

# ALKALI METAL

## 1. PHYSICAL STATE

- (a) One electron in outermost shell & **General formula  $ns^1$** .
- (b) Francium is radioactive element.
- (c) All are silvery white
- (d) Light soft, malleable and ductile metals with metallic lustre.
- (e) Alkali metals are paramagnetic, diamagnetic and colourless in form of ions.

## 2. ATOMIC SIZE

- (a) Biggest in their respective period  
(except noble gas element)
- (b) Size increases from Li to Fr due to addition of an extra shell.  
 $Li < Na < K < Rb < Cs < Fr$

## 3. SOFTNESS

- (a) Alkali metals are soft because of -
  - (i) Large atomic size
  - (ii) BCC crystal structure (HCP in Li)
  - (iii) Loose packing (68% packing efficiency)
  - (iv) Weak metallic bond
- (b) Cs is the softest metal in s-block

$\text{Atomic size} \propto \frac{1}{\text{strength of metallic bond}} \propto \text{softness} \propto \frac{1}{\text{Melting \& Boiling point}}$
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## 4. MELTING POINT AND BOILING POINT

- (a) Weak interatomic bonds are due to their large atomic radii and presence of only one valence electron hence melting point and boiling point are low.
- (b) Decreasing order of melting point and boiling point is  
 $Li > Na > K > Rb > Cs$
- (c) With the increase in the size of metal atom, the repulsion of the non-bonding electrons increases and therefore melting point and boiling point decreases from Li to Cs.

## 5. ELECTRO POSITIVE CHARACTER OR METALLIC CHARACTER

**Electropositivity  $\propto 1/\text{Ionisation Potential}$**

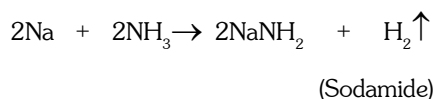
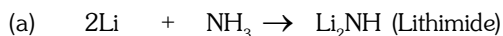
Due to their larger size electron can easily be removed to form  $M^+$  ion. Electro positive property increases from Li to Cs.

## 6. FLAME TEST

Alkali metals and their salts gives characteristic colour to bunsen flame. The flame energy causes an excitation of the outer most electron which on dropping back to ground state emits absorbed energy as visible light

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

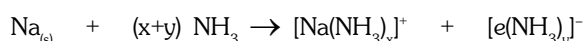
## 7. REACTION WITH $\text{NH}_3$



(b) Solubility in liquid ammonia

(i) All the alkali metals dissolves in  $\text{NH}_3$  (liq.) and produces blue solution.

(ii) This blue solution conducts electricity and possesses strong reducing power, due to the presence of ammoniated electrons.



ammoniated electron

(iii) This dilute solution is paramagnetic in nature.

## 8. PHOTO ELECTRIC EFFECT

(a) Atomic size of K, Rb and Cs is quite large, so their ionisation potential is very low

(b) 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.

## 9. STANDARD OXIDATION POTENTIAL

(a) All the alkali metals have high +ve values of standard oxidation potential (tendency of releasing electrons in water or self ionic solutions)

(b) So these are good reducing agent, having upper most positions in the electro chemical series.

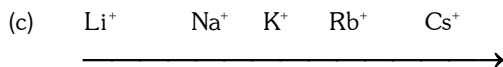
(c) Li has highest standerd oxidation potential (+3.05 eV) due to its high hydration energy. Such that it converts into.  $\text{Li}^+$  ion by loosing one electron.

Order of standard oxidation potential of s - block element														
Li	>	K	>	Ba	>	Sr	>	Ca	>	Na	>	Mg	>	Be
Hydration energy $\propto$ Charge density on ion														

## 10. HYDRATION ENERGY (HEAT OF HYDRATION)

(a) Alkali metals salts are generally soluble in water due to hydration of cations by water molecules.

(b) Smaller the cation, greater is the degree of its hydration.



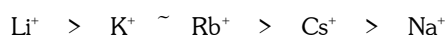
- \* Degree of hydration decreasing
- \* Hydration energy decreasing
- \* Hydrated ion size decreasing
- \* Ionic conductance increasing

## 11. REDUCING PROPERTY

- (a) Since alkali metals have high standard oxidation potential, so these are strongest reductants.
- (b) Reducing property increases down the group in gaseous or molten state

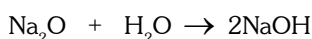
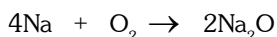


- (c) But in aqueous solution order is -

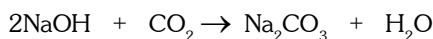


## 12. REACTION WITH AIR

- (a) Alkali metals gets tarnish in air due to the formation of oxide at their surface hence they are kept in kerosene or paraffin oil.
- (b) These elements reacts with moist air to form carbonates



(moist)



(in air)

In dry air only Li gives nitride and oxide both while other elements gives only oxides.

## 13. REACTION WITH OXYGEN

**Oxide ion  $[\text{O}^{2-}]$  :**

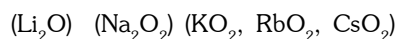
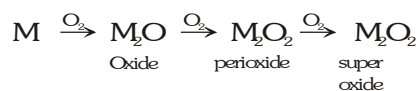
Li forms only  $\text{Li}_2\text{O}$  (Lithium oxide).

**Peroxide  $[\text{O}_2]^{-2}$  :**

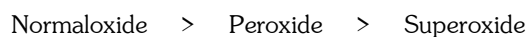
Na reacts with  $\text{O}_2$  to form peroxide ( $\text{Na}_2\text{O}_2$ ).

**Super oxide  $[\text{O}_2^-]$  :**

K, Rb and Cs forms  $\text{MO}_2$  type oxides (super oxides) in excess of  $\text{O}_2$ . So super oxides are paramagnetic and coloured.

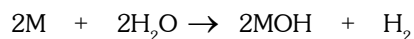


**Their stability order is -**



## 14. REACTION WITH WATER

- (a) Alkali metals react vigorously with water forming hydroxides with the liberation of  $H_2$ .



- (b) Reactivity with water increases from Li to Cs.

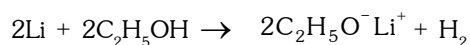
Li  $\rightarrow$  least reactive towards water

Na  $\rightarrow$  reacts vigorously

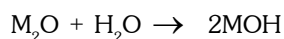
K  $\rightarrow$  reacts producing a flame

Rb, Cs  $\rightarrow$  reacts explosively.

- (c) These metals also reacts with alcohol gives alkoxide and  $H_2$ .



- (d) Monoxides gives strongly alkaline solution with water



## 15. HALIDES

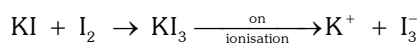
- (a) Alkali metals reacts directly with halogen to form MX

(M – alkalimetal, X – Halide ion)

- (b) Ionic properties of MX increases from LiCl to CsCl

- (c) LiCl is covalent in nature (due to polarisation of  $Cl^-$  ion by small  $Li^+$  ion). hence it hydrolyses with water while rest are ionic so do not hydrolyse.

- (d) K, Rb and Cs halides reacts with more halogens to gives polyhalides.



## 16. CARBONATES

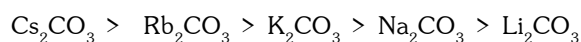
- (a) All the alkali metals forms  $M_2CO_3$  type carbonates.

- (b) Except  $Li_2CO_3$ , all the carbonates are stable towards heat



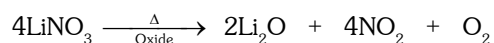
- (c) Thermal stability of carbonates  $\propto 1/\phi$  (Ionic potential)

Order of stability is –

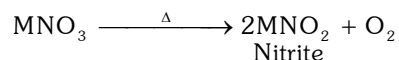


**17. NITRATES**

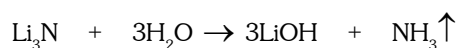
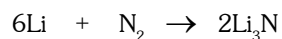
- (a) Alkali metals forms  $MNO_3$  type nitrates (M – alkali metal)
- (b) Stability increases from  $LiNO_3$  to  $CsNO_3$ .  $LiNO_3$  decomposes into Lithium oxide &  $NO_2$  on heating.



- (c) Other nitrates, on heating to give nitrite and oxygen.

**18. NITRIDES**

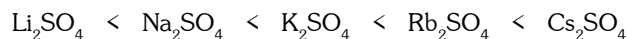
Only Li reacts directly with  $N_2$  to form nitride which gives  $NH_3$  on reacting with water.

**19. FORMATION OF AMALGAM**

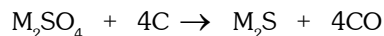
- (a) Alkali metals gives amalgam with Hg.
- (b) These metals reacts with other metals to give mixed metals (alloys)

**20. SULPHATES**

- (a) Alkali metals forms  $M_2SO_4$  type sulphates.
- (b) All alkali metal sulphates are ionic. Ionic properties increases from Li to Cs.

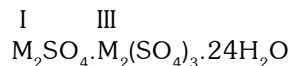


- (c)  $Li_2SO_4$  Least soluble in water.
- (d) These sulphates on burning with C forms sulphides

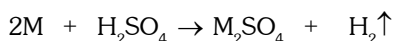


- (e) Except lithium, sulphates of IA group reacts with

sulphates of trivalent metals like  $Fe^{+3}$ ,  $Cr^{+3}$ ,  $Al^{+3}$  etc. gives double salts called alum.

**21. REACTION WITH ACIDS**

Reacts vigorously with acids.



## COMPOUNDS OF ALKALI METALS

### 1. SODIUM (NA), NATRIUM

(a) **Extraction : Down's Process**

By Electrolysis of fused  $\text{NaCl} + \text{CaCl}_2 + \text{NaF}$

At cathode (Iron Vessel) :  $\text{Na}^+ + \text{e}^- \longrightarrow \text{Na(s)}$

At Anode (Graphite) :  $2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$

- (i)  $(\text{CaCl}_2 + \text{NaF})$  is used to lower Melting point ( $800^\circ\text{C}$ ) of  $\text{NaCl}$  to about  $600^\circ\text{C}$ .
- (ii) Aqueous sodium chloride cannot be used for preparing sodium by electrolysis. Because instead of metallic sodium, hydrogen gas will be liberated at cathode.

(b) **Properties**

- (i) It is a crystalline soft metal.
- (ii) Highly reactive, so kept in kerosene.
- (iii)  $\text{Na}$  dissolves in liquid  $\text{NH}_3$  to give blue solution.

(c) **Uses**

- (i) In the preparation of sodium amalgam (used as reducing agent)
- (ii) In sodium vapour lamp, which emits monochromatic yellow light.
- (iii) As heat transfer medium in nuclear reactors.

### 2. SODIUM CHLORIDE $\text{NaCl}$

- (a) **Occurrence** : Sea water is the main source and also found in salt lakes.

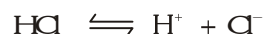
(b) **Preparation**

- (i) Sea water  $\text{NaCl}(2.7 - 2.9\%) \xrightarrow[\text{by solar heat}]{\text{Evaporation}}$  crude  $\text{NaCl}$

- (ii) It contains impurities –  $\text{Na}_2\text{SO}_4$ ,  $\text{MgCl}_2$ ,  $\text{CaCl}_2$  etc.

- (iii) Insoluble impurities removed by filtration.

- (iv) Filtrate  $\xrightarrow{\text{HCl gas passed}}$  Pure  $\text{NaCl}$  precipitation (Common ion effect)



Ionic product of  $[\text{Na}^+][\text{Cl}^-] > \text{solubility product of NaCl}$  hence it precipitates out.

- (v)  $\text{MgCl}_2$  and  $\text{CaCl}_2$  are more soluble in water so left in solution.

(c) **Properties**

- (i) Table salt is slightly hygroscopic due to the presence of magnesium and calcium chlorides in small amounts.
- (ii) Reaction with  $\text{AgNO}_3$



Reaction with  $\text{K}_2\text{Cr}_2\text{O}_7 + \text{conc. H}_2\text{SO}_4$

- (iii) 
$$4\text{NaCl} + \text{K}_2\text{Cr}_2\text{O}_7 + 5\text{H}_2\text{SO}_4 \xrightarrow{\Delta} 4\text{NaHSO}_4 + \text{K}_2\text{SO}_4 + 2\text{CrO}_2\text{Cl}_2 + 3\text{H}_2\text{O}$$
  
(orange red)

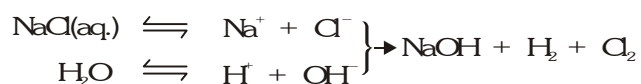
(d) **Uses**

- (i) As a preservative for pickles, meat and fish.
- (ii) For making freezing mixture with Ice.

### 3. SODIUM HYDROXIDE (NaOH), CAUSTIC SODA

(a) **Manufacture** : By electrolysis of NaCl.

(b) **Nelson Cell or Diaphragm Cell** : The following reactions takes place -



At cathode (Perforated steel) :  $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$  At anode (Carbon) :  $2\text{Cl}^-(\text{aq.}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

(c) **Castner - Kellner Cell** : (Hg - Cathode Process)

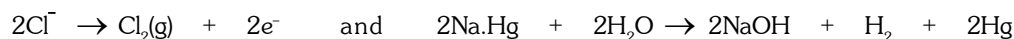
Electrolite (Brine)  $\text{NaCl} \rightleftharpoons \text{Na}^+ + \text{Cl}^-$

**On electrolysis -**

At Cathode (Hg)



At anode (Graphite)

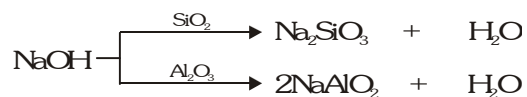


(d) **Properties**

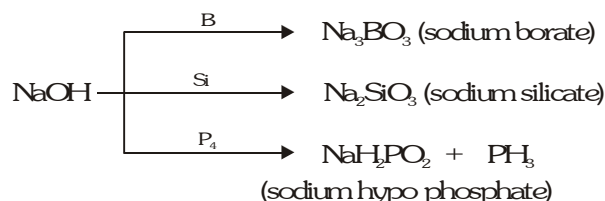
(i) It is deliquescent white crystalline solid.

(ii) It absorbs  $\text{CO}_2$  from air forming  $\text{Na}_2\text{CO}_3$ .

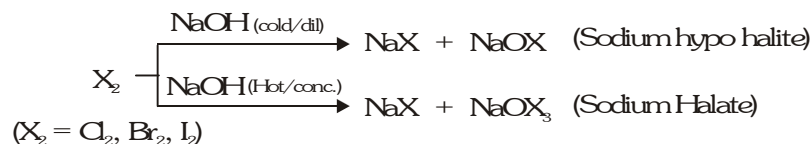
(iii) NaOH is **strong base**



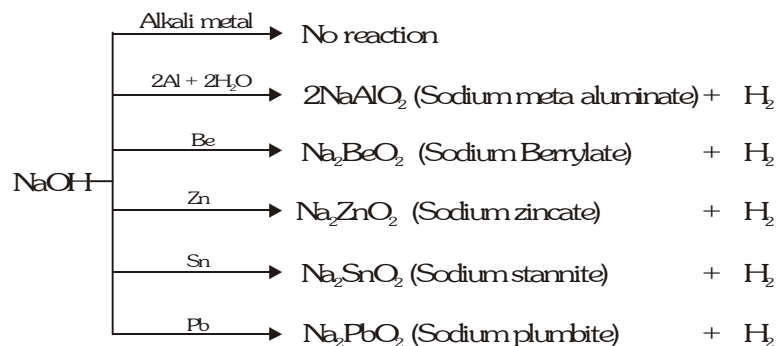
(iv) **Reaction with non metals** : no reaction with  $\text{H}_2$ ,  $\text{N}_2$  and C



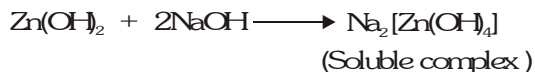
(v) **Reaction with halogens**



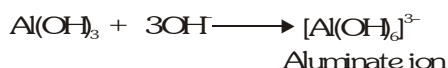
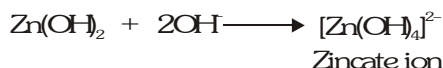
(vi) **Reaction with Metal** :



(vii) **Reaction with  $\text{ZnCl}_2$  or  $\text{ZnSO}_4$**



(viii) The hydroxides of aluminium, zinc, lead and tin, however, dissolve in excess of sodium hydroxide giving clear solution which can also be obtained when these metals are acted upon by the concentrated solution of sodium hydroxide.

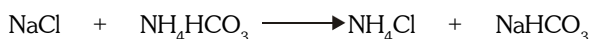
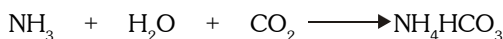
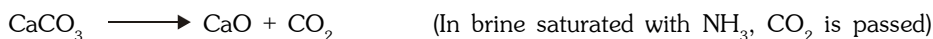


(e) **Uses**

- (i) In the manufacture of soap, rayon, dyes, paper and drugs.
- (ii) In petroleum refining.

**4. SODIUM BICARBONATE OR BAKING SODA ( $\text{NaHCO}_3$ )**

(a) **Preparation : Solvay process** (Commercial Scale)



(b) **Properties**

<b>Hydrolysis</b>	$\text{NaHCO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NaOH} + \text{H}_2\text{CO}_3$
<b>Effect of heat</b> (temp. > 100 C) (Process occurs during preparation of cake)	$2\text{NaHCO}_3 \longrightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 \uparrow$
<b>Reaction with acids</b> – gives $\text{CO}_2$	$\text{NaHCO}_3 + \text{HCl} \longrightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 \uparrow$
<b>Reaction with base</b>	$\text{NaHCO}_3 + \text{NaOH} \longrightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$

(c) **Uses**

- (i) In the preparation of baking powder.
- (ii) In the preparation of effervescent drinks.
- (iii) In the fire extinguishers.
- (iv) As antacid medicine (removing acidity)

**5. SODIUM CARBONATE OR WASHING SODA ( $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ )**

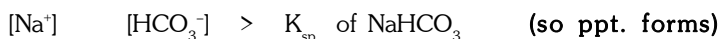
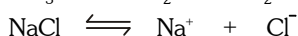
(a) **Occurrence** :  $\text{Na}_2\text{CO}_3$ –Soda ash.

(b) **Manufacture : By solvay process**

(i) Concentrated aqueous solution of  $\text{NaCl}$  is saturated with  $\text{NH}_3$ .

(ii) Current of  $\text{CO}_2$  passed through the solution.

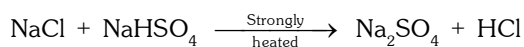
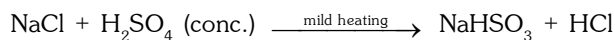
(iii)  $\text{NaHCO}_3$  precipitated –



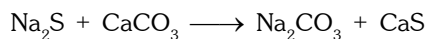
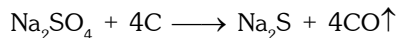
(iv) Potassium bicarbonate ( $\text{KHCO}_3$ ) cannot be prepared by solvay process as it is soluble in water.



(c) **Leblanc Process**



(Salt Cake)



(d) **Properties**

(i) **Efflorescence :**

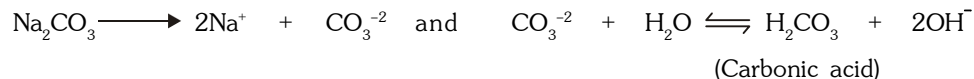
$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  when exposed to air it gives out nine out of ten  $\text{H}_2\text{O}$  molecules.



(Monohydrate)

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

(ii) **Hydrolysis :** Aqueous solution of  $\text{Na}_2\text{CO}_3$  is alkaline in nature due to anionic hydrolysis.

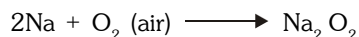


(e) **Uses**

- (i) For making fusion mixture ( $\text{Na}_2\text{CO}_3 + \text{K}_2\text{CO}_3$ )
- (ii) In the manufacture of glass, caustic soda, soap powders etc.
- (iii) In laundries and softening of water.

**6. SODIUM PEROXIDE  $\text{Na}_2\text{O}_2$**

(a) Sodium peroxide is manufactured by heating sodium metal on aluminium trays in air (free from  $\text{CO}_2$ )



- (i) When pure it is colourless, and the faint yellow colour of the usual product arises from the presence of a small amount of  $\text{NaO}_2$ .
- (ii) When it is exposed, it comes in contact with moist air and turns white due to formation of  $\text{NaOH}$  and  $\text{Na}_2\text{CO}_3$ . Thus



- (iii) Sodium peroxide is a powerful oxidizing agent and oxidizes chromium (III) hydroxide to sodium chromate, manganese (II) to sodium manganate and sulphides to sulphates.



(b) **Uses**

- (i) Sodium peroxide is widely used as an oxidizing agent yielding in inorganic chemistry; its reaction with organic compounds are dangerously violent.
- (ii) Sodium readily combines with carbon dioxide, sodium carbonate and oxygen, it may be used for the purification of air in confined spaces such as submarines.
- (iii) It is also used as a bleaching agent because of its oxidizing property.
- (iv) Sodium peroxide is used in the manufacture of dyes, and many other chemicals such as benzoyl peroxide, sodium perborate etc.

## 7. POTASSIUM HYDROXIDE KOH

- (a) **Preparation:** Electrolysis of KCl aqueous solution.
- (b) **Properties:** Same as NaOH
- (i) It is stronger base compared to NaOH.
- (ii) Solubility in water is more compared to NaOH.
- (iii) In alcohol, NaOH is sparingly soluble but KOH is highly soluble.
- (iv) As a reagent KOH is less frequently used but in absorption of  $\text{CO}_2$ , KOH is preferable used compared to NaOH. Because  $\text{KHCO}_3$  formed is soluble whereas  $\text{NaHCO}_3$  is insoluble and may therefore choke the tubes of apparatus used.

## 8. POTASSIUM CARBONATE

- (a) By leblance process, it can be prepared but by solvay process it cannot be prepared because  $\text{KHCO}_3$  is soluble in water.
- (b) **Properties:** It resembles with  $\text{Na}_2\text{CO}_3$ , m.p. is  $900^\circ\text{C}$  but a mixture of  $\text{Na}_2\text{CO}_3$  and  $\text{K}_2\text{CO}_3$  melts at  $712^\circ\text{C}$ .
- (c) **Uses:** It is used in glass manufacturing.

## 9. POTASSIUM CHLORIDE

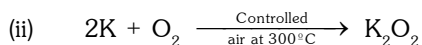
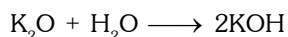
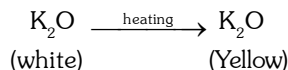
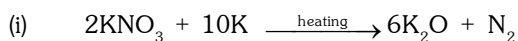
It also occurs in nature and sylvyne (KCl) or carnalite ( $2\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ )

**Uses:** It is used as fertiliser.

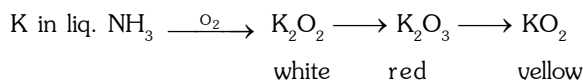
## 10. OXIDES OF POTASSIUM

	$\text{K}_2\text{O}$ ,	$\text{K}_2\text{O}_2$ ,	$\text{K}_2\text{O}_3$ ,	$\text{KO}_2$	$\text{KO}_3$
<b>Colours</b>	White	White	Red	Bright yellow	Reddish brown needles

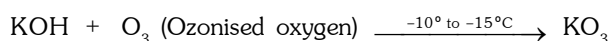
### Preparation



- (iii) Passage of  $\text{O}_2$  through a blue solution of K in liquid  $\text{NH}_3$  yields oxides  $\text{K}_2\text{O}_2$  (white),  $\text{K}_2\text{O}_3$  (red) and  $\text{KO}_2$  (deep yellow) i.e.



$\text{KO}_2$  reacts with  $\text{H}_2\text{O}$  and produces  $\text{H}_2\text{O}_2$  and  $\text{O}_2$  both



(Dry powdered)

(orange solid)

## ALKALINE EARTH METAL

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### 1. PHYSICAL STATE

- (a) Two electrons in outer most shell & General formula  $ns^2$ .
- (b) Radium is radioactive element.
- (c) All are greyish white.
- (d) These metals are harder than alkali metals.
- (e) These are diamagnetic and colourless in form of ions or in metal states.

### 2. ATOMIC SIZE

Smaller than IA group elements, since extra charge on nucleus attracts the electron cloud.

- (a) Size increases gradually from Be to Ba  

$$\text{Be} < \text{Mg} < \text{Ca} < \text{Sr} < \text{Ba}$$
- (b) In s-block elements  
 Be is the smallest, Cs is the biggest

### 3. SOFTNESS

- (a) These metals are slightly harder than IA group because of -
  - (i) Smaller atomic size
  - (ii) FCC, HCP crystal structures
  - (iii) Packing capacity 74%
  - (iv) Stronger metallic bond due to presence of two electrons in valence shell.
- (b) Be is the hardest metal in s-block.

### 4. MELTING POINT AND BOILING POINT

- (a) Metallic bond is stronger than IA group due to smaller atomic size and two electrons in valence shell hence melting point and boiling point are higher.
- (b) Decreasing order of melting point and boiling point is  

$$\text{Be} > \text{Ca} > \text{Sr} > \text{Ba} > \text{Mg}$$
- (c) Melting point and Boiling point of Ca, Sr and Ba is higher than Mg because of presence of d-orbitals in the outer most shell, which forms stronger metallic bond.

### 5. ELECTRO POSITIVE CHARACTER OR METALLIC CHARACTER

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

### 6. FLAME TEST

- (a) Be and Mg atoms, due to small size, bind their electrons more strongly, so are not excited to higher level, hence no flame test.
- (b) Other elements gives characteristic colour to flame

**Ca-Brick red**

**Sr-crimson red**

**Ba-Apple green**

### 7. REACTION WITH $\text{NH}_3$

- (a) On increasing metal ion concentrate solution converts into bronze colour due to cluster formation of metal ions.
- (b) Solubility in liquid ammonia
  - (i) Only Ca, Sr and Ba gives blue solution of ammoniated electron.

- (ii) Be and Mg are small in size and have high ionisation potential so do not dissolve in liquid  $\text{NH}_3$ .
- (iii) Dark blue colour of solution becomes fade if it allowed to stand for a long time, it is because of metal amide formation.
- (iv) Blue colour of solution disappears on addition of ammonium salt, due to  $\text{NH}_3$  formation.

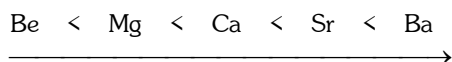


## 8. PHOTO ELECTRIC EFFECT

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

## 9. STANDARD OXIDATION POTENTIAL

- (a) They have lower values of standard oxidation potential due to their small size.
- (b) Increasing order of standard oxidation potential is -



- (c) Tendency of losing electron increases

## 10. HYDRATION ENERGY (HEAT OF HYDRATION)

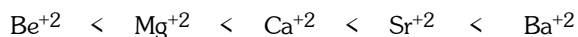
- (a) Due to smaller ionic size and higher charge density their hydration energy is high.
- (b) Its decreasing order is



- (c) Hydration energy  $\propto 1/\text{cation size}$

## 11. REDUCING PROPERTY

- (a) Less reductant than alkali metals
- (b) Order of reducing property in aqueous and gaseous medium is



## 12. REACTION WITH AIR

- (a) Except Be, these metals are easily tarnished in air, as a layer of oxide is formed on the surface.
- (b) Barium in powdered form, burst into flame on exposure to air.
- (c) In moist air, except Be all the elements convert into carbonates.
- (d) In dry air Be and Mg give nitride and oxide both while others give only oxides.

## 13. REACTION WITH OXYGEN

- (a) Alkaline earth metals react with  $\text{O}_2$  to form 'MO' type oxides  
(M = Be, Mg, Ca, Sr, Ba)
- (b) But Ca, Sr and Ba due to low ionisation potential and more reactivity, form  $\text{MO}_2$  (peroxides) at low temperature.  
**Ex.**  $\text{CaO}_2$ ,  $\text{SrO}_2$ ,  $\text{BaO}_2$
- (c) Peroxides are coloured due to lattice defect.
- (d) BeO shows amphoteric property.  
 $\text{MgO} \rightarrow$  weak base  
 $\text{CaO}$ ,  $\text{SrO}$  &  $\text{BaO} \rightarrow$  Strong base

- (e) Basic properties increases from Be to Ba
- (f) Its stability order    general oxide > peroxide > super oxide

#### 14. REACTION WITH WATER

- (a) These metals reacts slowly with water gives  $H_2$  and metals hydroxides.  

$$M + 2H_2O \rightarrow M(OH)_2 + H_2$$
- (b) Be does not reacts with water
- (c) Mg reacts only with hot water
- (d) Ca, Sr, Ba reacts with cold water but not as energetically as alkali metals. order of reactivity  
 $Ba > Sr > Ca > Mg > Be$
- (e) from  $Be(OH)_2$  to  $Ba(OH)_2$  basic property and stability increases.

#### 15. HALIDES

- (a) Alkaline metals reacts with X (Halogen) to form  $MX_2$ .  
**Ex.** ( $BeCl_2$ ,  $MgCl_2$ ,  $CaCl_2$  etc.)
- (b) Ionic nature of  $MX_2$  increases from  $BeCl_2$  to  $BaCl_2$
- (c) Ba burns in contact with  $Cl_2$
- (d) Hydrolytic nature of these halides decreases from  $BeCl_2$  to  $BaCl_2$
- (e)  $BeCl_2$  and  $MgCl_2$  are covalent in nature. Order of ionic nature –  
 $BeCl_2 < MgCl_2 < CaCl_2 < SrCl_2 < BaCl_2$   
 Solubility in water  
 $BeCl_2 > MgCl_2 > CaCl_2 > SrCl_2 > BaCl_2$

#### 16. CARBONATES

- (a) All the alkaline metals forms  $MCO_3$  type carbonates.
- (b) Except  $BeCO_3$ , all the carbonates are stable towards heat  

$$BeCO_3 \xrightarrow{\Delta} BeO + CO_2$$
- (c) Order of decreasing stability -  
 $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3 > BeCO_3$

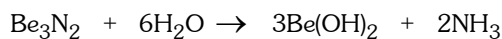
#### 17. NITRATES

- (a) Alkaline earth metals forms  $M(NO_3)_2$  type nitrates. (M –Alkaline earth metal).
- (b) 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.
- (c) All alkaline metals nitrates on heating gives oxides and  $NO_2 + O_2$   

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

**18. NITRIDES**

Only Be and Mg burns in  $N_2$  to give  $M_3N_2$  ( $Be_3N_2$ ,  $Mg_3N_2$ )

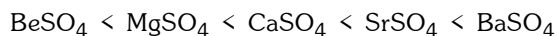
**19. FORMATION OF AMALGAM**

Shows same properties as alkali metals.

**20. SULPHATES**

(a) Alkaline earth metals form  $MSO_4$  type sulphates.

(b) Ionic nature of alkaline metal sulphate increases from Be to Ba

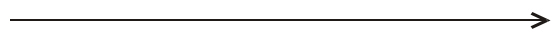


(c) Solubility decreases from  $BeSO_4$  to  $BaSO_4$  as  $Be^{+2}$  and  $Mg^{+2}$  are of small size so their hydration energy is high. Hydration Energy > Lattice energy.

(d) Order of solubility –



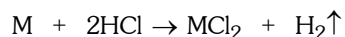
(e) Order of thermal stability –



Ionic nature increases, Thermal stability increases

**21. REACTION WITH ACIDS**

Freely reacts with acids and displaces hydrogen

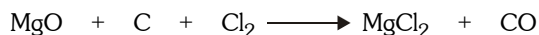
**COMPOUNDS OF ALKALINE EARTH METALS****1. MAGNESIUM**

(a) **Preparation :**

(i) **From Magnesite or Dolomite :** The ore is first calcined to form the oxide



(ii) **From MgO :** The oxide is mixed with carbon and heated in a current of chlorine gas



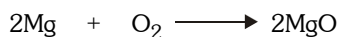
The chloride thus obtained is subjected to electrolysis.

(iii) The mixed oxides ( $CaO.MgO$ ) obtained from calcination of dolomite ( $CaCO_3.MgCO_3$ ) are reduced by ferrosilicon under reduced pressure above 1273 K.

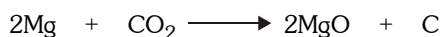
(iv) It is prepared by the electrolysis of fused magnesium chloride.

(b) **Properties**

- (i) Magnesium burns in air with dazzling light.



- (ii) Burning Mg continues to burn in  $\text{CO}_2$  forming MgO because reducing nature  $\text{Mg} > \text{C}$



(c) **Uses**

- (i) In preparation of alloy

Electron : 95% Mg + 5% Zn, air craft

Magnalium : 1 – 15% Mg + 85 – 99% Al, used in aeroplanes, balance beams, light instruments.

- (ii) In photographic flash light.

- (iii) In preparation of Grignard's reagent.

2. **MAGNESIUM CHLORIDE  $\text{MgCl}_2$**

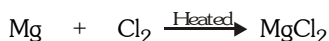
- (a) **Occurrence** : It is mainly found in sea water and carnallite  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ .

- (b) **Preparation** :

- (i) By reaction of dil HCl on  $\text{MgCO}_3$



- (ii)  $\text{MgCl}_2$  is obtained by burning Mg metal in chlorine



- (c) **Properties**

On heating  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ , it gets hydrolysed by its own water of crystallization to an oxy chlorides.



- (d) **Uses**

- (i) For preparation of metallic magnesium.

- (ii) In manufacture of magnesia cement.

- (iii) Used for dressing cotton threads.

3. **MAGNESIUM SULPHATE  $\text{MgSO}_4$**

- (a) **Occurrence** : It occurs naturally as kiserite ( $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ ) and epsomite ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ).

- (b) **Preparation**

By dissolving magnesite in dil.  $\text{H}_2\text{SO}_4$



- (c) **Properties** : On heating above  $200^\circ\text{C}$

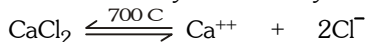


**Note** : It is used in medicine as purgative.

4. **CALCIUM**

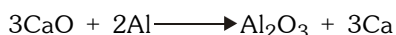
- (a) **Extraction**

- (i) It is obtained by the electrolysis of fused  $\text{CaCl}_2$ . By adding  $\text{CaF}_2$  melting point of  $\text{CaCl}_2$  ( $780^\circ\text{C}$ ) decreased.



At Cathode (Iron)  $\text{Ca}^{++} + 2\text{e}^- \longrightarrow \text{Ca}$  and at Anode (Graphite)  $2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$

- (ii) **Goldschmidt (thermite) Process**



CaO is reduced by Al because it has greater affinity for oxygen than Ca.





- (i) In the preparation of plaster of paris
- (ii) Anhydrous  $\text{CaSO}_4$  used as drying agent.
- (iii) Anhydride ( $\text{CaSO}_4$ ) is used for manufacture of sulphuric acid, ammonium sulphate.

**9. PLASTER OF PARIS ( $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$ )**

- (a) **Preparation :** It obtained when gypsum is heated at  $120^\circ\text{C}$



- (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  $200^\circ\text{C}$ , anhydrous  $\text{CaSO}_4$  is formed.

- (c) **Uses**

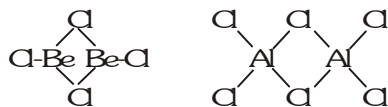
- (i) In surgery for setting broken bones
- (ii) In making casts for toys, statues etc.
- (iii) In making blackboard chalks.

**10. SIMILARITIES BETWEEN LITHIUM AND MAGNESIUM**

- (a) Both lithium and magnesium are harder and lighter than other elements in the respective groups.
- (b) Lithium and magnesium react slowly with cold water. Their oxides and hydroxides are much less soluble and their hydroxides decompose on heating. Both form a nitride by direct combination with nitrogen,  $\text{Li}_3\text{N}$  and  $\text{Mg}_3\text{N}_2$ .
- (c) The oxides,  $\text{Li}_2\text{O}$  and  $\text{MgO}$  do not combine with excess oxygen to give a peroxide or a superoxide.
- (d) The carbonates of lithium and magnesium decompose easily on heating to form the oxide and  $\text{CO}_2$ . Solid bicarbonates are not formed by lithium and magnesium.
- (e) Both  $\text{LiCl}$  and  $\text{MgCl}_2$  are soluble in ethanol.
- (f) Both  $\text{LiCl}$  and  $\text{MgCl}_2$  are deliquescent and crystallise from aqueous solution as hydrates,  $\text{LiCl} \cdot 2\text{H}_2\text{O}$  and  $\text{MgCl}_2 \cdot 8\text{H}_2\text{O}$ .

**11. DIAGONAL SIMILARITY BETWEEN BERYLLIUM AND ALUMINIUM :** In many of its properties, beryllium resembles aluminium. Thus –

- (a) The two elements have same electronegativity and their charge/ radius ratios.
- (b) Both metals are fairly resistant to the action of acids due to a protective film of oxide on the surface. Both metals are acted upon by strong alkalis to form soluble complexes, beryllates  $[\text{Be}(\text{OH})_4]^{2-}$  and aluminates,  $[\text{Al}(\text{OH})_4]^-$ .
- (c) The chlorides of both beryllium and aluminium



have bridged chloride structures in vapour phase.

- (d) Salts of these metals form hydrated ions, Ex.  $[\text{Be}(\text{OH}_2)_4]^{2+}$  and  $[\text{Al}(\text{OH}_2)_6]^{3+}$  in aqueous solutions. Due to similar charge/ radius ratios of beryllium and aluminium ions have strong tendency to form complexes. For example beryllium forms tetrahedral complexes such as  $\text{BeF}_4^{2-}$  and  $[\text{Be}(\text{C}_2\text{O}_4)_2]^{2-}$  and aluminium forms octahedral complexes like  $\text{AlF}_6^{3-}$  and  $[\text{Al}(\text{C}_2\text{O}_4)_3]^{3-}$ .

## IMPORTANT COMPOUNDS AND THEIR FORMULA

1.	Active nitrogen	:	N(atomic nitrogen)
2.	Alums	:	$M_2'SO_4 \cdot M_2''(SO_4)_3 \cdot 24H_2O$ $M' = K^+, NH_4^+, Na^+ \text{ etc.}$ $M'' = Cr^{+3}, Al^{+3}, Fe^{+3} \text{ etc.}$
3.	Asbestos	:	$CaMg_3(SiO_3)_4$
4.	Arsine	:	$AsH_3$
5.	Aquaregia	:	Conc. $HNO_3$ + Conc. $HCl$ (1 : 3 part)
6.	Anhydrone	:	$Mg(ClO_4)_2$
7.	Argentoferrous galena	:	$PbS + Ag_2S$
8.	Borax	:	$Na_2B_4O_7 \cdot 10H_2O$
9.	Blue vitriol	:	$CuSO_4 \cdot 5H_2O$
10.	Barytes	:	$BaSO_4$
11.	Baryta water	:	$Ba(OH)_2$ solution
12.	Baryta	:	$BaO$
13.	Baking soda	:	$NaHCO_3$
14.	Bleaching powder	:	$CaOCl_2$
15.	Boranes	:	Hydride of borone
16.	Brine	:	$NaCl$ solution
17.	Calgon	:	$Na_2[Na_4(PO_3)_6]$
18.	Coinage metals	:	$Cu, Ag \text{ and } Au$
19.	Carborundum	:	$SiC$
20.	Cementite	:	$FeC$
21.	Caliche	:	$NaNO_3 + Na_2CO_3$
22.	Caustic soda	:	$NaOH$
23.	Caustic potash	:	$KOH$
24.	Calomel	:	$Hg_2Cl_2$
25.	Corrosive sublimate	:	$HgCl_2$
26.	Deuterium	:	${}_1H^2$ of D
27.	D.D.T.	:	p-dichloro, diphenyl, trichloroethane
28.	Dry ice	:	Solid $CO_2$
29.	Freon	:	$CF_2Cl_2$
30.	Ferric Alum	:	$K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$

31.	Fenton's reagent	:	$\text{H}_2\text{O}_2$ + few drops of $\text{FeSO}_4$
32.	Fusion mixutre	:	$\text{Na}_2\text{CO}_3$ + $\text{K}_2\text{CO}_3$
33.	Fluid magnesia	:	12% solution of $\text{Mg}(\text{HCO})_2$
34.	Fehling solution	:	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ + $\text{NaOH}$ + Na, K tartarate
35.	King of metals	:	Gold
36.	Horn Silver	:	$\text{AgCl}$
37.	Green vitriol	:	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
38.	Graphite	:	An allotrope of carbon
39.	Gun powder	:	75% $\text{KNO}_3$ + 12%S + 13% charcoal (explosive)
40.	Glauber salt	:	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
41.	Hydrolith	:	$\text{CaH}_2$
42.	Heavy water	:	$\text{D}_2\text{O}$
43.	Hypo (sodium thiosulphate)	:	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
44.	Heavy hydrogen	:	$\text{D}_2$
45.	King of chemicals	:	$\text{H}_2\text{SO}_4$
46.	Lime (quick lime or burnt lime)	:	$\text{CaO}$
47.	Lead pencil	:	Graphite
48.	Lime water	:	$\text{Ca}(\text{OH})_2$
49.	Laughing gas	:	$\text{N}_2\text{O}$
50.	Lunar Caustic	:	$\text{AgNO}_3$
51.	Litharge (Masscote)	:	$\text{PbO}$
52.	Lithopone	:	$(\text{ZnS} + \text{BaSO}_4)$ , a pigment
53.	Mortar	:	Slaked lime + sand (1 : 3 in water)
54.	Mica	:	$\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
55.	Mohr salt	:	$\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$
56.	Matte	:	$\text{Cu}_2\text{S} + \text{FeS}$
57.	Milk of lime	:	$\text{Ca}(\text{OH})_2$ in water

58.	Minium	:	$\text{Pb}_3\text{O}_4$
59.	Micro cosmic salt	:	$\text{NaNH}_4 \cdot \text{HPO}_4 \cdot 4\text{H}_2\text{O}$ (used in test of silicates)
60.	Milk of magnesia	:	Paste of $\text{Mg}(\text{OH})_2$ in water (Antacid)
61.	Magnesia	:	$\text{MgO}$
62.	Marsh gas	:	$\text{CH}_4$
63.	Nitrolim	:	$\text{CaCN}_2 + \text{C}$ (a fertilizer)
64.	Nascent Hydrogen	:	H at the moment of generation
65.	Nessler's reagent	:	$(\text{K}_2\text{HgI}_4 + \text{KOH})$ aqueous solution
66.	Indian saltpetre, Bengal salt petre	:	$\text{KNO}_3$
67.	Oil of vitriol	:	Conc. $\text{H}_2\text{SO}_4$
68.	Ozone	:	$\text{O}_3$
69.	Oleum	:	$\text{H}_2\text{S}_2\text{O}_7$
70.	Permutit (Zeolite)	:	$\text{Na}_2\text{Al}_2\text{SiO}_8 \cdot \text{XH}_2\text{O}$
71.	Pearl ash (Potash)	:	$\text{K}_2\text{CO}_3$
72.	Plaster of paris	:	$\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$ or $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$
73.	Philosopher's wool (chinese white)	:	$\text{ZnO}$ (Zinc white)
74.	Phosgene	:	$\text{COCl}_2$
75.	Phosphine	:	$\text{PH}_3$
76.	Pig iron	:	Impure form of iron
77.	Producer gas	:	A mixture of $\text{CO} + \text{N}_2 + \text{H}_2$
78.	Quartz	:	$\text{SiO}_2$
79.	Refrigerant	:	$\text{CO}_2, \text{NH}_3 \cdot \text{CF}_2\text{Cl}_2$ etc.
80.	Red lead	:	$\text{Pb}_3\text{O}_4$
81.	Rochelle salt	:	Sodium - potassium tartarate
82.	Rust	:	$\text{Fe}_2\text{O}_3 \cdot \text{xH}_2\text{O}$
83.	Sorel's cement (Magnesia cement)	:	$\text{MgCl}_2 \cdot 5\text{MgO} \cdot \text{XH}_2\text{O}$
84.	Soda - lime	:	$\text{NaOH} + \text{CaO}$
85.	Soda ash	:	$\text{Na}_2\text{CO}_3$ (anhydrous)
86.	Slaked lime	:	$\text{Ca}(\text{OH})_2$
87.	Stainless steel	:	An alloy of Fe, Cr and C
88.	Salt cake	:	$\text{Na}_2\text{SO}_4$ (anhydrous)
89.	Super phosphate	:	$\text{Ca}(\text{H}_2\text{PO}_4) + 2\text{CaSO}_4$

90.	TNT	:	Trinitro toluene (an explosive)
91.	TNB	:	Trinitro benzene (an explosive)
92.	Tincal	:	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
93.	Talc	:	$3\text{MgO} \cdot 4\text{SiO}_2 \cdot \text{H}_2\text{O}$ or $\text{Mg}_2(\text{Si}_2\text{O}_3)_2 \cdot \text{Mg}(\text{OH})_2$
94.	Tritium	:	${}_1\text{H}^3$ (an isotope of H)
95.	Water glass	:	$\text{Na}_2\text{SiO}_3$
96.	Water gas	:	$\text{CO} + \text{H}_2$
97.	White vitriol	:	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
98.	Wrought iron	:	Pure form of iron
99.	Washing soda	:	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
100.	Willemite \ Zincite	:	$\text{ZnO}$
101.	Zinc white	:	$\text{ZnO}$
102.	Zinc blend	:	$\text{ZnS}$

## **INDUSTRIALLY IMPORTANT PROCESS**

Ammonia Soda process (Solvay process)	:	Manufacture of $\text{NaHCO}_3$ , $\text{Na}_2\text{CO}_3$
Birkeland - Eyde process	:	Manufacture of $\text{HNO}_3$
Bosch process	:	Manufacture of $\text{H}_2$
Castner process	:	Manufacture of Na
Caster - Kellner Cell process	:	Manufacture of $\text{NaOH}$
Contact process	:	Manufacture of $\text{H}_2\text{SO}_4$
Down process	:	Manufacture of Na
Dow's process	:	Manufacture of phenol
Deacon's process	:	Manufacture of $\text{Cl}_2$
Haber process	:	Manufacture of $\text{NH}_3$
Hasenclever process	:	Manufacture of Bleaching powder
L.D. process	:	Manufacture of steel
Lead chamber process	:	Manufacture of $\text{H}_2\text{SO}_4$
Nelson cell process	:	Manufacture of $\text{NaOH}$
Ostwald process	:	Manufacture of $\text{HNO}_3$