Magnetic behaviour : Dilute solutions are paramagnetic because of presence of free ammoniated electron, magnetic susceptibility decreases with increase in concentration of metal, the solution becomes almost diamagnetic in the region of the minimum conductivity.

Reducing character :

Solutions of alkali metals in liquid ammonia are valuable as powerful and selective reducing agents, for example Birch reduction. Transition metal complexes can be reduced to unusually low oxidation states either with or with out bond cleavage, e.g. :

$$K_2[Ni(CN)_4] \xrightarrow[-33^{o}]{NH_3/K} K_4[Ni(CN)_4]$$

Stability :

The solutions are unstable with respect to amide formation in presence of impurity and warming :

$$M + \text{liquid } NH_3 \longrightarrow MNH_2 + \frac{1}{2}H_2$$

In the absence of catalytic impurities such as transition metal ions, solutions can be stored for several days with only a few percent decomposition.

(viii) Reaction with $NH_3(g)$: Except Lithium, other metals form metal amide salt when heated with $NH_3(g)$.

$$\underset{\textbf{(M = Na, K, Rb, Cs)}}{M} + NH_3(g) \xrightarrow{\Delta} \underset{\textbf{Metal amide}}{MNH_2} + ½H_2(g)\uparrow$$

$$MNH_2 \xrightarrow{+H_2O} MOH + NH_3\uparrow$$

But lithium forms imide salt when heated with NH_3 (g).

$$Li + NH_3(g) \xrightarrow{\Delta} \underset{\textbf{Lithium imide}}{Li_2NH} + ½H_2\uparrow$$

$$Li_2NH \xrightarrow{H_2O} LiOH + NH_3\uparrow$$

(ix) Nature of carbonate and Bicorbonate salts : Except Li_2CO_3 other metal carbonates do not decompose even at high temperature due to their low polarising power (ϕ).

$$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2\uparrow$$

Order of thermal stability : $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

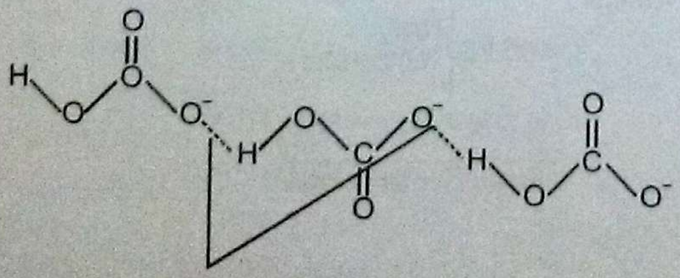
Order of solublility in water : $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

Except $LiHCO_3$ other alkali metal bicarbonates exist in solid state. Crystallisation of $LiHCO_3$ is not possible due to high polarising power of Li^+ and uncomparable size of Li^+ cation and HCO_3^- anion.

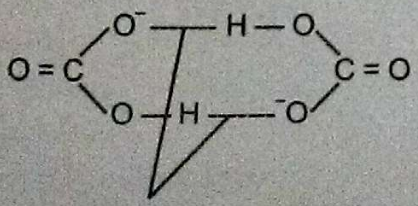
$LiHCO_3$ – exist in solution form

Order of solubility in water :

$NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$.

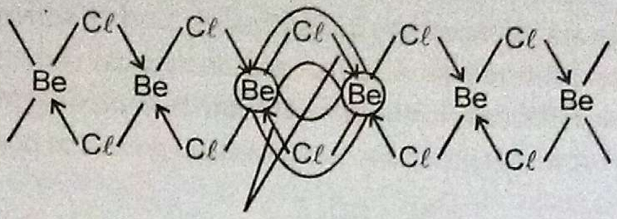


H-bonding in solid $NaHCO_3$



H-bonding solid $MHCO_3$ ($M^+ = K^+, Rb^+, Cs^+$)

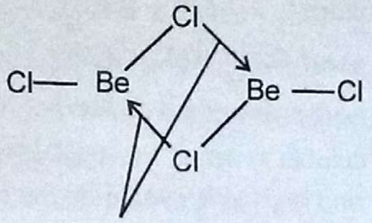
Except Be & Mg halides, all other halides of alkaline earth metals are ionic in nature. Beryllium halides are essentially covalent and also soluble in non-polar organic solvents Beryllium chloride has a chain structure in the solid state as shown below :



(3 centre 4 e⁻) bond

polymeric form of $BeCl_2$ in solid state

In the vapour phase $BeCl_2$ tends to form a chloro-bridged dimer which dissociates into the linear monomer at high temperature of the order of 1200 K. Hydrated halides of Be and Mg on heating suffer hydrolysis. Fluorides are relatively less soluble than the chlorides owing to their high lattice energies.



3 Centre-4e⁻ bond

(Dimer form of $BeCl_2$ in vapour phase)

$$\underset{\text{solid}}{BeCl_2} \xrightarrow{2H_2O} \underset{\substack{\text{white ppt.}\\ \text{(amphoteric)}}}{Be(OH)_2\downarrow} + 2HCl\uparrow \text{ (fumes in air)}$$

$$Be(OH)_2 \xrightarrow{NaOH} \underset{\text{Colourless Solution}}{Na_2[Be(OH)_4]}$$

$$MgCl_2 \xrightarrow{2H_2O} Mg(OH)_2 + 2HCl\uparrow$$

(vi) Reaction with N_2 : Ionic Metal Nitrides are formed

$$3M + N_2 \xrightarrow{\Delta} M_3N_2 \xrightarrow{6H_2O} M(OH)_2 + NH_3\uparrow$$

(M = Be, Mg, Ca, Sr, Ba)

(vii) Reaction with Carbon : Ionic metal carbides are formed.

Types of Carbide

Ionic carbide

s-block metals specially II^nd group metal form ionic carbide they are of following three types

- Methanide Carbide (C^{4-})
- Acetylide Carbide (C_2^{2-})
- Allylide Carbide (C_3^{4-})

Covalent carbide

p-block non-metals and metalloids form 3D covt. carbide and they being hard substances are used as abbrasive eg. SiC-(carborandom), B_4C-(Boron carbide)

Interstitial carbide

d-block metals from interstitial carbide with carbon eg. WC, CrC, TiC, Fe_3C etc.

Except Be other metals form acetylide carbide

$$\underset{(Ca,Sr,Ba)}{M} + 2C \xrightarrow{\Delta} \underset{\substack{\text{Acetylide}\\ \text{Carbide}}}{MC_2} \xrightarrow{+2H_2O} M(OH)_2 + \underset{\text{Acetylene}}{C_2H_2\uparrow}$$

$$Mg + 2C \xrightarrow{\Delta} \underset{\substack{\text{Acetylide}\\ \text{Carbide}}}{MgC_2} \xrightarrow[\text{temp.}]{\text{high}} \underset{\substack{\text{Allylide}\\ \text{carbide}}}{Mg_2C_3} \xrightarrow{+4H_2O} Mg(OH)_2 + \underset{\text{Propyne}}{C_3H_4\uparrow}$$