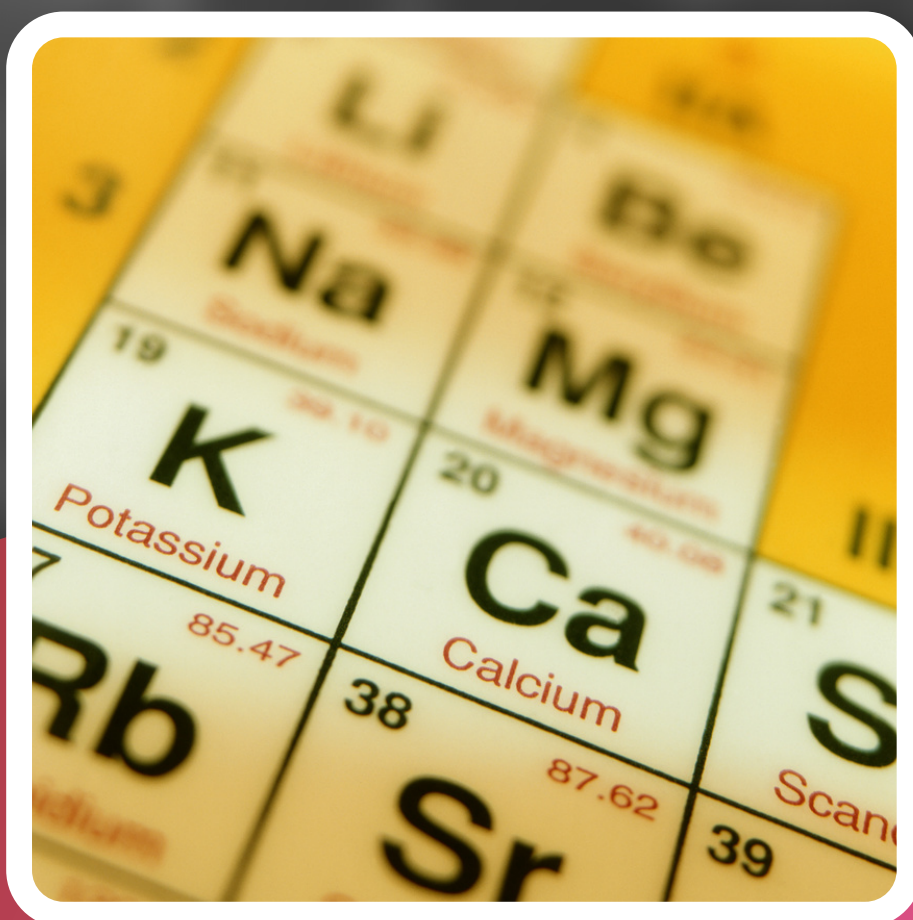


# INORGANIC CHEMISTRY

ENTHUSIAST | LEADER | ACHIEVER



**STUDY MATERIAL**

s-Block Elements

---

ENGLISH MEDIUM

---

## Copyright Statement

All rights including trademark and copyrights and rights of translation etc. reserved and vested exclusively with ALLEN Career Institute Private Limited. (ALLEN)

No part of this work may be copied, reproduced, adapted, abridged or translated, transcribed, transmitted, stored or distributed in any form retrieval system, computer system, photographic or other system or transmitted in any form or by any means whether electronic, magnetic, chemical or manual, mechanical, digital, optical, photocopying, recording or otherwise, or stored in any retrieval system of any nature without the written permission of the Allen Career Institute Private Limited. Any breach will entail legal action and prosecution without further notice.

This work is sold/distributed by Allen Career Institute Private Limited subject to the condition and undertaking given by the student that all proprietary rights (under the Trademark Act, 1999 and Copyright Act, 1957) of the work shall be exclusively belong to ALLEN Career Institute Private Limited. Neither the Study Materials and/or Test Series and/or the contents nor any part thereof i.e. work shall be reproduced, modify, re-publish, sub-license, upload on website, broadcast, post, transmit, disseminate, distribute, sell in market, stored in a retrieval system or transmitted in any form or by any means for reproducing or making multiple copies of it.

Any person who does any unauthorised act in relation to this work may be liable to criminal prosecution and civil claims for damages. Any violation or infringement of the propriety rights of Allen shall be punishable under Section- 29 & 52 of the Trademark Act, 1999 and under Section- 51, 58 & 63 of the Copyright Act, 1957 and any other Act applicable in India. All disputes are subjected to the exclusive jurisdiction of courts, tribunals and forums at Kota, Rajasthan only.

**Note:-** This publication is meant for educational and learning purposes. All reasonable care and diligence have been taken while editing and printing this publication. ALLEN Career Institute Private Limited shall not hold any responsibility for any error that may have inadvertently crept in. ALLEN Career Institute Private Limited is not responsible for the consequences of any action taken on the basis of this publication.

## s-BLOCK ELEMENTS

### 3.0 INTRODUCTION

The s-block elements of the Periodic Table are those in which the last electron enters in the outermost s-orbital. As the s-orbital can accommodate only two electrons, two groups (1 & 2) belong to the s-block of the Periodic Table. Group 1 of the Periodic table consists of the elements: lithium, sodium, potassium, rubidium, cesium and francium. They are collectively known as the alkali metals. They are so called because they form hydroxides on reaction with water which are strongly alkaline in nature. The elements of Group 2 include Beryllium, Magnesium, Calcium, Strontium, Barium and Radium. These elements with the exception of **beryllium** are commonly known as the alkaline earth metals. They are so called because their oxides and hydroxides are alkaline in nature and these metal oxides are found in the earth's crust.

### 3.1 PHYSICAL PROPERTIES OF S-BLOCK ELEMENTS

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

#### Atomic and Physical Properties of the Alkaline Metals

#### physical properties of s-Block Elements

ALKALI METALS	ALKALINE EARTH METALS
<b>Physical state</b>	
<ul style="list-style-type: none"> <li>One electron in outermost shell &amp; <b>General formula <math>ns^1</math></b>.</li> <li>Francium is radioactive element.</li> <li>All are silvery white</li> <li>Light soft, malleable and ductile metals with metallic lustre.</li> </ul>	<ul style="list-style-type: none"> <li>Two electrons in outer most shell &amp; <b>General formula <math>ns^2</math></b>.</li> <li>Radium is radioactive element.</li> <li>All are silvery white.</li> <li>These metals are harder than alkali metals.</li> </ul>
ALKALI METALS	ALKALINE EARTH METALS
<b>Atomic size</b>	
<ul style="list-style-type: none"> <li>Largest in their respective period (except noble gas element)</li> <li>Size increases from Li to Cs due to addition of an extra shell.</li> </ul> $Li < Na < K < Rb < Cs$ <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;"> <b>IA</b>            Li            Na            K            ↓            Rb            ↓            Cs         </div> <div style="text-align: center;"> <b>IIA</b>            Be            Mg            Ca            ↓            Sr            ↓            Ba         </div> </div>	<ul style="list-style-type: none"> <li>Smaller than IA group elements, since extra charge on nucleus attracts the electron cloud.</li> <li>Size increases gradually from Be to Ba  <math>Be &lt; Mg &lt; Ca &lt; Sr &lt; Ba</math></li> </ul> <p><b>In s-block elements</b>            Be has smallest size, while Cs has largest size.</p>
ALKALI METALS	ALKALINE EARTH METALS
<b>Melting point and Boiling point</b>	
<ul style="list-style-type: none"> <li>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.</li> <li>Decreasing order of melting point and boiling point is  <math>Li &gt; Na &gt; K &gt; Rb &gt; Cs</math></li> </ul>	<ul style="list-style-type: none"> <li>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.</li> <li>Decreasing order of            melting point <math>Be &gt; Ca &gt; Sr &gt; Ba &gt; Mg</math>            Boiling point <math>Be &gt; Ba &gt; Ca &gt; Sr &gt; Mg</math></li> </ul>
<b>Melting point &amp; Boiling point <math>\propto</math> Strength of metallic bond <math>\propto</math> Number of valence shell <math>e^-</math></b>	

ALKALI METALS	ALKALINE EARTH METALS
Ionisation energy (I.E.)	
<ul style="list-style-type: none"> <li>First ionisation energy (I.E.) is very less because of larger atomic size and only one electron in outer most shell.</li> <li>Decreasing order of ionisation energy- Li &gt; Na &gt; K &gt; Rb &gt; Cs</li> <li>Second ionisation energy of alkali metals is very high because by loosing one electron they achieve inert gas configuration.</li> </ul>	<ul style="list-style-type: none"> <li>First ionisation energy is higher than IA group because of smaller atomic size and completely filled s-orbital (stable electronic configuration)</li> <li>Decreasing order of ionisation energy- Be &gt; Mg &gt; Ca &gt; Sr &gt; Ba</li> <li>Second ionisation energy is lesser than IA group.</li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Oxidation state	
<ul style="list-style-type: none"> <li>The alkali metals shows only + 1 oxidation state. (difference between <math>IE_1</math> and <math>IE_2 &gt; 16\text{eV}</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Alkaline earth metal shows +2. Oxidation state (difference between <math>IE_1</math> and <math>IE_2 &lt; 11\text{eV}</math>)</li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Electro positive character or metallic character	
<ul style="list-style-type: none"> <li><b>Electropositivity <math>\propto 1/\text{Ionisation energy}</math></b> Due to their larger size electron can easily be removed to form <math>M^+</math> ion. Electro positive property increases from Li to Cs.</li> </ul>	<ul style="list-style-type: none"> <li>Their atomic size is smaller than IA group so these are lesser electro positive than IA group. Electropositivity increases from Be to Ba</li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Density ( $D = M/V$ )	
<ul style="list-style-type: none"> <li>In a group atomic volume also increase along with atomic weight but atomic weight increases more than atomic volume, so density increases from Li to Cs Increasing order of density Li &lt; K &lt; Na &lt; Rb &lt; Cs <b>Exception :</b> Density of K is less than Na. Why ? <b>Ans.</b> This is due to presence of vacant d-orbital in the inner shells of K (volume increases, density decreases)</li> </ul>	<ul style="list-style-type: none"> <li>Density increases from Be to Ba Increasing order of density Ca &lt; Mg &lt; Be &lt; Sr &lt; Ba</li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Conductivity	
<ul style="list-style-type: none"> <li>Due to the presence of loosely held valence electrons which are free to move in a metal structure, these elements are good conductor of heat and electricity.</li> </ul>	<ul style="list-style-type: none"> <li>These are also good conductor of heat and electricity due to presence of two free electrons. <b>Conductivity of IA &lt; Conductivity of IIA</b></li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Flame test	
<ul style="list-style-type: none"> <li>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 a visible light <b>Li - Crimson red; Na - Golden yellow; K-Violet; Rb - Red violet; Cs-Blue</b></li> </ul>	<ul style="list-style-type: none"> <li>Due to small size of Be &amp; Mg outer most electrons are tightly bounded. So not excited to higher level, hence they do not give flame test.</li> <li>Other elements gives characteristic colour to flame <b>Ca-Brick red; Sr-Crimson red; Ba-apple green</b></li> </ul>

ALKALI METALS	ALKALINE EARTH METALS
Photo electric effect	
<ul style="list-style-type: none"> <li>Atomic size of K, Rb and Cs is quite large, so their ionisation energy is very low</li> <li>Due to very low ionisation energy their valence shell electrons gets excited even by absorbing visible light. That's why Cs is used in photoelectric cells.</li> </ul>	<ul style="list-style-type: none"> <li>These elements do not show this property as their atomic size is small hence ionisation energy is higher than IA group.</li> </ul>
ALKALI METALS	ALKALINE EARTH METALS
Standard oxidation potential	
<ul style="list-style-type: none"> <li>All the alkali metals have high +ve values of standard oxidation potential (tendency of releasing electrons in water or self ionic solutions) So they are good reducing agent, having upper most positions in the electro chemical series.</li> <li>Li has highest standard oxidation potential (+3.05 eV) due to its high hydration energy. Such that it converts into <math>\text{Li}^+</math> ion by losing one electron.</li> <li>Order of standard oxidation potential is - <math>\text{Li} &gt; \text{Cs} \approx \text{Rb} \approx \text{K} &gt; \text{Na}</math></li> </ul>	<ul style="list-style-type: none"> <li>They have lower values of standard oxidation potential due to their high IE.</li> <li>Increasing order of standard oxidation potential is - <math>\text{Be} &lt; \text{Mg} &lt; \text{Ca} &lt; \text{Sr} &lt; \text{Ba}</math></li> </ul>
ALKALI METALS	ALKALINE EARTH METALS
Complex formation tendency	
<ul style="list-style-type: none"> <li>Only those elements can form complex compounds which have               <ol style="list-style-type: none"> <li>Small cation size</li> <li>High charge density</li> <li>Vacant orbitals to accept electrons.</li> </ol> </li> <li>Only <math>\text{Li}^+</math> can form complex compound, due to its small size rest alkali metals have very less tendency to form complex compounds.</li> </ul>	<ul style="list-style-type: none"> <li>Less tendency to form complex compound, but due to small size of cations Be and Mg forms complex compounds like <math>\text{Be}-(\text{BeF}_4)^{-2}</math>; Mg - Chlorophyll</li> </ul>

## Chemical properties of s-block elements

Reactivity	
<ul style="list-style-type: none"> <li>These elements are very reactive, so do not found in free state in nature.</li> </ul> <p><b>Reactivity <math>\propto 1/\text{Ionisation potential}</math></b> order of reactivity - <math>\text{Li} &lt; \text{Na} &lt; \text{K} &lt; \text{Rb} &lt; \text{Cs}</math></p>	<ul style="list-style-type: none"> <li>Less reactive than alkali metals.</li> </ul> <p>Order of reactivity :- <math>\text{Be} &lt; \text{Mg} &lt; \text{Ca} &lt; \text{Sr} &lt; \text{Ba}</math></p>
Reaction with air	
<ul style="list-style-type: none"> <li>Alkali metals gets tarnish in air due to the formation of oxide at their surface hence they are kept in kerosene or paraffin wax.</li> <li>These elements reacts with moist air to form carbonates               <math display="block">4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}</math> <math display="block">\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}</math> <p style="text-align: center;">(moist)</p> <math display="block">2\text{NaOH} + \text{CO}_2 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}</math> <p style="text-align: center;">(in air)</p> <p>In dry air only Li gives nitride and oxide both while other elements gives only oxides.</p> </li> </ul>	<ul style="list-style-type: none"> <li>Except Be, these metals easily tarnished in air.</li> <li>Beryllium in powdered form, burns brilliantly on ignition in air.</li> <li>In moist air, except Be all the elements converts into carbonates.</li> <li>In dry air all elements of II A give nitride and oxide both.</li> </ul>



**Reaction with oxygen**
**Oxide ion  $[O^{2-}]$  :**

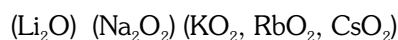
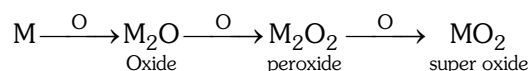
- Li forms mainly  $Li_2O$  (Lithium oxide).

**Peroxide  $[O_2^{2-}]$  :**

- Na reacts with  $O_2$  to form mainly peroxide ( $Na_2O_2$ ).

**Super oxide  $[O_2^-]$  :**

- K, Rb and Cs forms  $MO_2$  type oxides (super oxides) in excess of oxygen. Super oxides are paramagnetic and coloured.



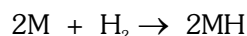
- Stability order of different oxide of a metal is due to Lattice Energy

Normal oxide > Peroxide > Superoxide

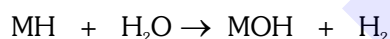
- Alkaline earth metals reacts with  $O_2$  to form 'MO' type oxides  
(M = Be, Mg, Ca, Sr, Ba)
- In IIA only Ca, Sr, Ba form peroxide.  
**Ex.**  $CaO_2$ ,  $SrO_2$ ,  $BaO_2$
- BeO shows amphoteric property.  
 $MgO \rightarrow$  weak basic  
 $CaO$ ,  $SrO$  &  $BaO \rightarrow$  Strong basic
- Basic properties increases from BeO to BaO.

**Reaction with hydrogen**

- Alkali metals combine with  $H_2$  forming ionic hydrides



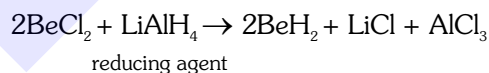
- Hydrides of alkali metals are attacked by water to give back hydrogen



Thermal stability decrease, Basic property increases  $\rightarrow$

- Except Be all the alkaline metals forms  $MH_2$  type hydrides, ( $MgH_2$ ,  $CaH_2$ ,  $SrH_2$ ,  $BaH_2$ ) on heating directly with  $H_2$

- $BeH_2$  is prepared by action of  $BeCl_2$  with  $LiAlH_4$



- $BeH_2$  and  $MgH_2$  are covalent, other are ionic.

**Reaction with water**

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



- Reactivity with water increases from Li to Cs.

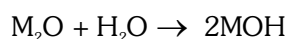
Li  $\rightarrow$  least reactive towards water

Na  $\rightarrow$  reacts vigorously

K  $\rightarrow$  reacts producing a flame

Rb, Cs  $\rightarrow$  reacts explosively.

- Monoxides gives strongly alkaline solution with water



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



- Be does not reacts with water

- Mg reacts only with hot water

- Ca, Sr, Ba reacts with cold water but not as energetically as alkali metals.

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

Halides	
<ul style="list-style-type: none"> <li>Alkali metals reacts directly with halogen to form MX (M – alkalimetal, X – Halide ion)</li> <li>Ionic nature of MX increases from LiCl to CsCl</li> <li>LiCl is covalent in nature (due to polarisation of <math>\text{Cl}^-</math> ion by small <math>\text{Li}^+</math> ion). hence its tendency of hydrolysis is more.</li> <li>K, Rb and Cs halides reacts with more halogens to gives polyhalides. <math>\text{KI} + \text{I}_2 \rightarrow \text{KI}_3</math> <math>\text{CsBr} + \text{Br}_2 \rightarrow \text{CsBr}_3</math></li> </ul>	<ul style="list-style-type: none"> <li>Alkaline metals reacts with X (Halogen) to form <math>\text{MX}_2</math>.</li> <li>Order of Ionic nature <math>\text{BeCl}_2 &lt; \text{MgCl}_2 &lt; \text{CaCl}_2 &lt; \text{SrCl}_2 &lt; \text{BaCl}_2</math></li> <li>Hydrolysis tendency of these halides decreases from <math>\text{BeCl}_2</math> to <math>\text{BaCl}_2</math> due to decrease in covalent nature.</li> <li><math>\text{BeCl}_2</math> and <math>\text{MgCl}_2</math> are covalent in nature. <math>\text{BeO} + \text{C} + \text{Cl}_2 \xrightarrow{\Delta} \text{BeCl}_2 + \text{CO}</math></li> </ul>
Nitrides	
<ul style="list-style-type: none"> <li>Only Li reacts directly with <math>\text{N}_2</math> to form nitride which gives <math>\text{NH}_3</math> on reacting with water. <math>6\text{Li} + \text{N}_2 \rightarrow 2\text{Li}_3\text{N}</math> <math>\text{Li}_3\text{N} + 3\text{H}_2\text{O} \rightarrow 3\text{LiOH} + \text{NH}_3 \uparrow</math></li> </ul>	<ul style="list-style-type: none"> <li>All elements of II A burns in <math>\text{N}_2</math> to give <math>\text{M}_3\text{N}_2</math> (nitrides) <b>For example :</b> <math>\text{Be}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Be}(\text{OH})_2 + 2\text{NH}_3</math> <math>\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Mg}(\text{OH})_2 + 2\text{NH}_3</math></li> </ul>
Formation of amalgam	
<ul style="list-style-type: none"> <li>Alkali metals gives amalgam with Hg.</li> <li>These metals reacts with other metals to give mixed metals (alloys)</li> </ul>	<ul style="list-style-type: none"> <li>Shows same properties.</li> </ul>
Solubility in liquid ammonia	
<ul style="list-style-type: none"> <li>All the alkali metals dissolves in <math>\text{NH}_3</math> (liq.) and produces blue coloured solution.</li> <li>The blue colour and reducing nature of solution is due to presence of ammoniated electron.</li> <li>Solution is a good conductor due to presence of both ammoniated ion and ammoniated electron. <math>\text{Na}_{(s)} + (x+y)\text{NH}_3 \rightarrow \left[ \text{Na}(\text{NH}_3)_x \right]^+ + \left[ e(\text{NH}_3)_y \right]^-</math> ammoniated ion                      ammoniated electron</li> <li>This dilute solution is paramagnetic in nature.</li> </ul>	<ul style="list-style-type: none"> <li>Only Ca, Sr and Ba gives blue solution of ammoniated electron.</li> <li>Be and Mg are small in size and have high ionisation energy so do not dissolves in liquid <math>\text{NH}_3</math>.</li> <li>Dark blue colour of solution becomes fade if it is allowed to stand for a long time, it is because of metal amide formation. <math>2\text{Na} + 2\text{NH}_3 \rightarrow 2\text{NaNH}_2 + \text{H}_2 \uparrow</math> (Sodamide)</li> <li>Exception <math>\Rightarrow</math> Li forms imide <math>2\text{Li} + \text{NH}_3 \rightarrow \text{Li}_2\text{NH} + \text{H}_2</math></li> <li>On increasing the concentration of metal in solution, it converts into bronze colour due to cluster formation of metal ions.</li> </ul>

**BEGINNER'S BOX-1**

- Which of the following is soluble in organic solvents like ethanol?  
 (1) LiCl (2) NaCl (3) KCl (4) RbCl
- Which of the following is the correct order of hydrated radii?  
 (1)  $\text{Li}^+ < \text{Na}^+ < \text{K}^+ < \text{Rb}^+ < \text{Cs}^+$  (2)  $\text{Rb}^+ < \text{Na}^+ < \text{Li}^+ < \text{Cs}^+ < \text{K}^+$   
 (3)  $\text{Cs}^+ < \text{Rb}^+ < \text{K}^+ < \text{Na}^+ < \text{Li}^+$  (4)  $\text{Li}^+ < \text{K}^+ < \text{Na}^+ < \text{Rb}^+ < \text{Cs}^+$
- As compared to potassium, sodium has  
 (1) Lower electronegativity (2) Higher ionization potential  
 (3) Larger atomic radius (4) Lower melting point
- Which of the following statement is correct regarding alkali metals  
 (1) All are black in colour (2) Cation is smaller in size than the parent atom  
 (3) Size of cation and parent atom is the same (4) Cation is greater in size than the parent atom
- Which shows golden yellow colour in flame test ?  
 (1) Li (2) Ca (3) Na (4) Cs
- Which of the following halides are ionic in nature ?  
 (1)  $\text{BaX}_2$  (2)  $\text{CaX}_2$  (3)  $\text{SrX}_2$  (4) All of these
- Which of the following carbonates is the most thermally stable ?  
 (1)  $\text{BeCO}_3$  (2)  $\text{MgCO}_3$  (3)  $\text{CaCO}_3$  (4)  $\text{BaCO}_3$
- Correct order of  $\Delta H_f$  of alkali metal fluorides  
 (1)  $\text{LiF} < \text{NaF}$  (2)  $\text{KF} < \text{CsF}$  (3)  $\text{RbF} < \text{CsF}$  (4)  $\text{LiF} > \text{CsF}$
- White metal is  
 (1) Li + Na (2) Li + Pb (3) Li + Mg (4) Na + K
- $\text{LiNO}_3 \xrightarrow{(\Delta)}$   
 $\text{NaNO}_3 \xrightarrow{(\Delta)}$   
 Common paramagnetic gas in the above reactions  
 (1)  $\text{O}_2$  (2)  $\text{N}_2$  (3)  $\text{NO}_2$  (4) NO

**COMPOUNDS OF s-BLOCK ELEMENTS**
**3.2 SODIUM CHLORIDE NaCl**

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

**Preparation :**

- Sea water  $\text{NaCl}(2.7 - 2.9\%) \xrightarrow[\text{by solar heat}]{\text{Evaporation}}$  crude NaCl
- It contains impurities –  $\text{Na}_2\text{SO}_4$ ,  $\text{MgCl}_2$ ,  $\text{CaCl}_2$  etc.
- Insoluble impurities removed by filtration.
- Filtrate  $\xrightarrow{\text{HCl gas passed}}$  Pure NaCl precipitation (Common ion effect)
- $\text{MgCl}_2$  and  $\text{CaCl}_2$  are more soluble in water so left in solution.



**Properties :**

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



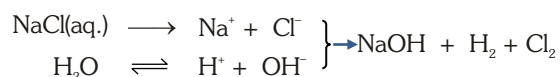
**Uses** i. As a preservative for pickles, meat and fish.

- For making freezing mixture with Ice.

**3.3 SODIUM HYDROXIDE [Caustic Soda(NaOH)]**

**Manufacture :** By electrolysis of NaCl.

- (a) **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) :  $2\text{Cl}^-(\text{aq.}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

- (b) **Castner – Kellner Cell :** (Hg – Cathode Process)

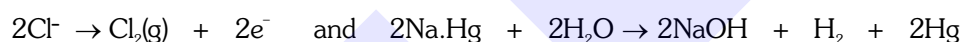


**On electrolysis –**

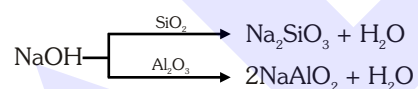
At Cathode (Hg)



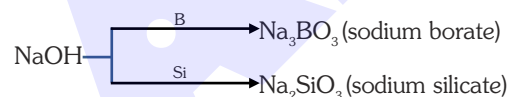
At anode (Graphite)

**Properties :**

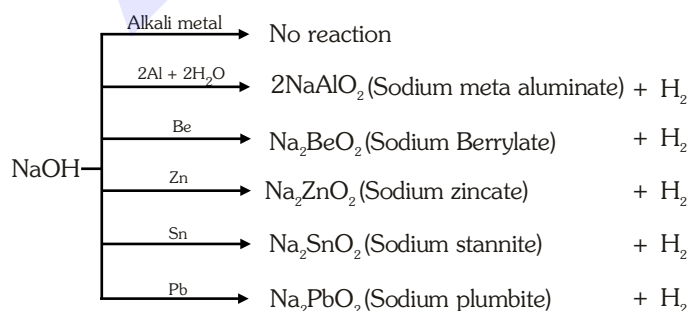
- It is deliquescent white crystalline solid.
- It absorbs  $\text{CO}_2$  from air forming  $\text{Na}_2\text{CO}_3$ .
- NaOH is **strong base**



- iv. **Reaction with non metals :** No reaction with  $\text{H}_2$ ,  $\text{N}_2$  and C

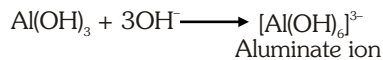
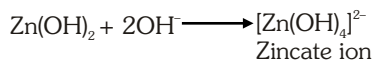


- v. **Reaction with Metal :**

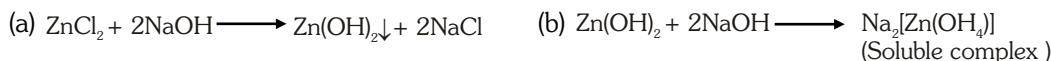


Pre-Medical

- vi. 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.



- vii. **Reaction with  $\text{ZnCl}_2$  or  $\text{ZnSO}_4$**

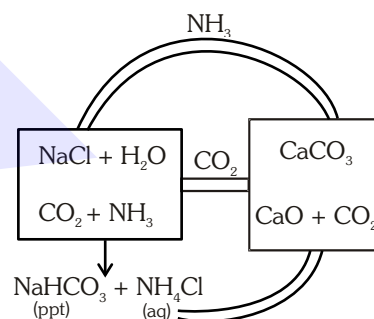


- Uses** (i) In the manufacture of soap, rayon, dyes, paper and drugs.  
(ii) In petroleum refining.

### 3.4 SODIUM BICARBONATE OR BAKING SODA ( $\text{NaHCO}_3$ ) and SODIUM CARBONATE OR WASHING SODA [ $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ]

**Preparation : Solvay Process** (Commercial Scale)/Ammonia Soda Process

- (i)  $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$   
(ii)  $\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \longrightarrow \text{NH}_4\text{HCO}_3$   
(iii)  $\text{NaCl} + \text{NH}_4\text{HCO}_3 \longrightarrow \text{NH}_4\text{Cl} + \text{NaHCO}_3$  (ppt)  
(iv) Sodium carbonate is prepared by heating of  $\text{NaHCO}_3$   
 $2\text{NaHCO}_3 \xrightarrow{\Delta} \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$   
(v)  $2\text{NH}_4\text{Cl} + \text{CaO} \longrightarrow \text{CaCl}_2 + 2\text{NH}_3 + \text{H}_2\text{O}$   
(Bye-product)



**Note :** Potassium bicarbonate ( $\text{KHCO}_3$ ) cannot be prepared by Solvay process as it is more soluble in water as compared to  $\text{NaHCO}_3$ .

#### Properties of $\text{NaHCO}_3$ :

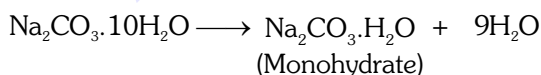
- (i) **Hydrolysis**  $\text{NaHCO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NaOH} + \text{H}_2\text{CO}_3$   
(ii) **Effect of heat** (temp.  $> 100^\circ\text{C}$ )  $2\text{NaHCO}_3 \longrightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 \uparrow$   
(iii) **Reaction with acids** – gives  $\text{CO}_2$   $\text{NaHCO}_3 + \text{HCl} \longrightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 \uparrow$   
(iv) **Reaction with bases**  $\text{NaHCO}_3 + \text{NaOH} \longrightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$

**Note :** Reaction (iii) and (iv) explain **amphoteric** behaviour of  $\text{NaHCO}_3$ .

#### Properties of $\text{Na}_2\text{CO}_3$

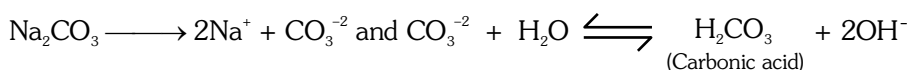
- (i) **Efflorescence :**

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

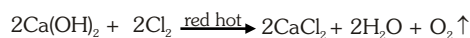
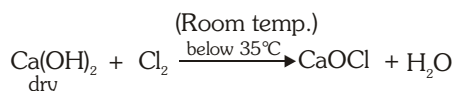


This process is called efflorescence. Hence washing soda loses weight on exposure to air.

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



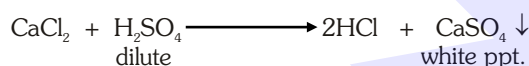


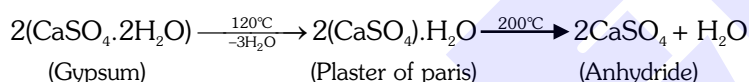
(ii) **Action of Chlorine :**

**Uses of Ca(OH)<sub>2</sub>**

- (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.

**3.7 CALCIUM SULPHATE [Gypsum CaSO<sub>4</sub>·2H<sub>2</sub>O]**

**Preparation :** CaSO<sub>4</sub>·2H<sub>2</sub>O is naturally occurring calcium sulphate. It can be obtained by the action of dil. H<sub>2</sub>SO<sub>4</sub> on a soluble calcium salt below 60°C.


**Properties of Gypsum**

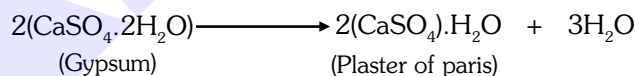
 (i) **Action of heat :**

 (ii) It forms an important fertilizer (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>

**Uses of Gypsum**

- (i) In the preparation of plaster of paris
- (ii) Anhydrous CaSO<sub>4</sub> used as drying agent.
- (iii) Anhydrite (CaSO<sub>4</sub>) is used for manufacture of sulphuric acid, ammonium sulphate.

**3.8 PLASTER OF PARIS [P.O.P.] 2(CaSO<sub>4</sub>)·H<sub>2</sub>O or CaSO<sub>4</sub>· $\frac{1}{2}$ H<sub>2</sub>O**

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


**Properties of POP**

- (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 is heated at 200°C, anhydrous CaSO<sub>4</sub> is formed.

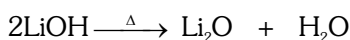
**Uses of POP**

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

### 3.9 SOME IMPORTANT POINTS TO REMEMBER

#### ANOMALOUS BEHAVIOR OF LITHIUM

- On account of its small size it exerts the greatest polarising effect out of all the alkali metals and ions, consequently covalent character is developed.
- Li has the highest ionisation energy and electronegativity as compared to other alkali metals.
- It is not affected by air easily and does not lose its lustre even on melting.
- It is harder and lighter than other alkali metal.
- It reacts slowly with water to liberate hydrogen.
- When burnt in air or oxygen, it forms only monoxide,  $\text{Li}_2\text{O}$ . However, the rest of the alkali metals give peroxide or superoxides.
- $\text{Li}_2\text{O}$  is less basic oxides than of other alkali metals.
- Lithium hydroxide decomposes when red heated to form  $\text{Li}_2\text{O}$ . Hydroxides of other alkali metals do not decompose.



- $\text{Li}_2\text{CO}_3$  is less stable, as it decomposes on heating.  $\text{Li}_2\text{CO}_3 \xrightarrow{\Delta} \text{Li}_2\text{O} + \text{CO}_2$
- $\text{Li}_2\text{SO}_4$  is the only alkali metal sulphate, which does not form double salts like Alum.
- Li when heated in  $\text{NH}_3$  forms imide  $\text{Li}_2\text{NH}$  while other alkali metals form amides ( $\text{MNH}_2$ ).
- Lithium shows resemblance with magnesium, an element of group IIA.

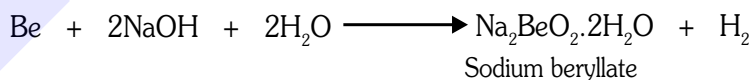
This resemblance is termed as diagonal relationship.

#### Similarities between lithium and Magnesium

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

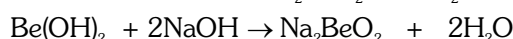
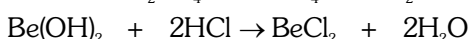
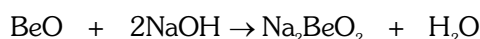
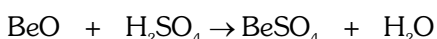
#### ANOMALOUS BEHAVIOR OF BERYLLIUM

- It is the hardest of all alkaline earth metal as maximum metallic bonding is there due to its smallest size.
- The melting and boiling points of the beryllium are the highest.
- It is least reactive due to highest ionisation potential.
- Due to high charge density its polarising effect is highest and it forms covalent bond.
- It dissolves in alkalis with the evolution of hydrogen



other alkaline earth metals do not react with alkalis.

- Oxides and hydroxides of beryllium are amphoteric in nature.



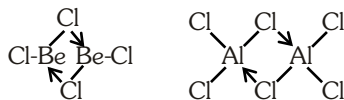
The hydroxide is Insoluble in water and is covalent in nature.

- Like  $\text{Al}_4\text{C}_3$ , its carbide ( $\text{Be}_2\text{C}$ ) on hydrolysis evolves methane.
- Due to its small size it has strong tendency to form complex.
- It shows diagonal relationship with Al.

**DIAGONAL SIMILARITY BETWEEN BERYLLIUM AND ALUMINIUM :**

In many of its properties, beryllium resembles with aluminium. Thus –

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

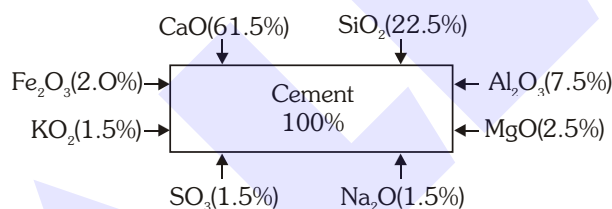


- Salts of these metals form hydrated ions, Ex.  $[\text{Be}(\text{OH})_4]^{2-}$  and  $[\text{Al}(\text{OH})_6]^{3+}$  in aqueous solutions. Due to similar charge/ radius ratios of beryllium and aluminium ions they have a strong tendency to form complexes. For example beryllium forms tetrahedral complexes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

**3.10 PORTLAND CEMENT**

It is a light grey, heavy fine powder, It is a homogenous mixture of silicates and aluminates of calcium, which form more than 90% of the cement are –

- |  |   |   |
|--|---|---|
| (i) Tricalcium silicate                                | - | $3\text{CaO} \cdot \text{SiO}_2$                                      |
| (ii) Dicalcium silicate (slowest setting component)    | - | $2\text{CaO} \cdot \text{SiO}_2$                                      |
| (iii) Tricalcium aluminate (fastest setting component) | - | $3\text{CaO} \cdot \text{Al}_2\text{O}_3$                             |
| (iv) Tetracalcium aluminino ferrite                    | - | $4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$ |

**Important Points :-**
**(i) Composition of Cement**


For high quality

$\Rightarrow \text{SiO}_2$  to  $\text{Al}_2\text{O}_3$  Ratio = 2.5–4

$\Rightarrow \text{CaO}$  to Rest all oxide = 2

**(ii) Raw Materials**

- Lime Stone – It provides  $\text{CaO}$
- Clay – It provides  $\text{Al}_2\text{O}_3$  and silica ( $\text{SiO}_2$ )
- Gypsum –  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

- Setting of cement :** When water is mixed to cement and the mixture is left it becomes very hard. This property of cement is called setting.

- Mortar :** It is a mixture of cement, sand and water to give a proper consistency.

- Concrete :** A mixture of cement, Sand gravel and water is known as concrete.

- Reinforced concrete cement (RCC) :** When concrete is filled in beams made of iron bars, it is called RCC. Iron imparts extra strength to the structure.

**3.11 BIOLOGICAL ROLE OF SODIUM, POTASSIUM, MAGNESIUM AND CALCIUM**
**(FROM BIOLOGY PORTION)**

Normally % of abundance in human body –  $\text{K} > \text{Na} > \text{Fe} > \text{Cu}$



## BEGINNER'S BOX-2

- Potassium carbonate cannot be made by the Solvay process because
  - (1) potassium hydrogen carbonate is unstable
  - (2) potassium hydrogen carbonate is rather too soluble in water to be precipitated
  - (3) potassium carbonate is insoluble in water
  - (4) potassium carbonate is soluble in water
- Plaster of Paris, a white powder, is—
  - (1)  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
  - (2)  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$
  - (3)  $\text{CaSO}_4$
  - (4)  $\text{CaSO}_4 \cdot \text{H}_2\text{O}$
- Which of the following is incorrect?
  - (1) Cement containing no iron is white.
  - (2) Cement containing excess amount of lime cracks during setting.
  - (3) Setting of cement is an endothermic process.
  - (4) Setting of cement is an example of hydration.
- On passing excess of  $\text{CO}_2$  in lime water, its milky appearance disappears because -
  - (1) Soluble  $\text{Ca}(\text{OH})_2$  is formed
  - (2) Soluble  $\text{Ca}(\text{HCO}_3)_2$  is formed
  - (3) Reaction becomes reversible
  - (4) Calcium compound evaporated
- In the preparation of sodium carbonate which of the following is used -
  - (1) Slaked lime
  - (2) Lime stone
  - (3) Lime
  - (4) quick lime
- When chlorine is passed slow over dry slaked lime  $\text{Ca}(\text{OH})_2$  at room temperature, the main product is
  - (1)  $\text{CaCl}_2$
  - (2)  $\text{CaOCl}_2$
  - (3)  $\text{Ca}(\text{ClO}_2)_2$
  - (4)  $\text{Ca}(\text{OCl})_2$
- Identify the correct statement -
  - (1) Gypsum contains a lower percentage of Ca than plaster of paris
  - (2) Gypsum is obtained by heating plaster of paris
  - (3) Plaster of paris can be obtained by hydration of gypsum
  - (4) Plaster of paris is obtained by partial oxidation of gypsum
- Quick lime is prepared on a commercial scale by heating \_\_\_\_\_ in a rotary kiln at 1070 – 1270 K.
  - (1)  $\text{CaSO}_4$
  - (2)  $\text{Ca}(\text{NO}_3)_2$
  - (3)  $\text{CaCO}_3$
  - (4)  $\text{Ca}(\text{OH})_2$
- $\text{Ca}^{2+}$  ions play an important role in
  - (i) neuromuscular function
  - (ii) interneuronal transmission
  - (iii) cell membrane integrity
  - (iv) blood coagulation
  - (1) (i), (ii)
  - (2) (ii), (iii)
  - (3) (ii), (iii), (iv)
  - (4) (i), (ii), (iii), (iv)
- Be, Mg are colorless since
  - (1) high electron affinity of electron cannot be excited by flame
  - (2) high ionisation potential of electron cannot be excited by flame
  - (3) low ionisation potential of electron cannot be excited by flame
  - (4) low electron affinity of electron cannot be excited by flame

## ANSWER'S KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	3	2	2	3	4	4	4	2	1
BEGINNER'S BOX-2	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	2	2	3	2	2	2	1	3	4	2