S-Block Elements

↳ last e^- enters into outermost s-orbital

S-Block

G1	G2
Alkali Metal ↳ rx^n with H_2O → Hydroxide (Strongly alkaline nature)	Alkaline Earth metal ↳ Oxide, hydride → alkaline nature found in Earth Crust.
General Electronic Configuration →	General Electronic Configuration →
[Inert Gas] ns^1	[Inert Gas] ns^2
Oxidation State = +1	Oxidation State = +2
Monovalent Ion = M^+	Divalent Ion = M^{+2}
Li – [He]2s¹ Na – [Ne]3s¹ K – [Ar]4s¹ Rb – [Kr]5s¹ Cs – [Xe]6s¹ Fr – [Rn]7s¹ - Radioactive	Be – [He]2s² Mg – [Ne]3s² Ca – [Ar]4s² Sr – [Kr]5s² Ba – [Xe]6s² Ra – [Rn]7s²

Diagonal Relationship (1st member ke nakhre)

Li → Mg   Be → Al

→ Diagonal relationship is due to similar ionic size, or $\frac{charge}{size}$ ratio.

Physical Properties

Atomic / Ionic Radius →

G1	G2
Period - Largest element in particular period	Period - Smaller than alkali, bcoz Z_{eff} ↑↑.
Group - Down the group size ↑↑.	Group - Down the group size ↑↑.

Ionization Energy →

G1	G2
Ionization energy $\propto \frac{1}{size}$	I.E.₁
Period - I.E. low in a period (size↑)	period - more I.E. than alkali G_2 has more I.E. than G_1.
Group - I.E. ↓↓ from top to bottom	I.E.₂ IE of G_1 > IE_2 of G_2 ↓ Inert gas configuration Group → I.E. ↓↓ from top to bottom

Hydration Enthalpy →

G1	G2
Hydration enthalpy $\propto \frac{Charge}{Size}$	Less size → More hydration.
Less Size → More hydration. $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$ ↓ Max hydration	$Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2} > Ra^{+2}$
Most of lithium salts are hydrated.	B/w alkali and alkaline → alkali - more size, alkaline - Less size.
NaCl → X KCl → X $LiCl \cdot 2H_2O$	→ Alkaline has more hydration energy than alkali. → Mostly G_2 Compounds are hydrated. $MgCl_2 \rightarrow MgCl_2 \cdot 6H_2O$ $CaCl_2 \rightarrow CaCl_2 \cdot 6H_2O$

Physical property →

G1	G2
Silvery white, Soft, light metal.	Silvery white, Soft (harder than G1), lustrous.
Density → Period → Size ↑ → Density ↓ Group → (exception) Li < K < Na < Rb < Cs	Be, Mg → greyish Colour
Melting, Boiling point → Low M.P. and B.P. Weak metallic bond (only 1 valence e^-).	Melting, Boiling point → MP and BP is more than G1. (more metallic bond)
	Electropositive Character → Size↑ दूरियां ↑ e^- break up↑ Size↑ electropositive character ↑ Be < Mg < Ca < Sr < Ba ↳ less tendency to give e^-

Flame — Colour →

G1	G2
Li → Crimson Red Na → Yellow K → Voilet Rb → Red-Voilet Cs → Blue	Be → X Mg → X Ca → Brick Red Sr → Crimson Ba → apple green

Note → Both alkali and alkaline have high electrical and thermal conductivity.

Chemical Property

G_1	G_2
High Reactive (large size, ↓↓ I.E.) e^- free easily. Group → down the grp. Size ↑ → Reactivity ↑	Less Reactive than alkali. Group - down the grp. Size ↑ → Reactivity ↑

Reaction with air

O_2, N_2

dry air + alkali metal → Oxide alkali metal gets tarnished. Moisture air + alkali → Hydroxide	Be + air/water, Mg + air/water } No rx.^{n} in normal condition ↓ becoz of oxide layer formation powdered form of Be, Mg reacts with O_2 and O_2

Reaction with O_2 →

$Li + O_2 \rightarrow Li_2O$ - Oxide (O^{2-}) $Na + O_2 \rightarrow Na_2O_2$ - Peroxide (O^{-1}) $K + O_2 \rightarrow KO_2$ $Rb + O_2 \rightarrow RbO_2$ $Cs + O_2 \rightarrow CsO_2$ } Super oxide ($O^{-\frac{1}{2}}$)	$Be + O_2 \rightarrow BeO$ $Mg + O_2 \rightarrow MgO$ $Ca + O_2 \rightarrow CaO$ $Sr + O_2 \rightarrow SrO$ $Ba + O_2 \rightarrow BaO$

Reaction with N_2 →

$Li + N_2 \rightarrow Li_3N$ Rest do not form nitride Li → Kept in paraffin wax Na, K, Rb, Cs → Kerosene Oil	$Be + N_2 \rightarrow Be_3N_2$ $Mg + N_2 \rightarrow Mg_3N_2$ $Ca + N_2 \rightarrow Ca_3N_2$ $Sr + N_2 \rightarrow Sr_3N_2$ $Ba + N_2 \rightarrow Ba_3N_2$

Reaction of H_2O →

G_1	G_2
Metal + H_2O → Metal Hydroxide + H_2↑ $Li + H_2O \rightarrow LiOH + H_2$ $Na + H_2O \rightarrow NaOH + H_2$ $K + H_2O \rightarrow KOH + H_2$ $Rb + H_2O \rightarrow RbOH + H_2$ $Cs + H_2O \rightarrow CsOH + H_2$	$Ca + H_2O \rightarrow Ca(OH)_2 + H_2$ $Sr + H_2O \rightarrow Sr(OH)_2 + H_2$ $Ba + H_2O \rightarrow Ba(OH)_2 + H_2$ $Mg + H_2O \text{ (hot)} \rightarrow Mg(OH)_2 + H_2$ Be → No Rx.^{n}

Reaction with H_2

Metal + H_2 → Metal hydride (MH) $Li + H_2 \rightarrow LiH$ - 1073K $Na + H_2 \rightarrow NaH$ $K + H_2 \rightarrow KH$ $Rb + H_2 \rightarrow RbH$ $Cs + H_2 \rightarrow CsH$ } 673K metal hydride → Ionic Solid (high melting point)	Metal Hydride (MH_2) Be → X $Mg + H_2 \rightarrow MgH_2$ $Ca + H_2 \rightarrow CaH_2$ $Sr + H_2 \rightarrow SrH_2$ $Ba + H_2 \rightarrow BaH_2$ another method of preparation of BeH_2 → $BeCl_2 + LiAlH_4 \rightarrow LiCl$, $AlCl_3$, BeH_2 BeH_2 → octet incomplete ↳ Bride Bond / Banana Bond (3 center 2e^-)

Reaction with Halogen →

Metal + X_2 → Metal Halide (MX) $Li + X_2 \rightarrow LiX$ → Covalent nature, Li - Small cation $Na + X_2 \rightarrow NaX$ $K + X_2 \rightarrow KX$ $Rb + X_2 \rightarrow RbX$ $Cs + X_2 \rightarrow CsX$ } Ionic nature LiF < LiCl < LiBr < LiI ↓ Covalent nature	Metal Halide (MX_2) $Be + X_2 \rightarrow BeX_2$ $Mg + X_2 \rightarrow MgX_2$ $Ca + X_2 \rightarrow CaX_2$ $Sr + X_2 \rightarrow SrX_2$ $Ba + X_2 \rightarrow BaX_2$ $(NH_4)_2BeF_4 \xrightarrow{\Delta} BeF_2 + NH_3$ $BeO + C + Cl_2 \xrightarrow{600-800K} BeCl_2 + CO$

Reducing Nature →

G_1	G_2
alkali metals are strong reducing agents becoz of large negative electrode potential. Li → Highest Reducing Nature ① Sublimation energy ② Ionization energy ③ Hydration energy Li → Size ↓ → H.E. ↑ → Reducing nature ↑↑	Strong reducing agents but less powerful than alkali. Reducing nature increases from Be to Ba Be < Mg < Ca < Sr < Ba (reducing nature) ↳ less reducing nature, High H.E. → size ↓

Reaction with Liq. NH_3 →

G_1	G_2
all alkali dissolve in liq. NH_3	all dissolve in liq. NH_3

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

→ deep blue sol^n
→ due to ammoniated e^-
→ paramagnetic

Conc. Sol^n →
↳ Diamagnetic
↳ Bronze Colour

Stand for long hours → H_2 gas release
↳ amide form

$M_{(am)} + e^- + NH_{3(l)} \rightarrow MNH_2 + H_2\uparrow$

→ deep blue black

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

Reaction With Acid →

G1	G2
$M + HCl \rightarrow MCl + H_2\uparrow$	$M + HCl \rightarrow MCl_2 + H_2\uparrow$
$M + H_2SO_4 \rightarrow M_2SO_4 + H_2\uparrow$	$M + H_2SO_4 \rightarrow MSO_4 + H_2\uparrow$

General Characteristics of Compounds of G1 and G2 →

G1

→ In excess of air.

$Li + O_2 \rightarrow Li_2O + \underset{some}{Li_2O_2}$

$Na + O_2 \rightarrow Na_2O_2 + \underset{some}{NaO_2}$

$K + O_2 \rightarrow KO_2$
$Rb + O_2 \rightarrow RbO_2$ } Super Oxide
$Cs + O_2 \rightarrow CsO_2$

Superoxide is stable with large size cation becoz, large anions are stable by large cation through Lattice Energy.

Hydrolysis of Oxide, peroxide, superoxide →

$M_2O + H_2O \rightarrow M^+ + OH^-$
$M_2O_2 + H_2O \rightarrow M^+ + OH^- + H_2O_2$
$MO_2 + H_2O \rightarrow M^+ + OH^- + H_2O_2 + O_2$

Oxide, peroxide → Colourless
Superoxide → yellow/orange
↳ paramagnetic

G2

$M + O \rightarrow$ Metal Oxide

$Be + O_2 \rightarrow BeO$ → covalent, amphoteric

$Mg + O_2 \rightarrow MgO$
$Ca + O_2 \rightarrow CaO$
$Sr + O_2 \rightarrow SrO$
$Ba + O_2 \rightarrow BaO$
} Basic nature Oxide ↳ ionic nature

$MO + H_2O \rightarrow$ Hydroxide

$MgO + H_2O \rightarrow Mg(OH)_2$
$CaO + H_2O \rightarrow Ca(OH)_2$
$SrO + H_2O \rightarrow Sr(OH)_2$
$BaO + H_2O \rightarrow Ba(OH)_2$

$Mg(OH)_2$
$Ca(OH)_2$
$Sr(OH)_2$
$Ba(OH)_2$
↓ Solubility ↑↑, Thermal stability ↑↑, Basic character ↑↑

$Be(OH)_2$ (amphoteric)

$Be(OH)_2 + OH^- \rightarrow [Be(OH)_4]^{-2}$
↳ Berylate ion

$Be(OH)_2 + HCl \rightarrow [Be(OH)_2]Cl_2$

Halides →

G1

MX ($X = F, Cl, Br, I$)
($M = Li, Na, K, Rb, Cs$)

Melting and boiling point →
Floride > Chloride > Bromide > Iodide

preparation →
Oxide
Hydroxide $+ HX_{(aq)} \rightarrow MX$ (metal halide)
Carbonate Hydro-halic acid

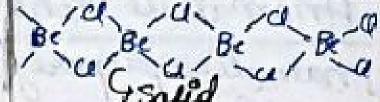
↳ all halides are soluble in H_2O.

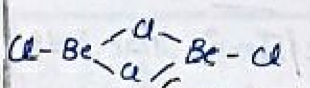
$LiF \rightarrow$ ↑↑ lattice energy
$CsI \rightarrow$ ↓↓ HE
} Very less Soluble

G2

all G2 halides are ionic except Berylium halide
↳ Covalent, Small Cation

$BeCl_2$ →
Solid state → polymer
Vapour state → dimer
> 1200K → monomer

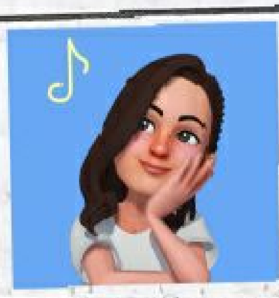

↳ Solid


↳ vapour

Cl–Be–Cl
↳ > 1200K

Tendency to form hydrate decreases down the group.

$MgCl_2 \cdot 8H_2O$
$CaCl_2 \cdot 6H_2O$
$SrCl_2 \cdot 6H_2O$
$BaCl_2 \cdot 2H_2O$



Salt of Oxo-Acid →

acidic proton should be attached to hydroxyl group, and oxo group should be attached to same atom.

e.g.
H_2CO_3 → HO–C(=O)–OH

H_2SO_4 → HO–S(=O)(=O)–OH

G1 forms salts with oxo acid.

$M + H_2CO_3 \rightarrow M_2CO_3$ (carbonate)
$\rightarrow MHCO_3$ (bicarbonate)

→ down the grp., thermal stability of carbonate and bicarbonate ↑↑ses.

$Li_2CO_3 \rightarrow$ Thermally unstable
$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$
$LiHCO_3 \rightarrow$ not solid

Carbonate

$M(OH)_2 + CO_2 \rightarrow M_2CO_3 + H_2O$

all
$M_2CO_3 \xrightarrow{\Delta} MO + CO_2$

Bicarbonate $\xrightarrow{\Delta}$ Carbonate $+ CO_2 + H_2O$

Thermal stability ↑↑ses down the group.

Sulphate

$M + H_2SO_4 \rightarrow MSO_4 + H_2\uparrow$
$MO + H_2SO_4 \rightarrow MSO_4 + H_2O$
$M(OH)_2 + H_2SO_4 \rightarrow MSO_4 + 2H_2O$
$MCO_3 + H_2SO_4 \rightarrow MSO_4 + CO_2 + H_2O$

$BeSO_4 \rightarrow Be^{+2}$
$MgSO_4 \rightarrow Mg^{+2}$
} Highly soluble in water ↳ ↑ H.E.

$CaSO_4$
$SrSO_4$
$BaSO_4$
} Solubility order →

$CaSO_4 > SrSO_4 > BaSO_4$

nitrate

$MO + HNO_3 \rightarrow M(NO_3)_2 + H_2O$
$M(OH_2)$ —"— → —"—
$M(CO_3)$ —"— → —"—

all nitrate decomposes to give oxide + nitrate + O_2.

$M(NO_3) \xrightarrow{\Delta} MO + NO_2 + O_2$
↳ Be, Mg, Ca, Sr, Ba

Anamalous Behaviours →

Anamalous property Li	Anamalous property Be
Size/Ionic size less	Size/Ionic Size less.
d orbital absent.	d-orbital absent.
Harder, M.P. and B.P. are high	Harder, M.P. and B.P. are high
High polarizing power	High polarizing power
Small Cation ↳↑↑ Covalent Character	Small Cation ↳↑↑ Covalent character
$Li \rightarrow Li_3N$, Li_2O	$Be \rightarrow Be_3N_2$ (Volatile) rest non-volatile nitride
LiCl → deliqusent $LiCl \cdot 2H_2O$	BeO and $Be(OH)_2$ ↳ amphoteric
$LiHCO_3$ → not solid (liquid)	Be → max. Coordination num. 4. While other shows CN = 6
$LiNO_3 \xrightarrow{\Delta} Li_2O + NO_2 + O_2$	
$NaNO_3 \xrightarrow{\Delta} NaNO_2 + O_2$	
$KNO_3 \xrightarrow{\Delta} KNO_2 + O_2$	
$RbNO_3 \xrightarrow{\Delta} RbNO_2 + O_2$	

Diagonal Relationships →

Li - Mg	Be - Al
Li, Mg → Reacts slowly with water	Be, Al + Acid → X
Oxide and hydroxide less soluble	$Be(OH)_2$, $Al(OH)_3$ $\xrightarrow{OH^-\ excess}$ $[Be(OH)_4]^{2}$, $[Al(OH)_4]$
Hydroxide $\xrightarrow{\Delta}$ decompose	$BeCl_2$, $AlCl_3$ } Vapour phase → Banana bond, Bridge bond
Li_3N and Mg_3N_2 (both nitride)	
Li_2O, MgO } do not form superoxide	
$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$	
$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$	

$LiHCO_3$ and $MgCO_3$ not solid

LiCl, $MgCl_2$ } deliqusent

$LiCl \cdot 2H_2O$
$MgCl_2 \cdot 8H_2O$

Compounds → G1 →

① NaCl →

→ Evaporation of sea water
→ Crude NaCl prepared by crystallization of Brine.
→ Impurity :- $NaSO_4$, $CaSO_4$, $MgCl_2$, $CaCl_2$
↳ removed by saturating solⁿ with HCl gas. ↓
Crystals of pure Sodium Chloride forms.

② NaOH (Caustic Soda) →

① Electrolysis of NaCl → Castner-Kellner cell

Brine Solution → Electrolysis.

(Cathode → Hg)
(Anode → Carbon)

Cathode → $Na^+ + e^- \xrightarrow{Hg}$ Na-amalgam
Anode → $Cl^- \rightarrow \frac{1}{2}Cl_2 + e^-$

Na-amalgam + $H_2O \rightarrow NaOH + Hg + H_2$

NaOH → deliquescent.
White translucent Solid.

$NaOH + CO_2 \rightarrow Na_2CO_3$

③ preparation of Na_2CO_3 →

Na_2CO_3 is prepared by Solvay's process

CAB rule →

① $CaCO_3$ = Calcium Carbonate
② NH_3 = Ammonia
③ $NaCl_{(aq)}$ = Brine Solution

① $CaCO_3 \rightarrow CaO + CO_2$
② $NH_3 + CO_2 \rightarrow NH_4HCO_3$
③ $NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$

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

Reaction of Na_2CO_3 with SiO_2 →

$Na_2CO_3 + SiO_2 \rightarrow Na_2\overset{+4}{Si}O_3 + CO_2$
(waterglass)
soluble in water

Reaction of Na_2CO_3 with HCl →

$Na_2CO_3 + HCl \rightarrow NaCl + NaHCO_3$

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

$Na_2CO_3 + \underset{(excess)}{HCl} \longrightarrow NaCl + H_2O + CO_2$

$Na_2CO_3 + H_2O \rightarrow NaOH + H_2O + CO_2$

Sodium Bicarbonate ($NaHCO_3$)

Baking Soda →

$\underset{\text{Carbonate (milkiness)}}{Na_2CO_3} + \underset{\text{excess}}{CO_2 + H_2O} \rightarrow \underset{\text{Bicarbonate (soluble)}}{NaHCO_3}$

(milkiness disappear)

Compounds → Gr 2 →

① Quicklime (CaO) →

preparation →

$CaCO_3 \xrightarrow[1070K-1270K]{\Delta} CaO + CO_2$

White amorphous solid

$CaO + H_2O \rightarrow Ca(OH)_2$

$CaO + CO_2 \rightarrow CaCO_3$

→ addition of limited amount of H_2O, breaks lump of lime → Slaking of lime.

CaO + Soda → Soda lime

CaO + NaOH → Soda lime

$CaO + SiO_2 \rightarrow CaSiO_3$

$CaO + P_4O_{10} \rightarrow Ca_3(PO_4)_2$

② Slaked lime ($Ca(OH)_2$) →

$CaO + H_2O \rightarrow Ca(OH)_2$

$CaCl_2 + NaOH \rightarrow Ca(OH)_2 + NaCl$

$CaCl_2 + H_2O \rightarrow Ca(OH)_2 + HCl$

It's suspension in water → milk of lime

Clear saturated Sol.^{n} is H_2O → lime water

$Ca(OH)_2 \xrightarrow{\Delta} CaO + H_2O$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$

It reacts with Cl_2 to give component of bleaching powder.

$Ca(OH)_2 + Cl_2 \rightarrow CaCl_2 + Ca(OCl)_2 + 2H_2O$

③ LimeStone ($CaCO_3$) →

preparation

$Ca(OH)_2 + Na_2CO_3 \rightarrow CaCO_3 + NaOH$

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + NaCl$

$CaO + CO_2 \rightarrow CaCO_3$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$

$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

④ Plaster Of Paris ($CaSO_4 \cdot \frac{1}{2} H_2O$)

$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow{393K} \underset{\text{POP}}{CaSO_4 \cdot \frac{1}{2} H_2O} \xrightarrow{>393K} \underset{\text{dead burnt plaster}}{CaSO_4}$

⑤ Cement →

→ portland Cement →

$CaO, SiO_2, Al_2O_3, MgO, Fe_2O_3, SO_3$

→ Good quality cement →

$SiO_2 / Al_2O_3 \rightarrow 2.5$ to 4

$CO_2 / SiO_2 + Al_2O_3 + Fe_2O_3 \rightarrow$ close to 2.