INTRODUCTION

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.
IA - Alkali metals Li Na K Rb Cs
IIA - Alkaline earth metals Be Mg Ca Sr Ba

PHYSICAL PROPERTIES OF S-BLOCK ELEMENTS

The atomic, physical and chemical properties of alkali metals are discussed below.

PHYSICAL STATE

ALKALI METAL	ALKALINE EARTH METAL
• One electron in outermost shell & ***General electronic configuration is ns^1***.	• Two electrons in outer most shell & ***General configuration is ns^2.***
• Francium is radioactive element.	• Radium is radioactive element.
• All are silvery white	• All are greyish white.
• Light soft, malleable and ductile metals with metallic lustre.	• These metals are harder than alkali metals.
• Alkali metals are paramagnetic, while their ions are diamagnetic and colourless.	• These are diamagnetic and colourless in form of ions or in metal states.

ATOMIC SIZE

• Biggest in their respective period (except noble gas element)	• Smaller than IA group elements, since extra charge on nucleus attracts the electron cloud more.
• Size increases from Li to Fr due to addition of an extra shell. in atomic and gaseous state Li < Na < K < Rb < Cs < Fr in aquatic state $\overset{+1}{Li} > \overset{+1}{Na} > \overset{+}{K} > \overset{+}{Rb} > \overset{+1}{Cs}$	• Size increases gradually from Be to Ra Be < Mg < Ca < Sr < Ba ***In s-block elements*** Be is the smallest, Cs is the biggest ***in aq. state*** $Mg^{+2}_{(aq)} > Ca^{+2}_{(aq)} > Sr^{+2}_{(aq)} > Ra^{+2}_{(aq)}$

SOFTNESS

• Alkali metals are soft because of - (a) Large atomic size (b) BCC crystal structure (HCP in Li) (c) Loose packing (68% packing efficiency) (d) Weak metallic bond	• These metals are slightly harder than IA group because of - (a) Smaller atomic size (b) FCC, HCP crystal structures (c) Packing capacity 74% (d) Stronger metallic bond due to presence of two electrons in valence shell.
• Cs is the softest metal in s-block	• Be is the hardest metal in s-block.

MELTING POINT AND BOILING POINT

• Decreasing order of melting point and boiling point is Li > Na > K > Rb > Cs	• Metallic bond is stronger than IA group elements due to smaller atomic size and two electrons in valence shell hence melting point and boiling point are higher. • Decreasing order of melting point and boiling point is Be > Ca > Sr > Ba > Mg

Melting & Boiling point $\propto$ Strength of metallic bond

IONISATION POTENTIAL (I.P.)

- Decreasing order of ionisation potential -
  Li > Na > K > Rb > Cs
- $I.P_{II} > I.P_{I}$
- Decreasing order of ionisation potential–
  Be > Mg > Ca > Sr > Ba
- $I.P_{I} > I.P_{II}$

OXIDATION STATE

- The alkali metals shows only + 1 oxidation state. (I^{st} and 2^{nd} ionisation potential difference > 16eV)
- Alkaline earth metal shows +2. Oxidation state (I^{st} and 2^{nd} ionisation potential difference < 11eV)

ELECTRO POSITIVE CHARACTER OR METALLIC CHARACTER

- $\text{Electropositivity} \propto \frac{1}{\text{Ionisation Potential}}$
  Electropositivity in both groups ↑ down the group
- Their atomic size is smaller than IA group so these are lesser electro positive than IA group. Electropositivity increases from Be to Ba

DENSITY

- (D = M /V)
- Li < K < Na < Rb < Cs
- Ca < Mg < Be < Sr < Ba
- K < Na < Ca < Mg

FLAME TEST

Li-Crimson red Na-Golden yellow K-Violet
Rb-Red violet Cs-Blue

- Be and Mg atoms, due to small size, bind their electrons more strongly, so are not excited to higher level, hence no flame test.
  Ca-Brick red Sr-dark red Ba-apple green or Crimson red

PHOTO ELECTRIC EFFECT

- Due to very low ionisation potential their valence shell electrons gets excited even by absorbing visible light. That's why Cs is used in photo cells.
- These elements do not show this property as their atomic size is small hence ionisation potential is higher than IA group.

HYDRATION ENERGY (HEAT OF HYDRATION)

- Alkali metals salts are generally soluble in water due to hydration of cations by water molecules.
- Smaller the cation, greater is the degree of its hydration.
- Li^{+} Na^{+} K^{+} Rb^{+} Cs^{+} →
  * Degree of hydration decreasing
  * Hydration energy decreasing
  * Hydrated ion size decreasing
  * Ionic conductance increasing
- Due to smaller ionic size and higher charge density their hydration energy is high.
- Its decreasing order is
  $Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$
- ***Hydration energy ∝ 1/cation size***

REDUCING PROPERTY

- Since alkali metals have high standard oxidation potential, so these are strongest reductants.
- Reducing property increases down the group in gaseous or molten state
  Li < Na < K < Rb < Cs
- But in aqueous solution order is -
  Li > K ≃ Rb > Cs > Na
- Less reductant than alkali metals
- Order of reducing property in aqueous and gaseous medium is
  Be < Mg < Ca < Sr < Ba

REACTIVITY - INCREASES IN GROUP

Reactivity $\propto$ 1/Ionisation potential

order of reactivity – Li < Na < K < Rb < Cs

- Less reactive than alkali metals.
- Order of reactivity

  Be < Mg < Ca < Sr < Ba

REACTION WITH OXYGEN

Li Oxide, Na Oxide & peroxide, K Rb Cs Super oxide

(Li_2O) (Na_2O_2) (KO_2, RbO_2, CsO_2)

- Their stability order is –

Normal oxide (paramagnetic) > Peroxide (diamagnetic) > Superoxide (paramagnetic)

Be Mg Ca Oxide; Sr Ba Peroxide

- Peroxides are coloured due to Lattice defect.

BeO MgO CaO SrO BaO → Basic strength increases

REACTION WITH HYDROGEN

- Alkali metals combine with H_2 forming ionic hydrides

  $2M + H_2 \rightarrow 2MH$
- LiH is covalent hydride while others are ionic.
- Hydrides of alkali metals are attacked by water to give H_2

LiH, NaH, KH, RbH, CsH → Thermal stability decreases, Basic nature increases

- Except Be all the alkaline metals forms MH_2 type hydrides, (MgH_2, CaH_2, SrH_2, BaH_2) on heating directly with H_2
- BeH_2 and MgH_2 are covalent, others are ionic.
- Be and Mg have tendency of polymerisation.

  $(BeH_2)_n$ $(MgH_2)_n$ Polymeric hydride

REACTION WITH WATER

- Monoxides gives strong alkaline solution with water

  $M_2O + H_2O \rightarrow 2MOH$

  LiOH < NaOH < KOH < KbOH < CsOH

Order of reactivity Ba > Sr > Ca > Mg > Be

- from $Be(OH)_2$ to $Ba(OH)_2$ basic nature and stability increases.

CARBONATES

- All the alkali metals forms M_2CO_3 type carbonates.
- Except Li_2CO_3, all the carbonates are stable towards heat

$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$ $Na_2CO_3 \xrightarrow{\Delta}$ x

- Thermal stability of carbonates $\propto$ $1/\phi$ (Ionic potential)

  Order of thermal stability is –

  $Cs_2CO_3 > Rb_2CO_3 > K_2CO_3 > Na_2CO_3 > Li_2CO_3$

- All the alkaline metals forms MCO_3 type carbonates.
- All the carbonates decompose on heating.

$BeCO_3 \xrightarrow{\Delta} BeO + CO_2$

- Order of decreasing thermal stability -

  $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3 > BeCO_3$

NITRATES

- Stability increases from $LiNO_3$ to $CsNO_3$. $LiNO_3$ decompoes into Lithium oxide & NO_2 on heating.

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

- Other nitrates, on heating, give nitrite and oxygen.

$2MNO_3 \xrightarrow{\Delta} \underset{\text{Nitrite}}{2MNO_2} + O_2$

- Stability increases from $Be(NO_3)_2$ to $Ba(NO_3)_2$ but these are less stable than IA group, due to smaller atomic size.
- All alkaline metals nitrates on heating gives oxides and $NO_2 + O_2$

$M(NO_3)_2 \xrightarrow{\Delta}$ Metal Oxides $+ NO_2 + O_2$

- $Be(NO_3)_2$ forms a layer of BeO on its surface so reaction stops.

NITRIDES

- Only Li reacts directly with N_2 to form nitride which gives NH_3 on hydrolysis.

  $6Li + N_2 \rightarrow 2Li_3N$

  $Li_3N + 3H_2O \rightarrow 3LiOH + NH_3\uparrow$

- Only Be and Mg burns in N_2 to give M_3N_2 (Be_3N_2, Mg_3N_2)

  $Be_3N_2 + 6H_2O \rightarrow 3Be(OH)_2 + 2NH_3$

  $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

SULPHATES

- All alkali metal sulphates are ionic. Ionic properties increases from Li to Cs.
- Li_2SO_4 Least soluble in water.
- These sulphates on burning with C forms sulphides

  $M_2SO_4 + 4C \rightarrow M_2S + 4CO$

- Except lithium, sulphates of IA group reacts with sulphates of trivalent metals like Fe^{+3}, Cr^{+3}, Al^{+3} etc. to form double salts called alum.

  I III

  $M_2SO_4.M_2(SO_4)_3.24H_2O$

- Ionic nature of alkaline metal sulphat is increases from Be to Ba

  $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

- Order of solubility–

  $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

- Order of thermal stability–

  $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

  $\longrightarrow$

  Ionic nature increases, Thermal stability increases

SOLUBILITY IN LIQUID AMMONIA

- All the alkali metals dissolves in NH_3 (liq.) and produces blue solution.
- This blue solution conducts electricity and possesses strong reducing power, due to the presence of ammoniated electrons.

  $Na_{(s)} + (x+y)\,NH_3 \rightarrow [Na(NH_3)_x]^+ + [e(NH_3)_y]^-$

  ammoniated electron

- Dark blue colour of solution becomes fade if it allowed to stand for a long time, it is because of metal amide formation.
- This dilute solution is paramagnetic in nature.
- $2Li + NH_3 \rightarrow Li_2NH$ (Lithimide) $+ H_2$

  $2Na + 2NH_3 \rightarrow 2NaNH_2 + H_2\uparrow$

  (Sodamide)

- Only Ca, Sr and Ba gives blue solution due to ammoniated electron.
- Be and Mg are small in size and have high ionisation potential so do not dissolves in liquid NH_3.
- Blue colour of solution disappears on addition of ammonium salt, due to NH_3 formation.

  $NH_4^+ + NH_2^- \rightarrow 2NH_3$

- On increasing metal ion concentration solution converts into bronze colour due to cluster formation of metal ions.

Sodium Hydroxide (NaOH), Caustic Soda

(a) *Manufacture :*

Castner – Kellner Cell : (Hg – Cathode Process)

Electrolite (Brine) $NaCl \rightleftharpoons Na^+ + Cl^-$

On electrolysis–

At Cathode (Hg)

$Na^+ + e^- \rightarrow Na.$; $Na + Hg \rightarrow Na.Hg$ (amalgum)

At anode (Graphite)

$2Cl^- \rightarrow Cl_2(g) + 2e^-$; $2Na.Hg + 2H_2O \rightarrow 2NaOH + H_2 + 2Hg$

Sodium Bicarbonate or Baking soda ($NaHCO_3$)

(a) *Preparation : Solvay process* (Commercial Scale)

$CaCO_3 \longrightarrow CaO + CO_2$ (In brine saturated with NH_3, CO_2 is passed)

$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$

$NaCl + NH_4HCO_3 \longrightarrow NH_4Cl + NaHCO_3$

$2NH_4Cl + CaO \longrightarrow CaCl_2 + 2NH_3 + H_2O$ (By-products)

(b) *Properties :*

Hydrolysis $NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3$

Effect of heat (temp. > 100°C) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2\uparrow$
(Process occurs during preparation of cake)

Reaction with acids – gives CO_2 $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$

Reaction with base $NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$

Sodium Carbonate or Washing Soda ($Na_2CO_3.10H_2O$)

(a) *Occurrence :* Na_2CO_3–Soda ash.

(b) *Manufacture : Solvay process*

(i) Concentrated aqueous solution of NaCl is saturated with NH_3.

(ii) Current of CO_2 passed through the solution.

(iii) $NaHCO_3$ precipitated –

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

(iv) Potassium bicarbonate ($KHCO_3$) cannot be prepared by solvay process as it is highly soluble in water.

(c) *Properties :*

(i) ***Efflorescence :***

$Na_2CO_3.10H_2O$ when exposed to air it gives out nine out of ten H_2O molecules.

$Na_2CO_3.10H_2O \longrightarrow Na_2CO_3.H_2O + 9H_2O$
(Monohydrate)

This process is called efflorescence. Hence washing soda losses weight on exposure to air.

(ii) ***Hydrolysis :***Aqueous solution of Na_2CO_3 is alkaline in nature due to anionic hydrolysis.

(c) Uses

(i) For making fusion mixture ($Na_2CO_3 + K_2CO_3$)

(ii) In the manufacturing of glass, caustic soda, soap powders etc.

(iii) In laundries and softening of water.

Plaster of Paris $(CaSO_4)_2.H_2O$ or $CaSO_4.1/2\ H_2O$

(a) Preparation : It obtained when gypsum is heated at 120°C

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

Gypsum

(b) Properties :

(i) It is a white powder.

(ii) It has the property of setting to a hard mass when a paste with water is allowed to stand aside for sometime.

(iii) When it heated at 200°C, anhydrous $CaSO_4$ is formed K/as dead burnt P.O.P.

(c) Uses

$$CaSO_4.\frac{1}{2}H_2O \xrightarrow[\Delta]{200^\circ C} \underset{\substack{\text{dead burnt+P.O.P.}\\(\text{very high T})}}{CaSO_4} + H_2O \rightarrow CaO + SO_3$$