s-BLOCK ELEMENTS & THEIR COMPOUNDS

Contents

Syllabus

s-BLOCK ELEMENTS & THEIR COMPOUNDS

Preparation and properties of the following compounds :
Oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates of sodium, potassium, magnesium and calcium.

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s-BLOCK ELEMENTS & THEIR COMPOUNDS

ANOMALOUS PROPERTIES OF LITHIUM :

The anomalous behavior of lithium is due to the : (i) exceptionally small size of its atom and ion, and (ii) high polarising power (i.e., charge/ radius ratio). As a result, there is increased covalent character of lithium compound which is responsible for their solubility in organic solvent. Further, lithium shows diagonal relationship to magnesium.

Points of Difference between Lithium and other Alkali Metals

- Lithium is much harder. Its melting point and boiling point are higher than the other alkali metals.
- Lithium is least reactive but the strongest reducing agent among all the alkali metals. On combustion in air it forms mainly monoxide, Li_2O and the nitride, Li_3N unlike other alkali metals.
- The lithium ion itself, and also its compounds are more heavily hydrated than those of the rest of the group. LiCl is deliquescent and crystallises as a hydrate, $LiCl.\ 2H_2O$ whereas other alkali metal chlorides do not form hydrates.
- Lithium hydrogencarbonate is not obtained in the solid form while all other elements form solid hydrogencarbonates.
- Lithium unlike other alkali metal forms no ethynide on reaction with ethyne.
- Lithium nitrate when heated gives lithium oxide, Li_2O, whereas other alkali metal nitrates decompose to give the corresponding nitrite.

$$4LiNO_3 \longrightarrow 2\,Li_2O + 4\,NO_2 + O_2$$

$$2NaNO_3 \xrightleftharpoons{500^\circ C} 2NaNO_2 + O_2 \quad ; \qquad 4NaNO_3 \xrightleftharpoons{800^\circ C} 2Na_2O + 5O_2 + 2N_2$$

$$2NaNO_2 + 2HCl \longrightarrow 2NaCl + H_2O + NO_2 + NO\ ; \qquad 2NO + O_2 \longrightarrow 2NO_2$$

$$2NaNO_3 + C \longrightarrow 2NaNO_2 + CO_2.$$

$$KNO_3 + Zn \longrightarrow KNO_2 + ZnO\ .$$

- LiF and Li_2O are comparatively much less soluble in water than the corresponding compounds of other alkali metals.
- Lithium hydroxide is less basic than the other hydroxides in the group and therefore, many of its salts are less stable, Li_2CO_3, $LiNO_3$ and LiOH all form the oxides on gentle heating; the analogus compounds of the rest of the group are stable. Another example of its less basic nature is that though lithium forms a bicarbonates in solution, it does not form a solid bicarbonate, where as the other all form stable solid carbonates.
- Lithium reacts directly with carbon to form anionic carbide. None of the other group 1 elements do this, but group 2 elements all react similarly with carbon.
- Lithium has a great tendency to form complexes than have the heavier elements, and ammoniated salts such as $[Li(NH_3)_4]^+$ exist as solids.

Points of Similarities between Lithium and Magnesium :

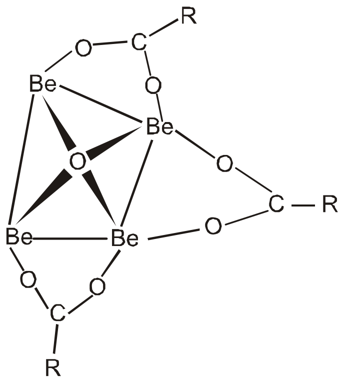
The similarity between lithium and magnesium is particularly striking and arises because of their similar size: atomic radii, Li = 152 pm, Mg = 160 pm; ionic radii : $Li^+ = 76$ pm, $Mg^{2+} = 72$ pm. The main points of similarity are:

- Both lithium and magnesium are harder and lighter than other elements in the respective groups.
- Lithium and magnesium react slowly with water. Their oxides and hydroxides are much less soluble and their hydroxides decompose on heating. Both form a nitride, Li_3N and Mg_3N_2, by direct combination with nitrogen.
- The oxides, Li_2O and MgO do not combine with excess oxygen to give any superoxide.
- The carbonates of lithium and magnesium decompose easily on heating to form the oxides and CO_2 . Solid hydrogencarbonates are not formed by lithium and magnesium.

- Both LiCl and $MgCl_2$ are soluble in ethanol.
- Both LiCl and $MgCl_2$ are deliquescent and crystallise from aqueous solution as hydrates, $LiCl.2H_2O$ and $MgCl_2.6H_2O$.

ANOMALOUS BEHAVIOUR OF BERYLLIUM

- Beryllium the first member of the Group 2 metals, shows anomalous behaviour as compared to magnesium and rest of the members. Further, it shows diagonal relationship to aluminium.
- Beryllium has exceptionally small atomic and ionic sizes and thus does not compare well with other members of the group. Because of high ionisation enthalpy and small size it forms compound which are largely covalent and get easily hydrolysed.
- Beryllium does not exhibit coordination number more than four as in its valence shell there are only four orbitals. The remaining member of the group can have a coordination number of six by making use of d-orbitals.
- The oxide and hydroxide of beryllium, unlike the hydroxides of other elements in the group, are amphoteric in nature.
- The beryllium hydride is electron deficient and polymeric, with multi-center bonding like aluminium hydride.
- The most unusual oxygen containing complexes of Be have formula $Be_4O(O_2CR)_6$ and are formed by refluxing $Be(OH)_2$ with carboxylic acids. These white crystalline compounds are soluble in non-polar organic solvents, such as alkanes, but are insoluble in water and lower alcohol. In solution, the compounds are unionised and monomeric.



The central oxygen atom is tetrahedrally surrounded by the four Be atoms and each Be atom is tetrahedrally surrounded by four oxygen atoms. The six acetate groups are arranged along the six edges of the tetrahedral ion.

Diagonal Relationship between Beryllium and Aluminium :

The ionic radius of Be^{2+} is estimated to be 31 pm; the charge/radius ratio is nearly the same as that of the Al^{3+} ion. Hence beryllium resembles aluminium in some ways. Some of the similarities are:

- Like aluminium, beryllium is not readily attacked by acids because of the presence of an oxide film on the surface of the metal, i.e. they are rendered passive by nitric acid.
- Beryllium hydroxide dissolves in excess of alkali to give a beryllate ion, $[Be(OH)_4]^{2-}$ just as aluminium hydroxide gives aluminate ion, $[Al(OH)_4]^-$
- The chlorides of both beryllium and aluminium have Cl^- bridged chloride structure in vapour phase. Both the chloride are soluble in organic solvents and are strong Lewis acids They are used as Friedel Craft catalysts.
- Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-} and AlF_6^{3-} respectively.

COMPOUNDS OF ALKALI METALS :

- **SODIUM OXIDE (Na_2O) :**

Preparation :

- By reduction of nitrites and nitrates of sodium with metallic sodium :

$$2NaNO_3 + 10Na \longrightarrow 6Na_2O + N_2 \quad ; \qquad 2NaNO_2 + 6Na \longrightarrow 4Na_2O + N_2$$

- By heating sodium in limited supply of air at 180ºC :

$$Na + O_2 \longrightarrow Na_2O$$

- Pure sodium oxide is formed when the mixture of sodium azide and sodium nitrite is heated

$$3NaN_3 + NaNO_2 \longrightarrow 2Na_2O + 5N_2$$

Properties :

- It is a white amorphous substance. It reacts with water violently forming sodium hydroxide and evolving a large amount of heat energy

$$Na_2O + H_2O \longrightarrow 2NaOH$$

- On heating at 400°C, it decomposes forming sodium peroxide and metallic sodium vapour.

$$2Na_2O \xrightarrow{400°C} Na_2O_2 + 2Na$$

- Reaction with liquid ammonia

$$Na_2O + NH_3 \longrightarrow NaNH_2 + NaOH$$

Use : It is used as dehydrating and polymerising agent in organic chemistry.

• SODIUM PEROXIDE (Na_2O_2) :

Preparation :

- It is formed by heating sodium in excess of air free from moisture and carbon dioxide or in excess of pure oxygen. $2Na + O_2(\text{excess}) \xrightarrow{350°C} Na_2O_2$
- Industrial method : It is a two stage reaction in the presence of excess air.

$$2Na + \frac{1}{2}O_2 \longrightarrow Na_2O \quad ; \quad Na_2O + \frac{1}{2}O_2 \longrightarrow Na_2O_2$$

Properties :

- It is a pale yellow (when impure) hygroscopic powder stable towards heat in dry air. On exposure to moist air, it becomes white as it reacts with moisture and carbon dioxide.

$$2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2$$

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O \ ; \qquad 2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$$

- Action of water :

$$Na_2O_2 + 2H_2O \xrightarrow{cold} 2NaOH + H_2O_2 \ ; \quad 2Na_2O_2 + 2H_2O \xrightarrow{warm} 4NaOH + O_2$$

- Action of acid :

$$Na_2O_2 + H_2SO_4 \xrightarrow{cold} Na_2SO_4 + H_2O_2 \ ; 2Na_2O_2 + H_2SO_4 \xrightarrow{warm} 2Na_2SO_4 + 2H_2O + O_2$$

- Reaction with CO and CO_2 :

$$Na_2O_2 + CO \longrightarrow Na_2CO_3 \ ; \quad 2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$$

So, it is used to purify the air in submarine and confined spaces as it removes both CO and CO_2 and gives oxygen.

- As an oxidising agent : It is a powerful oxidant and many of its reactions are dangerously violent, particularly with the reducing agents, such as Al powder, charcoal, sulphur and many organic liquids.

(a) Chromic compounds are oxidised to chromates

$$2Cr(OH)_3 + 3Na_2O_2 \longrightarrow 2Na_2CrO_4 + 2NaOH + 2H_2O$$

or

$$2Cr(OH)_3 + 3O_2^{2-} \longrightarrow 2CrO_4^{2-} + 2OH^- + 2H_2O$$

(b) Manganous salt is oxidised to sodium manganate.

$$MnSO_4 + 2Na_2O_2 \longrightarrow Na_2MnO_4 + Na_2SO_4$$

or

$$Mn(OH)_2 + 2O_2^{2-} \longrightarrow MnO_4^{2-} + 2OH^-$$

- $$Na_2O_2 + O_2 \xrightarrow[300 \text{ atm}]{450°} 2NaO_2$$

Use :

- Used for the production of oxygen under the name oxone.
- It is used as bleaching agent for bleaching wood pulp, paper and fabrics such as cotton and linen.

POTASSIUM SUPEROXIDE (KO_2) :

Preparation :

- It is prepared by burning potassium in excess of oxygen free from moisture.

$$K + O_2 \longrightarrow KO_2 \ ;$$

Properties :

- It is a orange coloured (chrome yellow) powder and reacts with water according to following reaction.

$$2KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$$

- It reacts directly with CO and CO_2.

$$2KO_2 + CO \longrightarrow K_2CO_3 + O_2 \ ; \ 2KO_2 + CO_2 \longrightarrow K_2CO_3 + \frac{3}{2}O_2$$

If more CO_2, in presence of moisture is present; then

$$4KO_2 + 4CO_2 + 2H_2O \longrightarrow 4KHCO_3 + 3O_2$$

- On heating with sulphur, it forms potassium sulphate

$$2KO_2 + S \longrightarrow K_2SO_4$$

Use :

It is used as an oxidising agent and air purifier in space capsules, submarine and breathing mask as it produces O_2 and removes CO_2.

CAUSTIC SODA (SODIUM HYDROXIDE): NaOH

Preparation : It is most conveniently manufactured by one of the following processes.

(a) Methods involving sodium carbonate as a starting material :

- **Gossage process (causticising process) :**

$$Na_2CO_3 + Ca(OH)_2 \rightleftharpoons CaCO_3 + 2NaOH$$

The most suitable concentration of sodium carbonate taken in this process is 15 – 20%. The caustic soda produced by this method is not pure and contains some calcium carbonate, sodium carbonate and calcium hydroxide as impurities.

- **Lowig's process :**

$$Na_2CO_3 + Fe_2O_3 \xrightarrow{\text{red heat}} 2NaFeO_2 + CO_2$$

The sodium ferrite is cooled and thrown into hot water, the hydrolysis of sodium ferrite occurs forming NaOH.

$$2NaFeO_2 + H_2O \longrightarrow 2NaOH + Fe_2O_3$$

- **Methods involving sodium chloride as starting material :**

Electrolysis of sodium chloride solution occurs according to following principle.

$$NaCl \rightleftharpoons Na^+ + Cl^- \ ; \qquad H_2O \rightleftharpoons H^+ + OH^-$$

On passing electricity, Na^+ and H^+ ions move towards cathode and Cl^- and OH^- ions move towards anode. The discharge potential of H^+ ions is less than Na^+ ions, thus hydrogen ions get discharged easily and hydrogen is liberated. Similarly, at anode Cl^- ions are easily discharged as their discharge potential is less than that of OH^- ions. Cl_2 gas is, therefore, liberated at anode.

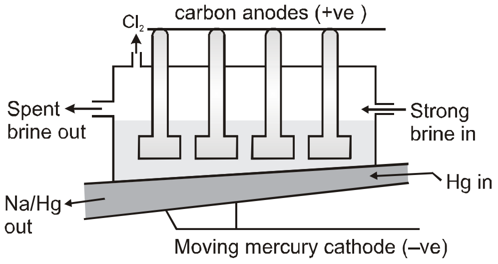
It is necessary that chlorine should not come in contact with sodium hydroxide during electrolysis, otherwise following reaction take place.

$$2NaOH + Cl_2 \longrightarrow NaCl + NaClO + H_2O$$

To overcome this problem, the anode is separated from the cathode in the electrolytic cell either by using a porous diaphragm or by using a mercury cathode.

(a) The mercury cathode cell (Castner-Kellner cell) :

In this cell mercury flows along the bottom of the cell and is made cathode (as shown in figure (a)). The brine solution flows in the same direction and anode consists of a number of graphite blocks. The brine electrolyzes and since, hydrogen has a high overvoltage at mercury cathode, sodium is preferentially discharged forming amalgam with mercury.



At the **anode** (+)
$2Cl^- \rightarrow Cl_2 + 2e^-$

At the **cathode** (–)
$Na^+ + e^- \rightarrow Na$
$Na + Hg \rightarrow NaHg$

The Castner-Kellner Cell

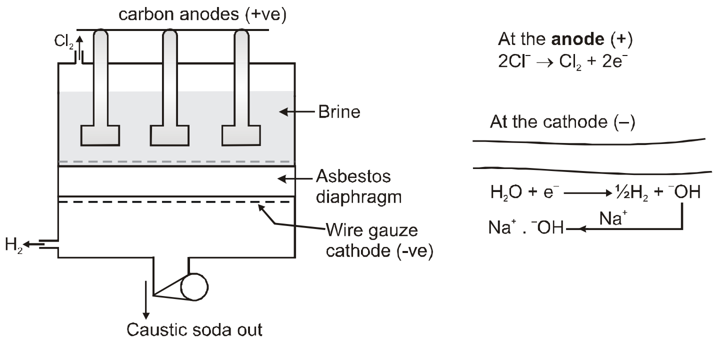
The sodium amalgam flows out and is reacted with water to give NaOH

$$2NaHg + 2H_2O \rightarrow 2NaOH + 2Hg + H_2$$

The mercury is re-circulated to the cell. Hydrogen and chlorine are the two important by-products.

(b) Diaphragm cell :

In this type of cell (as shown in figure (b)) alkali and chlorine are kept separate by use of a diaphragm and on contact with a negative wire gauze, electrolysis begins. Chlorine is liberated at graphite anode and sodium hydroxide is formed at the outside edges of cathode.



A Diaphragm cell

Preparation of pure sodium hydroxide :

Commercial sodium hydroxide is purified with the help of alcohol. Sodium hydroxide dissolves in alcohol while impurities like NaCl, Na_2CO_3, Na_2SO_4 etc., remain insoluble. The alcoholic filtrate is distilled. The alcohol distills off while pure solid sodium hydroxide is left behind.

Properties :

(i) It is a white crystalline solid and has soapy touch.

(ii) It's density is 2.13 g/mL and melting point is 318.4°C.

(iii) It is highly soluble in water and is bitter in taste, and is corrosive in nature.

(iv) Neutralisation and hydrolysis reactions :

$3NaOH + H_3PO_4 \longrightarrow Na_3PO_4 + 3H_2O$; $NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$

These are non-redox type of reactions.

(v) Reaction with acidic oxides :

$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

$2NaOH + 2NO_2 \longrightarrow NaNO_2 + NaNO_3 + H_2O$; $2NaOH + SO_3 \longrightarrow Na_2SO_4 + H_2O$

(vi) Reaction with amphoteric oxides :

$PbO + 2NaOH \longrightarrow Na_2PbO_2 + H_2O$; $ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$

$SnO + 2NaOH \longrightarrow Na_2SnO_2 + H_2O$; $SnO_2 + 2NaOH \longrightarrow Na_2SnO_3 + H_2O$

(vii) Reaction with non-metals :

(a) Halogens

➢ With cold & dilute NaOH :

$2NaOH + Br_2 \longrightarrow NaBr + NaOBr + H_2O$

➢ With hot & concentrated NaOH :

$6NaOH + 3Br_2 \longrightarrow 5NaBr + NaBrO_3 + 3H_2O$

(b) With sulphur : $6NaOH + 4S \longrightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$

(c) With silicon : $2NaOH + Si + H_2O \longrightarrow Na_2SiO_3 + 2H_2$

Reaction with metals and salts :

(a) Reaction with amphoteric metals (e.g. Al, Pb, Sn, Zn etc.) :
They liberate hydrogen gas.

$4NaOH + 2H_2O + 2Al \longrightarrow 2NaAlO_2 + 3H_2$

$6NaOH + 2Al \longrightarrow 2Na_3AlO_3 + 3H_2$; $Zn + NaOH \longrightarrow Na_2ZnO_2 + H_2$

(b) Reaction with salts of amphoteric metals :
Salts dissolves in sodium hydroxide (excess)

$SnCl_2 + 2NaOH \longrightarrow Sn(OH)_2 \downarrow (\text{white}) + 2NaCl$

$Sn(OH)_2 + 2NaOH \longrightarrow Na_2SnO_2 + 2H_2O$

(c) Reaction with salts of Cr, Ni, Fe, Mn, Cu etc., :
Form insoluble hydroxides

$CrCl_3 + 3NaOH \longrightarrow Cr(OH)_3 \downarrow (\text{green}) + 3NaCl$

$CuCl_2 + 2NaOH \longrightarrow Cu(OH)_2 \downarrow (\text{blue}) + 2NaCl$

(ix) Reaction with carbon monoxide :

$$NaOH + CO \xrightarrow[5-10\text{ atm}]{150-200^\circ C} HCOONa$$

Caustic property

Sodium hydroxide is a powerful cautery and breaks down the proteins of skin to a pasty mass. On account of this property, it is commonly called caustic soda.

● SODIUM CARBONATE OR WASHING SODA ($Na_2CO_3.10H_2O$) :

Preparation :

➢ By Solvay ammonia soda process :

It involves followings steps.

(a) Saturation of brine with ammonia and CO_2 (In ammonia absorber) :

$$2NH_3 + CO_2 + H_2O \longrightarrow (NH_4)_2CO_3$$

$$CaCl_2 + (NH_4)_2CO_3 \longrightarrow CaCO_3\downarrow + 2NH_4Cl\ ;\ MgCl_2 + (NH_4)_2CO_3 \longrightarrow MgCO_3\downarrow + 2NH_4Cl$$

Ammoniated brine is filtered to remove calcium and magnesium impurities as their insoluble carbonates.

(b) Formation of insoluble $NaHCO_3$ (In carbonation tower) :

$$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3\ ;\qquad NH_4HCO_3 + NaCl \xrightarrow{30^\circ C} NaHCO_3 + NH_4Cl$$

Reaction is exothermic and hence there is a cooling arrangement.

$NaHCO_3$ is insoluble in cold brine solution because of the common ion effect. It is separated by filtration and the filtered is used for recovering NH_3 & CO_2

(c) Calcination to get sodium carbonate :

$$2\,NaHCO_3 \xrightarrow{150^\circ C} Na_2CO_3 + CO_2 + H_2O$$

(d) Recovery of ammonia and carbondioxide (In recovery tower) :

$$NH_4HCO_3 \xrightarrow[\text{(steam)}]{\Delta} NH_3 + CO_2 + H_2O\ ;\qquad 2NH_4Cl + Ca(OH)_2 \xrightarrow[\text{(steam)}]{\Delta} 2NH_3 + 2H_2O + CaCl_2$$

$CaCl_2$ is obtained as by product.

(e) Preparation of CO_2 (In lime kiln) :

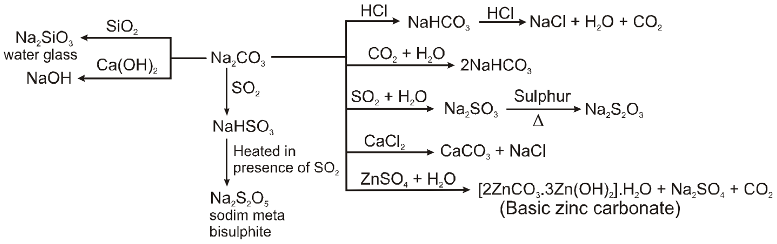
$$CaCO_3 \xrightarrow{1375\text{ K}} CaO + CO_2\ ;\qquad CaO + H_2O \longrightarrow Ca(OH)_2 \text{ (slaked lime)}$$

Properties :

➢ It is white crystalline solid. It is known in several hydrated forms. The common form is decahydrate, $Na_2CO_3.10H_2O$. This form is called **washing soda.** The decahydrate form on standing in air effloresces and crumbles to powder. It is the monohydrate, $Na_2CO_3.H_2O$.

➢ It is soluble in water with evolution of considerable amount of heat. The solution is alkaline in nature due to hydrolysis.

$$Na_2CO_3 + 2H_2O \rightleftharpoons 2NaOH + H_2CO_3$$



$$Na_2CO_3 + NO + NO_2 \longrightarrow 2NaNO_2 + CO_2$$

Bicarbonates precipitate normal carbonates while carbonates precipitate basic carbonates from some metal salt solutions.

$$MgCl_2 + NaHCO_3 \longrightarrow MgCO_3\downarrow + 2NaCl + CO_2 + H_2O$$

$$MgCl_2 + 2Na_2CO_3 + H_2O \longrightarrow MgCO_3\,.\,Mg(OH)_2\downarrow + 4NaCl + CO_2$$

$$NaNO_3 + HCl \longrightarrow KNO_3 + NaCl$$

● SODIUM BICARBONATE OR BAKING SODA ($NaHCO_3$) :

It is obtained as the intermediate product in the Solvay ammonia soda process. Normal carbonate can be changed to bicarbonate by passing carbon dioxide through its saturated solution.

$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3 \text{ (sparingly soluble)}$$

Properties :

It is a white crystalline solid, sparingly soluble in water. The solution is alkaline in nature due to hydrolysis. The solution is weakly basic and gives yellow colour with methyl orange but no colour with phenolphthalein.

$$NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3$$

On heating, it loses carbon dioxide and water forming sodium carbonate.

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

Use :

It is largely used for making baking powder. Baking powder contains $NaHCO_3$, $Ca(H_2PO_4)_2$ and starch. The $Ca(H_2PO_4)$ is acidic and when water is added, it reacts with $NaHCO_3$, giving CO_2. The starch is a filler. Improved baking powder contains about 40% starch, 30% $NaHCO_3$, 20% $NaAl(SO_4)_2$ and 10% $Ca(H_2PO_4)_2$. The $NaAl(SO_4)_2$ slows the reaction down so the CO_2 is given off more slowly.

- **SODIUM SULPHATE ($Na_2SO_4.10H_2O$) :**

It is also known as **Glauber's salt**.

Preparation :

- By heating NaCl with concentrated. H_2SO_4:

$$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$$

- By Hargreaves process :

$$4NaCl \text{ (dry lumps)} + 2SO_2 \text{ (g)} + 2H_2O \text{ (g)} + O_2 \text{ (g)} \longrightarrow 2Na_2SO_4 + 4HCl$$

Properties :

- It is a white crystalline solid and effloresces readily in dry air to form anhydrous sodium sulphate.
- It is reduced to sodium sulphide when heated with carbon.

$$Na_2SO_4 + 4C \longrightarrow Na_2S + 4\,CO\uparrow$$

- It forms sodium bisulphate when reacted with concentrated H_2SO_4.

$$Na_2SO_4 + H_2SO_4 \longrightarrow 2NaHSO_4$$

- Reaction with metal salts.

$$BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4\downarrow + 2NaCl\ ;\ \ Pb(NO_3) + Na_2SO_4 \longrightarrow PbSO_4\downarrow + 2NaNO_3$$

Properties :

It is a white crystalline solid and soluble in water . It is used as a fertilizer for tobacco and wheat.

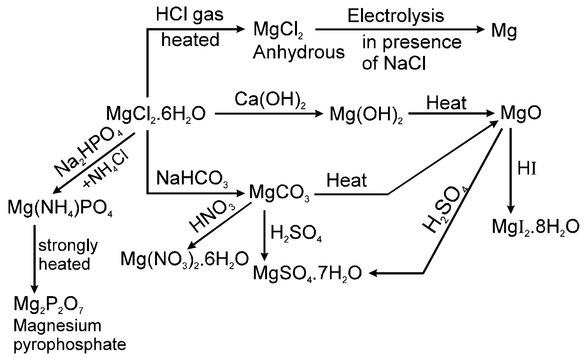
COMPOUNDS OF ALKALINE EARTH METALS :

- **MAGNESIUM CHLORIDE ($MgCl_2.6H_2O$)**

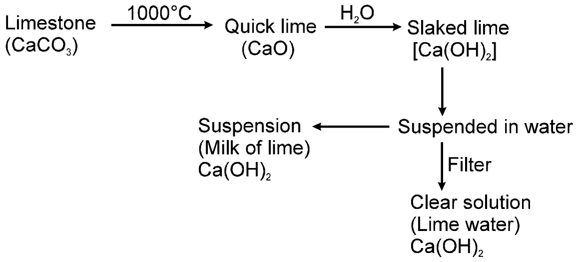
It occurs in nature as mineral carnallite, KCl, $MgCl_2.6H_2O$.

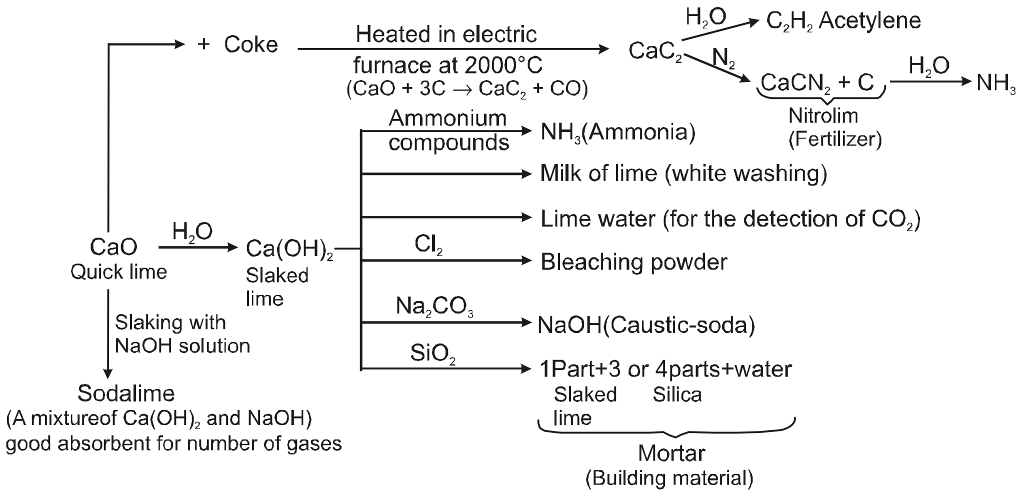
Properties :

It is a colourless crystalline solid, highly deliquescent and highly soluble in water.



- **QUICK LIME, SLAKED LIME AND LIME WATER.**





$$3Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2.\ Ca(OH)_2.\ CaCl_2.\ 2H_2O \text{ (bleaching powder).}$$

● MAGNESIUM CARBONATE ($MgCO_3$)

Properties :

➢ It dissolves readily in water containing excess of carbon dioxide.

$$MgCO_3 + CO_2 + H_2O \longrightarrow Mg(HCO_3)_2$$

➢ It dissolves in acids forming salts with evolution of CO_2.

$$MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$$

On heating, it decomposes with evolution of CO_2.

$$MgCO_3 \longrightarrow MgO + CO_2$$

● CALCIUM CARBONATE ($CaCO_3$)

Properties :

it is a white powder, insoluble in water. It dissolves in presence of CO_2 due to formation of calcium bicarbonate.

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

Uses :

➢ Precipitated chalk is used in tooth pastes and face powders, in medicine for indigestion, in adhesives and in cosmetics.

➢ Chalk is used in paints and distempers.

● CALCIUM SULPHATE ($CaSO_4$)

It is found in nature as anhydride ($CaSO_4$) and gypsum ($CaSO_4.2H_2O$)
It can be prepared by reacting any calcium salt with either sulphuric acid or a soluble sulphate.

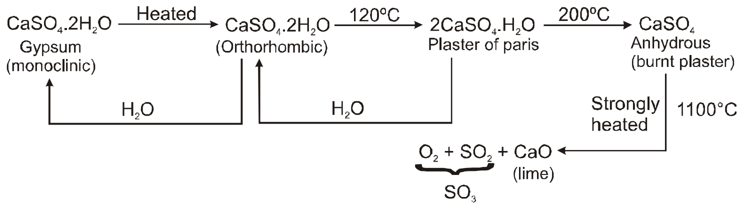
$$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HCl\ ; \qquad CaCl_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2NaCl$$

Properties :

➢ It is a white crystalline solid. It is sparingly soluble in water and solubility decreases as temperature increases.

➢ It dissolves in dilute acids. It also dissolves in ammonium sulphate due to the formation of double sulphate, $(NH_4)_2SO_4.CaSO_4.H_2O$.

➢ Gypsum when heated first changed from monoclinic form to orthorhombic form without loss of water. At 120°C, it loses three-fourth of its water of crystallisation and forms hemihydrate, ($2CaSO_4.H_2O$) which is commonly known as **Plaster of Paris**. At 200°C, it becomes anhydrous. The anhydrous form is known as **burnt plaster or dead plaster.**



- **Dead plaster** has no setting property as it takes up water only very slowly.
- A suspension of gypsum when saturated with ammonia and carbon dioxide forms ammonium sulphate, a nitrogenous fertilizer.

$$2NH_3 + CaSO_4 + CO_2 + H_2O \longrightarrow (NH_4)_2SO_4 + CaCO_3$$

- When strongly heated with carbon, it forms calcium sulphide.

$$CaSO_4 + 4C \longrightarrow CaS + 4CO$$

Use :

- For preparing blackboard chalk.
- In anhydrous form as drying agent.

PLASTER OF PARIS ($2CaSO_4.H_2O$)

(Calcium sulphate hemihydrate)

Preparation :

It is obtained when gypsum, calcium sulphate dihydrate ($CaSO_4.2H_2O$), is heated at 120°C (393 K).

$$\underset{\text{Gypsum}}{2[CaSO_4.2H_2O]} \longrightarrow \underset{\text{Plaster of Paris}}{2CaSO_4.H_2O} \text{ (calcium sulphate hemihydrate)} + 3H_2O$$

Properties :

- Plaster of Paris is a white powder.
- It has the property of setting to a hard mass when a paste with water is allowed to stand aside for sometime. Slight expansion occurs during the setting as water is absorbed to reform $CaSO_4.2H_2O$ (gypsum). The setting process is **exothermic**. The process of setting takes place in stages. In the first stage, there is conversion of Plaster of Pairs into orthorhombic form of gypsum (setting step) and in the second stage orthorhombic form changes into monoclinic form (hardening step).

$$\underset{\text{Plaster of Paris}}{2CaSO_4.H_2O} \xrightarrow[H_2O]{\text{Setting}} \underset{\text{Orthorhombic}}{CaSO_4.2H_2O} \xrightarrow{\text{Hardening}} \underset{\text{Monoclinic}}{CaSO_4.2H_2O}$$

The setting of Plaster of Paris may be **catalysed by sodium chloride** while it is retarded by borax or alum. Addition of alum to Plaster of Paris makes the setting very hard. The mixture is known as **Keene's cement**.

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

*** Marked Questions are having more than one correct option.**

Section (A) : Physical Properties of Alkali & Alkaline earth metals

A-1. Which is not s–block element ?
(A) $[Ar]4s^2 3d^{10} 4p^6 5s^1$ (B) $1s^2 2s^2 2p^1$ (C) $[He]\ 2s^2 2p^6 3s^1$ (D) None of these

A-2. Alkali metals are not characterised by :
(A) good conductor of heat and electricity (B) high oxidation potentials
(C) high melting points (D) solubility in liquid ammonia

A-3. Which of the following increases in magnitude as the atomic number of alkali metals increases?
(A) Electronegativity (B) First ionisation potential
(C) Ionic radius (D) Melting point

A-4. Sodium has, as compared to potassium :
(A) less electronegativity (B) more ionisation potential
(C) larger atomic radius (D) lower melting point

A-5. The metallic lustre exhibited by sodium is explained by :
(A) diffusion of sodium ions (B) oscillation of mobile valence electrons
(C) existence of free protons (D) existence of body centered cubic lattice

A-6. In view of their ionisation energies, the alkali metals are :
(A) weak oxidising agents (B) strong reducing agents
(C) strong oxidising agents (D) weak reducing agents

A-7. Which of the following has lowest melting point?
(A) Li (B) Na (C) K (D) Cs

A-8. A solution of sodium in liquid ammonia is strongly reducing and highly conducting due to the presence of
(A) sodium atoms (B) sodium hydride (C) sodium amide (D) solvated electrons

A-9. Sodium metal can be stored under :
(A) benzene (B) kerosene (C) alcohol (D) water

A-10. In certain matters, lithium differs from other alkali metals, the main reason for this is :
(A) small size of lithium atom and Li^+ ion (B) extremely high electropositivity of Li
(C) greater hardness of Li (D) hydration of Li^+ ion

A-11. The most electropositive amongst the alkaline earth metals is :
(A) Be (B) Mg (C) Ca (D) Ba

A-12. A fire work gave bright crimson light. It probably contained a salt of :
(A) Ca (B) Sr (C) Ba (D) Mg

A-13. Alkaline earth metal salts are :
(A) paramagnetic (B) diamagnetic (C) ferromagnetic (D) all

A-14. The first ionisation energies of alkaline earth metal are higher than those of the alkali metals. This is because:
(A) there is increase in the nuclear charge of the alkaline earth metal
(B) there is decrease in the nuclear charge of the alkaline earth metal
(C) there is no change in the nuclear charge
(D) none of these

A-15. The first ionisation potential (eV) of Be and B respectively are :
(A) 8.29, 9.32 (B) 9.32, 9.32 (C) 8.29, 8.29 (D) 9.32, 8.29

A-16.* The set representing the correct order of first ionisation potential is :
(A) K < Na < Li (B) Be > Mg > Ca (C) B > C > N (D) Ge > Si > C

A-17. Which of the following has maximum ionisation energy ?
(A) $Ba \longrightarrow Ba^+ + e^-$ (B) $Be \longrightarrow Be^+ + e^-$
(C) $Ca \longrightarrow Ca^{2+} + 2e^-$ (D) $Mg \longrightarrow Mg^{2+} + 2e^-$

A-18. Among the alkaline earth metals, the element forming predominantly covalent compound is :
(A) Ba (B) Sr (C) Ca (D) Be

Section (B) : Chemical Properties of Alkali & Alkaline earth metals

B-1. Na and Li are placed in dry air. We get :
(A) NaOH, Na_2O, Li_2O (B) Na_2O, Li_2O
(C) Na_2O, Li_2O, Li_3N, NH_3 (D) Na_2O, Li_3N, Li_2O

B-2. Which one of the following electrolyte is used in Down's process of extracting sodium metal ?
(A) NaCl + $CaCl_2$ + KF (B) NaCl (C) NaOH + KCl + KF (D) NaCl + NaOH

B-3. A metal M readily forms water soluble sulphate MSO_4, water insoluble hydroxide $M(OH)_2$ and oxide MO. The oxide and hydroxide are soluble in NaOH. The M is :
(A) Be (B) Mg (C) Ca (D) Sr

B-4. A piece of magnesium ribbon was heated to redness in an atmosphere of nitrogen and on cooling, water was added, the gas evolved was :
(A) ammonia (B) hydrogen (C) nitrogen (D) oxygen

B-5.* The hydration energy of Mg^{2+} ion is higher than that of :
(A) Al^{3+} (B) Ca^{2+} (C) Na^+ (D) None of these

B-6. When magnesium burns in air, compounds of magnesium formed are magnesium oxide and :
(A) Mg_3N_2 (B) $MgCO_3$ (C) $Mg(NO_3)_2$ (D) $Mg(NO_2)_2$

Section (C) : Compounds of Alkali metals

C-1. The substance X belonging to IA group gives a pale violet colour in flame test, X is :
(A) NaCl (B) LiCl (C) KCl (D) None of these

C-2. Which of the following has the highest melting point?
(A) NaCl (B) NaF (C) NaBr (D) NaI

C-3. Which salt on heating does not give brown coloured gas ?
(A) $LiNO_3$ (B) KNO_3 (C) $Pb(NO_3)_2$ (D) $AgNO_3$

C-4. Which of the following can not decompose on heating to give CO_2?
(A) Li_2CO_3 (B) Na_2CO_3 (C) $KHCO_3$ (D) $BaCO_3$

C-5. Which does not exist in solid state.
(A) $NaHCO_3$ (B) $NaHSO_3$ (C) $LiHCO_3$ (D) $CaCO_3$

C-6. Sodium burns in dry air to give :
(A) Na_2O (B) Na_2O_2 (C) NaO_2 (D) Na_3N

C-7. Which of the following has lowest thermal stability ?
(A) Li_2CO_3 (B) Na_2CO_3 (C) K_2CO_3 (D) Rb_2CO_3

C-8. Sodium carbonate can be manufactured by Solvay's process but potassium carbonate cannot be prepared because:
(A) K_2CO_3 is more soluble (B) K_2CO_3 is less soluble
(C) $KHCO_3$ is more soluble than $NaHCO_3$ (D) $KHCO_3$ is less soluble than $NaHCO_3$

C-9. When SO_2 gas in excess is passed into an aqueous solution of Na_2CO_3, product formed is :
(A) $NaHSO_4$ (B) Na_2SO_4 (C) $NaHSO_3$ (D) All

C-10. The principal products obtained on heating iodine with concentrated caustic soda solution is :
(A) NaIO + NaI (B) NaIO + $NaIO_3$ (C) $NaIO_3$ + NaI (D) $NaIO_4$ + NaI

C-11. Washing soda has the formula :
(A) Na_2CO_3 (B) $Na_2CO_3.H_2O$ (C) $Na_2CO_3.7H_2O$ (D) $Na_2CO_3.10H_2O$

C-12. Sodium carbonate on heating gives :
(A) CO_2 (B) water vapours
(C) carbon dioxide + water vapour (D) none of these

C-13. Sodium carbonate is prepared by:
(A) Solvay's process (B) Kolbe's process (C) Contact process (D) Nessler's process

C-14. Molecular formula of Glauber's salt is :
(A) $MgSO_4.\ 7H_2O$ (B) $CuSO_4.\ 5H_2O$ (C) $Na_2SO_4.\ 10H_2O$ (D) $FeSO_4.\ 7H_2O$

C-15. The compound that gives hydrogen peroxide on treatment with a dilute cold acid is :
(A) PbO_2 (B) Na_2O_2 (C) MnO_2 (D) SnO_2

Section (D) : Compounds of Alkaline earth metals

D-1. The right order of the solubility of sulphates of alkaline earth metals is :
(A) Be > Ca > Mg > Ba > Sr (B) Mg > Be > Ba > Ca > Sr
(C) Be > Mg > Ca > Sr > Ba (D) Mg > Ca > Ba > Be > Sr

D-2. Compounds of alkaline earth metals are less soluble in water than the corresponding alkali metal salts due to:
(A) their high ionisation energy (B) their low electronegativity
(C) their low hydration energy (D) their high lattice energy

D-3. BeF_2 is soluble in water, whereas, the fluorides of other alkaline earth metals are insoluble because of :
(A) ionic nature of BeF_2
(B) greater hydration energy of Be^{2+} ion as compared to lattice energy
(C) covalent nature of BeF_2
(D) none of these

D-4. Among LiCl, RbCl, $BeCl_2$, $MgCl_2$ the compounds with greatest and least ionic character respectively are :
(A) LiCl, RbCl (B) RbCl, $BeCl_2$ (C) RbCl, $MgCl_2$ (D) $MgCl_2$, $BeCl_2$

D-5.* Peroxide ion is present in :
(A) K_2O_2 (B) CaO (C) Li_2O (D) BaO_2

D-6. Sodium sulphate is soluble in water whereas barium sulphate is sparingly soluble because :
(A) the hydration energy of sodium sulphate is more than its lattice energy
(B) the lattice energy of barium sulphate is less than its hydration energy
(C) the lattice energy has no role to play in solubility
(D) the hydration energy of sodium sulphate is less than its lattice energy

D-7. Which of the following is the strongest base ?
(A) $Ca(OH)_2$ (B) $Sr(OH)_2$ (C) $Ba(OH)_2$ (D) $Mg(OH)_2$

D-8. Which of the following salts on heating gives a mixture of two gases ?
(A) $Ba(NO_3)_2$ (B) $NaNO_3$ (C) KNO_3 (D) $RbNO_3$

D-9. Amongst the following hydroxides, the one which has the lowest value of K_{sp} at ordinary temperature is :
(A) $Mg(OH)_2$ (B) $Ca(OH)_2$ (C) $Ba(OH)_2$ (D) $Be(OH)_2$

D-10.* Which of the following metal carbonate is/are thermally stable ?
(A) Na_2CO_3 (B) $MgCO_3$ (C) K_2CO_3 (D) Rb_2CO_3

D-11. Plaster of Paris is :
(A) $CaSO_4$ (B) $CaSO_4.\ H_2O$ (C) $2CaSO_4.H_2O$ (D) $CaSO_4.2H_2O$

D-12. Plaster of Paris hardens by :
(A) giving off CO_2 (B) utilising water
(C) changing into $CaCO_3$ (D) giving out water

D-13. A compound X on heating gives a colourless gas. The residue is dissolved in water to obtained Y. Excess CO_2 is bubbled through aqueous solution of Y, Z is formed. Z on gently heating gives back X. The compound X is:
(A) $CaCO_3$ (B) Na_2CO_3 (C) $Ca(HCO_3)_2$ (D) K_2CO_3

D-14. Identify the correct statement.
(A) Gypsum contains a lower percentage of calcium than Plaster of Paris
(B) Gypsum is obtained by heating Plaster of Paris
(C) Plaster of Paris is obtained by hydration of gypsum
(D) Plaster of Paris is obtained by partial oxidation of gypsum

D-15. Of the following the commonly used in the laboratory desiccator is :
(A) K_2CO_3 (B) $CaCl_2$ (C) NaCl (D) $CaCO_3$

D-16. Which of the following statement is not correct ?
(A) KOH is a stronger alkali than NaOH.
(B) Milk of magnesia is aqueous suspension of $Mg(OH)_2$.
(C) MgO is a refractory material used for lining electrical furnaces.
(D) $MgCl_2.6H_2O$ on heating yields $Mg(OH)_2$.

D-17. What are the products formed when an aqueous solution of magnesium bicarbonate is boiled ?
(A) $MgCO_3$, H_2O, CO_2 (B) $Mg(HCO_3)_2$, H_2O (C) $Mg(OH)_2$, H_2O (D) Mg, CO_2, H_2O

D-18. When hydrated $MgCl_2.\ 6H_2O$ is strongly heated :
(A) MgO is formed. (B) $Mg(OH)_2$ is formed.
(C) Mg(OH)Cl is formed. (D) anhydrous $MgCl_2$ is formed.

D-19. The mixture of $MgCl_2$ and MgO is called :
(A) sorrel cement (B) mixed salt (C) portland cement (D) magnesium oxychloride

PART - II : MISCELLANEOUS QUESTIONS

Comprehension

Comprehension # 1

Alkali metals oxide are obtained by combustion of the metals. Although Na normally gives Na_2O_2, it will take up further oxygen at elevated pressure and temperatures to form NaO_2. The per and superoxides of the heavier alkalies can also be prepared by passing stoichiometric amounts of oxygen into their solution in liquid ammonia.

The different alkali metal oxides can be distinguished by reaction with water. The superoxides reacts with CO_2 and give oxygen gas. The stability of per and superoxides is based upon that larger cation can stablise larger anion, due to larger lattice energy.

Alkali metals dissolve in liquid ammonia. Dilute solutions are dark blue in colour but as the concentration increases above 3M, the colour changes to copper bronze and the solution acquires the metallic lusture due to the formation of metal ions clusters. The solution of alkali metals in liquid ammonia are good conductors of electricity due to the presence of ammoniated cations and ammoniated electrons. However, the conductivity decreases as the concentrations increases, since ammoniated electrons and ammoniated cation associate.

1. Solution of sodium metals in liquid ammonia is strongly reducing due to the presence of :
(A) Sodium hydride (B) Sodium atoms (C) Sodium amide (D) Solvated electrons.

2. KO_2 is used in oxygen cylinders in space and submarines because it.
(A) Eliminates moisture (B) Absorbs CO_2 only
(C) Absorbs CO_2 and increases O_2 contents (D) Produces ozone.

3. Select the correct choice for alkali metal oxides.
(A) Metal oxides reacts with water forming only metal hydroxides
(B) Metal peroxides reacts with water forming metal hydroxides and oxygen gas
(C) Metal superoxides reacts with water forming metal hydroxide, Hydrogen peroxide and O_2 gas
(D) All of these

Comprehension # 2

$$Na_2CO_3(aq) \xrightarrow{SO_2} (P) \xrightarrow{Na_2CO_3} (Q) \xrightarrow[\Delta]{\text{Elemental S}} (R) \xrightarrow{I_2} (S)$$

4. Select the correct statement for compound (R).
(A) Compound (R) is used as antichlor.
(B) Compound (Q) and sodium sulphide give compound (R) with iodine gas.
(C) Compound (R) is used in photography.
(D) All of these

5. Which of the following statement is false for compound (Q) ?
(A) With dil . H_2SO_4 it produces a colourless irritating gas which turns acidified $K_2Cr_2O_7$ green.
(B) It produces a white precipitate with barium nitrate solution which is insoluble in dilute HCl.
(C) It does not decolourises the acidified $KMnO_4$ solution
(D) (B) and (C) both

6. Oxidation state of S in all the compounds P to S (if sulphur atoms more than one then consider the average oxidation state) are respectively.
(A) $+4, +4, +6, +\frac{5}{2}$ (B) $+4, +4, +2, +\frac{5}{2}$ (C) $+4, +4, -2, +\frac{5}{2}$ (D) None of these.

MATCH THE COLUMN

7.

Column (A)		**Column (B)**	
(a)	Castner's process	(i)	KCl
(b)	Solvay's process	(ii)	Potassium carbonate
(c)	Nelson's cell	(iii)	Sodium chloride
(d)	Oxone	(iv)	Mixture (NaOH + CaO)
(e)	Pearl's ash	(v)	Sodium
(f)	Rock salt	(vi)	Sodium peroxide
(g)	Sodalime	(vii)	Sodium hydroxide
(h)	Sylvine	(viii)	Sodium carbonate

8.

Column (A)		**Column (B)**	
(a)	Gypsum	(i)	CaH_2
(b)	Hydrolith	(ii)	CaO
(c)	Marble	(iii)	$Ca_3(PO_4)_2$
(d)	Bone ash	(iv)	$CaSO_4 . 2H_2O$
(e)	Slaked lime	(v)	$CaCO_3$
(f)	Quick lime	(vi)	$Ca(OH)_2$

9.

	Column (A)	**Column (B)**
(a)	$Ca(OH)_2 + Cl_2 \xrightarrow[35°C]{\text{below}}$ (slaked lime)	(i) Calcium chloride
(b)	$Ca(OH)_2 + Cl_2 \xrightarrow{\text{cold}}$ (milk of lime)	(ii) Calcium chloride and cal. chlorate
(c)	$2Ca(OH)_2 + 2Cl_2 \xrightarrow{\text{heat}}$	(iii) Bleaching powder
(d)	$2Ca(OH)_2 + 2Cl_2 \xrightarrow{\text{red heat}}$ (Slaked lime)	(iv) Calcium chloride and calcium hypochlorite
		(v) Calcium chloride & calcium chlorite

10.

Column I	**Column II**
(A) $Na_2SO_4 + C + CaCO_3 \xrightarrow{\Delta}$	(P) One of the products has sp^2 hybridisation of central atom.
(B) $NaCl + NH_4.HCO_3 \longrightarrow$	(Q) One of the products has sp^3 hybridisation of central atom:
(C) $Na_2CO_3 + Ca\,(OH)_2 \longrightarrow$	(R) One of the products is insoluble as precipitate.
(D) KOH + NO (2 : 4 by mole ratio)	(S) One of the products is a neutral oxide.

11. **Match the following :**

	Column (A)	**Column (B)**
	Reaction.	Product’s character.
(A)	$2\,Na_2O \xrightarrow{400^\circ C}$	(P) Diamagnetic.
(B)	$KOH + O_3 \longrightarrow$	(Q) Paramagnetic.
(C)	$Na + O_2$ (excess) $\xrightarrow{350^\circ C}$	(R) Bond order 1
(D)	K (dissolved in liquid NH_3) $\xrightarrow{3O_2}$	(S) Bond order 1.5

ASSERTION / REASONING

DIRECTIONS :

The following questions consist of two statements one labelled ASSERTION (A) and the another labelled REASON (R). Select the correct answers to these questions from the codes given below :

(A) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(B) Both Assertion and Reason are true but Reason is not correct explanation of Assertion
(C) Assertion is true but Reason is false
(D) Assertion is false but Reason is true

12. **Assertion :** Lithium is the weakest reducing agent among the alkali metals.
Reason : In alkali metals, ionization energy decreases down the group.

13. **Assertion :** Aqueous solution of Na_2CO_3 is alkaline in nature.
Reason : When dissolved in water, Na_2CO_3 undergoes anionic hydrolysis.

14. **Assertion :** Cesium is used in photoelectric cells.
Reason : Cesium is most electropositive element.

15. **Assertion :** Superoxides of alkali metals are paramagentic.

Reason : Superoxides contain the ion O_2^- which has one unpaired electron.

16. **Assertion :** Beryllium does not impart any characteristic colour to the bunsen flame.
Reason : Due to its very high ionization energy, beryllium requires a large amount of energy for excitation of the electrons.

17. **Assertion :** Best diagonal relationship is shown between Be and Al.
Reason : Ionization energy of Be is almost the same as that of Al.

18. **Assertion :** $BeCl_2$ fumes in moist air.
Reason : $BeCl_2$ reacts with moisture to form HCl gas.

19. **Assertion :** Setting of cement is an endothermic process.
Reason : It involves dehydration of calcium aluminates and calcium silicates.

20. **Assertion :** $BaCO_3$ is more soluble in HNO_3 than in plain water.
Reason : Carbonate is a weak base and reacts with the H^+ from the strong acid causing the barium salt to dissociate.

21. **Assertion :** Na_2SO_4 is soluble in water but $BaSO_4$ is insoluble.
Reason : Lattice energy of barium sulphate exceeds its hydration energy.

22. **Assertion :** Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.
Reason : The ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.

TRUE / FALSE

23. When lithium is burnt in oxygen, it forms superoxide, LiO_2 .

24. Li_2CO_3 decomposes on heating to give CO_2 gas.

25. Carbonates of alkali metals give weakly alkaline solutions due to the hydrolysis of carbonate ion.

26. Lithium fluoride is highly soluble in water.

27. The lattice energies of alkali metal halides decrease as the size of the halide ion increases.

28. Crude common salt is hygroscopic because of impurities of $CaSO_4$ and $MgSO_4$.

29. All group 1 and 2 elements impart characteristic colours to the flame.

30. BeO is amphoteric in nature.

31. Lattice energy of $Ba(OH)_2$ is less than that of $Be(OH)_2$.

32. Solubility of CaI_2 is more than that of $CaCl_2$.

33. BeO and Al_2O_3 are amphoteric.

34. Be and Al are made passive by HNO_3.

35. $LiHCO_3$ does not exist in solid state.

36. Permanent hardness is due to dissolved bicarbonates of Ca^{2+} and Mg^{2+}.

37. A colourless salt (X) on heating gives CO_2 and colourless salt (Y) soluble in water hence (X) is $Ca(HCO_3)_2$ and (Y) is $CaCO_3$.

38. When aqueous KO_2 solution reacts with CO_2 , O_2 is formed, thus KO_2 in used is submarines.

39. K_2O_2 is paramagnetic but KO_2 is diamagnetic.

40. SO_2 turns lime water milky.

41. When CO_2 is passed into lime water , white turbidity appears which dissolves in excess of CO_2.

42. $CaCO_3$ is the main constituent of egg shell.

43. Lattice energy of alkali metal chlorides is in order :
LiCl > NaCl > KCl > RbCl > CsCl

44. Solution of Na in liquid NH_3 is of blue colour due to solvated electron.

45. Solubility of sulphates of alkaline earth metals increases going down the group.

46. When 1 mol of Na_2CO_3 is heated strongly, 1 mol of CO_2 is formed.

FILL IN THE BLANKS

47. The ionic conductance for alkali metal is least for ______________.

48. The alkali metal that can react directly with carbon to form ionic carbide is ___________.

49. The metallic lustre exhibited by sodium is explained by the presence of ____________.

50. When sodium is dissolved in pure liquid ammonia, along with H_2 the other product evolved is ____________.

51. The alkali metals have low density because of their _______________.

52. Solubility of hydroxides of group 2 elements increases from $Be(OH)_2$ to $Ba(OH)_2$ because ____________ energy is greater than __________ energy.

53. Ionization enthalpy of Ra is ______________ than that of Ba.

54. Group 2 elements are _________ than group 1 elements because of their __________density.

55. Mg and Ca form simple oxides whereas Sr and Ba form __________ on burning in air.

56. Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with __________.

57. ....is used to control humidity.

58. Li_3N is decomposed by water forming ....gas.

59. Be dissolves in alkali to give ....

60. Be is not readily attacked by acids due to formation of ....layer.

61. $BeCO_3$ is placed in an atmosphere of ....since it is ....

62. Solubility of sulphates and carbonates of alkaline earth metals ....as the atomic number of the metal increases (down the group).

63. Alkali metal dissolve in liquid ammonia to give ....coloured solutions which upon standing slowly liberate H_2. The ....colour of metal–ammonia solutions is due to the presence of ....electrons.

64. The first element of a group in many ways differs from the other heavier members of the group. These differences arise on account of three factors.
(i)................ (ii) ....and (iii) ....

65. NaOH can't be stored in the vessel made of ....

66. ....of IA and ....of IIA show diagonal relationship.

67. Of the alkali metals only ....forms nitrides.

68. $BeCl_2$ is an .... and has ....structure in solid state.

69. Maximum (IE_2) in second period element is that of ....

70. Alkali metal and alkaline earth metal chlorides can be detected by ....test.

71. KO_2 is .... absorber and ....producer and is thus used in ....

72. Of the alkali metal carbonates, only ....decomposes to give CO_2 and metal oxide.

EXERCISE # 2

PART - I : MIXED OBJECTIVE

Single choice type

1. On dissolving large amount of sodium metal in liquid NH_3 at low temperature, which one of the following does not occur ?
(A) Blue coloured solution is obtained
(B) Na^+ ions are formed in the solution
(C) Liquid NH_3 solution becomes good conductor of electricity
(D) Liquid NH_3 solution remains diamagnetic

2. Equimolar amounts of which of the following will give maximum hydrogen ion concentration?
(A) NaOH (B) KOH (C) LiOH (D) RbOH

3. The deep colour produced when iodine is dissolved in a solution of potassium iodide is caused by the presence of:
(A) I_2 (B) I^- (C) I_3^- (D) I_2^-

4. Match the compounds /metal in (X) with their uses in (Y) :

	X		Y
A.	liquid sodium metal	I	breathing apparatus in submarine
B.	potassium stearate	II	explosive
C.	potassium nitrate	III	coolant in nuclear reaction
D.	potassium superoxide	IV	soft soap

	A	B	C	D		A	B	C	D
(A)	I	III	II	IV	(B)	III	IV	II	I
(C)	II	I	III	IV	(D)	IV	II	III	I

5. $LiAlH_4$ is used as :
(A) an oxidising agent (B) a reducing agent (C) a mordant (D) a water softener

6. Strong reducing agent of alkali metals is :
(A) Li (B) Na (C) K (D) Cs

7. Which reacts directly with nitrogen to form nitride ?
(A) Na (B) Li (C) K (D) Rb

8. Which of the following is different from other three oxides ?
(A) MgO (B) SnO (C) ZnO (D) PbO

9. Following are the ionisation potential values of :
(I_1) 899 kJ mol^{-1}, (I_2) 1757 kJ mol^{-1}, (I_3) 15000 kJ mol^{-1}
(A) Na (B) K (C) Be (D) Ne

10. The alkaline earth metals are :
(A) Na and K (B) Mg and Ca (C) Cu and Ag (D) Al and Fe

11. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame, no distinctive colour is noticed. What one is cation ?
(A) Mg^{2+} (B) Ba^{2+} (C) Pb^{2+} (D) Ca^{2+}

12. Which of the following is incorrect ?
(A) Mg burns in air releasing dazzling light rich in UV rays.
(B) $CaCl_2.6H_2O$ when mixed with ice gives freezing mixture.
(C) Mg cannot form complexes.
(D) Be can form complexes due to its very small size.

13. The set represnting the correct order of first ionisation potential is :
(A) K > Na > Li (B) Be > Mg > Ca (C) B > C > N (D) Ge > Si > C

14. Lithopone is a mixture of
(A) barium sulphate and zinc sulphide (B) barium sulphide and zinc sulphide
(C) calcium sulphate and zinc sulphide (D) calcium sulphide and zinc sulphide

15. The hydration energy of Mg^{2+} ions is higher than that of :
(A) Al^{3+} (B) Be^{2+} (C) Na^{+} (D) None of these

16. The name oxone is given to
(A) ozone (B) sodium peroxide (C) sodium oxide (D) sodamide

17. If NaOH is added to an aqueous solution of Zn^{2+} ions, a white precipitate appears and on adding excess of NaOH, the precipitate dissolves. In the solution, zinc exists in the :
(A) Anionic part (B) Cationic part
(C) both in anionic and cationic part (D) colloidal form

18. Zinc reacts with excess of caustic soda to form :
(A) $Zn(OH)_2$ (B) ZnO (C) Na_2ZnO_2 (D) $Zn(OH)_2.ZnCO_3$

19. Intermediate formed by heating microcosmic salt and which froms coloured bead with coloured cation is :
(A) NH_3 (B) H_3PO_3 (C) $NaPO_3$ (D) H_2O

20. When SO_2 gas is passed into aqueous Na_2CO_3, product formed is :
(A) $NaHSO_4$ (B) Na_2SO_4 (C) $NaHSO_3$ (D) ALL

21. The reaction of sodium thiosulphate with I_2 gives :
(A) sodium sulphide (B) sodium sulphite (C) sodium sulphate (D) sodium tetrathionate

22. Electrolysis of fused NaCl will give :
(A) Na (B) NaOH (C) NaClO (D) $NaClO_3$

23. If CO_2 is passed in excess into lime water, the milkiness first formed disappears due to :
(A) reversal of original reaction (B) formation of volatile calcium bicarbonate
(C) formation of soluble calcium bicarbonate (D) formation of soluble magnesium hydroxide

24. The colour of iodine solution is discharged by shaking it with aqueous solution of :
(A) H_2SO_4 (B) sodium sulphide (C) sodium sulphate (D) sodium thiosulphate

25. $Na_2S_2O_3.5H_2O$ is used in photography to :
(A) reduce AgBr to metallic Ag
(B) remove reduced Ag
(C) remove undecomposed AgBr as a soluble complex
(D) convert metallic Ag to silver salt

26. Calcium is extracted by the electrolysis of :
(A) Fused mixture of $CaCl_2$ and CaF_2 (B) $CaCl_2$ solution
(C) Fused mixture of $CaCl_2$ and NaF (D) $Ca_3(PO_4)_2$ solution

27. At high termperature, nitrogen combines with CaC_2 to give :
(A) calcium cyanide (B) calcium cyanamide (C) Calcium carbonate (D) calcium nitride

28. Identify the corect statement :
(A) Gypsum contains a lower percentage of calcium than Plaster of Paris
(B) Gypsum is obtained by heating Plaster of Paris
(C) Plaster of Paris is obtained by hydration of gypsum
(D) Plaster of Paris is obtained by partial oxidation of gypsum

29. K_2O can be prepared by
(A) burning metallic potassium in air.
(B) passing oxygen in liquid ammonia.
(C) reducing KNO_3 with metallic potassium.
(D) reducing K_2SO_4 with porous graphite.

30. Anhydrone is
(A) $NaClO_3$
(B) $NaClO_4$
(C) $KClO_3$
(D) $Mg(ClO_4)_2$

31. When hydated $MgCl_2 . 6H_2O$ is strongly heated :
(A) MgO is formed
(B) $Mg(OH)_2$ is formed
(C) Mg(OH)Cl is formed
(D) anhydrous $MgCl_2$ is formed

32. Anhydrous $MgCl_2$ may be obtained by heating $MgCl_2 . 6H_2O$
(A) until it fuses
(B) with lime
(C) with coal
(D) in a current of dry HCl

33. Carnallite is :
(A) KCl
(B) $LiAl(SiO_3)_2$
(C) $MgCl_2.6H_2O$
(D) $KCl.MgCl_2.6H_2O$

More than one choice type

34. Alkali metals are characterised by
(A) Good conductor of heat and electricity
(B) High oxidation potentials
(C) High melting points
(D) Solubility in liquid ammonia.

35. Which is/are not correct configuration of s–block elements :
(A) (Ar) $3d^{10}$ $4s^2$
(B) (Ar) $3d^{10}$ $4s^1$
(C) (Ar) $4s^2$
(D) (Ar) $4s^1$

36. Highly pure dilute solution of sodium in liquid ammonia
(A) Shows blue colour
(B) Exhibits electrical conductivity
(C) Produces sodium amide
(D) Products hydrogen gas

37. Nitrate can be converted into metal oxide on heating in case of :
(A) Li
(B) Na
(C) Mg
(D) None of these

38. Select correct statement (s) :
(A) Li_2CO_3 is only sparingly soluble in water and no $LiHCO_3$ has been isolated.
(B) K_2CO_3 cannot be made by a method similar to the ammonia – soda process.
(C) Li_2CO_3 and $MgCO_3$ both are thermally stable.
(D) $Na_2CO_3 . NaHCO_3 . 2H_2O$ is a mineral called trona.

39. Select correct statement (s) :
(A) stability of peroxides and superoxides of alkali metals increases with increase in size of the metal ion
(B) increase in stability in (A) is due to stabilisation of large anions by larger cations through lattice energy effects.
(C) the low solubility of LiF is due to its high lattice energy whereas low solubility of CsI is due to smaller hydration energy .
(D) NaOH does not form hydrated salt.

40. Flame test is not given by
(A) Be
(B) Mg
(C) Ca
(D) Sr

41. Be and Al resemble in :
(A) both become passive on reaction with HNO_3 due to formation of oxide layer
(B) their chlorides are Lewis acids
(C) chlorides exist in polymeric form
(D) hydroxides are soluble in alkali as well as in acid

42. Going down to II A group, following properties decrease :
(A) solubility of sulphates in H_2O (B) hydration energy
(C) thermal stability of carbonates (D) ionic radius in water.

43. Which is/are true statements ?
(A) the heats of hydration of the dipositive alkaline earth metal ions decrease with an increase in their ionic size.
(B) hydration of alkali metal ion is less than that of II A.
(C) alkaline earth metal ions, because of their much larger charge to size ratio, exert a much stronger electrostatic attraction on the oxygen of water molecule surrounding them.
(D) None

44. In water :
(A) temporary hardness is due to the bicarbonates of Ca^{2+} and Mg^{2+}
(B) permanent hardness is due to chlorides and sulphates of Ca^{2+} and Mg^{2+}
(C) hardness can be removed by adding phosphates.
(D) none is correct.

45. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because :
(A) the hydration energy of Na_2SO_4 is more than its lattice energy
(B) the lattice energy of $BaSO_4$ is more than its hydration energy
(C) the lattice energy has no role to play in solubility
(D) the lattice energy of Na_2SO_4 is more than its hydration energy

46. Be and Al have following resemblance due to diagonal relationship :
(A) have nearly equal electronegativity (B) form amphoteric oxides
(C) have same charge/radius ratio (D) both form dimeric halides

47. The pairs of compound which cannot exist together in aqueous solution are
(A) NaH_2PO_4 and Na_2HPO_4 (B) Na_2CO_3 and $NaHCO_3$
(C) NaOH and NaH_2PO_4 (D) $NaHCO_3$ and NaOH.

PART - II : SUBJECTIVE QUESTIONS

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1. Potassium carbonate can not be prepared by solvay process. Why ?

2. Mg_3N_2 when reacted with water gives off NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room tempt.

3. When Mg metal is burnt in air, a white powder is left behind as ash. What is this white powder ?

4. Complete the following reactions :
(a) $KF + BrF_3 \longrightarrow$
(b) $KO_2 + CO_2 + H_2O \longrightarrow$
(c) $KOH + NO \longrightarrow$
(d) $NaOH(s) + O_3 \longrightarrow$

5. Idenfiy the products [X] & [Y]

$NaNO_3 \xrightarrow{500°C} [X] + O_2$; $NaNO_3 \xrightarrow{800°C} [Y] + O_2 + N_2$

6. Idenfiy the products [A] to [D]

$$CH_3COONa + NaNH_2 \xrightarrow{\Delta} [A] \xrightarrow{CO_2} [B] \xrightarrow{HOH} [C] \xrightarrow[-H_2O]{\Delta / P_2O_5} [D]$$

7. Dilute solutions of alkali metals in liquid ammonia are good conductors of electricity. What happens when tempt is increased ?

8. Blocks of magnesium are often strapped to the steel hulls of ocean going ship.

9. In the manufacture of Mg by carbon reduction of MgO, the product is cooled in the stream of an inert gas. Explain

10. $BeCl_2$ in aqueous solution exists as $[Be(H_2O)_4]^{2+}$ rather than Be^{2+} and forms acidic solution. Explain.

11. Answer the following :
(i) What is meant by black ash ?
(ii) What is the action of NaOH on ammonium salts ?
(iii) What is washing soda ?
(iv) What is the intermediate product in Solvay's process ?
(v) Which chloride of an alkali metal is soluble in alcohol ?
(vi) Which substance is added to sodium chloride as to reduce its fusion temperature during manufacture of sodium ?
(vii) What product is formed when carbon monoxide is passed through sodium hydroxide under high pressure?

12. What happens when :
(i) Hot and concentrated caustic soda solution reacts with iodine.
(ii) White phosphorus is heated with caustic soda.
(iii) Excess of caustic soda reacts with zinc sulphate solution
(iv) Excess of NaOH is added to $AlCl_3$ solution
(v) Anhydrous potassium nitrate is heated with excess of metallic potassium
(vi) Sodium is strongly heated in oxygen and the product is treated with H_2SO_4

13. Write the balanced equations of the reactions of caustic soda on the following :
(i) zinc, (ii) silver nitrate, (iii) phosphorus,

14. Give one test each to make distinction between the following pairs :
(i) NH_4Cl KCl (ii) Na_2SO_3 Na_2SO_4 (iii) NaCl KCl

15. Arrange the following as indicated :
(a) LiOH, NaOH, KOH (Increasing solubility in water)
(b) $LiHCO_3$, $NaHCO_3$, $KHCO_3$ (Increasing solubility in water)
(c) Li_2CO_3, Na_2CO_3, K_2CO_3 (Increasing solubility in water)
(d) Li^+, Na^+, K^+, Rb^+, Cs^+ (Increasing size of hydrated ion)

16. What happen when the following are heated ?
(i) Hydrated magnesium chloride,
(ii) Gypsum,
(iii) Bicarbonates of alkaline earth metals,
(iv) Epsom salt,
(v) Barium nitrate.

17. Aqueous solution of sodium oxide can not be stored in zine or aluminium vessel. Why ?

18. On the basis of following reactions. Identify (A), (B), (C), (D) and (E) and write down their chemical formulae:

$$\text{(A) aq.} + Al \xrightarrow{\Delta} \text{(B) gas}$$

$$\text{(A) aq.} + \text{(C)} \xrightarrow{\Delta} PH_3 + \text{(D)}$$

$$\text{(A) aq.} + NH_4Cl \longrightarrow \text{(E) gas}$$

19. Identify (A) to (C)

$$\begin{tikzcd} KO_2 + S \arrow[r, "\Delta"] & {[A]} \arrow[r, "BaCl_2"] & (B) \arrow[d, "Crystallisation"', "Al_2(SO_4)_3 \text{ (equivalent amount)}"] \\ & & {} \end{tikzcd}$$

20. The hydroxides and carbonates of sodium and potassium are easily soluble while the corresponding salts of magnesium and calcium are sparingly soluble in water. Explain.

21. Why do alkali metals form unipositive ions and impart characteristic colours to flame?

22. How would you explain ?
(i) BeO is insoluble but $BeSO_4$ is soluble in water.
(ii) BaO is soluble but $BaSO_4$ is insoluble in water.

23. How is $BeCl_2$ prepared ? What is its structure in solid state and vapour state.

24. Pallets of potassium hydroxide become wet when exposed to air.

25. Which is the strongest reducing agent among alkali metals?

26. Why are alkali metals difficult to be reduced ?.

27. Why are alkali metals (except Li) kept in kerosene?

28. In aqueous solution , Li^+ ions has the least mobility among alkali metals . Why?

29. Alkali metal ions are colourless as well as diamagnetic. Explain.

30. Lithium forms monoxide, sodium gives peroxide while the rest of the alkali metals form superoxide. Explain

31. Does Mg impart charateristic colour to the flame?

32. IE_1 value of Mg is more than that of Na while it's IE_2 value is less. Explain.

33. What happens when
(i) Sodium metal is dropped in water ?
(ii) Sodium metal is heated in free supply of air ?
(iii) Sodium peroxide dissolves in water ?

34. LiF is least soluble among the fluorides of alkali metals. Explain.

35. Alkali metals are soft and can be cut with the help of a knife.

36. What is quick lime, slaked lime and lime water ?

37. The crystalline salts of alkaline earth metals contain more molecules of water of crystallisation than the corresponding salts of alkali metals . Explain.

38. Why is LiF almost insoluble in water where as LiCl is soluble not only in water but also in acetone ?

39. When an alkali metal dissolves in liquid ammonia the solution acquires different colours. Explain the reasons for this type of colour change.

40. Lithium is the only alkali metal to form a nitride directly. Why ?

41. LiI is more soluble than KI in ethanol.

42. Name the process used in the manufacture of Na_2CO_3 .

43. Sodium is prepared by electrolytic method and not by chemical method.

44. Why does a piece of burning Mg ribbon continues to burn in SO_2? Give the name of product.

45. Arrange the following in decreasing order of ionic characterr . $CaCl_2$, $BeCl_2$, $BaCl_2$, $MgCl_2$, $SrCl_2$.

46. Arrange the following in decreasing order of solubility in water .
(i) $Be(OH)_2$, $Ca(OH)_2$, $Ba(OH)_2$, $Sr(OH)_2$
(ii) $BaSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$

47. Beryllium chloride fumes in air . Why ?

48. Explain why alkaline earth metals are harder than alkali metals ?

49. Hydrated magnesium chloride cannot be dehydrated by heating .Why ?

50. Contrast the action of heat on the following and explain your answer.
(i) Na_2CO_3 and $CaCO_3$
(ii) $MgCl_2.6H_2O$ and $CaCl_2.6H_2O$
(iii) $Ca(NO_3)_2$ and $NaNO_3$

EXERCISE # 3

PART - I : IIT-JEE PROBLEMS (PREVIOUS YEARS)

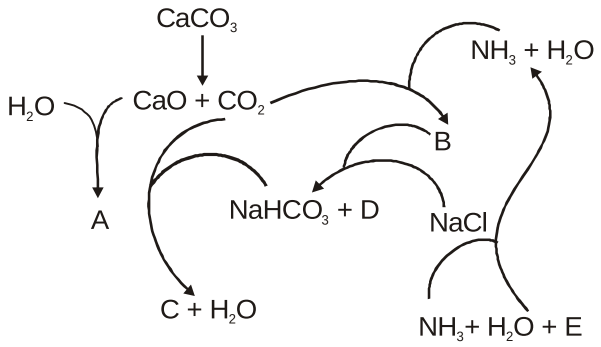
*** Marked Questions are having more than one correct option.**

1.* Highly pure dilute solution of sodium in liquid ammonia : **[JEE-1998, 1/200]**
(A) shows blue colour. (B) exhibits electrical conductivity.
(C) produces sodium amide. (D) produces hydrogen gas.

2*. Sodium nitrate decomposes above 800°C to give : **[JEE-1998, 1/200]**
(A) N_2 (B) O_2 (C) NO_2 (D) Na_2O

3. Beryllium chloride shows acidic nature in water or why $BeCl_2$ is easily hydrolysed ?**[JEE-1999, 2/200]**

4. The Haber's process can be represented by the following scheme :



Identify A, B, C, D and E. **[JEE-1999, 5/200]**

5. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid. **[JEE-1999, 4/200]**
(i) Identify the substances and explain with balanced equation.
(ii) Explain what would happen to the red litmus if the white solid were the other compound.

6. The set representing the correct order of first ionization potential is : **[JEE-2001, 1/35]**
(A) K > Na > Li (B) Be > Mg > Ca (C) B > C > N (D) Ge > Si > C

7. Identify the following :

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow[\Delta]{\text{elemental S}} C \xrightarrow{I_2} D$$

Also mention the oxidation state of S in all the compounds. **[JEE-2003, 4/60]**

8. **Statement-1 :** Alkali metals dissolve in liquid ammonia to give blue solutions.
Statement-2 : Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$ (M = alkali metals). **[JEE-2007, 3/162]**
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.

9.* The compound(s) formed upon combustion of sodium metal in excess air is(are) : **[JEE-2009, 4/160]**
(A) Na_2O_2 (B) Na_2O (C) NaO_2 (D) NaOH

10.* The reagent(s) used for softening the temporary hardness of water is(are) **[JEE-2010, 4/160]**
(A) $Ca_3(PO_4)_2$ (B) $Ca(OH)_2$ (C) Na_2CO_3 (D) NaOCl

PART - II : AIEEE PROBLEMS (PREVIOUS YEARS)

Marked Questions are having more than one correct option.

1. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it :
(1) Absorbs CO_2 and increases O_2 contents (2) Eliminates moisture
(3) Absorbs CO_2 (4) Produces ozone **[AIEEE-2002]**

2. A metal M readily forms water soluble sulphate MSO_4 , water insoluble hydroxide $M(OH)_2$ and oxide MO which becomes inert on heating. The hydroxide is soluble in NaOH. The M is : **[AIEEE-2002]**
(1) Be (2) Mg (3) Ca (4) Sr

3. In curing cement plasters, water is sprinkled from-time to time. This helps in : **[AIEEE-2003]**
(1) developing interlocking needle like crystals of hydrate silicates
(2) hydrated sand gravel mixed with cement
(3) converting sand into silicic acid
(4) keeping it cool.

4. The substance not likely to contain $CaCO_3$ is : **[AIEEE-2003]**
(1) calcined gypsum (2) sea shells (3) dolomite (4) a marble statue

5. The solubilities of carbonates decrease down the magnesium group due to a decrease in :
[AIEEE-2003]
(1) hydration energies of cations (2) inter ionic interaction
(3) entropy of solution formation (4) lattice energies of solids.

6. Several blocks of magnesium are fixed to the bottom of a ship to : **[AIEEE-2003]**
(1) make the ship lighter (2) prevent action of water and salt
(3) prevent puncturing by under-sea rocks (4) keep away the sharks.

7. One mole of magnesium nitride on the reaction with an excess of water gives : **[AIEEE-2004]**
(1) one mole of ammonia (2) one mole of nitric acid
(3) two moles of ammonia (4) two moles of nitric acid.

8. Beryllium and aluminium exhibit many properties which are similar. But, the two elements differ in **[AIEEE-2004]**
(1) exhibiting maximum covalency in compounds (2) forming polymeric hydrides
(3) forming covalent halides (4) exhibiting amphoteric nature in their oxides.

9. Following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct picture ? **[AIEEE-2006]**
(1) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group.
(2) In both the alkali metals and the halogens the chemical reactivity decreases with increase in atomic number down the group.
(3) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens.
(4) In alkali metals the reactivity increases but in the halogens it decreases with increase in atomic number down the group.

10. The ionic mobility of alkali metal ions in aqueous solution is maximum for : **[AIEEE-2006]**
(1) K^+ (2) Rb^+ (3) Li^+ (4) Na^+

11. Which one of the following is the correct statement ? **[AIEEE-2008, 3/105]**
(1) Beryllium exhibits coordination number of six
(2) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase
(3) $B_2H_6.2NH_3$ is known as 'inorganic benzene'
(4) Boric acid is a protonic acid

12. Which of the following on thermal decomposition yields a basic as well as acidic oxide ? **[AIEEE-2012, 4/120]**
(1) $NaNO_3$ (2) $KClO_3$ (3) $CaCO_3$ (4) NH_4NO_3

EXERCISE # 4

NCERT QUESTIONS

1. What are the common physical and chemical features of alkali metals ?

2. Discuss the general characteristics and gradation in properties of alkaline earth metals.

3. Why are alkali metals not found in nature ?

4. Find out the oxidation state of sodium in Na_2O_2.

5. Explain why is sodium less reactive than potassium.

6. Compare the alkali metals and alkaline earth metals with respect to
(i) ionisation enthalpy (ii) basicity of oxides and (iii) solubility of hydroxides.

7. In what ways lithium shows similarities to magnesium in its chemical behaviour?

8. Explain why can alkali and alkaline earth metals not be obtained by chemical reduction methods?

9. Why are potassium and caesium, rather than lithium used in photoelectric cells?

10. When an alkali metal dissolves in liquid ammonia the solution can acquire different colours. Explain the reasons for this type of colour change.

11. Beryllium and magnesium do not give colour to flame whereas other alkaline earth metals do so. Why ?

12. Discuss the various reactions that occur in the Solvay process.

13. Potassium carbonate cannot be prepared by Solvay process. Why ?

14. Why is Li_2CO_3 decomposed at a lower temperature whereas Na_2CO_3 at higher temperature?

15. Compare the solubility and thermal stability of the following compounds of the alkali metals with those of the alkaline earth metals.
(a) Nitrates (b) Carbonates (c) Sulphates.

16. Starting with sodium chloride how would you proceed to prepare :
(i) sodium metal (ii) sodium hydroxide (iii) sodium peroxide (iv) sodium carbonate ?

17. What happens when :
(i) magnesium is burnt in air (ii) quick lime is heated with silica
(iii) chlorine reacts with slaked lime (iv) calcium nitrate is heated ?

18. Describe two important uses of each of the following :
(i) caustic soda (ii) sodium carbonate (iii) quicklime.

19. Draw the structure of :
(i) $BeCl_2$ (vapour) (ii) $BeCl_2$ (solid).

20. The hydroxides and carbonates of sodium and potassium are easily soluble in water while the corresponding salts of magnesium and calcium are sparingly soluble in water. Explain.

21. Describe the importance of the following :
(i) limestone (ii) cement (iii) plaster of paris.

22. Why are lithium salts commonly hydrated and those of the other alkali ions usually anhydrous?

23. Why is LiF almost insoluble in water whereas LiCl soluble not only in water but also in acetone ?

24. Explain the significance of sodium, potassium, magnesium and calcium in biological fluids.

25. What happens when
(i) sodium metal is dropped in water ?
(ii) sodium metal is heated in free supply of air ?
(iii) sodium peroxide dissolves in water ?

26. Comment on each of the following observations :
(a) The mobilities of the alkali metal ions in aqueous solution are $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
(b) Lithium is the only alkali metal to form a nitride directly.
(c) $E^{\ominus}$ for $M^{2+} (aq) + 2e^- \longrightarrow M(s)$ (where M = Ca, Sr or Ba) is nearly constant.

27. State as to why
(a) a solution of Na_2CO_3 is alkaline ?
(b) alkali metals are prepared by electrolysis of their fused chlorides ?
(c) sodium is found to be more useful than potassium ?

28. Write balanced equations for reactions between
(a) Na_2O_2 and water (b) KO_2 and water (c) Na_2O and CO_2.

29. How would you explain the following observations?
(i) BeO is almost insoluble but $BeSO_4$ is soluble in water,
(ii) BaO is soluble but $BaSO_4$ is insoluble in water,
(iii) LiI is more soluble than KI in ethanol.

30. Which of the alkali metal is having least melting point ?
(a) Na (b) K (c) Rb (d) Cs

31. Which one of the following alkali metals gives hydrated salts ?
(a) Li (b) Na (c) K (d) Cs

32. Which one of the alkaline earth metal carbonates is thermally the most stable ?
(a) $MgCO_3$ (b) $CaCO_3$ (c) $SrCO_3$ (d) $BaCO_3$

ANSWERS

EXERCISE # 1

PART - I

A-1.	(B)	**A-2.**	(C)	**A-3.**	(C)	**A-4.**	(B)	**A-5.**	(B)	**A-6.**	(B)	**A-7.**	(D)
A-8.	(D)	**A-9.**	(B)	**A-10.**	(A)	**A-11.**	(D)	**A-12.**	(B)	**A-13.**	(B)	**A-14.**	(A)
A-15.	(D)	**A-16.***	(AB)	**A-17.**	(D)	**A-18.**	(D)	**B-1.**	(D)	**B-2.**	(A)	**B-3.**	(A)
B-4.	(A)	**B-5.***	(BC)	**B-6.**	(A)	**C-1.**	(C)	**C-2.**	(B)	**C-3.**	(B)	**C-4.**	(B)
C-5.	(C)	**C-6.**	(B)	**C-7.**	(A)	**C-8.**	(C)	**C-9.**	(C)	**C-10.**	(C)	**C-11.**	(D)
C-12.	(D)	**C-13.**	(A)	**C-14.**	(C)	**C-15.**	(B)	**D-1.**	(C)	**D-2.**	(D)	**D-3.**	(B)
D-4.	(B)	**D-5.***	(AD)	**D-6.**	(A)	**D-7.**	(C)	**D-8.**	(A)	**D-9.**	(D)		
D-10.*	(ACD)	**D-11.**	(C)	**D-12.**	(B)	**D-13.**	(A)	**D-14.**	(A)	**D-15.**	(B)	**D-16.**	(D)
D-17.	(A)	**D-18.**	(A)	**D-19.**	(A)								

PART - II

1.	(D)	**2.**	(C)	**3.**	(D)	**4.**	(D)	**5.**	(D)	**6.**	(B)

7. (a–v); (b–viii); (c–vii) (d–vi); (e–ii); (f–iii); (g–iv); (h–i)

8. (a – iv) ; (b – i); (c – v) ; (d – iii), (e – vi), (f – ii)

9. (a – iii) (b – iv) (c – ii) (d – i)

10. (A → P, Q, R) ; (B → P,Q,R) ; (C → P,Q) ; (D → P,Q,S)

11. (A → P,R) ; (B → Q,S) ; (C → P,R) ; (D → P)

12.	(D)	**13.**	(A)	**14.**	(A)	**15.**	(A)	**16.**	(A)	**17.**	(A)	**18.**	(A)
19.	(D)	**20.**	(A)	**21.**	(A)	**22.**	(B)						
23.	False	**24.**	True	**25.**	True	**26.**	False	**27.**	True	**28.**	False	**29.**	False
30.	True	**31.**	True	**32.**	False	**33.**	True	**34.**	True	**35.**	True	**36.**	False
37.	False	**38.**	True	**39.**	False	**40.**	True	**41.**	True	**42.**	True	**43.**	True
44.	True	**45.**	False	**46.**	False	**47.**	Lithium	**48.**	Lithium	**49.**	Conduction electrons		

50. Sodium amide **51.** Large size **52.** Hydration, lattice **53.** Greater

54. Harder, greater **55.** Peroxides **56.** Dry HCl **57.** LiCl **58.** NH_3

59. Na_2BeO_2 and H_2 **60.** oxide **61.** CO_2, thermally unstable **62.** decrease

63. blue, blue, solvated **64.** smaller size, greater charge density, lack of d-orbital

65. Zn or Al or Be **66.** Li, Mg **67.** Li **68.** electrophile, polymeric **69.** Li

70. flame **71.** CO_2, O_2, submarines **72.** Li_2CO_3

EXERCISE # 2

PART - I

1.	(D)	**2.**	(C)	**3.**	(C)	**4.**	(B)	**5.**	(B)	**6.**	(A)	**7.**	(B)
8.	(A)	**9.**	(C)	**10.**	(B)	**11.**	(A)	**12.**	(C)	**13.**	(B)	**14.**	(A)
15.	(C)	**16.**	(B)	**17.**	(A)	**18.**	(C)	**19.**	(C)	**20.**	(D)	**21.**	(D)
22.	(A)	**23.**	(C)	**24.**	(D)	**25.**	(C)	**26.**	(A)	**27.**	(B)	**28.**	(A)
29.	(C)	**30.**	(D)	**31.**	(A)	**32.**	(D)	**33.**	(D)	**34.**	(ABD)	**35.**	(AB)
36.	(AB)	**37.**	(AC)	**38.**	(ABD)	**39.**	(ABC)	**40.**	(AB)	**41.**	(ABCD)		
42.	(ABD)	**43.**	(ABC)	**44.**	(ABC)	**45.**	(AB)	**46.**	(ABCD)	**47.**	(CD)		

PART - II

1. Because intermediate product $KHCO_3$ is soluble in water.

2. Mg_3N_2 being salt of strong base [$(Mg(OH)_2$] and weak acid (NH_3) gives NH_3 on hydrolysis while $MgCl_2$ is a salt of strong acid (HCl) and strong base [$(Mg(OH)_2$] does not gives HCl on hydrolysis.

3. $3Mg + N_2 \longrightarrow Mg_3N_2$; $2Mg + O_2 \longrightarrow 2MgO$

4. (a) $K[BrF_4]$ (b) $4KHCO_3 + 3O_2$ (c) $2KNO_2 + N_2O + H_2O$ or $4KNO_2 + N_2 + 2H_2O$
(d) $2NaO_3$ (s) + $NaOH.H_2O$(s) + $1/2O_2$ (g)

5. [X] = $NaNO_2$; [Y] Na_2O

6. [A] = $NaCH_2COONa$ [B] = $NaOOC–COONa$ [C] $CH_2(COOH)_2$ [D] C_3O_2

7. Conductivity is due to the presence of ammoniated electrons and ammoniated cations. Conductivity decrease because solution conducts electricity like a metallic conductor.

8. Cathodic protection or sacrificial protection, as Mg is more reactive than steel.

9. $MgO + C \rightleftharpoons Mg + CO$
Inert gas does not permit reaction of Mg with CO.

10. $BeCl_2 + 4H_2O \longrightarrow [Be(H_2O)_4]^{2+} + 2Cl^-$
Due to extensive hydration on account of its small size. It hydrolyses to give H_3O^+. Hence its aqueous solution is acidic in nature.

11. (i) Black ash is impure sodium carbonate containing CaS produced in Le-Blanc process when salt cake is reduced by coke.
(ii) Ammonia is liberated: $NH_4Cl + NaOH \longrightarrow NH_3 + NaCl + H_2O$
(iii) Sodium carbonate decahydrate. (iv) Sodium Bicarbonate. (v) Lithium Chloride.
(vi) Calcium Chloride (vii) Sodium Formate

12. (i) $6NaOH + 3I_2 \longrightarrow 5NaI + NaIO_3 + 3H_2O$
(ii) $P_4 + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + PH_3$
(iii) $ZnSO_4 + 2NaOH \longrightarrow Zn(OH)_2 + Na_2SO_4$; $NaOH + Zn(OH)_2 \longrightarrow Na_2ZnO_2 + H_2O$
(iv) $AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 + 3NaCl$; $Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$
(v) $2KNO_3 + 10K \longrightarrow 6K_2O + N_2$
(vi) $2Na + O_2 \xrightarrow{Heat} Na_2O_2$; $2Na_2O_2 + H_2SO_4 \longrightarrow 2Na_2SO_4 + 2H_2O + O_2$

13. (i) $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

(ii) $2AgNO_3 + 2NaOH \longrightarrow 2AgOH + 2NaNO_3$; $2AgOH \xrightarrow{\Delta} Ag_2O \downarrow$ (brown) (भूरा) $+ H_2O$

(iii) $P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{sodium hypo phosphite}}{3NaH_2PO_2} + \underset{\text{phosphine}}{PH_3}$

14. (i) $NH_4Cl + NaOH \longrightarrow NH_3 + NaCl + H_2O$; $NH_3 + HCl \longrightarrow$ white fumes of NH_4Cl

(ii) $Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2$; SO_2 turns acidified $K_2Cr_2O_7$ green.
(iii) Flame test Na = Golden yellow

15. (a) $LiOH < NaOH < KOH$ (b) $LiHCO_3 < NaHCO_3 < KHCO_3$
(c) $Li_2CO_3 < Na_2CO_3 < K_2CO_3$ (d) $Cs^+ < Rb^+ < K^+ < Na^+ < Li^+$

16. (i) $MgCl_2.H_2O \xrightarrow{Heat} MgCl_2.2H_2O \xrightarrow{Heat} Mg(OH)Cl \xrightarrow{Heat} MgO + HCl + H_2O$

(ii) $CaSO_4.2H_2O \xrightarrow{120°C} 2CaSO_4.H_2O$

$$2CaSO_4.H_2O \xrightarrow{200°C} CaSO_4 \xrightarrow[\text{Heated}]{\text{Strongly}} CaO + SO_2 + \frac{1}{2}O_2$$

(iii) $M(HCO_3)_2 \longrightarrow MCO_3 + H_2O + CO_2$

(iv) $MgSO_4.7H_2O \xrightarrow{Heat} MgSO_4.H_2O \xrightarrow{Heat} MgSO_4 \xrightarrow[\text{Heated}]{\text{Strongly}} MgO + SO_2 + \frac{1}{2}O_2$

(v) $Ba(NO_3)_2 \xrightarrow{Heat} BaO + 2NO_2 + \frac{1}{2}O_2$

17. $Na_2O + H_2O \longrightarrow 2NaOH$
Zn तथा Al दोनों NaOH में घुल कर H_2 निकालते है।
$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

18. (A) = NaOH ; (B) = H_2 ; (C) = P_4
(D) = NaH_2PO_2 ; (E) = NH_3

19. (A) K_2SO_4 (B) $BaSO_4$ (C) $K_2SO_4.Al_2(SO_4)_3 24.H_2O$

20. Alkaline earth metal cations possess high lattice energy due to their small size and higher charge. The hydration energy can not compensate for the energy required to break the lattice in these compounds.

21. As removal of IInd electron from inert gas configuration requires very high energy, therefore, they form unipositive ions. As IE_1 of these metals are low, the excitation of electrons can be done by providing the less energy. This much of energy can be given by Bunsen flame.

22. (i) Be^{2+} & O^{2-} smaller in size & thus higher lattice energy and lattice energy is greater than hydration energy in BeO where as in $BeSO_4$ lattice energy is less due to bigger sulphate ion and is soluble.
(ii) In $BaSO_4$ lattice energy is greater than hydration energy while in BaO lattice energy is smaller than hydration energy.

23. $BeO + C + Cl_2 \xrightarrow{600-800K} BeCl_2 + CO$; In vapour state it exists as linear molecule where as in solid it has polymeric strucutre.

24. Highly deliquescent absorbs moisture from air and their surface become wet.

25. Lithium

26. Because of low IE_1 & high electro positive character they are themselves strong reducing agent.

27. Highly reactive elements as their IE_1 values are low.

28. Because of smallest size of Li^+, it has higher degree of hydration and has bigger hydrated ions. Hence Li^+ has least mobility.

29. In unipositive ions all electrons are paired.

30. Smaller cation is stabilised by smaller anion & bigger cation is stabilised by bigger anion.

31. No, as its IE_1 is very high & therefore requires higher energy for excitation of electron. This much of energy can not be provided by Bunsen flame.

32. Removal of IInd electron from Na^+ takes place from inert gas configuration.

33. (i) $Na + H_2O \longrightarrow NaOH + 1/2H_2$
(ii) $2Na + O_2 \longrightarrow Na_2O_2$
(iii) $Na_2O_2 + H_2O \longrightarrow 2NaOH + 1/2O_2$

34. Li^+ being smallest has highest polarising power, hence most covalent in character. So least soluble in H_2O.

35. Due to large atomic size & only one valence electron per atom, alkali metals have weak metallic bonds as inter particle forces.

36. Quick lime is CaO, slaked lime is $Ca(OH)_2$ and lime water is a clear solution of calcium hydroxide in water.

37. Higher positive charge density on alkaline earth metal cations attract more no. of water molceules leading to higher degree of hydration.

38. Li^+ & F^- are smaller & possess higher lattice energy therefore almost insoluble in water.LiCl has ionic as well as covalent character.

39. Refer text.

40. It being strongest reducing agent converts N_2 into N^{3-} .

41. 'Like dissolves like' LiI more covalent while KI is more ionic.

42. Ammonia soda process or Solvey process.

43. As Na itself is a strong reducing agent & more electro positive element.

44. Mg acts as strong reducing agent & reduces SO_2 to S thus utilises its oxygen for burning.

$$2Mg + SO_2 \longrightarrow 2MgO + S$$

45. $BaCl_2 > SrCl_2 > CaCl_2 > MgCl_2 > BeCl_2$.

46. (i) $Ba(OH)_2 > Sr(OH)_2 > Ca(OH)_2 > Be(OH)_2$
(ii) $MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

47. Due to the formation of HCl on hydrolysis

$BeCl_2 + H_2O \longrightarrow Be(OH)_2 + 2HCl$

48. Due to greater nuclear charge and small size, there is greater interparticle forces & thus pack more tightly in solid lattice.

49. Being covalent gets hydrolysed forming MgO.

$MgCl_2 . 6H_2O \xrightarrow{\Delta} MgO + 2HCl + 5H_2O$

50. (i) $Na_2CO_3 \xrightarrow{\Delta}$ कोई परिवर्तन नहीं (उष्मा के प्रति स्थायी) ; $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

(ii) $MgCl_2 . 6H_2O \xrightarrow{\Delta} MgO + 2HCl + 5H_2O$; $CaCl_2 . 6H_2O \xrightarrow{\Delta} CaCl_2 + 6H_2O$

(iii) $Ca(NO_3)_2 \xrightarrow{\Delta} CaO + 2NO_2 + 1/2O_2$; $NaNO_3 \xrightarrow{\Delta} NaNO_2 + 1/2O_2$

EXERCISE # 3

PART - I

1.* (AB) **2*.** (ABD)

3. Beryllium chloride is acidic, when dissolved in water because the hydrated ion hydrolysed producing H_3O^+. This happens because the Be–O bond is very strong, and so in the hydrated ion this weakens the O–H bonds, and hence there is tendency to lose portons.

$BeCl_2 + 4H_2O \longrightarrow [Be(H_2O)_4] Cl_2$; $[Be(H_2O)_4]^{2+} + H_2O \longrightarrow [Be(H_2O)_3 (OH)]^+ + H_3O^+$

4. In the manufacture of sodium carbonate by ammonia - soda process following reactions are involved.

(A) : $Ca(OH)_2$ $CaO + H_2O \longrightarrow \underset{(A)}{Ca(OH)_2}$

(B) : NH_4HCO_3 $NH_3 + H_2O + CO_2 \longrightarrow \underset{(B)}{NH_4HCO_3}$

(C) : Na_2CO_3 $2NaHCO_3 \longrightarrow \underset{(C)}{Na_2CO_3} + H_2O + CO_2$

(D) : NH_4Cl $NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + \underset{(D)}{NH_4Cl}$

(E) : $CaCl_2$ $2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + 2H_2O + \underset{(E)}{CaCl_2}$

So, $A = Ca(OH)_2$, $B = NH_4HCO_3$, $C = Na_2CO_3$, $D = NH_4Cl$, $E = CaCl_2$

5. (i) Na_2O_2 is powerful oxidant and bleaching agent and bleaches red litmus paper to white in aqueous solution according to the following reaction,

$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O + [O]$

$[O]$ + Litmus $\longrightarrow$ White (bleaching)

(ii) The other compound Na_2O will give NaOH on dissolution in water according to the following reaction.

$Na_2O + H_2O \longrightarrow 2NaOH$.

The red litmus will turn to blue due to stronger alkaline nature of NaOH

6. (B)

7. $Na_2CO_3 + SO_2 \xrightarrow{H_2O} 2NaHSO_3 \text{ (A)} + CO_2$

$2NaHSO_3 + Na_2CO_3 \longrightarrow 2Na_2SO_3 \text{ (B)} + H_2O + CO_2$

$Na_2SO_3 + S \xrightarrow{\Delta} Na_2S_2O_3 \text{ (C)}$

$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 \text{ (D)} + 2NaI$

Oxidation states of S + 4 in $NaHSO_3$ $[1 + 1 + x + 3(-2) = 0]$ and +4 in Na_2SO_3 $[2 + x + 3(-2) = 0]$;
+ 6 and – 2 (or an average + 2) in $Na_2S_2O_3$ and +5 and 0 (or an average + 5/2) in $Na_2S_4O_6$.

8. (B) **9.*** (AB) **10.*** (BCD)

PART - II

1. (1) **2.** (1) **3.** (1) **4.** (1) **5.** (1) **6.** (2) **7.** (3)
8. (1) **9.** (4) **10.** (2) **11.** (2) **12.** (3)