HYDROGEN & IT'S COMPOUNDS

INTRODUCTION

Hydrogen is a lightest gas and lightest element of periodic table and it contain 1e, 1p and zero neutron.

- Hydrogen is called hydrogen because maximum quantity of Hydrogen is used in preparation of H_2O.

Method of Preparation of H_2

(a) ***By acids :*** The metals which are placed above H in electrochemical series react with dil. acids like HCl or H_2SO_4 to liberate H_2.

Ex. $Fe + \underset{\text{(dil)}}{H_2SO_4} \rightarrow FeSO_4 + H_2$

$Cu + H_2SO_4 \rightarrow \times$ (No reaction)

Note: Mn and Mg react with dil. HNO_3 and evolves H_2. HNO_3 is not commonly used ,as being good oxidising agent, it forms an oxide layer on the surface of metal.

Lab preparation – When impure Zn reacts with dil. H_2SO_4 it forms H_2

$\underset{\text{(impure)}}{Zn} + \underset{\text{(dil)}}{H_2SO_4} \rightarrow ZnSO_4 + H_2$

$Zn + HNO_3 \rightarrow Zn(NO_3)_2 + H_2$ no reaction as HNO_3 reduces

(b) ***By alkalies :*** Only (Be, Zn, Si, Al, Sn, Pb) Amphoteric metals react with boiling NaOH or KOH to evolve H_2.

$M + 2NaOH \rightarrow \underset{Na_2MO_2}{\text{salt}} + H_2\uparrow$

$M = Zn, Sn, Pb$

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

(c) ***From water :*** All the metals which are placed above H when react with water to evolves H_2.

$Zn + H_2O \longrightarrow ZnO + H_2\uparrow$

Three type of water can be used:

(i) ***Cold water :*** Cold water (7 to 25°C) is used for highly reactive metals.

Such as Li, K, Ba, Sr, Ca, Na, means alkali metals or alkaline earth metals.

The reaction with alkali metals are vigorous.

To minimise the rate of reaction these metals are used in the form of amalgam.

$2Na(Hg) + H_2O \longrightarrow 2NaOH + H_2\uparrow$

(ii) ***Hot water :*** Hot water (25°C to 90°C) is used for moderate reactive metals, such as Mg, Al, Mn, Zn, Cr.

Ex. $Mg + H_2O \xrightarrow{\text{Boil}} MgO + H_2$

(iii) ***Steam :*** The steam (>100°C) is used for very less reactive metals like Fe, Cd, Co, Ni, Sn, Pb.

Ex. $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2\uparrow$

(iv) ***From Ionic hydride :*** Whenever ionic hydride reacts with water they form H_2.

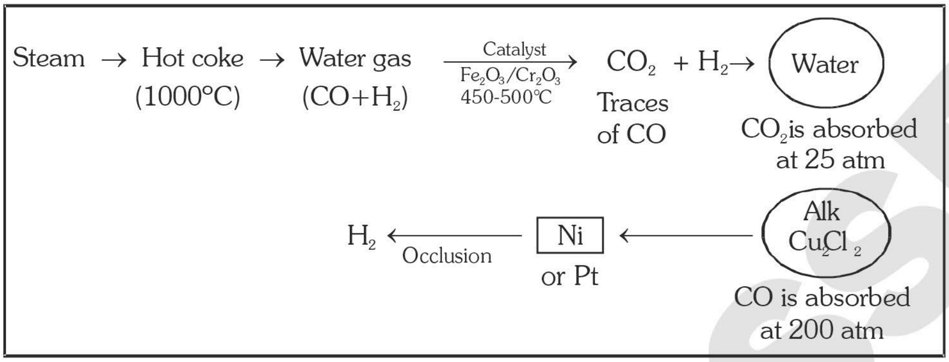
$\underset{\text{(Hydrolith)}}{CaH_2} + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

(d) Commercial or industrial method to prepare H_2

(i) ***Lane's process :*** In this process, steam is passed over hot iron.

$$\underset{\text{Hot}}{3Fe} + \underset{\text{Steam}}{4H_2O} \longrightarrow \underset{\text{Magnetic oxide}}{Fe_3O_4} + 4H_2\uparrow \quad ; \quad \Delta H = -160.7\text{ kJ}$$

(ii) ***Bosch's process :*** The maximum quantity of commercial hydrogen is obtained by the use of this method.



1. Formation of water gas from Coke is known as coal gasolification.

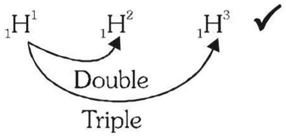
2. Seperation of H_2 from water gas is known as water gas shift reaction $(CO + H_2) + H_2O \rightarrow CO_2 + H_2$

(iii) ***From Natural gas :*** $C_nH_{2n+2} + nH_2O \xrightarrow{Ni/1000°C} nCO + (2n+1)H_2$ [Steam reforming process]

ISOTOPIC EFFECT

- Effect which can change physical & chemical properties of isotopes is called isotopic effect.
- Isotopic effect is found only in Hydrogen isotope because maximum mass number difference present in hydrogen isotopes.

${}_7N^{14}, {}_7N^{15}$ ✗ ${}_8O^{16}, {}_8O^{17}, {}_8O^{18}$ ✗



Note : Application of isotopes is not isotopic effect (Except H)

(i) Co_{60} in cancer treatment.

(ii) Iodine in thyroid gland treatment.

Example of isotopic effect :

(i) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (fast)

(ii) $CD_4 + Cl_2 \rightarrow CD_3Cl + DCl$ (slow)

Bond energy of C–D > C–H

$$\boxed{\text{Bond energy} \propto \frac{1}{\text{Rate of reaction}}}$$

POSITION OF HYDROGEN IN PERIODIC TABLE

Position of H is not fixed in Periodic Table because properties of hydrogen are similar with different groups i.e. IA,VIIA etc. so it is considered as ***rogue element*** of periodic table.

HYDRIDES

Compounds of hydrogen are known as hydrides

Types :

1. ***Ionic hydrides :*** Hydrides of s-block elements (in these hydrides oxidation number of H is –1).

$\overset{+}{Na}\overset{-}{H} \quad \overset{+}{K}\overset{-}{H}$

CaH_2 = Hydrolith

$2NaH \xrightarrow{2H_2O} 2NaOH + 3H_2$

2. *Covalent or molecular hydrides :-*

Hydrides of p-block elements are covalent hydrides

(a) Electron deficient : having less than 8e⁻ at central atom

BCl_3, $AlCl_3$, $GaCl_3$

(b) Electron rich : $\ddot{N}H_3$ $H_2\underset{\cdot\cdot}{\ddot{O}}$ $R{-}\underset{\cdot\cdot}{\ddot{O}}{-}H$ $R{-}\ddot{N}H_2$

having 8e⁻ and at least 1 ℓp at central atom

(c) Electron precise : Having 8e⁻ at central atom and ℓp = 0 CH_4 SiH_4 GeH_4

These are bad conducter of electricity.

3. *Metallic or interstitial hydrides :-*

Hydrides of d and f-block elements are known as metallic or intertitial hydrides there are not stoichiometric hydrides and do not obey law of constant proportion.

Ex. $ZrH_{x(1.3-1.75)}$ $TiH_{x(1.3-1.5)}$

- Their conductivity is similar to metals.
- ***Reactivity of reducing property :***

Simple atomic hydrogen > Nascent hydrogen > Adsorbed hydrogen (occluded hydrogen) >Molecular hydrogen

Water

Hard and Soft Water

Water from rivers, springs or even from wells contains a certain amount of dissolved mineral substances. Water containing soluble calcium and magnesium salts such as bicarbonates, chlorides, sulphates is termed ***hard water*** and if these salts are absent, the water is called ***soft water***.

Hard water is one which does not easily lathers with soap (Na or K salts of higher fatty acids). This is due to the formation of precipitate of Ca or Mg stearate while a sample of water which lathers easily with soap is called soft water.

$$\underset{\text{present in hard water}}{CaCl_2} + \underset{\text{sodium stearate (soap)}}{2C_{17}H_{35}COONa} \longrightarrow \underset{\text{Calcium Stearate}}{Ca(C_{17}H_{35}COO)_2\downarrow} + 2NaCl$$

Types of Hardness

Temporary Hardness : Due to presence of Ca and Mg bicarbonate like $Ca(HCO_3)_2$, $Mg(HCO_3)_2$

Permanent Hardness : Due to presence of Ca and Mg Chlorides and Sulphates like $CaCl_2$, $MgSO_4$ etc.

Removing Hardness from Water [Water Softening]

(1) Methods for Removal of temporary Hardness :

(i) ***By Boiling***

$$Ca(HCO_3)_2 \xrightarrow{\text{Boil}} CaCO_3\downarrow + CO_2 + H_2O$$

(ii) ***By Clark's process*** [Using $Ca(OH)_2$]

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$$

$$\underset{\text{(quick lime)}}{CaO\ (s)} + H_2O \longrightarrow \underset{\text{(Slaked lime)}}{Ca(OH)_2}$$

Note : Here $Ca(OH)_2$ can not used in excess quantity because $Ca(OH)_2$ by absorbing CO_2 further leads to the formation of $Ca(HCO_3)_2$.

(2) *Methods for Removal of Permanent Hardness and temporary hardness also removed.*

(i) ***By Na_2CO_3*** (washing soda)

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaCl$$

(3) *Method for Both Temporary and Permanent Hardness :*

(a) ***Lime and soda process :*** In this process both $Ca(OH)_2$ and Na_2CO_3 are added together to hard water.

(b) ***By Ion exchange process :***

(i) Inorganic process (ii) Organic process (iii) Calgon process

(i) ***Inorganic process :***

$$Na_2Z + CaCl_2 \rightarrow CaZ + 2NaCl$$

(ii) ***Organic Process :*** In organic process, always organic substance is used like.

$$H^+ + OH^- \longrightarrow H_2O$$

The water obtained so is free from all type of ions and known as deionised water.

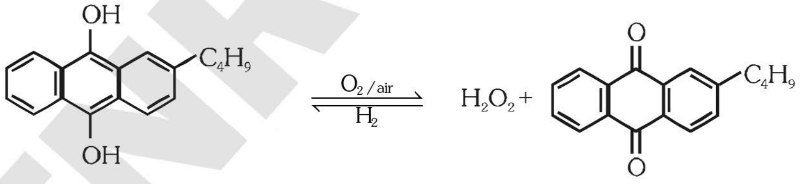
(iii) ***Calgon Process*** : Calgon is the trade name of sodium hexameta-phosphate, $Na_2(Na_4(PO_3)_6]$.

GOLDEN KEY POINTS

- Hard water is not always harmful for drinking purposes. However it is disadvantageous in the laundry work.
- Ethylene diaminetetraacetic acid (EDTA) is a versatile complexing agent hence it can remove hardness of water by forming stable complexes with metal ions. It is also used for estimating the hardness of water, volumetrically.

H_2O_2 (HYDROGEN PEROXIDE)

(a) Thenard discovered H_2O_2 and named it as oxygenated water.



2-butyl anthraquinol

(b) ***Electrolytic Process :*** Used 50% H_2SO_4 in electrolytic cell using Pt as anode and graphite as cathode.

$$2H_2SO_4 \longrightarrow 2H^+ + 2HSO_4^{\ominus}$$

At Cathode $2H^+ + 2e^- \longrightarrow H_2 \uparrow$

At Anode $2HSO_4^- \longrightarrow \underset{\text{Peroxo disulphuric acid}}{H_2S_2O_8} + 2e^-$

$$H_2S_2O_8 + H_2O \longrightarrow H_2SO_4 + H_2SO_5$$

$$H_2SO_5 + H_2O \longrightarrow H_2SO_4 + H_2O_2$$

- Now a days 50% $(NH_4)_2SO_4$ with 50% H_2SO_4 is used.

(c) ***By action of H_2SO_4 over Barium peroxide–***

$$BaO_2.8H_2O + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2 + 8H_2O$$

Chemical Property

(i) It is unstable in nature, decompose on standing and heating. It is an example of auto oxidation-reduction Reaction ; $H_2O_2 \rightarrow H_2O + O$

(ii) Decomposition of H_2O_2 ; $2H_2O_2 \rightleftharpoons 2H_2O + O_2$

- This is retarded by R–OH, acetanilide, glycerol and accelerated by ***Pt, Au, Ag, MnO_2.***

(iii) Acidic nature:

Pure H_2O_2 is weak dibasic acid, it turns blue litmus to red but aqueous solution of H_2O_2 is neutral towards litmus paper.

$$H_2O_2 \rightleftharpoons H^+ + HO_2^-$$

$$HO_2^- \rightleftharpoons H^+ + O_2^{-2}$$

(iv) Oxidizing nature:

It is more powerful oxidant in acidic medium than in alkaline medium.

In acidic medium $H_2O_2 + 2H^+ + 2e^- \xrightarrow{Fast} 2H_2O$; $E^0_{RP} = +1.77V$

In alkali medium $H_2O + OH^- + 2e^- \xrightarrow{Slow} 3OH^-$; $E^0_{RP} = +0.87V$

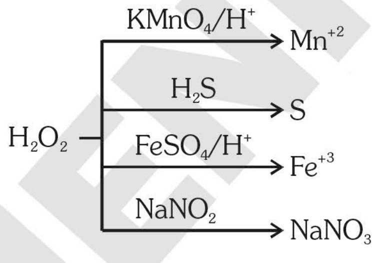
(v) Reducing nature:

It is better reductant in basic medium than in acidic medium.

$H_2O_2 \longrightarrow 2H^+ + O_2 + 2e^-$ (in acid)

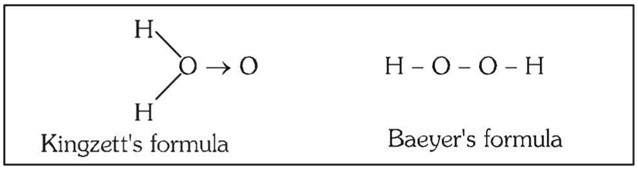
$H_2O_2 + 2OH^- \longrightarrow 2H_2O + O_2 + 2e^-$ (in alkali)

Ex.



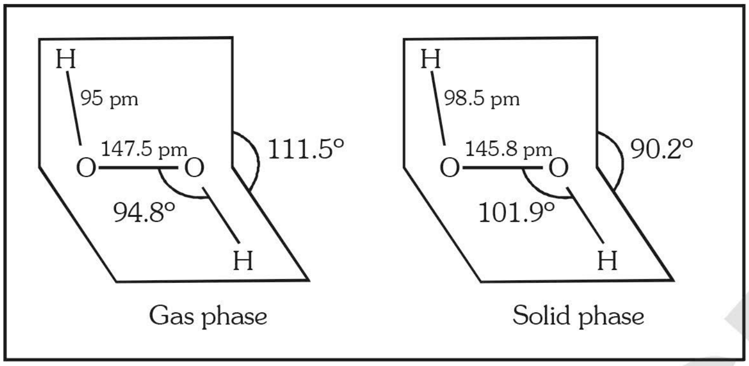
Structure of Hydrogen Peroxide

The vapour density as determined by Victor Meyer method at 90°C is 17. Hence, the molecular mass of H_2O_2 is 34. Two formulae have been suggested for hydrogen peroxide.



Kingzett's formula

Baeyer's formula



Storage of H_2O_2

(i) So the H_2O_2 usually stored in coloured, paraffin wax coated, plastic bottle.

(ii) Always with H_2O_2 add small quantity of inhibitor or negative catalyst to stay decomposition of H_2O_2. like H_3PO_4, acetanilides etc.

GOLDEN KEY POINTS

- It is not possible to determine the boiling point of H_2O_2 at atmospheric presseure because it decomposes vigorously on heating.
- Decomposition of H_2O_2 is favoured by certain metal ions (e.g., Fe^{2+}, Fe^{3+}), metal surface (Co, Au, Ag, Pt, etc.) and metal oxides (e.g.) MnO_2 strongly catalyze the reaction. Even carbon, rough surfaces, exposure to light, and traces of alkali (present in glass) catalyze its decomposition.

S-BLOCK ELEMENTS

INTRODUCTION

The s-block elements of the Periodic Table are those in which the last electron enters the outermost s-orbital. As the s-orbital can accommodate only two electrons, two groups (1 & 2) belong to the s-block of the Periodic Table.

IA - Alkali metals Li Na K Rb Cs

IIA - Alkaline earth metals Be Mg Ca Sr Ba

PHYSICAL PROPERTIES OF S-BLOCK ELEMENTS

The atomic, physical and chemical properties of alkali metals are discussed below.

PHYSICAL STATE

ALKALI METAL	ALKALINE EARTH METAL
• One electron in outermost shell & ***General electronic configuration is ns^1***.	• Two electrons in outer most shell & ***General configuration is ns^2.***
• Francium is radioactive element.	• Radium is radioactive element.
• All are silvery white	• All are greyish white.
• Light soft, malleable and ductile metals with metallic lustre.	• These metals are harder than alkali metals.
• Alkali metals are paramagnetic, while their ions are diamagnetic and colourless.	• These are diamagnetic and colourless in form of ions or in metal states.

ATOMIC SIZE

• Biggest in their respective period (except noble gas element)	• Smaller than IA group elements, since extra charge on nucleus attracts the electron cloud more.
• Size increases from Li to Fr due to addition of an extra shell. in atomic and gaseous state Li < Na < K < Rb < Cs < Fr in aquatic state $\overset{+1}{\mathrm{Li}} > \overset{+1}{\mathrm{Na}} > \overset{+}{\mathrm{K}} > \overset{+}{\mathrm{Rb}} > \overset{+1}{\mathrm{Cs}}$	• Size increases gradually from Be to Ra Be < Mg < Ca < Sr < Ba ***In s-block elements*** Be is the smallest, Cs is the biggest ***in aq. state*** $Mg^{+2}_{(aq)} > Ca^{+2}_{(aq)} > Sr^{+2}_{(aq)} > Ra^{+2}_{(aq)}$

SOFTNESS

• Alkali metals are soft because of - (a) Large atomic size (b) BCC crystal structure (HCP in Li) (c) Loose packing (68% packing efficiency) (d) Weak metallic bond	• These metals are slightly harder than IA group because of - (a) Smaller atomic size (b) FCC, HCP crystal structures (c) Packing capacity 74% (d) Stronger metallic bond due to presence of two electrons in valence shell.
• Cs is the softest metal in s-block	• Be is the hardest metal in s-block.

MELTING POINT AND BOILING POINT

• Decreasing order of melting point and boiling point is Li > Na > K > Rb > Cs	• Metallic bond is stronger than IA group elements due to smaller atomic size and two electrons in valence shell hence melting point and boiling point are higher. • Decreasing order of melting point and boiling point is Be > Ca > Sr > Ba > Mg

$\boxed{\text{Melting \& Boiling point} \propto \text{Strength of metallic bond}}$

IONISATION POTENTIAL (I.P.)

- Decreasing order of ionisation potential -
  Li > Na > K > Rb > Cs
- $I.P_{II} > I.P_{I}$

- Decreasing order of ionisation potential–
  Be > Mg > Ca > Sr > Ba
- $I.P_{I} > I.P_{II}$

OXIDATION STATE

- The alkali metals shows only + 1 oxidation state. (I^{st} and 2^{nd} ionisation potential difference > 16eV)

- Alkaline earth metal shows +2. Oxidation state (I^{st} and 2^{nd} ionisation potential difference < 11eV)

ELECTRO POSITIVE CHARACTER OR METALLIC CHARACTER

- Electropositivity $\propto \dfrac{1}{\text{Ionisation Potential}}$
  Electropositivity in both groups ↑ down the group

- Their atomic size is smaller than IA group so these are lesser electro positive than IA group. Electropositivity increases from Be to Ba

DENSITY

- (D = M /V)
- Li < K < Na < Rb < Cs

- Ca < Mg < Be < Sr < Ba
- K < Na < Ca < Mg

FLAME TEST

Li-Crimson red Na-Golden yellow K-Violet
Rb-Red violet Cs-Blue

- Be and Mg atoms, due to small size, bind their electrons more strongly, so are not excited to higher level, hence no flame test.
  Ca-Brick red Sr-dark red or Crimson red Ba-apple green

PHOTO ELECTRIC EFFECT

- Due to very low ionisation potential their valence shell electrons gets excited even by absorbing visible light. That's why Cs is used in photo cells.

- These elements do not show this property as their atomic size is small hence ionisation potential is higher than IA group.

HYDRATION ENERGY (HEAT OF HYDRATION)

- Alkali metals salts are generally soluble in water due to hydration of cations by water molecules.
- Smaller the cation, greater is the degree of its hydration.
- $Li^+ \qquad Na^+ \quad K^+ \quad Rb^+ \quad Cs^+$
  $\xrightarrow{\qquad\qquad\qquad\qquad}$
  * Degree of hydration decreasing
  * Hydration energy decreasing
  * Hydrated ion size decreasing
  * Ionic conductance increasing

- Due to smaller ionic size and higher charge density their hydration energy is high.
- Its decreasing order is
  $Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$
- ***Hydration energy $\propto$ 1/cation size***

REDUCING PROPERTY

- Since alkali metals have high standard oxidation potential, so these are strongest reductants.
- Reducing property increases down the group in gaseous or molten state
  Li < Na < K < Rb < Cs
- But in aqueous solution order is -
  Li > K $\simeq$ Rb > Cs > Na

- Less reductant than alkali metals
- Order of reducing property in aqueous and gaseous medium is
  Be < Mg < Ca < Sr < Ba

REACTIVITY - INCREASES IN GROUP

Reactivity $\propto$ 1/Ionisation potential

order of reactivity – Li < Na < K < Rb < Cs

- Less reactive than alkali metals.
- Order of reactivity

  Be < Mg < Ca < Sr < Ba

REACTION WITH OXYGEN

Li	Na	K Rb Cs
Oxide	Oxide & peroxide	Super oxide

(Li_2O) (Na_2O_2) (KO_2, RbO_2, CsO_2)

- Their stability order is –

$\underset{\text{(paramagnetic)}}{\text{Normal oxide}} > \underset{\text{(diamagnetic)}}{\text{Peroxide}} > \underset{\text{(paramagnetic)}}{\text{Superoxide}}$

Be Mg Ca	Sr Ba
Oxide	Peroxide

- Peroxides are coloured due to Lattice defect.

$$\xrightarrow[\text{Basic strength increases}]{BeO \quad MgO \quad CaO \quad SrO \quad BaO}$$

REACTION WITH HYDROGEN

- Alkali metals combine with H_2 forming ionic hydrides

  $2M + H_2 \rightarrow 2MH$
- LiH is covalent hydride while others are ionic.
- Hydrides of alkali metals are attacked by water to give H_2

$$\xrightarrow[\text{Thermal stability decreases, Basic nature increases}]{LiH, \quad NaH, \quad KH, \quad RbH, \quad CsH}$$

- Except Be all the alkaline metals forms MH_2 type hydrides, $(MgH_2, CaH_2, SrH_2, BaH_2)$ on heating directly with H_2
- BeH_2 and MgH_2 are covalent, others are ionic.
- Be and Mg have tendency of polymerisation.

  $(BeH_2)_n$ $(MgH_2)_n$ Polymeric hydride

REACTION WITH WATER

- Monoxides gives strong alkaline solution with water

  $M_2O + H_2O \rightarrow 2MOH$

  LiOH < NaOH < KOH < KbOH < CsOH

Order of reactivity Ba > Sr > Ca > Mg > Be

- from $Be(OH)_2$ to $Ba(OH)_2$ basic nature and stability increases.

CARBONATES

- All the alkali metals forms M_2CO_3 type carbonates.
- Except Li_2CO_3, all the carbonates are stable towards heat

  $Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$ $Na_2CO_3 \xrightarrow[\Delta]{} x$
- Thermal stability of carbonates $\propto$ $1/\phi$ (Ionic potential)

  Order of thermal stability is –

  $Cs_2CO_3 > Rb_2CO_3 > K_2CO_3 > Na_2CO_3 > Li_2CO_3$

- All the alkaline metals forms MCO_3 type carbonates.
- All the carbonates decompose on heating.

  $BeCO_3 \xrightarrow{\Delta} BeO + CO_2$
- Order of decreasing thermal stability -

  $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3 > BeCO_3$

NITRATES

- Stability increases from $LiNO_3$ to $CsNO_3$. $LiNO_3$ decompoes into Lithium oxide & NO_2 on heating.

  $4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$
- Other nitrates, on heating, give nitrite and oxygen.

  $2MNO_3 \xrightarrow{\Delta} \underset{\text{Nitrite}}{2MNO_2} + O_2$

- Stability increases from $Be(NO_3)_2$ to $Ba(NO_3)_2$ but these are less stable than IA group, due to smaller atomic size.
- All alkaline metals nitrates on heating gives oxides and $NO_2 + O_2$

  $M(NO_3)_2 \xrightarrow{\Delta}$ Metal Oxides $+ NO_2 + O_2$
- $Be(NO_3)_2$ forms a layer of BeO on its surface so reaction stops.

NITRIDES

- Only Li reacts directly with N_2 to form nitride which gives NH_3 on hydrolysis.

  $6Li + N_2 \rightarrow 2Li_3N$

  $Li_3N + 3H_2O \rightarrow 3LiOH + NH_3\uparrow$
- Only Be and Mg burns in N_2 to give M_3N_2 (Be_3N_2, Mg_3N_2)

  $Be_3N_2 + 6H_2O \rightarrow 3Be(OH)_2 + 2NH_3$

  $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

SULPHATES

- All alkali metal sulphates are ionic. Ionic properties increases from Li to Cs.
- Li_2SO_4 Least soluble in water.
- These sulphates on burning with C forms sulphides

  $M_2SO_4 + 4C \rightarrow M_2S + 4CO$
- Except lithium, sulphates of IA group reacts with sulphates of trivalent metals like Fe^{+3}, Cr^{+3}, Al^{+3} etc. to form double salts called alum.

  $\overset{I}{M_2}SO_4.\overset{III}{M_2}(SO_4)_3.24H_2O$
- Ionic nature of alkaline metal sulphat is increases from Be to Ba

  $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$
- Order of solubility–

  $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$
- Order of thermal stability–

  $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

  $\xrightarrow{\hspace{10cm}}$

  Ionic nature increases, Thermal stability increases

SOLUBILITY IN LIQUID AMMONIA

- All the alkali metals dissolves in NH_3 (liq.) and produces blue solution.
- This blue solution conducts electricity and possesses strong reducing power, due to the presence of ammoniated electrons.

  $Na_{(s)} + (x+y)\,NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{ammoniated electron}}{[e(NH_3)_y]^-}$
- Dark blue colour of solution becomes fade if it allowed to stand for a long time, it is because of metal amide formation.
- This dilute solution is paramagnetic in nature.
- $2Li + NH_3 \rightarrow Li_2NH$ (Lithimide) $+ H_2$

  $2Na + 2NH_3 \rightarrow \underset{\text{(Sodamide)}}{2NaNH_2} + H_2\uparrow$
- Only Ca, Sr and Ba gives blue solution due to ammoniated electron.
- Be and Mg are small in size and have high ionisation potential so do not dissolves in liquid NH_3.
- Blue colour of solution disappears on addition of ammonium salt, due to NH_3 formation.

  $NH_4^+ + NH_2^- \rightarrow 2NH_3$
- On increasing metal ion concentration solution converts into bronze colour due to cluster formation of metal ions.

Sodium Hydroxide (NaOH), Caustic Soda

(a) Manufacture :

Castner – Kellner Cell : (Hg – Cathode Process)

Electrolite (Brine) $NaCl \rightleftharpoons Na^+ + Cl^-$

On electrolysis–

At Cathode (Hg)

$Na^+ + e^- \rightarrow Na.$; $Na + Hg \rightarrow Na.Hg$ (amalgum)

At anode (Graphite)

$2Cl^- \rightarrow Cl_2(g) + 2e^-$; $2Na.Hg + 2H_2O \rightarrow 2NaOH + H_2 + 2Hg$

Sodium Bicarbonate or Baking soda ($NaHCO_3$)

(a) Preparation : Solvay process (Commercial Scale)

$CaCO_3 \longrightarrow CaO + CO_2$ (In brine saturated with NH_3, CO_2 is passed)

$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$

$NaCl + NH_4HCO_3 \longrightarrow NH_4Cl + NaHCO_3$

$2NH_4Cl + CaO \longrightarrow CaCl_2 + 2NH_3 + H_2O$ (By-products)

(b) Properties :

Hydrolysis $NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3$

Effect of heat (temp. > 100°C) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2\uparrow$
(Process occurs during preparation of cake)

Reaction with acids – gives CO_2 $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$

Reaction with base $NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$

Sodium Carbonate or Washing Soda ($Na_2CO_3.10H_2O$)

(a) Occurrence : Na_2CO_3–Soda ash.

(b) Manufacture : Solvay process

(i) Concentrated aqueous solution of NaCl is saturated with NH_3.

(ii) Current of CO_2 passed through the solution.

(iii) $NaHCO_3$ precipitated –

$$2NaHCO_3 \xrightarrow[\Delta]{} Na_2CO_3 + CO_2 + H_2O$$

(iv) Potassium bicarbonate ($KHCO_3$) cannot be prepared by solvay process as it is highly soluble in water.

(c) Properties :

(i) **Efflorescence :**

$Na_2CO_3.10H_2O$ when exposed to air it gives out nine out of ten H_2O molecules.

$$Na_2CO_3.10H_2O \longrightarrow \underset{\text{(Monohydrate)}}{Na_2CO_3.H_2O} + 9H_2O$$

This process is called efflorescence. Hence washing soda losses weight on exposure to air.

(ii) **Hydrolysis :** Aqueous solution of Na_2CO_3 is alkaline in nature due to anionic hydrolysis.

(c) Uses

(i) For making fusion mixture ($Na_2CO_3 + K_2CO_3$)

(ii) In the manufacturing of glass, caustic soda, soap powders etc.

(iii) In laundries and softening of water.

Plaster of Paris $(CaSO_4)_2.H_2O$ or $CaSO_4.1/2\ H_2O$

(a) Preparation : It obtained when gypsum is heated at 120^0C

$$\underset{\text{Gypsum}}{2(CaSO_4.2H_2O)} \longrightarrow 2CaSO_4.H_2O + 3H_2O$$

(b) Properties :

(i) It is a white powder.

(ii) It has the property of setting to a hard mass when a paste with water is allowed to stand aside for sometime.

(iii) When it heated at 200^0C, anhydrous $CaSO_4$ is formed K/as dead burnt P.O.P.

(c) Uses

$$CaSO_4.\frac{1}{2}H_2O \xrightarrow[\Delta]{200^\circ C} \underset{\substack{\text{dead burnt+P.O.P.} \\ \text{(very high T)}}}{CaSO_4} + H_2O \rightarrow CaO + SO_3$$