Chapter

10 The *s*-Block Elements

GROUP 1 ELEMENTS : ALKALI METALS
(Li, Na, K, Rb, Cs, Fr)

Atomic and Physical Properties

(i) **General electronic configuration:** General configuration of alkali metals is ns^1. They are highly electropositive metals, thus not found in free state in nature.

(ii) **Atomic and ionic radii :** These elements have the largest size in a particular period. Down the group their atomic size increases.

(iii) **Ionization enthalpy:** Alkali metals have low value of IE which decreases on moving down the group. As a result, Cs is the most electropositive element in the whole of periodic table.

(iv) **Hydration enthalpy:** Hydration energy decreases on going down in the group, due to increase in the size of metal ion

$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

$\therefore$ Li^+ has maximum degree of hydration. Due to high degree of hydration, lithium salts are mostly hydrated, example : LiCl. $2H_2O$

(v) **Density :** The density of alkali metals are quite low as compared to other metals. Order of densities of alkali metals

$Li < K < Na < Rb < Cs$

(vi) **Flame test :** Elements and their respective colours imparted to the flame are given below.

Element	Li	Na	K	Rb	Ca
Colour	Crimson red	Golden yellow	Violet	Red violet	Blue

(vii) **Lustrous surface :** Lustre is due to mobile electrons in the metallic lattice.

(viii) **Tendency of forming complex compounds :** These metals have weak tendency of forming complex compounds due to large size and low charge density.

(ix) **Melting point and boiling point :** Their melting and boiling points are low due to weak metallic bonds. Strength of metallic bond decreases in the group from Li to Cs, due to which hardness decreases from Li to Cs.

$Li > Na > K > Rb > Cs$

(x) **Photoelectric effect :** Size of Cs and K is large and they possess low I.E. Both contain one electron in outermost shell which got emitted by absorption of visible light

Chemical Properties:

(i) Reactivity towards air:

Li forms mono oxide (M_2O) and Na forms peroxide (M_2O_2) and K, Rb and Cs form superoxide (MO_2).

$$4Li + O_2 \longrightarrow 2Li_2O\,(\text{oxide})$$

$$2Na + O \longrightarrow Na_2O_2\,(\text{peroxide})$$

$$M + O_2 \longrightarrow MO_2\,(\text{superoxide})\ (M = K, Rb, Cs)$$

Basic nature, ionic character and reactivity of these oxides increases from Li to Cs. Due to high reactivity towards air and water, they are normally kept in kerosene oil.

(ii) Reactivity towards water:

$$2M + 2H_2O \longrightarrow 2M^+ + 2OH^- + H_2\ (M = \text{alkali metal})$$

Due to its small size and high HE, Li reacts less vigorously with water as compared to other alkali metals which react explosively with water. Basic nature of these hydroxides increases from Li to Cs.

$LiOH < NaOH < KOH < RbOH < CsOH$

Ionic character, melting point, boiling point, reactivity , thermal stability and solubility in water increases from Li to Cs.

(iii) Reactivity towards dihydrogen:

$$2M + H_2 \longrightarrow 2M^+ + 2H^-$$

These hydrides are ionic solids with high m.pts.

Thermal stability of LiH is highest. They are ionic hydrides and their stability depends on lattice energy.

$LiH > NaH > KH > RbH > CsH$

(iv) Reactivity towards halogens:

Alkali metals directly combine with halogen to form halides (MX)

$$2M + X_2 \longrightarrow 2M^+ + 2X^-$$

Except lithium halides which are covalent, other alkali metal halides are ionic in nature.

The ionic compounds get dissolved in water, while the covalent compounds get hydrolysed.

LiCl gets hydrolysed due to its covalent nature. Decreasing order of these halides in undergoing hydrolysis is as follows

$LiCl > NaCl > KCl > RbCl > CsCl$

(v) **Reducing nature:** They are strong reducing agents, Li being the strongest and Na the weakest. Electrode potential depends upon sublimation energy, ionization energy and hydration energy. Li due to its small size has the highest hydration energy which accounts for its high negative E° value.

(vi) **Solution in liquid ammonia:** Alkali metals have low I.E. and large size thus they dissolve in liquid ammonia to give deep blue solution which are conducting in nature.

$$M + (x+y)NH_3 \longrightarrow \left[M(NH_3)_x\right]^+ + \left[e(NH_3)_y\right]^-$$

The ammoniated electrons is responsible for the blue colour of the solution. These solutions are paramagnetic.

On standing or in presence of impurities or catalyst the blue colour solution forms amide.

$$2M^+(NH_3)_x + 2e^-(NH_3)_y \longrightarrow 2M^+NH_2^- + H_2 + (x+y-2)NH_3$$

In concentrated solution, blue colour changes to bronze colour and solution becomes becomes diamagnetic.

(vii) **Salts of oxoacids : Metal carbonates :**

(a) All these metals form M_2CO_3 type carbonates. (Li_2CO_3, Na_2CO_3, K_2CO_3, Rb_2CO_3, Cs_2CO_3)

(b) Li_2CO_3 is least stable out of all these carbonates, because it is covalent and decomposes to Li_2O and CO_2 at low temperature. Order of their stability is as follows : $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

Sulphates : $Li_2SO_4 < Na_2SO_4 < K_2SO_4 < RbSO_3 < Cs_2SO_4$

Nitrates : $LiNO_3$ decomposes to Li_2O at low temperature, whereas $NaNO_3$ gets decomposed to $NaNO_2$

Bicarbonates : These metals form $MHCO_3$ type bicarbonates and thermal stability of these bicarbonates increases from Li to Cs.

(viii) **Nitrides :** Among all alkali metals, only lithium directly combines with nitrogen to form nitride.

General Characteristics of Compounds of Alkali Metals

(i) **Oxides and hydroxides:** On combustion in excess of air, Li forms Li_2O, Na forms Na_2O_2 and K, Rb, Cs form superoxides of the formula, MO_2.

As the size of the metal ion increases, stability of peroxide or superoxide increases due to stabilisation of large anions by larger cations through lattice energy effects.

These oxides are easily hydrolysed by water to form hydroxides:

$$M_2O + H_2O \longrightarrow 2M^+ + 2OH^-$$

$$M_2O_2 + 2H_2O \longrightarrow 2M^+ + 2OH^- + H_2O_2$$

$$2MO_2 + 2H_2O \longrightarrow 2M^+ + 2OH^- + H_2O_2 + O_2$$

The pure, oxides and peroxides are colourless while superoxides are yellow or orange in colour. Superoxides are paramagnetic in nature. The alkali metal hydroxides are the strongest of all bases. They dissolve in water to produce large amount of heat due to intense hydration.

(ii) **Halides:** They are high melting, colourless crystalline solids. They have high –ve enthalpies of formation. M.pts and B.pts follow the order: $F^- > Cl^- > Br^- > I^-$

Note : The low solubility of LiF in water is due to its high lattice enthalpy while the low solubility of CsI is due to small HE of the two ions.

(iii) **Salts of Oxo-acids :** Oxo acids are those in which the acidic proton is on a hydroxyl group with an oxo group attached to the same atom. Ex: H_2CO_3, H_2SO_4.

Alkali metals form salts with all the oxo-acids. As electropositive character increases down the group, stability of carbonates and hydrogencarbonates increases.

Li_2CO_3 being unstable to heat, decomposes to form Li_2O and CO_2.

Anomalous Properties of Lithium

The anomalous behaviour of Li is due to:

(i) its exceptionally small size

(ii) high polarising power

This give rise to covalent character in Li compounds.

Points of difference between Li and other alkali metals

(i) Li is much harder. Its m.pt and b.pt. are higher than other alkali metals.

(ii) It is the least reactive and is the strongest reducing agent among all the alkali metals.

(iii) LiCl is deliquescent and crystallises as a hydrate.

(iv) $LiHCO_3$ is not obtained in solid state while other elements form solid hydrogencarbonates.

(v) Unlike other alkali metals, Li does not form ethynide with ethyne

(vi) $LiNO_3$ on heating gives Li_2O while others decompose to nitrite.

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

$$2NaNO_3 \longrightarrow 2NaNO_2 + O_2$$

(vii) LiOH, Li_2CO_3, LiF and Li_2O are less soluble in water compared to corresponding compounds of other alkali metals.

Diagonal Relationship Between Lithium and Magnesium

(i) Li and Mg both are hard metals due to the presence of strong metallic bonds in them.

(ii) Li and Mg both are hard, therefore, their melting and boiling points are high.

(iii) LiOH and $Mg(OH)_2$ both are weak bases.

(iv) LiCl and $MgCl_2$ are insoluble in water due to their covalent nature, but soluble in organic solvents.

(v) LiCl and $MgCl_2$ get hydrolysed due to their covalent nature.

(vi) Li and Mg directly combine with O_2 to form normal oxides (Li_2O and MgO) while other members of their groups form peroxide and super oxide.

(vii) Li and Mg directly combine with N_2 to form Li_3N and Mg_3N_2

(viii) Carbonates and nitrates of Li and Mg are unstable and readily decompose to form oxides.

(ix) Hydration energies of Li^{+1} and Mg^{+2} ions are higher due to small size.

Some Important Compounds of Sodium

(i) Sodium Carbonate (Washing soda); $Na_2CO_3.10H_2O$

Preparation: It is prepared by solvay process as follows:

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

$$(NH_4)_2CO_3 + H_2O + CO_2 \longrightarrow 2NH_4HCO_3$$

$$NH_4HCO_3 + NaCl \longrightarrow NH_4Cl + NaHCO_3$$

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

Note : K_2CO_3 cannot be prepared by this method because $KHCO_3$ is too soluble to be precipitated by addition of NH_4HCO_3 to saturated solution of KCl

Properties:

(a) It is white crystalline solid, existing as a decahydrate.

(b) It is readily soluble in water.

(c) On heating, it loses water of crystallisation to form monohydrate.

$$Na_2CO_3.10H_2O \xrightarrow{\Delta} Na_2CO_3.H_2O + 9H_2O$$

Above 373 K, monohydrate becomes completely anhydrous.

$$Na_2CO_3.H_2O \xrightarrow{>373K} \underset{\text{soda ash}}{Na_2CO_3} + H_2O$$

(d) The carbonate part gets hydrolysed to form alkaline solution

$$CO_3^{2-} + H_2O \longrightarrow HCO_3^- + OH^-$$

Uses:

(a) It is used in water softening, laundering and cleaning.

(b) It is used in manufacture of glass, soap, borax and caustic soda.

(c) It is used in paper, paints and textile industries.

(d) It is an important laboratory reagent.

(ii) Sodium Chloride; NaCl

Preparation : It is generally obtained by evaporation of sea water. Crude NaCl, obtained by crystallisation of brine solution, contains Na_2SO_4, $CaSO_4$, $CaCl_2$ and $MgCl_2$ as impurities. To obtain pure NaCl, crude salt is dissolved in minimum amount of water and filtered to remove insoluble impurities. The solution is then saturated with HCl gas, crystals of pure NaCl separate out due to common ion effect, leaving behind calcium chloride and magnesium chloride in solution.

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

$$HCl \rightleftharpoons H^+ + Cl^-$$

Properties:

(a) It melts at 1081 K. It is white crystalline solid.

(b) Its solubility is 36 g in 100 g of water at 273 K and the solubility does not increase appreciably with increase in temperature.

Uses

(a) It is used as common salt or table salt for domestic purposes.

(b) It is used for preparation of Na_2O_2, NaOH and Na_2CO_3.

(iii) Sodium Hydroxide, NaOH

Preparation:

It is prepared by electrolysis of NaCl in castner-kellner cell. Brine solution is electrolysed using Hg cathode and C anode.

At cathode: $Na^+ + e^- \xrightarrow{Hg} Na - amalgam$

At anode: $Cl^- \longrightarrow \frac{1}{2}Cl_2 + e^-$

$$2Na - amalgam + 2H_2O \longrightarrow 2NaOH + 2Hg + H_2$$

Properties:

(a) It is a white, translucent solid which melts at 591 K.

(b) It dissolves in water to give an alkaline solution.

(c) Crystals of NaOH are deliquescent.

(d) It reacts with CO_2 in the atmosphere to form Na_2CO_3.

Uses: It is used

(a) in manufacture of soap, paper, artificial silk and chemicals.

(b) in petroleum refining

(c) in purification of bauxite

(d) for preparation of fats and oils

(e) as a laboratory reagent.

(iv) Sodium Hydrogen Carbonate (Baking Soda), $NaHCO_3$

Preparation:

It is made by saturating a solution of Na_2CO_3 with CO_2.

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

Properties:

It is known as baking soda because it decomposes on heating to generate bubbles of CO_2.

Uses :

(a) It is mild antiseptic for skin infections.

(b) It is used in fire extinguishers.

Biological Importance of Na and K

Importance of Na^+ : Na^+ ions are found on the outside of cells and participate in transmission of nerve signals, in regulating flow of water across cell membranes and in transport of sugars and amino acids into cell.

Importance of K^+ : K^+ ions are the most abundant cations within cell fluids, where they activate many enzymes, participate in oxidation of glucose to produce ATP and with sodium, are responsible for the transmission of nerve signals.

GROUP 2 ELEMENTS: ALKALINE EARTH METALS

(Be, Mg, Ca, Sr, Ba, Ra → radioactive)

Atomic and Physical Properties

(i) **Electronic Configuration :** General electronic configuration of alkaline earth metals is [noble gas] ns^2. Their compounds are ionic in nature.

(ii) **Atomic and Ionic radii:** Their radii are smaller than alkali metals due to increased nuclear charge. The radii increases down the group with increase in atomic number.

(iii) **Ionization enthalpies:**

They have low IE due to large size and their IE decreases down the group. The first IE of group 2 elements are higher than those of group 1 elements due to their smaller size than group 1 elements. Second IE's of group 2 elements are smaller than those of group 1 elements. This is because removal of second e^- from group 2 elements results in stable noble gas configuration. On other hand, second e^- in group 1 has to be removed from noble gas core which needs large amount of energy.

(iv) **Hydration enthalpies**

Their HE's decreases with increase in ionic size, i.e., HE of group 2 cations will be in following order :

$Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$

Due to their smaller sizes than group 1 elements, HE's of group 2 elements are larger than those of group 1 elements. As a result, their compounds are more highly hydrated than those of alkali metals.

(v) **Density** : Atomic weight increases from Be to Ba in a group and volume also increases, but increase in atomic weight is more as compared to volume. Therefore, density increases from Be to Ba.

Exception :

Density of Mg is more as compared to Ca (Ca < Mg).

Density : Ca < Mg < Be < Sr < Ba

(vi) **Flame Test :** Elements and their respective colour imparted to the flame are given below :

Element	Be	Mg	Ca	Sr	Ba
Flame	–	–	Brick green	Blood red	Apple red

(vii) **Photoelectric effect :** Due to small size of these metals as compared to alkali metals, their ionisation potential is high. Thus, electrons can be released only by high energy radiations.

(viii) **Lustrous Surface :** Lustre is due to mobile electron in the metallic lattice.

(ix) **Tendency of forming Complex Compounds :** These metals have higher tendency of forming complex compounds as compared to alkali metals, due to their relatively smaller size. This tendency decreases from Be to Ba.

(x) **Melting Point and Boiling Point :** Melting and boiling points of these metals are low, but these metals are harder as compared to metals of IA group.

Hardness decreases from Be to Ba, due to which melting and boiling points decrease.

Be > Ca > Sr > Ba > Mg

Chemical Properties:

(i) **Reactivity towards air and water :** Be and Mg form normal MO type oxides, whereas, Ca, Sr and Ba form normal oxides (MO) as well as peroxides MO_2 . On burning in air they give corresponding oxides and nitrides.

They react with H_2O (even in cold) to form hydroxides.

Basic nature (BeO < MgO < CaO < SrO < BaO), ionic character, melting point, boiling point, thermal stability reactivity and solubility in water of these oxides increases from Be to Ba,

Ionic character, melting point, boiling point, reactivity, thermal stability and solubility in water of hydroxides increases from Be to Ba. Increasing order of basic character of these hydroxides is as follows :

$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

(ii) **Reactivity towards halogens:**

$M + X_2 \longrightarrow MX_2$ (X = F, Cl, Br, I)

BeF_2 is best prepared by thermal decomposition of $(NH_4)_2BeF_4$. $BeCl_2$ is prepared by :

$$BeO + C + Cl_2 \underset{}{\overset{600\text{-}800K}{\rightleftharpoons}} BeCl_2 + CO$$

Covalent character of these halides decreases from $BeCl_2$ to $BaCl_2$. Therefore, the amount of hydrolysis also decreases from $BeCl_2$ to $BaCl_2$.

(iii) **Reactivity towards hydrogen:**

Except Be, all elements combine with hydrogen to form hydride, MH_2.

BeH_2 is prepared by:

$2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$

These metals (except Be) combine with hydrogen to form MH_2 type hydrides. Thermal stability of these hydrides is as follows.

$BeH_2 < MgH_2 > CaH_2 > SrH_2 > BaH_2$

(iv) **Reactivity towards acids:**

$M + 2HCl \longrightarrow MCl_2 + H_2$

(v) **Reducing nature:** They are strong reducing agents.

(vi) **Solutions in liquid ammonia:**

$$M + (x+y)NH_3 \longrightarrow \left[M(NH_3)_x\right]^{2+} + 2\left[e(NH_3)_y\right]^-$$

The solution is deep blue black in colour.

General Characteristics of Group 2 Compounds

(i) **Oxides and Hydroxides:**

They have high ΔH°_f values and are thus very stable to heat. BeO is amphoteric while other oxides are basic in nature.

$MO + H_2O \longrightarrow M(OH)_2$

BeO is covalent while other oxides are ionic in nature. The solubility, thermal stability and basic character of these hydroxides increases down the group from $Mg(OH)_2$ to $Ba(OH)_2$

$Be(OH)_2$ is amphoteric as shown below:

$Be(OH)_2 + 2OH^- \longrightarrow \left[Be(OH)_4\right]^{2-}$ Berylate ion

$Be(OH)_2 + 2HCl + 2H_2O \longrightarrow \left[Be(OH)_4\right]Cl_2$

(ii) **Halides**

Be-halides are covalent while other group 2 halides are ionic in nature. In solid state, $BeCl_2$ has chain structure. In vapour phase, $BeCl_2$ exists as a chloro-bridged dimer. Down the group, tendency to form halide hydrates decreases. Due to high IE, fluorides are less soluble than chlorides.

(iii) **Salts of Oxo-acids :**

Metal carbonates :

(1) All these metals form MCO_3 type carbonates

($BeCO_3$, $MgCO_3$, $CaCO_3$, $SrCO_3$, $BaCO_3$)

(2) $BeCO_3$ is least stable out of all these carbonates because it is covalent and decomposes to BeO and CO_2 at low temperature. Order of their stability is as follows :

$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

(3) Stability of carbonates of IA group metals > stability of carbonates of IIA group metals.

Sulphates :

Solubility of Sulphates :

$BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

Increasing order of thermal stability

$BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

Nitrates : These metals also form $M(NO_3)_2$ and all nitrates give oxides on decomposition.

Bicarbonates : These metals form $M(HCO_3)_2$ type bicarbonates. The thermal stability of bicarbonates increases from Be to Ba.

Different Behaviour of Beryllium as Compared to Other Elements of its Group

(i) Ionisation potential and electronegativity of Be are higher than those of other metals.

(ii) $BeCl_2$ is insoluble in water, due to its covalent nature, but soluble in organic solvents. Other chlorides ($CaCl_2$, $SrCl_2$ and $BaCl_2$) get dissolved in water.

(iii) BeO and $Be(OH)_2$ are amphoteric in nature. Therefore they react with acids as well as bases. Other oxides react only with acids due to their alkaline nature.

(iv) Beryllium forms single type of oxide (MO), Ca Sr and Ba form peroxides also.

(v) Beryllium does not give flame test, Ca, Sr and Ba impart characteristic colours to the flame.

(vi) Due to small size, Be forms complex compounds.

(vii) Hydrides and halides of Be get polymerized.

Diagonal Relationship between Be and Al

(i) Be and Al both are hard due to strong metallic bonds. Therefore, their melting and boiling points are high.

(ii) $BeCl_2$ and $AlCl_3$ both are covalent compounds. Therefore, they are insoluble in water and soluble in organic solvents.

(iii) Melting points of $BeCl_2$ and $AlCl_3$ are low due to their covalent tendency.

(iv) Be and Al both have tendency of forming complex compounds due to small size.

(v) Both $BeCl_2$ and $AlCl_3$ are strong Lewis acids and are used as Friedel Crafts catalysts.

(vi) $Be(OH)_2$.$Al(OH)_3$, BeO and Al_2O_3 are amphoteric in nature.

(vii) $BeCl_2$ and $AlCl_3$ from dimers, because both are electron deficient compounds.

Some Important Compounds of Calcium

(i) **Calcium Oxide or Quick lime, CaO**

Preparation

By heating limestone at 1070-1270 K

$$CaCO_3 \underset{}{\overset{heat}{\rightleftharpoons}} CaO + CO_2$$

For the reaction to proceed, CO_2 is removed as soon as it is formed.

Properties:

(a) It is a white amorphous solid with a melting point of 2870 K.

(b) On exposure to air, it absorbs moisture and CO_2

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$CaO + CO_2 \longrightarrow CaCO_3$$

(c) Being basic, it combines with acidic oxides at high temperature.

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

$$6CaO + P_4O_{10} \longrightarrow 2Ca_3(PO_4)_2$$

(d) The process of breaking the lump of lime by addition of limited amount of water is called slaking of lime. Quick lime slaked with soda gives solid sodalime.

Uses: It is used

(a) for manufacturing cement.

(b) in the manufacture of Na_2CO_3 from caustic soda.

(c) in the purification of sugar and manufacture of dye stuffs.

(d) in the preparation of mortar, a building material.

(ii) **Calcium Hydroxide (Slaked lime), $Ca(OH)_2$**

It is prepared by adding water to quick lime.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Properties:

(a) It is a white amorphous powder.

(b) It is sparingly soluble in water.

(c) Its aqueous solution is known as lime water and a suspension of slaked lime in water is called milk of lime.

(d) $Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{milky}}{CaCO_3 \downarrow} + H_2O$

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

(e) $2Ca(OH)_2 + 2Cl_2 \longrightarrow CaCl_2 + \underset{\text{Bleaching powder}}{Ca(OCl)_2} + 2H_2O$

Uses. Calcium hydroxide is used: (i) in the manufacture of bleaching powder and caustic soda, (ii) for white washing buildings and for softening of water, and (iii) in the preparation of soda-lime (mixture of cal. hydroxide and caustic soda)

(iii) **Calcium Carbonate, $CaCO_3$**

Preparation:

(a) $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

(b) $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$

Properties

(a) It is a white fluffy powder and is insoluble in water.

(b) Action of heat : $CaCO_3 \xrightarrow{1200K} CaO + CO_2$

(c) Action of acids :

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

Uses: It is used

(a) as a building material in form of marble

(b) in manufacture of quick lime.

(c) as an antacid, mild abrasive in toothpaste, in chewing gum and a filler in cosmetics.

(iv) **Calcium Sulphate (Plaster of Paris), $CaSO_4.1/2H_2O$**

Preparation:

$$\underset{\text{Gypsum}}{2(CaSO_4.2H_2O)} \xrightarrow{393K} 2(CaSO_4).H_2O + 3H_2O$$

Above 393 K, anhydrous $CaSO_4$ is formed which is called 'dead burnt plaster'.

Properties:

With adequate quantity of water, it forms a plastic mass that sets into a hard solid.

Uses: It is used

(a) in building industry and in plasters.

(b) in dentistry, ornamental work and for making casts of statues and busts.

Biological Importance of Ca and Mg

Magnesium is used as a cofactor by enzymes that utilise ATP in phosphate transfer. Chlorophyll, the main pigment for the absorption of light in plants, contains Mg. 99% of body Ca is present in bones and teeth. Ca plays role in neuromuscular function, interneuronal transmission, cell membrane integrity and blood coagulation.

CONCEPT MAP

The *s*-Block Elements

Alkali Metals

Physical properties:
In alkali metals, on moving from Li to Cs
(a) atomic or ionic radii increases
(b) density increases
(c) m.p. and b.p. decrease
(d) I.E. decreases
(e) electropositive character increases
(f) electronegativity decreases
(g) hydration energy decreases

Characteristics of alkali metal compounds.
Li forms Li_2O, Na forms Na_2O_2 and others form MO_2
Ionic character, m.p., b.p. thermal stability and solubility increases from LiOH to CsOH decreasing order of hydrolysis
LiCl > NaCl > KCl > RbCl > CsCl
Stability of carbonates and bicarbonates increases from Li to Cs whereas solubilities also increase on descending the group.

Chemical properties:
Li forms monoxide, Na forms peroxide and other metals forms superoxides on reaction with air.

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

$2M + X_2 \longrightarrow 2MX$

$2M + H_2 \longrightarrow 2MH$

Alkali metals are strong reducing agents.
Alkali metals dissolve in NH_3 to give blue, conducting and paramagnetic solution.

Some Important Compounds of Sodium

NaCl: HCl is passed through the filtered solution of crude NaCl.

NaOH: Electrolysis of NaCl in Castner-Kellner cell by using a Hg cathode and Canode.

Na_2CO_3: CO_2 is passed through brine saturated with NH_3. $NaHCO_3$ formed is then heated to give Na_2CO_3

$NaHCO_3$: Saturating a cold solution of Na_2CO_3 with CO_2.

Alkaline Earth Metals

Physical properties
In alkaline earth metals, on moving from Be to Ba:
(a) atomic or ionic radii increases
(b) density increases
(c) m.p. and b.p. decreases
(d) I. E. decreases
(e) electropositive character increases
(f) electronegativity decreases
(g) hydration energy decreases
(h) reducing character increases.

Chemical properties
Be, Mg, Ca and Sr form MO type oxides whereas
Ba and Ra forms peroxides.

$M + 2H_2O \longrightarrow M(OH)_2 + H_2$

$M + X_2 \longrightarrow MX_2$

$M + H_2 \longrightarrow MH_2$

$M + 2HX \longrightarrow MX_2 + H_2$

Alkaline earth metals are also strong reducing agents although weaker than alkali metals.
Alkaline earth metals like alkali metals also get dissolved in NH_3 forming coloured solutions.

Some Important Compounds of Calcium
CaO: By heating limestone at 1070–1270K.
$Ca(OH)_2$: By adding water to quick lime.
$CaSO_4 . 1/2H_2O$: By heating gypsum at 393K
Portland cement: It is essentially a mix full of limestone and clay. Its approximates composition.
CaO 62%, SiO_2 22%, Al_2O_3 7.5%, MgO 2.5% and Fe_2O_3

Characteristics of alkali earth metal compounds
MO are prepared either by heating the metal in O_2 or by decomposing metal carbonate. Solubility, thermal stability and basic character of hydroxides increases on moving down the group, covalent character decreases from $BeCl_2$ to $BaCl_2$. The thermal stability of carbonates, bicarbonates and sulphates increases from Be to Ba

EXERCISE - 1
Conceptual Questions

1. Which of the following represents a correct sequence of reducing power of the following elements?
(a) Li > Cs > Rb (b) Rb > Cs > Li
(c) Cs > Li > Rb (d) Li > Rb > Cs

2. Nitrolium is:
(a) CaC_2 and graphite (b) $CaCN_2$ and graphite
(c) $Ca(CN)_2$ and graphite (d) $CaCN_2 + N_2$

3. The pair whose both species are used in ant- acid medicinal preparations is :
(a) $NaHCO_3$ and $Mg(OH)_2$
(b) Na_2CO_3 and $Ca(HCO_3)_2$
(c) $Ca(HCO_3)_2$ and $Mg(OH)_2$
(d) $Ca(OH)_2$ and $NaHCO_3$

4. Which one of the following properties of alkali metals increases in magnitude as the atomic number rises ?
(a) Ionic radius (b) Melting point
(c) Electronegativity (d) First ionization energy.

5. Largest difference in radii is found in case of the pair
(a) Li, Na (b) Na, K
(c) K, Rb (d) Rb, Cs.

6. Which compound will show the highest lattice energy ?
(a) RbF (b) CsF
(c) NaF (d) KF

7. Strongest bond is in between
(a) CsF (b) NaCl
(c) Both (a) and (b) (d) None of above

8. In crystals which one of the following ionic compounds would you expect maximum distance between centres of cations and anions?
(a) LiF (b) CsF
(c) CsI (d) LiI

9. Among the following components of cement which is present in highest amount?
(a) Ca_2SiO_4 (b) Ca_3SiO_5
(c) Al_2O_3 (d) $Ca_3Al_2O_6$.

10. Which of the following is not correct ?
(a) $2Li_2O \xrightarrow[673k]{heat} Li_2O_2 + 2Li$
(b) $2K_2O \xrightarrow[673k]{heat} K_2O_2 + 2K$
(c) $2Na_2O \xrightarrow[673k]{heat} Na_2O_2 + 2Na$
(d) $2Rb_2O \xrightarrow[673k]{heat} Rb_2O_2 + 2Rb$

11. When potassium dichromate crystals are heated with conc. HCl
(a) O_2 is evolved
(d) chromyl chloride vapours are evolved
(c) Cl_2 is evolved
(d) no reaction takes place

12. Which one of the alkaline earth metals shows some anomalous behaviour and has same electronegativity as aluminium?
(a) Sr (b) Ca
(c) Ba (d) Be

13. Which of the following does not illustrate the anomalous properties of lithium?
(a) The melting point and boiling point of Li are comparatively high
(b) Li is much softer than the other group I metals
(c) Li forms a nitride Li_3N unlike group I metals
(d) The ion of Li and its compounds are more heavily hydrated than those of the rest of the group

14. Which of the following statements is incorrect?
(a) Alkali metal hydroxide are hygroscopic
(b) Dissolution of Alkali metal hydroxide is endothermic
(c) Aqueous solution of alkali metal hydroxides are strongly basic
(d) Alkali metal hydroxides form ionic crystals

15. Which property of sodium is being used in street lights ?
(a) It shows photoelectric effect
(b) It has low melting point
(c) Sodium atom emits photons in the yellow region of visible spectrum, due to electrically stimulated transitions
(d) Sodium vapours show golden colour

16. Which is most basic in character ?
(a) CsOH (b) KOH
(c) NaOH (d) LiOH

17. An inorganic compound which on heating first melts, then solidifies and liberates O_2 gas, the inorganic compound is
(a) Al_2O_3 (b) $KMnO_4$
(c) MnO_2 (d) $KClO_3$

18. Which of the following has density greater than water?
(a) Li (b) Na
(c) K (d) Rb

19. A metal salt solution forms a yellow precipitate with potassium chromate in acetic acid, a white precipitate with dil H_2SO_4, but gives no precipitate with NaCl. The metal salt solution will consist of
(a) $PbCO_3$ (b) $BaCO_3$
(c) $MgCO_3$ (d) $CaCO_3$

20. When sulphur is heated with NaOH (*aq*)? The compounds formed are
(a) $Na_2S + H_2O$
(b) $Na_2SO_3 + H_2O$
(c) $Na_2S + Na_2S_2O_3 + H_2O$
(d) $Na_2S_2O_3 + H_2O$

21. The first (IE_1) and second (IE_2) ionisation energies (kJ/mol) of a few elements designated by Roman numerals are given below. Which of these would be an alkali metal?

		IE_1	IE_2
(a)	I	2372	5251
(b)	II	520	7300
(c)	III	900	1760
(d)	IV	16803	380

22. Washing soda has formula
(a) $Na_2CO_3.7H_2O$ (b) $Na_2CO_3.10H_2O$
(c) $Na_2CO_3.3H_2O$ (d) Na_2CO_3

23. Which of the following is known as fusion mixture ?
(a) Mixture of $Na_2CO_3 + NaHCO_3$
(b) $Na_2CO_3.10H_2O$
(c) Mixture of $K_2CO_3 + Na_2CO_3$
(d) $NaHCO_3$

24. Aqueous solution of sodium carbonate absorbs NO and NO_2 to give
(a) $CO_2 + NaNO_3$ (b) $CO_2 + NaNO_2$
(c) $NaNO_2 + CO$ (d) $NaNO_3 + CO$

25. Mg on heating to redness in an atmosphere of N_2 and then on treating with H_2O gives:
(a) NH_3 (b) N_2
(c) PH_3 (d) MgO

26. Molecular formula of Glauber's salt is :
(a) $MgSO_4.7H_2O$ (b) $CuSO_4.5H_2O$
(c) $FeSO_4.7H_2O$ (d) $Na_2SO_4.10H_2O$

27. A mixture of KCl and KF is added to sodium chloride
(a) to increase the conductivity of NaCl
(b) to decrease the melting point of NaCl
(c) to supress the melting of dissociation of NaCl
(d) to decrease the volatility of NaCl

28. What happens when carbonates of group IA elements are heated?
(a) CO_2 is given out
(b) Water vapours are given out
(c) Carbon dioxide and water vapours are evolved
(d) None of these

29. A well known reagent which contains copper sulphate, sodium potassium tartarate and sodium hydroxide is
(a) Fenton's reagent (b) Schiff's reagent
(c) Fehling's solution (d) Nessler's reagent

30. Baking soda is :
(a) $NaHCO_3$ (b) K_2CO_3
(c) Na_2CO_3 (d) NaOH

31. On strong heating sodium bicarbonate changes into:
(a) sodium monoxide (b) sodium hydroxide
(c) sodium carbonate (d) sodium peroxide

32. Which of the following compounds transforms baking soda into baking powder?
(a) KCl (b) $KHCO_3$
(c) $NaHCO_3$ (d) $KHC_4H_4O_6$

33. A certain metal M is used to prepare an antacid, which is used as a medicine in acidity. This metal accidently catches fire which cannot be put out by using CO_2 based extinguishers. The metal M is
(a) Ca (b) Mg
(c) C (d) All of these

34. Which of the following is commercially known as **oxone** ?
(a) $Na_2O_2 + HCl$ (b) $Na_2O + HCl$
(c) $Na_2O_2 + Na_2$ (d) none of these

35. Which pair cannot exist together in solution ?
(a) $NaHCO_3$ and NaOH (b) $NaHCO_3$ and NaCl
(c) $NaHCO_3$ and Na_2CO_3 (d) NaCl and Na_2CO_3

36. Baking powder contains :
(a) $NaHCO_3$, $Ca(H_2PO_2)_2$ and starch
(b) $NaHCO_3$, $Ca(H_2PO_2)_2$
(c) $NaHCO_3$, starch
(d) $NaHCO_3$

37. Which of the following is used widely in the manufacture of storage battery?
(a) Arsenic (b) Lithium
(c) Bismuth (d) Antimony

38. Alkaline earth's metals are denser than alkali metals, because metallic bonding in alkaline earth's metal, is :
(a) stronger (b) weaker
(c) volatile (d) not present

39. The order of solubility of sulphates of alkaline earth metals in water is
(a) Be > Mg > Ca > Sr > Ba
(b) Mg > Be >> Ba > Ca > Sr
(c) Be > Ca > Mg > Ba >> Sr
(d) Mg > Ca > Ba >> Be > Sr

40. Arrange the following compounds in order of increasing solubility
(i) MgF_2 (ii) CaF_2, (iii) BaF_2
(a) (i) < (ii) < (iii) (b) (ii) < (i) < (iii)
(c) (ii) < (iii) < (ii) (d) (iii) < (ii) < (i)

41. Potassium is kept in:
(a) alcohol (b) water
(c) kerosene (d) liquid ammonia

42. Which of the following atoms will have the smallest size ?
(a) Mg (b) Na
(c) Be (d) Li

43. The solubilities of carbonates decrease down the magnesium group due to a decrease in
(a) hydration energies of cations
(b) inter-ionic attraction
(c) entropy of solution formation
(d) lattice energies of solids

44. Which of the following relations is correct with respect to first (I) and second (II) ionization potentials of sodium and magnesium?
(a) $I_{Mg} = II_{Na}$ (b) $I_{Mg} < II_{Na}$
(c) $I_{Na} > I_{Mg}$ (d) $II_{Na} > II_{Mg}$

45. Epsom salt is
(a) $CaSO_4.2H_2O$ (b) $BaSO_4.2H_2O$
(c) $MgSO_4.2H_2O$ (d) $MgSO_4.7H_2O$

46. Which of the following has maximum ionization energy
(a) $Ba \longrightarrow Ba^+ + e^-$ (b) $Be \longrightarrow Be^+ + e^-$
(c) $Ca \longrightarrow Ca^{2+} + 2e^-$ (d) $Mg \longrightarrow Mg^{2+} + 2e^-$

47. The value of x is maximum for
(a) $MgSO_4.x\,H_2O$
(b) $CaSO_4.x\,H_2O$
(c) $BaSO_4.x\,H_2O$
(d) All have the same value of x.

48. Of the metals Be, Mg, Ca and Sr of group II A. In the periodic table the least ionic chloride would be formed by
(a) Be (b) Mg
(c) Ca (d) Sr

49. Which of the following is the component of most of the kidney stones?
(a) $(COO)_2Ca$ (b) $(COO)_2Ba$
(c) $(COONa)_2$ (d) $(COO)_2Mg$

50. Which one is known as barytes?
(a) $BaSO_4$ (b) $BaCl_2.2H_2O$
(c) BaO (d) $BaCO_3$

51. Which one of the following salts does not impart colour to the flame ?
(a) Kl (b) LiCl
(c) $CaCl_2$ (d) $MgCl_2$

52. The Formula of Mohar's Salt; $FeSO_4(NH_4)_2SO_4 \cdot XH_2O$ the value of X :
(a) 5 (b) 10
(c) 6 (d) 8

53. Which of the following compounds is used in preparation of green fire ?
(a) K_2SO_4 (b) $NaNO_3$
(c) $Ba(NO_3)_2$ (d) None of these

54. Amongst LiCl, RbCl, $BeCl_2$ and $MgCl_2$ the compounds with the greatest and least ionic character respectively are :
(a) LiCl and RbCl (b) $MgCl_2$ and $BeCl_2$
(c) RbCl and $BeCl_2$ (d) RbCl and $MgCl_2$

55. Lithopone is
(a) $BaO + ZnSO_4$ (b) $BaS + ZnSO_4$
(c) $ZnS + BaSO_4$ (d) $ZnO + BaSO_4$

56. Mixture of $MgCl_2$ and MgO is called :
(a) Portland cement (b) Sorel's cement
(c) double salt (d) none of these

57. K_2CS_3 can be called potassium
(a) Sulphocyanide (b) Thiocarbide
(c) Thiocarbonate (d) Thiocyanate

58. Estimation of calcium and magnesium is done by
(a) EDTA (b) oxalate
(c) Phosphate (d) none of these

59. Philosopher's wool on heating with BaO at 1100°C produces:
(a) $Ba + ZnCl_2$ (b) $BaCdO_2$
(c) $BaZnO_2$ (d) $BaO_2 + Zn$

60. Which one of the following processes will produce hard water?
(a) Saturation of water with $MgCO_3$
(b) Saturation of water with $CaSO_4$
(c) Addition of Na_2SO_4 to water
(d) Saturation of water with $CaCO_3$

61. In Solvay ammonia process, sodium bicarbonate is precipitate due to
(a) presence of NH_3
(b) reaction with CO_2
(c) reaction with brine solution
(d) reaction with NaOH

62. In India at the occasion of marriages, the fire works used give green flame. Which one of the following radicals may be present?
(a) Na^+ (b) K^+
(c) Ba^{2+} (d) Ca^{2+}

63. Which one of the following is flourspar?
(a) CaF_2 (b) CaO
(c) H_2F_2 (d) $CaCO_3$

64. Plaster of Paris is :
(a) $CaSO_4.2H_2O$ (b) $CaSO_4.H_2O$
(c) $CaSO_4.\frac{1}{2}H_2O$ (d) $CaSO_4.4H_2O$

65. Gypsum on heating at 120 – 130°C gives :
(a) anhydrous salt (b) hemihydrate
(c) monohydrate (d) dihydrate

66. Plaster of Paris on making paste with little water sets to hard mass due to formation of
(a) $CaSO_4$ (b) $CaSO_4.1/2H_2O$
(c) $CaSO_4.H_2O$ (d) $CaSO_4.2H_2O$

67. Which of the following compounds of cement sets at the slowest rate ?
(a) Dicalcium silicate
(b) Tricalcium silicate
(c) Tricalcium aluminate
(d) Tetracalcium aluminoferrite.

68. The chemical which is used for plastering the broken bones is
(a) $(CaSO_4)_2H_2O$ (b) $MgSO_4.7H_2O$
(c) $FeSO_4.7H_2O$ (d) $CuSO_4.5H_2O$

69. Colemanite is
(a) $Ca[B_3O_4(OH)_2].2H_2O$ (b) $Ca_2B_6O_{11}.5H_2O$
(c) $Ca(OH)_2$ (d) $Na_2B_4O_7.2H_2O$

70. Dead burn plaster is
(a) $CaSO_4.2H_2O$ (b) $MgSO_4.7H_2O$
(c) $CaSO_4.½H_2O$ (d) $CaSO_4$

71. Bone ash contains
(a) CaO (b) $CaSO_4$
(c) $Ca_3(PO_4)_2$ (d) $Ca(H_2PO_4)_2$

72. The wire of flash bulb is made of
(a) Mg (b) Cu
(c) Ba (d) Ag

73. Calcium cynamide is
(a) $CaCHNH_2$ (b) $CaCN_2$
(c) CaC_2N_2 (d) $Ca(CN)_2$

74. Calcium is obtained by
(a) roasting of lime stone
(b) reduction of $CaCl_2$ with carbon
(c) electrolysis of a solution of $CaCl_2$ in water
(d) electrolysis of molten $CaCl_2$

75. Mortar is a mixture of
(a) $CaCO_3$, sand and water
(b) slaked lime and water
(c) slaked lime, sand and water
(d) $CaCO_3$ and CaO

EXERCISE - 2
Applied Questions

1. Lithium can not be stored in kerosene oil because
(a) it is an alkali metal
(b) it reacts with kerosene oil
(c) it floats to the surface of kerosene oil
(d) none of the above is correct

2. Which one out of the NaOH and KOH, is a better absorber of CO_2 ?
(a) NaOH
(b) KOH
(c) both absorb CO_2 equally
(d) can not be predicted

3. Which one of the following has minimum value of cation/anion ratio ?
(a) NaCl (b) KCl
(c) $MgCl_2$ (d) CaF_2

4. All of the following substances react with water. The pair that gives the same gaseous product is
(a) K and KO_2 (b) Na and Na_2O_2
(c) Ca and CaH_2 (d) Ba and BaO_2

5. Which of the following is neither deliquescent nor efflorescent and is used for wool washing ?
(a) NaOH (b) KOH
(c) $NaHCO_3$ (d) $Na_2CO_3.NaCO_3.2H_2O$

6. Among the following oxides, which one is most basic
(a) ZnO (b) MgO
(c) Al_2O_3 (d) N_2O_5

7. Which of the following statement is false ?
(a) Strontium decomposes water readily than beryllium
(b) Barium carbonate melts at a higher temperature than calcium carbonate
(c) Barium hydroxide is more soluble in water than magnesium hydroxide
(d) Beryllium hydroxide is more basic than barium hydroxide.

8. The general formula of an alum is

$M_2SO_4.M_2'(SO_4)_3.24H_2O$

where M is univalent and M′ is a trivalent metal which of the following does not form alum ?
(a) Li (b) Na
(c) K (d) all of these form alum

9. What is the function of potassium nitrate in gun powder ?
(a) It is a sublime substance
(b) It is added to act as instant explosive
(c) It is added to provide oxygen
(d) It reacts with sulphur to form another compound that is highly explosive in nature

10. If NaOH is added to an aqueous solution of Zn^{2+} ions, a white precipitate appears and on adding excess NaOH, the precipitate dissolves. In this solution zinc exists in the :
(a) cationic part
(b) anionic part
(c) both in cationic and anionic parts
(d) there is no zinc left in the solution

11. Among LiI, NaI, KI, the one which is more ionic and more soluble in water is :
(a) KI (b) NaI
(c) LiI (d) None of these

12. A metal M readily forms its sulphate MSO_4 which is water-soluble. It forms its oxide MO which becomes inert on heating. It forms an insoluble hyroxide $M(OH)_2$ which is soluble in NaOH solution. Then M is
(a) Mg (b) Ba
(c) Ca (d) Be

13. In curing cement plasters water is sprinkled from time to time. This helps in
(a) developing interlocking needle-like crystals of hydrated silicates
(b) hydrating sand and gravel mixed with cement
(c) converting sand into silicic acid
(d) keeping it cool

14. On heating anhydrous Na_2CO_3,.....is evolved
(a) CO_2 (b) Water vapour
(c) CO (d) No gas

15. The metals A and B form oxide but B also forms nitride when both burn in air. The A and B are
(a) Cs, K (b) Mg, Ca
(c) Li, Na (d) K, Mg

16. Based on lattice energy and other considerations which one of the following alkali metal chlorides is expected to have the highest melting point
(a) LiCl (b) NaCl
(c) KCl (d) RbCl

17. An aqueous solution of salt 'R' when treated with dil HCl, a colourless gas is given out. The gas so evolved when passed through acidified $KMnO_4$ decolourises $KMnO_4$ solution. The salt 'R' is
(a) Na_2CO_3 (b) $NaClO_3$
(c) $NaNO_2$ (d) Na_2SO_3

18. Which of the following sulphates have the highest solubility in water?
(a) $MgSO_4$ (b) $BaSO_4$
(c) $CaSO_4$ (d) $BeSO_4$

19. On being placed in water, sodium peroxide not only produces an alkaline solution but also some bubbles. If we assume that the peroxide ion picks up two protons from water to produce a compound that can be seen as the dibasic conjugate acid of peroxide ion and then this compound undergoes a redox disproportion.

Using the above information complete the following equation.

$Na_2O_2(s) + H_2O(l) \longrightarrow (A) + (B)$

(A) and (B) are

(a) H_2O_2 and NaOH (b) H_2O and O_2

(c) NaOH and O_2 (d) Na_2O and NaOH

20. The metal X is prepared by the electrolysis of fused chloride. It reacts with hydrogen to form a colourless solid from which hydrogen is released on treatment with water. The metal is :

(a) Ca (b) Al (c) Zn (d) Cu

21. The correct order of radii is –

(a) $Li < Be < Mg$ (b) $H^+ < Li^+ < H^-$

(c) $Mn^{3+} < Mn^{2+} < Mn^{+7}$ (d) $K^+ > Cl^- > S^{2-}$

22. Select the correct statements :

I. Cs+ is more highly hydrated that the other alkali metal ions

II. Among the alkali metals Li, Na, K and Rb, lithium has the highest melting point

III. Among the alkali metals only lithium forms a stable nitride by direct combination with nitrogen

(a) I, II and III (b) I and II

(c) I and III (d) II and III

23. The melting point of lithium (181°C) is just double the melting point of sodium (98°C) because –

(a) down the group, the hydration energy decreases

(b) down the group, the ionization energy decreases

(c) down the group the cohesive energy decreases

(d) None of these

24. Magnesium form Mg^{2+} and Mg^+ because :

(a) ionic radius of Mg(II) is smaller than of Mg(I).

(b) hydration energy of divalent magnesium ion is higher.

(c) magnesium (II) carbonate is insoluble in water.

(d) generally higher oxidation states are preferred by metals.

25. A metal 'M' reacts with N_2 to give a compound 'A' (M_3N). 'A' on heating at high temperature gives back 'M' and 'A'; on reacting with H_2O gives a gas B. 'B' turns $CuSO_4$ solution blue on passing through it. M and B can be

(a) Al and NH_3 (b) Li and NH_3

(c) Na and NH_3 (d) Mg and NH_3

26. Which is not correctly matched

(1) Basic strength $Cs_2O < Rb_2O < K_2O < Na_2O < Li_2O$ of oxides

(2) Stability of $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$ peroxides

(3) Stability of $LiHCO_3 < NaHCO_3 < KHCO_3$ bicarbonates $< RbHCO_3 < CsHCO_3$

(4) Melting point $NaF < NaCl < NaBr < NaI$

(a) 1 and 4 (b) 1 and 3

(c) 1 and 2 (d) 2 and 3

27. On being placed in water, sodium peroxide not only produces an alkaline solution but also some bubbles. If we assume that the peroxide ion picks up two protons from water to produce a compound that can be seen as the dibasic conjugate acid of peroxide ion and then this compound undergoes a redox disproportion.

Using the above information complete the following equation.

$Na_2O_2(s) + H_2O(l) \longrightarrow (A) + (B)$

(A) and (B) are

(a) H_2O_2 and NaOH (b) H_2O and O_2

(c) NaOH and O_2 (d) Na_2O and NaOH

28. $BaSO_4$ is used in the X-ray investigation of intestinal track because it is opaque to X-rays. For this, one adds solid $BaSO_4$ in water to obtain a saturated solution with $BaSO_4$ (s) suspended in saturated solution.

$BaSO_4(solid) \longrightarrow BaSO_4(Soln.)$

$\longrightarrow Ba^{++} + SO_4^{2-}$

However one patient is allergic to Ba^{2+} ions and one has to reduce the concentration of Ba^{2+} ions from the saturated solution. The method adopted for this is :

(a) Heat the system because ionization reaction $BaSO_4 = Ba^{++} + SO_4^{2-}$ is endothermic

(b) Add more $BaSO_4$ solid to the solution

(c) reduce the volume of saturated solution over the solid $BaSO_4$

(d) Add enough Na_2SO_4 to solution so that Ba^{2+} ion can be precipitate due to excess SO_4^{2-}ions.

29. In which of the following the hydration energy is higher than the lattice energy?

(a) $MgSO_4$ (b) $RaSO_4$

(c) $SrSO_4$ (d) $BaSO_4$

30. The alkali metals form salt-like hydrides by the direct synthesis at elevated temperature. The thermal stability of these hydrides decreases in which of the following orders ?

(a) CsH > RbH > KH > NaH > LiH

(b) KH > NaH > LiH > CsH > RbH

(c) NaH > LiH > KH > RbH > CsH

(d) LiH > NaH > KH > RbH > CsH

31. Which of the following oxides is **not** expected to react with sodium hydroxide?

(a) CaO (b) SiO_2

(c) BeO (d) B_2O_3

32. Which of the following alkaline earth metal sulphates has hydration enthalpy higher than the lattice enthalpy?

(a) $CaSO_4$ (b) $BeSO_4$

(c) $BaSO_4$ (d) $SrSO_4$

33. The compound A on heating gives a colourless gas and a residue that is dissolved in water to obtain B. Excess of CO_2 is bubbled through aqueous solution of B, C is formed which is recovered in the solid form. Solid C on gentle heating gives back A. The compound is

(a) $CaSO_4.2H_2O$ (b) $CaCO_3$

(c) Na_2CO_3 (d) K_2CO_3

34. Which of the following compounds has the lowest melting point ?

(a) $CaCl_2$ (b) $CaBr_2$

(c) CaI_2 (d) CaF_2

35. Which one of the following is present as an active ingredient in bleaching powder for bleaching action ?

(a) $CaOCl_2$ (b) $Ca(OCl)_2$

(c) CaO_2Cl (d) $CaCl_2$

36. Which of the following statements is **incorrect**?

(a) Pure sodium metal dissolves in liquid ammonia to give blue solution.

(b) NaOH reacts with glass to give sodium silicate

(c) Aluminium reacts with excess NaOH to give $Al(OH)_3$

(d) $NaHCO_3$ on heating gives Na_2CO_3

37. Match List – I with List –II for the compositions of substances and select the correct answer using the code given below the lists :

List - I	**List - II**
Substances	**Composition**
(A) Plaster of paris	(i) $CaSO_4.2H_2O$
(B) Epsomite	(ii) $CaSO_4.\frac{1}{2}H_2O$
(C) Kieserite	(iii) $MaSO_4.7H_2O$
(D) Gypsum	(iv) $MgSO_4.H_2O$
	(v) $CaSO_4$

Code :

	(A)	(B)	(C)	(D)
(a)	(iii)	(iv)	(i)	(ii)
(b)	(ii)	(iii)	(iv)	(i)
(c)	(i)	(ii)	(iii)	(v)
(d)	(iv)	(iii)	(ii)	(i)

38. Equimolar solutions of the following substances were prepared separately. Which one of these will record the highest pH value ?

(a) $BaCl_2$ (b) $AlCl_3$

(c) LiCl (d) $BeCl_2$

39. The ease of adsorption of the hydrated alkali metal ions on an ion-exchange resins follows the order :

(a) $Li^+ < K^+ < Na^+ < Rb^+$

(b) $Rb^+ < K^+ < Na^+ < Li^+$

(c) $K^+ < Na^+ < Rb^+ < Li^+$

(d) $Na^+ < Li^+ < K^+ < Rb^+$

40. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it

(a) absorbs CO_2 and increases O_2 content

(b) eliminates moisture

(c) absorbs CO_2

(d) produces ozone.

41. The products obtained on heating $LiNO_2$ will be :

(a) $Li_2O + NO_2 + O_2$ (b) $Li_3N + O_2$

(c) $Li_2O + NO + O_2$ (d) $LiNO_3 + O_2$

42. What is the best description of the change that occurs when $Na_2O(s)$ is dissolved in water ?

(a) Oxide ion accepts sharing in a pair of electrons

(b) Oxide ion donates a pair of electrons

(c) Oxidation number of oxygen increases

(d) Oxidation number of sodium decreases

43. Which of the following on thermal decomposition yields a basic as well as acidic oxide ?

(a) $NaNO_3$ (b) $KClO_3$

(c) $CaCO_3$ (d) NH_4NO_3

44. The sequence of ionic mobility in aqueous solution is :

(a) $K^+ > Na^+ > Rb^+ > Cs^+$ (b) $Cs^+ > Rb^+ > K^+ > Na^+$

(c) $Rb^+ > K^+ > Cs^+ > Na^+$ (d) $Na^+ > K^+ > Rb^+ > Cs^+$

45. Property of the alkaline earth metals that increases with their atomic number is

(a) solubility of their hydroxides in water

(b) solubility of their sulphates in water

(c) ionization energy

(d) electronegativity

DIRECTIONS for Qs. 46 to 50 : These are Assertion-Reason type questions. Each of these question contains two statements : Statement-1 (Assertion) and Statement-2 (Reason). Answer these questions from the following four options.

(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

46. **Statement-1 :** Potassium and caesium are used in photoelectric cells.

Statement-2 : Potassium and caesium emit electrons on exposure to light.

47. **Statement-1 :** LiCl is predominantly a covalent compound.

Statement-2 : Electronegativity difference between Li and Cl is too small.

48. **Statement-1 :** Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.

Statement-2 : Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.

49. **Statement-1 :** Mg continue to burn in nitric oxide

Statement-2 : During burning, heat evolved do not decompose NO.

50. **Statement-1 :** Superoxides of alkali metals are paramagnetic.

Statement-2 : Superoxides contain the ion O^{2-} which has one unpaired electron.

EXERCISE - 3
Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

1. The alkali metals are low melting. Which of the following alkali metal is expected to melt if the room temperature rises to 30°C?
(a) Na (b) K
(c) Rb (d) Cs

2. Alkali metals react with water vigorously to form hydroxides and dihydrogen. Which of the following alkali metals reacts with water least vigorously?
(a) Li (b) Na
(c) K (d) Cs

3. The reducing power of a metal depends on various factors. Suggest the factor which makes Li, the strongest reducing agent in aqueous solution.
(a) Sublimation enthalpy
(b) Ionisation enthalpy
(c) Hydration enthalpy
(d) Electron–gain enthalpy

4. Metal carbonates decompose on heating to give metal oxide and carbon dioxide. Which of the metal carbonates is most stable thermally?
(a) $MgCO_3$ (b) $CaCO_3$
(c) $SrCO_3$ (d) $BaCO_3$

5. Which of the following carbonates given below is unstable in air and is kept in CO_2 atmosphere to avoid decomposition?
(a) $BeCO_3$ (b) $MgCO_3$
(c) $CaCO_3$ (d) $BaCO_3$

6. Metals form basic hydroxides. Which of the following metal hydroxide is the least basic?
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Sr(OH)_2$ (d) $Ba(OH)_2$

7. Some of the Group 2 metal halides are covalent and soluble in organic solvents. Among the following metal halides, the one which is soluble in ethanol is
(a) $BeCl_2$ (b) $MgCl_2$
(c) $CaCl_2$ (d) $SrCl_2$

8. The order of decreasing ionisation enthalpy in alkali metals is
(a) Na > Li > K > Rb (b) Rb < Na < K < Li
(c) Li > Na > K > Rb (d) K < Li < Na < Rb

9. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of Li in water is due to
(a) ionic nature of lithium fluoride
(b) high lattice enthalpy
(c) high hydration enthalpy for lithium ion
(d) low ionisation enthapy of lithium atom

10. Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?
(a) $Be(OH)_2$ (b) $Mg(OH)_2$
(c) $Ca(OH)_2$ (d) $Ba(OH)_2$

11. In the synthesis of sodium carbonate, the recovery of ammonia is done by treating NH_4Cl with $Ca(OH)_2$. The by – product obtained in this process is
(a) $CaCl_2$ (b) NaCl
(c) NaOH (d) $NaHCO_3$

12. When sodium is dissolved in liquid ammonia, a solution of deep blue colour is obtained. The colour of the solution is due to
(a) ammoniated electron (b) sodium ion
(c) sodium amide (d) ammoniated sodium ion

13. By adding gypsum to cement
(a) setting time of cement becomes less
(b) setting time of cement increases
(c) colour of cement becomes light
(d) shining surface is obtained

14. Dead burnt plaster is
(a) $CaSO_4$ (b) $CaSO_4.\frac{1}{2}H_2O$
(c) $CaSO_4.H_2O$ (d) $CaSO_4.2H_2O$

15. Suspension of slaked lime in water is known as
(a) lime water
(b) quick lime
(c) milk of lime
(d) aqueous solution of slaked lime

16. Which of the following elements does not form hydride by direct heating with dihydrogen?
(a) Be (b) Mg
(c) Sr (d) Ba

17. The formula of soda ash is
(a) $Na_2CO_3.10H_2O$ (b) $Na_2CO_3.2H_2O$
(c) $Na_2CO_3.H_2O$ (d) Na_2CO_3

18. A substance which gives brick red flame and breaks down on heating to give oxygen and a brown gas is
(a) magnesium nitrate (b) calcium nitrate
(c) barium nitrate (d) strontium nitrate

19. Which of the following statements is true about $Ca(OH)_2$?
(a) It is used in the preparation of bleaching powder.
(b) It is a light blue solid.
(c) It does not possess disinfectant property.
(d) It is used in the manufacture of cement.

20. A chemical 'A' is used for the preparation of washing soda to recover ammonia.When CO_2 is bubbled through an aqueous solution of 'A', the solution turns milky. It is used in white washing due to disinfectant nature. What is the chemical formula of 'A'?
(a) $Ca(HCO_3)_2$ (b) CaO
(c) $Ca(OH)_2$ (d) $CaCO_3$

21. Dehydration of hydrates of halides of calcium, barium and strontium i.e., $CaCl_2.6H_2O$, $BaCl_2.2H_2O$, $SrCl_2.2H_2O$ can be achieved by heating. These become wet on keeping in air. Which of the following statements is correct about these halides?

(a) Act as dehydrating agent
(b) Can absorb moisture from air
(c) Tendency to form hydrate decreases form calcium to barium
(d) All of the above

NEET/AIPMT (2013-2017) Questions

22. In Castner-Kellner cell for production of sodium hydroxide: ***[NEET Kar. 2013]***

(a) Brine is electrolyzed with Pt electrodes
(b) Brine is electrolyzed using graphite electrodes
(c) Molten sodium chloride is electrolysed
(d) Sodium amalgam is formed at mercury cathode

23. Solubility of the alkaline earth's metal sulphates in water decreases in the sequence :- ***[2015]***

(a) Ca > Sr > Ba > Mg (b) Sr > Ca > Mg > Ba
(c) Ba > Mg > Sr > Ca (d) Mg > Ca > Sr > Ba

24. The function of "Sodium pump" is a biological process operating in each and every cell of all animals. Which of the following biologically important ions is also a consituent of this pump : ***[2015]***

(a) Mg^{2+} (b) K^+
(c) Fe^{2+} (d) Ca^{2+}

25. On heating which of the following releases CO_2 most easily ? ***[2015 RS]***

(a) K_2CO_3 (b) Na_2CO_3
(c) $MgCO_3$ (d) $CaCO_3$

26. Which of the following statements is false ? ***[2016]***

(a) Mg^{2+} ions form a complex with ATP
(b) Ca^{2+} ions are important in blood clotting
(c) Ca^{2+} ions are not important in maintaining the regular beating of the heart.
(d) Mg^{2+} ions are important in the green parts of plants.

Hints & Solutions

EXERCISE - 1

1. (a) A reducing agent is a substance which can loose electron and hence a reducing agent should have low ionisation energy. Now since ionisation energy decreases from Li to Cs, the reducing property should increase from Li to Cs. The only exception to this is lithium. This is because the net process of converting an atom to an ion takes place in 3 steps.
   (i) $M(s) \rightarrow M(g)$ ΔH = Sublimation energy
   (ii) $M(g) \rightarrow M^+(g) + e^-$ ΔH = Ionisation energy
   (iii) $M^+(g) + H_2O \rightarrow M^+(aq)$ ΔH = Hydration energy
   The large amount of energy liberated in hydration of Li (because of its small size) makes the overall ΔH negative. This accounts for the higher oxidation potential of lithium i.e., its high reducing power.
2. (b) Nitrolim is $CaCN_2 + C$. It is used as fertilizer since it reacts with H_2O to form NH_3.
   $$CaCN_2 + 3H_2O \longrightarrow CaCO_3 + 2NH_3.$$
3. (a) $NaHCO_3$ is used in medicine to neutralise the acidicty in the stomach. $Mg(OH)_2$ is basic in nature and dissolves in acids forming corresponding salts. So both are used in antacid medicinal preparations.
4. (a) Within a group, ionic radius increases with increase in atomic number. The melting points decrease down the group due to weakening of metallic bond. The electronegativity and the 1st ionization energy also decreases down the group.
5. (b) Radii of atoms increase as we go down the group due to the addition of extra energy shell. Nuclear charge also increases on moving down the group but the influence of addition of energy shell predominates. This predomination is larger in case when we move from Na to K among all the options given.
6. (c) With the same anion, smaller the size of the cation, higher is the lattice energy. The correct order of size of cations is –
   $$Na^+ < K^+ < Rb^+ < Cs^+$$
   Hence, the lattice energy of NaF will be maximum. i.e., NaF.
7. (a) According to Fajan rules, ionic character increases with increase in size of the cation and decrease in size of the anion. Thus, CsF has higher ionic character than NaCl and hence bond in CsF is stronger than in NaCl.
8. (c) As Cs^+ ion has larger size than Li^+ and I^- has larger size than F^-, therefore maximum distance between centres of cations and anions is in CsI.
9. (b) Composition of cement depends upon its type. Portland cement is most common kind and contains 51% tricalcium silicate, 24% of dicalcium silicate and 6% of tricalcium aluminate.
10. (a) Lithium does not form peroxide.
11. (c)
12. (d) Be shows diagonal relationship with Al
13. (b) Li is much softer than the other group I metals. Actually Li is harder then other alkali metals
14. (b) During the dissolution of alkali metal hydrides energy is released in large amount, i.e., it is exothermic in nature.
15. (c) The property of sodium atom to emit photons in yellow region of visible spectrum, due to electrically stimulated electron transitions is used in street lights.
16. (a) Since the ionization energies of alkali metals decrease down the group, the ionic character and consequently basic property of their hydroxides increases in the same order, i.e. from LiOH to CsOH.
17. (d) $\underset{\text{solid}}{2KClO_3} \xrightarrow[\text{melts}]{\text{heat}} \underset{\text{solid}}{2KCl} + 3O_2$
18. (d) Li, Na, K are lighter than water but Rb is heavier than water.
19. (b) $BaCO_3$ forms a yellow ppt of barium chromate. $BaCO_3$ forms a white precipitate of $BaSO_4$. $BaCl_2$ is soluble in water.
20. (c) $4S + 6NaOH \rightarrow Na_2S_2O_3 + 2\ Na_2S + 3H_2O$
21. (b) As outermost electronic configuration of alkali metals is ns^1 and also their size are largest in their respective periods so their 1st I.E will be lowest among the given options. As second electron is to be removed from complete shell or noble gas core, so the IInd I.E. must be highest among the given options. So, option (b) is correct choice.
22. (b) Washing soda is $Na_2CO_3 . 10\ H_2O$.
23. (c) Mixture of K_2CO_3 and Na_2CO_3 is called fusion mixture
24. (b) $Na_2CO_3 + NO + NO_2 \rightarrow 2NaNO_2 + CO_2$
25. (a) Magnesium on heating to redness in an atmosphere of N_2 gives magnesium nitride.
    $$3Mg + N_2 \xrightarrow{\Delta} Mg_3N_2$$
    Then magnesium nitride is rapidly hydrolysed by water to give magnesium hydroxide and ammonia.
    $$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$$
26. (d) Glauber's salt is $Na_2SO_4 . 10\ H_2O$.
27. (b)
28. (d) Carbonates of group IA are fairly stable and will melt before they eventually decompose into oxides at temperature above 1000°C. Li_2CO_3 is considerably less stable than other carbonates of group 1A and on decomposition by heating, it gives CO_2.
    $Li_2CO_3 \longrightarrow Li_2O + CO_2$
    So, option (d) is more probable.
29. (c) Fehling's solution is a mixture of Alk. $CuSO_4 + Na - K$ tartarate (Rochelle salt)
30. (a) $NaHCO_3$ (baking soda) is one of the major constituents of baking powder.
31. (c) Sodium bicarbonate on heating changes into sodium carbonate by the loss of CO_2 and H_2O.
    $$\underset{\text{Sodium bicarbonate}}{2NaHCO_3} \xrightarrow{\Delta} \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O + CO_2$$
32. (d)
33. (b) Magnesium hydroxide is used to prepare an antacid which is used as medicine. Hence, the metal M is Mg.

34. (a) (Na_2O_2 + HCl) is commercially known as oxone and is used for bleaching of delicate fibres.
35. (a) $NaHCO_3$ and NaOH cannot exist together. $NaHCO_3$ being acid salt will react with alkali to from normal salt.
36. (a) Baking powder has starch, $NaHCO_3$ and $Ca(H_2PO_2)_2$.
37. (d) Lithium is widely used in the manufacture of storage battery.
38. (a) Metallic bonding in alkaline earth's metals is stronger because of larger number of electrons in the outer shell in alkaline earth's metal atoms.
39. (a)
40. (b) $BaF_2 > MgF_2 > CaF_2$
41. (c) Potassium is kept in kerosene as it is highly reactive and reacts with all other options given above namely alcohol forming alkoxide, water forming hydroxide and ammonia forming a complex but does not react with kerosene.
42. (c) Within a period, the size decreases from left to right, i.e., Na > Mg > Li > Be. Atomic size increases down the group.
43. (a) As we move down the group, the lattice energies of carbonates remain approximately the same. However the hydration energies of the metal cation decreases from Be^{++} to Ba^{++}, hence the solubilities of carbonates of the alkaline earth metal decrease down the group mainly due to decreasing hydration energies of the cations from Be^{++} to Ba^{++}.
44. (d) The IInd ionisation potential of Na is higher than Mg because it requires more energy to remove an electron from a saturated shell or stable (fully filled) orbital.

$$_{11}Na \longrightarrow 1s^2, 2s^2\,2p^6, 3s^1 \xrightarrow{I}$$

$$1s^2, 2s^2\,2p^6, 3s^0 \xrightarrow{II} 1s^2, 2s^2\,2p^5, 3s^0$$

$$_{12}Mg \longrightarrow 1s^2, 2s^2\,2p^6, 3s^2 \xrightarrow{I}$$

$$1s^2, 2s^2\,2p^6, 3s^1 \xrightarrow{II} 1s^2, 2s^2\,2p^6, 3s^0$$

Here Na-I < Mg-I and Na-II > Mg-II.
Option (d) is correct.

45. (d) 46. (d)
47. (a) Because of smaller size, Mg^{2+} ions are extensively hydrated.
48. (a) Because of small atomic size and high I.E. Be forms covalent chloride.
49. (a) 50. (a)
51. (d) Halides of group I and II impart characteristic colour to the flame due to low IE of the central atom. However, ionization energy of Be and Mg atoms is high due to their small size, hence they can't be excited to higher levels by Bunsen burner flame. Thus, their halides don't impart colour to flame.
52. (c) The Mohr's salt is represented by the molecular formula $FeSO_4(NH_4)_2SO_4.6H_2O$.
Hence, it has six molecules of water.
53. (c) $Ba(NO_3)_2$ is used in preparation of green fire.
54. (c) According to Fajan's rule,
Size of cation $\propto$ Ionic character.
Recall that size of metal (ion) increases while going down the group, and decreases on crossing the periods from left to right. Thus Rb^+ (group I) is largest and Be^{2+} (group II) is smallest in size. Hence RbCl has greatest, and $BeCl_2$ has lowest ionic character.
55. (c) ZnS + $BaSO_4$ is lithopone. It is used as white pigment.
56. (b) Mixture of MgO and $MgCl_2$ is called Sorel's cement. It is used for making magnesia cement.
57. (c) In K_2CO_3 replacement of O by S gives K_2CS_3 which is called potassium thiocarbonate.
58. (a) Calcium and magnesium are estimated by EDTA.
59. (c) Philosopher's wool is ZnO

$$ZnO + BaO \xrightarrow{1100^\circ C} BaZnO_2$$

60. (b) Permanent hardness of water is due to chlorides and sulphates of calcium and magnesium i.e $CaCl_2$, $CaSO_4$, $MgCl_2$ and $MgSO_4$.
61. (c) $NH_4HCO_3 + \underset{\text{Brine}}{NaCl} \longrightarrow \underset{\text{Sod. bicarbonate ppt.}}{NaHCO_3\downarrow} + NH_4Cl$
62. (c) 63. (a)
64. (c) Chemically plaster of Paris is $CaSO_4.1/2H_2O$.
65. (b) $CaSO_4 \cdot 2H_2O \xrightarrow{120^\circ C} CaSO_4 \cdot \frac{1}{2}H_2O$
Plaster of Paris is hemihydrate.
66. (d) Plaster of Paris ($CaSO_4 \cdot \frac{1}{2} H_2O$) on making paste with little water sets to a hard mass due to formation of gypsum ($CaSO_4.2H_2O$).

$$\underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2} H_2O} + \frac{3}{2} H_2O \rightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O} + \text{Heat}$$

67. (a) Dicalcium silicate $2CaO.SiO_2$ contains more SiO_2 as compared to tricalcium silicate $3CaO.SiO_2$. Therefore, it has slow setting rate.
68. (a) $(CaSO_4)_2.H_2O$ – Plaster of paris is used for plastering the broken bones.
69. (b) Colemanite is a mineral of boron having composition as $Ca_2B_6O_{11}.5H_2O$
70. (d) 71. (c) 72. (a) Mg. 73. (b)
74. (d) $CaCl_2 \rightarrow \underset{\text{Cathode}}{Ca^{+2}} + \underset{\text{Anode}}{2Cl^-}$
Cathode : $Ca^{+2} + 2e^- \rightarrow Ca$
Anode : $2Cl^- \rightarrow 2e^- + Cl_2$
75. (c)

EXERCISE - 2

1. (c) Because of its very low density lithium floats to the surface of kerosene oil.
2. (b) KOH is better absorber of CO_2 because K_2CO_3 formed is more soluble and does not separate out.
3. (c) Atomic size of $K^+ > Ca^{2+} > Mg^{2+}$ and that of $Cl^- > F^-$. Therefore, Mg^{2+}/Cl^- ratio has the minimum value.
4. (c) Ca and CaH_2 both react with H_2O to form H_2 gas,

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$$

$$CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + 2H_2$$

whereas K gives H_2 while KO_2 gives O_2 and H_2O_2

$$2K + 2H_2O \longrightarrow 2KOH + H_2$$

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

Similarly, Na gives H_2 while Na_2O_2 gives H_2O_2

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$

$$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$$

Likewise Ba gives H_2 while BaO_2 gives H_2O_2

$Ba + 2H_2O \longrightarrow Ba(OH)_2 + H_2$

$BaO_2 + 2H_2O \longrightarrow Ba(OH)_2 + H_2O_2$

5. (d) Sodium sesquicarbonate ($Na_2CO_3.NaCO_3.2H_2O$) is neither deliquescent nor efflorescent and is used for wool washing.
6. (b) MgO. N_2O_5 is strongly acidic, ZnO and Al_2O_3 are amphoteric, therefore, MgO is most basic.
7. (d) $Be(OH)_2$ is amphoteric, but the hydroxides of other alkaline earth metals are basic. The basic strength increases gradually.
8. (a) Li does not form alum because of its small size.
9. (c) KNO_3 is included in gun powder to provide a supply of oxygen.
10. (b) $Zn^{2+} + 2NaOH \longrightarrow 2Na^+ + Zn(OH)_2$

$Zn(OH)_2 + 2NaOH \longrightarrow Na_2ZnO_2 + 2H_2O$

Thus Na_2ZnO_2 forms $2Na^+$ and $[ZnO_2]^{2-}$ ions.
11. (a) Larger cation (K^+) develops less polarisation in anion and thus KI has more ionic nature and more soluble in water.
12. (d) Sulphate of alkaline earth metal are sparingly soluble or almost not soluble in water whereas $BeSO_4$ is soluble in water due to high degree of solvation. $Be(OH)_2$ is insoluble in water but soluble in NaOH.
13. (a) Setting of cement is exothermic process which develops interlocking crystals of hydrated silicates
14. (d) Anhydrous form of Na_2CO_3 does not decompose on heating even to redness. It is a amorphous powder called soda ash.
15. (d) K and Mg, both form oxides

$$K + O_2 \rightarrow KO_2; 2Mg + O_2 \rightarrow 2MgO$$

Mg form nitride also $3Mg + N_2 \rightarrow Mg_3N_2$

K does not form nitride.
16. (b) Although lattice energy of LiCl is higher than NaCl but LiCl is covalent in nature and NaCl ionic there after, the melting point decreases as we move towards NaCl because the lattice energy decreases as a size of alkali metal atom increases (lattice energy α melting point of alkali metal halide)
17. (d) Since 'R' gives a colourless gas on reaction with dil HCl, so it contains CO_3^{2-} or SO_3^{2-} as anion (i.e., CO_2 or SO_2 is evolved)

Since the gas decolourises acidified $KMnO_4$ solution so it is SO_2 and thus the anion present is SO_3^{2-} i.e., the salt 'R' is Na_2SO_3.
18. (d) $BeSO_4$ is most soluble because hydration energy is more than lattice energy.

$$\xrightarrow[\text{Hydration energy decreases hence, solubility decreases.}]{BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4}$$
19. (c) From the given information, we can see that the reaction proceeds via formation of H_2O_2 (which is diabasic conjugate acid of peroxide ion), H_2O_2 then disproportionates into water and oxygen.

$Na_2O_2(s) + H_2O(\ell) \longrightarrow 2NaOH(aq) + H_2O_2(aq)$

$H_2O_2(aq) \longrightarrow H_2O(\ell) + \frac{1}{2}O_2(g)$

Thus over all reaction is

$Na_2O_2(s) + H_2O(\ell) \longrightarrow 2NaOH(aq) + \frac{1}{2}O_2(g)$

20. (a) $Ca + H_2 \longrightarrow CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + H_2$
21. (b) H^+ cation is smaller than parent H-atom. H^- and Li^+ are isoelectronic species so Li^+ with higher nuclear charge (i.e. 3) will be smaller than H^- having smaller nuclear charge (i.e. 1).
22. (d) Amongst alkali metal Li ions are highly hydrated.
23. (c) The atom becomes larger on descending the group, so the bonds becomes weaker (metallic bond), the cohesive force/energy decreases and accordingly melting point also decreases.
24. (b) Statement (b) is correct.
25. (b) From the given data 'M' is a metal from group 1 as it forms M_3N. Since on heating to high temperature, M_3N gives back the metal 'M' the metal is most likely to be Li.

Writing various reactions

$$\underset{\text{'M'}}{6Li} + N_2 \rightarrow \underset{\text{'A'}}{2Li_3N} \xrightarrow{\text{Heat}} 6Li$$

$$Li_3N + 3H_2O \rightarrow 3LiOH + \underset{\text{'B'}}{NH_3(g)}$$

$$CuSO_4 + 4NH_3(g) \rightarrow \underset{\text{Blue solution}}{[Cu(NH_3)_4]SO_4}$$

Thus M is Li and B is $NH_3(g)$.
26. (a) Basic strength of the oxides increase in the order $Li_2O < Na_2O < K_2O < Rb_2O < Cs_2O$. The increase in basic strength is due to the decrease in I.E. and increase in electropositive character.

The melting points of the halides decrease in the order NaF > NaCl > NaBr > NaI, as the size of the halide ion increases. The decrease in melting point is due to increase in the covalent character with increase in the size of anion according to Fajan's rule.
27. (c) From the given information, we can see that the reaction proceeds via formation of H_2O_2 (which is diabasic conjugate acid of peroxide ion), H_2O_2 then disproportionates into water and oxygen.

$Na_2O_2(s) + H_2O(\ell) \longrightarrow 2NaOH(aq) + H_2O_2(aq)$

$H_2O_2(aq) \longrightarrow H_2O(\ell) + \frac{1}{2}O_2(g)$

Thus over all reaction is

$Na_2O_2(s) + H_2O(\ell) \longrightarrow 2NaOH(aq) + \frac{1}{2}O_2(g)$

28. (d) To reduce the concentration of Ba^{+2} ions, add enough Na_2SO_4 to solution. As the concentration of SO_4^{--} increases, Ba^{+2} combine with SO_4^{--} and are precipitated.
29. (a) In alkaline earth metals ionic size increases down the group. The lattice energy remains constant because sulphate ion is so large, so that small change in cationic sizes do not make any difference. On moving down the group the degree of hydration of metal ions decreases very much leading to decrease in solubility

$\therefore$ $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

30. (d) The stability of alkali metal hydrides decreases from Li to Cs. It is due to the fact that M–H bonds become weaker with increase in size of alkali metals as we move down the group from Li to Cs. Thus the order of stability of hydrides is
LiH > NaH > KH > RbH > CsH
i.e. option (d) is correct answer.

31. (a) NaOH is a strong alkali. It combines with acidic and amphoteric oxides to form salts. Since CaO is a basic oxide hence does not reacts with NaOH.

32. (b) Be^{2+} is very small, hence its hydration enthalpy is greater than its lattice enthalpy

33. (b) $\underset{\text{A}}{CaCO_{3(s)}} \xrightarrow{\Delta} \underset{\text{colourless}}{CO_{2(g)}} \uparrow + \underset{\text{B}}{CaO_{(s)}}$

$\underset{\text{B}}{CaO_{(s)}} + H_2O \longrightarrow Ca(OH)_{2(aq)}$

$Ca(OH)_2 + 2CO_2 \longrightarrow \underset{\text{C}}{Ca(HCO_3)_{2(aq)}}$

$Ca(HCO_3)_{2(s)} \longrightarrow \underset{\text{A}}{CaCO_{3(s)}} + CO_{2(g)} + H_2O_{(g)}$

$\therefore$ Correct choice : (b)

34. (c) Melting points of halides decreases as the size of the halogen increases. The correct order is
$CaF_2 > CaCl_2 > CaBr_2 > CaI_2$

35. (b) Active ingredient in bleaching powder for bleaching action is $Ca(OCl)_2$

36. (c) $2Al(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow \underset{\text{sod. meta aluminate}}{2NaAlO_2} + 3H_2$

37. (b) (A) Plaster of paris $= CaSO_4.\frac{1}{2}H_2O$
(B) Epsomite $= MgSO_4.7H_2O$
(C) Kieserite $= MgSO_4.H_2O$
(D) Gypsum $= CaSO_4.2H_2O$

38. (a) ($AlCl_3$, LiCl & $BeCl_2$)) all these solutions are acidic due to cationic hydrolysis, whereas $BaCl_2$, is salt of strong base and strong acid, hence its solution will almost neutral i.e., pH $\approx$ 7.

39. (b) All alkali metal salts are ionic (except Lithium) and soluble in water due to the fact that cations get hydrated by water molecules. The degree of hydration depends upon the size of the cation. Smaller the size of a cation, greater is its hydration energy.
Relative ionic radii : $Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$
Relative degree of hydration:
$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

40. (a) $4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$.
KO_2 is used as an oxidising agent. It is used as air purifier in space capsules. Submarines and breathing masks as it produces oxygen and remove carbon dioxide.

41. (a) $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

42. (b)

43. (c) Calcium carbonate on thermal decomposition gives CaO (Basic oxide) and CO_2 (Acidic oxide)

$CaCO_3 \xrightarrow{\Delta} \underset{\text{Basic oxide}}{CaO} + \underset{\text{Acidic oxide}}{CO_2}\uparrow$

44. (b) Smaller the ion more is its ionic mobility in aqueous solution. Ionic radii of the given alkali metals is in the order $Na^+ < K^+ < Rb^+ < Cs^+$ and thus expected ionic mobility will be in the order $Cs^+ < Rb^+ < K^+ < Na^+$. However due to high degree of solvation (or hydration) because of lower size or high charge density, the hydrated ion size follows the order $Cs^+ < Rb^+ < K^+ < Na^+$ and thus conductivity order is $Cs^+ > Rb^+ > K^+ > Na^+$ i.e. option (b) is correct answer.

45. (a) Lattice energy decreases more rapidly than hydration energy for alkaline earth metal hydroxides. On moving down a group $\therefore$ solubility of their hydroxides increases.

Sol. For Qs. 46-50
The thermal stabilities of carbonates increase down the group due to increase in metallic character i.e. electropositive character. Further bigger cation stabilises bigger anion through crystal lattice energy effect.
Solution of alkali in liquid ammonia has high electrical conductivity due to the presence of ammoniated electrons.

$M + (x + y)NH_3 \longrightarrow [M(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$

Sodium carbonate is prepared by solvay process not potassium carbonate, as $KHCO_3$ is quite soluble in water.

46. (a) K and Cs emit electrons on exposure of light due to low ionisation potential.

47. (c) Statement-1 is true but statement-2 is false.
Due to high polarizing power of Li^+, LiCl is a covalent compound.

48. (b) Sulphate is estimated as $BaSO_4$ because Ba^{2+} being larger ion is hydrated to a lesser extent hence it has high lattice energy group.

49. (c) When Mg is burnt in nitric oxide, it continue to burn because during burning the heat evolved decompose NO to N_2 and O_2. Oxygen thus, produced helps Mg to burn.

50. (a) Presence of unpaired electrons in superoxides of alkali metals make them paramagnetic.

EXERCISE - 3

Exemplar Questions

1. (d) Alkali metals have low melting and boiling points. The melting point of alkali metals decreases from Li to Cs as cohesive force decreases with increase in atomic size.

2. (a) The reactivity of alkali metals with water increases on moving down the group from Li to Cs due to increase in electropositive character.

3. (c) Reducing character is measured by tendency of an element to lose electron in aqueous solution. Higher the negative E°_{RP} value, greater is the ability to lose electrons.
E°_{RP} depends on:
(i) enthalpy of sublimation
(ii) ionisation of enthalpy
(iii) enthalpy of hydration
Thus, in aqueous medium, order of reactivity of alkali metals is Na < K < Rb < Cs < Li. E°_{RP} value of Li is least (–3.04 V) among all alkali metals.

The formation of Li^+ (aq) from Li involves following steps:

(i) $Li(s) \xrightarrow{\text{Sublimation}} Li(g)$;
ΔH_s = Enthalpy of sublimation

(ii) $Li(g) \longrightarrow Li^+(s)$; IE_1 = Ionisation enthalpy

(iii) $Li^+(g) \longrightarrow Li^+(aq)$; ΔH_n = Enthalpy of hydration

For alkali metals, enthalpies of sublimation are almost same. IE_1 value of Li is positive & highest and hydration enthalpy is negative and maximum for smallest Li^+ which makes it strongest reducing agent.

4. (d) $BaCO_3$ is thermally most stable due to the small size of resulting oxide ion. As the atomic number increases the stability of the metal ion decreases hence, stability of carbonates increases.

5. (a) $BeCO_3$ is unstable due to high polarising power of smallest Be^{2+} ion. Also, it shows reversible reaction, because of more stability of oxide formed. Hence, $BeCO_3$ has least stability and it is stable only in CO_2 atmosphere.

6. (a) The basic character of the given hydroxides increases down the group due to decrease in ionization enthalpies. On moving down the group, the ionic size increases, so M–O bond in metal hydroxides gets weaker and easily gives OH^- in the solution and I.E. further decreases. Hence, $Mg(OH)_2$ will be least basic. The order of basicity will be:
$Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

7. (a) Ethanol is a covalent compound and only a compound which has more covalent character can be dissolved in it. Also the group ionic character increases and beryllium halide have covalent character due to its small size and high effective nuclear charge. Hence, among the given halides, $BeCl_2$ can be soluble in ethanol.

8. (c) On moving down the group from Li to Rb increased screening effect makes the removal of electron easier. Thus, the order of decreasing ionization enthalpy will be: Li > Na > K > Rb

9. (b) Among fluorides, the order of solubility is LiF < NaF < KF < RbF < CsF. On moving down the group solubility increases because lattice energy decreases.
Also, LiF exhibit very high lattice energy.

10. (a) $Be(OH)_2$ is an amphoteric hydroxide thus gets dissolve both in acids and alkalies.
Basic nature :

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

Acidic nature:

$$Be(OH)_2 + 2NaOH \longrightarrow \underset{\text{Sodium beryllate}}{Na_2BeO_2} + 2H_2O$$

11. (a) Sodium carbonate can be synthesised by Solvay ammonia soda process.
The reactions involved in the process are :

$$NH_3 + H_2O + CO_2 \longrightarrow \underset{\text{Ammonium bicarbonate}}{NH_4HCO_3}$$

$$NaCl + NH_4HCO_3 \longrightarrow \underset{\text{Sodium bicarbonate}}{NaHCO_3} \downarrow + NH_4Cl$$

$$2NaHCO_3 \xrightarrow{\Delta} \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O + CO_2$$

NH_3 is recovered from NH_4HCO_3 and NH_4Cl

$$NH_4HCO_3 \xrightarrow{\Delta} NH_3 + H_2O + CO_2$$

$$\underset{\text{Ammonium chloride}}{2NH_4Cl} + Ca(OH)_2 \rightarrow \underset{\text{Ammonia}}{2NH_3} + \underset{\text{Calcium chloride}}{CaCl_2} + 2H_2O$$

12. (a) Alkali metals dissolve in liquid NH_3 giving deep blue coloured solution.

$$Na + (x+y)NH_3 \longrightarrow \underset{\text{Ammoniated cation}}{\left[Na(NH_3)_x\right]^+} + \underset{\text{Ammoniated electron}}{e^-(NH_3)_y}$$

When light fall on the solution, the ammoniated electrons get excite to higher energy level by absorbing certain wavelength and transmit blue colour.

13. (b) Gypsum ($CaSO_4.2H_2O$) is added to cement to increase its setting time so that it gets sufficiently hardened. Setting of cement is an exothermic process and involves hydration of calcium aluminates and silicates.

14. (a) On heating plaster of Paris at certain temperature, it forms anhydrous calcium sulphate which is known to be dead burnt plaster and has no setting property as it absorbs water very slowly.

$$CaSO_4.\frac{1}{2}H_2O \xrightarrow{200°C} \underset{\text{(Anhydrous)}}{CaSO_4} \xrightarrow{1100°C} CaO + SO_3$$

15. (c) Slaked lime [$Ca(OH)_2$] is sparingly soluble in water and it forms a suspension of slaked lime in water which is called milk of lime and a clear solution obtained after the suspension settles is known as lime water.

16. (a) Except Be, all alkaline earth metals form hydrides (MH_2) on directly heating with H_2. BeH_2 can't be prepared by direct heating but it can be prepared by the action of $LiAlH_4$ on $BeCl_2$.

$$2BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$$

17. (d) On heating washing soda, it loses its water of crystallisation. Above 373 K, it becomes completely anhydrous white powder called soda ash.

$$\underset{\text{Washing soda}}{Na_2CO_3.10H_2O} \xrightarrow{\text{Above 373K}} \underset{\substack{\text{Soda ash}\\ \text{(Anhydrous form)}}}{Na_2CO_3}$$

18. (b) Calcium gives brick red coloured flame. Also, calcium nitrate on heating decomposes into calcium oxide and evolution of a mixture of NO_2 and O_2 takes place.

$$2Ca(NO_3)_2 \rightarrow 2CaO + \underset{\text{brown coloured gas}}{4NO_2} + O_2$$

19. (a) $Ca(OH)_2$ is used in the manufacture of bleaching powder.

$$\underset{\text{Slaked lime}}{2Ca(OH)_2} + 2Cl_2 \xrightarrow{\text{Cold}} CaCl_2 + \underset{\text{Bleaching powder}}{Ca(OCl)_2} + 2H_2O$$

20. (c) To recover NH_3 in Solvay process $Ca(OH)_2$ is used. On passing CO_2 through $Ca(OH)_2$, it turns milky due to the formation of $CaCO_3$. Also, $Ca(OH)_2$ is used for white washing due to its disinfectant nature.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 \downarrow + H_2O$$

21. (d) Chlorides of alkaline earth metals are hydrated salts. Due to their hygroscopic nature, they can be used as a dehydrating agent and can absorb moisture from air. Extent of hydration decreases from Ca to Ba.

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22. (d) In Castner Kellner cell, sodium amalgam is formed at mercury cathode.

23. (d) Solubility of alkaline earth metal sulphates decreases down the group due decrease in hydration energy.

$$MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$$

Hydration energy ↓ Solubility ↓

24. (b) K^+ ion is a constituent of sodium pump.

25. (c) Carbonates becomes more thermally stable down the group, therefore $MgCO_3$ will leave CO_2 easily.

26. (c)