Chapter - 10

The s-Block Elements

- *s*-Block elements consists of group-I (Alkali metals) and group-2 (Alkaline earth metals).
- Group 1st elements—Li, Na, K, Rb, Cs, Fr.
- Group 2nd elements—Be, Mg, Ca, Sr, Ba, Ra.
- **Atomic radius—**Atomic radius of alkali metals are greater than alkaline earth metals.
- **Hydration enthalpy :** Decreases with increases in ionic sizes.
- **Ionic mobility :** Smaller the size of ion, more highly it is hydrated and hence lower is its ionic mobility.

  $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
- **Ionisation enthalpies :** 1st I.E. of group 1st is smaller than group 2nd elements but 2nd I.E. of group 2nd is smaller than group 1st elements.
- **Flame colouration :** Due to low I.E., *s*-block elements and their salts imparts characteristics colour of oxidising flame (except Be and Mg). Be and Mg do not show flame colouration because they have small size and very high ionisation enthalpy.
- **Reducing character :** Due to large negative electrode potentials alkali metals are stronger reducing agent than alkaline earth metal.
- **Reactivity towards air :**

  $4Li + O_2 \longrightarrow 2Li_2O$ (Lithium oxide)

  $2Na + O_2 \longrightarrow Na_2O_2$ (Sodium peroxide)

  $M + O_2 \longrightarrow MO_2$ (M = K, Rb, Cs metal superoxide)

  Alkaline earth metals being smaller in size do not from superoxides.
- **Reactivity towards H_2O :**

  $2M + 2H_2O \longrightarrow 2MOH + H_2$

(Alkali metal)

$M + 2H_2O \longrightarrow M(OH)_2 + H_2$

(Alkaline earth metals)

- **Reactivity towards hydrogen :**

  $2M + H_2 \longrightarrow 2MH$

  (M = Li, Na, K, Rb, Cs)

  $M + H_2 \longrightarrow MH_2$

  (M = Mg, Ca, Sr, Ba)

  $2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$.

- Reactivity towards halogens :

  $2M + X_2 \longrightarrow 2MX$ (M = Li, Na, K, Rb, Cs)

  $M + X_2 \longrightarrow MX_2$ (M = Mg, Ca, Sr, Ba)

  $BeO + C + Cl_2 \underset{}{\overset{600\text{-}800\ K}{\rightleftharpoons}} BeCl_2 + CO$

- **Solution in liquid ammonia :** The fresh solution of alkali metals and alkaline earth metls (except Be and Mg) is deep blue, paramagnetic and highly reducing due to presence of ammoniated electrons.
- Solubility of alkaline earth metal hydroxide in water :

  $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < RbCO_3 < Cs_2CO_3$
- Solubility of alkaline earth metl carbonates in water.

  $BaCO_3 < SrCO_3 < CaCO_3 < MgCO_3 < BeCO_3$
- Solubility of alkaline earth metal sulphates in water :

  $BaSO_4 < SrSO_4 < CaSO_4 < MgSO_4 < BeSO_4$
- Thermal stability of alkali metal carbonates :

  $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
- Thermal stability of alkaline earth metal carbonates :

  $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$
- **Anamolous behaviour of Li and Be :** It is done to very small size, high I.E. and high polarising power (*i.e.*, charge/radius)
- **Diagonal relationship (similarities) between Li and Mg :**

  (i) Both Li and Mg are hard.

  (ii) Both react with N_2 to form nitrides.

$6Li + N_2 \longrightarrow 2Li_3N$

$3Mg + N_2 \longrightarrow Mg_3N_2$

(iii) Decomposition of carbonates :

$Li_2CO_3 \longrightarrow Li_2O + CO_2$

$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$

(iv) Both LiCl and $MgCl_2$ are deliquescent. They form hydrates salts $LiCl.2H_2O$ and $MgCl_2.6H_2O$.

(v) Decomposition of netrates :

$4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$

$2Mg(NO_3)_2 \xrightarrow{\Delta} 2MgO + 4NO_2 + O_2$

- Diagonal relationship (similarities) between Be and Al :

(i) Both are passive to acids due to formation of oxide layer.

(ii) Hydroxides of both dissolve in alkali to form $[Be(OH)_4]^{2-}$ and $[Al(OH)_4]^-$.

(iii) Chloride of both has bridged structure.

(iv) Both have tendency of form complexes of BeF_4^{2-}, AlF_6^{3-}.

- Manufacturing of washing soda ($Na_2CO_3.10H_2O$) :

Solvay process :

$NH_3(g) + CO_2(g) + H_2O\ (l) \longrightarrow NH_4HCO_3\ (aq)$

$NH_4HCO_3\ (aq) + NaCl\ (aq) \longrightarrow NaHCO_3(s) + NH_4Cl\ (aq)$

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O(l) + CO_2(g)$

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

- **Manufacturing of causing soda (NaOH) :** Castner-Kellner cell.

Cathode : $Na^+ + e^- \xrightarrow{Hg}$ Na-Hg

Anode : $Cl^- \longrightarrow e^- + \frac{1}{2}Cl_2$

$2Na\text{-}Hg + 2H_2O \longrightarrow 2NaOH + 2Hg + H_2$

- **Plaster of paris :** ($CaSO_4.½H_2O$)

$2(CaSO_4.2H_2O) \xrightarrow[393K]{\Delta} 2(CaSO_4).H_2O + 3H_2O$

Gypsum

- **Cement** is a finely powdered mixture of calcium silicates and aluminate along with small quantities of gypsum which sets into a hard stone like mass when treated with water.

Group 1
Elements and their Compounds

1-Mark Questions

1. What is the oxidation state of K in KO_2 ?
2. Why are group I element called alkali metals ?
3. Potassium carbonate cannot be prepared by solvay process. Why ?
4. LiCl is soluble in organic solvent. Why ?
5. Why are group 1 elements called alkali metals ?
6. Alkali metals are strong reducing agents. Why ?
7. Why do alkali metals give characteristics flame colouration ?
8. Arrange the following in order of increasing covalent character : MCl, MBr, MF, MI (where M = Alkali metal) [**Ans.** MF < MCl < MBr < MI]
9. Alkali metals can not be obtained by chemical reduction method. Explain.
10. Why is sodium metal kept under kerosene oil ?

Group 2
Elements and their Compounds

11. Why Be and Mg do not give characteristics colour to the flame ?
12. Arrange the alkaline earth metal carbonate in the decreasing order of thermal stability.
13. Why do alkaline earth metals not form any superoxide ?
14. Why gypsum is added to cement ?
15. How plaster of paris is obtained from gypsum ?
16. BeO is insoluble in water but $BeSO_4$ is soluble in water ? Why ?
17. Why second I.E. of group 2 elements is less than group 1 elements ?
18. What is quick lime ? How is it prepared ?
19. Why does Be shows similarities with Al ?
20. Name the alkaline earth meta hydroxide which is amphoteric.

Group 1
Elements and their Compounds

2-Mark Questions

1. Why are alkali metals soft and how low melting points ?
2. Write any four similarities but Li and Mg. [NCERT]
3. Why are potassium and caesium rather than Lithium used in photoelectric cells ? [NCERT]
4. Why is Li_2CO_3 decomposed at a lower temperature whereas Na_2CO_3 at higher temperature ? [NCERT]
5. Among the alkali metals which has :

   (i) Highest melting point.

   (ii) Most electropositive character

   (iii) Lowest size of ion.

   (v) Strongest reducing character. [**Ans.** (i) Li (ii) Cs (iii) Li (iv) Li]

Group 2
Elements and their Compounds

6. Why does the solubility of alkali earth metal carbonates and sulphates decreases down the group ? [NCERT]
7. Draw the structure of $BeCl_2$ in (i) Vapour phase (ii) Solid state.[NCERT]
8. When CO_2 gas is passed in lime water it turns milky but in case of excess CO_2 milkiness disappears. Support the statement by giving suitable reaction equations.
9. (i) E° for $M^{2+}(aq) + 2e^- \longrightarrow M(s)$ (where M = Ca, Sr, Ba) is nearly constant. [NCERT]

   (ii) What is dead burnt plastar ? How is it obtained from gypsum.
10. Write two important uses of (i) Limestone (ii) Quick lime.

Group 1
Elements and their Compounds

3-Mark Questions

1. Assign reason for the following :

   (i) Compounds of lithium are generally covalent.

   (ii) Alkali metals are strong reducing agent.

(iii) LiCl is more covalent than NaCl.

2. Discuss the various reactions that occur in Solvay process. [NCERT]

3. Explain why ?

(i) Lithium salts are commonly hydrated.

(ii) Sodium peroxide is widely used as as oxidising agent.

(iii) Sodium wire is used to remove moisture from benzene but can't be used for drying alcohol.

4. Sodium hydroxide is generally prepared by electrolysis of brine solution in the Caster-Keller cell :

(i)Write the reactions that occur in the cell.

(ii) Write any two uses of NaOH.

5. State as to why ?

(a) A solution of Na_2CO_3 is alkaline.

(b) Alkali metals are prepared by electrolysis of their fused chlorides.

(c) Sodium is found to be more useful than potassium ?

Alkaline Earth Metals and their Compounds

6. Arrange the following in order of property mentioned against each :

(i) $BaCl_2$, $MgCl_2$, $BeCl_2$, $CaCl_2$ (Increasing ionic character)

(ii) $Mg(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$, $Ca(OH)_2$ (Increasing solubility in water)

(iii) BeO, MgO, BaO, CaO (Increasing basic strength)

7. What happens when :

(i) Mg is burnt in air.

(ii) Quick lime is heated with silica.

(iii) Chlorine is heated with slaked lime.

8. Write the raw material required for the manufacture of portland cement ? Why gypsum is added into it.

9. (i) Why alkaline earth metals cannot be obtained by reduction of their oxide ?

(ii) Why the elements of group 2 are known as alkaline earth metals ?

10. (i) Alkaline earth metls forms ionic salt having bivalent cations. Explain. Why ?

(ii) A piece of magnesium ribbon continues to burn in SO_2. Why ?

Group 1
Elements and their Compounds

5-Mark Questions

1. Explain the following observation :

(a) LiI is more soluble than KI in ethanol.

(b) Sodium reacts with water less vigorously than potassium.

(c) LiF is insoluble in water.

(d) The mobilities of the alkali metal ions in aqueous solution are $Li^+ < Na^+ < K^+ < RB^+ < Cs^+$.

(e) Lithium is the only alkali metal to frm a nitride directly.

Group 2
Elements and their Compounds

2. Complete the following reaction equations :

(i) $BeCl_2 + LiAlH_4 \rightarrow$

(ii) $CaO + SiO_2 \rightarrow$

(iii) $Ca(OH)_2 + Cl_2 \rightarrow$

(iv) $CaO + P_4O_{10} \rightarrow$

(v) $C(OH)_2 + CO_2 \rightarrow$