

s-Block Elements

Introduction

In this chapter we will study the general characteristics of the alkali and alkaline earth metals and their compounds. We will also study the compounds of sblock elements, their uses and importance, commercially and industrially. The biological significance of sodium, potassium, calcium and magnesium will also be discussed is this chapter.

The s-Block Elements

Those elements in which last electron enters in s-orbital are called s-block elements. These are located at extreme left hand side of the periodic table. Since s orbital can accommodate only two electrons, the elements having one electron in their outermost s-orbital are grouped into group-1 and those having two electrons are grouped into group-2 of periodic table.

Goup-1 Elements : Alkali Metals

(i) Group 1 elements are called alkali metals because their oxides and hydroxides when treated with water, form alkaline solutions.

(ii) This includes the typical or representative elements

of IA such as Li and Na as well as K, Rb, Cs and Fr.

(iii) They are never found in the free state, because of their high reactivity,

(iv) Francium is radioactive element.

(v) All are silvery white, light, soft, malleable and ductile metals with metallic lustre.

1. **Electronic Configuration**

The alkali metals have one valence electron, outside the noble gas core therefore configuration is [Noble gas] ns^1 ; where n = 2 to 7

Since the outermost electron is loosely held, alkali metals readily lose electron to give monovalent M⁺ ions, that is why they are most electropositive metals

Element	Symbol	Electronic configuration
Lithium	Li	[He]2s ¹
Sodium	Na	[Ne]3s ¹
Potassium	Κ	[Ar]4s ¹
Rubidium	Rb	[Kr]5s ¹
Caesium	Cs	[Xe]6s ¹
Francium	Fr	$[Rn]7s^1$

The electronic configurations of alkali metals are given

below

Atomic and Ionic Radii

The atoms of alkali metals have the largest size in their respective periods. The atomic radius increases on moving down the group.

Size order :

Li < Na < K < Rb < Cs < Fr

Ionic radii :

$$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+ < Fr^+$$

SOLVED EXAMPLE

Example-1

2.

Why the alkali metals are never found in free state in nature?

The alkali metals readily lose electron to give

monovalent M⁺ ions, hence they are highly reactive

and therefore they are never found in free state in nature.

Sol.

3.

Ionization Enthalpy

The first ionisation enthalpies of alkali metals are low as compared to the elements of other groups belonging to the same period. However, within the group the ionization enthalpies of the alkali metals decrease down the group.

IE order: Li > Na > K > Rb > Cs > Fr

4. Hydration Enthalpy

The alkali metal ions are extensively hydrated in aqueous solutions. Smaller the ion more is the extent of hydration. The hydration enthalpies of alkali metal ions decrease with increase in ionic size :

 $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$ (hydration energy decreases) Li⁺ has maximum degree of hydration and for this reason many lithium salts exist as hydrated salts. For example, LiCl. 2H₂O

5. Melting point and Boiling point :

(a) Weak interatomic bonds are due to their large atomic radii and presence of only one valence electron hence melting point and boiling point are low.

(b) Decreasing order of melting point and boiling point is Li > Na > K > Rb > Cs

(c) With the increase in the size of metal atom, the repulsion of the non-bonding electrons increases and therefore melting point and boiling point decreases from Li to Cs.

(6) **Density** : (D = M/V)

In a group atomic volume also increase along with atomic weight but atomic weight increases more than atomic volume, so density increases from Li to Cs

Exception : Density of Na is higher than K as empty d-orbitals are present in K. Maximum capacity of M shell is of 18 electrons but it contains only 8 electron, which decreases its density. Increasing order of density

Li < K < Na < Rb < Cs

(7) Standard oxidation potential :

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

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

(c) Li has highest standerd oxidation potential (-3.05 eV) due to its high hydration energy. Such that it converts into Li⁺ ion by losing one electron.

 $\label{eq:constraint} \begin{array}{c} \mbox{Order of standard oxidation potential of s-block elements} \\ \hline $Li>K>Ba>Sr>Cs>Na>Mg>Be$ \\ \hline $Hydration energy \propto Charge density on ion} \end{array}$

Note: Li is the strongest reducing agent among all elements of periodic table due to high hydration energy.

(8) Complex formation tendency :

(a) Only those elements can form complex compounds which have

(i) Small cation size

(ii) High charge density

(iii) Vacant d-orbital to accept electrons.

(b) Only Li⁺ can form complex compound, due to its small size rest alkali metals have very less tendency to form complex compounds.

Flame Colouration

9.

10.

When alkali metals and their salts are heated in the oxidizing flame of a Bunsen burner, they impart characteristic colours to the flame. This happens because the heat from the flame excites the outermost orbital electron to a higher energy level. When the excited electron comes back to the ground state, there is emission of radiation in the visible region as given below.

Metal	Li	Na	K	Rb	Cs
Colour	Crimson	Golden	Violet	Ped violet	Blue
Colour	red	Yellow	violet	Keu vioiei	
λ/nm	670.8	589.2	766.5	780.0	455.5

This particular property of alkali metals is helpful in detecting them by respective flame tests and can be determined by flame photometry or atomic absorption spectroscopy.

Photoelectric Effect

Alkali metals (except Li) exhibit photoelectric effect (a phenomenon of emission of electrons from surface by exposing it to visible light). These elements when irradiated with light, the light energy absorbed may be sufficient to make an atom lose electron. This property makes caesium and potassium useful as electrodes in photoelectric cells.

Property	Lithium	Sodium	Potassium	Rubidium	Caesium	Francium
	Li	Na	К	Rb	Cs	Fr
Atomic number	3	11	19	37	55	87
Atomic mass (g mol ⁻¹)	6.94	22.99	39.10	85.47	132.91	(223)
Electronic configuration	[He] 2s ¹	[Ne] $3s^1$	$[Ar] 4s^1$	[Kr] 5s ¹	[Xe] 6s ¹	[Rn] 7s ¹
Ionization enthalpy/kJ mol ⁻¹	520	496	419	403	376	-375
Hydration enthalpy/kJ mol ⁻¹	-506	-406	-330	-310	-276	
Metallic radius / pm	152	186	227	248	265	
Ionic radius M ⁺ / pm	76	102	138	152	167	(180)
m.p. / K	454	371	336	312	302	
b.p/K	1615	1156	1032	961	944	_
Density/g cm ⁻³	0.53	0.97	0.86	1.53	1.90	_
Standard potentials E ⁻ / V for (M ⁺ /M)	-3.04	-2.714	-2.925	-2.930	-2.927	
Occurrence in lithosphere [*]	18*	2.27**	1.84**	78-12*	2-6*	~10 ⁻¹⁸ *

Table : Atomic and Physical Properties of the Alkali Metals

* ppm(part per million), ** percentage by weight; Lithosphere : The Earth's outer layer: its crust and part of the upper mantle

SOLVED EXAMPLE

Example-2

	Among the follow	wing which element is the rarest of all?
	(1)Na	(2) Fr
	(3) Cs	(4) K
Ans.	(2)	
Sol.	Fr is radioactive	and less abundant therefore rarest of
	all.	

Example-3

What is the correct o	rder of density?
(1)Li>Na>K	(3)Na>K>Li
(2) K $>$ Na $>$ Li	$(4) \operatorname{Na} = K > Li$
(1)	
Density of K is less the d-orbitals	han Na due to presence of vacant
	What is the correct o (1) Li>Na>K (2) K>Na>Li (1) Density of K is less th d-orbitals

Example-4

The elements of group 1 are called alkali metals because -

- (1) Their oxides form acidic solutions on treating with water
- (2) Their peroxides form alkaline solution on treating with water
- (3) Their oxides and hydroxides form alkaline solutions on treating with water
- (4) Their hydroxides form acidic solution on treating with water

Ans. (3)

Sol.

Ans.

Sol.

Their oxides and hydroxides form alkaline solutions on treating with water

Example-5

The ionic radii of alkali metal ions in water (hydrated
radii) are in the order -
(1) $Li^+ > Na^+ > K^+ > Rb^+ < Cs^+$
(2) $Li^+(aq.) > Na^+(aq.) > K^+(aq.) > Rb^+(aq.) > Cs^+(aq.)$
(3) $LI^+ < Na^+ > K^+ > Rb^+ > Cs^+$
(4) $Li^+(aq.) > Na^+(aq.) < K^+(aq.) < Rb^+(aq.) < Cs^+(aq.)$
(2)
charge
Hydrated radii $\propto \frac{1}{10000000000000000000000000000000000$

 $Li^{+}_{(aq)} > Na^{+}_{(aq)} > Rb^{+}_{(aq)} > Cs^{+}_{(aq)}$ Hydrated radii

Example-6

The metals Li, Na, K and Rb and their salts, when introduced into flame, give the following characteristic colour to flame -

- (1) Violet, Red violet, golden yellow and crimson red respectively
- (2) Red violet, violet, golden yellow and crimson red respectively
- (3) Crimson red, golden yellow, violet and Red violet respectively
- (4) Crimson red, Golden yellow, Red violet and Violet (4)
- Ans. Sol.

Li _____Flame test _____ Crimson red

 $Na \longrightarrow Golden yellow$

 $K \longrightarrow Pale violet$

 $Rb \longrightarrow violet$

Chemical Properties

The alkali metals are highly reactive elements. The cause for their high chemical reactivity is (i) Low value of first ionisation enthalpy (ii) Large size (iii) low heat of atomisation. The reactivity of these metals increases down the group.

(i) Reactivity towards air : You might have seen that alkali metals tarnish in dry air because of formation of their oxides and when these oxides react with moisture they form hydroxides.

Alkali metals burn very fast in oxygen and form different kind of oxides like monoxides, peroxides and superoxides. Lithium forms monoxide, sodium forms peroxide and other metals form superoxides. The superoxide O_2^- ion generally remain stable only in the presence of large cations like K, Rb, Cs. This stability is related to the compatibility of size and higher lattice energy

 $4\text{Li} + \text{O}_2 \rightarrow 2\text{Li}_2\text{O} \qquad (\text{oxide})$ $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2 \qquad (\text{peroxide})$ $M + \text{O}_2 \rightarrow \text{MO}_2 \qquad (\text{superoxide})$ (M = K, Rb, Cs)

In all the compounds formed by alkali metals with oxygen, their oxidation state is +1.

The temperature required for the reaction to take place decrease on descending the group.

The stability of peroxide or superoxide increases as the size of the alkali metal increases. This is due to stabilization of large anions by large cations through lattice energy effects.

The oxides and the peroxides are colourless when pure but superoxides are yellow or orange in colour, peroxides are diamagnetic whereas superoxide are paramagnetic in nature. The normal oxides of alkali metal dissolve readily in water to form hydroxides and a large amount of heat is produced.

 $M_2O(s) + H_2O(l) \rightarrow 2MOH(aq) + Heat$ $\rightarrow 2M^+ + 2OH^-$

The peroxides and superoxides are also readily hydrolysed by water as shown below:

$$\begin{split} & M_2O_2 + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2O_2 \\ & Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2 \\ & 2MO_2 + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2O_2 + O_2 \\ & 2KO_2 + 2H_2O \rightarrow 2KOH + H_2O_2 + O_2 \end{split}$$

The higher oxides generally act as good oxidising agent, sodium peroxide is widely used as an oxidising agent in inorganic chemistry.

The hydroxides which are obtained by reaction of the oxides with water are white crystalline solids. The hydroxides of alkali metals are strong bases. The basic character of alkali metal hydroxides increases in going down the group.

$$\frac{\text{LiOH} < \text{NaOH} < \text{KOH} < \text{RbOH} < \text{CsOH}}{\text{Basic character increases}} \rightarrow$$

Alkali metal hydroxides are freely soluble in water and their dissolution in water is accompanied by evolution of much heat due to intense hydration.

NOTE: (a) Due to diagonal relationship with magnesium, lithium like magnesium forms its nitride, Li₃N. Rest of the alkali metals do not behave in this way.

(b) Alkali metals are generally kept immersed in kerosene oil because they are highly reactive towards air and water, but due to less density Li is kept wrapped in paraffin wax.

(ii) Reactivity towards water : The alkali metals on reaction with water form their respective hydroxide and dihydrogen.

 $2M + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2$ (M = an alkali metal) They also react with proton donors or acidic hydrogen such as alcohol, gaseous ammonia, hydrogen halide and alkynes.

$$\begin{split} & 2M + 2C_2H_5OH \rightarrow 2C_2H_5OM + H_2 \\ & 2M + HC = CH \rightarrow M^+ - C \equiv C^-M^+ + H_2 \\ & 2M + 2HX \rightarrow 2MX + H_2 \end{split}$$

(iii) Reactivity towards dihydrogen: Alkali metal react with dry dihydrogen at about 673 K (lithium at 1073 K) to form crystalline hydrides which are ionic in nature and have high melting points.

 $2M + H_2 \xrightarrow{Heat} 2M^+H^-$

(iv) Reactivity towards halogens : The alkali metals combine with halogens to form metal halides, which are ionic colourless, crystalline solids having high melting point and general formula MX.

(X = F, Cl, Br, I) $2M + X_2 \rightarrow 2MX$ $2Na + Cl_2 \rightarrow 2NaCI$ Reactivity with particular halogen : Li < Na < K < Rb < CsReactivity with particular alkali metal M $F_{2} > Cl_{2} > Br_{2} > l_{2}$

The alkali metal halides can be prepared by the reaction of the appropriate oxide, hydroxide or carbonate with aqueous hydrogen halide (HX).

All of these halides have high negative enthalpies of formation; the $\Delta_{f} H^{\circ}$ value for fluorides become less negative as we go down the group, while the reverse is true for $\Delta_f H^\circ$ for chlorides, bromides and iodides.

For a given metal $\Delta_f H^\circ$ always becomes less negative from fluoride to iodide. The melting and boiling points always follow the trend, fluoride > chloride > bromide > iodide.

All halides of the alkali metals except lithium fluoride (LiF) are freely soluble in water. The low solubility of lithium fluoride is attributed to greater force of attraction between lithium ions and fluoride ions in the crystal lattice or high lattice enthalpy.

Caesium iodide (CsI) also has relatively low solubility in water. This is attributed to smaller hydration energy of its large sized ions.

LiCl, LiBr and Lil are soluble in ethanol, acetone and other solvents of low polarity. This is due to predominant covalent character of these halides. The predominant covalent character of lithium halides is due to greater polarizing power of Li⁺ ion.

Among lithium halides Lil has maximum covalent character due to large polarizability of iodide ion. LiCl is soluble in pyridine also.

(v) Reducing Nature : The alkali metals have strong tendency to get oxidised, that is why they act as strong reducing agents, among these lithium is the strongest and sodium is the least powerful reducing agent. The standard electrode potential (E°) measures the reducing power and represents the changes.

 $M(s) \rightarrow M(g)$ Sublimation enthalpy $M(g) \rightarrow M^+(g) + e^-$ ionization enthalpy $M^+(g) + H_2O \rightarrow M^+(aq)$ hydration enthalpy Since lithium ion has small size, it has the highest hydration enthalpy which gives an explanation for its high negative E° value and its high reducing power. Higher the negative value of E° value more reducing will be the ionic species.

SOLVED EXAMPLE

Example-7

	-	
	Among the alk	ali metal halides which of the alkali metal
	halide is the m	ost covalent?
	(1)LiCl	(2) Nal
	(3) Kl	(4)Lil
Ans.	(4)	
Sol.	According to I	Fajan's rule small cation and large anion
	form covalent	compound.

Example-8

structure(sp).

(vi)

	The hybridisation	of BeCl ₂ in solid state and above
	1200 K is respective	ely
	(1) sp^3 , sp^3	(2) sp^3 , sp^2
	(3) sp^2 , sp^2	(4) sp^{3} , sp
Ans.	(4)	
Sol.	In solid state Be	cl_2 is polymer and shows sp^3
	hybridisation wh	ile above 1200 K it has linear

Solutions in liquid ammonia : All alkali metals dissolve in liquid ammonia and give deep blue colour solution which are conducting in nature. These solutions contain ammoniated cations and ammoniated electrons as shown below

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

The blue colour of the solution is considered to be due to ammoniated electrons which absorb energy corresponding to red region of visible light for their excitation to higher energy levels. The transmitted light thus, imparts blue colour to the solution. The electrical conductivity of the solution is due to both ammoniated cations and ammoniated electrons. The blue solution on standing slowly liberates hydrogen resulting in the formation of amide.

$$\mathbf{M}^{+}(\mathbf{am}) + \mathbf{e}^{-} + \mathbf{NH}_{3}(l) \rightarrow \mathbf{MNH}_{2(\mathbf{am})} + \frac{1}{2}\mathbf{H}_{2}(\mathbf{g})$$
(Metalamide)

(where 'am' denotes solution in ammonia). At concentrations above 3M, the solution of alkali metals in liquid ammonia are copper bronze coloured. These solutions contain cluster of metal ions and hence possess metallic lusture. The blue solutions are paramagnetic whereas bronze coloured solutions are diamagnetic.

Salts of oxo-acids

Oxo-acids are those acids in which the acidic proton is on a hydroxyl group with an oxo group attached to the same atom e.g., carbonic acid, $H_2CO_3[OC(OH)_2]$, sulphuric acid, $H_2SO_4[O_2S(OH)_2]$. The alkali metals form salts with all the oxo-acids.

The salts of oxo-acids are generally soluble in water and thermally stable.

The carbonates (M_2CO_3) and bicarbonates $(MHCO_3)$ of alkali metals are quite stable towards heat. Li_2CO_3 , however, is considerably less stable and decomposes readily on heating. Lithium being very small in size polarises a large CO_3^{2-} ions leading to the formation of stable Li_2O and CO_2 on heating

 $Li_2CO_3 \rightarrow Li_2O + CO_2$

As the electropositive character increases down the group, the stability of the carbonates and hydrogen carbonates increases.

(i)

(ii)

... Order of stability :

 $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < CsCO_3$

SOLVED EXAMPLE

Example-9

On heating alkali metal nitrates product formed are (except LiNO₃)

(2) NO₂ only

(4) MNO₂ and O₂

(1) NO₂ and O₂ only(3) NO₂ and MO only

(4)

Ans. Sol.

 $\begin{array}{l} 4\text{LiNO}_3 \rightarrow 2\text{Li}_2\text{O} + 4\text{NO}_2 + \text{O}_2 \\ 2\text{NaNO}_3 \rightarrow 2\text{NaNO}_2 + \text{O}_2 \end{array}$

Sulphates :

(a) Alkali metals forms M_2SO_4 type sulphates.

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

$$Li_2SO_4 < Na_2SO_4 < K_2SO_4 < Rb_2SO_4 < Cs_2SO_4$$

(c) Li_2SO_4 is least soluble in water.

(d) These sulphates on burning with C forms sulphides $M_2SO_4 + 4C \rightarrow M_2S + 4CO$

(e) Except lithium, sulphates of IA group reacts with sulphates of trivalent metals like Fe^{+3} , Cr^{+3} , Al^{+3} etc. to form alum.

 $M_2SO_4.M'_2(SO_4)_3.24H_2O$

M = Monovalent, M' = Trivalent

Formation of Amalgam :

(a) Alkali metals gives amalgam with Hg.

(b) These metals reacts with other metals to give mixed metals (alloys)

ANOMALOUS PROPERTIES OF LITHIUM

Lithium shows properties which are very different from the other members of its group. This is due to the (i) exceptionally small size of its atom and ion and (ii) greater polarizing power of lithium ion (i.e., charge/ radius ratio). Due to these factors, there is increased covalent character of lithium compounds which is responsible for their solubility in organic solvents. Further, lithium shows diagonal relationship to magnesium which has been discussed subsequently.

Points of difference between Lithium and other Alkali Metals

As compared to other alkali metals, lithium is harder and its melting point and boiling point are higher.

- Among all the alkali metals lithium is least reactive but the strongest reducing agent. When burnt in air it forms mainly monoxide, Li₂O and the nitride, Li₃N unlike other alkali metals.
- LiCl is deliquescent and crystallises as a hydrate, LiCl.2H₂O whereas other alkali metal chlorides do not form hydrates.
- (iv) Except for lithium, rest of alkali metal's hydrogen carbonates are obtained in the solid form.
- (v) Lithium unlike other alkali metals forms no ethynide on reaction with ethyne.
- (vi) Lithium nitrate when heated gives lithium oxide, Li₂O, whereas other alkali metal nitrates decompose to give the corresponding nitrite.

 $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$ $2NaNO_3 \rightarrow 2NaNO_2 + O_2$

(vii) LiF and Li₂O are comparatively much less soluble in water than the corresponding compounds of other alkali metals

Points of similarities between Lithium and Magnesium

The similarity between lithium and magnesium is because of their similar sizes; comparable atomic radii and electronegativities.

Li = 152 pm Ionic radii : Li⁺ = 76 pm Mg = 160 pm $Mg^{2+} = 72 pm$

The major similarities are

- (i) Both lithium and magnesium are harder and lighter than other elements of the respective groups.
- Both lithium and magnesium react slowly with water. Their oxides and hydroxides are less soluble and their hydroxides decompose on heating. Both lithium and magnesium form nitride, Li₃N and Mg₃N₂, by direct combination with nitrogen.
- (iii) Their oxides like Li₂O and MgO do not combine with excess oxygen to give their superoxide.
- (iv) The carbonates of both decompose easily on heating and form oxides and CO_2 and both do not form solid hydrogen carbonates.
- Both LiCl and MgCl₂ are soluble in ethanol, are deliquescent and crystallise from aqueous solution as hydrates, LiCl.2H₂O and MgCl₂.6H₂O.

SOME IMPORTANT COMPOUNDS OF SODIUM

Sodium Carbonates (Washing soda), Na₂CO₃.10H₂O It is prepared by **Solvay process** which exploits the low solubility of sodium hydrogencarbonate whereby it gets precipitated in the reaction of sodium chloride with ammonium hydrogen carbonate. The ammonium hydrogen carbonate is prepared by passing CO_2 to a concentrated solution of sodium chloride saturated with ammonia, where ammonium carbonate followed ammonium hydrogen carbonate are formed.

 $\begin{aligned} &2\mathrm{NH}_3 + \mathrm{H}_2\mathrm{O} + \mathrm{CO}_2 \rightarrow (\mathrm{NH}_4)_2\mathrm{CO}_3 \\ &(\mathrm{NH}_4)_2\mathrm{CO}_3 + \mathrm{H}_2\mathrm{O} + \mathrm{CO}_2 \rightarrow 2\mathrm{NH}_4\mathrm{HCO}_3 \\ &\mathrm{NH}_4\mathrm{HCO}_3 + \mathrm{NaCl} \rightarrow \mathrm{NH}_4\mathrm{Cl} + \mathrm{NaHCO}_3 \end{aligned}$

Sodium hydrogen carbonate crystal separates. These are heated to give sodium carbonate.

 $2\mathrm{NaHCO_3} \rightarrow \mathrm{Na_2CO_3} + \mathrm{CO_2} + \mathrm{H_2O}$

When solution having NH_4Cl is treated with $Ca(OH)_2$, NH_3 is produced and recovered and $CaCl_2$ is obtained as a by product.

 $2\mathrm{NH}_4\mathrm{Cl} + \mathrm{Ca(OH)}_2 \rightarrow 2\mathrm{NH}_3 + \mathrm{CaCl}_2 + \mathrm{H}_2\mathrm{O}$

Potassium carbonate cannot be manufactured by solvay process because potassium hydrogen carbonate is too soluble to be precipitated by the addition of ammonium hydrogen carbonate to a saturated solution of potassium chloride.

Properties of Sodium Carbonate :

Sodium carbonate is a white coloured crystalline solid which is found as a decahydrate, $Na_2CO_3.10H_2O$. This is also called as washing soda. It is easily soluble in water. When heated decahydrate loses, its water of crystallisation and form monohydrate. Above 375 K, the monohydrate becomes completely anhydrous and changes to a white powder called **soda ash**.

 $Na_2CO_3.10H_2O \xrightarrow{375K} Na_2CO_3.H_2O + 9H_2O$

 $Na_2CO_3H_2O \xrightarrow{>375K} Na_2CO_3 + H_2O$

Carbonate part of sodium carbonate get hydrolysed by water to form an alkaline solution

 $\text{CO}_3^{2-} + \text{H}_2\text{O} \longrightarrow \text{HCO}_3^- + \text{OH}^-$

Uses of Sodium Carbonate :

(i) It is used for softening hard water, for washing purposes in laundry and cleaning

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

(iii) It is used in paper, paints and textile industries.(iv) As an important laboratory reagent both in qualitative and quantitative analysis.

(v) For making fusion mixture i.e. $Na_2CO_3 + K_2CO_3$

Sodium Chloride, NaCl

Preparation :

Sea water is the major source of sodium chloride.

Sea water $\xrightarrow{\text{Evaporation}}$ Crude NaCl.

(i) It contains impurities of Na₂SO₄, MgCl₂, CaCl₂ etc.
(ii) Insoluble impurities removed by filtration.

(iii) Filtrate $\xrightarrow{HCl gas passed}$ Pure NaCl (ppt)

Then HCl gas is passed through the solution to get saturated solution due to common ion effect, the crystals of pure NaCl seperate out.

(iv) $MgCl_2$ and $CaCl_2$ being more soluble remain in the solution.

Properties :

(i) fcc structure of solid.

(ii) Its solubility in water is 36 gm in 100 gm of water at 0° C.

(iii) Pure sodium chloride is non-hygroscopic but due to the impurities of $CaCl_2$ and $MgCl_2$ it behave as hygroscopic.

(iv) Reaction with $K_2Cr_2O_7 + H_2SO_4$ (conc.)

$$4\text{NaCl} + \text{K}_2\text{Cr}_2\text{O}_7 + 5\text{H}_2\text{SO}_4 \xrightarrow{\Delta} \\ 4\text{NaHSO}_4 + \text{H}_2\text{SO}_4 + 2\text{CrO}_2\text{Cl}_2\uparrow + 3\text{H}_2\text{O}$$

Uses of Sodium chloride :

(i) It is an essential constituent of our food. It is used as common salt or table salt for domestic purposes.

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

(iii) It is used in freezing mixture.

SOLVED EXAMPLE

Example-10

	Aqueous solution of soda lime is
	(1) Acidic
	(2) Alkaline
	(3) Neutral
	(4) Initially acidic changes to alkaline after some time
Ans.	(2)
Sol.	Soda lime is mixture of NaOH and CaO, both are basic
	in nature.

Example-11

	The aqueous solution of baking soda is				
	(1) Acidic	(2) Alkalii	ne		
Ans.	(3) Neutral (2)	(4) Amph	oteric		
Sol.	NaHCO ₃ — H ₂	^o → NaOH	+	$H_2O + CO_2$	

strong base

weak acid

Sodium Hydroxide (Caustic soda), NaOH

Sodium hydroxide is manufactured by the electrolysis of sodium chloride solution (brine) in a specially designed cell called **Castner-Kellner cell**. A brine solution is electrolysed using a mercury cathode and a carbon anode. Sodium metal discharged at the cathode combines with mercury to form sodium amalgam. Chlorine gas is evolved at the anode.

Cathode: $Na^+ + e^- \rightarrow Sodium$ amalgam

Anode :
$$\operatorname{Cl} \to \frac{1}{2} \operatorname{Cl}_2 + e^-$$

The amalgam is treated with water to give sodium hydroxide and hydrogen gas.

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

Properties of sodium hydroxide :

Sodium hydroxide is a white, translucent solid. It melts at 591 K. It is readily soluble in water to give a strong alkaline solution. Crystals of sodium hydroxide are deliquescent. On prolonged exposure, CO_2 is absorbed resulting in the formation at the surface a layer of Na_2CO_3 . It is highly soluble in water and the solution has a very corrosive action on animal tissue.

Uses of sodium hydroxide

(i) It is used in the manufacture of paper, soap and artificial silk.

- (ii) It is used for petroleum refining.
- (iii) It is used for mercerizing cotton.
- (iv) It is used in purification of bauxite.
- (v) It is used for the preparation of pure fats and oils.
- (vi) it is used as a laboratory reagent.

Sodium hydrogen carbonate (Baking soda), NaHCO3

Sodium hydrogen carbonate is obtained as intermediate product in Solvay's process for the manufacture of sodium carbonate. It can also be made by saturating a solution of sodium carbonate with carbon dioxide. The white crystalline powder of sodium hydrogen carbonate, being less soluble, gets separated out. $Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$

Uses of sodium hydrogen carbonate

(i) It is used as component of baking powder

(ii) It is used in fire extinguishers

(iii) It is used in medicines. It acts as a mild antiseptic for skin infections and also used as antacid.

BIOLOGICAL IMPORTANCE OF SODIUM AND POTASSIUM

Sodium ions are found primarily on the outside of cells, being located in blood plasma and in the interstitial fluid which surrounds the cells. These ions participate in the transmission of nerve signals. They also regulate flow of water across cell membranes and in transport of sugars and amino acids into the cells.

Potassium ions are the most abundant cations within cell fluids, where they activate many enzymes, participate in oxidation of glucose to produce ATP (adenosine triphosphate), potassium ions, in combination with sodium ions are responsible for transmission of nerve signals.

There is a considerable variation in the concentrations of Na⁺ and K⁺ ions found on the opposite sides of cell membranes. The functional features of nerve cells depend upon the sodium-potassium ion gradient that is established on the cell. These ionic gradients are maintained by sodium-potassium pumps that operate across the cell membranes. As a typical example, in blood plasma, sodium is present to the extent of 143 m mol L⁻¹ whereas the potassium level is only 5 m mol L⁻¹ within the red blood cells. These concentration change to 10 m mol L⁻¹ (Na⁺) and 105 m mol L⁻¹ (K⁺). Sodium-potassium pump consumes more than one-third of the ATP used by a resting animal and about 15 kg per 24 h in a resting human.

A typical 70 kg man contains about 90 g of Na and 170 g of K, compared with only 5 g of iron and 0.06 g of copper.

USES

- 1. Lithium is used as a metal in a number of alloys. Its alloys with magnesium, containing about 14% lithium is extremely tough and corrosion resistant which is used for armour plate and aerospace components; with lead to make white metal with aluminium to make aircraft parts.
- 2. Lithium hydroxides is used in the ventilation systems of space crafts and submarines to absorb carbon dioxide
- 3. Lithium aluminium hydride (LiAlH₄) is a powerful reducing agent which is commonly used in organic

synthesis.

- 4. Liquid sodium or its alloys with potassium is used as a coolant in nuclear reactors.
- 5. Sodium-lead alloy is used for the preparation of tetraethyl lead, $Pb(C_2H_5)_4$, which is used as an antiknocking agent in petrol.

$$(Pb+4Na)+4C_2H_5Cl \rightarrow (C_2H_5)_4Pb+4NaCl$$

Lead-sodium alloy tetraethyl lead

- 6. Sodium is used in the production of sodium vapour lamps.
- 7. Potassium chloride is used as fertilizer.
- 8. Potassium hydroxide is used in the manufacture of soft soaps and also as absorbent of carbon dioxide.
- 9. Potassium ions play a vital role in biological systems.
- 10. Caesium is used in photoelectric cells.

GROUP-2 ELEMENTS : ALKALINE EARTH METALS

The elements of group-2 are Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). Except Be, rest are known as alkaline earth metals, because these are alkaline in nature and exist in the earth.

Beryllium is not considered alkaline earth metal because its oxide i.e., BeO is amphoteric in nature, which can be explained by its reaction with acids as well as alkalies.

$$\begin{split} & \text{BeO} + 2\text{HCI} \rightarrow \text{BeCl}_2 + \text{H}_2\text{O} \\ & \text{BeO} + 2\text{NaOH} + \text{H}_2\text{O} \rightarrow \text{Na}_2[\text{Be(OH)}_4] \\ & \text{Sodium beryllate} \end{split}$$

Property	Beryllium	Magnesium	Calcium	Strontium	Barium	Radium
	Be	Mg	Ca	Sr	Ba	Ra
Atomic number	4	12	20	38	56	88
Atomic mass (g mol ⁻¹)	9.01	24.31	40.08	87.62	137.33	226.03
Electronic Configuration	[He] 2s ²	[Ne] $3s^2$	$[Ar] 4 s^2$	[Kr] 5s ²	[Xe] 6 s ²	[Rn] 7s ²
Ionization enthalpy (l)/kJ mol ⁻¹	899	737	590	549	503	509
Ionization Enthalpy (II)/kJ mol ⁻¹	1757	1450	1145	1064	965	979
Hydration enthalpy (kJ/mol)	-2494	-1921	-1577	-1443	-1305	
Metallic Radius / pm	111	160	197	215	222	
Ionic radius M ²⁺ / pm	31	72	100	118	135	148
m.p. / K	1560	924	1124	1062	1002	973
b.p / K	2745	1363	1767	1655	2078	(1973)
Density / g cm ⁻³	1.84	1.74	1.55	2.63	3.59	(5.5)
Standard potentials E®/ V for (M ²⁺ / M)	-1.97	-2.36	-2.84	-2.89	-2.92	-2.92
Occurrence in lithosphere	2*	2.76**	4.6**	384*	390*	10^{-6} *

Table : Atomic and Physical Properties of the Alkaline Earth Metals

*ppm (parts per million); ** percentage by weight

Electronic Configuration

The alkaline earth metals have 2 electrons in the s-orbital of the valence shell. Their general electronic configuration may be represented as [Noble gas] ns^2 ; where n = 2 to 7

Element	Symbol	Electronic configuration
Beryllium	Be	[He]2s ²
Magnesium	Mg	[Ne]s ²
Calcium	Ca	[Ar]4s ²
Strontium	Sr	[Kr]5s ²
Barium	Ba	[Xe]6s ²
Radium	Ra	[Rn] 7s ²

Atomic and Ionic Radii

(a) These are smaller than IA group elements, since extra charge on nucleus attracts the electron cloud.
(b) Be < Mg < Ca < Sr < Ba

In s-block elements Be is the smallest while Cs is the biggest. \therefore Size order :

 $Be\!<\!Li\!<\!Mg\!<\!Na\!<\!Ca\!<\!Sr\!<\!Ba\!<\!K\!<\!Rb\!<\!Cs$

Ionization Enthalpies

The first ionisation enthalpies of the alkaline earth metals are higher than those of the corresponding group 1 metals due to stable full filled s^2 configuration. Be > Mg > Ca > Sr > Ra > Ba

Hydration Enthalpies

The hydration enthalpies of alkaline earth metal ions are larger than those of alkali metal ions. Therefore, compounds of alkaline earth metals are more extensively hydrated, for example, magnesium chloride and calcium chloride exist as hexahydrates (MgCl₂.6H₂O and CaCl₂.6H₂O) whereas sodium chloride and potassium chloride do not form such hydrates.

Like alkali metal ions, the hydration enthalpies of alkaline earth metal ions decrease with increase in ionic size down the group.

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

Physical Properties

The alkaline earth metals are silvery white, lustrous and relatively soft but harder than the alkali metals.

Beryllium and magnesium appear to be some what greyish. The melting and boiling points of these metals are higher than the corresponding alkali metals due to smaller sizes. But this trend is not systematic, because of the low ionisation enthalpies, they are strongly electropositive in nature. The electropositive character increases down the group from Be to Ba.

Flame test :

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

(b) Other elements gives characteristic colour to flame Ca-brick red

Sr-dark red (Crimson red)

Ba-green (Apple green)

Photo-electric effect :

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

Standard oxidation potential :

(a) They have lower values of standard oxidation potential due to their small size.

- (b) Increasing order of standard oxidation potential is Be < Mg < Ca < Sr < Ba
- (c) Tendency of loosing electron increases hydration energy ∞ Charge density on ion

Complex formation tendency :

(a) Less tendency to form complex compound, but due to small size of cations Be and Mg forms complex compounds like

 $(BeF_4)^{-2}$, $Be_4O(CH_3COO)_6$ Mg – Chlorophyll

Chemical properties :

(i) Reaction with air :

(a) Except Be, these metals are easily tarnished in air, as a Layer of oxide is formed on the surface.

(b) Barium in powdered form, burst into flame on exposure to air.

(c) In moist air, except Be all the elements converts into carbonates.

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

(ii) Reaction with oxygen :

(a) Alkaline earth metals reacts with O_2 to form 'MO' type oxides

(M = Be, Mg, Ca, Sr, Ba)

(b) But Ca, Sr and Ba due to low ionisation potential and more reactivity, forms MO_2 (peroxides) at low temperature.

Ex. CaO₂, SrO₂, BaO₂

(c) BeO shows amphoteric property

MgO \rightarrow weak base CaO, SrO & BaO \rightarrow Strong base

(d) Basic properties increases from Be to Ba

(iii) Reaction with hydrogen :

(a) Except Be all the alkaline metals forms MH₂ type hydrides, (MgH2, CaH2, SrH2, BaH2) on heating directly with H₂

(b) BeH₂ is prepared by action of BeCl₂ with LiAlH₄ $2BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$

(c) BeH₂ and MgH₂ are covalent, other are ionic.

(d) Be and Mg hydride have tendency of polymerisation.

(iv) Reaction with water :

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

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

(b) Be does not reacts with water

(c) Mg reacts only with hot water

(d) Ca, Sr, Ba reacts with cold water but not as energetically as alkali metals.

order of reactivity Ba > Sr > Ca > Mg > Be

(e) from Be(OH)₂ to Ba(OH)₂ basic property and stability increases.

(v) Halides :

(a) Alkaline earth metals reacts with X_2 (Halogen) to form MX_2 .

Ex. (BeCl₂, MgCl₂, CaCl₂ etc.)

(b) Ionic nature of MX₂ increases from BeCl₂ to BaCl₂ (c) Ba burns in contact with Cl_2

(d) Beryllium forms covalent halides, all other members forms ionic halides. Beryllium halides are soluble in organic solvents. Beryllium chloride has a chain structure

$$Be \subset CI \\ CI \\ Be \subset CI \\ Be - CI \\$$

BeCl₂ in vapour phase form a chloro-bridged dimer which at high temperatures of the order of 1200 K dissociates into linear monomer.

The tendency to form halide hydrates gradually decreases, (for example, MgCl₂.8H₂O, CaCl₂.6H₂O, SrCl₂.6H₂O and BaCl₂.2H₂O) down the group. The hydrated chlorides, bromides and iodides of Ca, Sr and Ba can be dehydrated by heating but the corresponding hydrated halides of Be and Mg on heating undergoes hydrolysis.

The fluorides of alkaline earth metals are less soluble than chlorides due to their high lattice energies.

(e) BeCl₂ and MgCl₂ are covalent in nature.

 $BeCl_2 < MgCl_2 < CaCl_2 < SrCl_2 < BaCl_2$

SOLVED EXAMPLE

Example-12

Amongst the follow	ving hydroxides, the one which has
the lowest value of	Ksp is -
(1) Mg(OH),	(2) Ca(OH) ₂
$(3) \operatorname{Ba(OH)}_2^2$	$(4) \operatorname{Be}(OH)_2$
-	-

Ans. (4)

Sol.

The solubility of most salt's decreases with increased atomic weight. But trend is reversed with the fluorides and hydroxides.

> BeF₂, Be(OH)₂ K sp 🖌 Mg (OH)₂ Ca(OH)₂ decreases $Sr(OH)_2$ Ba (OH)₂ BaF_2

Example-1

Sol.

Explain the following:

- (a) Why should an alkali metal never be put into a burette ?
- (b) LiF has the lowest solubility of the group 1st metal halides.
- (c) BeCl₂ in aqueous solution exists as $[Be(H_2O)_4]^{2+1}$ rather than Be²⁺.
- (a) It gives a deposit of a carbonate with CO₂ of atmosphere, which can jam the tap.
 - (b) LiF has very large lattice energy because of the small size of both the Li⁺ and F⁻ ions. Thus its lattice energy exceeds the hydration energy and so is water insoluble.
 - (c) Be²⁺ on account of vacant p-orbital and it high polarising power form complex with water as ligands.

$$BeCl_2 + 4H_2O \longrightarrow [Be(H_2O)_4]^{2+} + 2Cl^-$$

Example-13

Sol.

Element (A) burns in nitrogen to give an ionic compound B. Compound B reacts with water to give (C) and (D). A solution of (C) becomes milky on bubbling CO₂. The chloride of element (A) imparts brick red colour to Bunsen flame. Identify (A) to (D). A = Ca, $B = Ca_{3}N_{2}$, $C = Ca(OH)_{2}$, $D = NH_{3}$. Ans. $3M + N_2 \longrightarrow M_3N_2$ (A) (B) $M_3N_2 + 6H_2O \longrightarrow 3M(OH)_2 + 2NH_3$ (B) (C) (D) $M(OH)_2 + CO_2 \longrightarrow MCO_3 \downarrow (milky) + H_2O$ As the colour of the flame is brick red, metal (A) can be Ca.

(vi) Carbonates :

(a) All the alkaline metals forms MCO₃ type carbonates. (b) Except BeCO₃, all the carbonates are stable towards heat. \therefore BeCO₃ is kept stored in atmosphere of CO₂.

$$BeCO_3 \xrightarrow{\Delta} BeO + CO_2$$

(c) Order of decreasing stability :

 $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3 > BeCO_3$

(vii) Nitrates :

(a) Alkaline earth metals forms $M(NO_3)_2$ type nitrates. (M-Alkaline earth metals).

(b) Stability increases from Be(NO₃)₂ to Ba(NO₃)₂ but these are less stable than IA group, due to smaller atomic size.

(c) All alkaline metals nitrates on heating gives oxides and $NO_2 + O_2$

$$M(NO_3)_2 \xrightarrow{\Delta} Oxides + NO_2 + O_2$$

(d) $Be(NO)_2$ forms a layer of BeO on its surface so reaction stops.

(viii) Nitrides :

(a) Only Be and Mg burns in N_2 to give $M_3 N_2$ (BeN₂, Mg_3N_2)

 $Be_3N_2 + 6H_2O \rightarrow 3Be(OH)_2 + 2NH_3$ $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

(ix) Sulphates :

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

from Be to Ba

 $BeSO_4 \! < \! MgSO_4 \! < \! CaSO_4 \! < \! SrSO_4 \! < \! BaSO_4$ (c) Solubility decreases from $BeSO_4$ to $BaSO_4$ as Be^{+2} and Mg⁺² are of small size so their hydration energy is high

Hydration Energy > Lattice energy

(d) Order of solubility -

 $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

(e) Order of thermal stability : BeSO₄, MgSO₄, CaSO₄, SrSO₄, BaSO₄

- Thermal stability increases

ANOMALOUS BEHAVIOUR OF BERYLLIUM

Beryllium shows different behaviour from the rest members of its group and shows diagonal relationship to aluminium due to reasons discussed below.

- (i) Beryllium has exceptionally small atomic and ionic sizes and therefore does not compare well with other members of the group, because of high ionisation enthalpy and small size it forms compounds which are largely covalent and get easily hydrolysed.
- (ii) Beryllium does not exhibit coordination number more than four as in its valence shell, there are only four orbitals. The remaining members of the group can have a coordination number of six by making use of d-orbitals.
- (iii) The oxides and hydroxide of beryllium unlike the hydroxide of other elements in the group, are amphoteric in nature.

SOLVED EXAMPLE

Example-14

	Halides of Be dissolve in organic solvent while of Ba
	do not
	(1) High hydration energy of Be halides
	(2) High lattice energy of barium halides
	(3) Large size of Ba ²⁺
	(4) Halides of Be are covalent but that of Ba are ionic
Ans.	(4)
Sol.	Halides of Be are covalent but that of Ba are ionic (Like dissolve like therefore covalent halide of Be dissolve in organic solvent while ionic halide of Ba in water).
	6

Example-15

А

The rat	io of moles	of water as wa	ater of crystal	lisation
in LiCl	and BaCl ₂ is	;		
(1)1:1	(2) 1:2	(3) 1:4	(4) 1:3	
(1)				

Ans.

LiCl.2H₂O and BaCl₂.2H₂O , have water of Sol. crystallisation in 1:1.

Example-16

Sol.

Which of the following statement is not correct?
(1) KOH is a stronger alkali than NaOH.
(2) Milk of magnesia is aqueous suspension of
Mg(OH) ₂ .
(3) MgO is a refractory material used for lining electrical
furnaces.
(4) $Mg(OH)_2$ precipitates on heating hydrated $MgCl_2$.
$MgCl_2.6H_2O \xrightarrow{\Delta} Mg_2OCl_2 \xrightarrow{\Delta} MgO$
Therefore, (4) option is correct.

⁻ Ionic nature increases

Example-17

Which is not correctly matched ?(i) Basic strength of oxides $Cs_2O < Rb_2O < K_2O < Na_2O < Li_2O$ (ii) Stability of peroxides $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$ (iii) Stability of bicarbonatesLiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3(iv) Melting pointNaF < NaCl < NaBr < NaI</td>(1) i and iv(2) i and iii(3) i and ii(4) ii and iii

Sol. (1) Basic strength of the oxides increases in the order $Li_2O < Na_2O < K_2O < Rb_2O < Cs_2O$. The increase in basic strength is due to the increase in metallic character down the group.

> (4) The melting and boiling points of alkali metals follow the trend : fluoride > chloride > bromide > iodide. As the size of anions increase, their tendency to get polarised increases and therefore, their covalent character increases and thus melting points decrease. So the melting points of the halides increases in the orderNaF > NaCl > NaBr > NaI,

Therefore, (1) option is correct.

Diagonal relationship between Beryllium and Aluminium

The ionic radius of Be^{2+} is approx. 31 pm; the charge/ radius ratio is nearly the same as that of the Al^{3+} ion. Hence beryllium resembles aluminium in some ways. Similarities between Al and Be is given below.

- (i) Like aluminium, beryllium is not readily attacked by acids because of the presence of an oxide film on the surface of the metal.
- (ii) Beryllium hydroxide dissolves in excess of alkali to give a beryllate ions, [Be(OH)₄]²⁻ just as aluminium hydroxide gives aluminate ion, [Al(OH)₄]⁻
- (iii) The chlorides of both beryllium and aluminium have Cl- bridged chloride structure in vapour phase. Both the chlorides are soluble in organic solvents and are strong lewis acids. They are used as Friedel Crafts catalysts.
- (iv) Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-} , AIF_6^{3-} .

SOME IMPORTANT COMPOUNDS OF CALCIUM

Calcium Oxide or Quick Lime (CaO)

It is prepared on a commercial scale by heating limestone $(CaCO_3)$ in a rotary kiln at 1070 - 1270 K.

 $CaCO_3 \rightarrow CaO + CO_2$

The carbon dioxide is removed as soon as it is produced to enable the reaction to proceed to completion.

Calcium oxide is a white amorphous solid. It has a melting point of 2870 K. On exposure to atmosphere, it absorbs moisture and carbon dioxide.

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

$$CaO + CO_2 \rightarrow CaCO_3$$

When small amount of water is added to lime it breaks the lump, this process is called slaking of lime. Quick lime slaked with soda gives solid soda lime. Being a basic oxide, it combines with acidic oxides at high temperature.

 $CaO + SiO_2 \rightarrow CaSiO_3$ $6CaO + P_4O_{10} \rightarrow 2Ca_3(PO_4)_2$

Uses of Calcium Oxide

(i) Calcium oxide is the cheapest form of alkali, it is also important primary material for manufacturing cement.(ii) it is used in the manufacture of sodium carbonate from caustic soda.

(iii) It is used in the purification of sugar and in the manufacture of dye stuffs

Calcium Hydroxide (Slaked Lime), Ca(OH)₂

Calcium hydroxide is prepared by adding water to quick lime (CaO).

Calcium hydroxide is a white amorphous powder. It is sparingly soluble in water. The aqueous solution is known as **lime water** and a suspension of slaked lime in water is known as **milk of lime**.

When carbon dioxide is passed through lime water it turns milky due to the formation of calcium carbonate. $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

When excess of CO_2 is passed, the precipitate dissolves to form calcium hydrogen carbonate.

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

Milk of lime reacts with chlorine to form hypochlorite, a constituent of bleaching power.

 $2Ca(OH)_2 + 2Cl_2 \rightarrow CaCl_2 + Ca(OCl)_2 + 2H_2O$

Uses of Calcium Hydroxide

- (i) It is used in preparation of building material called mortar.
- (ii) Due to its disinfectant nature, it is used in white wash.
- (iii) It is used in making glass, in tanning industry, for the purification of bleaching powder and for the purification of sugar.

Calcium Carbonate, CaCO₃(Lime stone)

Calcium carbonate is found in various forms like limestone, chalk, marbles etc. It can be prepared by passing carbon dioxide through slaked lime or by the addition of sodium carbonate to calcium chloride.

 $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

In this preparation, excess of carbon dioxide is avoided because it lead to the formation of water soluble calcium hydrogen carbonate. Calcium carbonate is a white fluffy powder. It is almost insoluble in water. When heated to 1200 K, it decomposes to evolve carbon dioxide.

$$CaCO_3 \xrightarrow{1200K} CaO + CO_2$$

It reacts with dilute acid to liberate carbon dioxide.

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

 $\rm CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

Uses of Calcium Carbonate, CaCO₃

In the form of marble and in the manufacture of quick lime, it is used as a building material. It is used as flux in extraction of iron when mixed with magnesium. Specially precipitated $CaCO_3$ is extensively used in the manufacture of high quality paper. It is also used as an antacid; mild abrasive in tooth paste, a constituent of chewing gum, and as filler in cosmetics.

Plaster of Paris CaSO₄.
$$\frac{1}{2}$$
H₂O

It is a hemihydrate of calcium sulphate. It is obtained when gypsum, $CaSO_4.2H_2O$, is heated at 393 K.

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

Above 393 K, no water of crystallisation is left and anhydrous calcium sulphate, $CaSO_4$ is formed. This is known as **'dead burnt plaster'**.

It has a unique property of setting with water. On mixing with a sufficient quantity of water it forms a plastic mass that gets into a hard solid in 5 to 15 minutes.

Uses of Plaster of Paris

Used in building industry and in plasters. It is used for immobilising the affected part of organ where there is a bone fracture or sprain. It is also used in dentistry, in ornamental work and for making casts of statues and busts.

CEMENT

Cement was first introduced in England in 1824 by Joseph Aspdin. It is also called Portland cement because it resembles with the natural lime tone quarried in the Isle of Portland, England.

Cement is obtained by combining CaO with clay, which contains silica, SiO_2 along with oxides of aluminium, iron and magnesium. The average composition of Portland cement is

CaO	\rightarrow	50 to 60%
SiO ₂	\rightarrow	20-25%
Al ₂ O ₃	\rightarrow	5 to 10%
MgO	\rightarrow	2 - 3%
Fe ₂ O ₃	\rightarrow	1 - 2%
SO ₃	\rightarrow	1 - 2%

For a good quality cement the ratio of silica (SiO_2) to alumina (Al_2O_3) should be between 2.5 and 4 and the ratio of lime (CaO) to the total of the oxides of silicon (SiO_2) aluminium (Al_2O_3) and iron (Fe_2O_3) should be close as possible to 2.

During manufacture of cement clay and lime are strongly heated together, they fuse and react to form cement clinker. This clinker is mixed with 2-3% by weight of gypsum (CaSO₄.2H₂O) to form cement. Thus important ingredient present in Portland. Cement are dicalcium silicate (Ca₂SiO₄) 26%, tricalcium silicate (Ca₃SiO₅) 51% and tricalcium aluminate (Ca₃Al₂O₆) 11%.

Setting of Cement

When mixed with water the setting of cement takes place which gives a hard mass. This is due to hydration of the molecules of the constituents and their rearrangement. The reason of adding gypsum is only to slow down the process of setting of the cement so that it gets sufficiently hardened.

Uses of Cement

- (i) It has become an important commodity next to iron and steel.
- (ii) It is used in concrete and reinforced concrete, in plastering and in the construction of bridges, dams and buildings.

SOLVED EXAMPLE

Example-18

On heating gypsum al	bove 393 K, the product formed
is	
(1)2(CaSO ₄).H ₂ O	(2) CaSO ₄ .H ₂ O
(3) CaSO ₄ .H ₂ O	(4) Dead burnt plaster

- Ans. (4)
- Sol. Above 393 K, no water of crystallisation is left and anhydrous calcium sulphate, $CaSO_4$ is formed. This is known as 'dead burnt plaster'.

BIOLOGICAL IMPORTANCE OF MAGNESIUM AND CALCIUM

An adult body contains about 25 g of Mg and 1200 g of Ca compared with only 5 g of iron and 0.06 g of copper. The daily requirement in the human body has been estimated to be 200-300 mg.

All enzymes that uses ATP in phosphate transfer require magnesium as the cofactor. The chlorophyll contain magnesium. About 99% of body calcium is present in bones and teeth.

It also plays important roles in neuromuscular function, inter neuromal transmission, cell membrane integrity and blood coagulation. The calcium concentration in plasma is regulated at about 100 mg L^{-1} . It is maintained by two hormones: calcitonin and parathyroid hormone. Bone is continuously solublised and redeposited to the extent of 400 mg per day in man.

Uses of alkaline earth metals

(i)

- Beryllium is used in the manufacture of alloys. Cooper-Beryllium alloys are used in the making of high strength springs.
- Metallic beryllium is used for making windows of Xrays tubes.
- (iii) Magnesium, being a light metal, forms many light alloys with aluminum, zinc, manganese and tin.
- (iv) Magnesium (Powder and ribbon) is used in flash powders and bulbs, incendiary bombs and signals).
- (v) Magnesium-aluminium alloys are used in aircraft construction.
- (vi) Magnesium is used as sacrificial anode for the prevention of corrosion of iron.
- (vii) A suspension of magnesium hydroxide in water (called milk of magnesia) is used as an ant-acid to control excess acidity in stomach.

(viii) Magnesium carbonate is an ingredient of toothpaste.

- (ix) Calcium is used in the extraction of metals from oxides which are difficult to reduce with carbon.
- (x) Calcium and barium metals are used to remove air from vacuum tubes, due to their tendency to react with oxygen and nitrogen at high temperature.
- (xi) Radium salts are used for radio therapy of cancer.

EXERCISE-I

Properties of Alkali Metals

- Q.1 The alkali metals which form normal oxide, peroxide as well as super oxides are (1) Na, Li (2) K, Li (3) Li, Cs (4) K, Rb
- Q.2 Potassium is kept in (1) Alcohol (2) Water (3) Kerosene (4) Liquid ammonia
- Q.4 Which of the following statement is correct regarding alkali metals
 - (1) Cation is less stable than the atom
 - (2) Cation is smaller than the atom
 - (3) Size of cation and atom is the same
 - (4) Cation is greater in size than the atom
- Q.5 On flame test K give colour -(1) Golden yellow (2) Crimson red (3) Violet (4) Apple green
- Q.6 Which of the following alkali metals is smallest in size (1) Rb (2) K (3) Na (4) Li
- Q.7 Which one does not form a peroxide on heating in air (1) Na (2) Ba (3) Ca (4) Li
- Q.8 The alkaline earth metals, which do not impart any colour to Bunsen flame are
 (1) Be and Mg
 (2) Mg and Ca
 (3) Be and Ca
 (4) Be and Ba

Properties of compounds of Alkali Metals

- **Q.10** Na₂CO₃ can be manufactured by Solvay's process but K_2CO_3 cannot be prepared because (1) K_2CO_3 is more soluble (2) K_2CO_3 is less soluble (3) KHCO₃ is less soluble than NaHCO₃ (4) KHCO₃ is less soluble than NaHCO₃
- Q.11 Which metal forms amide with NH₃ at 300°C (1) Mg (2) Pb (3) Al (4) Na

- Q.12Which does not exists in solid state -
(1)LiHCO3
(2)CaCO3
(3)NaHCO3(2)CaCO3
(4)Na2CO3
- Q.13 Which of the following alkali metal carbonate is the least stable and decomposes readily
 (1) Li₂CO₃
 (2) Na₂CO₃
 (3) K₂CO₃
 (4) Cs₂CO₃
- Q.14A solid compound 'X' on heating gives CO_2 gas and
a residue. The residue mixed with water forms 'Y'.
On passing an excess of CO_2 through 'Y' in water, a
clear solution, 'Z' is obtained. On boiling 'Z',
compound 'X' is reformed. The compound 'X' is
(1) Na_2CO_3
(2) K_2CO_3
(3) Ca(HCO_3),
(4) CaCO_3
- Q.15 Amongst LiCl, RbCl, BeCl₂ and MgCl₂ the compounds with the greatest and least ionic character respectively are (1) LiCl and RbCl (2) MgCl₂ and BeCl₂

(3) RbCl and BeCl ₂	(4) RbCl and MgC

- Q.16 Which of the following pair can't exist in solution (1) NaHCO₃ and NaOH (2) Na₂CO₃ and NaOH (3) Na₂CO₃ and NaCl (4) NaHCO₃ and NaCl
- Q.17 In the Down's method for the extraction of sodium, the melting point of the electrolyte is lowered by adding (1) Potassium chloride (2) Calcium chloride
 (3) Potassium fluoride (4) Cryolite
- Q.18 A blue coloured solution of sodium in liquid NH₃ acts strong reducing agent, because of
 (1) ammoniated sodium
 (2) Ammonia dissociates
 - (3) Sodium nitride is formed
 - (4) ammoniated electron

Properties of Alkaline Earth Metals

- Q.19 The correct order of hydration energy of alkaline earth metal ions is -
 - (1) $Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$
 - (2) $Ba^{+2} > Be^{+2} > Ca^{+2} > Mg^{+2} > Sr^{+2}$
 - (3) $Mg^{+2} > Be^{+2} > Ba^{+2} > Ca^{+2} > Sr^{+2}$
 - (4) None
- Q.20 Beryllium differs from rest of the members of its family (Group-IIA) in many ways. The reason for this is its (1) Small size and higher electronegativity
 - (2) Small size and lower electronegativity
 - (3) Large size and lower ionisation energy
 - (4) Large size and largest ionic radius

Properties of compounds of Alkali Metals

Q.21	Mg is present in -		
	(1) Chlorophyll	(2) Haemoglobin	
	(3) Vitamin–B ₁₂	(4) Vitamin $-B_2$	

- Q.22 Gypsum CaSO₄.2H₂O on heating to about 120°C forms a compound which has the chemical composition represented by (1) CaSO₄ (2) 2CaSO₄.H₂O (3) CaSO₄.H₂O (4) 2CaSO₄.3H₂O
- Q.23 Bleaching powder is a compound having the molecular formula
 (1) CaOCl₃ (2) CaOCl₂ (3) CaClO (4) CaClO₃
- $\begin{array}{ccc} \textbf{Q.24} & \text{Calcium cynamide is} \\ & (1) \, \text{CaCHNH}_2 & (2) \, \text{CaCN}_2 \\ & (3) \, \text{CaC}_2 \text{N}_2 & (4) \, \text{Ca(CN)}_2 \end{array}$
- Q.25 Which of the alkaline earth metal sulphates is the least soluble ?

(1) BeSO_4 (2) CaSO_4 (3) SrSO_4 (4) BaSO_4

- Q.26 Which of the following has correct increasing basic strength -
 - (1) MgO < BeO < CaO < BaO
 - (2) BeO < MgO < CaO < BaO
 - (3) BaO < CaO < MgO < BeO
 - $(4) \, CaO < BaO < BeO < MgO$

Q.27 Melting point of calcium halides decreases in the order

(1) $CaF_2 > CaCl_2 > CaBr_2 > CaI_2$ (2) $CaI_2 > CaBr_2 > CaCl_2 > CaF_2$ (3) $CaBr_2 > CaI_2 > CaF_2 > CaCl_2$ (4) $CaCl_2 > CaBr_2 > CaI_2 > CaF_2$

 $\begin{array}{ll} \textbf{Q.29} & \text{The correct order of the increasing ionic character is} \\ (1) & \text{BeCl}_2 < \text{MgCl}_2 < \text{CaCl}_2 < \text{BaCl}_2 \\ (2) & \text{BeCl}_2 < \text{MgCl}_2 < \text{BaCl}_2 < \text{CaCl}_2 \\ (3) & \text{BeCl}_2 < \text{BaCl}_2 < \text{MgCl}_2 < \text{CaCl}_2 \\ (4) & \text{BaCl}_2 < \text{CaCl}_2 < \text{MgCl}_2 < \text{BeCl}_2 \\ \end{array}$

- **Q.30** The incorrect statement(s) is/are
 - (1) Mg cannot form complexes
 - (2) Be can form complexes due to a very small atomic size
 - (3) the first ionisation potential of Be is higher than that of Mg
 - (4) Mg forms an alkaline hydroxide while Be forms amphoteric oxides

EXERCISE-II

- Q.1 Alkali metals are not characterised by : (1) good conductor of heat and electricity
 - (2) high oxidation potentials
 - (3) high melting points
 - (4) solubility in liquid ammonia
- Q.2 Cs⁺ ion impart violet to Bunsen flame. This is due to the fact that the emitted radiations are of (1) high energy (2) lower frequencies (3) longer wave-lengths (4) zero wave number
- Q.4 Which one of the following electrolyte is used in Down's process of extracting sodium metal ? (1) NaCl+CaCl₂+KF (2) NaCl (3) NaOH+KCl+KF (4) NaCl+NaOH

- **Q.5** A solution of sodium in liquid ammonia is strongly reducing and highly conducting due to the presence of
 - (1) sodium atoms(3) sodium amide

Q.6

(4) solvated electrons

(2) sodium hydride

The reaction of an element A with water produces combustible gas B and an aqueous solution of C. When another substance D reacts with this solution C also produces the same gas B.D also produces the same gas even on reaction with dilute H_2SO_4 at room temperature. Element A imparts golden yellow colour to Bunsen flame. Then A,B,C and D may be identified as

(1) Na,H₂, NaOH and Zn (2) K,H₂,KOH and Zn (3) K,H₂ NaOH and Zn (4) Ca,H₂ CaCOH, and Zn

- Q.7 Which salt on heating does not give brown coloured gas ? (1) LiNO₃ (2) KNO₃ (3) Pb(NO₃)₂ (4) AgNO₃
- Q.8 Solution of sodium metal in liquid ammonia is a strong reducing agent due to presence of-(1) solvated sodium ions (2) solvated hydrogen ions
 - (3) sodium atoms or sodium hydroxide
- (4) solvated electrons
 Q.9 The order of solubility of lithium halides in non-polar solvents follows the order :
 (1) LiI>LiBr>LiCl>LiF (2) LiF>LiI>LiBr>LiCl
 (3) LiCl>LiF>Lil>LiBr (4) LiBr>LiCl>LiF>LiI

Q.10 Na + Al₂O₃
$$\xrightarrow{\text{High temperature}} X \xrightarrow{\text{CO}_2\text{in}} Y;$$

Compound Y is-
(1) NaAlO₂ (2) NaHCO₃
(3) Na₂CO₃ (4) Na₂O₂

- Q.11 Which of the following statement is not correct ?

 (1) KOH is a stronger alkali than NaOH.
 (2) Milk of magnesia is aqueous suspension of Mg(OH)₂.
 - (3) MgO is a refractory material used for lining electrical furnaces.
 - (4) MgCl₂.6H₂O on heating yields Mg(OH)₂.
- Q.12 (White ppt)D $\leftarrow \frac{Na_2CO_3}{(in acetiacid)} A \frac{K_2CrO_4}{(in acetiacid)} B$ (Yellow ppt) dil.H₂SO₄ \downarrow C(White ppt)

If A is the metallic salt, then the white ppt. of D must be of-

- (1) stronsium carbonate (2) red lead
- (3) barium carbonate (4) calcium carbonate

The chemical formulae of A and B are-(1) NaOH and Ca(OH), (2) Ca(OH), and NaOH (3) NaOH and CaO (4) CaO and Ca(OH), Q.14 A fire work gave bright crimson light. It probably contained a salt of : (1)Ca (2) Sr (3) Ba (4) Mg Q.15 A piece of magnesium ribbon was heated to redness in an atmosphere of nitrogen and on cooling, water was added, the gas evolved was : (2) hydrogen (1) ammonia (3) nitrogen (4) oxygen The hydration energy of Mg²⁺ is-Q.16 (1) more than that of Mg^{3+} ion (2) more than that of Na^+ ion (3) more than that of Al^{3+} ion (4) more than that of Be^{3+} ion EDTA is used in the estimation of-Q.17 (1) Mg^{2+ions} (2) Ca^{2+} ions (3) both Ca^{2+} and Mg^{2+} ions (4) Mg²⁺ ions but not Ca²⁺ ions Q.18 A metal M readily forms water soluble sulphate MSO₄, water insoluble hydroxide M(OH)2 and oxide MO. The oxide and hydroxide are soluble in NaOH. The M is : (1)Be (2) Mg (3) Ca (4) Sr Which of the following salts on heating gives a mixture Q.19 of two gases ? (1) Ba(NO₃)₂ (2) NaNO₃ (3) KNO₃ (4) RbNO₃ Q.20 A compound X on heating gives a colourless gas. The residue is dissolved in water to obtained Y. Excess CO₂ is bubbled through aqueous solution of Y, Z is formed. Z on gently heating gives back X. The compound X is: (1)CaCO₃ (2)Na₂CO₃ (3) Ca(HCO₃)₂ $(4) K_{2}CO_{3}$

(Milky Cloud) $C \xleftarrow{CO_2} A + Na_2CO_3 \rightarrow B + C$

Q.13

EXERCISE-III

MCQ/COMPREHENSION/MATCHING/NUMERICAL

- Q.1 Select correct statement(s) :
 - (A) Li₂CO₃ is only sparingly soluble in water and no LiHCO₃ has been isolated.
 - (B) K₂CO₃ cannot be made by a method similar to the ammonia soda (Solvay) process.
 - (C) Li₂CO₃ and MgCO₃ both are thermally stable.
 - (D) Na₂CO₃. NaHCO₃. 2H₂O is a mineral called trona.

KO₂ finds use in oxygen cylinders used for space and submarines. The fact(s) related to such use of KO₂ is/ are-

(A) it produces O₂

Q.2

- (B) it produces O₃
- (C) it absorbs CO_{2}
- (D) it absorbs both CO and CO_2

Q.3	The compound(s) which have -O-O bond(s) is/are-
	(A) BaO_2	$(B) \operatorname{Na_2O_2}$
	(C) CrO ₅	$(D) \operatorname{Fe}_2O_3$

Q.4 Highly pure dilute solution of sodium in ammonia -

- (A) shows blue colouration due to solvated electrons(B) shows electrical conductivity due to both solvated electrons as well as solvated sodium ions
- (C) shows red colouration due to solvated electrons but a bad conductor of electricity
- (D) produces hydrogen gas or carbonate

Q.5 Select correct statement(s) :

- (A) Stability of peroxides and superoxides of alkali metals increases with increase in size of the cation.
- (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.
- Q.6 Select correct statment :
 - (A) Oxides (M₂O) and peroxides (M₂O₂) of alkali metals are diamagnetic and colourless.
 - (B) Superoxides (MO₂) of alkali metals are paramagnetic.
 - (C) Li and Na do not form superoxides.
 - (D) All are correct.
- Q.7 Which of the following substance(s) is/are used in laboratory for drying purposes ?
 - (A) anhydrous P_2O_5
 - (B) graphite
 - (C) an hydrous ${\rm CaCl}_{\rm 2}$
 - $(D) Na_3 PO_4$
- **Q.8** Na_2SO_4 is water soluble but $BaSO_4$ is insoluble because-
 - (A) the hydration energy of Na_2SO_4 is higher than that of its lattice energy
 - (B) the hydration energy of Na₂SO₄ is less than that of its lattice energy
 - (C) the hydration energy of BaSO₄ is less than that of its lattice energy
 - (D) the hydration energy of BaSO₄ is higher than that of its lattice energy
- Q.9 Which of the following are ionic carbides ? (A) CaC_2 (B) Al_4C_3 (C) SiC (D) Be_2C

- Q.10 In water :
 - (A) temporary hardness is due to the bicarbonates of ${\rm Ca}^{2+}$ and ${\rm Mg}^{2+}$
 - (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.

- Q.11 Slaked lime, Ca(OH), is used :
 - (A) in the manufacture of sodium hydroxide.
 - (B) in the manufacture of bleaching powder.
 - (C) in the preparation of ammonia from ammonium salts.
 - (D) in the detection of carbondioxide gas.
- Q.12 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.

Comprehension #1 (Q. no. 13 to 15)

Bleaching powder is considered as a mixed salt of Hydrochloric acid and Hypochlorous acid. It is a pale yellow powder. It shows oxidising and beaching properties. A good sample of bleaching powder contains 35-38 % of available chlorine. Bleaching

powder can be prepared by reacting $Ca(OH)_2$, with

 Cl_2 .

Q.13 Which of the following is formed by the reaction of Bleaching powder with acetone.

(A) CCl ₄	(B) CHCl ₃
(C) CCl ₃ CHO	(D) CH ₃ Cl

Q.14 Maximum percentage of available chlorine on the basis of CaOCl₂.H₂O formula is

(A) 35	(B)40
(C)45	(D)49

- Q.15 On long standing bleaching powder undergoes autoxidation. The products formed are
 - (A) CaCl₂ and HClO

(B) $Ca(ClO_3)_2$ and $CaCl_2$

- (C) $Ca(ClO_4)_2$ and $CaCl_2$
- (D) $Ca(ClO_3)_2$ and $Ca(ClO_4)_2$

Q.16 Match the particulars/name of process listed in Column-I with the formula of the compounds listed in

Column-IColumn-II(A) Solvay process $(p) Na_2O$ (B) Evolve CO_2 on heating $(q) Na_2O_2$ (C) Aqueous solution is not neutral towards litmus $(r) NaHCO_3$ (D) Used as air purifier in submarine $(s) Na_2CO_3$

Q.17 Match the reactions given in Column I with the main products obtained and given in Column II. Column - I Column - II

(A) $Ca(OH)_2 + Cl_2$	→ below 35°C	(p) Calcium chloride and oxygen gas.
(slaked lime)		
$(B) Ca(OH)_2 + Cl_2$	cold (below 25°C) →	(q) Calcium chloride and calcium chlorate.
(milk of lime)		
$(C) Ca(OH)_2 + Cl_2$	heat (above 35°C)	(r) Bleaching powder.
(D) $Ca(OH)_2 + Cl_2$	red hot	(s) Calcium chloride and calcium hypochlorite.
(slaked lime)		(t) Calcium chloride & calcium chlorite.

NUMERICAL VALUE BASED

- Q.18 How many X–O–X linkages are present in the structure of calgon (NaPO₃)₆
- Q.19 How many of the following are correctly matched?

Element	Colour in flame test
Κ	Violet/Lilac
Na	Yellow
Be	Crimson red
Ca	Brick red
Sr	Apple green
Mg	No colour
Rb	Red violet
Cs	Blue
Li	Crimson red

- Q.20 How many of the following form polymeric chains? BeCl₂, AlCl₃, NaHCO₃, Li₂CO₃, BeH₂, Na₂CO₃
- Q.21 NaOH + PbO $\xrightarrow{\Delta} x + H_2O$ NaOH + SnO₂ $\xrightarrow{\Delta} y + H_2O$ NaOH + H₂O + Al $\xrightarrow{\Delta} z + H_2$

Sum of the number of atoms present in one molecule each of x, y, z is......

Q.22 Molecular formula of Glauber's salt in $Na_2SO_4.xH_2O$. The value of x is_____.

EXERCISE-IV

0.2

JEE-MAIN PREVIOUS YEAR'S

Q.1 The hottest region of Bunsen flame shown in the figure below is: [JEE Main-2016]



(1) region 2 (2) region 3 (3) region 4 (4) region 1

The main oxides formed on combustion Li, Na and K in excess of air are, respectively: [JEE Main-2016]

(1) Li_2O , Na_2O and KO_2 (2) LiO_2 , Na_2O_2 and K_2O (3) Li_2O_2 , Na_2O_2 and KO_2 (4) Li_2O , Na_2O_2 and KO_2 Q.3 Both lithium and magnesium display several similar properties due to the diagonal relationship; however, the one which is incorrect is : [JEE Main-2017]

- (1) Both form basic carbonates
- (2) Both form soluble bicarbonates
- (3) Both form nitrides
- (4) Nitrates of both Li and Mg yield NO_2 and O_2 on heating
- Q.4 When metal 'M' is treated with NaOH, a white gelatinous precipitate 'X' is obtained, which is soluble in excess of NaOH. Compound 'X' when heated strongly gives an oxide which is used in chromatography as an adsorbent. The metal 'M' is [JEE Main-2018] (1) Ca (2) Al (3) Fe (4) Zn
- Q.5 A metal on combustion in excess air forms X, X upon hydrolysis with water yields H_2O_2 and O_2 along with another product. The metal is:

(1) Na (2) Rb [JEE Main - 2019 (January)] (1) Na (2) Rb (3) Mg (4) Li

- Q.6 The metal used for making X-ray tube window is [JEE Main - 2019 (January)] (1) Mg (2) Na (3) Be (4) Ca
- Q.7 Sodium metal on dissolution in liquid ammonia gives a deep blue solution due to the formation of [JEE Main 2019 (January)]
 - (1) sodium ammonia complex
 - (2) sodamide
 - (3) sodium ion-ammonia complex
 - (4) ammoniated electrons
- Q.8 NaH is an example of: [JEE Main 2019 (January)] (1) electron rich hydride (2) metallic hydride (3) saline hydride (4) molecular hydride
- **Q.9** The alkaline earth metal nitrate that does not crystallise with water molecules is [JEE Main 2019 (January)] (1) $Mg(NO_3)_2$ (2) $Sr(NO_3)_2$ (3) $Ca(NO3)_2$ (4) $Ba(NO_3)_2$
- $\begin{array}{c} \textbf{Q.11} & \text{The amphoteric hydroxide is:} \\ & \textbf{[JEE Main 2019 (January)]} \\ (1) \text{Be}(\text{OH})_2 & (2) \text{Ca}(\text{OH})_2 \\ (3) \text{Mg}(\text{OH})_2 & (4) \text{Sr}(\text{OH})_2 \end{array}$
- Q.13 Magnisium powder burns in air to give : [JEE Main 2019 (April)]

(1) MgO only	(2) MgO and Mg(NO ₃) ₂
(3) MgO and Mg ₃ N ₂	$(4) Mg(NO_3)_2$ and Mg_3N_2

- Q.14 The covalent alkaline earth metal halide (X = Cl, Br, I) is [JEE Main 2019 (April)] (1) CaX, (2) SrX, (3) BeX, (4) MgX,
- Q.15 Among the following, the energy of 2s orbital is lowest in: [JEE Main 2019 (April)] (1) K (2) Na (3) Li (4) H
- Q.16 The INCORRECT statement is [JEE Main 2019 (April)]
 - (1) Lithium is least reactive with water among the alkali metals
 - (2) LiCl crystallises from aqueous solution as LiCl.2H₂O
 - (3) Lithium is the strongest reducing agent among the alkali metals
 - (4) LiNO₃ decomposes on heating to give LiNO₂ and O₂

Q.18 A metal (A) on heating in nitrogen gas gives compound B. B on treatment with H_2O gives a colorless gas which when passed through $CuSO_4$ solution gives a dark blueviolet coloured solution. A and B respectively, are :

[JEE Main-2020 (January)]

(1) Mg and Mg_3N_2 (2) Na and NaNO₃ (3) Mg and Mg(NO₃)₂ (4) Na and Na₃N

- Q.19 Among the statements (a) (d), the correct ones are : [JEE Main-2020 (January)]
 (a) Lithium has the highest hydration enthalpy among the alkali metals.
 (b) Lithium chloride is insoluble in pyridine.
 (c) Lithium cannot form ethynide upon its reaction with ethyne.
 (d) Both lithium and magnesium react slowly with H₂O.
 (1) (a), (b) and (d) only (2) (b) and (c) only
 - (3) (a) and (d) only (4) (a), (c) and (d) only
- Q.20 Two elements A and B have similar chemical properties. They don't form solid hydrogencarbonates, but react with nitrogen to form nitrides. A and B, respectively, are [JEE Main-2020(September)] (1) Li and Mg (2) Cs and Ba (3) Na and Rb (4) Na and Ca
- **0.21** Among the statements (I IV), the correct ones are
 - [JEE Main-2020 (September)]
 - (I) Be has smaller atomic radius compared to Mg.
 - (II) Be has higher ionization enthalpy than Al.
 - (III) Charge/radius ratio of Be is greater than that of Al.
 - (IV) Both Be and Al form mainly covalent compounds.

(1) (I), (III) and (IV)	(2)(I),(II) and (IV)
(3) (I), (II) and (III)	(4) (II), (III) and (IV)

Q.22 An alkaline earth metal 'M' readily forms water soluble sulphate and water insoluble hydroxide. Its oxide MO is very stable to heat and does not have rock-salt structure. M is [JEE Main-2020(September)] (1) Ca (2) Mg (3) Sr (4) Be

Q.24 Match the following compounds (Column-I) with their uses (Column-II) [JEE Main-2020 (September)]

S. No.	Column-I	S. No.	Column-II
(I)	Ca(OH) ₂	(A)	Casts of statues
(II)	NaCl	(B)	White wash
(III)	CaSO ₄ . $\frac{1}{2}$ H ₂ O	(C)	Antacid
(IV)	CaCO ₃	(D)	Washing soda
			preparation

(1)(I)-(B),(II)-(C),(III)-(D), (IV)-(A)
(2)(I)-(B),(II)-(D),((III)-(A), (IV)-(C)
(3)(I)-(C),(II)-(D),((III)-(B), (IV)-(A)
(4) (I)-(D), (II)-(A), ((III)-(C), (IV)-(B)
Among the sulpha	ates of alkaline earth metals, the
solubilities of BeSC	O ₄ and MgSO ₄ in water, respectively,
are	[JEE Main-2020(September)]
(1) poor and poor	(2) poor and high
(3) high and poor	(4) high and high

ANSWER KEY

Q.25

				EXE	RCISE-I				
Q.1 (4)	Q.2 (3)	Q.3 (4)	Q.4 (2)	Q.5 (3)	Q.6 (4)	Q.7 (4)	Q.8 (1)	Q.9 (2)	Q.10 (3)
Q.11 (4)	Q.12 (1)	Q.13 (1)	Q.14 (4)	Q.15 (3)	Q.16 (1)	Q.17 (2)	Q.18 (4)	Q.19 (1)	Q.20 (1)
Q.21 (1)	Q.22 (2)	Q.23 (2)	Q.24 (2)	Q.25 (4)	Q.26 (2)	Q.27 (1)	Q.28 (4)	Q.29 (1)	Q.30 (1)

EXERCISE-II

Q.1 (3)	Q.2 (1)	Q.3 (4)	Q.4 (1)	Q.5 (4)	Q.6 (1)	Q.7 (2)	Q.8 (4)	Q.9 (1)	Q.10 (3)
Q.11 (4)	Q.12 (3)	Q.13 (2)	Q.14 (2)	Q.15 (1)	Q.16 (2)	Q.17 (3)	Q.18 (1)	Q.19 (1)	Q.20 (1)

EXERCISE-III

MCQ/COMPREHENSION//MATCHING/NUMERICAL

Q.1 (ABD)	Q.2 (AC)	Q.3 (ABC)	Q.4 (AD)	Q.5 (ABC)	Q.6 (AB)	Q.7 (AC)	Q.8 (CD)	Q.9 (ABD)	Q.10 (ABC)
Q.11 (ABCD)		Q.12 (ABCE))	Q.13 (B)	Q.14 (D)	Q.15 (B)			
Q.16 (A) – r, s	s (B)-r (C))–p,q,r,s (D) – q	Q.17 (A) – r	(B) - s (C)	-q(D)-p	Q.18 [6]	Q.19 [7]	Q.20 [3]
Q.21 [15]	Q.22 [10]								

EXERCISE-IV

JEE-MAIN PREVIOUS YEAR'S

Q.1 (1)	Q.2 (4)	Q.3 (1)	Q.4 (2)	Q.5 (2)	Q.6 (3)	Q.7 (4)	Q.8 (3)	Q.9 (4)	Q.10 (2)	
Q.11 (1)	Q.12 (1)	Q.13 (3)	Q.14 (3)	Q.15 (1)	Q.16 (4)	Q.17 (2)	Q.18 (1)	Q.19 (4)	Q.20 (1)	
Q.21 (2)	Q.22 (4)	Q.23 (3)	Q.24(2)	Q.25 (4)						

EXERCISE (Solution)

EXERCISE-I

Q.1 (4)

 $M + O_2 \rightarrow M_2O \xrightarrow{+O_2} M_2O_2 \xrightarrow{+O_2} MO_2$ M = K, Rb, Cs

Q.2 (3)

Alkali metals are highly reactive metals. They react with Alcohol $- 2C_2H_5OH + 2K \rightarrow 2C_2H_5OK + H_2$

Water $-2K + 2H_2O \rightarrow 2KOH + H_2$ Ammonia $-K + (x + y)NH_3 \rightarrow$

 $\begin{bmatrix} K(NH_3)_x \end{bmatrix}^+ + \begin{bmatrix} e(NH_3)_y \end{bmatrix}^-$ Ammoniated cation

But they do not react with kerosene.

Q.3 (4)

Smaller size ion in gas form have greater size ion in aq. medium.

Q.4 (2)

After removal of an electron the effective nuclear charge per electron increases hence the size decreases.

Q.6	(4)				
	Element –	Li	Na	Κ	Rb
	Atomic radius (pm) –	152	186	227	248

Q.7 (4)

Li forms only oxides Q.8 (1)

High IE of Be & Mg. Q.9 (2)

H.E. $\propto \frac{\text{charge}}{\text{size}}$

Q.10 (3)

Q.11 (4) $2Na + 2NH_3 \xrightarrow{heat} 2NaNH_2 + H_2$

Q.12 (1) Greater size of HCO_3^- not stable with Li^+

Q.13 (1)

In polyatomic anions stability inversely depends on polarising power of cation.

Q.14 (4)

The given compound x must be $CaCO_3$. It can be explained by following reactions,

$$CaCO_{(x)} \xrightarrow{\Delta} CaO_{Residue} + CO_{2} \uparrow ; CaO + H_{2}O \rightarrow$$

$$Ca(OH)_{2}$$

$$Ca(OH)_{2} + CO_{2} + H_{2}O \rightarrow Ca(HCO_{3})$$

$$z$$

$$Ca(HCO_{3})_{2} \xrightarrow{\Delta} CaCO_{3} + CO_{2} \uparrow + H_{2}O$$

Q.15 (3)

According to Fajan's rule RbCl has greatest ionic character due to large ionic size of Rb^+ ion. $BeCl_2$ has least ionic (Maximum covalent) due to small size of Be^{+2} ion which has highly polarising.

Q.16 (1) Q.17 (2)Q.18 (4) $Na \xrightarrow{NH_3} Na^+_{(NH_3)_x} + e^-_{(NH_3)_y}$ Q.19 (1) Q.20 (1) (i) Small atomic size. (ii) High electronegativity (iii) Absence of d orbitals Q.21 (1) Q.22 (2)Q.23 (2)Q.24 (2)Q.25 (4) Solubility of IIA sulphates decreases down to the group. **Q.26** (2)

Basic strength of oxides $\propto \frac{1}{EN}$

- Q.27 (1) M.P. of s-block metal halides \propto L.E. $F^->Cl^->Br^->l^-$
- **Q.28** (4)
- **Q.29** (1) $BeCl_2 < MgCl_2 < CaCl_2 < BaCl_2$ As we go down the group I.E. decreases. Hence ionic character increases.
- Q.30 (1) Chlorophyl is complex of Mg.

EXERCISE-II

- Q.1 (3)
 - They have weak metallic bond because of one valence electron per atom. So they have low melting points.
- Q.2 Cs⁺ ion impart violet to Bunsen flame. This is due to the fact that the emitted radiations are of (1) high energy
 (2) lower frequencies
 - (3) longer wave-lengths
 - (4) zero wave number

Q.3 (4)

Li reacts with N_2 and O_2 of air forming Li₃N and Li₂O but Na reacts with only O_2 forming Na₂O not with N_2 forming Na₃N (it requires high temperature.)

Q.4 (1)

Down's process involves the electrolysis of fused sodium chloride containing $CaCl_2 \& KF$ using Fe as cathode & graphite as anode at about 600°C. $CaCl_2 \& KF$ are added to decrease fusion temperature (1600°C).

Q.5 (4)

 $M + (x + y) NH_3 \longrightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-;$ solution contains unpaired solvated electrons which are responsible for their strongly reducing and highly conducting nature.

Q.6 (1)
Na + H₂O
$$\rightarrow$$
 NaOH + H₂

A C B (Combustible) $Zn + NaOH \rightarrow Na_2ZnO_2 + H_2$ Amphoteric $Zn + dil H_2SO_4 \rightarrow ZnSO_4 + H_2$

Q.7

(2)

(1)
$$2\text{LiNO}_{3} \xrightarrow{\Delta} \text{Li}_{2}\text{O} + 2\text{NO}_{2} \uparrow (\text{brown}) + \frac{1}{2}\text{O}_{2} \uparrow$$

(2) $\text{KNO}_{3} \xrightarrow{\Delta} \text{KNO}_{2} + \frac{1}{2}\text{O}_{2} \uparrow$
(3) $\text{Pb}(\text{NO}_{3})_{2} \xrightarrow{\Delta} \text{PbO} + 2\text{NO}_{2} \uparrow (\text{brown}) + \frac{1}{2}\text{O}_{2} \uparrow$
(4) $2\text{AgNO}_{3} \xrightarrow{\Delta} 2\text{Ag} + 2\text{NO}_{2} \uparrow (\text{brown}) + \text{O}_{2} \uparrow$

Q.8 (4)

$$\begin{array}{rl} \mathrm{Na}_{\scriptscriptstyle(\mathrm{s})} + & (\mathrm{x} + \mathrm{y})_{\scriptscriptstyle(\mathrm{g})} \mathrm{NH}_{\scriptscriptstyle 3} \rightarrow & \mathrm{Na}^{\scriptscriptstyle(}(\mathrm{NH}_{\scriptscriptstyle 3})_{\mathrm{x}} + & \mathrm{e}(\mathrm{NH}_{\scriptscriptstyle 3})_{\mathrm{y}} \\ & & \mathrm{solvated} \\ & & \mathrm{ion} \\ \end{array}$$

Q.9 (1)

Fajan rule solubility inpolar solvent ∞ Ionic character solubility in non polar ∞ cavalent character solvent

Q.10 (3)

Na + Al₂O₃ \rightarrow Na₂O + Al (Position in electrochemical series) Na₂O + CO₂ \rightarrow Na₂CO₃

Q.11 (4)

 $MgCl_2$ being covalent in nature, gets hydrolysed by the water of crystallisation present, into MgO. $MgCl_2.6H_2O \longrightarrow MgO+2HCl+5H_2O$

Q.12 (3)

$$\begin{cases} BaCO_{3} \text{ white ppt.} \\ CO_{3}^{2^{-}} \\ Ba^{2^{+}} + CrO_{4}^{2^{-}} \rightarrow BaCrO_{4}(s) \\ \\ SO_{4}^{2^{-}} \\ \\ SO_{4}(s) + \text{ white ppt.} \end{cases}$$

Q.13 (2)

$$A \longrightarrow Ca(OH)_{Lime water}$$

$$\begin{array}{c} \operatorname{Ca(OH)}_{2} + \operatorname{CO}_{2} \longrightarrow \operatorname{CaCO}_{3} + \operatorname{H}_{2}\operatorname{O}_{\operatorname{White \, ppt}}_{(C)} \end{array}$$

$$C \rightarrow CaCO_3$$
 $Ca(OH)_2 + Na_2CO_3 \rightarrow CaCO_3 + NaOH_B$

Q.14 (2)

(1) Ca salt imparts brick red colour to the flame. (2) Sr salt imparts bright crimson colour to the flame. (3) Ba salt imparts apple green colour to the flame. (4) Mg salt does not impart any colour to the flame because of high ionization energy.

Q.15 (1)

> $Mg + 3N_2 \longrightarrow Mg_3N_2$; $Mg_3N_2 + 6H_2O \longrightarrow$ $3Mg(OH)_2 + 2NH_2$.

Q.16 (2)

Hydration energy ∞ polarising power $Na^+ < Mg^{2+} < Mg^{3+} < Al^{3+} < Be^{3+}$

Q.17 (3)

> $Ca^{2+} \text{ or } Mg^{2+} + EDTA^{4-}$ [Ca(EPTA)]²⁻ Hardness or [MgEDTA]2causing ion

Q.18 (1)

For alkaline earth metals,

(a) solubility of sulphates decreases down the group. (b) solubility of hydroxide increases down the group. BeO and Be(OH)₂ are amphoteric; so they are soluble in NaOH forming soluble [Be(OH)₄]²⁻. Hence metal M is Be.

$$Ba(NO_3)_2 \xrightarrow{\Delta} BaO + 2NO_2 + \frac{1}{2}O_2$$
; Alkali metal

nitrates gives only O2 gas.

Alkali metal nitrates give only O2 on heating below 500°C according to following reaction,

$$MNO_3 \longrightarrow MNO_2 + \frac{1}{2}O_2$$

$$\begin{array}{ccc} \textbf{Q.20} & (1) \\ \text{CaCO}_3 & \longrightarrow & \text{CaO} + \text{CO}_2 \,, \text{CaO} + \text{H}_2\text{O} \longrightarrow & \text{Ca(OH)}_2 \,, \\ \text{X} & \text{Y} \end{array}$$

$$\begin{array}{c} \text{Ca(OH)}_2 + 2\text{CO}_2 \longrightarrow \text{Ca(HCO}_3)_2, \text{Ca(HCO}_3)_2 \\ & \longrightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \\ & Z \end{array}$$

EXERCISE-III

JEE-ADVANCED

MCQ/COMPREHENSION/STATEMENT/MATCHING Q.1 (ABD)

(A) The solubility of the alkali metal carbonates increases down the group from Li to Cs. This is because of the fact that down the group with increasing size of cation the lattice energy as well as hydration energy also decrease but the change in lattice energy is more as compare to that of hydration energy. Lithium hydrogencarbonate is not obtained in the solid form while all other elements form solid hydrogencarbonates. (B) K₂CO₂ can not be prepared by Solvey process because intermediate formed, KHCO₃ is appreciably soluble in water.

(C) Li₂CO₂ and MgCO₂ both are not thermally stable. (D) Na₂CO₃.NaHCO₃.2H₂O is a mineral called trona.

$$KO_2 \xrightarrow{\Delta} K_2O + \frac{1}{2}O_2$$
$$KO_2 + H_2O \xrightarrow{O^{\circ}C} KOH + O_2$$

C

 Na^+ \overline{O} – \overline{O} Na^+ Ba^{2+} (O⁻ — O⁻)

Q.4 (AD)

Sodium when dissolved in liquid ammonia produces solvated electron which imparts blue colour to the sol. refer (ques. 15)

Q.5 (ABC)

(A) The increasing stability of the peroxide or superoxide, as the size of the metal ion increases, is due to the stabilisation of large anions by larger cation through lattice energy effects.

(B) Bigger cation stabilises bigger anion and similarly smaller cation stabilises smaller anion 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 is deliquescent in nature. So, NaOH absorbs moisture.

Q.6 (AB)

- Q.7 (AC) $P_2O_5 + H_2O \rightarrow H_3PO_4$ $CaCl_2 + H_2O \rightarrow CaCl_2.2H_2O$ $P_2O_5 \& CaCl_2 \text{ are dehydrating agent.}$
- Q.8 (CD)

Q.9

For solubility Hydration energy should be greater then lattice energy.



- Q.10 (ABC) (A), (B) and (C) are correct statements.

Q.12 (ABCD)

Beryllium the first member of the Group 2 metals, shows anomalous behavior as compared to magnesium and rest of the members. Further, it shows diagonal relationship to aluminium. All statements are correct because they show diagonal relationship.

Q.13 (B)

$$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

$$CH_3COCH_3 + 3Cl_2 \longrightarrow CCl_3 - CO - CH_3$$

 $2CCl_{3}COCH_{3} + Ca(OH)_{2} \longrightarrow (CH_{3}COO)_{2}Ca + 2CHCl_{3}$

Q.14 (D)

$$CaOCl_2.H_2O \longrightarrow Cl_2$$

$$145 \qquad 71$$

$$\% \quad \frac{71 \times 100}{145} = 49$$

Q.15(B)

 $6CaOCl_2 \longrightarrow Ca(ClO_3)_2 + 5CaCl_2$

$$(B) 2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 \uparrow + H_2O \uparrow$$

(C) $Na_2O + H_2O \longrightarrow 2NaOH$; NaOH being basic turns red litmus blue.

 $Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$; NaOH being basic turns red litmus blue but H_2O_2 being oxidising agent bleaches coloured litmus.

 $NaHCO_3 + H_2O \implies NaOH + H_2CO_3$; solution is alkaline and turns red litmus blue.

 $Na_2CO_3 + 2H_2O \implies 2NaOH + H_2CO_3$; solution is alkaline and turns red litmus blue.

(D) $Na_2O_2 + CO \longrightarrow Na_2CO_3$; $2Na_2O_2 + 2CO \longrightarrow 2Na_2CO_3 + O_2$. Hence, it absorbs CO and CO₂ and liberates oxygen.

(A) - r (B) - s (C) - q (D) - p(A) $3Ca(OH)_2 + 2Cl_2 \xrightarrow{below} Ca(OCl)_2$. CaCl₂. $Ca(OH)_2$. $H_2O + H_2O$ (slaked lime) bleaching powder (B) $2Ca(OH)_2 + 2Cl_2 \xrightarrow{cold (below 25^{\circ}C)} CaCl_2 +$ $Ca(OCl)_2 + 2H_2O.$ (milk of lime) calcium hypochlorite (C) $6Ca(OH)_2 + 2Cl_2 \xrightarrow{\text{heat (above 35°C)}} 5CaCl_2 +$ $Ca(OCl_3)_2 + 6H_2O$ (slaked lime) calcium chlorate (D) $2Ca(OH)_2 + 2Cl_2 \xrightarrow{\text{red heat}} 2CaCl_2 + 2H_2O + O_2$ ↑ calcium chloride

NUMERICAL VALUE BASED

Q.18

- [6] It is a cyclic structure having six P–O–P linkages.
- Q.19 [7] Except Be and Sr all are correctly matched.
- Q.20 [3] Except Li₂CO₃, Na₂CO₃ all form polymeric chains. AlCl₃ dimeric chain.

Q.21 [15]
$$x = Na_2PbO_2$$
 $y = Na_2SnO_3$ $z = NaAlO_2$

Q.22 [10] Glauber's salt is Na₂SO₄.10H₂O

EXERCISE-IV

JEE-MAIN PREVIOUS YEAR'S Q.1 (1)

(1) It is fact.

Q.2 (4)

Q.3 (1)

Mg can form basic carbonate like

 $5\mathrm{Mg^{+2}}+6\mathrm{CO_3^{2-}}+7\mathrm{H_2O}\rightarrow 4\mathrm{MgCO_3}.\,\mathrm{Mg(OH)_2}.\,5\mathrm{H_2O}\downarrow$

 $+2HCO_3^-$ While Li can form only carbonate (Li₂CO₃) not basic carbonate.

Q.4 (2)

 $\begin{array}{c} \text{Al} + 3\text{H}_2\text{O} & \underline{\text{NaOH}} & \text{Al}(\text{OH})_3 \downarrow + 3/2 \text{ H}_2(\text{g}) \\ & (X) \\ & \text{white gelatinous ppt.} \\ & \downarrow \\ & \text{Soluble in excess of NaOH} \\ & \text{and form Na}[\text{Al}(\text{OH})_4] \end{array}$

$$2\text{Al(OH)}_3 \xrightarrow{\Delta} \text{Al}_2\text{O}_3 + 3\text{H}_2\text{C}_3$$

Used as adsorbent in chromatogrphy, So metal is Al.

- Q.5 (2) Rb form super oxides on reaction with excess air $Rb + O_2 \rightarrow RbO_2$ $2RbO_2 + H_2O \rightarrow 2RbOH + H_2O_2 + O_2^{\uparrow}$
- Q.6 (3) Fact based
- Q.7 (4) $Na(s) + (x + y) NH_3 \rightarrow Na^+ (NH_3)_x + e^- (NH_3)_y$ Blue colour ammoniated electrons
- Q.8 (3) NaH is an example of saline hydride.
- Q.9 (4) Due to larger size of Ba^{2+} ion, $Ba(NO_3)_2$ can not hold water molecules during crystallization.

Q.10 (2)

The only alkali metli which forms nitride by reacting directly with N_2 is 'Li'.

Q.11 (1)

For group - 2 metal hydroxides, basicity increases down the group, as : Be $(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$ This is beacuse as the size of metal atom increases, M – OH bond length increases or M – OH bond become weaker thus readily breaks to release OH⁻ ions which are responsible for the basicity of these solutions. But Be $(OH)_2$ shows amphoteric (basic as well as acidic) character as it reacts with acid and alkali both whch is shown in the following reactions. Be $(OH)_2$ as a base: Be $(OH)_2 + 2HCI \rightarrow BeCl_2 + 2H_2O$

Be (OH), as an acid :

 $Be(OH)_{2} + 2NaOH \rightarrow Na_{2}[Be(OH)_{4}]$

Q.12 (1)

Hydration enthalpy depends upon ionic potential (charge / size). As ionic potential increases hydration enthalpy increases.

Mg + air
$$\xrightarrow{\Delta}$$
 MgO + Mg₃N₂

Q.14 (3)

All halides of Be are predominantly covalent in nature.

Q.15 (1)

(2)

In 'K', 2s orbital feel maximum attraction from nucleus (So having less energy) due to more Z_{eff}

Q.16 (4)

$$2\text{LiNO}_3 \xrightarrow{\Delta} \text{Li}_2\text{O} + 2\text{NO}_2(g) + \frac{1}{2}\text{O}_2(g)$$

$$CaSO_4.2H_2O \xrightarrow{393K} CaSO_4.\frac{1}{2}H_2O$$

Q.18 (1)

Q.17

$$3Mg + N_2 \rightarrow Mg_3N_2 \xrightarrow{H_2O} Mg(OH)_2 + NH_3$$

Q.19 (4) Theory based.

Q.20 (1) Solid hydrogenearbonates are not formed by lithium and magnesium. $6 \text{Li} + \text{N}_2 \rightarrow 3 \text{Li}_3 \text{N}$ $3 \text{Mg} + \text{N}_2 \rightarrow 3 \text{Mg}_3 \text{N}_2$ **Q.21** (2)

Be < Mg (atomic radius) Be > Al (I.E₁) Be \approx Al (Charge/radius ratio) Both Be and Al form mainly covalent compound.

Q.22 (4)

Solubility of $BeSO_4$ is highest among the given $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$ $BeSO_4$ is soluble and $Be(OH)_2$ is insoluble. Solubility order for hydroxide. $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$ BeO does not form rock salt like structure.

 $4Li + O_2 \rightarrow 2Li_2O$ $2Na + O_2 \rightarrow Na_2O_2$ $K + O_2 \rightarrow KO_2$ **Q.24** (2)

 $CaSO_4 \cdot \frac{1}{2}H_2O$ – Used for making casts of statues

CaCO₃ – Used as an antacid

Q.25 (4)

 $BeSO_4$ and $MgSO_4$ are readily soluble in water. Reason \rightarrow The greater hydration enthalpies of Be^{2+} and Mg^{2+} ions dominate over their lattice enthalpies and therefore their sulphates are highly soluble.