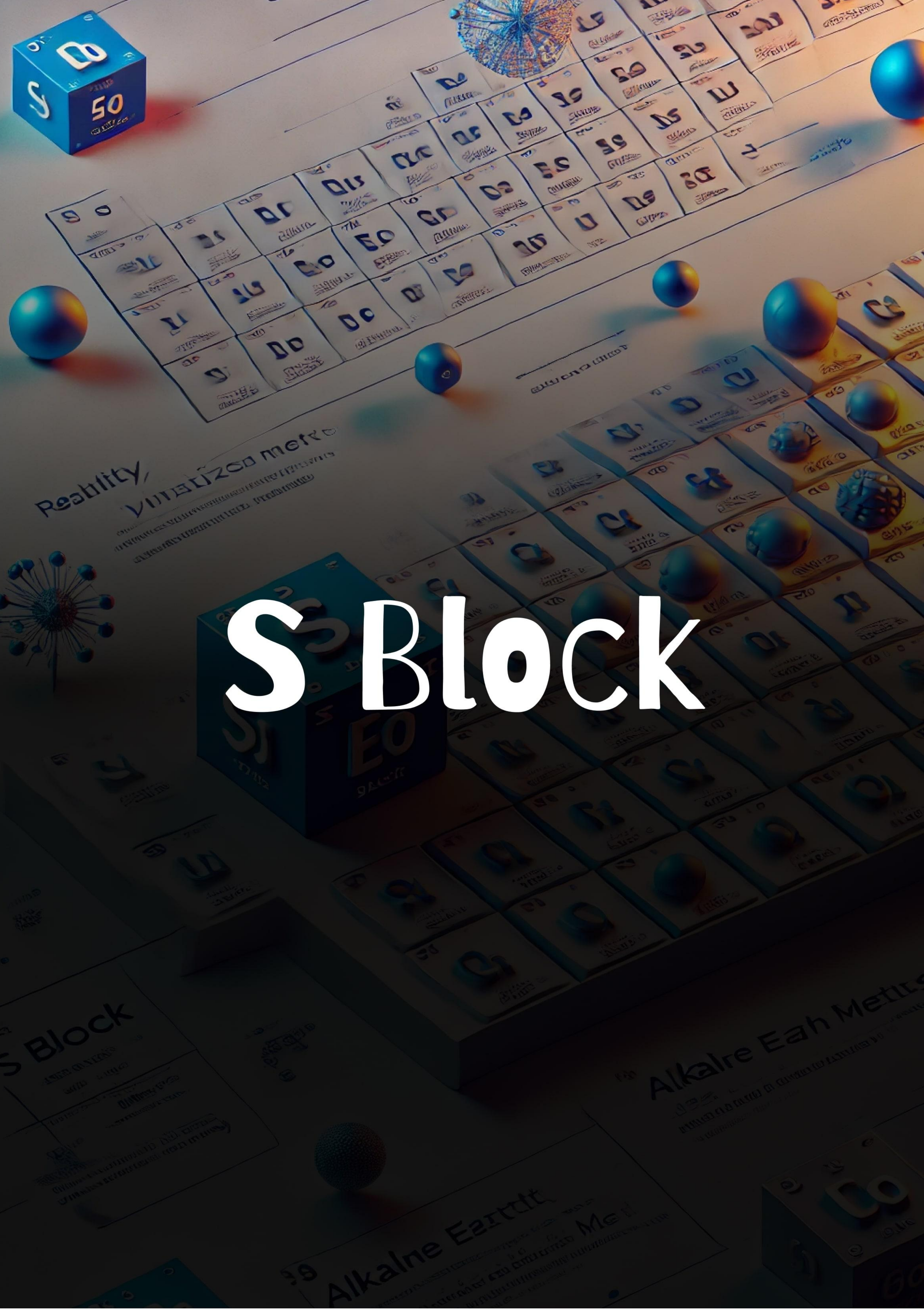


S Block

* S-Block *

Elements in which last e^- enters into S subshell, are called S Block elements

Group-1 → [IG] ns^1	Group 2 [IG] ns^2
2nd P → Li [He] $2s^1$	Be [He] $2s^2$
3rd P → Na [Ne] $3s^1$	Mg [Ne] $3s^2$
4th P → K [Ar] $4s^1$	Ca [Ar] $4s^2$
5th P → Rb [Kr] $5s^1$	Sr [Kr] $5s^2$
6th P → Cs [Xe] $6s^1$	Ba [Xe] $6s^2$
7th P → Fr [Rn] $7s^1$ ↳ Radioactive	Ra [Rn] $7s^2$
① alkali metals (because on reaction with water they form hydroxide → (strongly alkaline nature)	→ alkaline earth metal because all oxide and hydroxide are alkaline in nature and also found in earth crust # Be is not an alkaline earth metal; because oxide & hydroxide of Be is amphoteric in nature
② General electronic configuration [IG] ns^1 → Oxidation state → +1 → valency ⇒ 1 → Monovalent	General electronic configuration [IG] ns^2 ⇒ Oxidation state = +2 ⇒ valency → 2 → divalent

First element of each Group shows different behaviour due to
① Small size
② High IE

* Diagonal Relationship

# Li → Mg	# Be → Al

They show diagonal relationship because of same ionic potential or charge / size ratio.

$$\text{ionic potential} = \frac{\text{charge}}{\text{size}}$$

* Atomic Radius or Ionic radius

→ down the group size ↑ because no. of shell ↑	→ down the group size ↑
Li < Na < K < Rb < Cs	Be < Mg < Ca < Sr < Ba

Between G1 and G2 elements
G1 has more size than G2.

* Ionization Energy

$$IE \propto \frac{1}{\text{size}}$$

→ down the group size ↑ IE ↓	→ Down the group size ↑ IE ↓
Li > Na > K > Rb > Cs	Be > Mg > Ca > Sr > Ba

G1 elements have large size than G2 elements
so G1 elements have less IE than G2 elements

* Hydration Energy

$$HE \propto \frac{\text{charge}}{\text{size}}$$

G1 (M^+)	G2 (M^{+2})
$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$	$Be^{+2} > M^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$
↳ Li has max. hydration energy so Li salts are hydrated $LiCl \cdot 2H_2O$	Bet^n alkali and alkaline alkali → size more alkaline → size less

∴ alkaline has more hydration energy than alkali

→ So mostly alkaline forms hydrated salt $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$

* Physical properties

Alkali	Alkaline
→ Silvery white	→ Silvery white
→ soft (can be cut with Plastic knife)	→ soft (harder than alkali)
	→ lusturous
→ light metal	→ light metal.

Be, Mg } — Greyish colour

* Density

in period → density ↓

in Group → density ↑

exception

Li < K < Na < Rb < Cs

exception

Ca < Mg < Be < Sr < Ba < Ra

* Melting & boiling point

→ MP & BP ∝ metallic bonding

metallic bonding

i) valence e^- → directly proportional

ii) Size of atom - inversely ″

G1 → # 1 valence e^-

Low MP & B.P

→ # 2 valence e^-

High MP & BP than alkali

* Electropositive character

→ Size ↑ ; dist. of e^- from nucleus is far e^- removal easy and hence electropositive character increase

Li < Na < K < Rb < Cs

→ size ↑ electropositive character ↑

Be < Mg < Ca < Sr < Ba

* Flame colours.

Li → Crimson Red.

Na → Golden Yellow.

K → Violet

Rb → Red violet

Cs → Blue

Be, Mg → IE more ; size less, no flame colour

Ca → Brick Red

Sr → Crimson Red

Ba → apple green

Note- Both G1 and G2 have high electrical & Thermal conductivity.

* Chemical property.

→ Size is Big.

→ IE is less.

→ e^- is removed in less energy.

→ Reactivity is high.

→ Size is less than alkali

→ IE is more than alkali

→ Reactivity is less than alkali

Size ↑ IE↓ → down the Group Reactivity ↑

Li < Na < K < Rb < Cs

Be < Mg < Ca < Sr < Ba

* Reactivity toward air.

→ dry air + G1 → Oxide

due to this metal gets tarnished

→ moist air + G1 → Hydroxide

Reaction with O_2

$Li + O_2 \rightarrow Li_2O$ (oxide) O^{-2}

$Na + O_2 \rightarrow Na_2O_2$ (peroxide) O^{-1} O_2^{-2}

$K + O_2 \rightarrow KO_2$, $Rb + O_2 \rightarrow RbO_2$, $Cs + O_2 \rightarrow CsO_2$ } Superoxide

Be + (air & water) → no rxn.

Mg + (air & water) → no rxn

because oxide film layer is formed on their surface

$Be + O_2 \rightarrow BeO$ → amphoteric

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

When G1 elements are mixed with liq. NH_3 and then reacted with Oxygen then all forms oxide.

Li (liq. NH_3) + $O_2 \rightarrow Li_2O$
Na (") + $O_2 \rightarrow Na_2O$
K (") + $O_2 \rightarrow K_2O$
Rb (") + $O_2 \rightarrow Rb_2O$
Cs (") + $O_2 \rightarrow Cs_2O$
} Basic nature

→ Since these oxides are basic in nature so they react with acid.

$Li_2O + HCl \rightarrow LiCl + H_2O$
$Na_2O + HCl \rightarrow NaCl + H_2O$
$K_2O + HCl \rightarrow KCl + H_2O$
$Rb_2O + HCl \rightarrow RbCl + H_2O$
$Cs_2O + HCl \rightarrow CsCl + H_2O$

* Reaction with N_2

$Li + N_2 \rightarrow Li_3N$
Na
K
Rb
Cs
} no Rxn.

$BeO \rightarrow$ amphoteric
MgO
CaO
SrO
BaO
} Basic nature

So Basic oxides reacts with acid.

$BeO + HCl \rightarrow BeCl_2 + H_2O$
$BeO + NaOH \rightarrow Na_2BeO_2 + H_2O$
(sodium Berylate)
$MgO + HCl \rightarrow MgCl_2 + H_2O$
$CaO + HCl \rightarrow CaCl_2 + H_2O$
$SrO + HCl \rightarrow SrCl_2 + H_2O$
$BaO + HCl \rightarrow BaCl_2 + H_2O$

$Be + N_2 \rightarrow Be_3N_2$
$Mg + N_2 \rightarrow Mg_3N_2$
$Ca + N_2 \rightarrow Ca_3N_2$
$Sr + N_2 \rightarrow Sr_3N_2$
$Ba + N_2 \rightarrow Ba_3N_2$

* Reaction with H_2O.

M^+ OH^-

Metal + $H_2O \rightarrow MOH + H_2\uparrow$

- Li + $H_2O \rightarrow LiOH + H_2\uparrow$
- Na + $H_2O \rightarrow NaOH + H_2\uparrow$
- K + $H_2O \rightarrow KOH + H_2\uparrow$
- Rb + $H_2O \rightarrow RbOH + H_2\uparrow$
- Cs + $H_2O \rightarrow CsOH + H_2\uparrow$

(Na to Cs: highly explosive)

→ less size → so high IE → so Lithium reacts less vigourslly with water so less explosive

Be + H_2O (cold) ↛ no rxn

Be + H_2O (hot) ↛ no rxn

Mg + H_2O (cold) → no rxn

Mg + H_2O (hot) → $Mg(OH)_2 + H_2\uparrow$

Ca + H_2O (cold/hot) → $Ca(OH)_2 + H_2\uparrow$

Sr + H_2O (cold/hot) → $Sr(OH)_2 + H_2\uparrow$

Ba + H_2O (cold/hot) → $Ba(OH)_2 + H_2\uparrow$

→ Since G1 elements are highly explosive with water so they are kept in kerosene also, Li is less denser than kerosene So Li is kept in paraffin wax

* Reaction with Hydrogen

$M^+ + H_2 \rightarrow MH$ (Metal hydride)

Li + $H_2 \rightarrow LiH$ (1073k)

Na + $H_2 \rightarrow NaH$ }
K + $H_2 \rightarrow KH$ } 673 k
Rb + $H_2 \rightarrow RbH$ }
Cs + $H_2 \rightarrow CsH$ }

$M^{+2} + H_2 \rightarrow MH_2$ (metal hydride)

Be + $H_2 \rightarrow$ ~~BeH_2~~ no rxn

Mg + $H_2 \rightarrow MgH_2$

Ca + $H_2 \rightarrow CaH_2$

Sr + $H_2 \rightarrow SrH_2$

Ba + $H_2 \rightarrow BaH_2$

all these metal hydrides are ionic solid (high melting point)

→ Other preparation method for BeH_2.

$BeCl_2 + LiAlH_4 \rightarrow BeH_2 + LiCl + AlCl_3$

Lithium Aluminium hydride

$BeH_2 \rightarrow$ 2 bond ; $4e^-$; e^- deficient

Banana bond, Bridge bond, 3 center $2e^-$ bond

* Reaction with Halogen.

$M^+ + X^- \rightarrow MX$ (metal halide)

$Li + X_2 \rightarrow LiX$ → covalent nature
↓
small cation or Large anion
↓
Fajan's Rule
↑
max covalent character

$Na + X_2 \rightarrow NaX$

$K + X_2 \rightarrow KX$

$Rb + X_2 \rightarrow RbX$

$Cs + X_2 \rightarrow CsX$

$LiF < LiCl < LiBr < LiI$

Order of covalent character

$M^{+2} + X_2 \rightarrow MX_2$ (metal halide)

$Be + X_2 \rightarrow BeX_2$ → BeF_2 & $BeCl_2$ will not form

$Mg + X_2 \rightarrow MgX_2$

$Ca + X_2 \rightarrow CaX_2$

$Sr + X_2 \rightarrow SrX_2$

$Ba + X_2 \rightarrow BaX_2$

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

Ammonium Tetra Fluro Berylate

$BeO + C + Cl_2 \rightarrow BeCl_2 + CO$

* Reducing Nature.

$M \rightarrow M^+ + e^-$ (Oxidation)
↓
Reducing Nature

G_1 has more size than G_2

So G_1 has more Reducing nature than G_2 because of large negative electrode potential

$M \rightarrow M^{+2} + 2e^-$ (Oxidation)
↓
Reducing Nature

→ These are less powerful Reducing agent than alkali

→ Reducing nature increases from Be to Ba.

→ As we go down the grp size ↑
e^- releasing tendency ↑
Reducing Nature ↑
(Li) > Cs > Rb > K > Na
↓
Highest Reducing Nature
3 Factors
① Sublimation Energy
② Ionization Energy
③ Hydration Energy
↳ Li (Size ↓ HE ↑)

→ Because the value of electrode potential becomes more negative down the group

* Reaction with liq. NH_3.
→ All alkali metals dissolve in liq. NH_3

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

(ammoniated electron)

→ deep blue colour soln
→ Ammoniated electron.
→ Paramagnetic.
→ Stand alone for long hours it releases H_2 & forms amide

$$M^+(am) + e^- + NH_3 \xrightarrow{\text{stand for long hours}} MNH_2 + \frac{1}{2}H_2 \uparrow$$

→ Concentrated solution
- diamagnetic
- Blue - Bronze colour

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

→ deep blue black solution due to ammoniated e^-

* Reaction with Acid.

$M^+ + HCl \rightarrow MCl + H_2$

$M^+ + H_2SO_4 \rightarrow M_2SO_4 + H_2$

$M^+ + H_3PO_4 \rightarrow M_3PO_4 + H_2$

General Characteristics of Alkali

In excess of air

$Li \rightarrow Li_2O$ & Li_2O_2 (small amount)

$Na \rightarrow Na_2O_2$ & Na_2O (small amount)

$K \rightarrow KO_2$
$Rb \rightarrow RbO_2$
$Cs \rightarrow CsO_2$
} (only superoxide)

→ Superoxide is stable with large cation

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

$M^{+2} + HCl \rightarrow MCl_2 + H_2$

$M^{+2} + H_2SO_4 \rightarrow MSO_4 + H_2$

$M^{+2} + H_3PO_4 \rightarrow M_3PO_4 + H_2$

General characteristics of Alkaline

→ These metals only form Oxide.

→ Oxide & Hydroxide of Be & Mg are more covalent than Ca, Sr, Ba.

$BeO \rightarrow$ amphoteric – acid, base

MgO
CaO
SrO
BaO
} – Basic

Basic oxides of Grp 2 when reacted with $H_2O \rightarrow$ Hydroxide

$MgO + H_2O \rightarrow Mg(OH)_2$

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

$SrO + H_2O \rightarrow Sr(OH)_2$

$BaO + H_2O \rightarrow Ba(OH)_2$

In hydroxides, solubility, Thermal stability, Basic character increases down the grp

$BeO + H_2O \rightarrow Be(OH)_2$
amphoteric → amphoteric

$Be(OH)_2 + OH^-$ excess $\rightarrow [Be(OH)_4]^{2-}$ Beryllate ion.

$Be(OH)_2 + HCl$ (acid) $\rightarrow [Be(OH)_4]Cl_2$

* Halide

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

MP & BP → Floride > Chloride > Bromide > Iodide

Small cation — Large cation
Large anion — Small anion
↓ covalent character — ↓ ionic character

Preparation

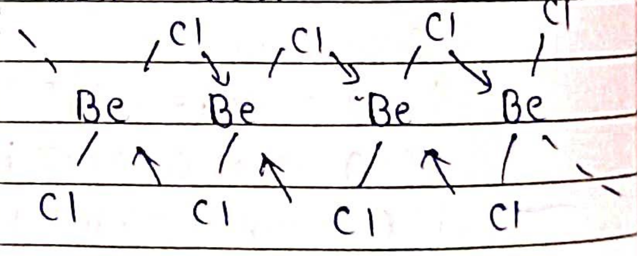
Oxide or hydroxide or carbonate + HX (hydrohalic acid) → MX (Metal halide)

→ all halides are soluble in H_2O
LiF & CsI → insoluble
(High Lattice Energy) → (low hydration energy)

Preparation

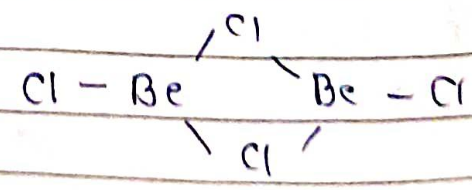
all G2 Halides are ionic except Beryllium halide
Beryllium halide → covalent
$BeCl_2$ — Solid → Polymer
Vapour → dimer
T ≃ 1200 K → monomer

Solid - $BeCl_2$



3 center 4e⁻ bond
octet complete ; stable
Banana bond

Vapour - $BeCl_2$



3 centre 4e⁻ ; 3 bond ; e⁻ deficient ; if T ≃ 1200 K Cl – Be – Cl

DATE

* Important Compounds of S-Block

Group 1

1) Sodium Carbonate (Na_2CO_3)
2) Sodium Chloride ($NaCl$)
3) Sodium hydroxide ($NaOH$)
4) Sodium Bicarbonate ($NaHCO_3$)

1) Sodium Carbonate

→ Called as washing soda

→ Molecular formula → $Na_2CO_3 \cdot 10H_2O$

→ Prepared by Solvay process
↳ 4 steps

Step 1 - $NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

Step 2 - $(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow (NH_4)HCO_3$

Step 3 - $(NH_4)HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$ (used to recover ammonia)

$NaHCO_3$ less soluble; therefore precipitate is formed

Step 4 - $NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

Solvay process → Na_2CO_3

→ In this process first Ammonium Hydrogen carbonate is formed

→ The ammonium hydrogen carbonate on reaction with NaCl it forms sodium hydrogen carbonate ($NaHCO_3$)

→ Since, $NaHCO_3$ is less soluble, hence it gets precipitated in reaction at last, $NaHCO_3$ is heated to gives Na_2CO_3

Ammonia + H_2O + CO_2 → Ammonium carbonate

Ammonium carbonate + excess H_2O & CO_2 → Ammonium bicarbonate

Ammonium bicarbonate + NaCl → Sodium Bicarbonate

Sodium bicarbonate $\xrightarrow{\Delta}$ Sodium carbonate + H_2O + CO_2

In solvay process, NH_3 is recovered back

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

NH_4^+ Ca^{+2}
Cl^- OH^-

Solvay process can't be used to prepared K_2CO_3 because $KHCO_3$ is highly soluble in water

Properties of Sodium Carbonate
→ White crystalline solid.
→ exist as decahydrate ($Na_2CO_3 \cdot 10H_2O$)
→ called as washing soda
→ soluble in water.

Heating of Sodium Carbonate:

$$\underset{\text{decahydrate}}{Na_2CO_3 \cdot 10H_2O} \xrightarrow[375\,K]{\Delta} \underset{\text{monohydrate}}{Na_2CO_3 \cdot H_2O}$$

$$\underset{\text{monohydrate}}{Na_2CO_3 \cdot H_2O} \xrightarrow{>375\,k} \underset{\text{anhydrous}}{Na_2CO_3} \quad \text{(white powder) (soda ash)}$$

2) NaCl (Sodium Chloride)
Crude sodium chloride is manufactured from crystallisation of Brine solution (Brine solution contains Na_2SO_4, $CaSO_4$, $CaCl_2$, $MgCl_2$ as impurity)
→ $CaCl_2$ & $MgCl_2$ are deliquescent in nature
↳ tendency to absorb H_2O
To obtain pure sodium chloride, crude NaCl is mixed with H_2O & filtered out to remove insoluble impurity. Then saturated with HCl gas, then crystal of Na is formed
M.P of NaCl is 1081 K.

3) NaOH (Sodium Hydroxide)

→ also called as caustic soda.

→ prepared commercially by electrolysis of sodium chloride in castner - kellner cell

→ A Brine solution is electrolysed ~~during~~ using mercury cathode & carbon anode.

→ Sodium metal is discharged at cathode, combines with mercury and forms sodium amalgam.

→ Chloride gas is evolved at anode

cathode $Na + e^- \xrightarrow{Hg} Na\text{-}Amalgam$.

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

→ This sodium amalgam on hydrolysis gives NaOH & H_2 gas

$Na\ Amalgam + H_2O \longrightarrow NaOH + H_2 + Hg$.

white, translucent solid.

MP is 591 k

Soluble in H_2O

Sodium Hydroxide at surface, reacts with CO_2 and forms Na_2CO_3

4) $NaHCO_3$ (Sodium Hydrogen carbonate) / (Sodium bicarbonate) (Baking Soda)

→ It decomposes on heating to generate bubbles of CO_2 (leaving holes in cakes & pastries & making it light & fluffy)

→ manufactured by saturating a solution of sodium carbonate with carbon dioxide.

→ It is less soluble & hence it is separated out

$Na_2CO_3 + H_2O + CO_2 \longrightarrow NaHCO_3$

* Important Compounds Of Group -2.

1) Calcium Oxide CaO
2) Calcium Hydroxide $Ca(OH)_2$
3) Calcium Sulphate $CaSO_4$
4) Calcium carbonate $CaCO_3$
5) Cement

1) Calcium Oxide, CaO, Quicklime.

→ prepared commercially by heating $CaCO_3$

$$CaCO_3 \xrightarrow{heat} CaO + CO_2$$

→ CaO is white amorphous solid.

→ MP → 2870 K

→ on exposure to air, it absorbs moisture & CO_2

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

$$CaO + CO_2 \longrightarrow CaCO_3$$

Slacking of lime - on adding limited amount of water it breaks lump of lime, called slacking of lime

Soda-lime → Quick lime slacked with soda gives sodalime
3:1 mixture of NaOH & CaO

→ CaO is a basic oxide, so it combines with acidic oxide

$$\underset{Basic}{CaO} + \underset{Acidic}{SiO_2} \longrightarrow CaSiO_3$$

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

2) $Ca(OH)_2$ Calcium Hydroxide , Slacked lime

→ prepared by adding H_2O to Quicklime CaO.

→ White amorphous powder , Sparingly soluble in H_2O.

→ The aq. soln of $Ca(OH)_2$ is known as lime water

→ Suspension of Slacked lime in H_2O is known as milk of lime

→ On passing CO_2 in calcium hydroxide , it form calcium carbonate.

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

On passing CO_2 in excess. turns lime water milky.

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

milkiness disappear

→ milk of lime reacts with chlorine to form hypochlorite

$$Ca(OH)_2 + Cl_2 \longrightarrow \underbrace{CaCl_2 + Ca(OCl_2)_2}_{\text{Bleaching powder constituents}} + 2H_2O$$

3) Calcium Carbonate $CaCO_3$

→ Limestone.

→ Prepared by passing CO_2 through Slaked lime or by addition of sodium carbonate to calcium chloride

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

$$CaCl_2 + Na_2CO_3 \longrightarrow NaCl + CaCO_3$$

Avoid giving excess CO_2 because it forms Calcium Bicarbonate

It reacts with dilute acid to give carbon dioxide

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

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

*4) Calcium Sulphate ($CaSO_4 \cdot \frac{1}{2} H_2O$) (POP)

→ Hemihydrate of calcium sulphate.

→ When Gypsum is heated at 393 K

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow[393K]{\Delta} 2\,CaSO_4 \cdot H_2O + 3H_2O \quad \text{or} \quad CaSO_4 \cdot \frac{1}{2} H_2O$$

→ When heated at high temp (>393K)

$$CaSO_4 \cdot \frac{1}{2} H_2O \xrightarrow{\Delta} CaSO_4$$ (anhydrous calcium sulphate) (dead burnt plaster)

5) Cement

→ portland cement

→ Composition

CaO	50-60 %
SiO_2	20-25 %
Al_2O_3	5-10 %
MgO	2-3 %
Fe_2O_3	1-2 %
SO_3	1-2 %

Good Quality Cement

$$\frac{SiO_2}{Al_2O_3} = 2.5 \text{ to } 4$$

$$\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3} \simeq 2$$