# ICSE Living Science

# CHEMISTRY

## Book 9

# TEACHER'S HANDBOOK

Ratna Sagar P. Ltd.

## CHAPTER – 1

## THE LANGUAGE OF CHEMISTRY

### P. 12 CHECK YOUR PROGRESS

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. 14 CHECK YOUR PROGRESS

1. Ferrous sulphate or Iron(II) sulphate
2. Mercuric oxide
3. Copper(II) chloride
4. Potassium permanganate
5. Lead(II) nitrate
6. Silver nitrate
7. Zinc sulphite
8. Barium chloride
9. Calcium fluoride
10. Manganese sulphate

### P. 16 CHECK YOUR PROGRESS

1. $2Pb_3O_4 \rightarrow 6PbO + O_2$
2. $2Zn\ (NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2$
3. $2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$
4. $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$
5. $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

### P. 19 CHECK YOUR PROGRESS

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 ($NH_2CONH_2$)

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

   $= 60\,u$

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

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

   $= 342\,u$

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 ($H_2O_2$)

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

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

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

$= 94.11\%$

### P. 20 EXERCISES

**A. 1.** The symbols of elements were usually derived from the first letter of the name of the element either the Latin name or Greek name or the modern name. If first letters of the two elements were same, the symbols of those elements were derived from the first two letters of their English names.

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

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

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

**4.** 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.

**5.**

| Column A | Column B |
|---|---|
| Potassium | K |
| Phosphorus | P |
| Copper | Cu |
| Cobalt | Co |
| Sulphur | S |
| Sodium | Na |
| Mercury | Hg |
| Manganese | Mn |
| Tin | Sn |
| Titanium | Ti |

**6.** An atom or group of atoms of the same or different elements which carries charge and behaves as a single unit is called a redical. 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 ($PH_4^+$).

**7.** The main characteristics of chemical equation are:

- **i.** It tells us the names of the reactants that take part in the reaction.
- **ii.** It tells us the names of the products that are formed in the reaction.
- **iii.** It tells us the physical state of the reactants and products.
- **iv.** It tells us the number of molecules of the reactants and products.

**8.** The limitations of a chemical equation are as follows:

- **i.** No information is given in an equation about the conditions which bring about the chemical change.
- **ii.** It does not give any information about the accompaniments of the chemical changes such as colour change, evolution or absorption of heat, etc.
- **iii.** It does not tell whether the reaction is complete or not.
- **iv.** It does not tell about the rate of the reaction, i.e. it does not tell about the time taken by the reaction for its completion.

**9.** If in a chemical equation, the number of atoms of each element in the reactants is equal to the number of atoms of each element in the products, the chemical equation is said to a balanced chemical equation.

**10.** Balancing of equation is based on the law of conservation of mass.

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

The mass equal to 1/12th of the mass of a $^{12}C$ atom is called one *atomic mass unit*.

**12.** 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 1/12th the mass of one $^{12}C$ atom is called *relative molecular mass of a compound*.

**13.** This statement means that an atom of bromine on average is 80/12 times heavier than one atom of $^{12}C$.

**B. 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

**6.** Balance the equations.

**a.** $2Na + 2H_2O \rightarrow 2NaOH + H_2$

**b.** $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

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

**d.** $2Ca(NO_3)_2 \xrightarrow{\Delta} 2CaO + 4NO_2 + O_2$

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

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

**g.** $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$

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

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

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

**7. a.** Molecular mass of white vitriol ($ZnSO_4 \cdot 7H_2O$)

$= 65\text{ u} + 32\text{ u} + 4 \times 16\text{ u} + 7(2 \times 1 + 16)\text{ u}$

$= 287\text{ u}$

Percentage of water of crystallisation

$$= \frac{7 \times (2 \times 1 + 16)\text{ u}}{287\text{ u}} \times 100$$

$$= \frac{126\text{ u}}{287\text{ u}} \times 100 = 43.9\%$$

**b.** Molecular mass of Glauber's salt ($Na_2SO_4 \cdot 10H_2O$)

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

$= 322\text{ u}$

Percentage of water of crystallisation

$$= \frac{10(2 \times 1\text{ u} + 16\text{ u})}{322\text{ u}} \times 100$$

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

$= 55.9\%$

**c.** Molecular mass of blue vitriol [$CuSO_4 \cdot 5H_2O$]

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

$= 249\text{ u}$

Percentage water of crystallisation

$$= \frac{5(2 \times 1\text{ u} + 16\text{ u})}{249\text{ u}} \times 100$$

$$= \frac{90\text{ u}}{249\text{ u}} \times 100 = 36.1\%$$

**8. a.** Molecular mass of $H_2O$

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

$= 18\text{ u}$

**b.** Molecular mass of $CO_2$

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

$= 44\text{ u}$

**c.** Molecular mass of $CH_4$

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

$= 16\text{ u}$

**9.** Molecular mass of sodium sulphate ($Na_2SO_4$)

$= 2 \times 23\text{ u} + 32\text{ u} + 4 \times 16\text{ u}$

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

$= 142\text{ u}$

Mass percentage of sodium (Na) in sodium sulphate ($Na_2SO_4$)

$$= \frac{46\text{ u}}{142\text{ u}} \times 100$$

$= 32.4\%$

Mass percentage of sulphur(S) in sodium sulphate

$$= \frac{32\text{ u}}{142\text{ u}} \times 100$$

$= 22.6\%$

Mass percentage of oxygen (O) in sodium sulphate

$$= \frac{64\text{ u}}{142\text{ u}} \times 100$$

$= 45\%$

Therefore, sodium sulphate contains 32% sodium, 22.6% sulphur and 45% oxygen.

**C. 1.** Elements sometimes have variable valency so that they can stabilise themselves by having either half or fully-filled orbitals.

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

### P. 21 QUESTIONS FROM PREVIOUS ICSE EXAMINATIONS

**1. a.** NO +2

**b.** $N_2O$ +1

**c.** $NO_2$ +4

**2. a.** $X_2(SO_4)_3$

**b.** $X(OH)_3$

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

**4.** $XSO_4$ and $X(OH)_2$

**CHAPTER – 2**

**CHEMICAL CHANGES AND REACTIONS**

### P. 27 CHECK YOUR PROGRESS

1. Decomposition reaction
2. Double decomposition reaction (precipitation reaction)
3. Direct combination reaction
4. Decomposition reaction
5. Displacement reaction
6. Double decomposition (neutralisation) reaction.

### P. 28 EXERCISES

**A. 1. a.** Activity series

**b.** exothermic

**c.** released

**d.** double decomposition

**e.** neutralisation

**2.** A permanent change in which the original substance gives rise to one or more new substances with different properties, is called a *chemical change*.

**3.** In displacement reaction, a more reactive element displaces a less reactive element from its compound. For example, zinc displaces hydrogen from sulphuric acid

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

**4.** The arrangement of the metals in decreasing order of their chemical reactivity is called Metal activity series.

| | | |
|---|---|---|
| Reactivity decreases | K | Potassium → Most reactive |
| | Na | Sodium |
| | Ca | Calcium |
| | Mg | Magnesium |
| | Al | Aluminium |
| | Zn | Zinc |
| | Fe | Iron |
| | Pb | Lead |
| | [H] | Hydrogen |
| | Cu | Copper |
| | Hg | Mercury |
| | Ag | Silver |
| | Au | Gold → Least reactive |

**5.** Aluminium is more reactive.

**6.** Displacement reaction

**7. a.** Direct combination reaction

**b.** Decomposition reaction

**c.** Displacement reaction

**d.** Double decomposition (precipitation reaction)

**e.** Double decomposition (precipitation reaction)

**f.** Direct combination

**8.** Silver chloride when exposed to sunlight, it undergoes decomposition to form grey silver metal and evolves chlorine gas.

$$\underset{\text{White}}{2AgCl(s)} \xrightarrow{\text{Sunlight}} \underset{\text{Grey}}{2Ag(s)} + Cl_2(g)$$

This chemical reaction is photochemical decomposition reaction.

**9. a.** In decomposition reaction, a compound breaks down to form two or more simple substances.

For example:

$$2Pb_3O_4(s) \xrightarrow{\Delta} 6PbO(s) + O_2(g)$$

whereas in double decomposition reaction, there is mutual exchange of atoms or group of atoms between the solution of two compounds.

For example:

$$BaCl_2(aq) + H_2SO_4(aq) \longrightarrow \underset{\text{White curdy precipitate}}{BaSO_4(s)\downarrow} + 2HCl(aq)$$

**b.** In photochemical reaction, the compound is decomposed by the light.

For example:

$$2AgCl(s) \xrightarrow{\text{Sunlight}} 2Ag(s) + Cl_2(g)$$

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

For example:

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

**c.** In Exothermic reactions, heat is given out.

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

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

whereas in endothermic reaction, heat is absorbed by the reactants.

For example: Decomposition of calcium carbonate

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

**10. a.** In reaction,

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

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

**b.** In reaction, $MgCO_3 \longrightarrow MgO + CO_2$

Magnesium carbonate, a single reactant decomposes to give two products, i.e. magnesium oxide and corban dioxide. Therefore, this reaction is called a *decomposition reaction*.

**c.** The given reaction is a displacement reaction.

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$$

In this reaction, aluminium being more reactive then iron, displaces iron from ferric oxide and forms aluminium oxide.

**11.** 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.

**12.** 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.

**13.** 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 there involves change in the internal energy ($\Delta$**E**) of the reaction which is denoted by

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

- 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 sytem 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, $\Delta$**H**, is equal to $\Delta \mathbf{H} = \mathbf{H_p} - \mathbf{H_r}$

**14. Exothermic reactions**

- In these reactions, energy is liberated into the surroundings by the reactants.
- In these reactions, enthalpy of reactants is greater than enthalpy of products, hence, change in enthalpy is negative.

**Endothermic reactions**

- In these reactions, energy is supplied to the reactants from the surroundings.
- In these reactions, enthalpy of products is greater than enthalpy of reactants, hence, change in enthalpy is positive.

**15.** Coal on burning releases large amount of heat and light, hence, it is used as fuel.

**B. 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, than 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.** Iron can displace copper from copper sulphate because iron lies above in the activity series from copper and, thus, more reactive than copper and hence, displaces copper from copper sulphate.

But iron cannot displace zinc from zinc sulphate because iron lies below from zinc in the activity series and, thus, less reactive than zinc.

**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.

This is because reaction stops after sometime due to the formation of insoluble crust of lead sulphate which stops further reaction.

**C. 1.** Take two clean copper wires, one zinc wire and two clean iron nails with five test tubes, and label these tubes as 'A', 'B', 'C', 'D' and 'E'. Now take 'A' and add a solution of iron (II) sulphate in it and, put the copper wire in this solution and observe it after twenty minutes. Now take test tube 'B' and add a solution of zinc sulphate and put another copper wire in this solution and note the observation after twenty minutes. Similarly, take the test tube 'C' and add a solution of copper(II) sulphate in it with a clean iron nail and note the observation after twenty minutes. Now take test tube 'D' and add a solution of zinc sulphate and put an iron nail to it for twenty minutes and record the observation. At last, take test tube E and add a solution of iron (II) sulphate and put zinc wire in it for twenty minutes, than record the observation.

**Observations**

**i.** In test tube A : No change takes place.

**ii.** In test tube B : No change takes place.

**iii.** In test tube C : The iron nail gets coated with a layer of red copper metal.

**iv.** In test tube D : No change takes place.

**v.** In test tube E : The zinc wire coated with a green coloured layer of iron metal.

**Conclusion:** Zinc is more reactive than iron and iron is more reactive than copper as iron displaces copper from copper (II) sulphate solution (in test tube C) and zinc displaces iron from iron (II) sulphate solution. Thus, the order of their reactivity is zinc > iron > copper.

**Chemical reactions:**

$Cu(s) + FeSO_4(aq) \longrightarrow$ No reaction

$Cu(s) + ZnSO_4(aq) \longrightarrow$ No reaction

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

$Fe(s) + ZnSO_4(aq) \longrightarrow$ No reaction

$Zn(s) + FeSO_4(aq) \longrightarrow ZnSO_4(aq) + Fe(s)$

## CHAPTER – 3

## WATER

### P. 33 CHECK YOUR PROGRESS

**1.** Mass of sodium chloride (solute) = 20 g

Volume of the solution = 250 mL

Mass by volume percentage

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

$$= \frac{20}{250} \times 100$$

= 8%

**2.** Volume of ethanol (solute) = 8.5 mL

Volume of water (solvent) = 80 mL

Volume of solution = Volume of solute + Volume of solvent
= 8.5 mL + 80 mL
= 88.5 mL

Volume percentage of the solution

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

$$= \frac{8.5\text{ mL}}{88.5\text{ mL}} \times 100$$

= 9.6%

**3.** Mass of urea (solute) = 20 g

Mass of the solution = 125 g

Mass percentage of the solution

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

$$= \frac{20\text{g}}{125\text{g}} \times 100$$

= 16%

**4.** 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

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%

### P. 36 CHECK YOUR PROGRESS

**1.** True

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

### P. 37 CHECK YOUR PROGRESS

**1.** Two advantages of soft water are:

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

**ii.** Clothes get cleaned easily.

**2.** 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.

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

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

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

$$CaSO_4 + Na_2CO_3 \longrightarrow MgSO_4\downarrow + Na_2SO_4$$

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

**4.** Temporary hardness of water is due to the presence of soluble hydrogen carbonates of calcium and magnesium.

### P. 39 EXERCISES

**A. 1. a.** unsaturated solution

**b.** solvent

**c.** polar, non-polar

**d.** drying or dessicating

**e.** Temporary

**f.** efflorescence

**2. a.** 34%

**b.** efflorescent substance

c. Volume of solute, ethyl alcohol = 40 mL

Volume of solvent, pertrol = 60 mL

Total volume of solution = 60 + 40 = 100 mL

Volume percentage of the solution

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

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

d. $ZnSO_4 \cdot 7H_2O$, i.e. hydrated zinc sulphate is called white vitriol.

3. a. **Solution:** A homogeneous mixture of two or more substances.

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

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

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

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

f. **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.

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

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

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

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

b. The solute cannot be removed by filtration.

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

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

5. Temperature and the nature of the solute and the solvent.

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

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

**Characteristics of solubility curve**

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

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

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

8. **Uses of solubility curve:**

i. It helps to compare the solubilities of different solutes at a given temperature.

ii. The knowledge of the solubility curves of different substances aids in fractional distillation.

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

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

9. 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.

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

**Hydrated salts:**

$FeSO_4 \cdot 7H_2O$, $NO_2SO_4 \cdot 10H_2O$, $CuSO_4 \cdot 5H_2O$, $MgSO_4 \cdot 7H_2O$

**Anhydrous salts:**

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

11. 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, phosphorus pentoxide.

12. Hygroscopic salts when exposed to the atmosphere absorb moisture from the atmosphere without dissolving in it like calcium oxide. Whereas, the deliquescent substances when exposed to the atmosphere absorb sufficient moisture from air to completely dissolve in it to form a saturated solution like caustic soda (NaOH), caustic potash (KOH).

**13. a.**

| Hard water | Soft water |
|---|---|
| This type of water do not produces 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. |

**b.**

| Temporary hardness | Permanent hardness |
|---|---|
| It is due to the presence of soluble hydrogen carbonates 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 sulphates into insoluble carbonates. |

**14. a.** Soft water does not contain any soluble salts and hence, gives lather with soap readily. On the other hand, hard water contains soluble hydrogen carbonates, chlorides and sulphates of calcium and magnesium. Therefore, when soap dissolves in hard water, these salts precipitates and hence, hard water does not form lather with soap readily.

**b.** Temporary harness of water is due to the presence of soluble hydrogen carbonates of calcium and magnesium which can be easily removed by simply boiling the hard water.

**c.** 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.

**B. 1.** The boiling point of water increases with increase in pressure. This principle is used in cooking food in pressure cookers where pressure is increased by production of steam and food cooks quickly.

**2.** Water is known as universal solvent because it dissolves most of the known substances which is due to its polar nature and its high dielectric constant value.

**3.** The percentage of oxygen in boiled off water is more than that in air because oxygen is more soluble in water than any other gas like nitrogen.

**4.** 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

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

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

**5.** 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

**6.** 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

Volume percentage of the solution

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

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

**7.** 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

≈ 3.35%

**8.** Mass of sugar = 30 g

Mass of solution = 200 g

$\therefore$ Mass percentage of solution

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

**9.** 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 solute dissolves rapidly. Hence, solubility of the solute increases.

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

**11.** 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 on the other hand, anhydrous copper sulphate is colourless and amorphous.

**12.** **a.** Potassium nitrate

**b.** Potassium nitrate

**c.** 32.5 °C

**13.** If anhydrous copper sulphate on addition to a liquid turns the liquid into blue colour, this indicates the presence of moisture in the liquid. This is because anhydrous copper sulphate absorbs moisture from the liquid and turns back into the pentahydrate from regaining the blue colour.

**14.**

| | **Name** | **Formula** |
|---|---|---|
| **a.** | Gypsum (calcium sulphate dihydrate) | $CaSO_4 \cdot 2H_2O$ |
| **b.** | Blue vitriol (copper sulphate pentahydrate) | $CuSO_4 \cdot 5H_2O$ |
| **c.** | Green vitriol (ferrous sulphate heptahydrate) | $FeSO_4 \cdot 7H_2O$ |

**15.** Potassium nitrate, $KNO_3$

**16.** Sodium carbonate, $Na_2CO_3$

**17.** Compound P is sodium carbonate as it is used for softening the hard water.

$$KaCl_2 + \underset{P}{Na_2CO_3} \rightarrow CaCO_3\downarrow + 2NaCl$$

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

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

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

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

**C. 1.** Dielectric constant means tendency to break electrostatic forces of attraction in ionic solids. As water has a high dielectric constant, it has a high tendency to break the forces of attraction of ionic solids hence, it can dissolve all the polar compounds or ionic compounds easily. Hence, due to high dielectric constant, water acts as a universal solvent.

## P. 40 Questions from 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 maine animals like molluscs and sea urchins are composed of calcium carbonate is 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 slightly increases with increase in temperature.

**b.** Solubility of calcium sulphate increases sharply with increase in temperature but upto a certain limit around 32.8 °C and beyond this temperature, the solubility decreases.

## CHAPTER – 4

## ATOMIC STRUCTURE AND CHEMICAL BONDING

### P. 52 Check Your Progress

**1.**

$$A = 44$$
$$p = 2$$
$$n = ?$$
$$A = n + p$$
$$\Rightarrow \quad n = A - p$$
$$= 4 - 2$$
$$= 2$$

Helium atomic has two neutrons.

**2.** The rays originated from the cathode, (a negatively charged electrode) and consists of negatively charged particles (electrons) are called cathode rays.

**3.** Electron is a subatomic particle have mass equal to $\frac{1}{1837}$ of that of a hydrogen atom and carries one unit of negative charge. The relative mass of electron is 0.00054864 and relative charge is –1.

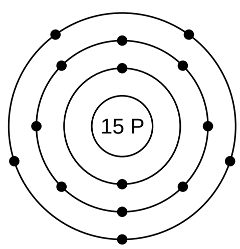
**4.** The mass of electron is equal to $\frac{1}{1837}$ of the weight of a hydrogen atom. This is equivalent to 0.0005486 u or $5.486 \times 10^{-4}$ u.

**5.** The atom will be neutral because in the given atom number of electron is equal to the number of proton, i.e. the number of negative charge in equal to the number of positive charge.

**6.** In accordance to Rutherford's alpha particle scattering experiment, most of the $\alpha$-particles passed through the foil without any deflection. Therefore, Rutherford's concluded that most of the space within an atom is empty.

**7.** The electrons revolve around the nucleus in a certain circular paths having certain amount of energy called energy levels.

The atomic number of phosphorus is 15. It has 15 protons and 15 neutrons. Therefore, its electronic configuration $K_2, L_8, M_5$. This suggests that there are 2 electrons in *K*-shell, 8 electrons in *L*-shell and 5 electrons in *M*-shell. The arrangement of electrons in their energy levels can be depicted as:

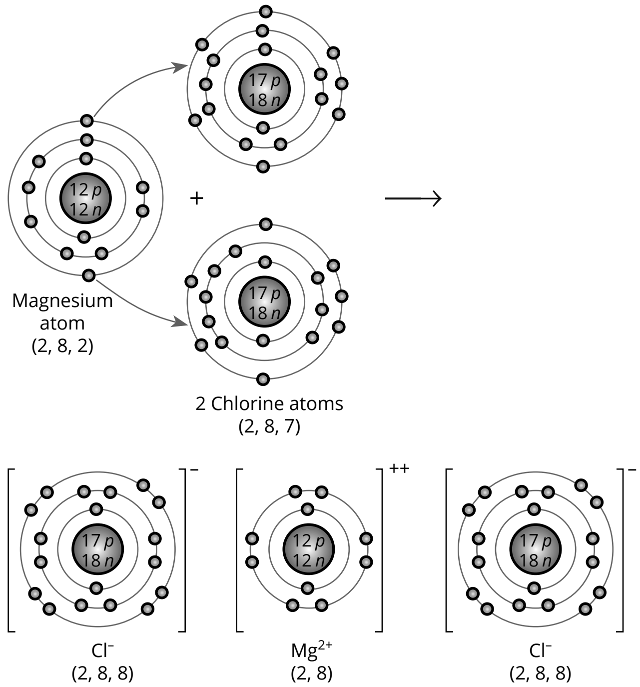


Phosphorus ($Z$ = 15)

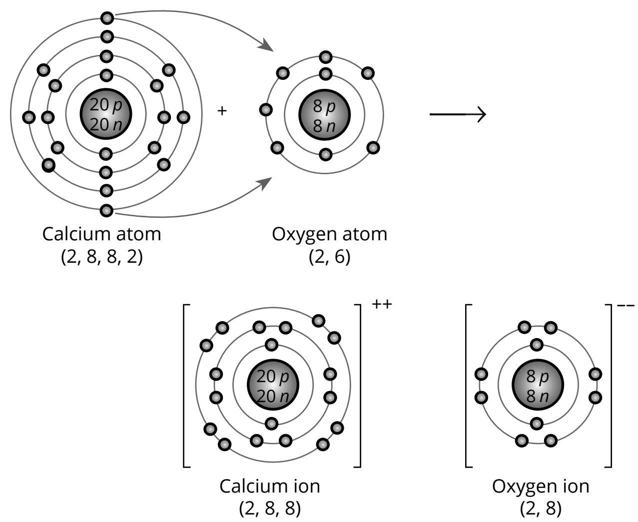
**8.** From the symbol, $^{35}_{17}Cl$, the atomic number of chlorine is 17 and mass number of chlorine is 35.

### P. 58 Check Your Progress

**1. a.** Magnesium chloride




**b.** Calcium oxide




**2.** The conditions favouring the formation of a covalent bond are:

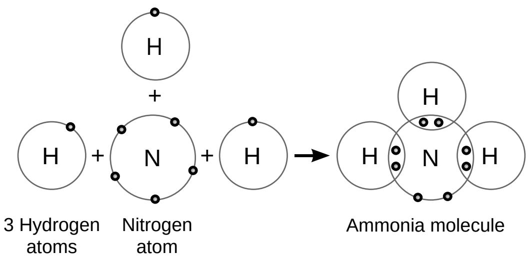
**i.** For the formation of a covalent bond, both the atoms should have four or more electrons [5, 6, 7] in their valence shells.

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

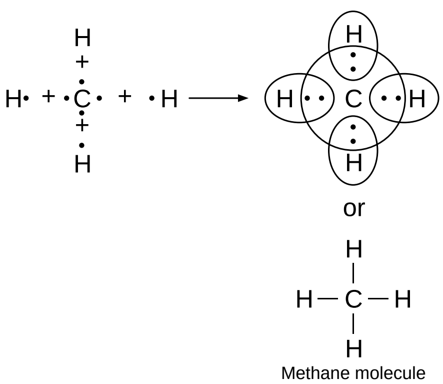
3. Hydrogen forms any single bond because a hydrogen atom has one electron in its outermost shell and requires only one more electron to attain stability. This stability can be achieved by sharing its one electron with other atoms.

4. a. **Ammonia:** Nitrogen atom has 5 valence electrons. It requires 3 more electrons to attain stable octet in its outermost shell. The hydrogen atom has 1 valence electron and requires 1 more electron to attain duplet. So, one atom of nitrogen shares its three electrons with three hydrogen atoms to form ammonia molecule.

   So, ammonia molecule is a covalent compound having 3 covalent bonds in it.



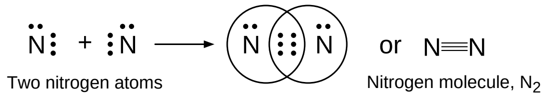

   b. **Methane, $CH_4$:** The atomic number of carbon is 6. Its electronic configuration is 2, 4. Carbon has four electrons, in its outermost shell. It requires four more electrons to attain octet and become stable. Hydrogen has one electron in its outermost shell. It requires one more electron to attain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



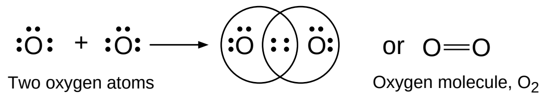

Methane molecule

   Thus, carbon atom forms four single covalent bonds with four hydrogen atoms.

   c. **Nitrogen Molecule ($N_2$):** The atomic number of nitrogen is 7. Its electronic configuration is 2, 5. Thus, nitrogen atom has five electrons in its outermost shell. It needs 3 more electrons to attain octet structure of an inert gas and become stable. Thus, two nitrogen atoms combine together by sharing 3 pairs of electrons to form a nitrogen molecule. Therefore, a triple covalent bond is formed between two nitrogen atoms.




   d. **Oxygen Molecule ($O_2$):** The atomic number of oxygen is 8. Its electronic configuration is 2, 6. An oxygen has 6 electrons in its outermost shell. It requires two electrons to achieve stable octet. The oxygen atom shares two electrons of another oxygen atom. Thus, two oxygen atoms share two pairs of electrons, and hence, the double covalent bond is formed between the two atoms.




## P. 59 Exercises

1. a. **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.

   b. **Proton:** A subatomic particle having mass equal to that of a hydrogen atom and carrying one unit of positive charge is called proton.

   c. **Neutron:** A subatomic particle having mass equal to that of a hydrogen atom and carrying zero charge is called neutron.

   d. **Isotopes:** Atoms of the same element which have same number of protons but different number of neutrons inside their nuclei, are called isotopes. In simple language, isotopes are the atoms of same element having similar atomic number but different mass number.

   e. **Isobars:** Elements having same mass numbers but different atomic numbers are called isobars.

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

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

   h. **Electronic configuration:** The arrangement of electrons in various shells (or orbits) of an atom of the element is called electronic configuration.

**2.** From alpha particle scattering experiment, Rutherford concluded that,

**i.** Most of the space inside the atom is empty as majority of the alpha particles pass through the gold foil without any deflection.

**ii.** A positively charged mass is present at the centre of an atom as some of the positively charged alpha particles get deflected through small or large angles. This deflection occurs due to repulsion between alpha particles and the positive mass present in the centre of an atom.

**iii.** The size of the positively charged mass is very small as compared to the size of an atom as most of the $\alpha$-particles passed straight without deflection.

**3.**

| | Electron | Proton | Neutron |
|---|---|---|---|
| **a.** Mass | → $9.107 \times 10^{-28}$ g | $1.672 \times 10^{-24}$ g | $1.672 \times 10^{-24}$ g |
| **b.** Charge | → Negatively charged | Positively charged | Electrically neutral |
| **c.** Location | → Present in the shells | Present inside the nucleus | Present inside the nucleus |

**4.** Problem Strategy:

In a neutral atom,

Atomic number

= Number of protons = Number of electrons

Mass number

= Number of protons + Number of neutrons

∴ Number of neutrons

= Mass number – Number of protons

| At. no. | Element | At. mass no. | *e* | *p* | *n* |
|---|---|---|---|---|---|
| 1 | H | 1 | 1 | 1 | 0 |
| 2 | He | 4 | 2 | 2 | 2 |
| 3 | Li | 7 | 3 | 3 | 4 |
| 4 | Be | 9 | 4 | 4 | 5 |
| 5 | B | 11 | 5 | 5 | 6 |
| 6 | C | 12 | 6 | 6 | 6 |
| 7 | N | 14 | 7 | 7 | 7 |
| 8 | O | 16 | 8 | 8 | 8 |
| 9 | F | 19 | 9 | 9 | 10 |
| 10 | Ne | 20 | 10 | 10 | 10 |
| 11 | Na | 23 | 11 | 11 | 12 |
| 12 | Mg | 24 | 12 | 12 | 12 |
| 13 | Al | 27 | 13 | 13 | 14 |
| 14 | Si | 28 | 14 | 14 | 14 |
| 15 | P | 31 | 15 | 15 | 16 |
| 16 | S | 32 | 16 | 16 | 16 |
| 17 | Cl | 35 | 17 | 17 | 18 |
| 18 | Ar | 40 | 18 | 18 | 22 |
| 19 | K | 39 | 19 | 19 | 20 |
| 20 | Ca | 40 | 20 | 20 | 20 |

**5.** Chlorine has two isotopes $^{35}Cl$ and $^{37}Cl$ in 3 : 1 ratio, therefore, relative atomic mass is calculated as

$$= \frac{3 \times 35 + 1 \times 37}{4}$$

$$= \frac{142}{4} = 35.5$$

**6.** **a.** Helium

**b.** metal, non-metal

**c.** Covalent

**d.** covalent

**e.** overlapped region.

**B. 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.** Rutherford in 1911, performed an alpha scattering experiment. In this experiment, fast moving $\alpha$-particles were allowed to fall on a thin gold foil. From this experiment, he observed that:

**i.** Most of the $\alpha$-particles passed through the foil without any deflection.

**ii.** A small fraction were deflected through small angles.

**iii.** Only a very few $\alpha$-particles (1 in 12000) suffered a deflection of 180°.

From these observations, he concluded that:

- Very little space in an atom is occupied by matter.
- Most of the matter in an atom is located at the centre.
- At this centre positive charge is concentrated.
- Only such an atom could account for the behaviour of $\alpha$-particles striking a metal sheet.

This line of reasoning led Rutherford to suggest the **nuclear model** of the atom.

**3.** The main drawback of Rutherford's model was that he could not explain the stability of an atom. According to his model, that 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.** Bohr's Theory is different from Rutherford's Theory because of its preciseness about the location and mode of rotation of electrons around the nucleus.

**5.** Protium, an isotope of hydrogen does not contain neutron.

6. $^{103}_{45}X$ Number of $p = 45$

Number of $e = 45$

Number of $n = 103 - 45 = 58$

Electronic configuration of 45 : 2, 8, 18, 15, 2

Yes, it matches with **Rh** in the periodic table.

7. Relative atomic weight of C

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

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

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

8. a. **An atom and a cation:** An atom is electrically neutral containing equal number of protons and electrons. Whereas a cation is a positively charged particle in which the number of protons is greater than that of electrons.

b. **An atom and an anion:** An atom is electrically neutral containing equal number of protons and electrons. Whereas an anion is a negatively charged particle in which the number of electrons is greater than that of protons.

**C.** 1. Because of the difference in the number of neutrons present in the nucleus.

2. Cathode rays:
- They are made up of electrons.
- They deflect towards positive field and away from the negative field.
- They travel in straight lines because they cast shadow if an object was placed in their path.

3. When high voltage and low pressure is applied, rays are emitted from anode which pass through holes in the cathode and strike the end coated with zinc sulphide thereby producing fluorescence.

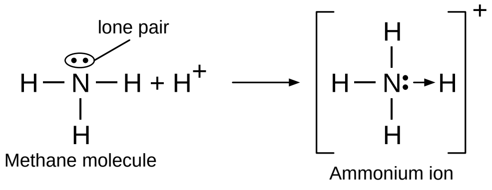
4. This configuration is according to s, p, d, f notation in which filling of electrons is governed by Aufbau's principle.

## P. 60 QUESTIONS FROM PREVIOUS ICSE EXAMINATIONS

1. a. sharing

b. nitrogen

2.




3. a. Sodium chloride → ionic bond

b. Ammonium ion → covalent and coordinate bond

c. Carbon tetrachloride → covalent bond

4. a. Cation and anion

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

c. Two in each nitrogen atom.

d. Mg is oxidised and chlorine atoms get reduced.

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

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

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

8.

| 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 |

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

b. P = 15 = 2, 8, 5

10. Isotopes are atoms of the same elements with different mass numbers but same atomic numbers.

11. a. 35

b. 20

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

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

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

Formula is $XY_3$.

14. a. 13

b. 13

c. 14

d. 2, 8, 3

15. Hydrogen

16. a. i. A ii. B iii. C

b. $BA_2$

17. See answer A-1 Exercises, page 59 of the textbook.

18. a. Y

b. Z

c. X

19. See answer A-5 of Exercises, page 59 of the textbook.

**20.** **a.** **i.** Z **ii.** W

**b.** $X_2Y$

**21.** **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

**22.** **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.

**23.** *p* = 16

*n* = 16

**24.** Refer diagram of sulphur (*Z* = 16) from Page 49 of the textbook.

**25.** $^{4}_{2}He$ Mass number = 4

Atomic number = 2

**26.** See answer A-1 of Exercises, page 59 of the textbook.

## CHAPTER – 5

## THE PERIODIC TABLE

### P. 65 Check Your Progress

1. Johann Wolfgang Dobereiner
2. Johann Wolfgang Dobereiner arranged the elements with similar properties in groups of three called Dobereiner 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.
3. The expected atomic mass of selenium is the average of atomic masses of sulphur and tellurium.

   $$\text{Atomic mass of selenium} = \frac{32 + 128}{2} = \frac{160}{2} = 80$$
4. Yes because he could identify only three triads from the elements known at the time.
5. 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 is also known as the Law of octaves.
6. Newland's law of octaves fails due to the following drawbacks:
   - **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.
7. His classification was important because he concluded that elements when arranged in increasing atomic weights, elements with similar properties were repeated.
8. **a.** Johann Wolfgang Dobereiner

   **b.** properties of, repetition of

### P. 67 Check Your Progress

1. Cobalt and nickel
2. Beryllium and gold
3. Scandium
4. In Mendeleev's periodic table, there were six periods and eight groups.

### P. 71 Check Your Progress

1. Moseley in 1913
2. The horizontal rows of elements in the Periodic Table are called periods.

   The vertical columns of elements in the Periodic Table are called groups.
3. The isotopes of an element have the same number of protons, so their atomic number is same. Therefore, in spite of having different atomic masses, the isotopes of an element are assigned the same position in the Periodic Table as Periodic Table is based on atomic number of elements.
4. **a. Group 2 elements:** Beryllium (Be) and Magnesium (Mg)

   **b. Group 15 elements:** Nitrogen (N) and Phosphorus (P)

   **c. Group 18 elements:** Helium (He) and Neon (Ne)
5. Cs (Cesium), as it belongs to group 1 while rest all belong to group 2 of the Periodic Table.
6. Ne (Neon) as it lies in second period while rest all lie in third period of the Periodic Table.
7. **a.** Ca and Ra belong to same group, i.e. group 2 and Si and Ge belong to same group, i.e. group 14 in the Periodic Table.

   **b.** Ca, Ge, As and Kr belong to the same period, i.e. period 4 in the Periodic Table.
8. **a.** 18, 7

   **b.** atomic number

   **c.** halogens

### P. 73 Exercises

1. **a. i.**    **b. iv.**

   **c. ii.**    **d. ii.**

   **e. i.**    **f. i.**

2. **a.** Moseley **b.** groups, periods
**c.** 17 **d.** average
**e.** scandium **f.** germanium
**g.** gallium **h.** alkali metals
**i.** halogens **j.** alkaline earth metals
**k.** noble gases **l.** zero
**m.** position **n.** decreases, increases
**o.** atomic masses **p.** eighth

3. To make the study of elements more easy and systematic, it is necessary to classify elements.

4. **Dobereiner's Law of Triads:** If elements with similar properties were grouped in three's and placed in an increasing order of their atomic weights 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.

5.

| Li | Na | K | |
|---|---|---|---|
| 7 | 23 | 39 | $\frac{39+7}{2} = \frac{46}{2} = 23$ |
| Ca | Sr | Ba | |
| 40 | 87.6 | 137 | $\frac{40+137}{2} = \frac{177}{2} = 88.5$ |

6. $65 + 200.5 = \frac{265.5}{2} = 132.75$

No because atomic weight of cadmium is not the average of the other two.

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

8. His law was rejected as Law of Triads could not be applied for all the elements.

9. See answer 5 of Check Your Progress (Page 65 of the textbook).

10. **a.** Sodium
**b.** Beryllium
**c.** Nitrogen

11. See answer 6 of Check Your Progress (Page 65 of the textbook).

12. See answer 7 of Check Your Progress (Page 65 of the textbook).

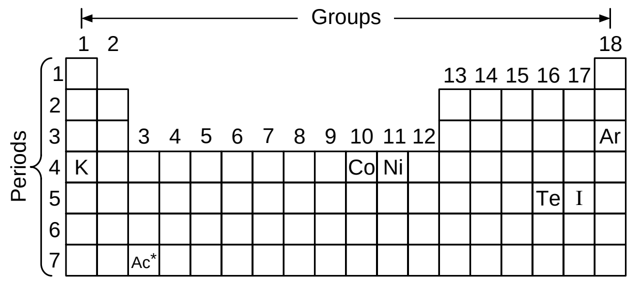
13. **Mendeleev's Law:** The physical and the chemical properties of elements are periodic functions of their atomic masses.

14. 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 seven horizontal rows called periods.

15. Germanium and gallium. He called germanium as eka-silicon and gallium as eka-aluminium.

16. Mendeleev's Law was not accepted due to following reasons:
**i.** Could not give fixed place to hydrogen.
**ii.** Lighter elements were placed after heavier elements, contrary to the law.

17. Ar (Argon) and K (Potassium) placed in 18th and Ist group 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)

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

19. **a.** 18 groups
**b.** 18 columns
**c.** Alkali metals
**d.** Alkaline earth metals
**e.** Scandium
**f.**

| Groups | Special Names |
|---|---|
| 1 | Alkali metals |
| 2 | Alkaline earth metals |
| 13 | Boron family |
| 14 | Carbon family |
| 15 | Nitrogen family (Pnicogens) |
| 16 | Oxygen family (Chalcogens) |
| 17 | Halogens |
| 18 | Noble or Inert gases |

**g.** Transition elements are always metals because they have two electrons in their outer shell.

- **h.** 1st period is shortest. It has hydrogen and helium.
- **i.** 6th period is the longest.
- **j.** 7th period is incomplete.
- **k.** Lanthanide series and actinide series.
- **l.** Both contain 14 elements. They are placed below outside the main table.

**20.** 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 help us to predict the properties of yet to be discovered elements.

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

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

**B. 1.** **a.** 5th group

**b.** 3rd period

**c.** Valency is +5.

**d.** It is a non-metal.

**C. 1.** According to Lothar Meyer's volume curve, elements possessing similar properties occupy same places on the curve.

**2.** Lanthanides and Actinides are placed at the bottom of the table so that the arrangement of the element does not get disturbed. Moreover Lanthanides resemble lanthanum and Actinides resemble actinium. Hence, they are kept together with these elements respectively. No, there are no other forms of the periodic arrangement of elements as well.

## P. 75 Questions From 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. 84 Check Your Progress

1. a. $2K + 2H_2O \rightarrow 2KOH + H_2\uparrow$

   b. $2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$

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

   d. $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2\uparrow$

   e. $2Al + 2NaOH + 6H_2O \rightarrow 2Na[Al(OH)_4] + 3H_2\uparrow$

2. The three uses of hydrogen are:

   i. It is used in the hydrogenation of vegetable oils to produce vanaspati ghee.

   ii. It is used as a constituent of many fuel gases like coal gas and water gas.

   iii. It is used in the manufacture of ammonia, hydrogen chloride, methyl alcohol.

3. Lavoisier identified this gas as an element that combines with oxygen from the air to form water.

4. A mixture of hydrogen and oxygen is burnt is a specially-designed apparatus called an oxy-hydrogen torch to produce a flame of very high temperature of 2000-2500 °C. This flame is used for cutting and welding metals.

### P. 86 Check Your Progress

1. a.
   Oxidation
   $3MnO_2 + 4Al \longrightarrow 3Mn + 2Al_2O_3$
   Reduction

   Oxidised substance : Al

   Reduced substance : $MnO_2$

   Oxidising agent : $MnO_2$

   Reducing agent : Al

   b.
   Reduction
   $Fe_2O_2 + 3CO \longrightarrow 2Fe + 3CO_2$
   Oxidation

   Oxidised substance : CO

   Reduced substance : $Fe_2O_3$

   Oxidising agent : $Fe_2O_3$

   Reducing agent : CO

2. a.
   Oxidation
   $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$
   Reduction

   Oxidised : $H_2$ (*g*)

   Reduced : $Cl_2$ (*g*)

   b.
   Reduction
   $H_2(g) + CuO(s) \longrightarrow Cu(s) + H_2O(l)$
   Oxidation

   Oxidised : $H_2$ (*g*)

   Reduced : CuO (*s*)

   c.
   Reduction
   $2H_2S(g) + SO_2(g) \longrightarrow 3S(s) + 2H_2O(l)$
   Oxidation

   Oxidised : $H_2S$ (*g*)

   Reduced : $SO_2$ (*s*)

   d.
   Oxidation
   $2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2(g)$
   Reduction

   Oxidised : Al (*s*)

   Reduced : HCl (*aq*)

3. Oxidation is the process which involves the addition of oxygen or removal of hydrogen. The substance which causes the addition of oxygen or removal of hydrogen from other substances called an oxidising agent. In redox reactions, the oxidising agent is reduced. This suggests that the substance which undergoes reduction causes the oxidation of the other substance either by adding oxygen to the other substance or removing hydrogen from that substance.

   **For example:**

   Reduction
   $CuO + H_2 \longrightarrow Cu + H_2O$
   Oxidation

   In the above reaction, CuO gives oxygen to hydrogen ($H_2$) and $H_2$ gains oxygen. Therefore, CuO acts as a reducing agent and $H_2$ undergoes oxidation.

4. a.
   Oxidation
   $Cr_2O_3 + 2Al \longrightarrow 2Cr + Al_2O_3$
   Reduction

   Oxidising agent : $Cr_2O_3$

   Reducing agent : Al

   b.
   Oxidation
   $ZnO + C \longrightarrow Zn + CO$
   Reduction

   Oxidising agent : ZnO

   Reducing agent : C

## P. 88 EXERCISES

**A. 1.** Hydrogen molecule is diatomic. Both atoms share one electron pair between them. Thus, both attain a duplet.


**2.** 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.

**3.** Yes, because like halogens, hydrogen can also gain one electron to form monovalent anion $H^-$ (hydride).

**4. a. Cold water:** Cold water reacts with metals like, potassium, sodium, and calcium to liberate hydrogen.

$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$

**b. Boiling water:** Magnesium reacts with boiling water to liberate hydrogen.

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

**c. Steam:** Steam liberates hydrogen when reacted with red-hot iron, aluminium and zinc.

$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2\uparrow$

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

$Zn + H_2O \rightarrow ZnO + H_2\uparrow$

**d. Dilute acids:** Dilute sulphuric acid and dilute hydrochloric acid liberate hydrogen when reacted with metals placed above hydrogen in the metal reactivity series.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

**e. Alkalis:** Amphoteric metals such as zinc and aluminium react with hot and concentrated alkalis to liberate hydrogen.

$2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2\uparrow$

**5.** In the laboratory, hydrogen is prepared by adding dil. $H_2SO_4$ to zinc granules.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

**6.** Bosch process

Step I: Production of water gas

$$\underset{\text{Coke}}{C} + \underset{\text{Super heated steam}}{H_2O} \xrightarrow{1000\ °C} \underbrace{H_2 + CO}_{\text{Water gas}}$$

Step II: Production of hydrogen

$$\underbrace{CO + H_2}_{\text{Water gas}} + \underset{\text{Steam}}{H_2O} \xrightarrow[450-500\ °C]{Fe_2O_3,\ Cr_2O_3} 2H_2 + CO_2$$

Step III: Removal of carbon monoxide and carbon dioxide

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

$$CO_2 + H_2O \rightarrow H_2CO_3$$

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

**7.** During electrolysis of acidified water, hydrogen is collected at cathode.

**8.** In the presence of diffused sunlight.

**9.** $N_2 + 3H_2 \underset{\text{Process}}{\overset{\text{Haber's}}{\rightleftharpoons}} 2NH_3 + \text{Heat}$

**Conditions**

| | |
|---|---|
| Catalyst | Finely divided iron Fe |
| Promoter | Molybdenum |
| Pressure | 200 to 900 atm |
| Temperature | 450–500 °C |

Gases should be pure.

**10.** Conversion of unsaturated vegetable oils to saturated fat by bubbling hydrogen through vegetable oils in the presence of nickel at 250–300 °C is called hydrogenation of vegetable oils.

**11.** $ZnO + H_2 \xrightarrow{\Delta} Zn + H_2O$

**12.** Hydrogen is used for

**i.** hydrogenation of vegetable oils.

**ii.** manufacture of ammonia by Haber's process.

**13. a.** Calcium

**b.** Aluminium

**c.** Iron (III) oxide (magnetic oxide)

**d.** Sodium

**e.** Nitric acid

**f.** Zinc

**g.** Anhydrous calcium chloride

**h.** Hydrogen sulphide ($H_2S$), arsine ($AsH_3$), phosphine ($PH_3$)

**i.** Catalyst $Fe_2O_3$ and promoter $Cr_2O_3$

**j.** Carbon dioxide and carbon monoxide

**k.** Cuprous chloride

**l.** Vanaspati ghee

**14. a.** hydrogen ($H^+$) ion or hydride ($H^-$)

**b.** diatomic

**c.** water, generating

**d.** reversible, exothermic

**e.** copper

**f.** catalyst, molybdenum, reversible, volume

**g.** oxy-hydrogen flame, welding

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

Oxidation

$$Mg + O_2 \longrightarrow MgO$$

$$H_2S + Br_2 \longrightarrow HBr + S$$

Oxidation

**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

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

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

**17.**

| **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:**<br>$2Mg + O_2 \rightarrow 2MgO$<br>$H_2S + Br_2 \rightarrow 2HBr + S$ | **Example:**<br>$2Na + H_2 \xrightarrow{\Delta} 2NaH$<br>$Fe_2O_3 + CO \xrightarrow{\Delta} 2Fe + 3CO$ |

**B. 1.** The metallic characteristics shown by hydrogen are:

**i.** Hydrogen was one electron in its valence shell and thus, shows a valency of 1.

**ii.** Hydrogen forms a positive ion by the loss of one electron.

$$H \rightarrow H^+ + e^-$$

**iii.** Hydrogen act as a good reducing agent.

$$CuO + H_2 \xrightarrow{\text{Heat}} Cu + H_2O$$

**iv.** Hydrogen combines with non-metals like oxygen, sulphur and halogens to form their corresponding compounds like $H_2O$, $H_2S$, HCl, HF, HBr and HI.

**2.** As, hydrogen shows ressemblance in chemical properties with halogens, they should be placed with non-metallic halogens. The ressemblance of hydrogen with halogens are:

**i.** Hydrogen and halogen need only one electron to acquire stable noble gas configuration.

**ii.** Both hydrogen and halogen have valency of –1.

**iii.** Like halogens, hydrogen forms a negative ion.

**iv.** Like halogens, hydrogen also exists as diatomic molecules.

**v.** Like halogens, hydrogen is also a gas.

**vi.** Hydrogen also shows non-metallic character like halogens.

**3.** 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 so produced catches fire. | The heat evolved is not sufficient for the hydrogen to catch fire. |

**4.** Reaction with sodium and water can be controlled if, in place of sodium metal, sodium amalgam is used. Sodium amalgam when reacts with water, the alloy sinks and stays under water. The reaction is thus slower and can be controlled and therefore, hydrogen gas can be collected.

**5.** The reaction is highly violent and explosive in nature.

**6.** 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.

**7.** 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 $NH_3$.

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

9. Amphoteric metals like zinc, aluminium, that can react with acids as well as bases liberate hydrogen from alkalis.
10. Granulated zinc contains traces of copper as an impurity which catalyses the reaction and prevents the deposition of the gas on the zinc.
11. This is because hydrogen forms explosive mixture with air.
12. The apparatus should be sealed properly to prevent leakage of hydrogen. The flame should not be brought near hydrogen as it is a combustible gas.
13. a. To absorb arsine ($AsH_3$) and phosphine ($PH_3$) impurities.
    b. To absorb hydrogen sulphide impurity.
    c. To absorb impurities like carbon dioxide, nitrogen dioxide and sulphur dioxide.
    d. To absorb moisture.
14. It burns with a pale blue flame. Sulphur also burns in the same way.
15. Both are reducing gases.

C. 1. This is because when hydrogen burns, heat is liberated which can be used as fuel.
2. Vegetable oil is hydrogenated catalytically by passing hydrogen gas through vegetables oils at 250–300 °C in the presence of nickel.

## P. 90 Questions From Previous ICSE Examinations

1. $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$
2. Both carbon monoxide and hydrogen are colourless neutral gases. Carbon monoxide turns ammoniacal cuprous chloride solution brown while hydrogen does not.
3. Hydrogen
4. $3Fe + 4H_2 \rightleftharpoons Fe_3O_4 + 4H_2$
5. 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.
6. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
7. Sodium
8. 2H represents two atoms of hydrogen.

   $H_2$ represents a molecule of hydrogen gas.

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

## CHAPTER – 7

## STUDY OF GAS LAWS

### P. 97 CHECK YOUR PROGRESS

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. Gaseous are highly compressible because there are large inter-molecular spaces between the gaseous molecules.
3. 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. as STP,

Volume of gas, $V_2$ = ?

Temperature, $T_2$ = 273 K

Pressure, $P_2$ = 1 atm

From the gas equation,

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

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

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

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

4. 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,

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

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

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

$$= 184.93 \text{ mL}$$

5. 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,

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

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

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

$$= 13.28 \text{ mL}$$

6. According to Charles' Law, volume of a fixed mass of a gas is directly proportional to its temperature at constant pressure.
7. 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.
8. The temperature 0 °C or 273 K is called standard temperature.

### P. 98 EXERCISES

A. 1. **a.** molecules
**b.** inversely related
**c.** directly related
**d.** elastic
**e.** The average kinetic energy
**f.** pressure

2. 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.

3. The properties of gases are as follows:

i. Gases have no definite shape or volume.

ii. Gases exert pressure in all directions.

iii. They are highly compressible.

iv. They are indefinitely expansible.

v. They diffuse or disperse with no outside help.

vi. They have relatively low density.

4. 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 inter-molecular force of attraction between particles of a gas in negligible.

v. Gases diffuse with other gases easily.

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

5. **Boyle's Law:** Temperature remaining constant, the volume of a given mass of gas is inversely proportional to the pressure applied to it.

6. **Charles' Law:** Pressure remaining constant, the volume of a given mass of a gas is directly proportional to its absolute temperature.

7. **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.

8. 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,

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

This mathematical relation is called Gas Equation.

9. N.T.P. or S.T.P. are standard temperature and pressure at which

Temperature = 0 °C or 273 K

Pressure = 760 mm of Hg or 76 cm or 1 atm

**B.** 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

$$P_1V_1 = P_2V_2$$

$$V_1 = \frac{P_2 V_2}{P_1} = \frac{1050 \times 800}{1500}$$

$$= 560 \text{ cm}^3$$

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

$$= 416 \text{ K}$$

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

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

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

$$= 715.8 \text{ mL}$$

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,

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

∴ $V_2$ = 180 mL

$T_2$ = ?

By Charles' Law

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

$$\therefore \quad T_2 = \frac{V_2T_1}{V_1} = \frac{180 \times 300}{600} = 90$$

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

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

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

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

$$= 1345.5 \text{ mL}$$

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

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

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

$$= 92.8 \text{ cm}$$

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 $\quad P_2 = 3P$

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

By Gas Equation

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

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

$$= 1230.6 \text{ K}$$

(1230.6 – 273) °C = 957.6 °C

The final temperature should be 957.6 °C.

**10.** Initial conditions $\quad$ Final conditions

$P_1 = 540$ mm $\quad P_2 = 648$ mm

$V_1 = 892$ cc $\quad V_2 = ?$

$T_1 = (273 - 50)$ K $= 223$ K $\quad T_2 = -50$ °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

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

or $$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{540 \times 892 \times 280}{223 \times 684}$$

The final volume will be 884.2 cc.

## P. 99. Questions From 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 $\quad$ Final conditions

$P_1 = P$ atm $\quad P_2 = 2P$ atm

$V_1 = 22.4$ L $\quad V_2 = ?$

$T_1 = 273$ K $\quad T_2 = 546$ 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

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

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

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

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

Increase in final temperature

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

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

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

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

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

∴ The final volume is 80 cm$^3$.

**4. Boyle's Law:** Temperature remaining constant, volume of a given mass of a gas is inversely proportional to the pressure applied to it.

**5.** Initial conditions $\quad$ Final conditions

$P_1 = 70$ cm $\quad P_2 = 76$ cm

$T_1 = 273 + 27 = 300$ K $\quad T_2 = 273$ K

$V_1 = 760$ cm$^3$ $\quad V_2 = ?$

By Gas Equation

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

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

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

Final volume is 637 cm$^3$.

**6.** Kelvin zero in °C = –273 K

## CHAPTER – 8

## ATMOSPHERIC POLLUTION

### P. 106 Check Your Progress

1. Methane ($CH_4$)
2. Smelting activities, fly ash plants, fossil fuels, transportation, construction activities and forest fires are the main sources of particulate matter.
3. CO, NO, $NO_2$, Pb, soot, $SO_2$, smoke, organic vapours like $CH_4$.
4. Sulphuric acid, nitric acid, nitrous acid
5. Carbon dioxide
6. Carbon dioxide
7. Chlorofluorocarbons (freons)

### P. 108 Exercises

**A.** 1. The two main sources of air pollution are combustion of fossil fuels in homes, industries and transportation.

2. The air pollutants released by vehicles are carbon monoxide, carbon dioxide, nitrogen oxides and hydrocarbons.
3. Smelting activities, fly ash plants, fossil fuels, transportation, construction activities and forest fires are some of the sources of suspended particulate matter.
4. When rain water contains very high amounts of nitric and sulphuric acids, it is called acid rain.
5. 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.
6. Ozone layer is the layer of stratospheric ozone layer present in the atmosphere, at altitudes between 18 km and 40 km from earth's surface. The ozone layer prevents harmful ultraviolet radiations from reaching earth's surface.
7. The depletion of ozone in a region of the ozone layer, particularly over Antarctica is called ozone hole.
8. 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 break down of ozone molecules.
9. The sources of chlorofluorocarbons are aerosol spray, air conditioning and refrigerating units and cleansing agents for electronic equipment.
10. Hydrofluorocarbons affect ozone 90% less than CFCs.
11. The major greenhouse gases are carbon dioxide, methane, oxides of nitrogen, water vapour and chlorofluorocarbons.
12. 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 are high, the result is the rise of the temperature of the planet above normal.

**B.** 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.

2. Sulphur dioxide damages vegetation, causes respiratory problems in humans, irritation of eyes and contaminates water with sulphuric acid.
3. 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.
4. Asbestos, lead and mercury.
5. **i.** Suspended particulate matter 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 corrodes metals, monuments and buildings.
6. The chemical equations involved in acid rain formation are:
   - **i.** $2SO_2 + O_2 \rightarrow \underset{\text{Sulphur trioxide}}{2SO_3}$

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

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

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

**7.** 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.

**8.** 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.

**9.** By phasing out CFCs and using hydrofluorocarbons.

**10.** 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 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.

**11.** The sources of carbon dioxide emission are exhaust from vehicles, combustion or burning and deforestation.

**12.** 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.

**13.** The main source of nitrous oxide emission is automobile exhaust. Disposal of human and animal waste is sewage treatment plants is another source of nitrous oxide emission.

**14.** 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.

**15.** The harmful effects of global warming are rise in global temperature, melting of ice caps in polar regions, rise in sea levels, submerging of coastal areas resulting in migration and loss of livelihoods, change in global weather patterns resulting in hurricanes, floods, etc., loss of biodiversity, and emergence of new diseases, etc.

**16.** 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.

**17.** 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.

**C. 1.** 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.

**2. i.** Use of public transport and car pools.

**ii.** Improve fuel economy. An increase in fuel economy is eqivalent to same amount of decrease in carbon dioxide emissions. While driving avoid accelerating quickly, braking hard and driving at high speeds, particularly when in heavy traffic.

iii. Saving energy in and around the house. Saving energy reduce carbon emissions because most energy sources require burning of fossil fuels.

iv. Manage heating and cooling in an efficient way. Change the thermostat setting of the refrigerator during winters. Similarly during summers, maintain the temperature setting of the air conditioner at the optimum level.

v. Reduce household wastage of food and other wastes. Recycle everything you can: aluminum, paper, glass, plastic and cardboard.

3. i. Limit the use of private vehicles. Vehicular emissions cause smog which leads to deterioration of the ozone layer. Car pool, use of public transport, walking, using a bicycle should be preferred instead of using individual transport.

ii. Use of eco-friendly household products.

iii. Avoid using pesticides.

iv. Banning the use of nitrous oxide.

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.

## CHAPTER – 9

## PRACTICAL WORK

### P. 119 Exercises

**A. 1. a.** Oxygen

**b.** Hydrogen sulphide

**c.** Carbon dioxide

**d.** Water vapours

**e.** Nitrogen dioxide

**2. 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.

**3. a.** Mercuric oxide turns from orange red amorphous powder to deep red and then black.

**b.** Copper nitrate turns from deep blue to pale green and then gives a black residue.

**c.** On strong heating, greyish brown crystals of iodine sublimes to form violet vapours.

**d.** 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.

**e.** Hydrated copper sulphate turns from blue to white and then black.

**4.**

| Colour of the flame | Inference |
|---|---|
| Golden yellow | $Na^+$ |
| Lilac/violet | $K^+$ |
| Brick red | $Ca^{++}$ |
| Blue green | $Cu^{++}$ |

**5.** Water that does not give lather with soap but instead forms a sticky mass called scum is called hard water.

**6.** Bicarbonates, sulphates and chlorides of calcium and magnesium.

**7.** Hardness of water can be permanent hardness or temporary hardness.

**8.** Hard water can be converted to soft water by boiling or by the use of washing soda crystals.

**9.** Detergents are preferred to soaps because they do not form scum with hard water.

**10.** Washing soda removes hardness of both types.

**B. 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 $O_2$ gas | **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 dilute sulphuric acid | **Zinc sulphate** It has no effect. | **Zinc sulphide** It liberates hydrogen sulphide gas which smells like rotten eggs. |
| **e.** | With dilute sulphuric acid | **Copper carbonate** It liberates carbonate which turns lime water milky and extinguishes burning splinter. | **Copper sulphite** It liberates sulphur dioxide which turns lime water milky but does not extinguish burning splinter. |

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 Activity series.
5. Washing soda precipitates calcium and magnesium salts as respective carbonates and thus softens water.

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

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

**C.** 1. **Uses of hard water:**
   - i. Makes our teeth and bones strong.
   - ii. Gives taste to water.
   - iii. Prevents lead poisoning.

   **Harms of hard water:**
   - i. Forms scum.
   - ii. Involves wastage of water.
   - iii. Causes scales is boilers

2. 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.
3. It is an experiment to be done practically.
4. The paper will not show any change because both gases recombine at the cooler part of the test tube to form ammonium chloride.
5. i. Zinc displaces all elements from the salt solution hence it is the most reactive element.
   - ii. Iron can displace lead and copper from their solutions but not zinc.
   - iii. Lead can displace only copper from its salt solution.
   - iv. Copper cannot displace any metal cation hence it is the least reactive element.

   Thus, the decreasing order of reactivity of these elements in the Activity series is Zn, Fe, Pb, Cu.