation
Ammonium	Moist red litmus paper	blue
Sulphide	Lead acetate paper	Silvery grey
Chloride	Silver nitrate solution	Milky white ppt
Carbonate	Lime water and $KMnO_4$	Lime water milky and no effect on $KMnO_4$
Sulphate	Barium chloride	Thick curdy white ppt

D. Equations-based questions

1. $CuO + 2HCl \rightarrow CuCl_2 + H_2O$
2. $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$
3. $2Pb(NO_3)_2 \rightarrow 2PbO + O_2 + 4NO_2$
4. $2Cu(NO_3)_2 \rightarrow 2CuO + O_2 + 4NO_2$
5. $CuCO_3 \rightarrow CuO + CO_2$
6. $PbCO_3 \rightarrow PbO + CO_2$
7. $(CH_3COO)_2Pb + H_2S \rightarrow 2CH_3COOH + PbS\downarrow$
8. $NH_4^+ + NaOH \rightarrow Na^+ + H_2O + NH_3$

E. Answer the following questions.

1. With concentrated hydrochloric acid, MnO_2 releases greenish yellow chlorine gas.

2. Nitrate anion

3. Barium chloride is used.

4. Carbonate radical

5. i. With silver nitrate solution, milky white ppt of silver chloride is formed.

ii. Turns moist blue litmus red and finally bleaches it.

IV. Application and Skill-based Questions

1. Sodium carbonate and sodium sulphate

Add HCl (dil.) to both the compounds and pass the gas liberated through acidified potassium dichromate solution.

Sodium carbonate on treating with HCl forms carbonate radical. When water extract or the acid extract is treated with barium chloride, a white ppt is formed. If HCl is added to this white ppt, it dissolves with effervescence.

It has no effect on potassium dichromate solution.

Sodium sulphate on treating with HCl forms sulphite radical and sulphur dioxide. When water extract or the acid extract is treated with barium chloride, a white ppt is formed. If dilute HCl is added to this white ppt, it does not dissolve.

The gas liberated turns potassium dichromate solution green.

2. Ferric nitrate and lead nitrate

When ammonium hydroxide is added to both the solutions, the following reactions take place.

$Fe(NO_3)_3 + 3NH_4OH \rightarrow Fe(OH)3^- + 3NH_4NO_3$ (reddish brown precipitate)

$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)2^- + 2NH_4NO_3$ (Chalky white precipitate)

3. Manganese dioxide and copper (II) oxide

To both the compounds add conc. HCl and heat. Following are the observations.

Manganese dioxide reacts with concentrated hydrochloric acid to liberate greenish yellow chlorine gas. The gas turns moist blue litmus red and then bleaches it

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2^-$

Copper oxide reacts with concentrated hydrochloric acid to form copper(II) chloride and water. The solution turns light green if water is added to the reaction.

$CuO + HCl \rightarrow CuCl_2 + H_2O$

V. Reasoning/Observation-based Questions

1. P – Copper carbonate. Copper salt is blue in colour. It produces a gas with CO_2, which turns lime water milky. It must be a carbonate. Hence, P is copper carbonate.
2. Q – lead nitrate. Nitrate compounds always produce reddish brown gas. Yellow ppt. is of lead oxide. Hence, Q is lead nitrate.
3. R – MnO_2. Black salt R is manganese dioxide which reacts with HCl to produce chlorine gas.
4. S – copper sulphite. Copper salts are blue in colour. It produces a gas with SO_2, which turns lime water milky and $K_2Cr_2O_7$ green. It must be a sulphite
5. T – zinc nitrate. Nitrate compounds always produce reddish brown gas. They form yellow ppt. when hot and white when cold is of zinc oxide. Hence, Q is zinc nitrate.

P. 259–260 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

2011

1. **a.** barium chloride
2. **a.** NO_3^-

2012

1. SO_2 gas
2. **a.** NO_3^- ion
   b. Cl^- ion
   c. CO_3^{2-} ion
   d. SO_4^{2-} ion
3. **a.** Sodium carbonate when treated with dil H_2SO_4 will liberate colourless odourless gas with brisk effervescence. The gas will turn lime water milky and will have no effect on acidified potassium permanganate solution.
   b. Aqueous ferrous nitrate when treated with NaOH solution gives a dirty green ppt.
   Aqueous lead nitrate when treated with NaOH solution gives a white ppt. which dissolves in excess of NaOH.
   c. When Manganese dioxide is heated with conc. HCl a pungent smelling greenish yellow chlorine gas is evolved.
   When copper oxide is heated with conc. HCl no such gas is evolved.
4. The blue colour of the copper sulphate solution disappears due to the formation of colourless zinc sulphate.
5. $AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$

2013

1. **a.** Add silver nitrate solution to both the solutions. Sodium chloride will form a curdy white precipitate while sodium nitrate does not react with silver nitrate.
   b. Ammonia gives dense white fumes with a rod dipped in concentrated hydrochloric acid while hydrogen sulphide gas does not give any fumes with ammonia.
   c. When NaOH solution is added in excess to both the solutions, white precipitate is formed in $Zn(CO_3)_2$ which dissolves in NaOH solution and no such precipitate is formed with $Ca(NO_3)_2$.
   d. SO_2 turns pink $KMnO_4$ solution colourless and orange acidified $K_2Cr_2O_7$ solution green. CO_2 has no effect on $KMnO_4$ and $K_2Cr_2O_7$ solutions.
2. CO

2014

1. Using dilute sulphuric acid:

Sodium Nitrate	Sodium Sulphite
Sodium bisulphate ($NaHSO_4$) and HNO_3 are formed	Na_2SO_4 and SO_2 are formed

2. Starch iodide paper turns blue-black.
3. Cation P is Ca^{2+}
4. **a.** Gas Q is hydrogen sulphide gas.
   b. Substance R is a base.

2015

1. Hydrogen sulphide
2. Lead acetale turns silvery black because of the formation of black lead sulphide.
   $(CH_3COO)_2Pb + H_2S \rightarrow 2CH_3COOH + PbS\downarrow$
3. **a.** Cl^-
   b. CO_3^{2-}
   c. SO_3^{2-}
4. **a.** Zn^{2+}
   b. Cu^{2+}
   c. Ca^{2+}
   d. NH_4^+

2016

1. **a.** Fe^{3+}
   b. Pb^{2+}
   c. Mg^{2+}

2017

1. a. Salt 'P' is potassium chloride (KCl)
   b. Salt 'Q' is zinc carbonate ($ZnCO_3$)

2018

1. **a. i.** Calcium nitrate
2. Thick curdy white ppt is formed.
3. On adding silver nitrate solution to both, sodium chloride will form a curdy white precipitate whereas sodium nitrate will not show any reaction. Sodium nitrate can also be confirmed by brown ring test as sodium chloride doesn't show this test.

2019

1. Reddish brown nitrogen dioxide gas will be evolved along with formation of yellow residue of lead oxide.
2. Manganese dioxide reacts with concentrated hydrochloric acid to liberate greenish yellow chlorine gas. The gas turns moist blue litmus red and then bleaches it

   $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$

   Copper oxide reacts with concentrated hydrochloric acid to form copper(II) chloride and water. The solution turns light green if water is added to the reaction.

   $CuO + HCl \rightarrow CuCl_2 + H_2O$

2020

1. Zinc carbonate on heating strongly decomposes to zinc oxide and carbon dioxide gas
   $ZnCO_3 \rightarrow ZnO + CO_2\uparrow$
   CO_2 turns blue litmus red and lime water mlky.
2. a.– iv, b – iii, c – ii, d – i
3. **a.** When sodium hydroxide is added to ammonium sulphate ammonia, a colourless gas, is formed, which has a sharp pungent smell. Sodium sulphate does not react with sodium hydroxide.

   b. Magnesium nitrate can be confirmed by brown ring test whereas magnesium chloride does not give this test.
4. **a.** P - Copper carbonate. Copper salt is blue in colour. It produces a gas with CO_2, which turns lime water milky. It must be a carbonate. Hence, P is copper carbonate.

   b. Q - lead nitrate. Nitrate compounds always produce reddish brown gas. Yellow ppt. is of lead oxide. Hence, Q is lead nitrate.

   c. R - MnO_2. Black salt R is manganese dioxide which reacts with HCl to produce chlorine gas.

2022 (Semester 2)

1. **a.** CO_2
   b. NO_2
2. On adding barium chloride solution, sodium sulphate forms thick curdy white precipitate whereas sodium sulphite does not form white precipitate. Sodium sulphite with dilute sulphuric acid on heating releases sulphur dioxide gas which has burning sulphur like smell whereas sodium sulphate does not show any such reaction.