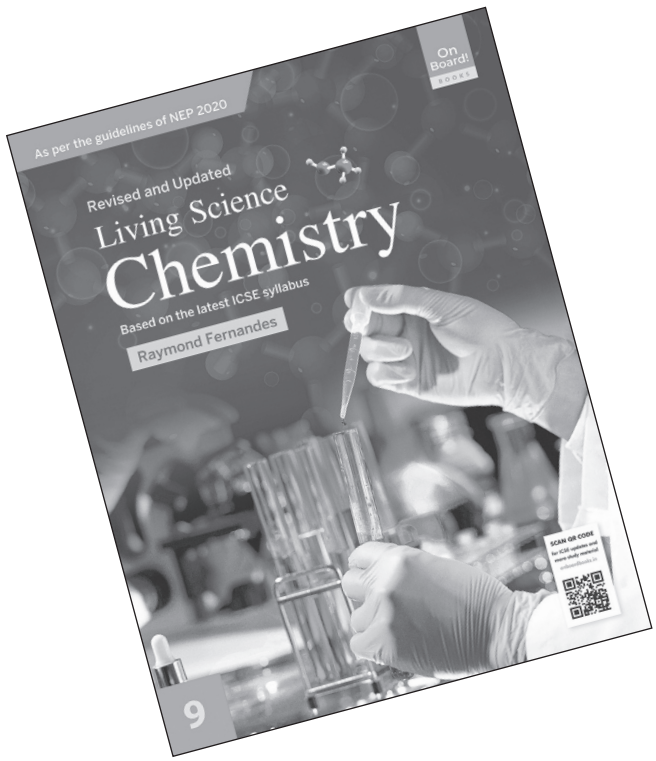
TEACHER'S HANDBOOK

ICSE Living Science
CHEMISTRY
Book 9



On Board! BOOKS

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Contents

CHAPTER – 1

THE LANGUAGE OF CHEMISTRY

P. 12 CHECK YOUR PROGRESS 1

1. C (Carbon), B (Boron)

2. Ca (Calcium), Al (Aluminium)

3. Sb (Latin name: Stibium),
Cu (Latin name: Cuprum)

4. Three atoms of hydrogen combine with one atom of nitrogen to form a molecule of ammonia (NH_3). So, the valency of nitrogen is 3.

5. Chromium (Variable valency: 2, 3 and 6),
Copper (1 and 2)

6. Acid radical or electronegative radical or anion

7. No. Since sodium has one valence electron, it loses one electron to form positive ion (+1).

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

P. 14 CHECK YOUR PROGRESS 2

1. $CaCl_2$ **2.** NH_4NO_3

3. $ZnSO_4$ **4.** $Cu(NO_3)_2$

5. PbO_2 **6.** $K_2Cr_2O_7$

7. Na_3PO_4 **8.** $BaCl_2$

9. $Fe_2(SO_4)_3$ **10.** $Al_2(SO_3)_3$

P. 16 CHECK YOUR PROGRESS 3

1. a. Ferrous sulphate or Iron(II) sulphate

b. Mercuric oxide

c. Cupric chloride or copper(II) chloride

d. Potassium permanganate

e. Lead(II) nitrate

f. Silver nitrate

g. Zinc sulphate

h. Barium chloride

i. Calcium fluoride

j. Manganese sulphate

2. a. Magnesium ion

b. Strontium ion

c. Calcium ion

d. Copper(I) ion or Cuprous ion

e. Copper(II) ion or Cupric ion

f. Stannous ion

g. Stannic ion

h. ammonium ion

i. Mercury(I) ion or Mercurous ion

j. Iron(II) ion or Ferrous ion

3. a. Oxide ion

b. Nitride ion

c. Carbide ion

d. Chlorite ion

e. Perchlorate ion

f. Sulphite ion

g. Sulphate ion

h. Dichromate ion

i. Cyanide ion

j. Hydrogen sulphate ion

P. 20 CHECK YOUR PROGRESS 4

1. $2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2$

2. $2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$

3. $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

4. $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

5. $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$

6. $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

7. $2H_2SO_4 + S \rightarrow 3SO_2 + 2H_2O$

P. 22 CHECK YOUR PROGRESS 5

1. a. Molecular mass of nitric acid (HNO_3)

$= 1\,u + 14\,u + 3 \times 16\,u = 15\,u + 48\,u$

$= 63\,u$

b. Molecular mass of sulphur dioxide (SO_2)

$= 32\,u + 2 \times 16\,u = 32\,u + 32\,u$

$= 64\,u$

c. Molecular mass of urea (NH_2CONH_2)

$= 14\,u + 2 \times 1\,u + 12\,u + 16\,u + 14\,u + 2 \times 1\,u$

$= 60\,u$

d. Molecular mass of sugar ($C_{12}H_{22}O_{11}$)

$= 12 \times 12\,u + 22 \times 1\,u + 11 \times 16$

$= 144\,u + 22\,u + 176\,u$

$= 342\,u$

2. a. Mass percentage of oxygen in water (H_2O)

$$= \frac{\text{Mass of oxygen in one molecule of water } (H_2O)}{\text{Molecular mass of water } (H_2O)} \times 100$$

$$= \frac{16\,u}{(2 \times 1\,u + 16\,u)} \times 100$$

$$= \frac{16\,u}{18\,u} \times 100$$

$= 88.89\%$

b. Mass percentage of oxygen in hydrogen peroxide (H_2O_2)

$$= \frac{\text{Mass of oxygen in one molecule of hydrogen peroxide } (H_2O_2)}{\text{Molecular mass of hydrogen peroxide } (H_2O_2)} \times 100$$

$$= \frac{(2 \times 16\ \text{u})}{(2 \times 1\ \text{u} + 2 \times 16\ \text{u})} \times 100$$

$$= \frac{32\ \text{u}}{34\ \text{u}} \times 100$$

$$= 94.11\%$$

P. 23–26 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

B. Fill in the blanks.

1. hydrogen

2. 1 or one

3. SO_4^{2-}

4. lead nitrite

5. 2

6. conservation of mass

7. $\frac{1}{12}$ or one-twelfth, ^{12}C or C-12

8. average

9. 2, 1, 2, 1

10. S

11. 2, 1, 1, 1 ($2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$)

12. 2, 3, 1, 3 ($2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$)

II. Balance the Following Chemical Equations by the Hit and Trial Method.

1. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

2. $2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$

3. $2Ca(NO_3)_2 \rightarrow 2CaO + O_2 + 4NO_2$

4. $4HNO_3 \rightarrow 2H_2O + 4NO_2 + O_2$

5. $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$

6. $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

7. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

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

III. Very Short Answer Type Questions

A. Answer the following questions.

1. In diborane (B_2H_6), 12 valence electrons are involved in bonding. Out of them 3 from each boron atom and 1 from each hydrogen atom. A boron atom contributes 3 valence electrons. Hence, the valency of boron is 3.

2. The formula of thiosulphate radical is $S_2O_3^{2-}$.

3. For potassium (K), Latin name is *Kalium*.

For sodium (Na), Latin name is *Natrium*.

4. Tungsten (W), German name is *Wolfram*.

5. Valency is the combining capacity of an element. It is equal to the number of valence electrons of an element which actually takes part in chemical reactions.

6. The average mass of an atom of an element in atomic mass unit is called atomic mass.

The relative atomic mass of an element is the average mass of an atom of an element as compared to $\frac{1}{12}$ th the mass of one carbon-12 atom.

7. The average mass of one molecule of a compound in atomic mass unit is called molecular mass.

The average mass of one molecule of a compound as compared to $\frac{1}{12}$ th the mass of one C-12 atom is called relative molecular mass of a compound.

8. An atom or group of atoms of the same or different elements which carries charge and behaves as a single unit is called a radical. It may be an acidic radical (that carries negative charge) or a basic radical (that carries positive charge). For example, nitrate (NO_3^-), ammonium (NH_4^+), phosphonium (PH_4^+).

B. Choose the odd one out.

1. c. F (electronegative element)

2. c. Ca^{2+} (Copper, mercury and lead exhibit variable valency, but calcium does not show variable valency.)

C. Match the following.

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

IV. Short Answer Type Questions

A. Give reasons for the following.

1. Since we know while forming compound potassium and dichromate radical will interchange their valencies. The valency of potassium is 1 and that of dichromate radical

is 2. Hence, the correct formula of potassium dichromate after interchanging their valencies will be $K_2Cr_2O_7$ and not $K(Cr_2O_7)_2$.

2. CO represents a molecule of carbon monoxide. The symbol of cobalt is derived from first two letters of its English names. The first letter is always an upper case letter and the second letter is a lower case letter. Hence, the symbol of cobalt is Co.
3. Hydrogen peroxide (H_2O_2) consists of peroxide ion (O_2^{2-}) whose valency is 2 and H^+ ion whose valency is 1. Two H^+ ions combine with O_2^{2-} to form hydrogen peroxide. HO would be an alcohol group and not peroxide.
4. When an atom of an element can lose more electrons than are present in its valence shell, then it exhibits the additional valency over and above its usual valency. This means there is involvement of the inner shell just before the valence shell and the loss of electrons occurs from there. This, however, happens under certain favourable conditions.

B. Correct the following statements.

1. The formula of ammonium carbonate is $(NH_4)_2CO_3$.
2. The valency of iron in Fe_2O_3 is 3.
3. The molecular mass of calcium hydrogencarbonate is 162.

$Ca(HCO_3)_2 = 40\ u + 2\ u + 24\ u + 96\ u = 162\ u$

4. The chemical formula of the compound lead acetate is $Pb(CH_3COO)_4$.

C. Answer the following questions.

1. The symbols of some elements were derived from the first letter of their English names while the symbols of some elements were derived from the first two letters of their English names. Furthermore, the symbols of some elements were derived from the Latin or German names.
2. A chemical equation gives out the information of a chemical reaction. There are two aspects – qualitative and quantitative of a chemical reaction that its chemical equation tells.

   Qualitative: A chemical equation represents the names of reactants and products.

   Quantitative:

   i. It represents the relative number of molecules of reactants and products.

   ii. It represents the relative number of moles of reactants and products.

   iii. A chemical equation, when balanced, also tells us the amount of reactants reacting to produce the products.

   iv. If the reactants and products are in gaseous state, the volumes of reactants and products can also be known from the chemical equation.
3. A chemical equation has certain distinct limitations. It does not give any information about the physical state of the reactants and the products. The following are some more important limitations of the given chemical equation:

   i. No information is given about the conditions which bring about the chemical change.

   ii. We get no information about the changes such as colour change, precipitation and evolution or absorption of heat, light or other forms of energy.

   iii. The equation gives no information about the rate of the reaction and the reversibility of the reaction.
4. An equation that has an equal number of atoms of each element on both sides of the equation is called a balanced chemical equation, i.e. the mass of the reactants is equal to the mass of the products.

   - In other words, the mass and the charge are balanced on both sides of the reaction.
   - According to the law of conservation of mass, when a chemical reaction occurs, the mass of the products should be equal to the mass of the reactants. Therefore, the amount of the atoms in each element does not change in the chemical reaction.
   - For example, consider the reaction:

     $2Mg(s) + O_2(g) \rightarrow 2MgO(g)$

     In this reaction, 2 atoms of magnesium and oxygen are present in the reactant side and in the product side of the chemical reaction. Hence, the chemical reaction obeys the law of conservation of mass. So the chemical reaction is a balanced chemical equation.
5. The balancing of a chemical equation is entirely based on law of conservation of mass. The law of conservation of mass requires that the total mass of the reactants in a chemical reaction must be equal to the total mass of all the products.
6. The relative atomic mass of bromine is 80 means that the relative mass of bromine is calculated

as the ratio of the mass of one atom bromine to $\frac{1}{12}$ th of the mass of carbon-12 atom.

The formula that can be used to calculate the relative atomic mass:

Relative atomic mass of an element (A_r)

$$= \frac{\text{Average mass of one atom of the element}}{\frac{1}{12} \times (\text{Mass of one } {}^{12}\text{C atom})}$$

V. Knowledge-based Questions

1. The formula of sulphate and hydroxide is $X_2(SO_4)_3$ and $X(OH)_3$.

The charge of nitride ion is –3 and the charge of X is therefore +3. Both balances each other to form the formula XN.

We know that the charge of sulphate is –2. So, the formula of metal sulphate would be $X_2(SO_4)_3$. Similarly, the charge of hydroxide is –1. Hence, the formula of metal hydroxide would be $X(OH)_3$.

2. **a.** K **b.** P **c.** Cu **d.** S **e.** Co

f. Na **g.** Hg **h.** Mn **i.** Sn **j.** Ti

3. The balanced chemical equation of photosynthesis is

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

4. The Haber's process for the synthesis of ammonia is based on the reaction of nitrogen and hydrogen. The chemical reaction is

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

5. Since element X is trivalent. So, the compound with oxygen is X_2O_3.

The chemical reaction is

$$4X + 3O_2 \rightarrow 2X_2O_3$$

6. As charge on X in XCl_2 is +2 and that on Cl is –1.

Since the charge on sulphate is –2 and that on hydroxide is –1. So, the formulae of the sulphate and the hydroxide would be XSO_4 and $X(OH)_2$.

7. When potassium chlorate is heated in the presence of a manganese dioxide catalyst, it decomposes to create potassium chloride and oxygen gas.

The balanced chemical equation is

$$2KClO_3(s) \xrightarrow[MnO_2]{\Delta} 2KCl(s) + 3O_2(g)$$

8. The balanced chemical equation is

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

9. The balanced chemical equation is

$$K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$$

10. In order to determine percent composition of the elements in a compound, the molar mass (MM) of each element is divided by the MM of the compound and multiplied by 100.

$$\% \text{ composition of element} = \frac{\text{MM of element}}{\text{MM of compound}} \times 100$$

The molar mass of ammonium carbonate ($(NH_4)_2CO_3$) is 96 u. (Determined by multiplying the subscripts of each element times its MM using its atomic mass of N = 14 u, H = 1 u, C = 12 u and O = 16 u.)

Determine the MM of each element in the compound by multiplying the subscript of each element by its MM (relative atomic mass in u from the periodic table).

N: (2 × 14 u) = 28 u

H: (8 × 1 u) = 8 u

C: (1 × 12 u) = 12 u

O: (3 × 16 u) = 48 u

Now determine the percent composition of each element in the compound.

$$\% \text{ composition N} = \frac{28 \text{ u}}{96 \text{ u}} \times 100 = 29.166\% \text{ N}$$

$$\% \text{ composition H} = \frac{8 \text{ u}}{96 \text{ u}} \times 100 = 8.333\% \text{ H}$$

$$\% \text{ composition C} = \frac{12 \text{ u}}{96 \text{ u}} \times 100 = 12.5\% \text{ C}$$

$$\% \text{ composition O} = \frac{48 \text{ u}}{96 \text{ u}} \times 100 = 50\% \text{ O}$$

Add the percentages: 29.166% + 8.333% + 12.5% + 50% = 99.999% ≈ 100%

11. **a.** Molecular mass of White vitriol

$[ZnSO_4 \cdot 7H_2O]$

= 65 u + 32 u + 4 × 16 u + 7(2 × 1 u + 16 u)

= 97 u + 64 u + 126 u

= 287 u

Mass of water of crystallisation in White vitriol

= 7 × 18 u

= 126 u

Using the formula,

% of water of crystallisation

$$= \frac{\text{Mass of water of crystallisation}}{\text{Mass of White vitriol}} \times 100$$

$$= \frac{126 \text{ u}}{287 \text{ u}} \times 100$$

= 43.91%

Thus, the % of water of crystallisation in White vitriol is 43.91%.

b. Molecular mass of Glauber's salt

$[Na_2SO_4 \cdot 10H_2O]$

$= 2 \times 23\text{ u} + 32\text{ u} + 4 \times 16\text{ u} + 10(2 \times 1\text{ u} + 16\text{ u})$

$= 46\text{ u} + 32\text{ u} + 64\text{ u} + 180\text{ u}$

$= 322\text{ u}$

Mass of water of crystallisation in Glauber's salt

$= 10 \times 18\text{ u}$

$= 180\text{ u}$

Using the formula,

% of water of crystallisation

$$= \frac{\text{Mass of water of crystallisation}}{\text{Mass of Glauber's salt}} \times 100$$

$$= \frac{180\text{ u}}{322\text{ u}} \times 100$$

$= 55.9\%$

Thus, the % of water of crystallisation in Glauber's salt is 55.9%.

c. Molecular mass of Blue vitriol

$[CuSO_4 \cdot 5H_2O]$

$= 63\text{ u} + 32\text{ u} + 4 \times 16\text{ u} + 5(2 \times 1\text{ u} + 16\text{ u})$

$= 63\text{ u} + 32\text{ u} + 64\text{ u} + 90\text{ u}$

$= 249\text{ u}$

Mass of water of crystallisation in Blue vitriol

$= 5 \times 18\text{ u}$

$= 90\text{ u}$

Using the formula,

% of water of crystallisation

$$= \frac{\text{Mass of water of crystallisation}}{\text{Mass of Blue vitriol}} \times 100$$

$$= \frac{90\text{ u}}{249\text{ u}} \times 100$$

$= 36.1\%$

Thus, the % of water of crystallisation in Blue vitriol is 36.1%.

12. a. The chemical formula of water is H_2O.

Molar mass of water is

$H_2O = 2 \times 1\text{ u} + 16\text{ u}$

$= 2\text{ u} + 16\text{ u}$

$= 18\text{ u}$

b. The chemical formula of carbon dioxide is CO_2.

Molar mass of carbon dioxide is

$CO_2 = 12\text{ u} + 2 \times 16\text{ u}$

$= 12\text{ u} + 32\text{ u}$

$= 44\text{ u}$

c. The chemical formula of methane is CH_4.

Molar mass of methane is

$CH_4 = 12\text{ u} + 4 \times 1\text{ u}$

$= 12\text{ u} + 4\text{ u}$

$= 16\text{ u}$

13. In order to determine percent composition of the elements in a compound, the molar mass (MM) of each element is divided by the MM of the compound and multiplied by 100.

The molar mass of sodium sulphate (Na_2SO_4) is 142 u. (Determined by multiplying the subscripts of each element times its MM using its atomic mass of Na = 23 u, S = 32 u and O = 16 u.)

Determine the MM of each element in the compound by multiplying the subscript of each element by its MM (relative atomic mass in u from the periodic table).

Na: $(2 \times 23\text{ u}) = 46\text{ u}$

S: $(1 \times 32\text{ u}) = 32\text{ u}$

O: $(4 \times 16\text{ u}) = 64\text{ u}$

Now determine the percent composition of each element in the compound.

$$\%\text{ composition of Na} = \frac{46\text{ u}}{142\text{ u}} \times 100 = 32.4\%$$

$$\%\text{ composition of S} = \frac{32\text{ u}}{142\text{ u}} \times 100 = 22.6\%$$

$$\%\text{ composition of O} = \frac{64\text{ u}}{142\text{ u}} \times 100 = 45\%$$

Therefore, sodium sulphate (Na_2SO_4) contains 32.4% Na, 22.6% of S and 45% of O.

14. The term 'vitriol' is derived from Latin word *vitrum*.

VI. Application and Reasoning-based Questions

1. This is because both these cations exhibit variable valency. In both these compounds metal cation is in higher state therefore ending is 'ic'.

2. Cl: It represents an atom of chlorine.

Cl^-: It represents chloride ion which is formed when an electron is gained by a chlorine atom.

Cl_2: It represents a chlorine gas molecule made up of two chlorine atoms.

3. Oxygen always exhibits –2 valency in all its oxides. Hence, w.r.t. O the valency of N in all oxides will be

NO	+2
NO_2	+4
N_2O	+1
N_2O_3	+3
N_2O_5	+5

4. a. Valency of chlorine in the given compounds is

KCl	–1
KClO	+1
$KClO_2$	+3
$KClO_3$	+5
$KClO_4$	+7

b. Sulphur in

Sulphuric acid	+6
Sulphurous acid	+4

c. Manganese in

Potassium manganate	K_2MnO_4	Mn = +6
Potassium permanganate	$KMnO_4$	Mn = +7

5. a. Ammonia
b. Borax
c. Copper sulphate (hydrated)
d. Sulphurous acid
e. Carbonic acid
f. Potassium perchlorate
g. Sodium nitrite
h. Potassium chlorite
i. Sulphur trioxide
j. Phosphorus trichloride
k. Phosphorus pentachloride
l. Sucrose (cane sugar)
m. Sodium carbonate (hydrated)
n. Sulphuric acid
o. Nitric acid
p. Potassium hypochlorite
q. Sodium nitrate
r. Potassium chlorate
s. Carbon monoxide
t. Carbon dioxide
u. Carbon tetrachloride

CHAPTER – 2

CHEMICAL CHANGES AND REACTIONS

P. 29–30 CHECK YOUR PROGRESS 1

1. Choose the correct option.

a. iii.

b. iv. (All of the above.)

c. iii.

d. iii.

e. i.

2. Fill in the blanks.

a. solution

b. sunlight

c. catalyst or positive catalyst

d. negative catalyst

3. Match the following.

d. I-iii, II-ii, III-i, IV-iv

4. Give reason for the following change:

Ultraviolet radiation in sunlight helps in the ozone formation–destruction process in the stratosphere rapidly and constantly, maintaining an ozone layer.

5. Differentiate between the two reactions given below.

$$2Na(s) + 2H_2O \rightarrow 2NaOH(aq) + H_2\uparrow$$

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O$$

The first reaction occurs in the solid state of sodium. Sodium is such a reactive metal that first of all it cannot be held between two fingers without any protection. So, it is held by a pair of tongs, and in this way as soon as it is bought to the surface of water, it catches fire, and what happens in the reaction is given by the equation. So, the first reaction is an example of reaction by close contact. On the other hand, the second reaction occurs in the solution phase. And it is a reaction between an acid and a base in aqueous solution.

P. 34 CHECK YOUR PROGRESS 2

1. Choose the correct option.

a. ii. **b. ii.** **c. iv.** **d. iii.**

2. Give reason for the following.

a. The decomposition of molten sodium chloride is an electrolytic decomposition reaction. So, when electricity is passed through molten sodium chloride in a proper set-up, the following reaction takes place.

$$2NaCl(l) \xrightarrow{\text{Electricity}} 2Na(l) + Cl_2(g)$$

b. The decomposition of HI is a photochemical decomposition reaction. Hence, the reaction takes place in presence of sunlight (UV light) according to the following reaction.

$$2HI(l) \xrightarrow{\text{uv light}} H_2(g) + I_2(g)$$

c. Copper can displace silver from silver nitrate because copper lies above silver in the activity series and, thus, is more reactive than silver. Hence, it displaces silver from silver nitrate. But copper cannot displace iron from iron(II) sulphate because copper lies below iron in the activity series and, thus, is less reactive.

In the activity series of metals copper occurs above silver and, thus, is a more reactive metal than silver. Therefore, it can replace Ag from $AgNO_3$, and the reaction is

$$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$$

On the other hand, iron is more reactive metal than copper as the former occurs higher in position than copper in the activity series. Hence, Cu cannot react with $FeSO_4$ to form Fe. Contrarily the opposite reaction takes place, that is,

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

3. Differentiate between the following two reactions.

These two reactions are examples of a direct combination reaction.

In the first reaction, two elements combine to form a compound. Carbon burns in oxygen to give carbon dioxide.

In the second reaction, two compounds combine to form a new compound. Ammonia combines with hydrogen chloride to form ammonium chloride.

4. Match the following.

a. D.

b. D.

P. 36–37 CHECK YOUR PROGRESS 3

1. b.

2. a. negative or –

b. positive or +

3. a.

4. b.

5. In a chemical reaction the bonds between reactants are broken and new bonds between products are formed. The energy already possessed by the reactants is known as the internal energy of reactants (E_r). Similarly the energy of products is called the internal energy of products, denoted by E_p. The difference between these two quantities, called the change in internal energy, denoted by ΔE, is $\Delta E = E_p - E_r$ and it denotes the change in the energy in the process. Since in case of endothermic reactions internal energy of reactants is less compared to that of products, energy is required to be supplied for carrying out the reaction. That is the reason why energy is absorbed in an endothermic reaction.

6. c.

7. a. iv. [Explanation: The other three reactions are endothermic reactions and (iv) is an exothermic reaction.]

b. ii. [Explanation: The other three reactions are exothermic reactions and (ii) is an endothermic reaction.]

8. a. In the first reaction of formation of ammonia, heat is released and hence it is an exothermic reaction. The formation of nitric oxide gas as shown by the second equation is an endothermic process and heat is absorbed in this reaction.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + \text{heat}$$

$$N_2(g) + O_2(g) + \text{heat} \rightarrow 2NO(g)$$

b. In the first reaction of formation of carbon dioxide, heat is released and hence it is an exothermic reaction. The formation of carbon monoxide gas as shown by the second equation is an endothermic process and heat is absorbed in this reaction.

$$C(s) + O_2(g) \rightarrow CO_2(g) + \text{heat}$$

$$2C(s) + O_2(g) + \text{heat} \rightarrow 2CO(g)$$

P. 38–40 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. a.

2. b.

3. c.

4. d.

5. d. Double decomposition

6. c.

In reaction,

$$2K + 2H_2O \rightarrow 2KOH + H_2$$

Potassium displaces hydrogen from water, therefore, this reaction is a displacement reaction.

7. b.

In reaction,

$$CaCO_3 \rightarrow CaO + CO_2$$

Calcium carbonate, a single reactant decomposes to give two products, i.e., calcium oxide and carbon dioxide. Therefore, this reaction is called a decomposition reaction.

8. b.

In reaction,

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$$

When aqueous solution of silver nitrate is added to a solution of sodium chloride, formation of white precipitate of silver chloride is observed.

9. d.

10. b.

In reaction,

$$2HgO \rightarrow 2Hg + O_2$$

In general, decomposition reactions occur when a solid compound is heated. This type of reaction almost always produces a gas. Heating mercury(II) oxide produces oxygen gas.

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

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

B. Fill in the blanks.

1. hydrogen

2. Br_2

3. highest or topmost

4. above

5. positive catalyst

6. $NaNO_3$

7. double decomposition

8. displacement

9. reactant

10. evolved

II. Very Short Answer Type Questions

A. Give one example for each of the following.

1. In endothermic reaction, heat is absorbed by the reactants.

For example: Decomposition of calcium carbonate

$$CaCO_3(s) + \text{Heat} \xrightarrow{1000\ ^\circ C} CaO(s) + CO_2(g)$$

2. In exothermic reactions, heat is given out.

For example: In addition of water to calcium oxide, heat is given out.

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$ + heat

3. In photochemical reaction, the compound is decomposed by the light.

For example:

$2HI(l) \xrightarrow{\text{uv light}} H_2(g) + I_2(g)$

4. In electrochemical reaction, the compound in aqueous state or in molten state is decomposed by the passage of electricity.

For example:

$2H_2O \xrightarrow[\text{current}]{\text{Electric}} 2H_2(g) + O_2(g)$

B. Match the following.

1. c. I-iv (Displacement reaction), II-i, III-ii, IV-iii

2. c. I-iv, II-i, III-ii, IV-iii

C. Choose the odd reaction out.

2. The reaction $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$ is a displacement reaction while the other reactions are examples of double decomposition reaction.

D. Classify the following reactions.

1. Direct combination reaction

2. Decomposition reaction

3. Displacement reaction

4. Double decomposition (precipitation reaction)

5. Double decomposition (precipitation reaction)

6. Direct combination

III. Short Answer Type Questions

A. 1. Magnesium (Mg) is the most reactive metal.

2. Iron (Fe) is the least reactive metal.

3. Yes. Since aluminium is placed above zinc in the reactivity series, it is more reactive than zinc. So, aluminium can replace zinc from its compound.

4. True. Iron is less reactive than zinc as it is placed below zinc, so iron cannot replace zinc from its compound.

B. Give reasons for the following.

1. Silver nitrate undergoes photodissociation to produce metallic silver. So, silver nitrate is kept in dark-coloured bottles in order to keep away from sunlight.

$2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

2. The blue colour of the copper sulphate solution changes to green colour because copper of copper sulphate is replaced by iron and ferrous sulphate is formed which is green coloured. This happens because the displacement reaction takes place as iron is a more active metal than copper and hence can displace it.

$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

(blue) (green)

3. Molybdenum (Mo) is used in the manufacture of ammonia because it increases the efficiency of the catalyst iron as it acts as a promoter, increasing the efficiency of the catalyst in the manufacture of ammonia resulting in higher yield.

4. Coal on burning releases large amount of heat and light, hence, it is a source of energy and is used as fuel.

C. Explain the following statements.

1. Zinc can displace copper from copper sulphate because zinc lies above copper in the activity series and, thus, is more reactive than copper. So, it displaces copper from copper sulphate.

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

But copper cannot displace zinc from zinc sulphate because copper lies below zinc in the activity series and, thus, is less reactive than zinc. So, the reverse reaction is not possible.

$Cu + ZnSO_4 \rightarrow$ No reaction

2. The photosynthesis reaction by which plants make food (glucose) does not take place in the dark because it is a photochemical reaction and hence the energy required for the reaction comes from the sunlight. Therefore, in absence of sunlight the reaction does not take place.

$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$

3. Pure water is a bad conductor of electricity. By adding a few drops of sulphuric acid, it becomes a good conductor of electricity as H^+ ions are released. H^+ ions conduct electricity. So, when electricity is passed through water containing a little sulphuric acid, it decomposes to give hydrogen and oxygen.

$2H_2O(l) \xrightarrow{\text{electricity}} 2H_2(g) + O_2(g)$

4. The reaction

$C + 2S \rightarrow CS_2$, ΔH +ve

Since ΔH of this reaction is positive, this reaction is endothermic reaction. In endothermic reaction, energy is supplied to the reactants externally or from the surroundings. Hence, this

reaction occurs only on heating, and does not take place at room temperature.

5. Aluminium metal displaces manganese from manganese(IV) oxide because aluminium lies above manganese in the activity series and, thus, is more reactive than manganese. Hence, it displaces manganese from manganese(IV) oxide.

$$4Al + 3MnO_2 \rightarrow 2Al_2O_3 + 3Mn$$

D. What happens when

1. When a piece of sodium metal is dropped in water, an exothermic reaction occurs as sodium reacts vigorously with water to form sodium hydroxide with the evolution of hydrogen gas. This hydrogen gas catches fire and a large amount of energy is released.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow \Delta H \text{ –ve}$$

2. When sodium chloride is added to the aqueous solution of silver nitrate, a curdy white precipitate of silver chloride is formed.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl\downarrow + NaNO_3(aq)$$

3. When calcium reacts with nitrogen, a white ionic solid of calcium nitride (Ca_3N_2) is formed. This Ca_3N_2 on hydrolysis with H_2O gives ammonia.

$$3Ca(s) + N_2(g) \rightarrow Ca_3N_2(s)$$

4. When hydrochloric acid is added to aqueous solution of sodium hydroxide, neutralization reaction takes place as shown in the equation below. In this reaction salt and water are formed.

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

IV. Knowledge-based Questions

1.

Physical Change	Chemical Change
No new substance is formed.	A chemical change is always accompanied by one or more new substance(s).
Physical change is easily reversible, i.e., original substance can be recovered.	Chemical changes are irreversible, i.e., original substance cannot be recovered.
Only physical properties change like shape, size, melting and boiling points.	Chemical properties change which in turn affect the physical properties as well.

2. The data provided by the reactivity series can be used to predict whether a metal can displace another in a single displacement reaction. It can also be used to obtain information on the reactivity of metals towards water and acids. Metals placed above in the metal reactivity series are more reactive and will displace metals below them in the series. For example, copper can displace silver from silver nitrate solution, but will not displace iron from iron(II) sulphate solution. Iron in turn can displace copper from copper(II) sulphate solution.

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

$$Cu(s) + FeSO_4(aq) \rightarrow \text{No reaction}$$

3. In photochemical reaction, the compound is decomposed by the light.

For example:

$$2HI(l) \xrightarrow{\text{uv light}} H_2(g) + I_2(g)$$

whereas, in electrochemical reaction, the compound in aqueous state or in molten state is decomposed by the passage of electricity. For example, when electricity is passed through acidulated water, it decomposes to give hydrogen and oxygen.

$$2H_2O \xrightarrow[\text{current}]{\text{Electric}} 2H_2(g) + O_2(g)$$

4. In endothermic reaction, heat is absorbed by the reactants.

For example: Decomposition of calcium carbonate

$$CaCO_3(s) + \text{heat} \xrightarrow{1000\ ^\circ C} CaO(s) + CO_2(g)$$

whereas in exothermic reactions, heat is given out.

For example: In addition of water to calcium oxide, heat is given out.

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + \text{heat}$$

5. Decomposition reaction is called opposite of combination reaction because in decomposition reaction, a single compound breaks to form two or more substances while in a combination reaction, two or more substances react to give a simple new substance.

One example of thermal decomposition reaction is as follows:

Magnesium carbonate on heating strongly at 1000 °C gives magnesium oxide and carbon dioxide.

$$MgCO_3(s) \xrightarrow{1000\ ^\circ C} MgO(s) + CO_2(g)$$

One example of combination reaction is as follows:

Hydrogen combines with chlorine in the presence of light to form hydrogen chloride.

$$H_2(g) + Cl_2(g) \xrightarrow{\text{light}} 2HCl(g)$$

6. Internal energy of a substance is the sum total of its kinetic energy and potential energy of its molecules. It is denoted by **E**. The internal energy of the reactants and products are always different, therefore it involves change in the internal energy (Δ**E**) of the reaction which is denoted by

$$\Delta E = \mathbf{E_p} - \mathbf{E_r}$$

- If $\mathbf{E_p} > \mathbf{E_r}$, reaction is endothermic.
- If $\mathbf{E_p} < \mathbf{E_r}$, reaction is exothermic.

Enthalpy is the sum of the internal energy of the system and the product of the pressure and volume. It is denoted by '**H**'. When any change is done in open vessel, at constant pressure, then enthalpy change, Δ**H**, is equal to $\Delta\mathbf{H} = \mathbf{H_p} - \mathbf{H_r}$.

V. Application and Reasoning-based Questions

1. In graph (a), reactants possess a large amount of heat content as compared to products. It means as the reaction progresses, the heat content of products decreases. This means heat is liberated in the reaction, therefore, the graph (a) represents an exothermic change.

In graph (b), heat content of the reactants is less than the heat content of the products. It means as the reaction progresses, the heat content of the products increases. This means heat is absorbed in the reaction, therefore, the graph (b) represents an endothermic change.

2. B represents a reactant, A represents a product and C represents the heat of the reaction which is given by the reactant B to convert into the product A. Thus, graph represents an exothermic change.

If A and B are interchanged, then energy of reactants becomes less than that of products, hence, energy will be absorbed by the reactants to convert into products. Thus, the reaction will become endothermic.

3. Potassium chlorate decomposes at a much lower temperature (300 °C) in the presence of manganese dioxide, which is a catalyst in this reaction.

A catalyst's role is to enhance the reaction without getting changed. So, the catalyst is obtained as such after the completion of a chemical reaction.

In the reaction

$$2KClO_3 + MnO_2 \rightarrow 2KCl + 3O_2(g) + MnO_2$$

We see that MnO_2 (catalyst) is present on the reactant side as well as on the product side.

4. Sodium hydroxide forms a precipitate with lead (II) nitrate because sodium being more reactive than lead, it displaces lead from lead nitrate solution and forms sodium nitrate. But it cannot react with potassium nitrate because sodium being less reactive than potassium cannot displace potassium from potassium nitrate.

5. This is because reaction stops after sometime due to the formation of insoluble crust of lead sulphate on the surface of lead carbonate which stops further reaction of sulphuric acid on it.

6. The first reaction is a decomposition reaction because in first reaction, a single compound sodium chloride decomposes to give its constituent elements, sodium and chlorine. But when these two constituent elements combine, a single compound sodium chloride is formed. Therefore, the second reaction is a combination reaction.

CHAPTER – 3

WATER

P. 43 CHECK YOUR PROGRESS 1

1. a. ii.

b. i.

2. c.

3. c.

4. c.

5. a. 100

b. 0

c. less

d. less

P. 45 CHECK YOUR PROGRESS 2

1. a. iv.

b. ii.

c. ii.

d. iii. Both i. and ii.

e. iii.

2. a. homogeneous

b. aqueous

c. non-aqueous

d. cannot

3. Mass of sodium chloride (solute) = 20 g

Volume of solution = 250 mL.

Concentration of sodium chloride in solution in terms of mass by volume percentage

$$\text{Mass by volume percentage} = \frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$$

$$= \left(\frac{20}{250}\right) \times 100$$

$$= 8\%$$

4. Volume of ethanol = 8.5 mL

Volume of water = 80 mL

Volume of solution = volume of ethanol + volume of water = 8.5 + 80 = 88.5 mL

$$\text{Volume percentage of the solution} = \frac{\text{Volume of ethanol}}{\text{Volume of solution}} \times 100$$

$$= \left(\frac{8.5}{88.5}\right) \times 100 = 9.60\%$$

P. 47–48 CHECK YOUR PROGRESS 3

1. a. solute; 100; solvent

b. increases

c. can

d. Henry's

2. a. i.

b. ii.

c. i.

d. iii.

e. i.

f. ii.

g. i.

h. iii.

P. 51 CHECK YOUR PROGRESS 4

1. False – Copper sulphate is not wet. It is a hydrated salt, as it contains water molecules. Presence of water molecules imparts blue colour to it, thus it is also called as Blue vitriol.

2. a. Water of crystallisation: The water molecules that form part of the structure of a crystalline substance are called water of crystallisation. In sodium carbonate, $Na_2CO_3 \cdot 10H_2O$, there are ten molecules of water of crystallisation attached to a molecule of sodium carbonate.

b. Anhydrous salt: When a crystalline salt like washing soda loses its water of crystallisation, it loses crystalline nature and becomes amorphous. This amorphous salt is now called *anhydrous salt*.

3. Two disadvantages of hard water are:

i. Hard water precipitates with soap, hence forms scum. Therefore, it is not suitable for laundry.

ii. As it forms scum, it is harmful for boilers. It causes deposition of salts in the form of scale on the inner surface of the boiler. This reduces the efficiency of the boiler.

4. Sodium carbonate reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates which get precipitated, and hence, these salts are removed, thereby making the water soft.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$

$$MgCl_2 + Na_2CO_3 \rightarrow MgCO_3\downarrow + 2NaCl$$

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3\downarrow + Na_2SO_4$$

$$MgSO_4 + Na_2CO_3 \rightarrow MgCO_3\downarrow + Na_2SO_4$$

5. Temporary hardness of water is due to the presence of soluble hydrogencarbonates of calcium and magnesium.

P. 52–55 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

18. d.

Explanation: Volume of solute, methyl alcohol = 40 mL

Volume of solvent, petrol = 60 mL

Total volume of solution = 60 + 40 = 100 mL

$$\text{Volume percentage of the solution} = \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$$

$$= \frac{40 \text{ mL}}{100 \text{ mL}} \times 100 = 40\%$$

B. Fill in the blanks.

1. unsaturated solution

2. solvent

3. polar; non-polar solute

4. drying or desiccating

5. Temporary

6. efflorescence

7. temperature

8. hydrated

9. anhydrous

10. dehydrating

II. Very Short Answer Type Questions

A. Answer the following questions.

1. Importance of dissolved gases in natural water:

- The dissolved oxygen is used for respiration in aquatic plants and animals.
- The dissolved CO_2 is used for photosynthesis in aquatic plants.

2. Mass of solute = 4 g

Mass of water (solvent) = 36 g

Total mass of solution

= mass of solute + mass of solvent

= 4 g + 36 g = 40 g

$$\text{Mass percentage of solution} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

$$= \frac{4 \text{ g}}{40 \text{ g}} \times 100$$

$$= 10\%$$

3. Two advantages of soft water are:

i. As soap in soft water gives lather readily, less soap is used for cleaning.

ii. No scale is deposited in pipes and inner surface of the boiler.

4. The substances which when exposed to the atmosphere at ordinary temperature absorb moisture from atmosphere without dissolving in it are called hygroscopic substances.

For example, calcium oxide (CaO), phosphorus pentoxide (P_4O_{10}), conc. sulphuric acid (H_2SO_4) and silica gel.

5. The characteristics of a true solution are as follows:

i. In a true solution, the solute does not separate under gravity.

ii. The solute cannot be removed by filtration.

iii. The solute can be recovered from its solution in its original chemical form by changing the temperature or evaporation.

iv. The properties of the solution show close resemblance to those of the solute and the solvent.

6. The factors that affect the solubility of a solute in a solvent are temperature and the nature of the solute and the solvent.

7. The factors that affect rate of dissolution are particle size, stirring, amount of solute already dissolved, and temperature.

8. A crystalline salt that does not contain water of crystallisation is potassium chloride (KCl).

B. Match the following.

1. b. I–ii, II–iii, III–iv, IV–i

2. c. I–iii, II–i, III–iv, IV–ii

III. Short Answer Type Questions

A. Define the following.

1. Solution: A homogeneous mixture of two or more substances.

2. Solute: The component of the solution present in smaller amount and dissolved in the solvent.

3. Solvent: The component of the solution present in larger amount in which solute dissolves.

4. Saturated solution: The solution in which no more of the solute can be dissolved at a given temperature is called saturated solution.

5. Unsaturated solution: The solution that can dissolve more of the solute at a given temperature is called unsaturated solution.

6. **Supersaturated solution:** A solution that contains more solute than is present in the saturated solution for the same quantity of the solvent is called supersaturated solution.

7. **Solubility:** The number of grams of the solute required to saturate 100 g of the solvent at a particular temperature is called solubility.

8. **Concentration of a solution:** The amount of solute present in a given amount (mass/volume) of solution is called concentration of a solution.

B. Differentiate between:

1. Hygroscopic substances like calcium oxide (CaO) when exposed to the atmosphere absorb moisture from the atmosphere without dissolving in it. On the other hand, the deliquescent substances when exposed to the atmosphere absorb sufficient moisture from air to completely dissolve in it to form a saturated solution. Examples are caustic soda (NaOH) and caustic potash (KOH).

2.

Hard water	Soft water
This type of water does not produce lather with soap readily.	This type of water produces lather with soap readily.
It is unsuitable for laundry as it produces scum with soap.	It is suitable for laundry.

3.

Temporary hardness	Permanent hardness
It is due to the presence of soluble hydrogencarbonates of calcium and magnesium.	It is due to the presence of soluble chlorides and sulphates of calcium and magnesium.
It can be easily removed by simply boiling the hard water.	It cannot be removed easily by simply boiling the hard water. It is removed by adding washing soda to it which converts soluble chlorides and sulphates into insoluble carbonates.

4.

Saturated solution	Unsaturated solution
The solution in which no more of the solute can be dissolved at a given temperature is called saturated solution.	The solution that can dissolve more of the solute at a given temperature is called unsaturated solution.
With an increase in temperature, the saturation of the solution decreases.	Unsaturation increases with an increase in temperature.

5.

Efflorescence	Deliquescence
The phenomenon in which a substance on exposure to air loses a part or whole of its water of crystallisation is called efflorescence.	The phenomenon in which a chemical substance absorbs moisture from the atmosphere to completely dissolve in it to form a saturated solution is called deliquescence.
Efflorescence occurs when vapour pressure in the hydrated substance is more than the atmospheric pressure.	Deliquescence occurs when the vapour pressure of the substance is much lower compared to the atmospheric vapour pressure.
Example: Washing soda ($Na_2CO_3 \cdot 10H_2O$) loses nine water molecules when exposed to dry air, and becomes a monohydrate ($Na_2CO_3 \cdot H_2O$).	Example: Caustic soda (NaOH), caustic potash (KOH), copper nitrate [$Cu(NO_3)_2$], zinc nitrate [$Zn(NO_3)_2$].

C. Give reasons for the following.

1. Soft water contains low concentrations of soluble salts, and hence, gives lather with soap readily. On the other hand, hard water contains soluble hydrogencarbonates, chlorides and sulphates of calcium and magnesium. Therefore, when soap dissolves in hard water, these salts precipitate, and hence, hard water does not form lather with soap readily.

$$\underset{\text{soap}}{2RCOONa} + Ca^{2+} \rightarrow (RCOO)_2Ca\downarrow + 2Na^+$$

$$\underset{\text{soap}}{2RCOONa} + Mg^{2+} \rightarrow (RCOO)_2Mg\downarrow + 2Na^+$$

2. Temporary harness of water is due to the presence of soluble hydrogencarbonates of calcium and magnesium which can be easily removed by simply boiling the hard water.

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow + CO_2\uparrow + H_2O$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + CO_2\uparrow + H_2O$$

3. Hard water is harmful for the boilers. It causes deposition of salts in the form of scale on the inner surface of the boiler. This reduces the efficiency of the boiler. Hence, hard water is softened before being used in boilers.

4. The solubility of a gas in a liquid is inversely proportional to the temperature. This means, if the temperature is increased, the solubility of gases decreases. This is why, a bottle of soda water is kept under refrigeration, so that the dissolved carbon dioxide does not escape from water with an increase in temperature.

D. Explain the following statements.

1. The water which we usually drink does not taste flat because of the presence of minerals like calcium and magnesium in water. It gives water a refreshing taste. The calcium salts strengthen bones and teeth.

2. The property of anomalous expansion of water offers a very unique feature and allows aquatic lives to live in water even at the freezing condition. In fact when the top surface of water in rivers and lakes freezes in cold condition, aquatic animals remain alive and continue with their normal activities underneath. This happens because when the temperature drops, the temperature of water molecules at the surface quickly decreases. However, water being bad conductor of heat, this drop in temperature does not get carried till the bottom so quickly. Hence, when further temperature drop happens and the surface attains 0 °C, the freezing starts there. And due to the solidification, water molecules cannot carry the temperature drop any further at the bottom. Hence, water remains warmer at the bottom. So, aquatic animals generally shift to the bottom to survive.

3. The concentric rings are formed in tap water because of the dissolved minerals and salts along with other impurities. But these impurities are absent in rain water which is considerably pure so it does not leave concentric rings when boiled.

4. Water never has an absolute density because its density varies with temperature in an unusual manner. In case of liquids, in general, the density decreases with an increase in temperature. This is because as the temperature increases, the thermal motion of molecules also increases, resulting in the spreading of molecules, and hence, the density decreases. However, in case of water, the density first increases from temperature 0 °C up to 4 °C, and thereafter, it decreases. Hence, the maximum density of water is 1 g/cc at 4 °C.

IV. Numerical Problems

1. Mass of sugar (solute) = 20 g
   Mass of water (solvent) = 180 g
   Total mass of solution = 20 + 180
   = 200 g
   Concentration of sugar in water in terms of mass percentage

$$= \frac{\text{Mass of sugar}}{\text{Total mass of solution}} \times 100$$

$$= \frac{20}{200} \times 100 = 10\%$$

2. Mass of solution of glucose = 250 g
   Mass percentage of solution = 20%

$$\therefore \quad 20 = \frac{\text{Mass of glucose}}{250} \times 100$$

$$\Rightarrow \quad \frac{20 \times 250}{100} = \text{Mass of glucose}$$

   Mass of glucose = 50 g
   $\because$ Mass of glucose solution = Mass of glucose + Mass of water
   $\Rightarrow$ Mass of water = Mass of glucose solution – Mass of glucose
   = 250 – 50
   = 200 g

3. Volume of ethyl alcohol = 15 mL
   Volume of water = 110 mL
   Volume of solution = Volume of ethyl alcohol + Volume of water
   = 15 + 110
   = 125 mL

$$\text{Volume percentage of the solution} = \frac{\text{Volume of ethyl alcohol}}{\text{Volume of solution}} \times 100$$

$$= \frac{15}{125} \times 100 = 12\%$$

4. Mass of common salt = 18 g
   Mass of water = 520 g
   $\therefore$ Total mass of solution = 18 + 520 = 538 g
   $\therefore$ Mass percentage of solution $= \frac{18}{538} \times 100$
   = 3.345
   $\approx$ 3.35%

5. Mass of sugar = 30 g
   Mass of solution = 200 g
   $\therefore$ Mass percentage of solution

$$= \frac{30}{200} \times 100 = 15\%$$

V. Knowledge-based Questions

1. Solubility curve is a curve on which the variations of solubility with temperature are plotted.
Characteristics of the solubility curve

i. The curve plots the changes of the solubility of a solid in a solvent at different temperatures.

ii. The variations in temperature are plotted on the X-axis.

iii. The solubility is plotted on the Y-axis.

2. Uses of the solubility curve:

i. It helps in comparing the solubilities of different solutes at any given temperature.

ii. The knowledge of the solubility curve of different substances aids in fractional crystallisation.

iii. A discontinuity in the solubility curve indicates that two different substances are involved.

iv. It helps to determine the solubility of a solute at a particular temperature.

3. The water molecules that form part of the structure of a crystalline substance are called water of crystallisation. For example, gypsum ($CaSO_4 \cdot 2H_2O$) contains two molecules of water of crystallisation and blue vitriol ($CuSO_4 \cdot 5H_2O$) contains five molecules of water of crystallisation.

4. Hydrated salts contain water of crystallisation while anhydrous salts do not contain water of crystallisation.

Hydrated salts:

$FeSO_4 \cdot 7H_2O$; $Na_2SO_4 \cdot 10H_2O$; $CuSO_4 \cdot 5H_2O$; $MgSO_4 \cdot 7H_2O$

Anhydrous salts:

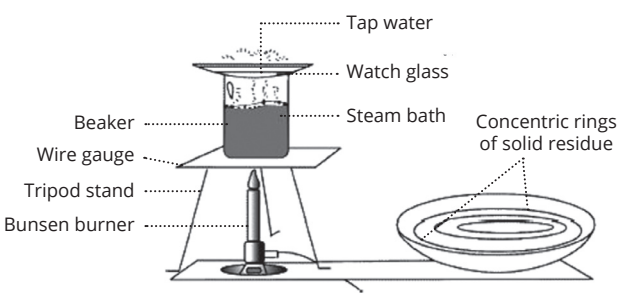
KCl; KNO_3; $C_{12}H_{22}O_{11}$; $K_2Cr_2O_7$; NaCl

5. Experiment:

Aim: To show that tap water contains dissolved minerals.

Materials required: Tap water, beaker, watch glass, wire gauge, Bunsen burner, tripod stand

Procedure:



- Take some tap water on a clean watch glass, and place it over a beaker containing water.
- Place the beaker over the Bunsen burner and allow the water in the beaker to heat up.
- Stir the water in the watch glass with a glass rod and allow the water to evaporate.
- When all the water has evaporated from the watch glass, remove it from the burner and let it cool.

Observation:

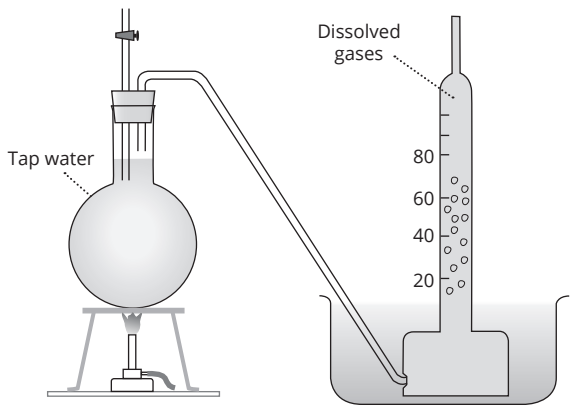
- There are concentric circles of solid particles on the watch glass.
- These are the dissolved minerals left behind after the evaporation of water.

6. Experiment:

Aim: To show that water sample contains dissolved gases.

Materials required: Round-bottom flask, two glass tubes fitted with stopper, delivery tube, Bunsen burner, tripod stand, clamp, water and wire gauge

Procedure:



- Place the round-bottom flask on the tripod stand and a wire gauge.
- Fill the flask with water and insert the delivery tube so that the tube itself becomes completely filled with water.
- Insert a small glass tube through the other hole of the cork.
- Fill the cylinder with water completely and place the lid over it.
- Take a water trough and place the cylinder with its open end dipped in the trough.
- Heat the flask by means of Bunsen burner.

Observation:

- Gas bubbles come out of the delivery tube and are collected in the cylinder.

- The water level in the inverted cylinder can be seen coming down, which means the gas gets collected in the jar by downward displacement of water.

Inference: The water in the flask contains dissolved gases.

7. Hydrated copper sulphate, i.e. $CuSO_4 \cdot 5H_2O$ is blue in colour because it contains five molecules of water as water of crystallisation which is often responsible for their colour and crystalline nature of the salt. On the other hand, anhydrous copper sulphate ($CuSO_4$) is colourless and amorphous.

VI. Application and Reasoning-based Questions

1. When a solute dissolves, the change takes place only at the surface of the solute particles. So, if the total area of solute particles is increased, then the solute dissolves rapidly. A solute must be ground well before adding it to a solvent because when solute grounded, the total surface area of the solute particles increases and the solubility of the solute increases.

2. When the solution is stirred or agitated, fresh portions of the solvent come in contact with the solute thereby increasing the rate of dissolution.

3. a. Potassium nitrate (KNO_3)

b. Lead nitrate ($Pb(NO_3)_2$)

c. 32.5 °C

4. Anhydrous copper sulphate is white in colour. When it comes in contact with water, it forms $CuSO_4 \cdot 5H_2O$ which is blue in colour. So, when anhydrous copper sulphate is added to liquid containing moisture, it turns blue. This is how it is used to detect moisture in a liquid.

5.

Name	**Formula**
a. Gypsum (calcium sulphate dihydrate)	$CaSO_4 \cdot 2H_2O$
b. Blue vitriol (copper sulphate pentahydrate)	$CaSO_4 \cdot 5H_2O$
c. Green vitriol (iron sulphate heptahydrate)	$FeSO_4 \cdot 7H_2O$

6. Compound P is washing soda (sodium carbonate) as it is used for softening the hard water.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$
P

When 'P', i.e. sodium carbonate reacts with dilute HCl, a colourless and odourless carbon dioxide gas 'Q' with brisk effervescence is released.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2\uparrow + H_2O$$

Gas Q, i.e. carbon dioxide extinguishes fire and turns lime water milky.

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3\downarrow + H_2O$$
Q Lime water Milky white ppt.

7. a. ii.

b. iv.

c. iii.

d. i.

e. i.

P. 55 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

1. Saturated solution would not dissolve any amount of solute at the given temperature while unsaturated solution do so.

2. By heating the solution.

3. Solubility of KNO_3 increases sharply with temperature but that of calcium sulphate ($CaSO_4$) increases slowly.

4. Tap water contains dissolved chloride ions which will react with silver ions to form white turbid silver chloride solution but distilled water is free from chloride ions. Hence, distilled water is preferred to tap water.

5. temperature

6. Oxygen is more soluble in water than in air or other gases.

7. Biological importance of dissolved

i. Oxygen

- Marine life form uses dissolved oxygen for respiration.

ii. Carbon dioxide

- Aquatic plants make use of dissolved carbon dioxide for photosynthesis.
- Shells of marine animals like molluscs and sea urchins are composed of calcium carbonate in the form of calcite and aragonite that crystallised out in an organic matrix. Calcium carbonate is formed from dissolved carbon dioxide.

8. a. Solubility of sodium chloride (NaCl) slightly increases with increase in temperature.

b. Solubility of calcium sulphate ($CaSO_4$) increases sharply with increase in temperature but up to a certain limit around 32.8 °C and beyond this temperature, the solubility decreases.

CHAPTER – 4

ATOMIC STRUCTURE AND CHEMICAL BONDING

P. 61–62 CHECK YOUR PROGRESS 1

1. Choose the correct option.

a. iii.

b. i.

c. i.

d. ii.

2. Fill in the blanks.

a. coulomb or C

b. 1837

c. empty

d. negative charge

3. Give one word for each of the following.

a. Nucleus

b. Proton

c. Electron

d. Neutron

4. Match the following.

a. D.

b. B.

5. Give reasons for the following.

a. According to Rutherford's model of an atom, most of the matter in an atom is located at the centre in a very little space called nucleus, which is electrically positive in charge. Electrons surround the nucleus covering the empty space. The space around the nucleus is several times bigger than the size of the nucleus. Therefore, when alpha particles were passed through the thin gold foil, they went through without any deflection.

b. In an atom, the nucleus, which is positively charged, is present in the centre of the atom, occupying a small space. Therefore, the positively charged alpha particles of the order of 1 in 10000 encountered the positively charged nucleus. Therefore, these alpha particles underwent deflection of 180° after striking the centrally placed nucleus.

c. We know that atoms are quite stable. Rutherford's model could not explain the stability of an atom. According to Bohr's theory, electrons revolve around the nucleus in certain circular orbits. Each of these orbits is associated with certain amount of energy. As long as an electron revolves in a particular orbit, it neither loses nor absorbs energy. Therefore, electrons remain stable in these orbits around the nucleus even if they are in constant circular motion.

d. According to Bohr's theory, electrons revolve around the nucleus in certain circular orbits. Each of these orbits is associated with certain amount of energy. As long as an electron revolves in a particular orbit, it neither loses nor absorbs energy. These orbits are fixed-energy orbits. Therefore, electrons remain stable in these orbits around the nucleus even if they are in constant circular motion.

P. 65 CHECK YOUR PROGRESS 2

1. Choose the correct option.

a. iv.

b. iv.

2. Match the following.

a. D.

b. A.

3. Give reasons for the following:

According to the Bohr–Bury scheme, the maximum number of electrons which can be accommodated in an energy shell (orbit) follows $2n^2$ rule, where n is the number of the shell (or orbit). For the K shell, the value of n equals 1, so it can accommodate maximum of 2 electrons, according to the given formula.

4. Consider the following electronic configuration and answer the questions given below.

a. 6

b. 12

P. 68–69 CHECK YOUR PROGRESS 3

1. Choose the correct option.

a. iii.

b. ii.

2. Fill in the blanks.

a. 1

b. isobars

c. 3

d. octet

e. lose

3. Match the following.

a. B.

b. D.

4. Choose the odd one out in the series below and give reason.

^{19}F. Others are all isobars.

P. 73–74 CHECK YOUR PROGRESS 4

1. Choose the correct option.

a. i.

b. i.

c. iii.

d. ii.

2. State true or false.

a. True

b. False

c. False

d. True

e. False

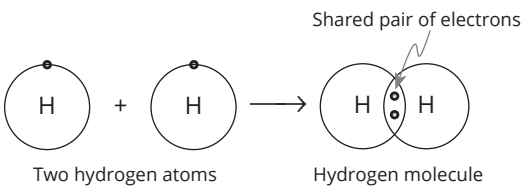
3. Match the following.

a. C.

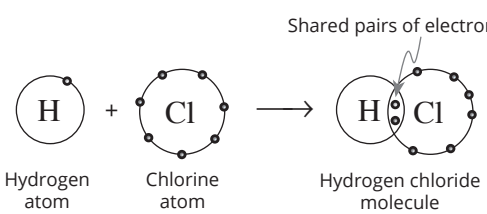
b. D.

4. Give reasons for the following.

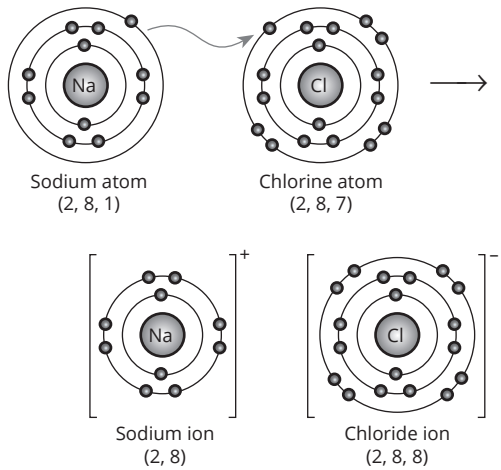
a. There is one electron in the shell of the hydrogen atom. In order to attain the nearest noble gas (helium) configuration, hydrogen shares one electron with another hydrogen atom, forming a hydrogen molecule. Hence, in a hydrogen molecule, two hydrogen atoms are held together by a single bond.



b. Hydrogen chloride (HCl) is a covalent compound. It is formed by the sharing of electrons between the hydrogen and chlorine atoms, resulting in a molecule with a polar covalent bond.



Sodium chloride (NaCl), on the other hand, is an ionic compound. It is formed by the transfer of electrons from sodium atoms to chlorine atoms, resulting in the formation of positively charged sodium (Na^+) ions and negatively charged chloride (Cl^-) ions, which are attracted to each other by strong electrostatic forces forming an ionic or electrovalent bond.



P. 75–77 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

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

11. d. All of the above

12. b. **13. b.** **14. a.** **15. c.** **16. c.**

17. a. **18. b.**

B. Fill in the blanks.

1. helium (He)

2. positive, negative; Or negative, positive

3. 2, 8, 6

4. two

5. hydrogen

6. orbits

7. no (or zero)

8. 31

9. valence electrons

10. isotopes

11. mass number

12. Covalent

13. covalent

14. overlapped region

II. Very Short Answer Type Questions

A. Answer the following questions.

1. In 1897, Sir J J Thomson found that the cathode rays consist of negatively charged particles, which were named as electrons.
2. The charge on an individual proton is $+1.602 \times 10^{-19}$ coulomb. Therefore, the relative charge of a proton is +1.
3. The nucleus contains all the positively charged particles (protons) and uncharged particles (neutrons) of the atom. The protons and neutrons in nucleus of an atom are collectively called nucleons.
4. Nobel gas configuration. As the noble gases are chemically unreactive, we can conclude that the atoms of these elements have stable electronic configurations as the valence electrons do not participate in chemical reactions.

B. Find the odd one out.

1. CaO (Explanation: CaO is an ionic compound, others are covalent compounds.)
2. CO_2 (Explanation: CO_2 is a covalent compound, rest all are ionic compounds.)
3. Na (Explanation: Na is a metal, whereas He, Kr and Ar are inert gases or noble gases.)
4. KCl (Explanation: KCl is an electrovalent compound, whereas H_2, Cl_2 and N_2 are covalent compounds.)
5. Na (Explanation: Na is a metal, whereas H_2, C and Cl_2 are non-metals.)

C. Give one example in each of the following cases.

1. Single covalent bond: Hydrogen (H_2) molecule contains single covalent bond. Each hydrogen atom shares its one electron and forms single covalent bond.
2. Double covalent bond: Oxygen (O_2) contains double covalent bond. Each oxygen atom shares its two electrons and forms double covalent bond.
3. Triple covalent bond: Nitrogen (N_2) contains triple covalent bond. Each nitrogen atom shares its three electrons, forming triple covalent bond.
4. An isotope: Protium (^1_1H) is an isotope of hydrogen.
5. An inert gas: Helium (He) is an inert gas.

D. Name each of the following.

1. Protium, deuterium and tritium
2. Phosphorus
3. Helium
4. K

E. Match the following.

1. b.

III. Short Answer Type Questions

A. Give reasons for the following.

1. Chlorine has two isotopes: Cl-35 and Cl-37. The ratio of their abundance is 3:1. While calculating the relative atomic mass, both these isotopes are considered along with their abundance. Therefore, the average relative atomic mass of chlorine is:

$$\frac{(35 \times 3) + (37 \times 1)}{(3 + 1)} = \frac{105 + 37}{4} = 35.5$$

2. According to Rutherford's model, electrons continuously revolve around the nucleus. An electrically charged particle in motion radiates energy, and therefore, the revolving electron should lose energy and fall into the nucleus, leading to the total collapse of the atom. In other words, atom would have been unstable according to this model. But this does not happen.
3. Bohr's model suggested that electrons revolve around the nucleus in certain circular orbits. Each of these orbits is associated with certain amount of energy. As long as an electron revolves in a particular orbit, it neither loses nor absorbs energy. These orbits are fixed-energy orbits. Therefore, electrons remain stable in these orbits around the nucleus.
4. Atoms can gain stable octet configuration by losing or gaining electron(s). Metals lose electron(s) while non-metals gain electron(s). By losing electron, a metal acquires positive charge while by gaining electron a non-metal acquires negative charge. The extent of positive or negative charge on a metal or a non-metal, respectively, depends of how many electrons are lost or gained. For loss of every electron, there is a positively charged ion, called cation whereas with the gain of every electron, there is a negatively charged ion called anion. Cations and anions attract each other to form an ionic bond which is held together by electrostatic force of attraction.
5. The isotopes of an element possess the same electronic configuration. Therefore, they have the same number of valence electrons and exhibit the same chemical properties.

B. Complete the following table.

1. a. N, 7, 7

b. 39, 19, 19

c. 21, 21, 24

d. 26, 26, 30

2. a. 2, 5; 2, 5; 3; 3; covalent bond

b. 2, 6; 2, 6; 2; 2; covalent bond

c. 2, 8, 1; 2, 8, 7; 1; 1; ionic bond

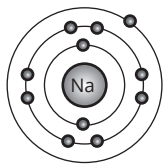
d. 1; 2, 6; 1; 2; covalent bond

e. 2, 8; 2, 8; 0; 0; no bond

C. Write the structure of the following.

1. Na: The electronic configuration of sodium is 2, 8, 1.

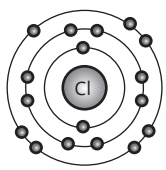
The structure of sodium is



Sodium atom
(2, 8, 1)

2. Cl: The electronic configuration of chlorine is 2, 8, 7.

The structure of chlorine is



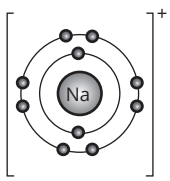
Chlorine atom
(2, 8, 7)

3. Na^+: Sodium donates an electron and becomes a positively charged sodium ion.

$$Na - e^- \rightarrow Na^+$$

Sodium atom (2, 8, 1) — Electron — Sodium ion (cation) (2, 8)

The structure of sodium ion is



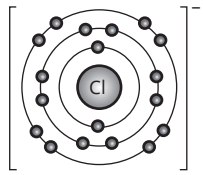
Sodium ion
(2, 8)

4. Cl^-: Chlorine accepts an electron and becomes negatively charged chloride ion.

$$Cl + e^- \rightarrow Cl^-$$

Chlorine atom (2, 8, 7) — Electron — Chloride ion (anion) (2, 8, 8)

The structure of chloride ion is



Chloride ion
(2, 8, 8)

D. Differentiate between the following.

1.

Ionic bond	Covalent bond
The chemical bond formed between two atoms by transfer of electrons from one atom to another is called ionic or electrovalent bond.	The chemical bond formed by the mutual sharing of two or more electrons between two atoms is called a covalent bond.
Metal atoms generally have 1, 2 or 3 electrons in their valence shell. They can lose these electrons to acquire stable nearest noble gas configuration. Non-metals gain electrons to complete their octet.	The atoms of non-metals generally have 5, 6 or 7 electrons in their valence shells. Non-metals complete their octet by sharing electrons.
Example: Sodium and chlorine form an ionic bond, forming sodium chloride (NaCl). An ionic bond will form when two atoms have different electronegativity values.	Example: Consider the example of hydrogen chloride. Hydrogen is a non-metal and chlorine is also a non-metal. When hydrogen combines with chlorine to form hydrogen chloride, electrons are shared between hydrogen and chlorine atoms, resulting in the formation of covalent bond.

2.

Atomic number	Mass number
The number of protons in the nucleus of an atom is called its atomic number.	The total number of protons and neutrons in the nucleus of an atom is called its mass number.
The atomic number of an element is represented by Z.	The mass number of an element is represented by A.
It has no unit.	The mass number is measured by using atomic mass unit (amu).

3.

C-12	C-14
The carbon-12 has 6 neutrons in its atomic nucleus.	The carbon-14 has 8 neutrons in its atomic nucleus.
The mass number of carbon-12 is 12. It is represented as $^{12}_{6}C$.	The mass number of carbon-14 is 14. It is represented as $^{14}_{6}C$.
The relative natural abundance of carbon-12 is 98.892%.	The relative natural abundance of carbon-14 is negligible.

4.

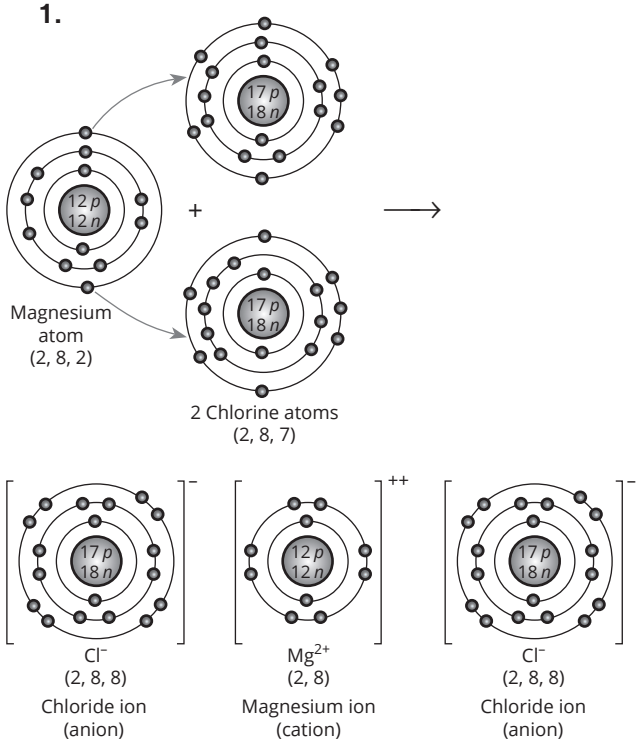
An atom	A cation
An atom is electrically neutral containing equal number of protons and electrons.	A cation is a positively charged particle in which the number of protons is greater than that of electrons. It is formed by loss of electrons.
Example: Ag, Na	Example: Ag^+, Na^+

5.

An atom	An anion
An atom is electrically neutral containing equal number of protons and electrons.	An anion is a negatively charged particle in which the number of electrons is greater than that of protons. It is formed by gain of electrons.
Example: Cl, Br	Example: Cl^-, Br^-

IV. Knowledge-based Questions

1.



- The atomic number of magnesium is 12. Its electronic configuration is 2, 8, 2.
- Magnesium has 2 electrons in its valence (outermost) shell, therefore, it can lose 2 electrons to acquire the nearest noble gas configuration of neon (2, 8) and form positive magnesium ion, Mg^{2+}.

$$Mg - 2e^- \rightarrow Mg^{2+}$$

- The atomic number of chlorine is 17. Its electronic configuration is 2, 8, 7.
- The chlorine atom has 7 electrons in the valence shell. The chlorine atom requires only one electron in the valence shell to acquire the nearest noble gas configuration of argon (2, 8, 8). One chlorine atom can accept only one electron, and therefore, two chlorine atoms are required to accept the two electrons from one magnesium atom.

$$2Cl + 2e^- \rightarrow 2Cl^-$$

- In this way, 2 chlorine atoms combine with one magnesium atom and form magnesium chloride.

2. Atomic mass of Carbon

$$= \frac{\sum(\%\ \text{Abundance} \times \text{Atomic weight})}{98 + 1.2 + 0.8}$$

$$= \frac{98 \times 12 + 1.2 \times 13 + 0.8 \times 14}{100}$$

$$= \frac{1176 + 15.6 + 11.2}{100}$$

$$= \frac{1202.8}{100} = 12.028$$

3. The main drawback of Rutherford's model was that he could not explain the stability of an atom. According to his model, the electrically charged particle in motion radiates energy and therefore the revolving electron should lose energy and fall into the nucleus leading to the total collapse of the atom. But this does not happen.

4. The mass number and atomic number are represented by A and Z, respectively. The atomic number and the mass number are written as subscripts and superscripts alongside the symbol of the element (X) respectively.

Let us take this example: ${}^{A}_{Z}X$

Mathematically,

$$Z = e \text{ or } p$$

$$A = n + p$$

Therefore, $n = A - Z$

Example: Let us take the example of oxygen.

$$A = n + p$$
$$X = O$$
$$Z = 8$$
$$A = 16$$

It is represented as $^{16}_{8}O$.

Since $Z = e$ or p

$A = n + p$

So, e or $p = 8$

$16 = n + 8$

$n = 16 - 8$

$= 8$

5. The conditions favouring the formation of a covalent bond are the following:

i. For the formation of a covalent bond, both the atoms should have four or more electrons [5, 6, 7] in their valence shells.

ii. Both the atoms should have high ionization energy, and the electronegativity difference between the combining atoms should be either zero or negligible.

6. Atomic mass of an element (X)

$$= \frac{\sum(\%\ \text{Abundance} \times \text{Atomic weight})}{1.5 + 1.8 + 1}$$

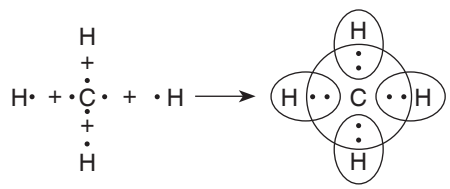
$$= \frac{1.5 \times 18 + 1.8 \times 20 + 1 \times 22}{4.3}$$

$$= \frac{27 + 36 + 22}{4.3}$$

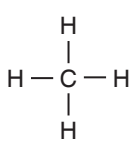
$$= \frac{85}{4.3}$$

$= 19.77$ u

7. Methane, CH_4: The atomic number of carbon is 6. Its electronic configuration is 2, 4. Carbon has four electrons in its outermost shell. It requires four more electrons to attain octet and become stable. Hydrogen has one electron in its outermost shell. It requires one more electron to attain duplet in its outermost shell. The carbon atom shares four valence electrons with four hydrogen atoms and forms a methane molecule.



or



Methane molecule

V. Application and Reasoning-based Questions

1. Dalton's atomic theory states that matter is made up of small indivisible and indestructible particles called atoms. But the modern atomic theory states that atom can be further subdivided into protons, electrons and neutrons.

2. Bohr's theory is different from Rutherford's theory because of its precise explanation about the location and distribution of electrons around the nucleus.

3. Protium, an isotope of hydrogen, does not contain neutron.

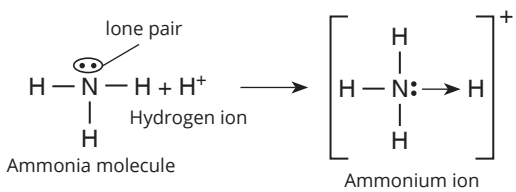
4. Because of the difference in the number of neutrons in the nucleus these atoms exist as isotopes. Isotopes have same atomic number but different mass numbers.

P. 78–79 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

1. a. sharing

b. nitrogen

2.



3. a. Cation and anion

b. Electron pair is shared between two electron contributing atoms.

c. Two in each nitrogen atom.

d. Magnesium (Mg) is oxidised and chlorine (Cl) atoms get reduced.

4. Proton: It is a positively charged particle. Number of protons is equal to the atomic number.

5. An electrically neutral atom has equal number of protons and electrons.

6. This is due to different number of neutrons in the nucleus of the atoms.

7.

Element	Atomic number	Mass number	*p*	*n*	*e*
Be	4	9	4	5	4
F	9	19	9	10	9
Na	11	23	11	12	11
Al	13	27	13	14	13
P	15	31	15	16	15

8. a. Al = 13 = 2, 8, 3

b. P = 15 = 2, 8, 5

9. a. 35

b. 20

10. Atoms differ because of different number of neutrons present in their nucleus.

11. $^{27}_{13}X$ = 2, 8, 3 No. of electrons = 13

$^{37}_{17}Y$ = 2, 8, 7 No. of neutrons = 20

Formula is XY_3.

12. a. 13

b. 13

c. 14

d. 2, 8, 3

13. a. i. A

ii. B

iii. C

b. BA_2

14. a. Y

b. Z

c. X

15. a. i. Z

ii. W

b. X_2Y

16. a. The number of protons in the nucleus of an atom is called atomic number. An atom is the smallest particle of an element.

b. Cl = 17 = 2, 8, 7

c.

$^{35}_{17}Cl$	$^{37}_{17}Cl$
$e = 17$	$e = 17$
$p = 17$	$p = 17$
$n = 18$	$n = 20$

17. a.

$^{24}_{12}Mg$	$^{26}_{12}Mg$
$p = 12$	$p = 12$
$n = 12$	$n = 14$

b. Both possess 2, 8, 2 configuration.

c. They differ in the number of neutrons.

18. $p = 16$

$n = 16$

19. $^{4}_{2}He$ Mass number = 4

Atomic number = 2

20. Atomic number: The number of protons in the nucleus of an atom is called atomic number.

Atomic mass number: The sum total of protons and neutrons inside the nucleus of an atom is called atomic mass number.

Electron: A subatomic particle having mass equal to $\frac{1}{1837}$ of that of a hydrogen atom and carrying one unit of negative charge is called electron.

CHAPTER – 5

THE PERIODIC TABLE

P. 82 CHECK YOUR PROGRESS 1

1. **b.**
2. **c.**
3. **c.**
4. **Fill in the blanks.**
   - **a.** triads
   - **b.** three
   - **c.** atomic masses
   - **d.** eighth
   - **e.** $\frac{(a+b)}{2}$
   - **f.** lighter
   - **g.** tenth
5. **a.** bromine
   - **b.** sodium
   - **c.** helium
5. **Give reasons for the following.**
   - **a.** According to the Newlands' law of octaves, when elements are arranged in the order of increasing atomic masses, the physical and chemical properties of every eighth element are a repetition of the properties of the first element. Since the repetition in the properties of the first and the eighth elements is just like the repetition of the eighth note in an octave, Newlands' law of periodicity is also known as the law of octaves.
   - **b.** Drawbacks of Newlands' law of octaves:
     - **i.** The law of octaves was applicable only for lighter elements. For elements after calcium, every eight element did not exhibit properties similar to that of the first.
     - **ii.** Newlands assumed that only 56 elements existed in nature and no new element would be discovered in future.
     - **iii.** In order to fit the elements in his periodic table, Newlands assigned one position to two elements. For example, only one position was assigned to Co and Ni, and Ce and La.

P. 84 CHECK YOUR PROGRESS 2

1. **a.**
2. **b.**
3. **c.**
4. **State True or False.**
   - **a.** True
   - **b.** False
   - **c.** True
   - **d.** False
   - **e.** False
   - **f.** False
5. **Fill in the blanks.**
   - **a.** six; eight
   - **b.** I; VIII
   - **c.** two; A and B
   - **d.** VIII
6. **a.** Co and Ni / Te and I
   - **b.** Cu, Ag and Au placed with most active metals such as Li, Na and K, in the same group.
   - **c.** Halogens
   - **d.** RO_3
7. **c.**

P. 90–91 CHECK YOUR PROGRESS 3

1. **c.**
2. **a.**
3. **b.**
4. **b.**
5. **d.**
6. **b.**
7. **c.**
8. **Fill in the blanks.**
   - **a.** noble
   - **b.** seven
   - **c.** eight
   - **d.** 32
9. **Match the following.**
   - **a.** c.
   - **b.** c. I–iv, II–iii, III–i, IV–ii

P. 92–95 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

B. Fill in the blanks.

1. germanium	**2.** alkaline earth metals
3. position	**4.** eighth

II. Very Short Answer Type Questions

A. Give one example of the following.

1. Li, Na and K are the examples of Dobereiner's triad. The atomic mass of lithium is 7 and that of potassium is 39. The average of these two values is 23 which is equal to the atomic mass of sodium.

Li	Na	K	$\frac{39+7}{2} = \frac{46}{2} = 23$
7	23	39	

2. Helium (He)

3. Copper (Cu)

4. Lanthanum (La)

5. Fluorine (F)

B. Give the common term for the following.

1.

Groups	Common Terms
1	Alkali metals
2	Alkaline earth metals
13	Boron family
14	Carbon family
15	Nitrogen family (Pnicogens)
16	Oxygen family (Chalcogens)
17	Halogens

2. Elements of groups 3 to 12: Transition elements or metals

3. Elements from atomic number 58 to 71: Lanthanoids

4. Elements from atomic number 90 to 103: Actinoids

C. Find the odd one out.

1. b. Na (Explanation: Na (Sodium), as it belongs to group 1 while rest all belong to group 2 of the Periodic Table.)

2. d. Ce (Explanation: Ce (Cerium), as it lies in sixth period while rest all lie in fourth period of the Periodic Table.)

3. c. Ca (Explanation: Ca (Calcium), as it belongs to group 2 while rest all belong to group 1 of the Periodic Table.)

4. a. O (Explanation: O (Oxygen), as it belongs to group 16 while rest all belong to group 17 of the Periodic Table.)

D. Match the Following.

1. d.

2. d.

3. b.

4. c.

E. Answer the following questions with respect to the modern periodic table.

1. Scandium

2. Period 1 is the shortest period. It has only two elements: hydrogen (H) and helium (He).

3. Transition elements are known as transition metals because they have a tendency to lose electrons. Additionally, transition metals have high melting and boiling points, which are typical properties of metals.

4. The seventh period of the periodic table is unique for several reasons. It is a long period with 32 elements. This period also contains 14 inner transition elements, Actinoids, and 10 transition elements. Actinoids are also called rare-earth elements and are placed at the bottom of the periodic table.

III. Short Answer Type Questions

A. Give reasons for the following.

1. J W Dobereiner arranged the elements with similar properties in groups of three called triads. In such triads, the atomic mass of the middle element is average of the other two elements' atomic masses, for example, lithium, sodium and potassium.

The atomic mass of lithium is 7 and that of potassium is 39. The average of these two values = $\frac{7+39}{2}$ = 23 which is equal to the atomic mass of sodium.

2. Newlands' law of octaves fails in arranging all elements due to the following drawbacks:

i. The law of octaves was applicable only for lighter elements. For elements after calcium, every eighth element did not exhibit properties similar to that of the first.

ii. Newlands assumed that only 56 elements existed in nature and no new element would be discovered in future.

iii. In order to fit the elements in his periodic table, Newlands assigned one position to two elements. For example, only one position was assigned to Co and Ni.

3. Mendeleev's periodic table was based on atomic mass. Defects of Mendeleev's Periodic table:

i. Position of hydrogen could not be explained.

ii. Elements with higher atomic masses were placed before elements of lower atomic masses.

iii. The position of isotopes could not be explained.

iv. Elements with identical properties placed in different groups.

v. Elements with different properties placed in the same group.

The given anomalies in the Mendeleev's periodic table were explained when the elements were arranged in the order of their increased atomic numbers as per the Modern Periodic Law.

4. The isotopes of an element have the same number of protons and different number of neutrons. Atomic number is the number of protons present in the element. Neutrons are not considered in assigning atomic numbers. Periodic table is based on the atomic number of elements. Therefore, the isotopes of an element are assigned the same position in the periodic table, and hence, do not create any problem.

5. All elements present in a group in the modern periodic table show similar properties because they have similar electronic configurations and have same number of valence electrons. The valence electrons are responsible for an element's chemical behaviour, including its reactivity and bonding properties. As a result, elements with the same number of valence electrons exhibit similar chemical behaviours.

6. The atomic size of elements in the periodic table generally increases as we move down a group. This is because as we move down the group, new energy levels or shells are added in an atom. This results in an increase in the atomic radius because the valence electrons are present farther from the nucleus, thus attraction between the valence electrons and the nucleus reduces. The atomic size therefore increases as we move from lithium to francium.

$$Li < Na < K < Rb < Cs < Fr$$

atomic size increases $\longrightarrow$

B. Differentiate between the following.

1.

Dobereiner's triads	Newlands' law of octaves
J W Dobereiner arranged the elements with similar properties in groups of three called Dobereiner triads.	John Newlands arranged the then known elements in the order of increasing atomic masses. He found out that every eighth element had properties similar to the first element.
Dobereiner, therefore, proposed that, if elements with similar properties were grouped in three's and placed in an increasing order of their atomic masses therein, then the atomic mass of the element placed in the middle was approximately equal to the average of the atomic masses of the other two elements of the triad.	According to the Newlands' law of octaves, when elements are arranged in the order of increasing atomic masses, the physical and chemical properties of every eighth element are a repetition of the properties of the first element.

2.

Mendeleev's periodic law	Modern periodic law
The physical and chemical properties of elements are the periodic functions of their atomic masses.	The physical and chemical properties of elements are the periodic functions of their atomic numbers.
There are a total of 8 groups and 6 periods.	There are a total of 18 groups and 7 periods.
There is no place allotted for isotopes.	Isotopes are kept in the same place due to their atomic numbers being the same.

3.

Group	Period
The vertical columns of elements in the periodic table are called groups.	The horizontal rows of elements in the periodic table are called periods.
There are 18 groups in the modern periodic table.	There are 7 periods in the modern periodic table.
All elements present in a group have similar electronic configurations and have same number of valence electrons.	All elements present in a period have the different electronic configurations and valence electrons increase from left to right.
Valency remains same.	On going from left to right valency increases from 1 to 4 and then decreases to zero.

4.

Transition elements	Inner transition elements
Transition elements, also known as transition metals, are the elements of groups 3 to 12.	Inner transition elements, also known as rare-earth elements, are the elements placed at the bottom of the periodic table.

Examples of transition elements include iron, copper, nickel and titanium.	Examples of inner transition elements include uranium, plutonium and neodymium.

C. Explain the following statements.

1. On moving down a group, the size of atoms increases. This is because on moving down a group, a new shell of electrons is added to each succeeding element. The electrons are farther from the nucleus, thus force of attraction between nucleus and valence electrons decreases. In a group, element with smallest atomic size is found at the top of the group and element with the largest atomic size is found in the lowest part of the group. For example, in group 1 of alkali metals, the atomic size increases from lithium (Li) to francium (Fr).

Li < Na < K < Rb < Cs < Fr

atomic size increases →

2. With the basis of classification shifting from atomic masses to atomic numbers, all the anomalies that were present in Mendeleev's classification were eliminated. The theory of transition elements, inner transition elements and isotopes found satisfactory explanations. The positions of cobalt and nickel were also justified. However, the modern periodic table, which represents a nearly perfect classification of elements, is yet not faultless because the position of hydrogen is debatable as it displays properties of group 1 as well as group 17.

D. Answer the following questions.

1. The important features of Mendeleev's classification are as follows:

i. There are eight vertical columns called groups, i.e. Group I to Group VIII. Each of these groups is sub-divided into sub-groups A and B.

ii. All elements of a sub-group or of Group VII (which has no sub-groups) have similar properties.

iii. There are six horizontal rows called periods.

2. Modern Periodic Law: The physical and chemical properties are periodic functions of their atomic numbers.

3. The importance of the Modern Periodic Table is as follows:

i. The periodic table has simplified the study of 117 diverse elements and their compounds.

ii. The periodic table has helped us immensely to correlate the properties of elements with their atomic numbers and electronic configurations. The chemical reactivity of an element can be predicted on the basis of its position in the periodic table.

iii. The periodic table has helped us to find relationships between various elements.

iv. The periodic table helps us to predict the properties of yet to be discovered elements.

4. On moving from left to right along a period, the number of valence electrons increases.

5. Transition metals and some non-metals, including copper, iron, chromium, sulphur and nitrogen, exhibit variable valency.

6. On moving down a group from top to bottom, the number of valence (or outer) electrons remains same.

IV. Knowledge-based Questions

1. Dobereiner was the first chemist to recognise the relationship between atomic weights and chemical properties.

2. Mendeleev's Law was not accepted due to the following reasons:

i. Could not give fixed place to hydrogen.

ii. Lighter elements were placed after heavier elements, contrary to the law.

3. The characteristics of groups are as follows:

i. Similar valence electrons: All the elements of a group in a periodic table have the same number of valence electrons and hence the same valency.

ii. Metallic character: On moving down a group, the metallic character increases.

iii. Increasing atomic size: On moving down in a group, the size of atoms increases. This is because on moving down a group, a new shell of electrons is added to each succeeding element.

iv. Similar chemical reactivity: The elements of a group in the periodic table have similar electronic configuration. Hence, all the elements of a group exhibit similar chemical properties.

4. The characteristics of periods are the following:

i. Similar number of shells: On moving from

left to right in a given period, the number of shells remains the same.

ii. **Valence electrons:** On moving from left to right along a period, the number of valence electrons increases from 1 to 8, except in the first period.

iii. **Decreasing atomic size:** On moving from left to right along a period, the size of atoms decreases. In any period, the alkali metal atom is biggest in size whereas the halogen atom is smallest in size.

iv. **Change in chemical reactivity:** On moving from left to right in a period, the chemical reactivity of elements first decreases and then increases.

5. a. VA group

b. 3rd period

c. Valency is 3.

d. It is a non-metal.

V. Application and Reasoning-based Questions

1. Zn Cd Hg

65 112 200.5

$65 + 200.5 = \frac{265.5}{2} = 132.75$

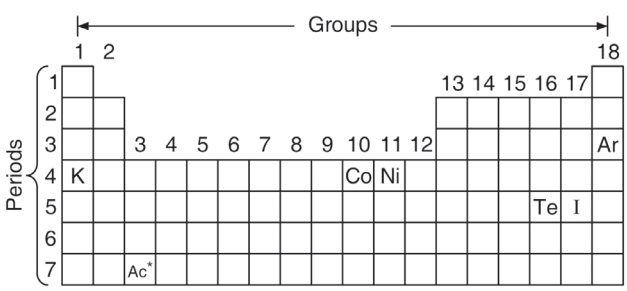
No, because atomic weight of cadmium (Cd) is not the average of the other two.

2. a. Hydrogen (H) or Sodium (Na) or Potassium (K)

b. Beryllium (Be)

c. Nitrogen (N)

3. Ar (Argon) and K (Potassium) placed in 18th and 1st groups and periods 3 and 4, respectively. Te (Tellurium) and I (Iodine) placed in 16th and 17th groups and period 5. Actinides [Th (Thorium) and Pa (Protactinium)] placed in 3rd group and period 7 of the Periodic Table.



Ac* = Actinides (Th and Pa)

4. The atomic size of elements decreases in moving from left to right along a period. This is due to an increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size of the atom. The atomic size increases down the group. This is because on moving down a group, a new shell of electrons is added to each succeeding element. This increases the distance between the outermost electrons and the nucleus so that there is less force of attraction, thus atomic size increases in spite of the increase in nuclear charge.

5. The increase in the number of elements from the third period to the fourth period is due to the addition of a new electron shell, which can accommodate up to 10 more elements. In contrast, there is no increase in the number of electron shells from the second period to the third period.

6. Physical and chemical properties remain similar along a group as we move from top to bottom because the valence electrons, which are responsible for the properties of elements, are in the same outermost energy level or shell. Therefore, the chemical and physical properties of the elements within a group remain similar due to the similarity in their valence electron configurations.

7. The oxides of elements in group 15 change their character from acidic to basic as one moves down the group due to a change in the electronic configuration and bonding of the elements with oxygen. The elements in group 15 have five valence electrons, and they can form covalent bonds with oxygen to form oxides. As we move down the group, the electronegativity of the elements decreases, and the size of the atoms increases. This results in weaker bonding between the oxygen and the element, making it easier for the oxygen to accept electrons from the element. The oxides of nitrogen and phosphorus are acidic due to the presence of non-bonding electrons on the central atom, which can donate hydrogen ions in aqueous solutions. However, as we move down the group to elements such as arsenic (As), antimony (Sb) and bismuth (Bi), the oxides become more basic because the central atom has a lower electronegativity and a larger size, which favours the formation of ionic bonds with oxygen, resulting in the formation of basic oxides.

8. The oxides of elements across a period, say in period 3 from Na to Cl, change their character

from basic to acidic as one moves across the period because the electronegativity of the elements increases from left to right. Metallic character decreases from left to right. The metals on the left side of the period, such as sodium (Na), have a lower electronegativity and tend to lose electrons and form basic oxides, while the non-metals on the right side, such as chlorine (Cl), have a higher electronegativity and tend to gain electrons and form acidic oxides. Silicon (Si) in the middle of the period forms an oxide that is amphoteric, meaning it can exhibit both acidic and basic properties.

P. 95 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

1. Vertical columns are called groups.

2. Eight elements

3. number of outer electrons

4. Period 1 = 2 elements
Period 2 = 8 elements
Period 3 = 8 elements

5. Hydrogen and helium

6. Both elements contain 8 or octet of electrons.

7. Non-metallic

8. metallic

CHAPTER – 6

STUDY OF THE FIRST ELEMENT – HYDROGEN

P. 98 CHECK YOUR PROGRESS 1

1. **a.**
2. **a.**
3. **b.**
4. **b.**
5. **a.** halogens
   b. 17
6. **b.**
7. **b.**

P. 102 CHECK YOUR PROGRESS 2

1. **d.**
2. **a.**
3. **a.**
4. **b.**
5. **a.** potassium
   b. below
   c. hydrogen
   d. Amphoteric
6. **c.**
7. **a.** Displacement of hydrogen from acid
   b. Displacement of hydrogen from alkali
8. $2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

P. 104 CHECK YOUR PROGRESS 3

1. **d.**
2. **c.**
3. **a.**
4. **d.**
5. **b.** False
6. **a.** Silver nitrate solution
   b. Lead nitrate solution
   c. Caustic potash
   d. moisture or water vapour
   e. water
   f. Methane
7. **a.** Water gas
   b. Zinc granules
   c. Bosch process

P. 106 CHECK YOUR PROGRESS 4

1. **d.**
2. **d.**
3. **c.**
4. **c.**
5. **c.**
6. **b.**
7. **a.** CaH_2
   b. 2Na
   c. Fe_2O_3
   d. C_2H_4
8. **a.** Haber's process
   b. Exothermic reaction
   c. Reversible reaction
   d. Hydrogenation reaction
9. N (Explanation: N belongs to the Group 15 of the periodic table, rest all belong to Group 1.)
10. $O_2 + 2H_2 \rightarrow 2H_2O$ (This reaction is exothermic, rest all are endothermic reactions.)

P. 109 CHECK YOUR PROGRESS 5

1. **a.**
2. **a.**
3. **b.**
4. **d.**
5. **a.**
6. **a.** CO_2
   b. 2Mg
   c. Br_2
   d. Cu
7. **a.** **i.** Reduction
   ii. Oxidation
   b. **i.** Reduction
   ii. Oxidation
8. **a.** H_2
   b. Cl_2

P. 111–113 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

B. Fill in the blanks.

1. hydrogen (H^+) ion or hydride (H^-)
2. diatomic
3. water, generating
4. reversible, exothermic
5. copper
6. catalyst, molybdenum
7. oxy-hydrogen flame, welding
8. react
9. Aluminium/zinc/lead
10. exothermic

II. Very Short Answer Type Questions

A. Give one example for each of the following chemical reactions.

1. When hydrogen combines with non-metals, it can form covalent compounds known as hydrides. One example of this is hydrogen chloride (HCl), which is a compound formed by the combination of hydrogen and chlorine.
2. Hydrogen gas can be prepared from cold water and certain active metals. In this process, the metal reacts with water to form the corresponding metal hydroxide and hydrogen gas. One example of this is the reaction between cold water and potassium (K) metal, which produces potassium hydroxide (KOH) and hydrogen (H_2) gas according to the following equation:

$$2K + 2H_2O \rightarrow 2KOH + H_2\uparrow$$

3. Hydrogen gas can be prepared from hot water and certain active metals. In this process, the metal reacts with hot water to form the corresponding metal hydroxide and hydrogen gas.

   Example: Magnesium does not react with cold water but it decomposes with hot water to liberate hydrogen (H_2) gas according to the following equation:

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2\uparrow$$

$$Mg + H_2O \rightarrow MgO + H_2\uparrow$$

(Steam)

4. Hydrogen gas can be prepared from steam and certain active metals. In this process, the metal reacts with water to form the corresponding metal oxide and hydrogen gas.

   Example: At high temperature, aluminium reacts with steam to form aluminium oxide and hydrogen gas.

$$2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2\uparrow$$

(Steam)

Aluminium does not react with water under ordinary conditions. It forms a thin layer of oxide on its surface which prevents further reaction.

B. Find the odd one out.

1. **Na (Explanation:** Sodium metal reacts violently with dilute hydrochloric acid, while all other elements react moderately with dilute acid to liberate hydrogen gas. In case of sodium, the hydrogen gas obtained catches fire due to the highly exothermic nature of the reaction.)
2. **NH_3 (Explanation:** NH_3 is basic in nature but SO_2, H_2S and CO_2 are acidic in nature.)
3. **Hg (Explanation:** The odd one out is Hg (Mercury), as it is the only element that is a liquid at room temperature, whereas Fe, Zn and Cu are solids at room temperature.)
4. **Pb (Explanation:** Lead (Pb) reacts with dilute sulphuric acid or HCl and forms an insoluble coating of lead sulphate or lead chloride. The others react with dilute sulphuric acid or HCl to liberate hydrogen.)

C. Name the following.

1. Calcium
2. Aluminium
3. Iron(III) oxide (magnetic oxide)
4. Sodium
5. Nitric acid
6. Zinc
7. Anhydrous calcium chloride
8. Hydrogen sulphide (H_2S), arsine (AsH_3), phosphine (PH_3)
9. Catalyst Fe_2O_3 and promoter Cr_2O_3
10. Vanaspati ghee

III. Short Answer Type Questions

A. Define the following terms.

1. **Oxidation:** A process which involves the addition of oxygen or removal of hydrogen is called oxidation. For example,

$$\overset{\text{Oxidation}}{\overbrace{}}$$
$$Mg + O_2 \longrightarrow MgO$$
$$H_2S + Br_2 \longrightarrow HBr + S$$
$$\underbrace{}_{\text{Oxidation}}$$

2. **Reduction:** A process which involves the addition of hydrogen or removal of oxygen is called reduction.

Reduction

$$2K + H_2 \xrightarrow{\Delta} 2KH$$

$$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$$

Reduction

3. **Oxidising agent:** A substance which causes addition of oxygen or removal of hydrogen from other substances is called oxidising agent.

4. **Reducing agent:** A substance which causes addition of hydrogen or removal of oxygen from other substances is called reducing agent.

B. Differentiate between the following pairs.

1.

Oxidation	Reduction
Oxidation is a chemical reaction which involves addition of oxygen or any other electronegative atom or ion to a substance.	Reduction is a chemical reaction which involves removal of oxygen or any other electronegative atom or ion from a substance.
This also involves removal of hydrogen or any other electropositive atom or ion from a substance.	This also involves addition of hydrogen or any other electropositive atom or ion to a substance.
Example: $2Mg + O_2 \rightarrow 2MgO$ $H_2S + Br_2 \rightarrow 2HBr + S$	Example: $2Na + H_2 \xrightarrow{\Delta} 2NaH$ $Fe_2O_3 + CO \xrightarrow{\Delta} 2Fe + 3CO$

2.

Oxidising agent	Reducing agent
A substance which causes addition of oxygen or removal of hydrogen from other substances is called oxidising agent.	A substance which causes addition of hydrogen or removal of oxygen from other substances is called reducing agent.
They oxidized the other substance present in a chemical reaction.	They reduced the other substances present in a chemical reaction.
Example: Oxygen, fluorine, chlorine, hydrogen peroxide, nitric acid, conc. sulphuric acid, potassium chlorate, potassium permanganate, etc. Consider the following reaction: $H_2S + Cl_2 \rightarrow 2HCl + S$ Hydrogen sulphide is oxidised to sulphur, and chlorine is the oxidising agent as it is able to remove hydrogen from hydrogen sulphide.	Example: Hydrogen, carbon, sodium, magnesium, aluminium, mercury, hydrogen sulphide, sulphur dioxide, nitrous acid, tin(II) chloride, carbon monoxide, etc. Consider the following reaction: $Cl_2 + H_2S \rightarrow 2HCl + S$ Chlorine is reduced to hydrochloric acid, and hydrogen sulphide is the reducing agent since it is able to add hydrogen to chlorine.

3.

Metals above hydrogen in the activity series	Metals below hydrogen in the activity series
Metals above hydrogen in the activity series can displace hydrogen from dilute acids, because they are more reactive than hydrogen.	Metals below hydrogen in the activity series cannot displace hydrogen from dilute acids, because they are less reactive than hydrogen.
Metals which are more reactive than hydrogen are potassium, sodium, calcium, magnesium, aluminium, zinc, iron, tin and lead.	Metals which are less reactive than hydrogen are copper, mercury, silver and gold.
Example: Iron can displace copper from copper(II) sulphate solution. $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$	Example: Copper will not displace iron from iron(II) sulphate solution. $Cu(s) + FeSO_4(aq) \rightarrow$ No reaction

C. Give reasons for the following.

1. The reason for this is potassium and sodium being highly reactive, their reaction with acids is violent in nature, and hence, are avoided in the preparation hydrogen by reaction with dilute acids.

2. a. Silver nitrate solution absorbs the impurities like arsine and phosphine.

$$AsH_3 + 6AgNO_3 \rightarrow Ag_3As + 3AgNO_3 + 3HNO_3$$

$$PH_3 + 6AgNO_3 \rightarrow Ag_3P + 3AgNO_3 + 3HNO_3$$

b. Lead nitrate solution absorbs the impurity like hydrogen sulphide.

$$Pb(NO_3)_2 + H_2S \rightarrow PbS + 2HNO_3$$

c. Potassium hydroxide absorbs the impurities such as carbon dioxide, nitrogen dioxide and sulphur dioxide.

$$CO_2 + 2KOH \rightarrow K_2CO_3 + H_2O$$

$$2NO_2 + 2KOH \rightarrow KNO_2 + KNO_3 + H_2O$$

$$SO_2 + 2KOH \rightarrow K_2SO_3 + H_2O$$

d. Water vapour is eliminated by passing the gas over anhydrous calcium chloride which is used as a drying agent.

3. The following precautions should be taken while preparing hydrogen as it is a highly inflammable gas.

i. Care must be taken to seal any leakage of the gas.

ii. No flame must be brought near the apparatus because hydrogen is a combustible gas.

iii. The end of the thistle funnel must be below the level of the acid in the flask so as to prevent the gas from escaping through the funnel.

iv. Care should be taken to collect the gas only after all the air contained in the apparatus has escaped.

4. a. Reduced

b. Oxidised

c. Reduced

IV. Knowledge-based Questions

1. Reaction of water with:

Sodium	Calcium
It is highly vigorous.	It is fairly vigorous.
Sodium melts to form a ball that moves around on the surface. It reacts vigorously with water, and hydrogen thus produced catches fire.	The heat evolved is not sufficient for the hydrogen to catch fire.

2. Granulated zinc contains traces of copper as an impurity which catalyses the reaction and prevents the deposition of the gas on the zinc.

3. Bosch process consists of the following stages:

Stage I: When steam is passed over white hot coke, a mixture of hydrogen and carbon monoxide called water gas is formed. The reaction is endothermic and the temperature is maintained at about 1000 °C.

$$C + H_2O \xrightarrow{1000\ ^\circ C} \underbrace{CO + H_2}_{\text{Water gas}} - \Delta$$

Stage II: The water gas is mixed with more steam and passed over a catalyst at 450 °C. CO is converted into CO_2 and more hydrogen is produced.

$$\underbrace{CO + H_2}_{\text{Water gas}} + H_2O \rightarrow CO_2 + 2H_2$$

The catalyst used is iron(III) oxide mixed with chromium(III) oxide which acts as a promoter. This reaction is exothermic.

Stage III: The primary impurities in this method are carbon monoxide and carbon dioxide.

Removal of carbon monoxide: Carbon monoxide is removed by passing the mixture of water gas and steam through ammoniacal copper(I) chloride solution which absorbs it.

$$CO + CuCl + 2H_2O \rightarrow CO{\cdot}CuCl{\cdot}2H_2O$$

Removal of carbon dioxide: Carbon dioxide is removed by passing the mixture through water under 30 atmospheric pressure or in caustic potash solution which dissolves the carbon dioxide, leaving behind H_2.

$$CO_2 + H_2O \xrightarrow{30\ atm} H_2CO_3$$

$$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$$

4. Here are some of the key physical properties of hydrogen:

i. It is a colourless, tasteless and odourless gas.

ii. It is the lightest gas known with a density of 0.0899 g/mL.

iii. It is practically insoluble in water. 100 mL of water dissolves only about 20 mL of hydrogen.

iv. It is difficult to liquefy.

v. It is adsorbed on heating with certain transition metals such as palladium, platinum and nickel.

5. Just like alkali metals (Na, K, etc.) hydrogen can also lose one electron to form positive ion H^+. Therefore, it should be placed with alkali metals.

6. Like halogens, hydrogen can also gain one electron to form monovalent anion H^- (hydride).

V. Application and Reasoning-based Questions

1. Sodium and potassium are highly reactive metals, their reactions with water are violent in nature, and hence, are avoided in the preparation of hydrogen by reaction with water. On the other hand, reaction with sodium or potassium and water can be controlled if, in place of sodium or potassium metal, sodium amalgam or potassium amalgam is used. Sodium amalgam or potassium amalgam when reacts with water, the alloy sinks and stays under water.

2. Granulated zinc contains traces of copper as an impurity which catalyses the reaction and prevents the deposition of the gas on zinc.

3. Hydrogen cannot be collected by downward displacement of air even though it is lighter than it because it forms an explosive mixture with air.

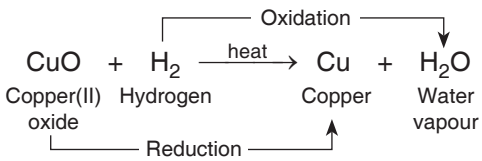
4. Lead is not used to prepare hydrogen although it is placed above hydrogen in the reactivity series because the reaction is slow and the products ($PbCl_2$ and $PbSO_4$) formed are insoluble and form a layer over the metal preventing further reaction.

5. Nitric acid is an oxidising agent and hydrogen is a reducing agent. Therefore, dilute nitric acid oxidises the hydrogen produced to water and itself reduces to any of the nitrogen oxides like N_2O, NO_2, N_2 and NH_3.

6. Copper is placed below hydrogen in the reactivity series and therefore cannot displace hydrogen from dilute acids.

7. Oxidation and reduction always occur together in the same reaction, as they are complementary to each other. Oxidation involves loss of electron or electrons, while reduction involves gain of electron or electrons. In a chemical reaction, when one species loses electrons, another species must simultaneously gain those electrons. This is why oxidation and reduction are always observed together and are referred to as oxidation–reduction or redox reaction.

   For example:



   In the above reaction, CuO gives oxygen and therefore, CuO is the oxidising agent. H_2 gains oxygen and therefore, H_2 is the reducing agent.

P. 113 QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

1. $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$
2. Hydrogen
3. $3Fe + 4H_2 \rightleftharpoons Fe_3O_4 + 4H_2$
4. Pure hydrogen burns with a pop sound. The jar in which hydrogen burns quietly contains impure hydrogen while the other jar in which hydrogen does not burn quietly contains pure hydrogen.
5. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
6. Sodium
7. 2H represents two atoms of hydrogen.

   H_2 represents a molecule of hydrogen gas.

   H^+ represents hydrogen ion.
8. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
9. It means hydrogen can again reduce magnetic oxide to iron.
10. By reaction with Zn, refer Answer 1 above.

CHAPTER – 7
STUDY OF GAS LAWS

P. 115–116 CHECK YOUR PROGRESS 1

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

6. a. no

b. straight

c. walls of the container

d. intermolecular

P. 119 CHECK YOUR PROGRESS 2

4 1. **d.** **2. a.** **3. a.** **4. a.** **5. a.**

6. c.

7. a. doubled

b. physical

c. pressure; volume

d. mass

8. a. 4.0

b. 8.0

c. 0.5

d. 0.25

P. 122–123 CHECK YOUR PROGRESS 3

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

6. a. **7. c.**

8. a. straight line

b. isobars

c. 273

9. a. At absolute zero (0 K), the kinetic energy of the gas particles is zero, i.e., gas molecules stop moving completely at absolute zero. This is why it is not possible to attain a temperature that is below absolute zero.

b. Due to increase in temperature, the kinetic energy and speed of gas particles increase. If the pressure remains constant and if one of the walls of the container is flexible, then as the temperature increases, the flexible wall of the container will be pushed outward due to more number of and more powerful collisions. This will result in increase in volume.

c. The equation $V_1/T_1 = V_2/T_2$ is known as Charles' law. It describes the relationship between the volume and temperature of a gas under certain conditions. In this equation, V_1 represents the initial volume of a gas, T_1 represents the initial temperature of the gas, V_2 represents the final volume of the gas, and T_2 represents the final temperature of the gas.

It states that if the pressure of a gas is kept constant, then the ratio of the initial volume to the initial temperature is equal to the ratio of the final volume to the final temperature.

d. The volume of a gas should become zero at –273 °C (also known as absolute zero) because at this temperature, the gas particles have reached the lowest possible energy state, and are no longer moving. According to the kinetic theory of gases, the volume of a gas is directly proportional to the average kinetic energy of its particles. As the temperature of a gas decreases, the average kinetic energy of its particles decreases as well, causing the particles to slow down and move closer together. As the temperature approaches absolute zero, the gas particles come to a complete stop and are no longer in motion. At this point, the gas has reached its minimum possible volume and cannot be compressed any further.

10. c. –273 K (**Explanation:** 0 K is known as absolute zero, which is equivalent to –273 °C. 273 K is equivalent to 0 °C, which is the freezing point of water. 283 K is equivalent to 10 °C, which is a temperature commonly found in the environment. –273 K is equivalent to –273 °C, which is a temperature that cannot physically exist.)

P. 125 CHECK YOUR PROGRESS 4

1. Given:

Volume of gas, $V_1 = 82$ mL

Pressure of gas, $P_1 = 2.9$ atm

Temperature, $T_1 = 37\ °C = 37 + 273 = 310$ K

As standard conditions of temperature and pressure, i.e. at S.T.P.,

Volume of gas, $V_2 = ?$

Temperature, $T_2 = 273$ K

Pressure, $P_2 = 1$ atm

From the gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\Rightarrow \quad V_2 = \frac{P_1V_1 \times T_2}{T_1 \times P_2}$$

$$= \frac{2.9 \text{ atm} \times 82 \text{ mL} \times 273 \text{ K}}{310 \text{ K} \times 1 \text{ atm}}$$

$$V_2 = 209.4 \text{ mL}$$

2. Given:

Volume of gas, V_1 = ?

Temperature, T_1 = 0 °C = 0 + 273 = 273 K

At 37 °C, volume of gas, V_2 = 210 mL

Temperature, T_2 = 37 + 273 = 310 K

From Charles' Law,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\Rightarrow \quad V_1 = \frac{V_2 \times T_1}{T_2}$$

$$\Rightarrow \quad V_1 = \frac{210 \text{ mL} \times 273 \text{ K}}{310 \text{ K}}$$

$$= 184.93 \text{ mL}$$

3. Given:

Volume, V_1 = 152 mL

Temperature, T_1 = 23 °C = 23 + 273 K

= 296 K

Pressure, P_1 = 72 mm of Hg

At NTP,

V_2 = ?

T_2 = 273 K

P_2 = 760 mm of Hg

From the gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{72 \times 152}{296} = \frac{760 \times V_2}{273}$$

$$V_2 = \frac{72 \times 152 \times 273}{760 \times 296}$$

$$= 13.28 \text{ mL}$$

4. According to Charles' Law, volume of a fixed mass of a gas is directly proportional to its temperature at constant pressure.

5. According to Boyle's Law, volume of a fixed mass of a gas is inversely proportional to the pressure applied to it, provided the temperature remains constant.

P. 126–129 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

1. d. $\frac{T_2V_1}{P_2} = \frac{T_1V_2}{P_1}$

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

B. Fill in the blanks.

1. molecules

2. inversely related

3. directly related

4. elastic

5. The average kinetic energy

6. pressure

7. *t*

8. do not

II. Very Short Answer Type Questions

A. Choose the odd one out.

1. 1 torr – The relationship between the units of pressure is: 1 atm = 76 cm of Hg = 760 mm of Hg = 760 torr. So we can say that 1 atm is equal to 76 cm of Hg and 760 mm of Hg. The odd one out is 1 torr.

2. 1 L – The relationship between the units of volume is: 1 $m^3 = (10)^3$ dm^3 = 1000 dm^3 = 1000 L. So we can say that 1 m^3 is equal to 1000 dm^3 and 1000 L. The odd one out is 1 L.

3. 0 K – The formulas for interconversion between the scales of temperature are: $\frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5}$. So we can say that 373 K is equal to 212 °F and 100 °C. The odd one out is 0 K.

4. 0 °F – The temperature 0 °C is equal to 273 K. The odd one out is 0 °F.

5. 0.1 atm – The pressure 760 mm of Hg is equal to 76 cm of Hg. The odd one out is 0.1 atm.

B. Match the following.

1. c. **2. c.**

C. Name the following.

1. Boyle's law **2.** Charles' law

3. Ideal gas **4.** Absolute zero

5. N.T.P. or S.T.P.

D. Answer the following questions.

1. Gases have neither a fixed volume nor a fixed shape. This is because there is negligible force of attraction between the gaseous molecules. Therefore, the gaseous molecules are free to move in the entire space available to them and they attain the shape of the container in which they are kept.
2. S.T.P. is standard temperature and pressure at which

   Temperature = 0 °C or 273 K

   Pressure = 760 mm of Hg or 76 cm or 1 atm
3. In Boyle's law, the temperature remains constant. In Charles' law, the pressure remains constant.
4. At absolute zero (0 K or –273 °C), the volume of a gas should become zero. This implies that any further decrease in temperature is not possible because it will correspond to negative volume, which is meaningless. So, it is not possible for a gas to exist at a temperature of –5 K.

III. Short Answer Type Questions

A. Give reasons for the following.

1. According to Charles' law, at constant pressure, the volume of a fixed mass of a gas is directly proportional to its absolute (Kelvin) temperature. This means that as the temperature of the gas increases, its volume will also increase, assuming that the pressure remains constant.
2. This is a specific case of Boyle's law, which states that at constant temperature, the volume of a given mass of a gas is inversely proportional to the pressure applied to it. When volume is plotted against reciprocal of pressure, a straight line passing through the origin is obtained. This indicates that 1/P is directly proportional to V, and therefore, P is inversely proportional to V. Therefore, the statement is true: the graph of volume versus inverse of pressure at constant temperature is a straight line.
3. The volume of a gas should become zero at –273 °C. This implies that any further decrease in temperature is not possible because it will correspond to negative volume, which is meaningless. The lowest possible hypothetical to theoretical temperature of –273 °C at which all gases are supposed to have zero volume is called absolute zero.
4. This is correct statement. According to Boyle's Law, at a constant temperature, the volume of a given mass of a gas is inversely proportional to the pressure applied to it. This means that if the volume of the gas is decreased, the pressure will increase, assuming that the temperature remains constant. Conversely, if the volume is increased, the pressure will decrease, again, assuming that the temperature remains constant.

B. Define:

1. **Absolute zero:** The lowest possible hypothetical to theoretical temperature of –273 °C at which all gases are supposed to have zero volume is called absolute zero.
2. **Pressure of a gas:** The pressure of a gas is defined as the force exerted by the gas per unit area on the walls of the container.
3. **Kelvin scale of temperature:** Lord Kelvin suggested a new temperature scale in which the lowest possible temperature is corresponding to –273 °C. This scale of temperature is called Kelvin scale or absolute scale of temperature.
4. **Diffusion of a gas:** Diffusion of a gas refers to the process by which gas molecules move from an area of high concentration to an area of low concentration. This movement occurs because gases consist of particles that are always in random motion and are constantly colliding with each other. These collisions cause gas molecules to spread out and mix with other gas molecules, resulting in a uniform distribution of gas throughout the entire volume of the container.

C. Answer the following questions.

1. Explanation of Boyle's law by kinetic theory of gases:
   - According to the kinetic theory of gases, the pressure exerted by a gas results from the combined collisions of its molecules on the walls of the container.
   - The number of collisions depends on the concentration of molecules at a certain temperature.
   - When the volume of a gas is reduced to one-fifth, the concentration of the gas molecules is increased five times, and hence, the pressure increases five times.
   - Thus, at constant temperature, the pressure of the gas is inversely proportional to the volume of a gas. Under ordinary conditions, Boyle's law is entirely satisfactory. But at very low temperatures or under high pressures, deviations may occur. In these conditions,

correction factors have been suggested in Boyle's law. A gas which obeys Boyle's law is said to show ideal behaviour.

2. On heating the gas, the kinetic energy of molecules increases. This means the molecules will move faster. Hence, the gas will expand, provided pressure remains constant.

3. Charles' law states that at constant pressure, the volume of a fixed mass of a gas is directly proportional to its absolute (Kelvin) temperature. As the temperature of a gas decreases, its volume decreases proportionally. This means that at a certain point, called absolute zero, the volume of a gas would become zero. Absolute zero is the lowest possible hypothetical to theoretical temperature of –273 °C at which all gases are supposed to have zero volume. Therefore, the relationship between temperature and volume described by Charles' law provides the basis for the concept of absolute zero.

4. There are three temperature scales commonly used: Celsius (°C), Fahrenheit (°F) and Kelvin (K). The formulas for interconversion between these scales are as follows:

$$\frac{C}{100} = \frac{F-32}{180} = \frac{K-273}{100}$$

or

$$\frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5}$$

Where,

C – value of temperature on Celsius scale.

K – value of temperature on Kelvin scale.

F – value of temperature on Fahrenheit scale.

IV. Numerical Problems

1. Initial conditions — Final conditions

V_1 = 400 mL — V_2 = 2000 mL

P_1 = ? — P_2 = 5 atm

By Boyle's Law

$$P_1V_1 = P_2V_2$$

$$P_1 = \frac{P_2V_2}{V_1} = \frac{5 \times 2000}{400}$$

Initial pressure = 25 atm

2. Initial conditions — Final conditions

V_1 = 700 cm^3 — V_2 = 1400 cm^3

P_1 = ? — P_2 = 2.8 atm

By Boyle's Law

$$P_1V_1 = P_2V_2$$

$$P_1 = \frac{2.8 \times 1400}{700}$$

Initial pressure = 5.6 atm

3. Initial conditions — Final conditions

P_1 = 1500 mm of Hg — P_2 = 1500 – 450 = 1050 mm of Hg

V_1 = ? — V_2 = 800 cm^3

By Boyle's Law

$$P_1V_1 = P_2V_2$$

$$V_1 = \frac{P_2V_2}{P_1} = \frac{1050 \times 800}{1500}$$

= 560 cm^3

4. Initial conditions — Final conditions

V_1 = 500 mL — V_2 = 650 mL

T_1 = (47 + 273) K = 320 K — T_2 = ?

By Charles' law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{500}{320} = \frac{650}{T_2}$$

or $$T_2 = \frac{650 \times 320}{500}$$

= 416 K

or = (416 – 273) °C = 143 °C

5. Initial conditions — Final conditions

T_1 = 67 °C = (273 + 67) K = 340 K — T_2 = 67 °C + 40 °C = 107 °C = (107 + 273) K = 380 K

V_1 = ? — V_2 = 800 mL

By Charles' law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_1 = \frac{V_2T_1}{T_2} = \frac{800 \times 340}{380}$$

= 715.8 mL

The initial volume was 715.8 mL.

6. Initial conditions

V_1 = 600 mL

T_1 = (27 + 273) K = 300 K

Final conditions

As gas is 30% compressed. Therefore,

$$30\% \text{ of } 600 = \frac{30 \times 600}{100} = 180 \text{ mL}$$

$\therefore$ $V_2 = 180$ mL

$T_2 = ?$

By Charles' Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\therefore \quad T_2 = \frac{V_2 T_1}{V_1} = \frac{180 \times 300}{600} = 90 \text{ K}$$

Final temperature is 90 K or (90 – 273) °C

= –183 °C.

7. Initial conditions | Final conditions

$V_1 = 500$ mL | $V_2 = ?$

$P_1 = 760$ mm of Hg | $P_2 = 300$ mm of Hg

$T_1 = 273$ K | $T_2 = (17 + 273)$ K = 290 K

By Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1}{T_1P_2}T_2$$

$$= \frac{760 \times 500 \times 290}{273 \times 300}$$

= 1345.5 mL

The final volume will be 1345.5 mL.

8. Initial conditions | Final conditions

$P_1 = 80$ cm of Hg | $P_2 = ?$

$V_1 = 300$ mL | $V_2 = 250$ mL

$T_1 = (273 + 27)$ K = 300 K | $T_2 = (273 + 17)$ K = 290 K

By Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{80 \times 300 \times 290}{300 \times 250}$$

= 92.8 cm

The final pressure will be 92.8 cm of mercury.

9. Initial conditions | Final conditions

$T_1 = (273 + 20)$ K = 293 K | $T_2 = ?$

$P_1 = P$ atm | $P_2 = 3P$

$V_1 = V$ mL | $V_2 = V + \frac{2V}{5} = \frac{7V}{5}$

By Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = \frac{P_2V_2T_1}{P_1V_1} = \frac{3P \times 7V \times 293}{5 \times P \times V}$$

= 1230.6 K

(1230.6 – 273) °C = 957.6 °C

The final temperature should be 957.6 °C.

10. Initial conditions | Final conditions

$P_1 = 540$ mm | $P_2 = 648$ mm

$V_1 = 892$ cc | $V_2 = ?$

$T_1 = (273 – 50)$ K = 223 K | $T_2 = –50$ °C + 57 °C = 7 °C = (273 + 7) K = 280 K

Final pressure increases by 20% of 540

$$= \frac{20 \times 540}{100} = 108 \text{ mm}$$

Final pressure = 540 + 108 = 648 mm

By Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or $$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{540 \times 892 \times 280}{223 \times 648}$$

The final volume will be 933.33 cc.

V. Knowledge-based Questions

1. The main postulates of kinetic theory of gases are as follows:

i. Gases are made up of minute particles called molecules, atoms or ions.

ii. The actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas.

iii. The particles of a gas are in rapid motion in straight lines until they collide with each other or with the walls of the container. The pressure exerted by gases are the result of these collisions.

iv. The particles of a gas are perfectly elastic. No energy is lost when the particles collide.

v. The average kinetic energy of the particles increases in direct proportion to the absolute temperature of the gas.

vi. Intermolecular force of attraction between particles of a gas is negligible.

2. The kinetic theory of gas justifies the properties of gases in the following ways:

i. Gases have no definite shape or volume.

According to kinetic theory of gases, molecules in a gas are far apart and in random motion. This random motion causes the gas to expand and fill the closed container.

ii. Gases exert pressure in all directions.

According to kinetic theory of gases, the particles of a gas are in rapid motion in straight lines until they collide with each other or with the walls of the container. The pressure exerted by gases are the results off these collisions.

iii. Gases are highly compressible.

According to kinetic theory of gases, the actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas.

iv. Gases are indefinitely extensible.

According to kinetic theory of gases, the intermolecular force of attraction between particles of a gas is negligible.

v. Gases diffuse with other gases easily.

According to kinetic theory of gases, the intermolecular spaces are very large.

3. Explanation of Boyle's law by kinetic theory of gases: According to the kinetic theory of gases, the pressure exerted by a gas results from the combined bombardment of its molecules on the walls of the container. The number of bombardments depend on the concentration of molecules at a certain temperature. As the volume of the gas is reduced, the concentration of the gas molecules is increased and hence, the pressure increases. Thus, at constant temperature the pressure of the gas is inversely proportional to the volume of a gas.

Explanation of Charles' law by kinetic theory of gases: On heating the gas, the kinetic energy of molecules increases. This means the molecules will move faster. Hence, the gas will expand, provided pressure remains constant.

4. According to Boyle's Law

$$V \propto \frac{1}{P};\ T \text{ constant}$$

According to Charles' Law

$$V \propto T;\ P \text{ constant}$$

Combining both laws

$$V \propto \frac{T}{P}$$

$$V = \frac{kT}{P} \qquad [k \text{ is gas constant}]$$

or $$\frac{PV}{T} = k = \text{gas constant}$$

If the volume of a fixed mass of the gas changes from V_1 to V_2, its pressure from P_1 to P_2 and temperature from T_1 to T_2, then,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

This mathematical relation is called Gas Equation.

5. a. ii.

b. i.

c. ii.

d. iv.

e. iv.

VI. Application and Reasoning-based Questions

1. The kinetic theory enables us to visualise and understand the behaviour of gases. According to this theory, gases have the following properties:

a. Gases have no definite shape or volume: Molecules in a gas are far apart and in random motion. This random motion causes the gas to expand and fill the closed container.

b. Gases are highly compressible: Gases are highly compressible because there are large intermolecular spaces between the gaseous molecules.

c. Gases are indefinitely expansible: The intermolecular force of attraction between particles of a gas is negligible.

d. Gases have low density: The actual volume occupied by the gas particles is only a small fraction of the entire space occupied by the gas.

Overall, the kinetic theory of gases helps to explain the behaviour of gases and their unique properties, including their lack of definite shape or volume, high compressibility, indefinite expansibility and low density.

2. The pressure in the water at the bottom of the vessel is higher than the pressure at the top of the vessel because of the weight of the water above it. As the bubbles rise to the top, they move to a region with lower pressure. According to Boyle's law, the volume of a given

mass of a gas is inversely proportional to the pressure applied to it at constant temperature. This means that as the pressure on the bubble decreases, the volume of the bubble increases. Therefore, as the bubbles rise to the top, the pressure decreases and the volume of the bubble increases, resulting in bigger bubbles.

3. At high altitudes where pressure of air is less, the density of oxygen becomes less. As a result, breathing at high altitude becomes difficult. This can cause symptoms such as shortness of breath, dizziness, fatigue and headaches. By carrying a cylinder of oxygen, mountaineers can supplement the amount of oxygen they are breathing in and prevent these symptoms. That is one of the reasons mountaineers carry oxygen cylinders with them for breathing at high altitudes.

4. When stating the volume of a gas, the pressure and temperature should also be given because on changing pressure and temperature conditions, volume of a gas will change. Hence, a fixed amount of a gas can attain a wide range of volume depending on the temperature and pressure conditions.

5. At higher temperature, the average kinetic energy of the air molecules inside the tyre increases, that is, molecules start moving faster. Hence, the pressure on the walls of the tube increases. If its pressure inside is not kept low at the time of inflation, at the higher temperature, the pressure may become so high that the tyre may burst.

6. Charles' law establishes a relationship between the temperature of a gas and its volume, at constant pressure. Since volume is directly proportional to the temperature of a gas, density is inversely proportional to temperature. In other words, density decreases when temperature increases and vice-versa.

P. 129. QUESTIONS BASED ON PREVIOUS ICSE EXAMINATIONS

1. No, because according to Charles' law if temperature changes, volume changes and by Boyle's Law if pressure changes, volume also changes.

2. Initial conditions — Final conditions

$P_1 = P$ atm — $P_2 = 2P$ atm

$V_1 = 22.4$ L — $V_2 = ?$

$T_1 = 273$ K — $T_2 = 546$ K

According to Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or $$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{P \times 22.4 \times 546}{273 \times 2P}$$

$$= 22.4 \text{ L}$$

The volume remains 22.4 L.

3. $P_1 = 760$ mm of Hg $\quad P_2 = 1140$ mm of Hg

$T_1 = 0\,°C = 273$ K $\quad T_2 = 273 + 54.6 = 327.6$ K

$V_1 = 100$ cm^3 $\quad V_2 = ?$

$$\text{Final pressure} = 760 \times 1\frac{1}{2}$$

$$760 \times \frac{3}{2} = 1140 \text{ mm}$$

Increase in final temperature

$$= 273 \times \frac{1}{5} = 54.6 \text{ K}$$

$$\text{By Gas Equation} = \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$$

$$= \frac{760 \times 100 \times 327.6}{273 \times 1140}$$

$$= 80 \text{ cm}^3$$

$\therefore$ The final volume is 80 cm^3.

4. Initial conditions — Final conditions

$P_1 = 70$ cm — $P_2 = 76$ cm

$T_1 = 273 + 27 = 300$ K — $T_2 = 273$ K

$V_1 = 760$ cm^3 — $V_2 = ?$

By Gas Equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$\therefore$ $$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{70 \times 760 \times 273}{300 \times 76}$$

$$= 637 \text{ cm}^3$$

Final volume is 637 cm^3.

5. Kelvin zero, also known as absolute zero, is equal to –273 °C.

CHAPTER – 8

ATMOSPHERIC POLLUTION

P. 132–133 CHECK YOUR PROGRESS 1

1. **c.**
2. **b.**
3. **b.**
4. **c.**
5. **a.** hydrocarbons
   b. Suspended Particulate Matter
   c. smog
   d. Chlorofluorocarbons or CFCs
6. **b.**
7. **b.**
8. **Man-made pollutants:** chemical industries and ore refining
   Natural pollutants: volcanic eruption and forest fire

P. 136 CHECK YOUR PROGRESS 2

1. **a.**
2. **b.**
3. **d.**
4. **c.**
5. **d.**
6. **b.**
7. **a.** $2SO_3$
   b. SO_3
   c. 2NO
   d. $2NO_2$
8. **b.**
9. **a.** HFCs or Hydrofluorocarbons
   b. Carbon dioxide
   c. Methane or CH_4
   d. Nitrogen or N
10. **a.** H_2O (**Explanation:** The gases that cause acid rain are SO_2, NO_2 and CO_2. So, the odd one out is H_2O.)

P. 138–139 CHECK YOUR PROGRESS 3

1. **b.**
2. **d.**
3. **b.**
4. **c.**
5. **c.**
6. **a.** tropical
   b. ozone
   c. UV
   d. chlorine
7. **a.** Ozone
   b. CFCs or Chlorofluorocarbons
8. **d.**

P. 140–142 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

B. Fill in the blanks.

1. Chlorofluorocarbon
2. air pollution
3. acid rain
4. 78

II. Very Short Answer Type Questions

A. Answer the following questions.

1. When rain water contains very high amounts of nitric and sulphuric acids, it is called acid rain.
2. The greenhouse gases in the earth's atmosphere allow short wave radiations from the Sun to easily reach the earth's atmosphere. But these greenhouse gases do not allow long wave infrared radiations radiating from earth's surface to escape from the earth's atmosphere. This way, these gases in the atmosphere trap the heat radiated from earth. This process is termed as the greenhouse effect.
3. The major greenhouse gases are carbon dioxide, methane, oxides of nitrogen, water vapour and chlorofluorocarbons.
4. The sources of carbon dioxide emission are exhaust from vehicles, combustion or burning and deforestation.
5. The main source of nitrous oxide emission is automobile exhaust. Disposal of human and animal waste in sewage treatment plants is another source of nitrous oxide emission.

B. Match the following.

1. d. **2. d.**

C. State in each of the following whether the effect of greenhouse gas described is advantageous or harmful.

1. a. **2. a.** **3. b.**

III. Short Answer Type Questions

A. Answer the following questions.

1. Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. The two main sources of air pollution are combustion of fossil fuels at homes and transportation.

2. The air pollutants released by vehicles are carbon monoxide, carbon dioxide, nitrogen oxides and hydrocarbons.

3. The ozone layer is a region in the earth's stratosphere, at altitudes between 18 km and 40 km from earth's surface. It contains high concentrations of ozone and protects the earth from the harmful ultraviolet radiations of the sun. The depletion of ozone in a region of the ozone layer, particularly over Antarctica is called ozone hole.

4. The sources of chlorofluorocarbons are aerosol spray, air conditioning and refrigerating units, and cleansing agents for electronic equipment.

5. Some of the steps that should be taken to control acid rain are as follows:

i. Minimize the use of fossil fuels.

ii. Use non-conventional sources of energy like solar energy, wind energy, biogas, etc.

iii. More efficient and environment friendly engines should be used in vehicles to reduce pollution.

iv. Use of catalytic converters in automobile exhaust to convert harmful pollutants to less harmful ones.

v. Use of scrubbers and electrostatic precipitators in the chimneys of industries.

vi. Use coal with less sulphur in coal-based power plants.

vii. Use limestone powder to reduce soil acidity.

B. Complete the following reactions with balancing the equation wherever necessary.

1. 2O

2. O_2 and O

3. Cl and CF_2Cl

4. ClO and O_2

IV. Knowledge-based Questions

1. The harmful effects of acid rain are as follows:

i. Surface water in lakes and rivers becomes too acidic. This is harmful for aquatic life.

ii. Acid rain releases aluminium from soil, which eventually flows into water bodies and harms aquatic life.

iii. Acid rain causes damage to trees, forests and forest soil.

iv. Acid rain erodes metals, marble, limestone, monuments and buildings.

2. The ozone layer is being destroyed due to the presence of certain chemicals/compounds like chlorofluorocarbons in the atmosphere. The powerful ultraviolet radiations break them into free chlorine which reacts with ozone to form oxygen molecule. The free chlorine is thus continuously being formed and this causes the breakdown of ozone molecules.

3. Hydrofluorocarbons (HFCs) affect ozone 90% less than chlorofluorocarbons (CFCs). They do not harm or break down the ozone molecule. Due to this, the use of CFCs is being decreased, and it is being replaced by HFCs.

4. The primary cause of global warming is the increase in carbon dioxide level in the atmosphere. When there is the right amount of carbon dioxide in the air, it maintains the planet's temperature by trapping the infrared radiations coming from the earth. But when the concentration of carbon dioxide is high, the result is the rise of the temperature of the planet above normal.

5. Sulphur dioxide damages vegetation, causes respiratory problems in humans and irritation of eyes, and contaminates water with sulphuric acid.

6. Nitrogen oxides cause smog as well as greenhouse effect. Further, nitrogen oxides like NO_2 spoil the leaves of plants and decrease the rate of photosynthesis. It also causes respiratory problems and lung infection in humans.

7. Asbestos, lead and mercury.

8. The harmful effects of suspended particulate matter (SPM) are the following:

i. SPM can enter our respiratory system and damage the lungs.

ii. They cause asthma and bronchitis, heart disease and affect the respiratory system of animals.

iii. These particles corrode metals, monuments and buildings.

9. The chemical equations involved in acid rain formation are:

i. $2SO_2 + O_2 \rightarrow 2SO_3$

Sulphur trioxide

$$SO_3 + H_2O \rightarrow \underset{\text{Sulphuric acid}}{H_2SO_4}$$

ii. $$2NO_2 + H_2O \rightarrow \underset{\text{Nitric acid}}{HNO_3} + \underset{\text{Nitrous acid}}{HNO_2}$$

iii. $$\underset{\text{(Rain water)}}{CO_2} + H_2O \rightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

10. Vehicular traffic is one of the major cause of air pollution. It causes release of carbon monoxide, carbon dioxide, nitrogen oxides and hydrocarbons into the atmosphere.

Industries cause release of sulphur oxides, fluorides, organic vapours and dust into the atmosphere.

V. Application and Reasoning-based Questions

1. The ozone layer prevents harmful ultraviolet radiations from the sun from reaching earth's surface and thus saves damage to the cells of plants and animals on earth. Therefore, ozone layer is important to life on earth.

The three harmful effects due to ozone layer depletion are:

i. Ozone layer depletion increases the risk of developing skin cancer as direct exposure to ultraviolet radiation increases.

ii. This also increases the risk of cataract.

iii. Breathing problems also increases due to ozone layer depletion.

2. By phasing out chlorofluorocarbons (CFCs) and using hydrofluorocarbons (HFCs).

3. Methane is released in the atmosphere due to activities such as raising livestock, coal mining, drilling for oil and natural gas, rice cultivation, and filling of landfills with garbage.

4. a. Global warming can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yield of crops. Higher temperatures also interfere with the ability of plants to get and use moisture. Evaporation of water from the soil increases when temperatures rise and plants also increase transpiration—that is, lose more moisture from their leaves.

b. Global warming is already causing melting of the polar ice caps, which is leading to a rise in the sea levels. Some low-lying areas will be submerged. When polar ice caps melt, the water thus formed will go into the oceans and decrease the salinity and disturb currents in the ocean.

c. Global warming will lead to a rise in the sea level. Some low-lying coastal areas will be submerged.

d. The effect of global warming is to increase the average temperature of the earth. It would lead to extreme change in climate. It would make hotter days more hotter, rainfall and flooding heavier, hurricanes stronger and droughts more severe.

e. Global warming will lead to disappearance of different terrestrial and marine flora and fauna.

f. Global warming leads to economic problems. More money will be spent during times like hurricanes and during break out of diseases. It will also cause shortage of food, leading to severe economic crisis.

5. A greenhouse gas is a gas that traps heat in the earth's atmosphere. Hence, water vapour is also considered a greenhouse gas, because if there is cloud cover, heat is trapped by the water vapour and the earth's temperature stay warm. Water molecules capture the heat that earth radiates, and then re-radiate it in all directions, thus warming the earth's surface.

6. Some of the measures that should be taken to reduce and prevent global warming are as follows:

i. Use of fossil fuels to meet our energy demand should be curbed.

ii. To meet our energy demands, we should develop energy production from renewable sources of energy.

iii. Prevent deforestation.

7. The two ways by which industries can prevent pollution of air by SPMs are as follows:

i. Use of filters to remove particulate material from gas stream.

ii. Electrostatic precipitators are used to collect particles from the air. It can work in very high temperatures as in boilers in thermal power plants, steel plants and cement factories.

CHAPTER – 9

PRACTICAL WORK

P. 148 CHECK YOUR PROGRESS 1

1. **d.**

2. **a.**

3. **c.**

4. **c.**

5. **d.**

6. **a.**

7. **b.**

8. **a.** Lime water test – CO_2 turns milky; hydrogen no reaction.

$$Ca(OH)_2 + CO_2 \rightarrow \underset{\text{(White ppt.)}}{\underset{\text{Lime water}}{CaCO_3\downarrow}} + H_2O$$

b. Alkaline pyrogallol reaction – H_2 no reaction; O_2 turns the pyrogallol solution brown.

c. Acidified $KMnO_4$ test – No reaction with CO_2; decolourised by SO_2.

$$\underset{\text{(Pink)}}{2KMnO_4} + 2H_2O + 5SO_2 \rightarrow \underset{\text{(Colourless)}}{K_2SO_4 + 2MnSO_4} + 2H_2SO_4$$

d. Silver nitrate test – White ppt of AgCl with HCl but black ppt of Ag_2S with H_2S.

9. **a.** NO_2

b. Cl_2

c. SO_2

d. NH_3

10. **a.** 2HgO

b. $2PbO_2$

c. $ZnCO_3$

d. 2CuO, $4NO_2$, O_2

P. 151–152 CHECK YOUR PROGRESS 2

1. **b.**

2. **b.**

3. **b.**

4. **a.**

5. **d.**

6. **b.**

7. **a.** 200; 500

b. 300

c. Winkler titration

d. Biochemical Oxygen Demand

8. Al [Reason: Others are heavy metals found in water, mostly as contaminant due to their excess amount than threshold limit.]

9. Dissolved oxygen or DO

10. Pollutants in water include pathogens which cause diseases like typhoid and cholera.

P. 152–154 EXERCISES

I. Objective Type Questions

A. Choose the correct option.

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

6. **c.** **7.** **a.**

II. Very Short Answer Type Questions

A. Match the following.

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

B. Name the following.

1. $CuSO_4 \cdot 5H_2O$ **2.** $Na_2CO_3 \cdot 10H_2O$

3. I_2 **4.** $(NH_4)_2Cr_2O_7$

C. Name the following gases.

1. Oxygen **2.** Hydrogen sulphide

3. Carbon dioxide **4.** Nitrogen dioxide

III. Short Answer Type Questions

A. What happens when (write chemical equations):

1. Turns acidified $KMnO_4$ solution from pink to colourless.

$$\underset{\text{(Pink)}}{2KMnO_4} + 2H_2O + 5SO_2 \rightarrow \underset{\text{(Colourless)}}{K_2SO_4 + 2MnSO_4} + 2H_2SO_4$$

2. Turns lead acetate paper silvery-black (due to the formation of lead sulphide, PbS).

$$(CH_3COO)_2Pb + H_2S \rightarrow \underset{\text{(Black)}}{PbS\downarrow} + 2CH_3COOH$$

3. Gives dense white fumes with rod dipped in concentrated hydrochloric acid (due to the formation of NH_4Cl).

$$NH_3 + HCl \rightarrow \underset{\text{(Dense white fumes)}}{NH_4Cl}$$

4. A colourless, odourless gas is liberated which extinguishes a glowing splint. The gas turns lime water milky but has no effect on acidified potassium dichromate paper. This suggests that the liberated gas is carbon dioxide.

$$CuCO_3 \xrightarrow{\Delta} CuO + CO_2$$

5. On strong heating to 200 °C, blue crystalline copper sulphate loses its molecules of water of crystallisation and forms a white amorphous powder.

$$CuSO_4 \cdot 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$$

6. On strong heating, washing soda loses its water of crystallisation and forms a white amorphous powder.

$$Na_2CO_3 \cdot 10H_2O \xrightarrow{\Delta} Na_2CO_3 + 10H_2O$$

(White residue)

B. What will you observe when the following compounds are heated strongly in a dry test tube?

1. Mercuric oxide turns from orange red amorphous powder to deep red and then black.
2. Copper nitrate turns from deep blue to pale green and then gives a black residue.
3. On strong heating, greyish-brown crystals of iodine sublimes to form violet vapours.
4. Ammonium chloride is in the form of white crystals which sublime and collect as a white solid at the cooler part of the test tube.
5. Hydrated copper sulphate turns from blue to white and then black.

C. Answer the following questions.

1. **a.** Hydrogen:
   - **i.** It is colourless, odourless and neutral gas.
   - **ii.** It bums with a pop sound.

   b. Hydrogen chloride:
   - **i.** It is a colourless gas with irritating odour.
   - **ii.** It forms a curdy white precipitate when passed through $AgNO_3$ solution. The precipitate dissolves in NH_4OH solution.

   c. Ammonia:
   - **i.** It is a colourless, pungent smelling and basic gas.
   - **ii.** Gives dense white fumes with rod dipped in concentrated hydrochloric acid.

   d. Sulphur dioxide:
   - **i.** It is a colourless gas which smells of burnt sulphur, a suffocating odour.
   - **ii.** It turns acidified $KMnO_4$ solution from pink to colourless.
2. Bicarbonates, sulphates and chlorides of calcium and magnesium.
3. Washing soda removes hardness of both types.
4. Detergents are preferred to soaps because they do not form scum with hard water.

IV. Knowledge-based Questions

1. Hard water can be converted to soft water on a large scale by the use of permutit. In this method, hard water is allowed to pass through permutit. Exchange of radicals (Ca^{++} and Mg^{++}) between hard water and permutit (Na^+) takes place and thus water gets purified.
2. The paper will not show any change because both gases recombine at the cooler part of the test tube to form ammonium chloride.

V. Application and Reasoning-based Questions

1. Chlorine gas turns moist blue litmus to red and finally bleaches it. Sulphur dioxide turns moist red litmus to blue.
2. On heating strongly
   - **i.** Red lead leaves pale yellow residue of lead monoxide.
   - **ii.** Red mercuric oxide leaves behind black powder.
   - **iii.** Ammonium dichromate leaves behind dark green flakes of chromium(III) oxide.

3.

a.	Upon heating both evolve dense brown NO_2 and O_2 gases	**Zinc nitrate** It leaves behind zinc oxide which is yellow when hot and white when cold.	**Lead nitrate** It decrepitates on heating and leaves behind pale yellow lead monoxide which fuses with the gas.
b.	Upon heating	**Ammonium chloride** It sublimes at the cooler part of the test tube.	**Sodium chloride** It simply decrepitates but undergoes no change.
c.	On bringing moist red litmus paper	**Ammonia** It turns to blue.	**Hydrogen chloride gas** It has no effect.
d.	On adding acidified $KMnO_4$ solution	**Sulphur dioxide** It turns acidified $KMnO_4$ solution from purple to colourless.	**Carbon dioxide gas** It has no effect on acidified $KMnO_4$ solution.
e.	With solution of ammonia	**Hydrogen chloride** It gives dense white fumes when a rod dipped in ammonia solution is brought near it.	**Hydrogen sulphide** It gives no such fumes, when a rod dipped in ammonia solution is brought near it.

4. Copper is present below hydrogen in the Activity series therefore cannot displace hydrogen from dilute hydrochloric acid but zinc can do so as it is above hydrogen in the Activity series.

5. Washing soda precipitates calcium and magnesium salts as respective carbonates and thus softens water.

$$MgCl_2 + Na_2CO_3 \rightarrow MgCO_3\downarrow + 2NaCl$$

$$MgSO_4 + Na_2CO_3 \rightarrow MgCO_3\downarrow + Na_2SO_4$$