ALKALI METAL

1. PHYSICAL STATE
   (a) One electron in outermost shell & General formula \( \text{ns}^1 \).
   (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.
      \( \text{Li} < \text{Na} < \text{K} < \text{Rb} < \text{Cs} < \text{Fr} \)

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

<table>
<thead>
<tr>
<th>Atomic size</th>
<th>1</th>
<th>Softness</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \propto )</td>
<td>( \propto )</td>
<td>( \propto )</td>
<td>( \propto )</td>
</tr>
<tr>
<td>strength of metallic bond</td>
<td>Melting &amp; Boiling point</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
      \( \text{Li} > \text{Na} > \text{K} > \text{Rb} > \text{Cs} \)
   (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 \( \propto \frac{1}{\text{Ionisation Potential}} \)

Due to their larger size electron can easily be removed to form \( \text{M}^+ \) ion. Electro positive property increases from Li to Cs.
6. **FLAME TEST**

   Alkali metals and their salts give characteristic colour to bunsen flame. The flame energy causes an excitation of the outermost 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 NH₃**

   (a) \[ 2\text{Li} + \text{NH}_3 \rightarrow \text{Li}_2\text{NH} \text{ (Lithimide)} \]
   \[ 2\text{Na} + 2\text{NH}_3 \rightarrow 2\text{NaNH}_2 + \text{H}_2 \uparrow \]
   (Sodamide)

   (b) Solubility in liquid ammonia

   (i) All the alkali metals dissolve in NH₃ (liq) and produces blue solution.

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

   \[ \text{Na} \text{ (s)} + (x+y) \text{NH}_3 \rightarrow [\text{Na(NH}_3)_x]^+ + [\text{e(NH}_3)_y]^- \]
   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 get 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 standard oxidation potential (+3.05 eV) due to its high hydration energy. Such that it converts into \( \text{Li}^+ \) ion by losing one electron.

   **Order of standard oxidation potential of s-block element**

<table>
<thead>
<tr>
<th>Li &gt; K &gt; Ba &gt; Sr &gt; Ca &gt; Na &gt; Mg &gt; Be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydration energy ( \propto ) Charge density on ion</td>
</tr>
</tbody>
</table>

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.
(c) \[\text{Li}^+ \quad \text{Na}^+ \quad \text{K}^+ \quad \text{Rb}^+ \quad \text{Cs}^+\]

* 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

\[\text{Li}^+ < \text{Na}^+ < \text{K}^+ < \text{Rb}^+ < \text{Cs}^+\]

(c) But in aqueous solution order is -

\[\text{Li}^+ > \text{K}^+ > \text{Rb}^+ > \text{Cs}^+ > \text{Na}^+\]

12. REACTION WITH AIR

(a) Alkali metals gets turnish 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

\[
\begin{align*}
4\text{Na} + \text{O}_2 & \rightarrow 2\text{Na}_2\text{O} \\
\text{Na}_2\text{O} + \text{H}_2\text{O} & \rightarrow 2\text{NaOH} \\
(\text{moist}) & \\
2\text{NaOH} + \text{CO}_2 & \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \\
(\text{in air}) &
\end{align*}
\]

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.

\[
\begin{align*}
\text{M} & \overset{\text{O}}{\rightarrow} \text{M}_2\text{O} \overset{\text{O}_2}{\rightarrow} \text{M}_2\text{O}_2 \overset{\text{O}_2^-}{\rightarrow} \text{M}_2\text{O}_2^- \\
(\text{Li}_2\text{O}) & \quad (\text{Na}_2\text{O}_2) \quad (\text{KO}_2, \text{RbO}_2^-, \text{CsO}_2^-)
\end{align*}
\]

Their stability order is –

Normal oxide > Peroxide > Superoxide
14. **REACTION WITH WATER**

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

$$2M + 2H_2O \rightarrow 2MOH + H_2$$

(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 $H_2$.

$$2Li + 2C_2H_3OH \rightarrow 2C_2H_3O^-Li^+ + H_2$$

(d) Monoxides gives strongly alkaline solution with water

$$M_2O + H_2O \rightarrow 2MOH$$

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.

$$KI + I_2 \rightarrow KI_3 \xrightarrow{\text{on ionisation}} K^+ + I_3^-$$

$$CsBr + Br_2 \rightarrow CsBr_3 \rightarrow Cs^+ + Br_3^-$$

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

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

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

Order of stability is –

$$Cs_2CO_3 > Rb_2CO_3 > K_2CO_3 > Na_2CO_3 > Li_2CO_3$$
17. NITRATES
   (a) Alkali metals forms MNO₃ type nitrates (M - alkali metal)
   (b) Stability increases from LiNO₃ to CsNO₃. LiNO₃ decomposes into Lithium oxide & NO₂ on heating.

\[
4\text{LiNO}_3 \xrightarrow{\Delta \text{Oxide}} 2\text{Li}_2\text{O} + 4\text{NO}_2 + \text{O}_2
\]

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

\[
\text{MNO}_3 \xrightarrow{\Delta} 2\text{MNO}_2 + \text{O}_2
\]

18. NITRIDES

Only Li reacts directly with N₂ to form nitride which gives NH₃ on reacting with water.

\[
6\text{Li} + \text{N}_2 \rightarrow 2\text{Li}_3\text{N}
\]

\[
\text{Li}_3\text{N} + 3\text{H}_2\text{O} \rightarrow 3\text{LiOH} + \text{NH}_3\uparrow
\]

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 M₂SO₄ type sulphates.
   (b) All alkali metal sulphates are ionic. Ionic properties increases from Li to Cs.

\[
\text{Li}_2\text{SO}_4 < \text{Na}_2\text{SO}_4 < \text{K}_2\text{SO}_4 < \text{Rb}_2\text{SO}_4 < \text{Cs}_2\text{SO}_4
\]

(c) Li₂SO₄ Least soluble in water.

(d) These sulphates on burning with C forms sulphides

\[
\text{M}_2\text{SO}_4 + 4\text{C} \rightarrow \text{M}_2\text{S} + 4\text{CO}
\]

(e) Except lithium, sulphates of IA group reacts with
sulphates of trivalent metals like Fe³⁺, Cr³⁺, Al³⁺ etc. gives double salts called alum.

\[
\text{I}_{\text{M}_2\text{SO}_4 \cdot \text{M}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}}
\]

21. REACTION WITH ACIDS

Reacts vigorously with acids.

\[
2\text{M} + \text{H}_2\text{SO}_4 \rightarrow \text{M}_2\text{SO}_4 + \text{H}_2\uparrow
\]
**COMPOUNDS OF ALKALI METALS**

1. **SODIUM (NA), NATRIUM**

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

      By Electrolysis of fused NaCl + CaCl₂ + NaF

      At cathode (Iron Vessel): \[ \text{Na}^- + e^- \rightarrow \text{Na(s)} \]

      At Anode (Graphite): \[ 2\text{Cl}^- \rightarrow \text{Cl}_2 + 2e^- \]

   (i) (CaCl₂ + NaF) is used to lower Melting point (800°C) of NaCl to about 600°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) Na dissolves in liquid NH₃ 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 NaCl**

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

   (b) **Preparation**

      (i) Sea water NaCl(2.7 – 2.9%) → Evaporation by solar heat → crude NaCl

      (ii) It contains impurities – Na₂SO₄, MgCl₂, CaCl₂ etc.

      (iii) Insoluble impurities removed by filtration.

      (iv) Filtrate → HCl gas passed → Pure NaCl precipitation (Common ion effect)

      \[ \text{HCl} \rightleftharpoons \text{H}^+ + \text{Cl}^- \quad \text{NaCl} \rightleftharpoons \text{Na}^+ + \text{Cl}^- \]

      Ionic product of [Na⁺][Cl⁻] > solubility product of NaCl hence it precipitates out.

   (v) MgCl₂ and CaCl₂ 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 AgNO₃

      \[ \text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgCl(white ppt.)} \]

      Reaction with K₂Cr₂O₇ + conc. H₂SO₄

      (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 –

\[
\begin{align*}
NaCl(aq.) & \rightleftharpoons Na^+ + Cl^- \\
H_2O & \rightleftharpoons H^+ + OH^- \\
\end{align*}
\]

\[\rightarrow NaOH + H_2 + Cl_2\]

At cathode (Perforated steel) : \(2H^+ + 2e^- \rightarrow H_2(g)\)  
At anode (Carbon) : \(2Cl^-(aq.) \rightarrow Cl_2(g) + 2e^-\)

(c) Castner – Kellner Cell : (Hg – Cathode Process)

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

On electrolysis –

At Cathode (Hg)

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

At anode (Graphite)

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

(d) Properties

(i) It is deliquescent white crystalline solid.

(ii) It absorbs CO\(_2\) from air forming Na\(_2\)CO\(_3\).

(iii) NaOH is strong base

\[
\begin{align*}
NaOH + SiO & \rightarrow Na_2SiO_3 + H_2O \\
NaOH + AlO & \rightarrow 2NaAlO_2 + H_2O
\end{align*}
\]

(iv) Reaction with non metals : no reaction with H\(_2\), N\(_2\) and C

\[
\begin{align*}
NaOH + B & \rightarrow Na_2BO_3 (sodium borate) \\
NaOH + Si & \rightarrow Na_2SiO_3 (sodium silicate) \\
NaOH + P & \rightarrow NaH_2PO_2 + PH_3 \quad \text{(sodium hypo phosphate)}
\end{align*}
\]

(v) Reaction with halogens

\[
\begin{align*}
NaOH (\text{cold/dil}) + \text{X}_2 & \rightarrow NaX + NaOX \quad \text{(Sodium hypo halite)} \\
NaOH (\text{hot/conc}) + \text{X}_2 & \rightarrow NaX + NaOX_3 \quad \text{(Sodium Halate)} \\
\end{align*}
\]

\(\text{X}_2 = \text{Cl}_2, \text{Br}_2, \text{I}_2\)

(vi) Reaction with Metal :

<table>
<thead>
<tr>
<th>Metal</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali metal</td>
<td>No reaction</td>
</tr>
<tr>
<td>NaOH + 2Al + 2H(_2)O</td>
<td>2NaAlO(_2) (Sodium meta aluminate) + H(_2)</td>
</tr>
<tr>
<td>NaOH + Be</td>
<td>Na(_2)BeO(_2) (Sodium Beryllate) + H(_2)</td>
</tr>
<tr>
<td>NaOH + Zn</td>
<td>Na(_2)ZnO(_2) (Sodium zincate) + H(_2)</td>
</tr>
<tr>
<td>NaOH + Sn</td>
<td>Na(_2)SnO(_2) (Sodium stannite) + H(_2)</td>
</tr>
<tr>
<td>NaOH + Pb</td>
<td>Na(_2)PbO(_2) (Sodium plumbite) + H(_2)</td>
</tr>
</tbody>
</table>
(vii) Reaction with ZnCl₂ or ZnSO₄

\[
\text{ZnCl}_2 + 2\text{NaOH} \rightarrow \text{Zn(OH)}_2 + 2\text{NaCl}
\]

\[
\text{Zn(OH)}_2 + 2\text{NaOH} \rightarrow \text{Na}_2[\text{Zn(OH)}_4]^- \quad \text{(Soluble complex)}
\]

(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.

\[
\text{Zn(OH)}_2 + 2\text{OH} \rightarrow [\text{Zn(OH)}_4]^2- \quad \text{Al(OH)}_3 + 3\text{OH} \rightarrow [\text{Al(OH)}_4]^{3-}
\]

(b) **Uses**

(i) In the manufacture of soap, rayon, dyes, paper and drugs.

(ii) In petroleum refining.

4. SODIUM BICARBONATE OR BAKING SODA (NaHCO₃)

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

\[
\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \quad \text{(In brine saturated with NH}_3, \text{ CO}_2 \text{ is passed)}
\]

\[
\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{NH}_4\text{HCO}_3
\]

\[
\text{NaCl} + \text{NH}_4\text{HCO}_3 \rightarrow \text{NH}_4\text{Cl} + \text{NaHCO}_3
\]

\[
2\text{NH}_4\text{Cl} + \text{CaO} \rightarrow \text{CaCl}_2 + 2\text{NH}_3 + \text{H}_2\text{O} \quad \text{(Bye-products)}
\]

(b) **Properties**

<table>
<thead>
<tr>
<th>Hydrolysis</th>
<th>NaHCO₃ + H₂O ⇌ NaOH + H₂CO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of heat (temp. &gt; 100°C)</td>
<td>2NaHCO₃ → Na₂CO₃ + H₂O + CO₂ ↑</td>
</tr>
<tr>
<td>(Process occurs during preparation of cake)</td>
<td></td>
</tr>
<tr>
<td>Reaction with acids - gives CO₂</td>
<td>NaHCO₃ + HCl → NaCl + H₂O + CO₂ ↑</td>
</tr>
<tr>
<td>Reaction with base</td>
<td>NaHCO₃ + NaOH → Na₂CO₃ + H₂O</td>
</tr>
</tbody>
</table>

(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 (Na₂CO₃·10H₂O)

(a) **Occurrence** : Na₂CO₃–Soda ash.

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

(i) Concentrated aqueous solution of NaCl is saturated with NH₃.

(ii) Current of CO₂ passed through the solution.

(iii) NaHCO₃ precipitated –

\[
\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{NH}_4\text{HCO}_3 \quad \text{NH}_4^+ + \text{HCO}_3^- \quad \text{NaCl} \quad \text{Na}^+ + \text{Cl}^-
\]

\[
[\text{Na}^+] \quad [\text{HCO}_3^-] > K_p \text{ of NaHCO}_3 \quad \text{(so ppt. forms)}
\]

\[
2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2
\]

(iv) Potassium bicarbonate (KHCO₃) cannot be prepared by solvay process as it is soluble in water.
**Leblanc Process**

\[ \text{NaCl} + \text{H}_2\text{SO}_4 \text{ (conc.)} \xrightarrow{\text{mild heating}} \text{NaHSO}_3 + \text{HCl} \]

\[ \text{NaCl} + \text{NaHSO}_4 \xrightarrow{\text{Strongly heated}} \text{Na}_2\text{SO}_4 + \text{HCl} \]

(Salt Cake)

\[ \text{Na}_2\text{SO}_4 + 4\text{C} \rightarrow \text{Na}_2\text{S} + 4\text{CO}\uparrow \]

\[ \text{Na}_2\text{S} + \text{CaCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CaS} \]

**Properties**

(i) **Efflorescence**:

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

\[ \text{Na}_2\text{CO}_3\cdot10\text{H}_2\text{O} \rightarrow \text{Na}_2\text{CO}_3\cdot\text{H}_2\text{O} + 9\text{H}_2\text{O} \]

(Monohydrate)

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

(ii) **Hydrolysis**:

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

\[ \text{Na}_2\text{CO}_3 \rightarrow 2\text{Na}^+ + \text{CO}_3^{2-} \text{ and } \text{CO}_3^{2-} + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + 2\text{OH}^- \]

(Carbonic acid)

**Uses**

(i) For making fusion mixture (Na\(_2\text{CO}_3\) + 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 Na\(_2\text{O}_2\)**

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

\[ 2\text{Na} + \text{O}_2 \text{ (air)} \rightarrow \text{Na}_2\text{O}_2 \]

(i) When pure it is colourless, and the faint yellow colour of the usual product arises from the presence of a small amount of NaO\(_2\)^-.

(ii) When it is exposed, it comes in contact with moist air and turns white due to formation of NaOH and Na\(_2\text{CO}_3\). Thus

\[ \text{Na}_2\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2\text{O}_2 \text{ and } 2\text{NaOH} + \text{CO}_2 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \]

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

\[ 2\text{Cr(OH)}_3 + 3\text{O}_2^{2-} \rightarrow \text{CrO}_4^{2-} + 2\text{OH}^- + 2\text{H}_2\text{O} \]

(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 CO\(_2\), KOH is preferable used compared to NaOH. Because KHCO\(_3\) formed is soluble whereas 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 KHCO\(_3\) is soluble in water.

(b) **Properties**: It resembles with Na\(_2\)CO\(_3\), m.p. is 900\(^\circ\)C but a mixture of Na\(_2\)CO\(_3\) and K\(_2\)CO\(_3\) melts at 712\(^\circ\)C.

(c) **Uses**: It is used in glass manufacturing.

9. **POTASSIUM CHLORIDE**

It is also occurs in nature and sylvyne (KCl) or carnalite (2KCl \_ MgCl\(_2\) \_ 6H\(_2\)O)

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

10. **OXIDES OF POTASSIUM**

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Colour</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(K_2O)</td>
<td>White</td>
<td>(2KNO_3 + 10K \xrightarrow{\text{heating}} 6K_2O + N_2)</td>
</tr>
<tr>
<td>(K_2O_2)</td>
<td>White</td>
<td>(K_2O \xrightarrow{\text{heating}} K_2O) (white)</td>
</tr>
<tr>
<td>(K_2O_3)</td>
<td>Red</td>
<td>(K_2O + H_2O \rightarrow 2KOH)</td>
</tr>
<tr>
<td>(KO_2)</td>
<td>Bright yellow</td>
<td>(2K + O_2 \xrightarrow{\text{controlled air at 300(^\circ)C}} K_2O_2)</td>
</tr>
</tbody>
</table>
| \(KO_3\)   | Reddish brown needles | Passage of \(O_3\) through a blue solution of K in liquid NH\(_3\) yields oxides \(K_2O_2\) (white), \(K_2O_3\) (red) and \(KO_3\) (deep yellow) i.e.,

\(K\) in liq. NH\(_3\) \(\xrightarrow{O_3} K_2O_2 \rightarrow K_2O_3 \rightarrow KO_3\) (deep yellow)

\(KO_3\) reacts with H\(_2\)O and produces H\(_2\)O\(_2\) and O\(_2\) both

\(KOH + O_3\) (Ozonised oxygen) \(\xrightarrow{-10^\circ\text{C} to -15^\circ\text{C}} KO_3\) (Dry powdered) (orange solid)
1. **PHYSICAL STATE**
   
   (a) Two electrons in outer most shell & General formula ns².
   
   (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
   
   \[ \text{Ca-Brick red} \quad \text{Sr-crimson red} \quad \text{Ba-Apple green} \]

7. **REACTION WITH NH₃**

   (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 NH₃.

(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 NH₃ formation.

\[ \text{NH}_4^+ + \text{NH}_2^- \rightarrow 2\text{NH}_3 \]

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 -

\[ \text{Be} < \text{Mg} < \text{Ca} < \text{Sr} < \text{Ba} \]

(c) Tendency of loosing 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

\[ \text{Be}^{+2} > \text{Mg}^{+2} > \text{Ca}^{+2} > \text{Sr}^{+2} > \text{Ba}^{+2} \]

(c) **Hydration energy \( \propto \) 1/cation size**

11. **REDUCING PROPERTY**

(a) Less reductant than alkali metals

(b) Order of reducing property in aqueous and gaseous medium is

\[ \text{Be}^{+2} < \text{Mg}^{+2} < \text{Ca}^{+2} < \text{Sr}^{+2} < \text{Ba}^{+2} \]

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 converts into carbonates.

(d) In dry air Be and Mg gives nitride and oxide both while other gives only oxides.

13. **REACTION WITH OXYGEN**

(a) Alkaline earth metals reacts with O₂ 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, forms MO₂ (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

\( \text{CaO, SrO & BaO} \rightarrow \) Strong base
14. REACTION WITH WATER
(a) These metals react slowly with water giving \( \text{H}_2 \) and metals hydroxides.

\[
M + 2\text{H}_2\text{O} \rightarrow \text{M(OH)}_2 + \text{H}_2
\]
(b) Be does not react with water
(c) Mg reacts only with hot water
(d) Ca, Sr, Ba react with cold water but not as energetically as alkali metals. Order of reactivity

\[
\text{Ba} > \text{Sr} > \text{Ca} > \text{Mg} > \text{Be}
\]
(e) From Be(OH)\(_2\) to Ba(OH)\(_2\), basic properties and stability increase.

15. HALIDES
(a) Alkaline metals react with X (halogen) to form MX\(_2\).

Ex. \((\text{BeCl}_2, \text{MgCl}_2, \text{CaCl}_2 \text{ etc.})\)
(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 –

\[
\text{BeCl}_2 < \text{MgCl}_2 < \text{CaCl}_2 < \text{SrCl}_2 < \text{BaCl}_2
\]
Solubility in water

\[
\text{BeCl}_2 > \text{MgCl}_2 > \text{CaCl}_2 > \text{SrCl}_2 > \text{BaCl}_2
\]

16. CARBONATES
(a) All the alkaline metals form MCO\(_3\) type carbonates.
(b) Except BeCO\(_3\), all the carbonates are stable towards heat

\[
\text{BeCO}_3 \xrightarrow{\Delta} \text{BeO} + \text{CO}_2
\]
(c) Order of decreasing stability –

\[
\text{BaCO}_3 > \text{SrCO}_3 > \text{CaCO}_3 > \text{MgCO}_3 > \text{BeCO}_3
\]

17. NITRATES
(a) Alkaline earth metals form 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 give oxides and NO\(_2\) + O\(_2\)

\[
\text{M(NO}_3)_2 \xrightarrow{\Delta} \text{Oxides} + \text{NO}_2 + \text{O}_2
\]
(d) Be(NO\(_3\))\(_2\) forms a layer of BeO on its surface so reaction stops.
18. NITRIDES

Only Be and Mg burns in N₂ to give M₃N₂ (Be₃N₂, Mg₃N₂)

\[
\begin{align*}
\text{Be}_3\text{N}_2 + 6\text{H}_2\text{O} & \rightarrow 3\text{Be(OH)}_2 + 2\text{NH}_3 \\
\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} & \rightarrow 3\text{Mg(OH)}_2 + 2\text{NH}_3
\end{align*}
\]

19. FORMATION OF AMALGAM

Shows same properties as alkali metals.

20. SULPHATES

(a) Alkaline earth metals forms MSO₄ type sulphates.
(b) Ionic nature of alkaline metal sulphate is increases from Be to Ba

\[
\text{BeSO}_4 < \text{MgSO}_4 < \text{CaSO}_4 < \text{SrSO}_4 < \text{BaSO}_4
\]
(c) Solubility decreases from BeSO₄ to BaSO₄ as Be⁺² and Mg⁺² are of small size so their hydration energy is high. Hydration Energy > Lattice energy.
(d) Order of solubility –

\[
\text{BeSO}_4 > \text{MgSO}_4 > \text{CaSO}_4 > \text{SrSO}_4 > \text{BaSO}_4
\]
(e) Order of thermal stability –

\[
\text{BeSO}_4, \quad \text{MgSO}_4, \quad \text{CaSO}_4, \quad \text{SrSO}_4, \quad \text{BaSO}_4
\]

Ionic nature increases, Thermal stability increases

21. REACTION WITH ACIDS

Freely reacts with acids and displaces hydrogen

\[
\text{M} + 2\text{HCl} \rightarrow \text{MCl}_2 + \text{H}_2 \uparrow
\]

**COMPOUNDS OF ALKALINE EARTH METALS**

1. MAGNESIUM

(a) Preparation:

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

\[
\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2 \text{ and } \text{CaCO}_3 \cdot \text{MgCO}_3 \rightarrow \text{CaO} \cdot \text{MgO} + 2\text{CO}_2
\]

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

\[
\text{MgO} + \text{C} + \text{Cl}_2 \rightarrow \text{MgCl}_2 + \text{CO}
\]

The chloride thus obtained is subjected to electrolysis.

(iii) The mixed oxides (CaO.MgO) obtained from calcination of dolomite (CaCO₃ MgCO₃) 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.

\[ 2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO} \]

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

\[ 2\text{Mg} + \text{CO}_2 \rightarrow 2\text{MgO} + \text{C} \]

(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 \( \text{KCl.MgCl}_2.6\text{H}_2\text{O} \).

(b) **Preparation**:

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

\[ \text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{CO}_2 + \text{H}_2\text{O} \]

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

\[ \text{Mg} + \text{Cl}_2 \overset{\text{Heated}}{\rightarrow} \text{MgCl}_2 \]

(c) **Properties**

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

\[ \text{MgCl}_2.6\text{H}_2\text{O} \overset{\Delta}{\rightarrow} \text{MgO} + 2\text{HCl} + 5\text{H}_2\text{O} \]

(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 \( (\text{MgSO}_4.\text{H}_2\text{O}) \) and epsomite \( (\text{MgSO}_4.\text{7H}_2\text{O}) \).

(b) **Preparation**

By dissolving magnesite in dil \( \text{H}_2\text{SO}_4 \)

\[ \text{MgCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \uparrow \]

(c) **Properties**: On heating above 200°C

\[ 2\text{MgSO}_4 \overset{\text{200°C}}{\rightarrow} 2\text{MgO} + 2\text{SO}_2 + \text{O}_2 \]

**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°C) decreased.

\[ \text{CaCl}_2 \overset{780°C}{\rightarrow} \text{Ca}^{++} + 2\text{Cl}^- \]

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

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

\[ 3\text{CaO} + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 3\text{Ca} \]

CaO is reduced by Al because it has greater affinity for oxygen than Ca.
(b) **Properties**

(i) **With air**

\[ 2\text{Ca} + \text{O}_2 \xrightarrow{\text{Burning}} 2\text{CaO} \quad \text{and} \quad 3\text{Ca} + \text{N}_2 \xrightarrow{\text{Burning}} \text{Ca}_3\text{N}_2 \]

(ii) \[
\begin{align*}
\text{Ca} \quad \xrightarrow{\text{H}_2\text{O}} \quad \text{Ca}(	ext{H}_2\text{O})_2 + \text{H}_2 \\
\end{align*}
\]

(c) **Uses**

(i) For removal of sulphur from petroleum

(ii) As a dehydrating agent in preparation of absolute alcohol

(iii) It is used as a deoxidiser for copper, cast iron and steel

5. **CALCIUM OXIDE (CaO) QUICK LIME**

(a) **Preparation**: By heating limestones at 800°C.

\[ \text{CaCO}_3 \xrightarrow{800\degree C} \text{CaO} + \text{CO}_2 \]

(b) **Properties**

(i) **Action of water**: \[ \text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \] (quick lime)

Ca(OH)$_2$ paste in water called milk of lime.

(ii) **Basic Nature**:

\[ \text{CaO} + \text{SiO}_2 \xrightarrow{\Delta} \text{CaSiO}_3 \quad \text{and} \quad \text{CaO} + \text{P}_2\text{O}_5 \xrightarrow{\Delta} 2\text{Ca}_3(\text{PO}_4)_2 \]

(Calcium silicate)

(iii) Reaction with carbon: \[ \text{CaO} + 3\text{C} \xrightarrow{2000\degree C} \text{CaC}_2 + \text{CO} \uparrow \]

(c) **Uses**

(i) In the manufacture of bleaching powder, cement, glass, calcium carbide etc.

(ii) In the purification of sugar

(iii) As a drying agent for NH$_3$ and C$_2$H$_5$OH

(iv) As basic lining in furnaces

(v) For making Soda lime

6. **CALCIUM HYDROXIDE Ca(OH)$_2$ SLAKED LIME**

(a) **Preparation**: By the action of water on quick lime

\[ \text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{heat} \]

(b) **Properties**

(i) **Action of CO$_2$**: Lime water turns milky on passing CO$_2$ gas.

\[ \text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

Milkiness

\[ \text{CaCO}_3 \xrightarrow{\text{Excess of CO}_2} \text{Ca(HCO}_3)_2 \] (soluble)

(ii) **Action of Chlorine**:

\[ \text{Ca(OH)}_2 + \text{Cl}_2 \xrightarrow{\text{below 35}\degree \text{C}} \text{CaCl}_2 + \text{H}_2\text{O} \]

Bleaching powder

\[ 2\text{Ca(OH)}_2 + 2\text{Cl}_2 \xrightarrow{\text{red heat}} 2\text{CaCl}_2 + 2\text{H}_2\text{O} + \text{O}_2 \uparrow \]
(c) **Uses**

(i) For softening of hard water.

(ii) For purification of sugar and Coal gas.

(iii) In the manufacture of bleaching powder, Caustic soda and soda lime

(iv) In preparation of mortar, plaster and white washing.

7. **CALCIUM CARBONATE** (CaCO₃)

(a) It occurs in nature as marble, limestone, chalk, coral, calcite etc. It is prepared by dissolving marble or limestone in HCl and removing iron and aluminium present, by precipitating with NH₃ and then adding (NH₄)₂CO₃ to the solution.

\[ \text{CaCl}_2 + (\text{NH}_4)_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NH}_4\text{Cl} \]

(b) **Properties**

(i) It dissociates above 1000°C as follows: \( \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \)

(ii) It dissolves in water containing CO₂ forming Ca(HCO₃)₂ but is precipitated from the solution by boiling

\[ \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \underset{\text{boiling}}{\rightarrow} \text{Ca(HCO}_3)_2 \]

(c) **Uses**

(i) In the preparation tooth pastes, cosmetics face powder and medicine for indigestion.

(ii) In the preparation of Quick lime.

(iii) As a building material.

(iv) In manufacture of cement, glass, washing soad etc.

8. **CALCIUM SULPHATE** CaSO₄·2H₂O (GYPSUM)

(a) **Preparation** : CaSO₄·2H₂O is naturally occurring calcium sulphate. It can be obtained by the action of dil.H₂SO₄ on a soluble calcium salt below 60°C.

\[ \text{CaCl}_2 + \text{H}_2\text{SO}_4 \rightarrow 2\text{HCl} + \text{CaSO}_4 \downarrow \]

(b) **Properties**

(i) **Action of heat**

\[ 2\text{CaSO}_4·2\text{H}_2\text{O} \underset{120\text{°C}}{\rightarrow} (\text{CaSO}_4)\text{H}_2\text{O} \underset{200\text{°C}}{\rightarrow} 2\text{CaSO}_4 + \text{H}_2\text{O} \]

(Plaster of Paris) (Anhydride)

(ii) It forms an important fertilizer (NH₄)₂SO₄

\[ \text{CaSO}_4 + 2\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CaCO}_3 \downarrow + (\text{NH}_4)_2\text{SO}_4 \]

(c) **Uses**

(i) In the preparation of plaster of Paris

(ii) Anhydrous CaSO₄ used as drying agent.

(iii) Anhydride (CaSO₄) is used for manufacture of sulphuric acid, ammonium sulphate.
9. **PLASTER OF PARIS (2CaSO\(_4\).H\(_2\)O )**

(a) **Preparation**: It obtained when gypsum is heated at 120°C

\[
2(\text{CaSO}_4.\text{H}_2\text{O}) \rightarrow 2\text{CaSO}_4\cdot\text{H}_2\text{O} + 3\text{H}_2\text{O}
\]

(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°C, anhydrous 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, Li\(_3\)N and Mg\(_3\)N\(_2\).

(c) The oxides, Li\(_2\)O and 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 CO\(_2\). Solid bicarbonates are not formed by lithium and magnesium.

(e) Both LiCl and MgCl\(_2\) are soluble in ethanol.

(f) Both LiCl and MgCl\(_2\) are deliquescent and crystallise from aqueous solution as hydrates, LiCl.2H\(_2\)O and MgCl\(_2\).8H\(_2\)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 alkalies to form soluble complexes, beryllates [Be(OH)\(_4\)]\(^{2-}\) and aluminates, [Al(OH)\(_4\)]\(^{-}\).

(c) The chlorides of both beryllium and aluminium

\[
\begin{align*}
\text{Cl-Be-Cl} & \quad \text{Cl-Al-Cl} \\
\end{align*}
\]

have bridged chloride structures in vapour phase.

(d) Salts of these metals form hydrated ions, Ex. [Be(OH)\(_2\)]\(^{4+}\) and [Al (OH)\(_2\)]\(^{6+}\) 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 BeF\(_4\)\(^{2-}\) and [Be(C\(_2\)O\(_4\))\(_2\)]\(^{2-}\) and aluminium forms octahedral complexes like AlF\(_6\)\(^{3-}\) and [Al(C\(_2\)O\(_4\))\(_3\)]\(^{3-}\).
**IMPORTANT COMPOUNDS AND THEIR FORMULA**

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Active nitrogen</td>
<td>N(atomic nitrogen)</td>
</tr>
<tr>
<td>2.</td>
<td>Alums</td>
<td>$M_2'SO_4 \cdot M',_{27}(SO_4)_3 \cdot 24H_2O$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M' = K^+, NH_4^+, Na^+$ etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M'' = Cr^{3+}, Al^{3+}, Fe^{3+}$ etc.</td>
</tr>
<tr>
<td>3.</td>
<td>Asbestos</td>
<td>CaMg$_3$(SiO$_3$)$_4$</td>
</tr>
<tr>
<td>4.</td>
<td>Arsine</td>
<td>AsH$_3$</td>
</tr>
<tr>
<td>5.</td>
<td>Aquaregia</td>
<td>Conc. HNO$_3$ + Conc. HCl (1 : 3 part)</td>
</tr>
<tr>
<td>6.</td>
<td>Anhydride</td>
<td>Mg(ClO$_4$)$_2$</td>
</tr>
<tr>
<td>7.</td>
<td>Argentoferrous galena</td>
<td>PbS + Ag$_2$S</td>
</tr>
<tr>
<td>8.</td>
<td>Borax</td>
<td>Na$_2$B$_4$O$_7 \cdot 10H_2$O</td>
</tr>
<tr>
<td>9.</td>
<td>Blue vitriol</td>
<td>CuSO$_4$, 5H$_2$O</td>
</tr>
<tr>
<td>10.</td>
<td>Barytes</td>
<td>BaSO$_4$</td>
</tr>
<tr>
<td>11.</td>
<td>Baryta water</td>
<td>Ba(OH)$_2$ solution</td>
</tr>
<tr>
<td>12.</td>
<td>Baryta</td>
<td>BaO</td>
</tr>
<tr>
<td>13.</td>
<td>Baking soda</td>
<td>NaHCO$_3$</td>
</tr>
<tr>
<td>14.</td>
<td>Bleaching powder</td>
<td>CaOCl$_2$</td>
</tr>
<tr>
<td>15.</td>
<td>Boranes</td>
<td>Hydride of borone</td>
</tr>
<tr>
<td>16.</td>
<td>Brine</td>
<td>NaCl solution</td>
</tr>
<tr>
<td>17.</td>
<td>Calgon</td>
<td>Na$_2$[Na$_4$(PO$_3$)$_6$]</td>
</tr>
<tr>
<td>18.</td>
<td>Coinage metals</td>
<td>Cu, Ag and Au</td>
</tr>
<tr>
<td>19.</td>
<td>Carborundum</td>
<td>SiC</td>
</tr>
<tr>
<td>20.</td>
<td>Cementite</td>
<td>FeC</td>
</tr>
<tr>
<td>21.</td>
<td>Caliche</td>
<td>NaNO$_3$ + NaI$_2$O$_3$</td>
</tr>
<tr>
<td>22.</td>
<td>Caustic soda</td>
<td>NaOH</td>
</tr>
<tr>
<td>23.</td>
<td>Caustic potash</td>
<td>KOH</td>
</tr>
<tr>
<td>24.</td>
<td>Calomel</td>
<td>Hg$_2$Cl$_2$</td>
</tr>
<tr>
<td>25.</td>
<td>Corrosive sublimate</td>
<td>HgCl$_2$</td>
</tr>
<tr>
<td>26.</td>
<td>Deuterium</td>
<td>$^1_2H^2$ of D</td>
</tr>
<tr>
<td>27.</td>
<td>D.D.T.</td>
<td>p-dichloro, diphenyl, trichloroethane</td>
</tr>
<tr>
<td>28.</td>
<td>Dry ice</td>
<td>Solid CO$_2$</td>
</tr>
<tr>
<td>29.</td>
<td>Freon</td>
<td>CF$_2$Cl$_2$</td>
</tr>
</tbody>
</table>
| 30. | Ferric Alum                     | K$_2$SO$_4$ . Fe$_2$(SO$_4$)$_3$ . 24H$_2$O
<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical Name</th>
<th>Formula/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Fenton’s reagent</td>
<td>$\text{H}_2\text{O}_2$ + few drops of $\text{FeSO}_4$</td>
</tr>
<tr>
<td>32</td>
<td>Fusion mixture</td>
<td>$\text{Na}_2\text{CO}_3 + \text{K}_2\text{CO}_3$</td>
</tr>
<tr>
<td>33</td>
<td>Fluid magnesia</td>
<td>12% solution of Mg (HCO)$_2$</td>
</tr>
<tr>
<td>34</td>
<td>Fehling solution</td>
<td>$\text{CuSO}_4 \cdot 5\text{H}_2\text{O} + \text{NaOH} + \text{Na, K tartarate}$</td>
</tr>
<tr>
<td>35</td>
<td>King of metals</td>
<td>Gold</td>
</tr>
<tr>
<td>36</td>
<td>Horn Silver</td>
<td>$\text{AgCl}$</td>
</tr>
<tr>
<td>37</td>
<td>Green vitriol</td>
<td>$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>38</td>
<td>Graphite</td>
<td>An allotrope of carbon</td>
</tr>
<tr>
<td>39</td>
<td>Gun powder</td>
<td>75% KNO$_3 + 12%$S + 13% charcoal (explosive)</td>
</tr>
<tr>
<td>40</td>
<td>Glauber salt</td>
<td>$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>41</td>
<td>Hydrolith</td>
<td>$\text{CaH}_2$</td>
</tr>
<tr>
<td>42</td>
<td>Heavy water</td>
<td>$\text{D}_2\text{O}$</td>
</tr>
<tr>
<td>43</td>
<td>Hypo (sodium thiosulphate)</td>
<td>$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>44</td>
<td>Heavy hydrogen</td>
<td>$\text{D}_2$</td>
</tr>
<tr>
<td>45</td>
<td>King of chemicals</td>
<td>$\text{H}_2\text{SO}_4$</td>
</tr>
<tr>
<td>46</td>
<td>Lime (quick lime or burnt lime)</td>
<td>$\text{CaO}$</td>
</tr>
<tr>
<td>47</td>
<td>Lead pencil</td>
<td>Graphite</td>
</tr>
<tr>
<td>48</td>
<td>Lime water</td>
<td>$\text{Ca(OH)}_2$</td>
</tr>
<tr>
<td>49</td>
<td>Laughing gas</td>
<td>$\text{N}_2\text{O}$</td>
</tr>
<tr>
<td>50</td>
<td>Lunar Caustic</td>
<td>$\text{AgNO}_3$</td>
</tr>
<tr>
<td>51</td>
<td>Litharge (Masscote)</td>
<td>$\text{PbO}$</td>
</tr>
<tr>
<td>52</td>
<td>Lithopone</td>
<td>($\text{ZnS + BaSO}_4$), a pigment</td>
</tr>
<tr>
<td>53</td>
<td>Mortar</td>
<td>Slaked lime + sand ($1 : 3$ in water)</td>
</tr>
<tr>
<td>54</td>
<td>Mica</td>
<td>$\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 2\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>55</td>
<td>Mohr salt</td>
<td>$\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>56</td>
<td>Matte</td>
<td>$\text{Cu}_2\text{S} + \text{FeS}$</td>
</tr>
<tr>
<td>57</td>
<td>Milk of lime</td>
<td>$\text{Ca(OH)}_2$ in water</td>
</tr>
<tr>
<td>Number</td>
<td>Description</td>
<td>Chemical Formula</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>58.</td>
<td>Minium</td>
<td>$\text{Pb}_3\text{O}_4$</td>
</tr>
<tr>
<td>59.</td>
<td>Micro cosmic salt</td>
<td>$\text{NaNH}_4 \cdot \text{HPO}_4 \cdot 4\text{H}_2\text{O}$ (used in test of silicates)</td>
</tr>
<tr>
<td>60.</td>
<td>Milk of magnesia</td>
<td>Paste of $\text{Mg(OH)}_2$ in water (Antacid)</td>
</tr>
<tr>
<td>61.</td>
<td>Magnesia</td>
<td>$\text{MgO}$</td>
</tr>
<tr>
<td>62.</td>
<td>Marsh gas</td>
<td>$\text{CH}_4$</td>
</tr>
<tr>
<td>63.</td>
<td>Nitrolim</td>
<td>$\text{CaCN}_2 + C$ (a fertilizer)</td>
</tr>
<tr>
<td>64.</td>
<td>Nascent Hydrogen</td>
<td>H at the moment of generation</td>
</tr>
<tr>
<td>65.</td>
<td>Nessler's reagent</td>
<td>$(\text{K}_2\text{HgI}_4 + \text{KOH})$ aqueous solution</td>
</tr>
<tr>
<td>66.</td>
<td>Indian saltpetre, Bengal salt petre</td>
<td>$\text{KNO}_3$</td>
</tr>
<tr>
<td>67.</td>
<td>Oil of vitriol</td>
<td>Conc. $\text{H}_2\text{SO}_4$</td>
</tr>
<tr>
<td>68.</td>
<td>Ozone</td>
<td>$\text{O}_3$</td>
</tr>
<tr>
<td>69.</td>
<td>Oleum</td>
<td>$\text{H}_2\text{S}_2\text{O}_7$</td>
</tr>
<tr>
<td>70.</td>
<td>Permutit (Zeolite)</td>
<td>$\text{Na}_2\text{Al}_2\text{SiO}_8 \cdot \text{XH}_2\text{O}$</td>
</tr>
<tr>
<td>71.</td>
<td>Pearl ash (Potash)</td>
<td>$\text{K}_2\text{CO}_3$</td>
</tr>
<tr>
<td>72.</td>
<td>Plaster of paris</td>
<td>$\text{CaSO}_4 \frac{1}{2} \text{H}_2\text{O}$ or $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$</td>
</tr>
<tr>
<td>73.</td>
<td>Philosopher's wool (chinese white)</td>
<td>$\text{ZnO}$ (Zinc white)</td>
</tr>
<tr>
<td>74.</td>
<td>Phosphene</td>
<td>$\text{COCl}_2$</td>
</tr>
<tr>
<td>75.</td>
<td>Phosphine</td>
<td>$\text{PH}_3$</td>
</tr>
<tr>
<td>76.</td>
<td>Pig iron</td>
<td>Impure form of iron</td>
</tr>
<tr>
<td>77.</td>
<td>Producer gas</td>
<td>A mixture of $\text{CO} + \text{N}_2 + \text{H}_2$</td>
</tr>
<tr>
<td>78.</td>
<td>Quartz</td>
<td>$\text{SiO}_2$</td>
</tr>
<tr>
<td>79.</td>
<td>Refrigerant</td>
<td>$\text{CO}_2 \cdot \text{NH}_3 \cdot \text{CF}_2\text{Cl}_2$ etc.</td>
</tr>
<tr>
<td>80.</td>
<td>Red lead</td>
<td>$\text{Pb}_3\text{O}_4$</td>
</tr>
<tr>
<td>81.</td>
<td>Rochelle salt</td>
<td>Sodium - potassium tartarate</td>
</tr>
<tr>
<td>82.</td>
<td>Rust</td>
<td>$\text{Fe}_2\text{O}_3 \cdot \text{xH}_2\text{O}$</td>
</tr>
<tr>
<td>83.</td>
<td>Sorel's cement (Magnesia cement)</td>
<td>$\text{MgCl}_2 \cdot 5\text{MgO} \cdot \text{XH}_2\text{O}$</td>
</tr>
<tr>
<td>84.</td>
<td>Soda - lime</td>
<td>$\text{NaOH} + \text{CaO}$</td>
</tr>
<tr>
<td>85.</td>
<td>Soda ash</td>
<td>$\text{Na}_2\text{CO}_3$ (anhydrous)</td>
</tr>
<tr>
<td>86.</td>
<td>Slaked lime</td>
<td>$\text{Ca(OH)}_2$</td>
</tr>
<tr>
<td>87.</td>
<td>Stainless steel</td>
<td>An alloy of Fe, Cr and C</td>
</tr>
<tr>
<td>88.</td>
<td>Salt cake</td>
<td>$\text{Na}_2\text{SO}_4$ (anhydrous)</td>
</tr>
<tr>
<td>89.</td>
<td>Super phosphate</td>
<td>$\text{Ca(H}_2\text{PO}_4 \cdot 2\text{CaSO}_4$</td>
</tr>
<tr>
<td>90.</td>
<td>TNT</td>
<td>:</td>
</tr>
<tr>
<td>91.</td>
<td>TNB</td>
<td>:</td>
</tr>
<tr>
<td>92.</td>
<td>Tincal</td>
<td>:</td>
</tr>
<tr>
<td>93.</td>
<td>Talc</td>
<td>:</td>
</tr>
<tr>
<td>94.</td>
<td>Tritium</td>
<td>:</td>
</tr>
<tr>
<td>95.</td>
<td>Water glass</td>
<td>:</td>
</tr>
<tr>
<td>96.</td>
<td>Water gas</td>
<td>:</td>
</tr>
<tr>
<td>97.</td>
<td>White vitriol</td>
<td>:</td>
</tr>
<tr>
<td>98.</td>
<td>Wrought iron</td>
<td>:</td>
</tr>
<tr>
<td>99.</td>
<td>Washing soda</td>
<td>:</td>
</tr>
<tr>
<td>100.</td>
<td>Willemite \ Zincite</td>
<td>:</td>
</tr>
<tr>
<td>101.</td>
<td>Zinc white</td>
<td>:</td>
</tr>
<tr>
<td>102.</td>
<td>Zinc blend</td>
<td>:</td>
</tr>
</tbody>
</table>

### 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 $\text{HNO}_3$