DAY TWELVE

s-Block Elements

Learning & Revision for the Day

- Group 1 Elements (Occurrence and Electronic Configuration)
- Some Important Compounds
- Group 2 Elements (Occurrence and Electronic Configuration)
- Industrial Use of Lime and Limestone

The components in the long form of the periodic table have been partitioned into four blocks, in particular *s, p, d* and *f*-blocks. The elements of group I and II have their last electron enters in *s*-orbitals thus, they are called ***s*-block elements.**

Group 1 Elements [Occurrence and Electronic Configuration]

- Lithium ($Z = 3$), sodium ($Z = 11$), potassium ($Z = 19$), rubidium ($Z = 37$), caesium ($Z = 55$) and francium ($Z = 87$) are the elements of IA (or 1) group of the periodic table.
- These elements because of the highly alkaline nature of their water soluble hydroxides are known as **alkali metals.**
- Occurrence of alkali metals is fairly common in nature.
- Sodium (7th) and potassium (8th) are the most abundant alkali metals found in earth's crust.
- Rubidium and caesium are found in very less amount.
- Francium being radioactive is found only in trace amount.
- The **general electronic configuration** of alkali metals is [noble gas] ns^1[$n = 2$ to 7].

General Trends in Physical Properties

- Alkali metals are most electropositive and on moving down the group the electropositive character increases. Therefore, they readily lose electron to give monovalent, M^+ ions.
- The atomic and ionic radii are largest in the respective period and increases as we move down the group.
- Low densities of alkali metals are due to their large size.
- The ionisation enthalpies of alkali metals are considerably low and decrease down the group from Li to Cs.
- Hydration enthalpy of alkali metal ions decreases with increase in ionic size $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$.

- Mobility of their cations in aqueous medium is directly proportional to the size of cation due to poor hydration enthalpy. $\underset{\text{Mobility}}{\xrightarrow{\quad\quad\quad\quad\quad\quad\quad\quad}}$ $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
- Alkali metals give flame test. The colour of the flame depends upon the wavelength of radiation emitted. Caesium and potassium are used as semi-conducters due to their low ionisation enthalpy.
- Alkali metals are strong reducing agent and down the group, their reducing nature increases.
- Alkali metal compounds are most ionic in nature and down the group, ionic nature increases.
- Alkali metal oxides are most basic in nature and down the group, basic character increases.
- Metallic character of alkali metals increases on moving down the group.

General Trends in Chemical Properties

(i) With oxygen, alkali metals form oxides, peroxides and super oxides.

$$4Li + O_2 \longrightarrow 2Li_2O \text{ (Oxide)}$$
$$2Na + O_2 \longrightarrow Na_2O_2 \text{ (Peroxide)}$$
$$M + O_2 \longrightarrow MO_2 \text{ (Superoxide)}$$
$$(M = \text{K, Rb, Cs})$$

(ii) Water readily oxidises alkali metals through exothermic reactions, resulting in formation of hydroxides.

$$3M(s) + 2H_2O\,(l) \longrightarrow 2\,MOH(aq) + H_2\,(g)$$
(M=an alkali metal)

(iii) Alkali metals readily react with **halogens** to form MX type of halides. These are mainly ionic compounds having NaCl type of structure.

$$2M + X_2 \longrightarrow 2MX \left[\begin{array}{c}\text{where, } M = \text{Li, Na, K, Rb, Cs}\\ X = \text{F, Cl, Br or I}\end{array}\right]$$

(iv) The alkali metals dissolve in **liquid ammonia** giving deep blue solutions which are conducting in nature.

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

The blue colour of the solution is due to the ammoniated electrons.

Uses

- Lithium metal is used to make useful alloys, e.g. with lead to make 'white metal' bearing for motor engines, aircraft parts.
- Sodium is used to make a Na/Pb alloy needed to make $PbEt_4$ and $PbMe_4$.
- The organolead compounds were earlier used as anti-knock additives to petrol, but now a-days it is barred.
- Liquid sodium metal is used as a coolant in fast breeder nuclear reactors.
- Potassium hydroxide is used in the manufacturing of soft soap.
- Caesium is used in devising photoelectric cells.

Anomalous Properties of Lithium

Lithium due to its, exceptionally small size (like Mg) and high polarising power (i.e. charge/radius ratio) (like Mg), exhibits some properties which are different from those of the other members of first group but similar to that of magnesium (present diagonally in the next group, i.e. II group).

Digonal Relationship

The property of showing similarity in properties with the element present diagonally opposite in the next group of the periodic table is called **diagonal relationship**.

These properties are:

(i) Alkali metals do not react with nitrogen except Li.

$$6Li + N_2 \xrightarrow{\text{Heat}} \underset{\text{Lithium nitride}}{2Li_3N}$$

(Li metal is used as scavenger in metallurgy to remove O_2 and N_2 gases.)

$$3Mg + N_2 \longrightarrow \underset{\text{Magnesium nitride}}{Mg_3N_2}$$

(ii) Alkali metal carbonates, nitrates and hydroxides do not decompose on heating into their oxides except lithium.

$$NaOH \xrightarrow{\text{Heat}} \text{No reaction}$$
$$2\,LiOH \xrightarrow{\text{Heat}} Li_2O + H_2O$$
$$Na_2CO_3 \xrightarrow{\text{Heat}} \text{No reaction}$$
$$Li_2CO_3 \xrightarrow{\text{Heat}} Li_2O + CO_2$$
$$4LiNO_3 \xrightarrow{\text{Heat}} 2Li_2O + 4NO_2 + O_2$$
$$2NaNO_3 \longrightarrow 2NaNO_2 + O_2$$

(iii) $MgCl_2$ and LiCl are deliquescent and crystallise as their hydrates, $LiCl \cdot 2H_2O$ and $MgCl_2 \cdot 2H_2O$.

(iv) Both Li and Mg are harder and have higher melting point than the other metals in their respective groups.

Some Important Compounds

1. Sodium Chloride (Common Salt or Rock Salt, NaCl)

Preparation

NaCl involves evaporation of sea water, which contains 2.7-7.9% of this salt, to obtain crude salt. Now a days, salt is produced by some other sources, such as brine wells and salt-lakes.

Properties

- It is white crystalline solid, soluble in water.
- Pure NaCl is not hygroscopic, but sometimes it shows hygroscopic nature due to the presence of chlorides of Ca and Mg as an impurity.

2. Sodium Hydroxide (Caustic Soda, NaOH)

Preparation

Sodium hydroxide is made commercially by the electrolysis of sodium chloride in **Castner-Kellner cell** (or mercury cathode cell).

At cathode, $Na^+ + e^- \xrightarrow{Hg} Na\text{-}Hg$ (amalgam)

At anode, $Cl^- \longrightarrow \frac{1}{2}Cl_2 + e^-$ (by product)

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

$$2Na\text{-}Hg + 2H_2O \longrightarrow 2NaOH + 2Hg + H_2$$

Properties

- Sodium hydroxide is white, translucent solid and deliquescent.
- On exposure to atmosphere it absorbs moisture and CO_2.

$$2\,NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

- It is a strong alkali so reacts with acids, acidic oxides and amphoteric oxides to form their corresponding salts.
- Non-metals like halogens, phosphorus, sulphur, silicon, boron are attacked by NaOH.
- It reacts with metals like Zn, Al, Sn and Pb and evolve H_2 gas, e.g. $Zn + 2NaOH \longrightarrow 2\,Na_2ZnO_2 + H_2$

3. Sodium Carbonate (Washing Soda, $Na_2CO_3 \cdot 10H_2O$)

Preparation

Sodium carbonate is generally prepared by **Solvay process**, which involves following steps:

$$2NH_3 + H_2O + CO_2 \longrightarrow (NH_4)_2CO_3$$
$$(NH_4)_2CO_3 + H_2O + CO_2 \longrightarrow 2NH_4HCO_3$$
$$NH_4HCO_3 + NaCl \longrightarrow NH_4Cl + NaHCO_3$$
$$2NaHCO_3 \xrightarrow{150^\circ C} Na_2CO_3 + CO_2 + H_2O$$

Properties

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

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

- It is readily decomposed by acids.

4. Sodium Hydrogen Carbonate (Baking Soda, $NaHCO_3$)

Preparation

It is prepared as intermediate product in the **Solvay ammonia soda process**.

$$NH_3 + H_2O + CO_2 + NaCl \longrightarrow NaHCO_3 \downarrow + NH_4Cl$$

Properties

- It is white crystalline solid, sparingly soluble in water.
- Its aqueous solution is alkaline in nature due to hydrolysis.

Biological Importance of Sodium and Potassium

- Na^+ ions are found mainly in extracellular region (outside the cell) and play an important role in the transmission of nerve signals.
- Na^+ ions also regulate the flow of water across cell membranes and in transport of sugars and amino acid into the cells.
- Prolonged sweating results in sodium ion loss in sweat, thus, it is important that Na^+ ions are replaced through proper diet.
- 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 along with sodium ions are responsible for transmission of nerve signals. The functional features of nerve cells depend upon the sodium potassium ion gradient that is established in the cell.

Group 2 Elements

[Occurrence and Electronic Configuration]

- Be, Mg, Ca, Sr, Ba and Ra also belong to *s*-block and are called "alkaline earth metals".
- These are less metallic as compared to alkali metals.
- Occurrence of alkaline earth metals is quite common on the earth surface.
- These elements occur in the form of sulphates, silicates, carbonates, phosphates and hydroxides.
- Due to presence. alkaline hydroxide in earth's crust, the metals are called alkaline earth metals.
- The general electronic configuration of these elements is [inert gas] ns^2 (here, $n = 2$ to 7)

General Trends in Physical Properties

- The alkaline earth metals also have low ionisation enthalpies but these are higher than that of alkali metals.
- Atomic radii and ionic radii of these metals increases down the group due to addition of extra shells.
- Like alkali metal ions, the hydration enthalpies of alkaline metal ions decrease with increase in ionic size on moving down the group.

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

- The melting and boiling points of these metals are higher than the corresponding alkali metals due to smaller size.
- Except Be and Mg (due to their small size and high IE), all other alkaline earth metals give flame test like calcium, strontium and barium impart characteristic brick red, crimson and apple green colours, respectively to the flame.

General Trends in Chemical Properties

- These are slowly oxidised on exposure to air forming oxides, which are white crystalline solid and basic in nature. The basic strength of oxides increases down the group.
- Except Be, all these metal reacts with water, forming basic hydroxides.

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

(M = Mg, Ca, Sr and Ba)

- Be does not react directly with **hydrogen**. but rest of the elements react with hydrogen to form hydrides of MH_2 type.
- The hydride of Be is prepared by reducing its chloride as

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

- BeH_2 and MgH_2 are covalent in nature while other hydrides are ionic in nature.
- All alkaline earth metals react with **halogens** at elevated temperatures to form halides of MX_2 type.
- Among the halides, BeX_2 and MgX_2 have covalent character, while the other halides are ionic.

Anomalous Behaviour of Beryllium

Beryllium due to its exceptionally small size (like Al) and high polarising power (like Al). As a result Be shows similarities with aluminium, in its properties.

These properties are as follow

- BeO, like Al_2O_3, is amphoteric and covalent while oxides of other alkaline earth elements are ionic and basic in nature.
- Both $BeCl_2$ and $AlCl_3$ are soluble in organic solvents because of covalent nature and both have a bridged polymeric structure.
- Beryllium hydroxide dissolves in excess of alkali to give a beryllate ion, $[Be(OH)_4]^{2-}$ just as aluminium hydroxide gives aluminate ion, $[Al(OH)_4]^-$.
- Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-}, AlF_6^{3-}.
- Carbides of Be are covalent and react with water to produce methane gas whereas carbides of other members are ionic and produce acetylene with water.

Industrial Use of Lime and Limestone

- Lime (Quicklime), CaO is prepared as

$$\underset{\text{Limestone}}{CaCO_3} \xrightarrow{800°C} CaO + CO_2$$

  (i) It is used in the manufacture of $CaOCl_2$, $Ca(OH)_2$, CaC_2, glass and cement, etc.

  (ii) It is used as basic lining in the furnaces.

  (iii) It is used in the purification of sugar and in water softening.

- Limestone, $CaCO_3$ is prepared as

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{Milky}}{CaCO_3} + H_2O$$

  (i) It is used in the manufacture of quicklime, slaked lime, cement, glass and washing soda etc.

  (ii) It is used as a flux in smelting of iron and lead ores.

Biological Importance of Mg and Ca

- Mg^{2+} ions are present inside the animal cells while Ca^{2+} ions are in the body fluids, i.e. in the extracellular region, in such the same way as K^+ are inside the cell and Na^+ ions outside the cell.
- All enzymes that utilize ATP in phosphate transfer require Mg^{2+} as cofactor.
- In green plants, magnesium is present in chlorophyll.
- Ca^{2+} and Mg^{2+} are also essential for the transmission of impulses along nerve fibres.
- In bones and teeth, Ca is present as apatite, $Ca_3(PO_4)_2$ and in enamel on teeth as fluorapatite, $Ca_5(PO_4)_3$.
- Ca^{2+} ions play an important role in blood clotting and are required to trigger the contraction of muscles.
- Ca^{2+} ions also regulate the heart beats.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Francium is the least abundant alkali metal because it is
(a) highly reactive (b) radioactive
(c) undetectable (d) in gaseous state

2 The alkali metals include
(a) largest atom
(b) most electropositive elements
(c) hardest metal
(d) most dense metal

3 Ionic mobility of which of the following alkali metal ions is lowest when aqueous solution of their salts are put under an electric field? ➞ **NEET 2017**
(a) Na (b) K (c) Rb (d) Li

4 Shine at freshly cut sodium is
(a) due to oscillation of free electrons
(b) due to weak metallic bonding
(c) due to absorption of light in crystal lattice
(d) due to the presence of free valency at the surface

5 Alkali metals impart colour to Bunsen flame due to
(a) low ionisation energy (b) low melting point
(c) their softness
(d) the presence of one electron in the outer most shell

6 The ease of adsorption of the hydrated alkali metal ions on an ion-exchange resins follows the order ➞ **CBSE-AIPMT 2012**
(a) $Li^+ < K^+ < Na^+ < Rb^+$ (b) $Rb^+ < K^+ < Na^+ < Li^+$
(c) $K^+ < Na^+ < Rb^+ < Li^+$ (d) $Na^+ < Li^+ < K^+ < Rb^+$

7 Which is the weakest reducing agent?
(a) Na (b) K (c) Rb (d) Li

8 Among the alkali metals, caesium is the most reactive because
(a) its incomplete shell is nearest to the nucleus
(b) it has a single electron in the valence shell
(c) it is the heaviest alkali metal
(d) the outermost electron is more loosely bound than the outermost electron of the other alkali metals

9 Sodium peroxide which is a yellow solid, when exposed to air becomes white due to the formation of
(a) H_2O_2 (b) Na_2O
(c) Na_2O and O_3 (d) NaOH and Na_2CO_3

10 When sodium is heated with moist air, the product obtained is
(a) Na_2O_2 (b) Na_2CO_3 (c) NaOH (d) Na_2O

11 The alkali metal that reacts with nitrogen directly to form nitride is
(a) Li (b) K (c) Na (d) Rb

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 Which one of the alkali metals forms only, the normal oxide, M_2O on heating in air? ➞ **CBSE-AIPMT 2012**
(a) Rb (b) K (c) Li (d) Na

14 K_2CO_3 cannot be prepared by Solvay ammonia process because
(a) K_2CO_3 is fairly soluble in water
(b) it has no water of crystallisation
(c) $KHCO_3$ is highly soluble in water
(d) K_2CO_3 decomposes in H_2O

15 When washing soda is heated
(a) CO is released (b) CO + CO_2 is released
(c) CO_2 is released (d) water vapour is released

16 Fire extinguisher contains H_2SO_4 and
(a) Na_2CO_3 (b) $NaHCO_3$ (c) $CaCO_3$ (d) All of these

17 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 constituent of this pump? ➞ **CBSE-AIPMT 2015**
(a) Ca^{2+} (b) Mg^{2+} (c) K^+ (d) Fe^{2+}

18 Hydration enthalpy of Be^{2+} is greater than
(a) Li^+ (b) Mg^+
(c) Ba^+ (d) All the these

19 Solubility of the alkaline earth's metal sulphates in water decreases in the sequence ➞ **CBSE-AIPMT 2015**
(a) Mg > Ca > Sr > Ba (b) Ca > Sr > Ba > Mg
(c) Sr > Ca > Mg > Ba (d) Ba > Mg > Sr > Ca

20 Property of the alkaline earth metals that increases with their atomic number ➞ **CBSE-AIPMT 2010**
(a) solubility of their hydroxides in water
(b) solubility of their sulphates in water
(c) ionisation energy
(d) electronegativity

21 Which of the following alkaline earth metal sulphate has hydration enthalpy higher than the lattice enthalpy? ➞ **CBSE-AIPMT 2010**
(a) $CaSO_4$ (b) $BeSO_4$ (c) $BaSO_4$ (d) $SrSO_4$

22 $BaSO_4$ is insoluble in water due to its
(a) high hydration energy (b) high lattice energy
(c) high ionisation energy (d) high kinetic energy

23 Which of the following are arranged in correct increasing order of solubilities?
(a) $CaCO_3 < KHCO_3 < NaHCO_3$
(b) $NaHCO_3 < KHCO_3 < CaCO_3$
(c) $KHCO_3 < NaHCO_3 < CaCO_3$
(d) $CaCO_3 < NaHCO_3 < KHCO_3$

24 Identify the correct formula of halides of alkaline earth metals from the following
I. $BaCl_2 \cdot 2H_2O$ II. $BaCl_2 \cdot 4H_2O$
III. $CaCl_2 \cdot 6H_2O$ IV. $SrCl_2 \cdot 4H_2O$
(a) I, II and III (b) I and II only
(c) II and IV only (d) I and III only

25 The correct sequence of increasing covalent character is represented by
(a) $LiCl < NaCl < BeCl_2$ (b) $BeCl_2 < NaCl < LiCl$
(c) $NaCl < LiCl < BeCl_2$ (d) $BeCl_2 < LiCl < NaCl$

26 Which pair of the following chlorides do not impart colour to the flame?
(a) $BeCl_2$ and $SrCl_2$ (b) $BeCl_2$ and $MgCl_2$
(c) $CaCl_2$ and $BaCl_2$ (d) $BaCl_2$ and $SrCl_2$

27 In the alkaline earth metals, the element forming predominantly covalent compound is
(a) Ca (b) Sr
(c) Mg (d) Be

28 Among CaH_2, BeH_2 BaH_2, the order of ionic character is
(a) $BeH_2 < BaH_2 < CaH_2$ (b) $CaH_2 < BeH_2 < BaH_2$
(c) $BeH_2 < CaH_2 < BaH_2$ (d) $BaH_2 < BeH_2 < CaH_2$

29 Mg burns in CO to produce **→ NEET 2018**
(a) MgO + CO (b) MgO_2
(c) MgO + C (d) $MgCO_3$

30 Which of the following carbonates is the most stable?
(a) $MgCO_3$ (b) $CaCO_3$
(c) $SrCO_3$ (d) $BaCO_3$

31 Several blocks of magnesium are fixed to the bottom of a ship to
(a) keep away the sharks
(b) make the ship lighter
(c) prevent action of water and salt
(d) prevent puncturing by under-sea rocks

32 The pair whose both species are used in antacid 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 $NaHCO_3$

33 Which of the following oxides is most acidic in nature?
(a) BaO (b) BeO (c) MgO (d) CaO
→ NEET 2018

Direction (Q. Nos. 34-35) *In the following questions, Assertion* (A) *followed by a Reason* (R) *is given. Choose the correct answer out of the following choices.*
(a) Both A and R are true and R is correct explanation of A
(b) Both A and R are true but R is not correct explanation of A
(c) A is false but R is true
(d) Both A and R are false

34 **Assertion** (A) K, Rb and Cs form superoxides.
Reason (R) The stability of the superoxides increases from K to Cs due to decrease in lattice energy.

35 **Assertion** (A) Group 2 elements are known as alkaline earth metal.
Reason (R) *s*-orbital can accomodate a maximum of 2 electrons.

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 Which of the following statements is correct for $CsBr_3$?
(a) It is a covalent compound
(b) It contains Cs^+ and Br_3^- ions
(c) It contains Cs^{3+} and Br^- ions
(d) It contains Cs^+, Br^- and Br_2 molecule

2 The correct order of increasing thermal stabilities of K_2CO_3, $MgCO_3$, $CaCO_3$ and $BeCO_3$ is
(a) $BeCO_3 < MgCO_3 < K_2CO_3 < CaCO_3$
(b) $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$
(c) $MgCO_3 < BeCO_3 < CaCO_3 < K_2CO_3$
(d) $K_2CO_3 < MgCO_3 < CaCO_3 < BeCO_3$

3 A solution of sodium metal in liquid NH_3 is strongly reducing due to the presence of
(a) sodium ions (b) sodium amide
(c) solvated electrons (d) sodium hydride

4 Among KO_2, AlO_2^-, BaO_2 and NO_2^+, unpaired electron is present in
(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-
(c) Only KO_2 (d) Only BaO_2

5 KF combines with HF to form KHF_2. The compound contains species
(a) K^+, F^- and H^- (b) K^+ and $[HF_2]^-$
(c) K^+, F^- and HF (d) $[KHF]^+$ and F^-

6 A 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*. On boiling *Z*, compound, *X* is reformed. The compound *X* is
(a) $Ca(HCO_3)_2$ (b) $CaCO_3$ (c) Na_2CO_3 (d) K_2CO_3

7 Highly pure dilute solution of sodium in liquid ammonia

I. shows blue colour
II. exhibits electrical conductivity
III. produces sodium amide IV. produces hydrogen gas
Choose the correct option
(a)I and II (b) II and III (c) I and III (d) I, II and III

8 The alkali metals form salt-like hydride 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

9 A metal *M* readily forms its sulphate MSO_4 which is water soluble. It forms its oxide *M*O which becomes inert on heating. It forms its insoluble hydroxide $M(OH)_2$ which is soluble in NaOH. Then *M* is

(a) Be (b) Ba (c) Ca (d) Mg

10 LiF is almost insoluble in water whereas, LiCl is soluble not only in water but also in acetone. This is because

(a) of high hydration enthalpy of Li^+
(b) of low hydration enthalpy of Li^+
(c) of more ionic character in LiCl
(d) None of the above

11 Select the correct statement(s).

(a) Oxides and peroxides of alkali metals are diamagnetic and colorless
(b) Superoxides of alkali metals are paramagnetic
(c) Li and Na do not form superoxides
(d) All of the above are correct statemets

12 Lithium shows anomalous behaviour due to

I. relatively high electronegativity and high ionisation enthalpy.
II. very small size of its atom and ion.
III. high polarising power of Li^+ ion.
IV. absence of vacant *d*-orbital.

(a) Only I (b) Both I and II
(c) II, III and IV (d) I, II, III and IV

13 Match the compounds (given in Column I) with their colours given in Column II and choose the correct codes.

	Column I		Column II
A.	Li_3N	1.	Pale yellow
B.	K_2O	2.	Orange
C.	Cs_2O, KO_2	3.	Bright yellow
D.	Rb_2O	4.	Ruby red

Codes

	A	B	C	D		A	B	C	D
(a)	4	1	2	3	(b)	2	3	1	4
(c)	1	2	3	4	(d)	1	4	2	3

14 In the electrolysis of aqueous NaCl solution, side reactions taking place are:

I. $2OH^- + Cl_2 \longrightarrow 2OCl^- + H_2$
II. $2Na + 2H_2O \longrightarrow 2NaOH + H_2$
III. $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

Select the correct alternate.

(a) Both I and II (b) Both II and IIII
(c) Both I and III (d) I, II and III

15 Select the correct statement.

(a) Solubility of alkali hydroxides is in order LiOH > NaOH > KOH > RbOH
(b) Solubility of alkali carbonates is in order $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3$
(c) Solubility of alkali hydroxide is in order LiOH < NaOH < KOH > RbOH
(d) Both (a) and (b) are correct

ANSWERS

SESSION 1	**1** (b)	**2** (a, b)	**3** (d)	**4** (a)	**5** (a)	**6** (b)	**7** (a)	**8** (d)	**9** (d)	**10** (c)
	11 (a)	**12** (a)	**13** (c)	**14** (c)	**15** (d)	**16** (b)	**17** (c)	**18** (d)	**19** (a)	**20** (a)
	21 (b)	**22** (b)	**23** (d)	**24** (d)	**25** (c)	**26** (b)	**27** (d)	**28** (c)	**29** (c)	**30** (d)
	31 (c)	**32** (a)	**33** (b)	**34** (b)	**35** (b)					
SESSION 2	**1** (b)	**2** (b)	**3** (c)	**4** (c)	**5** (b)	**6** (b)	**7** (a)	**8** (d)	**9** (a)	**10** (a)
	11 (d)	**12** (d)	**13** (b)	**14** (c)	**15** (b)					

Hints and Explanations

SESSION 1

1 Francium is the only radioactive alkali metal, that is why it disintegrates soon and is least abundant alkali metal on earth.

2 Alkali metals are the most electropositive elements. An alkali metal has largest atomic size in its respective periodic, is soft and very less dense among metals (i.e. include light metals)

3 **Kye concept** More the extent of hydration, lesser is the ionic mobility.

Ionic mobility of alkali metal ions is lowest when aqueous solutions of their salts are put under an electric field. In all the alkali metals, Li^+ ion is smallest thus extent of hydration is maximum in Li^+ ion.

i.e. The dissolution of Li^+ in water occurs and get hydrated. Smaller the size of a cation, greater is the extent of hydration and lesser is the ionic mobility.

4 Metal surface (including sodium) shines due to oscillation of free electrons. This oscillation (movement in certain cases) is also responsible for metallic sound, conduction heat and electricity.

5 Due to their low ionisation energy, alkali metals impart colours to Bunsen flame. The different colours imparted depends on the different ionisation energy of these metals.

6 Ease of adsorption of the hydrated alkali metal ions on an ion-exchange resins decreases as the size of alkali metal ions increases. Since, the order of size of alkali metal ions

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

Thus, the ease of adsorption follows the order $Rb^+ < K^+ < Na^+ < Li^+$

7 Among alkali metals, Na is the weakest reducing agent. Reducing character of alkali metals increases down the group. (Li is exception)

8 Alkali metals have a tendency to lose the single valence electron and form +ve ion and gain inert gas configuration, in case of caesium, the distance of the valence electrons is maximum. So, force of attraction by the nucleus is least, hence, it is more reactive.

9 Sodium peroxide reacts with moisture and CO_2 of air (when exposed to air) and becomes white due to the formation of NaOH and Na_2CO_3

$$2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2$$
$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

10 $$2Na + \frac{1}{2}O_2 \xrightarrow{\text{Moist air}} Na_2O$$
$$Na_2O + 2H_2O \longrightarrow 2NaOH$$

11 $$6Li + N_2 \longrightarrow \underset{\text{Lithium nitride}}{2Li_3N}$$

12 On dissolving sodium in liquid ammonia, its colour turns deep blue due to the generation of ammoniated electrons.

$$Na + (X + Y)NH_3 \longrightarrow [Na(NH_3)_X]^+ + e[NH_3]_Y^-$$
Solvated or ammoniated electron

13 Li is the alkali metal which forms only normal oxide Li_2O when heated in air.

$$2Li + \frac{1}{2}O_2 \longrightarrow Li_2O$$

Sodium, when heated in air, forms peroxide while heavier alkali metals form superoxide as the major product.

14 Solvay ammonia process involves the formation of bicarbonate and carbonate of potassium, $KHCO_3$ is highly soluble in water. That's why K_2CO_3 cannot be prepared by Solvay ammonia process.

15 $Na_2CO_3 \cdot 10H_2O \rightarrow Na_2CO_3 \cdot H_2O + 9H_2O$.

16 Fire extinguisher contains acid (H_2SO_4) and baking soda ($NaHCO_3$). The reaction between the two releases carbon dioxide (CO_2) which extinguish fire.

17 The 'sodium pump' is also known as a sodium potassium pump. This pump is an important contributor to action potential produced by nerve cells. The process of moving sodium and potassium ions across the cell membrane is an active transport process involving the hydrolysis of ATP to provide the necessary energy.

This process is responsible for maintaining the large excess of Na^+ outside the cell and the large excess of K^+ ions on the inside.

18 Hydration enthalpy of alkaline earth metal is larger than that of an alkali metal of same perod. Moreover, hydration enthalpy of metals decreases down the group.

19 Solubility of the sulphates. The sulphates becomes less soluble as we go down the group, i.e. Mg > Ca > Sr > Ba

The magnitude of the lattice energy remains almost constant as the size of the sulphate ion is so big that small increase in the size of the cation from Be to Ba does not make any difference. However, the hydration energy decreases from Be^{2+} to Ba^{2+} appreciably as the size of the cation increases down the group. The significantly high solubility of $MgSO_4$ is due to high enthalpy of solvation of the smaller Mg^{2+} ions.

20 Electronegativity as well as ionisation energy both usually decrease on moving downward the group with increase in atomic number. The hydroxides and sulphates of alkaline earth metals are ionic solids and the solubility of ionic solids is governed by two factors, *viz*. lattice energy and hydration energy. For solubility, hydration energy > lattice energy.

Hydration energy varies inversely with size, i.e. decreases with increase in size. However, lattice energy in case of sulphates, remains almost same with increase in the atomic number of alkaline earth metals, due to large size of sulphate ion.

Hence, hydration energy only governs the solubility in this case. Thus, solubility of alkaline earth metal sulphates decreases as the hydration energy decreases on moving downward in the II A group. On the other hand, in case of hydroxides, the lattice energies are different because of medium size of hydroxide ions and decreases on moving from Be to Ba.

This tends to increase the solubility and to overcome the counter effect produced by the decrease in hydration energy. Hence, the solubility of alkaline earth metal hydroxides increases with increase in the atomic number of alkaline earth metals.

21 Hydration energy varies inversely with size in sulphates of alkaline earth metals, where as lattice energy remains almost constant. The order of size of alkaline earth metals is

$$Be^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$$

Thus, the order of hydration energy is

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

Hence, $BeSO_4$ has the hydration enthalpy higher than the lattice enthalpy.

22 Solubility depends upon lattice energy. High lattice favours low solubility. Hence, due to high lattice energy, $BaSO_4$ is insoluble in water.

23 Solubility in water in increasing order

$$CaCO_3 < NaHCO_3 < KHCO_3$$

24 As the size of metal cation increases, number of molecules of water of crystallisation decreases.

25 On the basis of Fajan's rule, lower the size of cation higher will be its polarising power and higher will be covalent character.

$$\text{Polarising power} \propto \frac{1}{\text{Size of cation}}$$

Covalent character ∝ polarising power
So, the correct order of covalent char acter is $NaCl < LiCl < BeCl_2$
($Na^+ > Li^+ > Be^{2+}$, i.e. ionic character)

26 Among the alkaline earth metals, the size of beryllium and magnesium metals is very small.

Therefore, the electrons in these metals are bounded more strongly and are not excited by the energy of flame to higher energy states. Hence, these metals or their salts do not impart any colour to the flame.

27 Ionic character increases from Be to Ba.

28 Accroding to the Fajan rule, compounds with small cation, large anion, more charge on cation or anion show more covalent character. As the above conditions opposes, it shows ionic character. Since, the size of cation decreases in the order $Ba^{2+} > Ca^{2+} > Be^{2+}$.

Therefore, the correct order of ionic character will be

$$BeH_2 < CaH_2 < BaH_2.$$

29 $Mg + CO \rightarrow Mg\,O + C$

30 The thermal stability of carbonates of elements of II A group elements increases as the size of metal increases. Thus, $BaCO_3$ is most stable among alkaline earth metal carbonates.

31 It prevents corrosion.

32 $NaHCO_3$ is used as medicine to neutralise the acidity in stomach.

Magnesium hydroxide is basic in nature and dissolves in acids, forming corresponding salts.

So, both are used in antiacid medicinal preparation.

33 Basic strength of the oxides of alkaline earth metals increases from BeO to BaO. Infact, BeO is amphoteric while all other oxides are basic. It is because all the alkaline earth metals are ionic in nature but BeO in addition to ionic character shows some covalent character also. Thus, BeO being amphoteric in nature behaves both as an acid and base.

$$\underset{\text{Amphoteric}}{BeO} \quad \underbrace{MgO}_{\text{Weak base}} \quad \underbrace{CaO\ SrO\ BaO}_{\text{Strong base}}$$

Note Degree of covalent character and concept of polarisation is put forwarded by Fajan's rule.

34 Superoxides are the species having an O —O bond and O in oxidation state of $-\frac{1}{2}$ (superoxide ion is O_2^-).

Usually these are formed by active metals such as KO_2, RbO_2 and CsO_2.

For the salts of larger anions (like O_2^-), lattice energy increases in a group. Since, lattice energy is the driving force for the formation of an ionic compound and its stability. The stability of the superoxides from K to Cs also increases.

35 The correct reason for the naming is that these metals are found as alkaline hydroxide in earth.

SESSION 2

1 $Cs[Br_3]$ contain Cs^+ and Br_3^- ions.

2 The carbonates become more thermally stable down the group and carbonates of alkali metals are more thermally stable than alkaline earth metals.

3 On dissolving sodium in liquid ammonia, its outermost electrons get free, in that solution electron becomes conducting and now known as ammoniated electrons.

$$Na + (x+4)\,NH_3 \longrightarrow \underset{\text{Solvated or ammoniated electron}}{[Na(NH_3)_x]^+ + e[NH_3]_4^-}$$

4 According to their MOT unpaired electrons present only in KO_2.

5 KHF_2 is colourless salt consists of the potassium cation and the bifluoride (HF_2^-) anion. This salt is used in etching of glass.

6 $\underset{(X)}{CaCO_3} \xrightarrow{\Delta(\text{Heat})} \underset{\text{Residue}}{CaO} + CO_2$

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

$$Ca(OH)_2 \xrightarrow[CO_2]{\text{Passing}} \underset{(Z)}{Ca(HCO)_3} \xrightarrow{\Delta} CaCO_3$$

7 Same as Question 3

8 The stability of alkali hydride decrease from Li to Cs.

9 $Be(OH)_2 + H_2SO_4 \longrightarrow BeSO_4 + 2H_2O$

10 Li^+ has highest hydration enthalpy so when Li^+ form ion easily it will be soluble in water and LiF is insoluble in water because of high electronegetivity of $F^\ominus$ which not loose Li^+.

11 According to MOT oxides and peroxides of alkali metals are diamagnetic and due to absence of unpaired electron these are colourless. Superoxides are paramagnetic due to presence of unpaired electrons. Li and Na not form superoxides due to their smaller size.

12 Li shows anomalous behavior due to high electronegativity, high ionisation enthalpy, smaller size and high polarizing power. Li does not has vacant *d*-orbitals.

13 Li_3N- orange, K_2O-bright yellow, Cs_2O, KO_2-pale yellow Rb_2O-ruby red.

14 Electrolysis of aqueous NaCl

	Anode	Cathode
ions attracted	$Cl^\ominus, OH^\ominus$	Na^+, H^+
ions discharged	$Cl^\ominus$	$H^\oplus$
ionic reaction	$2Cl^\ominus - 2e^\ominus \longrightarrow Cl_2$	$2H^+ + 2e^\ominus \longrightarrow H_2$

Reaction at cathode is

$$H_2O(l) + 2e^\ominus \longrightarrow H_2(g) + 2OH^\ominus$$

Reaction at Anode is

$$Cl^\ominus \longrightarrow 1/2Cl_2(g) + 1e^\ominus$$

So side reaction is

(i) $2OH^\ominus + Cl_2 \longrightarrow 2OCl^\ominus + H_2$

(ii) $4OH^\ominus \longrightarrow O_2 + 2H_2O + 4e^\ominus$

15 Solubility of alkali hydroxides and carbonates increases on moving down the group. So, correct order is

$$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3$$