* S-Block :-

IA alkali metals		IIA alkaline earth metals
$_{3}Li$		Be
$_{11}Na$	) 8	Mg
$_{19}K$	) 8	Ca
$_{37}Rb$	) 18	Sr
$_{55}Cs$	) 18	Ba
$_{87}Fr^{*}$	) 32	Ra^{*}
ns^1 config		ns^2 config

size ↑ ↓

Radioactive

$$Na = 1s^2 \underbrace{2s^2\, 2p^6}_{8e^{\ominus}} 3s^1$$

$$K = 1s^2 2s^2 2p^6 \underbrace{3s^2\, 3p^6\, 3d^0}_{18e^{\ominus}} 4s^1$$

vol. of K >> vol. of Na

Physical Properties of Alkali Metals :-

(a) Atomic Size because $n\uparrow$

(b) I.E ↓ becoz $n\uparrow$

$Li > Na > K > Rb > Cs < Fr^{*}$
$Be > Mg > Ca > Sr > Ba < Ra$ } due to poor shielding effect of 4f sub-shell.

(c) $D = \dfrac{M\uparrow}{V\uparrow}$

- D ↑ down the group

$Li < \overset{**}{Na > K} < Rb < Cs$

$D_{Na} > D_K$

(d) Photoelectric effect :- increases down the group because ionisation energy decrease.

Generally, K, Rb, Cs are used in photocell.

(e) electropositive character :- increases down the group because I.E. ↓.

(f) Crystalline structure :- BCC structure have C.N. = 8

(g) M.B.S. $\propto$ no. of upe

$\propto \dfrac{1}{size}$

* Lithium is harder than other elements of group IA because of high M.B.S. Also known as analogus behaviour of Lithium.

Down the group, M.B.S ↓

$Li > Na > K > Rb > Cs > Fr$

liq at 27°C

M.B.S ∝ BP/MP

$Li > Na > K > Rb > Cs > Fr$

liq at 27°C (not Room temperature)

(h) Reducing power:-

$Li > Cs > Rb > K > Na$

S.R.A

due to high H.E.

$$M_{(s)} \xrightarrow{\Delta H_f} M^{+n}_{(aq)} + ne^{\ominus}$$

$$M_{(s)} \xrightarrow{\Delta H_{sb}} M_{(g)} \xrightarrow{I.E.} M^{+}_{(g)} \xrightarrow{-\Delta H_{hy}} M^{+n}_{(aq)}$$

$$\Delta H_f = \Delta H_{sb} + I.E. - \Delta H_{hy}$$

(i) These metals are soft and easily cut by Knife. They have metallic lustre due to oscillation of $e^{\ominus}$.

* Chemical Properties:-

→ These metals are more reactive and form ionic compound except LiX ($X = Cl, Br, I$) is predominantly covalent. LiF = Ionic.

→ These metals are kept in Kerosene oil except Li. Li is lighter, so it is kept in paraffin paper.

* **Rxn with O_2 :-**

(a) $Li + O_2 \longrightarrow \underset{\text{(little } Li_2O_2)}{Li_2O} \xrightarrow{\text{excess}} \times$

(b) $Na + O_2 \longrightarrow Na_2O \xrightarrow{\text{excess}} \underset{}{Na_2O_2} \xrightarrow{\text{excess}} \times$ (little NaO_2)

(c) $M + O_2 \longrightarrow M_2O \xrightarrow{\text{Controlled}} M_2O_2 \xrightarrow{\text{excess}} MO_2$
(K, Rb, Cs) (oxide) (Peroxide) (Superoxide)

logic :- (i) These cations are stabilised by the comparable size of anion.
(ii) High polarising power of Li make it able to hold 'O' with high $e^{\ominus}$ density.

Note :- $O^{-2} \xrightarrow{\frac{1}{2}O_2} O_2^{-2} \xrightarrow{O_2} 2O_2^{\ominus}$
Oxide peroxide superoxide

* **Rxn with N_2 :-**

(a) $Li + N_2 \xrightarrow{\Delta} Li_3N \xrightarrow{\text{Hydrolysis}} LiOH + NH_3$
$Li_3N \xrightarrow{\Delta} Li + N_2$

(b) $M + N_2 \longrightarrow \times$
(Na, K, Rb, Cs)

* **Rxn with H_2 :-**

(a) $M + H_2 \longrightarrow M^+H^{\ominus}$
ionic
(high melting) → solids

(b) LiH – It is used as source of H_2 ~~for~~ military purpose and meterological balloons.

* Stability of Hydride decreases down the group.

(e) Reactivity order for formation of hydride :-

~~LiH > NaH >~~ Imp **

$Li > Na > K > Rb > Cs$ (lattice energy decide factor.)

* Rx^n with Halogen :-

(a) $M + X_2 \longrightarrow MX$

Ionic but LiX = covalent ($X = Cl, Br, I$)

(b) Order of reactivity For F_2,

$Li > Na > K > Rb > Cs$ } L.E. dominates bcz of comparable size

(c) Order of reactivity for Br_2; I_2

$Li < Na < K < Rb < Cs$ } I.E. dominates

(d) Alkali metal halide are water soluble except LiF which is sparingly / insoluble because of high LE.

Imp ** (e) Generally, lithium salts are hydrated due to high polarising power.

$LiCl \cdot 3H_2O$

→ Integer type.

Note:- Gun powder = S + Charcoal + Nitrate.

Nitrates which can be used here are:-

(a) $LiNO_3$ ✗ } due to strong polarisation, they get hydrated.

(b) $NaNO_3$ ✗

(c) KNO_3 ✓

* Reacn with $NH_3(g)$:-

(a) $M + NH_3(g) \longrightarrow MNH_2 \xrightarrow{Hydrolysis} MOH + NH_3$
(Na, K, Rb, Cs) (amide)

(b) $Li + NH_3(g) \longrightarrow Li_2NH \xrightarrow{''} LiOH + NH_3$
(imide)

Imp
**
* Rxn with $NH_3(l)$:-

(a) $M + (x+y)NH_3 \longrightarrow [M(NH_3)_x]^{\oplus} + [e(NH_3)_y]^{\ominus}$

* Blue colour
* Conductor
* ammoniated $e^{\ominus}$
* S.R.A.
* paramagnetic

(b) If conc. soln of M in NH_3 is used, then, blue colour changes to bronze and paramagnetic behaviour decreases because of increase in collision.

due to amide form.

(c) On standing, this soln liberates hydrogen due to amide form. If catalytic impurities (Pt, Zn, Fe) are absent, then soln becomes stable.

**
(d) Metal can be recovered from soln of alkali metals while ammoniates can be recovered from alkaline earth metal.

(e) Be, Mg donot form soln in liq. NH_3 bcz of ↑ I.E.

Imp
**
(f) $[Ni(CN)_4]^{-2} \xrightarrow[\text{birch redn}]{Na/NH_3(l)} [Ni(CN)_4]^{-4}$

* dsp^2
* ~~tetrahedral~~
* square planar
* Diamagnetic.

* sp^3
* tetrahedral
* Diamagnetic.

* Reaxn with water :-

$$\overset{0}{M} + \overset{+1}{H}-OH \xrightarrow{} \overset{+1}{M}OH + \overset{0}{H_2}$$

Oxi

Red.

Order, Li < Na < K < Rb < Cs

(a) Li reacts gently with water.
(B) Na " vigourously " ".
(c) K, Rb, Cs " violently " ".

This explaination lie in Kinetics, not in thermodynamics. When potassium react with water, then heat of rxn is sufficient to melt it or vapourise it. Molten metal spread on surface increasing surface area and rxn becomes faster.

* Group - II A :-

* Physical properties :-

(a) Atomic size ↑, n ↑

(b) I.E ↓, n ↑

Be > Mg > Ca > Sr > Ba** < Ra

(c) $D = \frac{M\uparrow}{V\uparrow}$ D ↑ down the group with some irregularity.

Be > Mg > Ca < Sr < Ba   > > < <

(d) M.P. ↓ down the group with some irregularity

Be > Mg < Ca > Sr > Ba   > < > >

* Here concept of MBS in MP / BP fails bcz all of them have different crystalline structure.

(e) B.P ↓ , Be > Mg < Ca > Sr < Ba   >< ><

(f) Reducing property

Be < Mg < Ca < Sr < Ba.
↓
weak reducing Agent

* Chemical properties :-

Generally, II A elements form ionic compound except

(a) BeX_2 = Predom. covalent
($X = F, Cl, Br, I$)

(b) $MgX_2 / AlX_3 / LiX$ – Predom. covalent
($X = Cl, Br, I$)

(c) $LiF / MgF_2 / AlF_3$ – Predom. Ionic.

* Reaxn with O_2 :-

(a) $M + O_2 \longrightarrow MO \xrightarrow{excess} \times$
(Be, Mg, Ca)

(b) $M + O_2 \longrightarrow MO \xrightarrow{''} MO_2 \xrightarrow{excess} \times$
(Sr, Ba)   oxide   peroxide

Note:- (a) BeO = covalent but other oxides are ionic having rock salt structure.
(b) BeO = amphoteric & others Basic.
(c) All are stable towards heat.

* Reaxn with N_2 :-

$$M + N_2 \xrightarrow{\Delta} M_3N_2 \xrightarrow{\text{Hydrolysis}} M(OH)_2 + NH_3\uparrow$$

$$M_3N_2 \xrightarrow{\Delta} M + N_2\uparrow$$

* Reaxn with air :-

(a) Be and Mg are Kinetically inert to oxygen and water ~~to oxygen~~ because of formation of oxide film on their surface, however powdered Be brilliantly on ignition in air to beryllium oxide and Be_3N_2. Mg is more electropositive and burns with dazzling brilliance in air to give MgO & Mg_3N_2.

(b) Ca, Sr, Ba are readily attacked by air to form oxide and nitride.

* Rxn with water :-

(a) Alkaline earth metal have lesser tendency to react with water as compared to alkali metal.

(b) * Be = inert
* Mg = react with warm water or when amalgamated with Hg.
* Ca, Sr, Ba = react with cold water.

(c) Mg forms protective layer of MgO, that's why it doesnt react readily unless layer is removed amalgamating with Hg.

* **Reacn with H_2 :-**

(a) $M + H_2 \longrightarrow MH_2 \xrightarrow{\text{Hydrolysis}} M(OH)_2 + H_2$
(Covalent)

(b) $Ca + H_2 \longrightarrow CaH_2 \xrightarrow{\text{Hydrolysis}} Ca(OH)_2 + H_2$
(Hydrolith) ** — same product as $Ca + H_2O$

Imp **
(c) All the elements except Beryllium combine with ~~oxygen~~ hydrogen upon heating to form their hydride.
BeH₂, however, can be prepared by rxn of $BeCl_2$ and $LiAlH_4$

$$\underset{3c-4e^{\ominus}}{BeCl_2} + LiAlH_4 \longrightarrow \underset{3c-2e^{\ominus}}{BeH_2} + LiCl + \underset{3c-4e^{\ominus}}{AlCl_3}$$ **

* **Reacn with X_2 :-**

(a) All the alkaline earth metals combine with halogen and form their halides.

(b) Thermal decomposition of $(NH_4)_2BeF_4$ is the best route for preparation of BeF_2 and $BeCl_2$ is conviently made from the oxide.

(c) The tendency to form halide hydrate gradually decreases down the group.
$MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$, $SrCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$

(d) *Except Be halide, all other halides of alkaline earth metals are ionic in nature and Be halides are essentially covalent and soluble in organic solvent.

(a) $(NH_4)_2BeF_4 \xrightarrow{\Delta} BeF_2 + NH_3$

(b) $BeO + C + Cl_2 \xrightarrow[800°C]{600°C-} BeCl_2 + CO\uparrow$

C → for reducing

* Reaxn with acids :-

Order, $Be < Mg < Ca < Sr < Ba$

Be: weak Reducing agent.

Rxn with X_2 (Remaining)

(e) The dehydration of hydrated chlorides, Bromides and Iodide of Ca, Sr, Ba can be achieved on heating, however, the corresponding hydrated halides of Be and Mg on heating suffer hydrolysis. (g) The fluorides are relatively less soluble than the chlorides due to their high lattice energy.

Keypoint of Rxns of Na_2O_2

Na_2O_2 → $NaOH$, H_2O_2

H_2O_2 → stable at 0°C

O.A. → unstable at 25°C giving H_2O and O_2.

$Na_2O_2 + H_2O \xrightarrow{0°C} NaOH + H_2O_2$

$Na_2O_2 + H_2O \xrightarrow{25°C} NaOH + O_2$

$$Na_2O_2 + H_2SO_4 \xrightarrow{0^\circ C} Na_2SO_4 + H_2O_2$$

$$Na_2O_2 + 2CO_2 \longrightarrow Na_2CO_3 + O_2$$

$$K_2O \xrightarrow{\Delta} K_2O$$
(white) (yellow)

* Solvay Process :- ($NaHCO_3$)

$$NH_3 + H_2O + CO_2 \longrightarrow (NH_4)_2CO_3$$
$$NH_3 + H_2O + (NH_4)_2CO_3 \longrightarrow (NH_4)HCO_3$$

$$NH_4HCO_3 + NaCl \longrightarrow \underbrace{\underset{\text{(Soluble)}}{NH_4Cl} + \underset{\text{(ppt.)}}{NaHCO_3}}_{\text{filtered}}$$
$NaHCO_3$

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

K_2CO_3 can't be prepared bcz $KHCO_3$ is soluble

$$NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + NH_3\uparrow + H_2O$$

In this process, NH_3 is recovered when soln containing NH_4Cl is treated with $Ca(OH)_2$, $CaCl_2$ is obtained by by-product.

Leblanc process :- (Na_2CO_3, K_2CO_3 preparation)

$$NaCl + H_2SO_4\ (conc.) \longrightarrow NaHSO_4 + HCl$$
$$NaCl + NaHSO_4 \xrightarrow[\text{heated}]{\text{strongly}} \underset{\text{(Salt Cake)}}{Na_2SO_4} + HCl$$

$$Na_2SO_4 + C \longrightarrow Na_2S + CO\uparrow$$
$$Na_2S + CaCO_3 \longrightarrow Na_2CO_3 + CaS$$

Castner - Kellner Cell :- (NaOH preparation)

NaOH is generally prepared commercially by electrolysis of NaCl in Caster-Kellner cell. A brine soln is electrolysed using a mercury cathode and a carbon anode. Na metal discharged at cathode combines with mercury to form sodium amalgam. Cl_2 is evolved at the anode

$$Na^+ + e^\ominus \xrightarrow{Hg} \text{Na-amalgam}$$

$$Cl^\ominus \longrightarrow \tfrac{1}{2}Cl_2 + e^\ominus$$

The amalgam is treated with H_2O to give NaOH.

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

Note:- Other methods for preparation of NaOH are
(i) Electrolysis of NaCl. (aq.)
(ii) Gossage's process.

$SnCl_2$ + $HgCl_2$
(RA) (OA)

$NaHCO_3$ + NaOH
(acid) (Base

} Donot exist together.