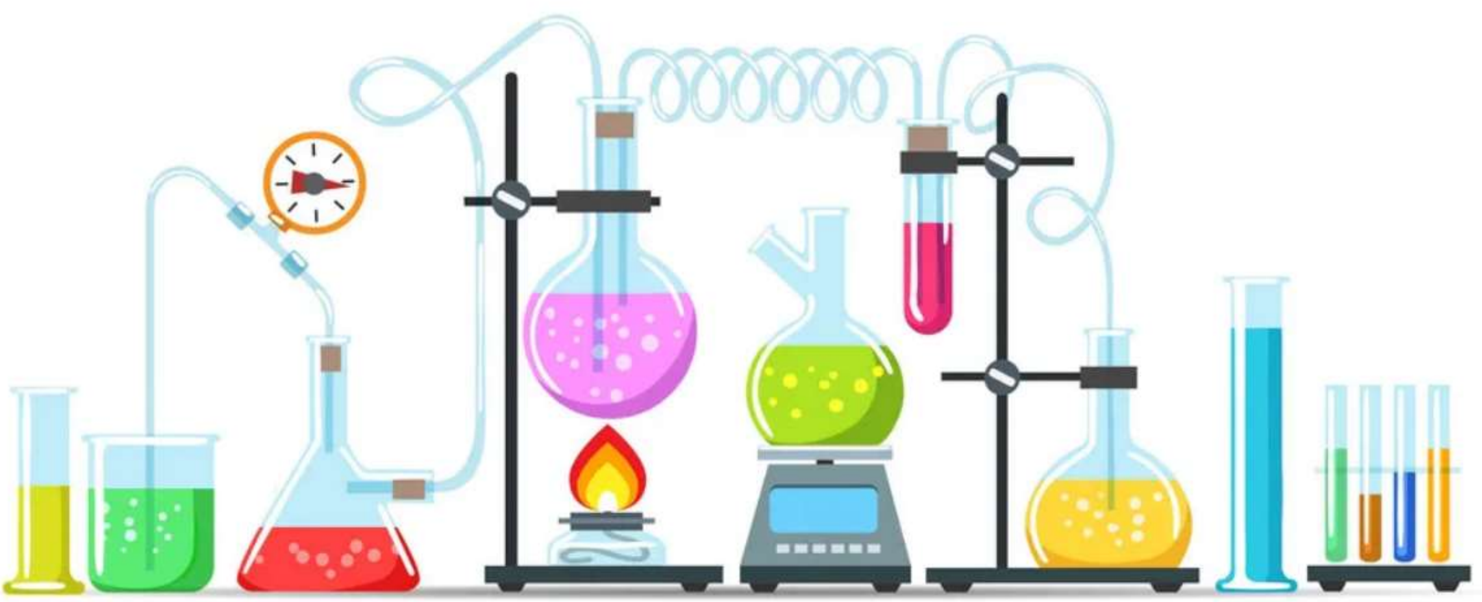
CHEMISTRY



THE S-BLOCK ELEMENTS

Introduction

In the previous chapter we have discussed about The Hydrogen but in this chapter we will study the general characteristics of the alkali and alkaline earth metals and their compounds. We will also study the compounds of s-block elements, their uses and importance, commercially and industrially. The biological significance of sodium, potassium, calcium and magnesium will also be discussed in this chapter.

The s-Block Elements

The s-block elements of the Periodic Table are those in which the last electron enters the outermost s-orbital. As the s-orbital can accommodate only two electrons, two groups (1 & 2) belong to the s-block of the Periodic Table.

Group-1 of periodic table contains

Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Caesium (Cs) and Francium (Fr). Together these elements are called alkali metals because they form hydroxides on reaction with water, which are strongly alkaline in nature.

The group-2

Includes Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). Except Beryllium, rest of the elements of group-2 are called the alkaline earth metals. These are called so because their oxides and hydroxides are alkaline in nature and these metal oxides are found in the earth crust.

Group-1 Elements : Alkali Metals

1. **Electronic Configuration**

Electronic Configuration of elements of group-1 is ns^1, where n represents the valence shell. The alkali metals have one valence electron, outside the noble gas core.

Element	Symbol	Electronic configuration
Lithium	Li	$1s^2 2s^1$
Sodium	Na	$1s^2 2s^2 2p^6 3s^1$
Potassium	K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Rubidium	Rb	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$
Caesium	Cs	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$ $4p^6 4d^{10} 5s^2 5p^6 6s^1$ or $[Xe]\,6s^1$
Francium	Fr	$[Rn]7s^1$

2. Atomic and ionic radii

The atoms of alkali metals have the largest size in their respective periods. The atomic radius increases on moving down the group because on moving down the group there is a progressive addition of new energy shells.

3. Ionization enthalpy

The ionization enthalpies of the alkali metals are generally low and decrease down the group from Li to Cs. This is because on moving down the group is due to increase in size of the atoms of alkali metals and increase in the magnitude of screening effect.

4. Hydration enthalpy

The alkali metal ions are extensively hydrated in aqueous solutions. The hydration enthalpies of alkali metal ions decrease with increase in ionic size $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$.

5. Physical properties

i. Alkali metals are silvery white in colour and are generally soft and light metals.

ii. The densities of alkali metals are low and increase down the group. Alkali metals have low melting and boiling point.

iii. When alkali are heated metals they impart characteristic colours to the flame.

iv. When the excited electron comes back to the ground state, there is emission of radiation in the visible region.

6. Chemical Properties

The alkali metals are highly reactive elements. The cause for their high chemical reactivity is:

i. Low value of first ionisation enthalpy

ii. Large size

iii. low heat of atomisation.

i. **Reaction with Air:** Alkali metals burn very fast in oxygen and form different kind of oxides like monoxides, peroxides and superoxides. In all the compounds formed by alkali metals with oxygen, their oxidation state is +1.

$4Li + O_2 \longrightarrow 2Li_2O$ (Oxide)

$Na + O_2 \longrightarrow Na_2O_2$ (Peroxide)

$M + O_2 \longrightarrow MO_2$ (Superoxide)

ii. **Reaction with Water:** The alkali metals on reaction with water form their respective hydroxide and dihydrogen.

$2M + 2H_2O \longrightarrow 2M^+ + 2OH^- + H_2$

(M = an alkali metal)

iii. **Reaction with Dihydrogen:** Alkali metal react with dry di-hydrogen at about 673K (lithium at 1073K) to form crystalline hydrides which are ionic in nature and have high melting points.

$2M + H_2 \longrightarrow 2M^+H^-$

iv. **Reaction with Halogens:** The alkali metals react vigorously with halogens and form halides which are ionic in nature, M^+X^-. But the halides of lithium are a bit covalent in nature.

v. **Reaction with Mercury:** The alkali metals have strong tendency to get oxidised, that is why they act as strong reducing agents, among these lithium is the strongest and sodium is the least powerful reducing agent.

vi. **Reducing Nature:** Alkali metals combine with mercury to form amalgams. The reaction is highly exothermic in nature.

$Na + Hg \longrightarrow Na[Hg]$

vii. **Solutions in liquid Ammonia:** All alkali metals dissolve in liquid ammonia and give deep blue colour solution which are conducting in nature. These solutions contain ammoniated cations and ammoniated electrons as shown below:

$M + (x + y)NH_3 \longrightarrow [M(NH_3)x]+ + [e(NH_3)y]^-$

Uses of Alkali Metals

1. Lithium is used as a metal in a number of alloys. Its alloys with aluminium to make

aircraft parts.

2. Lithium hydroxides is used in the ventilation systems of space crafts and submarines to absorb carbondioxide.
3. Lithium aluminium hydride ($LiAlH_4$) is a powerful reducing agent which is commonly used in organic synthesis.
4. Liquid sodium or its alloys with potassium is used as a coolant in nuclear reactors.
5. Sodium-lead alloy is used for the preparation of tetraethyl lead, $Pb(C_2H_5)_4$, which is used as an antiknocking agent in petrol.
6. Sodium is used in the production of sodium vapour lamps.
7. Potassium chloride is used as fertilizer.
8. Potassium hydroxide is used in the manufacture of soft soaps and also as absorbent of carbon dioxide.
9. Potassium ions play a vital role in biological systems.
10. Caesium is used in photoelectric cells.

Anomalous Properties of Lithium

Lithium shows properties which are very different from the other members of its group. This is due to the:

1. Exceptionally small size of its atom and ion.
2. Greater polarizing power of lithium ion.
3. As compared to other alkali metals, lithium is harder and its melting point and boiling point are higher.
4. Among all the alkali metals lithium is least reactive but the strongest reducing agent.

Some important Compounds of Sodium

Sodium is highly reactive and always found in combined state. The isotope of sodium (Na) is used in detection of leukemia. The compound of sodium are given below:

1. **Sodium Oxide (Na_2O)**

Preparation:

$$2NaNO_2 + 6Na \longrightarrow 4Na_2O + N_2$$

Properties:

1. Sodium oxide is a colourless ionic solid.
2. Aqueous solution of sodium oxide is strongly basic.
3. Sodium oxide on reaction with liquid ammonia forms sodamide.
4. At low temperature, when sodium peroxide is reacted with water or acids, H_2O_2 is formed.

2. **Sodium Peroxide (Na_2O_2)**

Preparation:

Sodium when heated in excess of air or when heated in excess of pure oxygen gives sodium peroxide.

$2Na + O_2 \longrightarrow Na_2O_2$

Properties:

1. Sodium peroxide is a pale yellow diamagnetic compound.
2. Sodium peroxide is a powerful oxidising agent.
3. Sodium peroxide combines with CO and CO_2 to give carbonate.
4. At low temperature, when sodium peroxide is reacted with water or acids, H_2O_2 is formed.

   $Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$

3. **Sodium Hydroxide (Caustic Soda) (NaOH)**

Preparation:

When sodium carbonate is treated with calcium hydroxide it give calcium carbonate along with sodium hydroxide. Also known as lime caustic soda process. It is a reversible reaction.

$Na_2CO_3 + Ca(OH)_2 \longrightarrow 2NaOH + CaCO_3$

Properties

1. Sodium hydroxide is a white crystalline deliquescent solid.
2. Sodium hydroxide is corrosive in nature.
3. Sodium hydroxide is highly soluble in water.
4. Sodium hydroxide reacts with acid forming corresponding salts.

   $NaOH + HCl \longrightarrow NaCl + H_2O$

Uses:

It is used in the manufacture of soap, paper, artificial silk and a number of chemicals,

1. In petroleum refining.
2. In the purification of bauxite.
3. In the textile industries for mercerising cotton fabrics.
4. For the preparation of pure fats and oils.
5. As a laboratory reagent.

4. **Sodium Carbonate (Na_2CO_3)**

Preparation:

$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$

$NaCl + NH_4HCO_3 \longrightarrow NaHCO_3 + NH_4Cl$

$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Properties:

1. Sodium carbonate is a white crystalline solid.
2. $Na_2CO_3.10H_2O$ is known as washing soda.
3. Sodium carbonate reacts with acids to give carbon dioxide.

Uses:

1. It is used in water softening, laundering and cleaning.
2. It is used in the manufacture of glass, soap, borax and caustic soda.
3. It is used in paper, paints and textile industries.
4. It is an important laboratory reagent both in qualitative and quantitative analysis.

$Na_2CO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

Properties:

On heating sodium bicarbonate loses CO_2 and H_2O forming Na_2CO_3.

$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

5. **Sodium Chloride (NaCl)**

Manufacture of sodium chloride is done from sea water. Sea water is allowed to dry up under summer heat in small tanks and solid crust so formed is collected.

Properties:

1. Sodium chloride is a white crystalline solid.
2. It is slightly hygroscopic.
3. It is soluble in water and insoluble in alcohol.

Uses:

1. It is used as a common salt or table salt for domestic purpose.
2. It is used for the preparation of Na_2O_2, NaOH and Na_2CO_3.

6. **Sodium Bicarbonate (Baking Soda) ($NaHCO_3$)**

Preparation:

When NaOH is treated with CO_2 in presence of H_2O it gives sodium bicarbonate.

$NaOH + CO_2 + H_2O \longrightarrow NaHCO_3$

Properties:

On heating sodium bicarbonate loses CO_2 and H_2O forming Na_2CO_3.

$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Group-2 Elements : Alkaline Earth Metals

The elements of group-2 are Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). Except for Be, rest are known as alkaline earth metals, because they were alkaline in nature and existed in the earth.

1. **Electronic Configuration**

The alkaline earth metals have 2 electrons in the s-orbital of the valence shell. Their general electronic configuration [Noble gas]ns^2

Element	Symbol	Electronic configuration
Beryllium	Be	$1s^2 2s^2$
Magnesium	Mg	$1s^2 2s^2 2p^6 3s^2$
Calcium	Ca	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
Strontium	Sr	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$
Barium	Ba	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^2$ or $[Xe]6s^2$
Radium	Ra	$[Rn]7s^2$

2. **Atomic and Ionic Radii**

The atomic radii as well as ionic radii of the members of the family are smaller than the corresponding members of alkali metals. Within the group, the atomic and ionic radii increase with increase in atomic number.

3. **Ionization Enthalpies**

The alkaline earth metals owing to their large size of atoms have fairly low values of ionization enthalpies. Within the group, the ionization enthalpy decreases as the atomic number increases.

4. **Hydration Enthalpies**

The hydration enthalpies of alkaline earth metal ions are larger than those of alkali metal ions. Therefore, compounds of alkaline earth metals are more extensively hydrated, for example, magnesium chloride and calcium chloride exist. the hydration enthalpies of alkaline earth metal ions decrease with increase in ionic size down the group. $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$

5. **Physical Properties**

The alkaline earth metals are silvery white, lustrous and relatively soft but harder than the alkali metals. The melting and boiling points of these metals are higher than the corresponding alkali metals. The electropositive character increases down the group from Be to Ba, Calcium, strontium and barium impart characteristic brick red, crimson and apple green colours respectively to the flame. The alkaline earth metals just like those of alkali metals have high electrical and thermal conductivities.

6. Chemical Properties

As compared to alkali metals, alkaline earth metals are less reactive due to their relatively higher ionization enthalpies. The reactivity of alkaline earth metals increases on going down the group.

i. **Reaction with water:** Ca Sr, and Ba have reduction potentials similar to those of corresponding group Ist metals and are quite high in the electrochemical series. They react with cold water readily, liberating hydrogen forming metal hydroxides.

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

ii. **Reaction with Air:** Except Be these metals are easily tarnished in air as a layer of oxide is formed on their surface. Ba in powdered form bursts into flame on exposure to air.

iii. **Reaction with hydrogen:** The elements Mg, Ca, Sr and Ba all react with hydrogen to form hydrides MH_2.

iv. **Reaction with oxygen:** Except Ba and Ra the elements when burnt in oxygen form oxides of the type MO.

v. **Reaction with halogens:** When heated with halogens the alkaline earth metals directly combine with them and form the halides of the type MX_2.

$Ca + Cl_2 \longrightarrow CaCl_2$

vi. **Reaction with acids:** The alkaline earth metals readily react with acids liberating dihydrogen.

$M + 2HCl \longrightarrow MCl_2 + H_2$

Uses of alkaline earth metals:

1. Beryllium is used in the manufacture of alloys. Cooper-Beryllium alloys are used in the making of high strength springs.
2. Metallic beryllium is used for making windows of X-rays tubes.
3. Magnesium, being a light metal, forms many light alloys with aluminum, zinc, manganese and tin.
4. Magnesium is used in flash powders and bulbs, incendiary bombs and signals.
5. Magnesium-aluminium alloys are used in aircraft construction.
6. Magnesium is used as sacrificial anode for the prevention of corrosion of iron.
7. A suspension of magnesium hydroxide in water (called milk of magnesia) is used as an ant-acid to control excess acidity in stomach.
8. Magnesium carbonate is an ingredient of tooth-paste.
9. Calcium is used in the extraction of metals from oxides which are difficult to reduce with carbon.

10. Calcium and barium metals are used to remove air from vacuum tubes, due to their tendency to react with oxygen and nitrogen at high temperature.
11. Radium salts are used for radio therapy of cancer.

Anomalous Behaviour of Beryllium

Beryllium shows different behaviour from the rest members of its group and shows diagonal relationship to aluminium due to reasons discussed below.

1. Beryllium has exceptionally small atomic and ionic sizes and therefore does not compare well with other members of the group, because of high ionisation enthalpy and small size it forms compounds which are largely covalent and get easily hydrolysed.
2. Beryllium does not exhibit coordination number more than four as in its valence shell, there are only four orbitals. The remaining members of the group can have a coordination number of six by making use of d-orbitals.
3. The oxides and hydroxide of beryllium unlike the hydroxide of other elements in the group, are amphoteric in nature.

Compounds of Calcium

1. **Calcium Oxide (CaO)**

Preparation:

Calcium carbonate when decomposed at 800°C gives calcium oxide.

$CaCO_3 \longrightarrow CaO + CO_2$

Properties:

1. Calcium oxide is also known as ‘Quick lime’ or ‘Burnt lime’, is white amorphous substance.
2. When water is added to lime a hissing sound is produced along with clouds of steam. The lime forms slaked lime [$Ca(OH)_2$].
3. Calcium oxide reacts with moist chlorine to form bleaching powder.

   $CaO + Cl_2 \longrightarrow CaOCl_2$
4. Calcium oxide on reaction with moist HCl gas forms $CaCl_2$.

   $CaO + 2HCl \longrightarrow CaCl_2 + H_2O$

2. **Calcium Carbonate ($CaCO_3$)**

Preparation:

Carbon dioxide when passed through lime water gives calcium carbonate.

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

Properties:

1. Calcium carbonate is a white powder insoluble in water.
2. Calcium carbonate dissolves in water in presence of CO_2 due to formation of calcium bicarbonate.

   $CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$

3. Calcium Chloride ($CaCl_2$)

Preparation:

Calcium oxide, calcium hydroxide or calcium carbonate when treated with HCl gives calcium chloride.

$CaO + 2HCl \longrightarrow CaCl_2 + H_2O$

Properties:

1. Calcium chloride is a colourless deliquescent crystalline substance which is soluble in water as well as in alcohol.
2. Crystals of calcium chloride when strongly heated gives off water of crystallizations.

4. **Calcium sulphate (Plaster of Paris)**

Preparation:

When Gypsum is heated at about 120° - 130°C, Plaster of Paris is formed.

$2CaSO_4 + 4H_2O \longrightarrow (CaSO_4)2H_2O + 3H_2O$

Properties:

1. It is a white crystalline solid. It is sparingly soluble in water.
2. It becomes anhydrous at about 200°C. Anhydrous form is known as dead burnt plaster.

5. **Calcium hydroxide $Ca(OH)_2$**

Preparation:

$CaO + H_2O \longrightarrow Ca(OH)2$

Properties:

1. It gives $CaCO_3$ and $Ca(HCO_3)_2$ with CO_2

   $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

2. On prolong treatment with CO_2 milkiness disappears due to formation of $Ca(HCO_3)_2$

   $CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO3)_2$

Summary-

1. **s-block elements:** The elements in which last electron enters into s-orbital are called s-block elements.
2. **Alkali metals:** The elements of group 1 whose hydroxide are strong alkali.
3. **Alkaline earth metal:** The elements of group 2, and their oxides and hydroxides are alkaline in nature and their oxides are found in the Earth's crust.
4. **Diagonal relationship:** The resemblance in properties of elements of second period with elements of third period present diagonally on the right hand side.
5. Monovalent sodium and potassium ions and divalent magnesium and calcium ions are found in large proportions in biological fluids. These ions perform important biological functions such as maintenance of ion balance and nerve impulse conduction.

MIND MAP : LEARNING MADE SIMPLE CHAPTER - 10

S- Block Elements

Group 1 Elements (Alkali Metals)

- **Atomic and Ionic Radii:** Increases with increase in atomic number.
- **I.E.:** Decreases down the group.
- **Hydration Enthalpy:** Decreases with increase in ionic sizes.
- **Physical properties**:
- Silvery white, soft and light metals.
- Low m.p. and b.p.
- Alkali metals and their salts impart colour to an oxidizing flame.

Chemical Properties:

$4Li + O_2 \rightarrow 2Li_2O$; $2Na + O_2 \rightarrow Na_2O_2$; $M + O_2 \rightarrow MO_2$ (M=K, Rb, Cs)

$2M + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2$

$2M + H_2 \rightarrow 2M^+H^-$

React vigorously with halogens to form ionic halides

$M + (x + y) NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$

Uses:

- Li is used to make useful alloys.
- Li is used in thermonuclear reactions and making electrochemical cells.
- Na is used to make Na/Pb alloy.
- Liquid Na metal is used as coolant in nuclear reactors.
- KCl is used as fertilizer.
- Cs is used in devising photoelectric cells.

Characteristics Of Compounds Of Alkali Metals:

– Oxide and Hydroxides

Combustion in excess of air $\xrightarrow{+Li} Li_2O$; $\xrightarrow{+Na} Na_2O_2$; $\xrightarrow{+K/Rb/Cs} MO_2$

- Halides
- Alkali metal halides (MX) have high melting, colourless crystalline solids.
- Preparation: Reaction of oxide, hydroxide or carbonate with aq HX.
- High negative enthalpies of formation.
- Melting and boiling points: F >Cl> Br > I
- Soluble in water.

Salts of Oxo-Acids:

- Alkali metals form salts with all oxo-acids.
- Soluble in water and thermally stable.
- Stability of carbonates and hydrogencarbonates increases

Anomalies properties of Li: Due to

(i) exceptionally small size of its atom and ion.

(ii) High polarising power.

Biological Importance of Na and K:

Na ions participate in nuclear signals transmission, regulator of flow of water across cell membranes. K ions activate many enzymes and oxidation of glucose to produce ATP.

Important Compounds of Calcium

(i) CaO, Quick Lime

Preparations: $CaCO_3 \overset{heat}{\rightleftharpoons} CaO + CO_2$

Properties : White amorphous solid with m.p. 2870 K

$CaO + H_2O \longrightarrow Ca(OH)_2$, $CaO + CO_2 \longrightarrow CaCO_3$

(ii)$Ca(OH)_2$ Calcium hydroxide : Preparations: Additional of water to CaO.

Properties: white amorphous powder .

$Ca(OH_2) + CO_2 \longrightarrow CaCO_3 + H_2O$

(iii)$CaSO_4 \cdot \frac{1}{2}H_2O$(Plaster of Paris)

$2(CaSO_4.2H_2O) \longrightarrow 2(CaSO_4).H_2O + 3H_2O$

Group 2 Elements (Alkaline Earth Metals)

- Atomic and Ionic Radii: Smaller than corresponding alkali in group,increases with increase in atomic number.
- I.E:IE_1 higher than corresponding Group 1 metals. IE_2 smaller than corresponding alkali metals.
- Hydration Enthalpies: Decreases with increase in ionic size down the group.

Physical properties:

- Slivery white, lustrous and relatively soft but harder than alkali metals.
- M.p. and b.p. higher than corresponding alkali metals.
- Electropositive character increases down the group.

Chemical properties:

- Be and Mg are kinetically inert to O and H_2O
- Mg is more electropositive and burns in air.
- Ca, Sr and Ba with air forms oxide and nitride.

$M + X_2 \longrightarrow MX_2 \, (X = F, Cl, Br, I)$

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

$M + 2HCl \longrightarrow MCl_2 + H_2$

$M + (x+y)NH_3 \longrightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$

Uses:

- Be is used in the manufacture of alloys.
- Metallic Be is used for making windows of X–rays tubes.
- Mg-Al alloys are used in air craft construction.
- Ca in extraction of metals.
- Ra is used in radiotherapy.

Characteristics of Compounds of Alkaline Earth Metals:

- **Oxides and Hydroxides**
- Alkaline earth metals burn oxygen to form MO.
- All oxides except BeO are basic in nature

$MO + H_2O \longrightarrow M(OH)_2$

$Be(OH)_2$ is amphoteric in nature

Halides:

- Except for Be halides, all other halides are ionic.
- Tendency to form halide hydrates decreases gradually.
- Salts of oxoacids: Forms carbonates, sulphates and nitrates.
- Anomalous behavior of Be: Small atomic and ionic sizes, does not exhibit C.N. more than four, its oxide and hydroxide are amphoteric.
- Be shows diagonal relationship with Al.

Biological Importance Of Mg And Ca:

- All enzymes that utilise ATP in PO_4 transfer requires Mg as cofactor. Chlorophyll contains Mg. Ca is present in bones and teeth. Important in neuromuscular function, intraneuronal transmission and blood coagulation.

Electronic Configuration

ns^1 : Alkaline metals; ns^2 : Alkaline earth metals

Important Compounds of Sodium:

(i)Sodium Carbonate (Washing Soda): Preparation: By Solvay process $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

$(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$

$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

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

Properties: (a)White, crystalline solid. (b)Readily soluble in water

$Na_2CO_3 \cdot 10H_2O \xrightarrow{375K} Na_2CO_3 \times H_2O + 9H_2O$

$Na_2CO_3 \cdot H_2O \xrightarrow{>373K} Na_2CO_3 + H_2O$

Uses: Water softening, laundering, cleaning, manufacture, as laboratory reagent.

(*i*)Sodium Chloride *(Nacl)*

Preparation: Crude NaCl by crystallization of brine solution.

-Pure NaCl is obtained by dissolving crude salt in minimum water and filtered to remove insoluble impurities. Solution is saturated with HCl gas. Uses: As common salt.

(ii)Sodium Hydroxide (NaOH)

Preparation: By electrolysis of NaCl in Castner-Kellner cel.

Uses: In manufacture of soap, paper, petroleum refining.

(iii)Sodium Hydrogencarbonate ($NaHCO_3$)

Preparation: $Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$

Important Questions

Multiple Choice questions-

Question 1. Beryllium shows diagonal relationship with

(a) Mg

(b) Na

(c) Al

(d) B.

Question 2. Which of the following metal has stable carbonates?

(a) Na

(b) Mg

(c) Al

(d) Si

Question 3. The reaction of Cl_2 with X gives bleaching powder X is

(a) CaO

(b) $Ca(OH)_2$

(c) $Ca(OCl)_2$

(d) $Ca(O3Cl)_2$

Question 4. NaOH is prepared by the method

(a) Downs cell

(b) Castner cell

(c) Solvay process

(d) Castner – Kellner cell.

Question 5. Milk of lime reacts with chlorine to form _________, a constituent of bleaching powder.

(a) $Ca(OCl)_2$

(b) $Ca(ClO_2)_2$

(c) $Ca(ClO_3)_2$

(d) $Ca(ClO_4)_2$

Question 6. Which one of these are main components of kidney stones?

(a) Sodium Oxalate

(b) Potassium Oxalate

(c) Calcium Oxalate

(d) Copper Oxalate

Question 7. A nitrate of an alkali metal M on heating gives $O_2.NO_2$ and M_2O. The metal M will be:

(a) Na

(b) K

(c) Rb

(d) Li

Question 8. Which of the following metal carbonates decompose on heating?

(a) $LiCO_3$ & $MgCO_3$

(b) Na_2CO_3

(c) K_2CO_3

(d) None of the Above

Question 9. Which of the following alkaline earth metals do not impart any color to the flame?

(a) Ca,Sr

(b) Mg,Ca

(c) Be,Mg

(d) Sr,Ba

Question 10. Which one of the following alkali metals emit light of longest wavelength in the flame test?

(a) Na

(b) K

(c) Cs

(d) Li

Question 11. What will be final weight of 286 gm $Na_2CO_3.10H_2O$ by Heating at 373 K?

(a) 206 gm

(b) 162 gm

(c) 186 gm

(d) 124 gm

Question 12. Solubilities of carbonates decrease down the magnesium group due to decrease in

(a) Entropy of solution formation

(b) Lattice energies of solids

(c) Hydration energy of cations

(d) Inter – ionic attraction.

Question 13. What are the products formed when Li_2CO_3 undergoes decomposition?

(a) Li_2O_2, CO

(b) Li_2O, CO

(c) Li_2O, CO_2

(d) LiO_2, CO

Question 14. Alkali metals give a __________ when dissolved in liquid ammonia

(a) Deep blue solution

(b) Colorless

(c) Red colour

(d) None of the Above

Question 15. ________ does not exhibit coordination number more than four.

(a) Magnesium

(b) Beryllium

(c) Calcium

(d) None of the Above

Very Short:

1. Which element is found in chlorophyll?
2. Name the elements (alkali metals) which form superoxide when heated in excess of air.
3. Why is the oxidation state of Na and K always + 1?
4. Name the metal which floats on the water without any apparent reaction with water.
5. Why do group 1 elements have the lowest ionisation enthalpy?
6. Why does the following reaction
7. Amongst Li, Na, K, Rb, Cs, Fr which one has the highest and which one has the lowest ionisation enthalpy?

8. What is the general electronic configuration of alkali metals in their outermost shells?
9. What is meant by dead burnt plaster?
10. Name three forms of calcium carbonate.

Short Questions:

1. Why the solubility of alkaline metal hydroxides increases down the group?
2. Why the solubility of alkaline earth metal carbonates and sulphates decreases down the group?
3. Why cannot potassium carbonate be prepared by the SOLVAY process?
4. What are the main uses of calcium and magnesium?
5. What is meant by the diagonal relationship in the periodic table? What is it due to?
6. Why is the density of potassium less than that of sodium?

Long Questions:

1. Why is it that the s-block elements never occur in a free state? What are their usual modes of occurrence?
2. Explain what happens when:
   (a) Sodium hydrogen carbonate is heated.
   (b) Sodium with Mercury reacts with water.
3. What is the effect of heat on the following compounds?
   (a) Calcium carbonate
   (b) Magnesium chloride hexahydrate
   (c) Gypsum
4. State as to why
   (a) An aqueous solution of sodium carbonate gives an alkaline test.
   (b) Sodium is prepared by electrolytic method & not by chemical method.
   (c) Lithium on being heated in the air mainly forms mono-oxide & not the peroxides.
5. What raw materials are used for making cement? Describe the manufacture of Portland cement. What is its approximate composition?

Assertion Reason Questions:

1. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

Assertion (A): The carbonate of lithium decomposes easily on heating to form lithium oxide and CO2.

Reason (R) : Lithium being very small in size polarises large carbonate ion leading to the formation of more stable Li2O and CO2.

(i) Both A and R are correct and R is the correct explanation of A.

(ii) Both A and R are correct but R is not the correct explanation of A.

(iii) Both A and R are not correct

(iv) A is not correct but R is correct.

2. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

   Assertion (A): Beryllium carbonate is kept in the atmosphere of carbon dioxide.

   Reason (R) : Beryllium carbonate is unstable and decomposes to give beryllium oxide and carbon dioxide.

   (i) Both A and R are correct and R is the correct explanation of A.

   (ii) Both A and R are correct but R is not the correct explanation of A.

   (iii) Both A and R are not correct.

   (iv) A is not correct but R is correct.

Case Study Based Question:

1. Alkali metals have the lowest ionization energy in their corresponding period in periodic table because they have large size which results in a large distance between the nucleus and the outermost electron. Ionization energy of alkali metals decreases from Li to Cs due to increase in atomic size. First ionization energy of alkali metals is very low but they have very high value of second ionization energy.

$$\underset{[\text{noble gas}]\,ns^1}{M_{(g)}} \xrightarrow{1^{st}\,I.E.} \underset{[\text{noble gas}]}{M^+} + e^-$$

Metal	Ionization Energy ($kJ\ mol^{-1}$)	
	IE_1	IE_2
Li	520.1	7296
Na	495.7	4563
K	418.6	3051
Rb	402.9	2633
Cs	375.6	2230

(1) Alkali metals are characterised by:

(a) Good conductors of heat and electricity

(b) High melting points

(c) Low oxidation potentials

(d) High ionisaiton potentials.

(2) Metals dissolve in liquid ammonia giving coloured solutions which are conducting in nature. The colour of the solution and reason of its conductance is:

(a) Yellow, NH_4^+

(b) Blue, ammoniated metals

(c) Orange, $[M(NH_3)_x]^+$

(d) Blue, ammoniated electron

(3) Alkali metals displace hydrogen from water forming bases due to the reason that:

(a) They are far above the hydrogen in electrochemical series based on oxidation potential.

(b) They are far below the hydrogen in electrochemical series based on oxidation potential.

(c) Their ionization potential is less than that of other elements.

(d) They contain only one electron in their outermost shell.

2. All alkali metals dissolve and form blue solution in liquid ammonia. When alkali metals are dissolved in liquid ammonia, there is a considerable expansion in total volume hence such solutions are called expanded metals. The blue solution of an alkali metal in ammonia shows certain characteristic properties which are explained on the basis of formation of ammoniated (solvated) metal cations and ammoniated electrons in the metal ammonia solution in the following way :

$$M \longrightarrow M^+ + e^-$$
$$M^+ + x\mathrm{NH_3} \longrightarrow [M(\mathrm{NH_3})_x]^+$$
$$e^- + y\mathrm{NH_3} \longrightarrow [e(\mathrm{NH_3})_y]^-$$
$$\text{Thus, } M + (x+y)\mathrm{NH_3} \rightarrow \underset{\substack{\text{Ammoniated}\\ \text{metal cation}}}{[M(\mathrm{NH_3})_x]^+} + \underset{\substack{\text{Ammoniated}\\ \text{electron}}}{[e(\mathrm{NH_3})_y]^-}$$

The blue solution is paramagnetic and has high electrical conductivity due to the presence of unpaired electron in the cavities in ammoniacal solution.

(1) Sodium dissolves in liquid NH3 to give a deep blue solution. This is due to:

(a) Ammoniated Na^+

(b) Ammoniated Na^-

(c) Formation of Na^+/Na^- pair

(d) Ammoniated electrons.

(2) The increasing order of the density of alkali metals is:

(a) Li < K < Na < Rb < Cs

(b) Li < Na < K < Rb < Cs

(c) Cs < Rb < Na < K < Li

(d) Cs < Rb < K < Na < Li

(3) The reaction between sodium and water can be made less vigorous by:

(a) Lowering the temperature

(b) Adding a little alcohol

(c) Amalgamating sodium

(d) Adding a little acetic acid.

Answer Key:

MCQ

1. (c) Al
2. (a) Na
3. (c) $Ca(OCl)_2$
4. (d) Castner – Kellner cell.
5. (a) $Ca(OCl)_2$
6. (c) Calcium Oxalate
7. (d) Li
8. (a) $LiCO_3$ & $MgCO_3$
9. (b) Mg,Ca
10. (b) K
11. (d) 124 gm

12.(c) Hydration energy of cations

13.(c) Li_2O, CO_2

14.(a) Deep blue solution

15.(b) Beryllium

Very Short Answer:

1. Magnesium

2. Potassium, rubidium and caesium.

3. It is due to their high second ionisation enthalpy and stability of their ions [Na+, K+].

4. Lithium floats on the water without any apparent reaction to it.

5. Because of the largest size in their respective periods, solitary electron present in the valence shell can be removed by supplying a small amount of energy.

6. Because larger K+ cation stabilizes larger anion.

7. Li has the highest and Fr has the lowest ionisation enthalpy.

8. ns1 where n = 2 to 7.

9. It is anhydrous calcium sulphate (CaS04).

10. Limestone, chalk, marble.

Short Answer:

Ans: 1. If the anion and the cation are of comparable size, the cationic radius ‘vill influence the lattice energy. Since lattice energy decreases much more than the hydration energy with increasing ionic size, solubility will increase as we go down the group. This is the case of alkaline earth metal hydroxides.

Ans: 2. If the anion is large compared to the cation, the lattice; energy will remain almost constant within a particular group. Since the hydration energies decrease down the group, solubility will decrease as found for alkaline earth metal carbonates and sulphates.

Ans: 3. If the anion is large compared to the cation, the lattice; energy will remain almost constant within a particular group. Since the hydration energies decrease down the group, solubility will decrease as found for alkaline earth metal carbonates and sulphates.

Ans: 4. Main uses of calcium:

1. Calcium is used in the extraction of metals from oxides which are difficult to reduce with carbon.

2. Calcium, due to its affinity for O2 and N2 at elevated temperatures, has often been used to remove air from vacuum tubes.

Main uses of Magnesium:

1. Magnesium forms alloys with Al, Zn, Mn and Sn. Mg-Al alloys being light in mass are used in aircraft construction.

2. Magnesium (powder and ribbon) is used in flashbulbs, powders incendiary bombs and signals.

3. A suspension of Mg (OH)2 in water is used as an antacid in medicine.

4. Magnesium carbonate is an ingredient of toothpaste.

Ans: 5. It has been observed that some elements of the second period show similarities with the elements of the third period situated diagonally to each other, though belonging to different groups. This is called a diagonal relationship.

	Group I	Group II	Group III	Group IV
Second period:	Li	Be	B	C
Third period:	Na	Mg	Al	Si

The cause of the diagonal relationship is due to the similarities in properties such as electronegativity, ionisation energy, size etc. between the diagonal elements. For example, on moving from left to right across a period, the electronegativity increases, which on moving down a group, electronegativity decreases. Therefore, on moving diagonally, two opposing tendencies almost cancel out and the electronegativity values remain almost the same as we move diagonally.

Ans: 6. Generally, in a group density increases with the atomic number, but potassium is an exception. It is due to the reason that the atomic volume of K is nearly twice Na, but its mass (39) is not exactly double of Na (23). Thus the density of potassium is less than that of sodium.

Long Answer:

Ans: 1. The elements belonging to s-block in the periodic table. These metals (Alkali & alkaline earth metals) are highly reactive because of their low ionization energy. They are highly electropositive forming positive ions. So, they are never found in a free state. They are widely distributed in nature in a combined state. They occur in the earth's crust in the form of oxides, chlorides, silicates & carbonates.

Ans: 2. Sodium hydrogen carbonate on heating decomposes to sodium carbonate.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O \ CO_2$$

When sodium with mercury reacts with water. It produces sodium hydroxide.

$$2Na\ Hg + 2H_2O \xrightarrow{\Delta} 2NaOH + H_2\uparrow + 2Hg$$

Ans: 3.

$$CaCO_3 \xrightarrow{1070K} CaO + CO_2$$

$$MgCl_2.6H_2O \xrightarrow{\Delta} Mg(OH)\ Cl + HCl + 5H_2O$$

$$CaSO_4.2H_2O \xrightarrow{120°C} (CaSO_4)_2 \ . \ H_2O$$

Ans: 4. Sodium carbonate gets hydrolise by water to form an alkaline solution.

$CO3^{2-} + H_2O \rightarrow HCO_3^- + OH$

Due to this, it gives an alkaline test.

Sodium is a very strong reducing agent. Therefore, it cannot be isolated by a general reduction of its oxides or other compounds. The metal formed by electrolysis will immediately react with water forming hydroxides. So, sodium is prepared by the electrolytic method only.

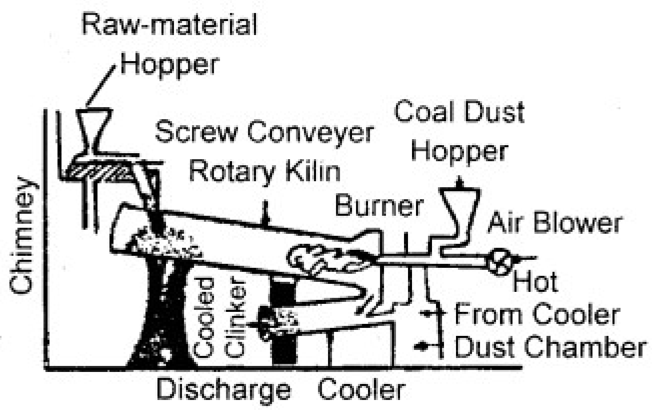
Lithium is the least reactive but the strongest reducing agent of all the alkali metals. It combines with air, it forms mono-oxide only because it does not react with excess air.

$$2Li + \frac{1}{2}O_2 \longrightarrow \underset{\text{(Lithium monoxide)}}{Li_2O}$$

Ans: 5. Raw materials: The raw materials required for the manufacture of cement are limestone, stone and clay, limestone in calcium carbonate, $CaCO_3$ and it provides calcium oxide, CaO. Clay- is a hydrated aluminum silicate, Al_2O_3 2Si02.2H20 and it provides alumina as well as silica. A small amount of gypsum, CaS04.2H20 is also required. It is added in calculated quantity in order to adjust the rate of setting of cement.

Manufacture: Cement is made by strongly heating a mixture of limestone and clay in a rotatory kiln. Limestone and clay are finely powdered, and a little water is added to get a thick paste called slurry. The slurry is led into a rotatory kiln from the top through the hopper.

The hot gases produce a temperature of about 1770-1870 K in the kiln. At this high temperature, the limestone and clay present in the slurry combine to form cement in the form of small pieces called clinker. This clinker is mixed with 2 – 3 % by weight of gypsum ($CaSO_4 .2H_2O$) to regulate the setting time and is then ground to an exceedingly fine powder.



Manufacture of cement

$$\text{Lime stone} + \text{Clay} \xrightarrow{1770-1870K} \underset{\text{(clinker)}}{\text{Cement}} + CO_2\uparrow + H_2O\uparrow$$

When mixed with water the cement reacts to form a gelatinous mass which sets to a hard mass when three-dimensional cross-links are formed between

…………..Si — O — Si……… and …….. Si — O — Al…… chains.

Composition of cement:

CaO = 50 – 60%

SiO_2 = 20 – 25%

Al_2O_3 = 5 – 10%

MgO = 2 – 3%

Fe_2O_3 = 1 – 2%

SO_3 = 1 – 2%

For a good quality cement, the ratio of silica (SiO_2) and alumina (Al_2O_3) should be between 2.5 to 4.0. Similarly, the ratio of lime (CaO) to the total oxide mixtures consisting of SiO_2, Al_2O_3 and Fe_2O_3 should be roughly 2: 1. If lime is in excess, the cement cracks during setting. On the other hand, if lime is less than required, the cement is weak in strength. Therefore, the proper composition of cement must be maintained to get cement of good quality.

Assertion Reason Answer:

1. (i) Both A and R are correct and R is the correct explanation of A.
2. (i) Both A and R are correct and R is the correct explanation of A.

Case Study Answer:

1. Answer:

(1) (a) Good conductors of heat and electricity

(2) (d) Blue, ammoniated electron

(3) (b) They are far below the hydrogen in electrochemical series based on oxidation potential.

2. Answer:

(1) (d) Ammoniated electrons

(2) (a) Li < K < Na < Rb < Cs

(3) (c) Amalgamating sodium.