

ALKALINE EARTH METALS

INTRODUCTION:

- * The metal oxides of these elements like lime^(CaO), Strontia^(SrO), Baryta^(BaO) etc., are thermally stable and exhibit basic character. Therefore these elements are called Alkaline earth metals.
- * The alkaline earth metals are beryllium^(Be), magnesium^(Mg), calcium^(Ca), strontium^(Sr), barium^(Ba) and Radium^(Ra).
- * The general outer electronic configuration of alkaline earth metals is ns^2 .
- * The typical elements among alkaline earth metals are Be and Mg.
- * Abundance: Ca is more abundant and is least abundant $Ca > Mg > Ba > Sr > Ra$.
- * Element Be Mg Ca Sr Ba Ra
Density 1.84 1.74 1.55 3.75 6.00
- * In melting and boiling points no regular trend is observed
- * Be has highest m.p and b. p values.
- * Mg has lowest m. p and b. p values.
- * Due to smaller size and higher nuclear charge. The second I.E. values are higher than their first I.E. values but much lower than the second I.E. values of alkali metals, due to inert gas configuration of unipositive alkalimetal ions $I.P_2$ of $IA < IIA$
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- * On moving down the group, the electro positive character increases due to increase in atomic radii.
- * Oxidation state:
- * Alkaline earth metals uniformly show an oxidation state of +2 despite the presence of high ionization energy. Because
 - i) In the solid state, the dipositive ions M^{2+} form strong lattices due to their small size and high charge (i.e., high lattice energy)
 - ii) In the aqueous solution, the M^{2+} cations are strongly hydrated due to their small size and high charge. The hydration energy released by the M^{2+} cation is very large and compensates ionisation potential values.
- * Hydration Energy: Hydration energy is higher than those of alkali metal ions.

$$= \frac{\text{charge of ion}}{\text{size of ion}}$$
- * It decreases for to with increase in size.
- * Like alkali metal salts, alkaline earth metal salts also impart characteristic flame colouration.
- * As we move down the group from Ca to Ba, the ionization energy decreases, hence the energy of the frequency of the emitted light increases.

Ca	Brick red
Sr	Crimson red
Ba	Apple green

- * Be and Mg because of their high ionization energies, however, do not impart any characteristic colour to the bunsen flame.
- i) Like alkali metals, these dissolve in liquid ammonia giving coloured solutions.
- ii) The tendency to form ammoniates decreases with increase in size of the metal atom from Be to Ba.
- * Reaction with water
- * Group 2 elements are less reactive with water as compared to alkali metals. They react with H_2O evolving H_2 gas.

$$M + 2H_2O \rightarrow M(OH)_2 + H_2$$
 where $M = Mg, Ca, Sr$ or Ba
- * Alkaline earth metals combine with Oxygen to form monoxides of the type MO and the peroxides of the type MO_2
- * The affinity for oxygen increases down the group.
- * Be, Mg and Ca when heated with O_2 form monoxides while Sr, Ba and Ra form peroxides.

$$2M + O_2 \xrightarrow{\Delta} 2MO$$

Metal oxide

$$M + O_2 \xrightarrow{\Delta} MO_2$$

Metal peroxide
- * Be, Mg do not form peroxide.
- * The stability and ease of formation of peroxides increases from Be to Ba.
- * BeO and $Be(OH)_2$ are amphoteric while the oxides and hydroxides of other alkaline earth metals are basic.
- * The basic strength, however, increases from Be to Ba according as the ionization energy of metal decreases down the group thus the order

$$BeO < MgO < CaO < SrO < BaO \quad \text{and} \quad Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$$
- * Aq. $Ba(OH)_2$ is known as baryta water.
- * Reactivity, however, increases down the group from Mg to Ba i.e. $Mg < Ca < Sr < Ba$
- * BeH_2 and MgH_2 are covalent and polymeric whereas the hydrides of Ca, Sr and Ba are ionic and monomeric in nature.
- * Polymeric $(BeH_2)_n$ structure is with three centre bonds.
- * is also called hydrolith
- * The stability of hydrides decreases from Be to Ba.
- * All the elements of group IIA combine with halogens at high temperature, forming their halides (MX_2)

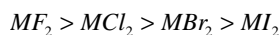
$$M + X_2 \xrightarrow{\Delta} MX_2$$

$$Mg + Cl_2 \xrightarrow{\Delta} MgCl_2$$
- * The solubility of halides decreases from Be to Ba

$$MgX_2 > CaX_2 > SrX_2 > BaX_2$$
- * Beryllium halides ($BeF_2, BaCl_2$ etc.) are covalent, hygroscopic and fume in air due to hydrolysis

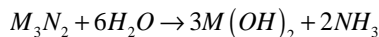
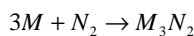
$$BeCl_2 + H_2O \rightarrow Be(OH)_2 + HCl$$
- * Anhydrous $CaCl_2$ is a good drying agent due to hygroscopic nature ($CaCl_2 \cdot 2H_2O$) and cannot be used to dry alcohol or ammonia as it forms addition products with them. Used as laboratory desiccant.
- * $BeCl_2$ has a polymeric structure in the solid state but exists as a dimer in the vapour state and as a monomer at 1200 K.

- * Melting points of halides decrease as the size of the halogen increases.

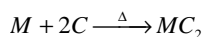
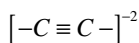


Nitrides:

- * These metals burn in nitrogen to form nitrides of the types M_3N_2 which are hydrolysed with water of evolve NH_3

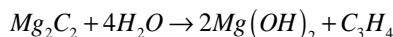


- * The ease of formation of nitrides increases from Be or Ba . (Be_3N_2) is volatile in nature.
- * When heated with carbon, these form their respective carbides of the general formula MC_2 (except Be) and are called acetylides containing the discrete C_2^{2-} anion.



(Where M=Mg, Ca, Sr or Ba)

- * On heating MgC_2 gives Mg_2C_3 called allylide which the discrete C_3^{4-} anion and gives allylene (methyl acetylene) on hydrolysis.



- * The carbonates of alkaline earth metals can be regarded as salts weak carbonic acid (H_2CO_3) and metal $M(OH)_2$ hydroxide,
- * Bicarbonates of these metals do not exist in solid state. Bicarbonates exist only in solution while the bicarbonates of 1A group exist in solid state.
- * The thermal stability of carbonates increases $BeCO_3$ form to $BaCO_3$
 $BaCO_3 > SrCO_3 > MgCO_3 > BeCO_3$
- * Solubility of carbonates : The solubility of the carbonates in water decreases down the group due to the decrease in the magnitude of hydration energy.
- * Be is harder and denser than other members of the group.
- * The m.p., b.p., and ionisation energy of Be are highest of all the alkaline earth metals.
- * BeO and $Be(OH)_2$ are amphoteric in character where as oxides and hydroxides of the group 2 metals are basic.
- * Be is least metallic of all the alkaline earth metals and forms covalent compounds.
- * Be forms Be_2C with carbon while the other members of the group form ionic carbide MC_2 .
- * Diagonal Relationship or Resemblance between Be and Al .
- * Both form fluoro complex anions BeF_4^{2-} and AlF_6^{3-} in solution.
- * Both react with conc. $NaOH$ liberating H_2

$$Be + 2NaOH \rightarrow Na_2BeO_2 + H_2$$

Sodium beryllate
- * Carbides of both liberate methane on hydrolysis

$$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$$

Sodium metaaluminate

$$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$$
- * Anhydrous chlorides of both i.e., $BeCl_2$ and $AlCl_3$ act as Lewis acids and dissolve in organic solvents.
- * Both do not impart any colour to the flame.

- * **Magnalium** $\begin{matrix} Al & + & Mg \\ (85-99\%) & & (1-15\%) \end{matrix}$

Magnalium is light and hard alloy. It is used in the preparation of balance beams, aeroplane parts or motor parts. This alloy can take a high polish.

- * **Elektron:** $\begin{matrix} Mg & + & Zn & + & Cu \\ (95\%) & & (4.5\%) & & 0.5\% \end{matrix}$

Electron is used in the manufacture of Aeroplane parts.

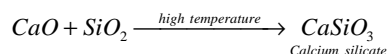
It is used in ratio tubes to remove the last traces of O_2 .

Calcium Oxide:

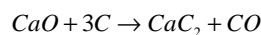
- * It is also known as quick lime

- * Chemical formula is CaO

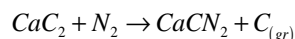
- * Reacts with acidic oxides to form salts, hence used as basic flux in metallurgy



- * With carbon



Calcium carbide reacts with water to produce acetylene, and with nitrogen on heating gives calcium cyanamide (nitrolim)

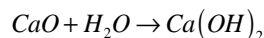


- * Nitrolim is used as a fertiliser.

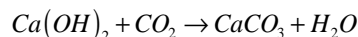
- * As a flux in metallurgy to remove silica and as a basic lining in furnaces

- * As a drying agent used in drying ammonia gas.

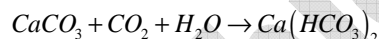
- * Action of water on quick lime



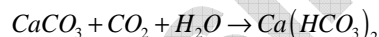
- * Carbondioxide makes lime water milky due to precipitation of calcium carbonate.



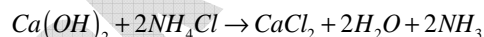
- * On passing excess carbondioxide, the precipitate first formed dissolves due to the formation of soluble bicarbonate



- * Being a strong base stronger than ammonia, it liberates ammonia gas on heating it with ammonium salt,



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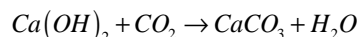


- * It forms hypochlorite in cold and chlorate salts when hot



- * It is found in nature in huge quantities in various forms such as limestone, marble, chalk, calcite, aragonite, etc.

- * It can be obtained by passing carbon dioxide through limewater



- * Adding sodium carbonate solution to $CaCl_2$

- * Calcium sulphate dihydrate is called gypsum. Finely divided naturally available form of $CaSO_4$ is called Alabaster.
- * Anhydrous $CaSO_4$ is called anhydrite.
- * The presence of Calcium Sulphate causes permanent hardness to water.
- * Gypsum is prepared by the action of dil. H_2SO_4 on CaO or $CaCO_3$

$$CaO + H_2SO_4 + H_2O \rightarrow CaSO_4 \cdot 2H_2O$$

$$CaCO_3 + H_2SO_4 + H_2O \rightarrow CaSO_4 \cdot 2H_2O + CO_2 \uparrow$$
- * $CaSO_4$ is readily soluble in hot. Conc. Solution of ammonium sulphate due to the formation of double salt $CaSO_4(NH_4)_2SO_4 \cdot H_2O$
 On heating gypsum to $200^\circ C$ gives "dead burnt" due to complete dehydration..

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow{120-130^\circ C} \underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2} H_2O} \xrightarrow{200^\circ C} \underset{\text{dead burnt}}{CaSO_4}$$
- * In the preparation of plaster of Paris, in agriculture, in the impregnation of filter paper.
- * Gypsum increases the setting time of cement. Therefore it is used for the manufacture of cement.
- * Anhydrous $CaSO_4$ is used as drying agent
- * Calcium sulphate hemihydrate or half hydrate is called Plaster of Paris.
- * When gypsum is heated to $120^\circ C$, plaster of Paris is obtained.

$$CaSO_4 \cdot 2H_2O \xrightarrow{120^\circ C} CaSO_4 \cdot \frac{1}{2} H_2O + \frac{3}{2} H_2O$$
- * Plaster of Paris combines with little water (half to its weight) and sets to a hard mass.
- * Setting of plaster of Paris involves hydration and it is exothermic reaction.
- * Setting of plaster of Paris is catalyzed by NaCl and retarded by borax or alum.
- * Setting of plaster of Paris

$$\underset{\text{Plaster of Paris}}{2CaSO_4 \cdot H_2O} \xrightarrow{\text{Setting stage}} \underset{\text{Ortho Rombic Hydrate}}{CaSO_4 \cdot 2H_2O}$$

$$\underset{\text{Ortho Rombic Hydrate}}{CaSO_4 \cdot 2H_2O} \xrightarrow{\text{Hardening stage}} \underset{\text{Monoclinic dihydrate}}{CaSO_4 \cdot 2H_2O}$$
- * Hardening of plaster of Paris is due to conversion of orthorhombic form to monoclinic form.
- * Plaster of Paris on heating to $200^\circ C$ gives anhydrous $CaSO_4$. It is called dead plaster (or) dead burnt Calcium sulphate.
- * In dentistry
- * In making black board chalks.
- * In making models, crucibles.
- * A mixture of 3 parts of sand, 1 part of slaked lime and water is called lime mortar.
- * A mixture of cement and mortar is called cement mortar. It is much harder than lime mortar.
- * Sand makes mortar not only porous but also harder. While hardening, sand prevents the cracks on contraction.
- * Lime stone and clay (containing 10% Aluminum silicate) when heated together, it gives hydraulic mortar.
- * Setting of mortar to hardness may be due to evaporation of water.
- * Mortar mixed with the cement is called cement mortar. This is stronger than mortar.
- * Mg^{2+} Ions get concentrated in animal cells.
- * In phosphate transfer Mg acts as cofactor.

- * Enzymes like phosphohydrylase and phosphotransferase contain Mg^{2+} ions. These enzymes participate in ATP reaction and release energy is complexed Mg^{2+} with ATP.
- * Mg^{2+} is constituent of chlorophyll, the green pigment in plants.
- * Bones and teeth contain Ca^{2+} as $[Ca_3(PO_4)_2]$ apatite.
- * Enamel on teeth contains fluorapatite, $[3Ca_3(PO_4)_2.CaF_2]$
- * In human body 99% of Ca is present in bones and teeth.
- * Role of Ca in Human body
 1. Neuro muscular function
 2. Inter neuronal transmission
 3. Cell membrane integrity
 4. Blood coagulation