Exercise-1

Marked Questions may have for Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Atomic and physical properties of alkali metals

A-1.

Sol. It is fact.

A-2.

Sol. The block of an element depends on the type of sub-shell which receives the last electron. As last electron enters in s-subshell of outer most shell according to Aufbau rule, the element of option (3) belongs to s-block.

A-4. **Sol.** Cs = 2.35Å covalent radius.

A-5. **Sol.** (1) Density of K is lower than that of Na on account of its larger atomic volume. (g/ml ; K = 0.86 ; Na = 0.97)

(2) Correct statement ; in case of noble gases atomic radii are expressed in terms of Vander Waal's radii.

(3) Decrease down the group.

(4) More softer than alkaline earth metals.

A-6.

Sol. Hydration energy of Metal cation $\propto \frac{1}{\text{Charge density}}$.

A-7. **Sol.** Down the group, size increases and thus the distance between valence shell electron and nucleus increases. As a result, the attraction between valence electron and nucleus decrease. Hence, tendency to lose electron increases.

A-8. **Sol.** Li is a strongest reducing agent amongst the alkali metals in aqueous solution because of it's highest hydration energy on account of it's small size and high charge density.

A-9. **Sol.** Li having smallest size have higher charge density. Hence it attracts more number of water molecules.

A-10. **Sol.** On account of low ionisation energies, they have greater tendency to lose an electron.

A-11.

Sol. (1) Down the group due to increase in size the strength of metallic bond decreases and so, melting point decreases.

(2) Atomic volume of K is larger as compared to Na. Increase in atomic mass does not over weigh the effect of increase atomic volume in case of potassium.

(3) They have low ionisation energies because of their larger atomic size. The heat from the flame excites the outer most orbital electron to a higher energy level. When the excited electrons come back to

the ground state, there is emission of radiation in the visible region. Hence, salts of Li to Cs impart characteristic colour to an oxidising flame. (of Bunsen burner).

A-13. **Sol.** When sodium and potassium react with water, the heat evolved causes them to melt, giving a larger area of contact with water, lithium on the other hand, does not melt under these condition and thus reacts more slowly.

	Li	Na	K
Melting point (ºC)	180	98	64.

A-14. **Sol.** (1) $4\ LiNO_3 \xrightarrow{} 2Li_2O + 4NO_2 + O_2$

$2NaNO_3\ \ 2NaNO_2 + O_2$ (similar decomposition with the nitrates of K, Rb and Cs)

(2) Only LiCl is deliquescent and crystallises as a hydrate $LiCl.2H_2O$

(3) $2M + 2H_2O \xrightarrow{} 2M^+ + 2OH^- + H_2$ (M = an alkali metal)

(4) Halides of Li are covalent in nature.

Section (B) : Atomic and physical properties of alkali metals and alkaline earth metals

B-2. **Sol.** Electropositive character is the measure of ease of formation of cation by losing electron(s). With increasing atomic size, the ionization energy decreases and, therefore, the ease of formation of cation by losing the electron increases resulting into more electropositive character of the metal. Down the group, metallic character increases due to decreases in ionisation energies and so electropositive character increase.

B-3. **Sol.** The electrons in beryllium and magnesium are too strongly bound to get excited by flame. Hence these elements do not impart any colour to the flame.

B-4. **Sol.** Along the period from left to right, atomic number increases and, therefore, nuclear charge also increases. So first ionization energy of alkaline earth metals are higher than those of the alkali metals of the same period because of higher nuclear charge.

B-5.

Sol. Down the group size increases and, therefore, attraction between valence shell electron and nucleus decreases and thus ionisation energies decrease.

Along the period the atomic size decreases and nuclear charge increases. So generally the ionization energy increases. However, half-filled and completely filled valence shell electron also affect the ionization energies along the period.

B-8.

Sol. (1) Along the period, the nuclear charge increases and, therefore, atomic size decreases. So Na has larger atomic radius than Mg.

(2) Mg is smaller than Na and Mg has two valence electrons per atom while Na has only one valence electron per atom. So Mg has stronger metallic bond than that of Na (Na is a soft metal).

(3) Because of weeker metallic bond in Mg than Ca, boiling and melting points of Mg are less than Ca.

(4) Mg does not impart characteristic colour to the flame because the electrons in Mg are too strongly bound to get excited by flame. Ca imparts brick red colour to the flame because of its low ionisation enthalpy.

B-9. **Sol.** (1) The thermal stability of oxy-acid salts of alkaline earth metals generally increases down the group with decreasing polarising power.

(2) The solublility of the alkaline earth metal hydroxides increases down the group from Be to Ba. 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.

(3) Down the group atomic size increases and, therefore, attraction between the valence shell electron and nucleus decreases ; so ionisation enthalpy decreases. Hence, they react with water with increasing vigour even in cold to form hydroxides from Be to Ba.

(4) The alkaline earth metals have low ionization enthalpies due to fairly large size of the atoms. Since the atomic size increases down the group, their first ionization enthalpy decreases.

B-10. Which of the following statements is false ?

(1) $BeCl_2$ exists as dimer in the vapour state and polymeric in the solid state
(2) Calcium hydride is called hydrolith
(3*) The oxides of Be and Ca are amphoteric
(4) Bicarbonates of Na and Sr are soluble in water

Section (C) : Chemical properties of alkali metals

C-1. **Sol.** Li reacts with N_2 and O_2 of air forms Li_3N and Li_2O but Na reacts with only O_2 forms Na_2O dose not react with N_2. (Na_3N is not possible due to large size of Na^+ ion)

C-2. **Sol.** According to crystal lattice energy effect.

C-3. **Sol.** Due to less polarizing power of Cs^+ it released easily OH^- ion.

C-4. **Sol.** Due to less polarising power of Rb^+ ion.

C-5. **Sol.** Due to high polarising power of Li^+ cation.

C-6. **Sol.** Alkali metal carbonates except Li_2CO_3 are stable towards heat.

Bigger CO_3^{2-} anion is polarised by smaller Li^+ and thus readily decomposes to give CO_2 gas.

$$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$$

C-7. **Sol.** Because of their low Lattice energy.

C-8. **Sol.** As size of anion increases, the covalent character increases and, thus melting point decreases.

C-9. **Sol.** Thermal stability of oxy-acid salts increases with increase in electropositive character of alkali metals.

C-10.

Sol. (1) Bigger anion is stabilised by bigger cation through lattice energy effect.

(2) Because of their high reactivity towards air and water on account of their higher electropositive character

(3) All alkali metals are highly basic in nature and, therefore, their hydrides are ionic solids with high melting points.

(4) In concentrated solution, unpaired electrons with opposite spins paired up-forming the solution diamagnetic.

C-11. **Sol.** (4) Diamagnetic in nature due to association of electrons of opposite spins.

C-12. **Sol.** $Mg + 3N_2 \longrightarrow Mg_3N_2$; $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$.

C-15. **Sol.** $4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$

Section (D) : Chemical properties of alkaline earth metals

D-1. **Sol.** Mg^{2+} has higher hydration energy than that of Na^+ because Na^+ has small charge and bigger size of atom than that of Mg^{2+}.

D-2. **Sol.** $3Mg + N_2 \longrightarrow Mg_3N_2$; $2Mg + O_2 \longrightarrow 2MgO$

D-3. **Sol.** Fluorides of alkaline earth metals except BeF_2 are insoluble in water. The solubility of BeF_2 in water is due to it's higher hydration energy on account of it's small size and high charge density.

D-4. **Sol.** Down the group the hydration energy is more decrease than that of lattice energy.

D-5. **Sol.** The compounds of beryllium is more covalent.

D-7. **Sol.** Lattice energy decreases with increasing size of cation from Be to Ba.

D-8. **Sol.** Along the period, atomic size decreases and nuclear charge increases and thus lattice energy increases,

$$\text{lattice energy} \propto \frac{\text{Charge on cation}}{\text{Size of cation}}.$$

D-9. **Sol.** The solubility of sulphates of alkaline earth metal salts decreases down the group from Be to Ba. 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 hydration energy is more as compare to that of lattice energy.

D-10. **Sol.** $BaSO_4$ is virtually insoluble in water suggesting $\Delta H_{lattice} > \Delta H_{hydration}$.

D-12. **Sol.** $LE \propto \frac{1}{r^+ + r^-}$

In alkalin earth metal down the group lattice energy decrease.

Section (E) : Compounds of alkali metals

E-1. **Sol.** (1) $M_2O + H_2O \longrightarrow 2M^+ + 2OH^-$ or $2MOH$

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

(3) $2MO_2 + 2H_2O \longrightarrow 2M^+ + 2OH^- + H_2O_2 + O_2$

E-2. **Sol.** (1) $2LiNO_3 \xrightarrow{\Delta} Li_2O + 2NO_2 + \frac{1}{2} O_2$ (2) $KNO_3 \xrightarrow{\Delta} KNO_2 + \frac{1}{2} O_2$

(3) $Pb(NO_3)_2 \xrightarrow{\Delta} PbO + 2NO_2 + \frac{1}{2} O_2$ (4) $2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

E-3. **Sol.** $2Na + \frac{1}{2} O_2 \longrightarrow Na_2O$ **0** and Na_2O_2.

E-4. **Sol.** $Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$

E-5. **Sol.** Washing soda is decahydrated sodium carbonate.

E-6. **Sol.** $2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + CaCl_2 + 2H_2O$

E-7. **Sol.** $KHCO_3$ is soluble in water so it can not be separated as intermediate product.

E-8. **Sol.** Cathode : $Na^+ + e^- \xrightarrow{Hg} Na\text{-amalgam}$

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

E-9. **Sol.** 2Na-Hg (amalgam) $2H_2O \longrightarrow 2NaOH + 2Hg + H_2$.

E-10. **Sol.** $M^+ (aq) + e^- + NH_3 (\ell) \longrightarrow MNH_2(aq) + \frac{1}{2} H_2 (g)$.

E-11. **Sol.** $2Na + O_2 \xrightarrow{350°C} Na_2O_2$; $2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$.

E-12. **Sol.** $NaCl \longrightarrow Na^+ + Cl^-$; $2\ Cl^- \longrightarrow Cl_2 \uparrow + 2e^-$

$HOH \longrightarrow H^+ + OH^-$; $2H^+ + 2e^- \longrightarrow H_2 \uparrow$; $Na^+ + OH^- \longrightarrow NaOH$.

E-13. **Sol.** $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$.

E-14. **Sol.** (1) $KHCO_3$ obtained as intermediate is water soluble. So it cannot be separated for obtaing K_2CO_3 by calcination in Solvay process.

(2) **LE-Blanc** process :

$KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$; $KHSO_4 + KCl \longrightarrow K_2SO_4 + HCl$

$K_2SO_4 + CaCO_3 + 2C \longrightarrow K_2CO_3 + CaS + 2CO_2$

(3) Prechts process :

(1) $2KCl + 3(MgCO_3 . 3H_2O) + CO_2 \longrightarrow 2(Mg\ CO_3 . KHCO_3 . 4H_2O) + MgCl_2$

(2) $2(MgCO_3 . KHCO_3 . 4H_2O) \xrightarrow{140°C} 2Mg\ CO_3 \downarrow + K_2CO_3 + 9H_2O + CO_2$.

E-15. **Sol.** (2) On account of higher polarising power, Mg^{2+} and Ca^{2+} have higher degree of hydration. So $MgCl_2$ and $CaCl_2$ form hydrated salts.

Section (F) : Compounds of alkaline earth metals

F-1. **Sol.** $Ca(NO_3)_2 \xrightarrow{\Delta} CaO + 2NO_2 + \frac{1}{2}O_2$; Alkali metal nitrates gives only O_2 gas.
Alkali metal nitrates give only O_2 on heating below 500ºC according to following reaction,

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

F-2. **Sol.** $\underset{\text{Plaster of Paris}}{2CaSO_4.H_2O} \xrightarrow[H_2O]{\text{Setting}} \underset{\text{Ortho rhombic}}{CaSO_4.2H_2O} \xrightarrow{\text{Hardening}} \underset{\text{Monoclinic}}{CaSO_4.2H_2O}$

F-3. **Sol.** $\underset{X}{CaCO_3} \xrightarrow{\Delta} CaO + CO_2$, $CaO + H_2O \longrightarrow \underset{Y}{Ca(OH)_2}$,

$Ca(OH)_2 + 2CO_2 \longrightarrow Ca(HCO_3)_2$, $Ca(HCO_3)_2 \longrightarrow CaCO_3 + H_2O + CO_2$

F-4. **Sol.** $\underset{\text{Gypsum}}{2[CaSO_4.2H_2O]} \longrightarrow \underset{\text{Plaster of Paris}}{2CaSO_4.H_2O}$ (calcium sulphate hemihydrate) + $3H_2O$

F-5. **Sol.** $2(CaSO_4.2H_2O) \longrightarrow 2\,(CaSO_4).\,H_2O + 3\,H_2O$.

F-6. **Sol.** $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$

Exercise-2

Marked Questions may have for Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Atomic and physical properties of alkali metals

1. **Sol.** Alkali metals have general electronic configuration = [inert gas] ns^1 or $(n–1)\,s^2\,p^6\,ns^1$.

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

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

3. **Sol.** Softness depends upon the strength of metallic bond. Softness $\propto \frac{1}{\text{strength of metallic bond}}$.
Down the group, with increase in size of atom, strength of metallic bond decreases. Hence, softness increases.

4. **Sol.** (4) Reducing nature increases down the group as their stability decreases down the group
CsH > RbH > KH > NaH > LiH

5. **Sol.** Very dilute solution of the metal are paramagnetic with approximately one unpaired e^- per metal atom.

Section (B) : Atomic and physical properties of alkali metals and alkaline earth metals

6. **Sol.** Electronic configuration of element having atomic number 20 is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$. Since in valence shell two electrons present in 4s subshell so it is a configuration of alkaline earth metals.

7. **Sol.** $CaCl_2(m) \rightleftharpoons Ca^{2+}(m) + 2Cl^-(m)$

At cathode : $Ca^{2+}(m) + 2e^- \longrightarrow Ca(s)$

At anode : $2Cl^-(m) \longrightarrow Cl_2(g) + 2e^-$.

8.
Sol. The alkaline earth metal compounds are diamagnetic because all electrons are paired.

9. **Sol.** Gyspum in not ore of magnesium.

Carnallite – $KCl.\ MgCl_2.\ 6H_2O$
Magnesite – $MgCO_3$
Dolomite – $CaCO_3.\ MgCO_3$
Gypsum – $CaSO_4.\ 2H_2O$

10. **Sol.** Composition of cement.

$Ca_2SiO_4 = 26\%$; $Ca_3SiO_5 = 51\%$
$Ca_3Al_2O_6 = 11\%$; $CaSO_4.\ 2H_2O = 2.3\ \%$

11. **Sol.** **S_1 :** This is because of diagonal relationship.

S_2 : It is true statement. Composition of portland cement is CaO = 50–60%; SiO_2 = 20 – 25%; Al_2O_3 = 5 – 10%; MgO = 2 – 3%; Fe_2O_3 = 1 – 2% and SO_3 = 1 – 2%.

S_3 : Greater hydration enthalpies of Be^{2+} and Mg^{2+} overcome the lattice enthalpy factor and therefore their sulphate are soluble in water.

S_4 : Thermal stability increases with increasing cationic size as bigger cation stabilises bigger anion. (CO_3^{2-} is bigger anion.)

12. **Sol.** Alkaline earth metals have higher ionisation energies than that of alkaline earth metals. They are thus weaker reducing agents than alkali metals.

13. **Sol.** (1) $BaCl_2.2H_2O$ (2) $CaCl_2.6H_2O$ (3) $SrCl_2.6H_2O$ (4) $MgCl_2.8H_2O$.

Section (C) : Chemical properties of alkali metals

14. **Sol.** K^+ ion gives violet color in flame test while Na^+ gives golden yellow flame and Li^+ gives crimson red colour in flame.

15. Sol. The formula of ‘A’ is M_3N suggest that M is monovalent metal.

$6Li + N_2 \rightarrow 2Li_3N \xrightarrow{\Delta} Li$

(1) lithium nitrate

$Li_3N + 3H_2O \rightarrow 3LiOH + \underset{B}{NH_3}$

$CuSO_4 + 4NH_3 \rightarrow [Cu(NH_3)_4]SO_4$

Lithium reacts with nitrogen to produce lithium nitride which with water produces, NH_3 which then reacts with $CuSO_4$ to form blue colour complex of copper.

16. Sol. $NaNO_2$ (sodium nitrite) acts both as oxidising agent and reducing agent because the nitrogen atom in it is in +3 oxidation state (+3 is intermediate oxidation state for nitrogen)

Oxidising property : $2NaNO_2 + 2KI + 2H_2SO_4 \rightarrow NaSO_4 + K_2SO_4 + 2NO + 2H_2O + I_2$

Reducing property : $NaNO_2 + H_2O_2 \rightarrow NaNO_3 + H_2O$.

17. Sol. Size of hydrated alkali ions depends on degree of hydration. Degree of hydration $\propto \frac{1}{\text{size of cation}}$. Hence the correct order of degree of hydration is $Li^+ > K^+ > Cs^+$.

18. Sol. Covalent character in ionic compounds is governed by Fazan's rules.

Covalent character $\propto$ size of anion ; Covalent character $\propto$ charge on cation.

As covalent character increases the ionic character decreases in the compounds.

Hence increasing order of ionic character is LiI < NaBr < KCl < CsF.

19. Sol. caesium is more reactive than other alkali metals because the outer electron of caesium in loosely bonded.

20. Sol. $Rb^+ O_2^{-1}$

O_2^{-1} is superoxide according to M.O.T. O_2^{-1} is paramagnetic $Rb^+ O_2^-$

21. Sol. $CO_2 + 2KO_2 \rightarrow K_2CO_3 + \frac{3}{2} O_2 \uparrow$

22. Sol. If size difference between cation and anion increase than solubility increases.

LiOH < NaOH < KOH < RbOH < CsOH

23. Sol. $Na_2O_2 + H_2O \longrightarrow NaOH + H_2O_2$; $2NaOH + CO_2 \longrightarrow Na_2CO_3$(white) ('osr) + H_2O

Section (D) : Chemical properties of alkaline earth metals

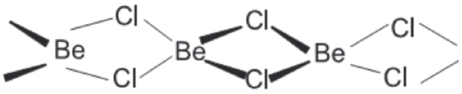
24. Sol. Mg has high ionisation energy and this much of energy can not be provided by Bunsen flame. So it does not give flame test.

25. **Sol.** As the coordination number of metal ion increases the solubility of sulphates increases. Here hydration energy exceeds the lattice energy down the group.

26.

Sol. $CaO + H_2O \longrightarrow Ca(OH)_2$; CaO is basic oxide and does not react with neutral or basic gases.

27. **Sol.** Beryllium chloride has a chain structure in the solid state as shown below :



28. **Sol.** In $BeCl_2$ and $MgCl_2$ bond are covalent so does not give. flame test.

29. **Sol.** $CaCl_2 + N_2 \rightarrow CaNCN + C(s)$

30. **Sol.** **S_1 :** Reducing nature is due to large hydration energy associated with the small Be^{2+} ion and relatively large value of the atomization enthalpy of the metal.

S_2 : Li^+ = 76 pm, Mg^{2+} = 72 pm, Both are diagonaly related and Mg^{2+} is smaller on account of higher positive charge.

S_3 : Among alkali metal carbonates, the Li_2CO_3 is least stable because of smaller Li^+.

Smaller Li^+ polarises bigger CO_3^{2-} anion and thus easily decomposes to give CO_2.

31. **Sol.** It can be understood by the fact that reduction potential depends mainly on (i) enthalpy of atomization, (ii) ionization energy, (iii) hydration enthalpy, etc.

32. **Sol.** (b) $KO_2 + 2H_2O \longrightarrow KOH + H_2O_2 + 1/2O_2$

(c) $4KO_2 + 2CO_2 \longrightarrow 2K_2CO_3 + 3O_2$

Section (E) : Compounds of alkali metals

33.

Sol. The chemical reactions which takes place in Solvay process are as follows -

(i) $NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$

(ii) $NH_4HCO_3 + NaCl \longrightarrow \underset{\text{sodium bicarbonate}}{NaHCO_3} + NH_4Cl$

(iii) $2NaHCO_3 \xrightarrow{\Delta} \underset{\text{sodium carbonate}}{Na_2CO_3} + H_2O + CO_2$

The CO_2 obtained in this step can be recycled. The CO_2 required in reaction is prepared by heating $CaCO_3$.

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

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

$Ca(OH)_2$ is used to decompose NH_4Cl

$Ca(OH)_2 + NH_4Cl \longrightarrow 2NH_3 + 2H_2O + CaCl_2$

The NH_3 thus obtained can be recycled.

∴ CO_2 and NH_3 are the products which can be recycled in Solvay process.

34. Sol. The reaction between sodium and chlorine takes place as follows :

$2Na + Cl_2 \longrightarrow 2NaCl$

$2Na - 2e \longrightarrow 2Na^+$ Oxidation

$Cl_2 + 2e^- \longrightarrow 2Cl^-$ Reduction

$2Na + Cl_2 \longrightarrow 2NaCl$

In this reaction, sodium atom is oxidised and chlorine is reduced.

35. Sol. Acidic and basic salts cannot exist together because they tend to react.

$NaHCO_3$ is acidic salt and NaOH is basic salt.

Therefore, they cannot exist together.

$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$.

36.

Sol. (1) **Gossage process :** used to prepare NaOH ; $Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + NaOH$.

(2) **Leblanc process :** used to prepare K_2CO_3 .

(3) **Solvay process :** used to prepare Na_2CO_3 .

(4) **Haber's process :** used to prepare NH_3 .

37. Sol. $2KO_2 + CO \longrightarrow K_2CO_3 + O_2$; $2KO + CO_2 \longrightarrow K_2CO_3 + \frac{1}{2} O_2$.

38. Sol. Carnallite is a double salt having composition, $KCl.\ MgCl_2.\ 6H_2O$. It being ionic breaks into its constituent ions giving K^+, Cl^- and Mg^{2+} ions when dissolved in water.

39. Sol. On strong heating $NaHCO_3$ sodium bicarbonate decomposes and gives sodium carbonate (Na_2CO_3)

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

40. Sol. Carbonates of alkali metals are stable towards heat.

41.

Sol. (1) It is used for making pulp in paper industry.

(2) $6NaOH + 2Al \longrightarrow 2Na_3AlO_3 + H_2$

$2NaOH + Zn \longrightarrow Na_2ZnO_2 + H_2$

(3) $Ca(OH)_2$ (milk of lime) + $Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaOH$

(4) It readily absorbs water on exposure to atmosphere and turns in to a liquid.

42.

Sol. $2\ NH_4Cl + Ca(OH)_2 \xrightarrow[steam]{\Delta} 2\ NH_3 + CaCl_2 + 2\ H_2O.$

$NH_4HCO_3 \xrightarrow[steam]{\Delta} NH_3 + CO_2 + H_2O.$

Section (F) : Compounds of alkaline earth metals

43. **Sol.** $CaSO_4 . 2H_2O$ – Gypsum

$CaSO_4 . \frac{1}{2} H_2O$ – Plaster of Paris or calcium sulphate hemihydrate

$\underset{\text{Gypsum}}{CaSO_4 . 2H_2O} \xrightarrow{390\ K} \underset{\text{Plaster of Paris}}{CaSO_4 . \frac{1}{2} H_2O} + 1\frac{1}{2} H_2O$

44. **Sol.** $\underset{\text{gypsum}}{CaSO_4 . 2H_2O} \xrightarrow{120^\circ C} \underset{\text{plaster of Paris}}{CaSO_4 . \frac{1}{2} H_2O}$

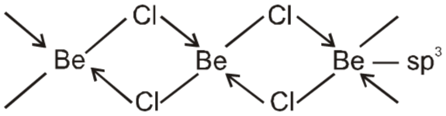
$CaCO_4 . 2H_2O \xrightarrow{>200^\circ C} \underset{\text{dead burnt plaster}}{CaSO_4 .} + 2H_2O$

45. **Sol.** $6\ CaOCl_2 \xrightarrow{\text{on standing}} Ca(ClO_3)_2 + 5\ CaCl_2 .$

46. **Sol.** $BeCl_2$ in vapour state at 100ºC exist as monomer.

$\underset{sp}{Cl — Be — Cl}$

$BeCl_2$ in solid state exists as polymeric structure.



47.

Sol. (i) $Ca(OH)_2 + Na_2CO_3 \longrightarrow CaCO_3 + NaOH$

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

(iii) $MgCl_2$ (from sea water) $+ Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$ (Dow's process).

48. **Sol.** $2\ CaSO_4 .H_2O \xrightarrow[+H_2O]{\text{setting}} CaSO_4 . 2\ H_2O$ (orthorhombic gypsum).

49. **Sol.** $Ca_2SiO_4 = 26\%$; $Ca_3SiO_5 = 51\%$

$Ca_3Al_2O_6 = 11\%$; $CaSO_4.2H_2O = 2.3\%$

50.

Sol. Because of the low ionization enthalpy of caesium, it when irradiated with light, the light energy absorbed is sufficient to make an atom lose electron. This property make caesium useful as electrodes in photoelectric cells.

Exercise-3

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1.

Sol. $4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$. It absorbs CO_2 and release O_2.

$4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$.

2. **Sol.** $BeSO_4$ is water soluble but $Be(OH)_2$ is water insoluble. Because of amphoteric nature, $Be(OH)_2$ dissolves in NaOH forming soluble sodium beryllate.

$Be(OH)_2 + 2NaOH \rightarrow Na_2BeO_2 + H_2O$.

3. **Sol.** Setting of cement is an exothermic process, Hence cement structures have to be cooled during setting to develops interlocking needle like structure crystals of hydrate silicates.

$2CaO.SiO_2 + xH_2O \xrightarrow{\text{Hydration}} 2CaO.SiO_2.xH_2O$.

4. **Sol.** Calcined gypsum is $CaSO_4$(burnt plaster); sea shells contain $CaCO_3$ and K_2CO_3; dolomite is $MgCO_3.CaCO_3$ and marble contains $CaCO_3$.

5. **Sol.** The solubility of the alkaline earth metal carbonates decreases down the group from Mg to Ba. 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 hydration energy is more as compare to that of lattice energy.

6. **Ans.** It gives cathodic protection or sacrificial protection, as Mg is more reactive than steel. Hence it prevent action of water and salt on steel body.

7. **Sol.** $MgN_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$.

8. **Sol.** Beryllium has the valency +2 while aluminum exhibit its valency as + 3.

9. **Sol.** All the alkali metals are highly reactive elements since they have a strong tendency to lose the single valence s-electron to form unipositive ions having inert gas configuration. This reactivity arises due to their low ionization enthalpies and high negative values of their standard electrode potentials.

However, the reactivity of halogens decreases with increase in atomic number due to following reasons.

(a) As the size increases, the attraction for an additional electron by the nucleus becomes less.

(b) Due to decrease in electronegativity from F to I, the bond between halogen and other elements becomes weaker and weaker.

10. **Sol.** $M^+ + nH_2O \rightarrow \underset{\text{hydrated cation}}{[M(aq)]^+}$

The extent of hydration depends upon the size of the ion, smaller the size of the ion, more highly it is hydrated and thus move slowly because of bigger size of hydrated ions. Hence with bigger atomic size the mobility of hydrated ion is highest and the order of the ionic mobility is, $Li^+ < Na^+ < K^+ < Rb^+$.

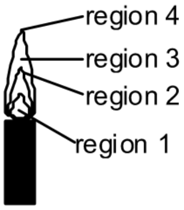
11. **Sol.** As metallic character of element attached to oxygen atom increases, the difference between the electronegativity values of element and oxygen increases and thus basic character of oxides increases and vice-versa. Hence the increasing correct order of basic nature is $Al_2O_3 < MgO < Na_2O < K_2O$.

12. **Sol.** $4LiNO_3 \longrightarrow 2Li_2O + 4NO_2 + O_2$

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

14. **Sol.** Down the group, solubility of sulphates of group 2 metals in water decreases. $BeSO_4$ is soluble in water (a known fact). Hence, hydration energy of $BeSO_4$ is more in magnitude than its lattice energy.

15. **Sol.** It is fact.



16. **Sol.** $Li + \underset{\text{(excess)}}{O_2(g)} \longrightarrow Li_2O$

$Na + \underset{\text{(excess)}}{O_2(g)} \longrightarrow Na_2O_2$

$K + \underset{\text{(excess)}}{O_2(g)} \longrightarrow KO_2$

17. **Sol.** Carbonate of Mg is basic in nature (many times occurs as $MgCO_3.Mg(OH)_2$) but carbonate of Li is not.

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2. **Sol.** Larger cation is able to stabilize polyatomic anion more than smaller cation.

3. **Sol.** Solubility of sulphates of alkaline earth metal decreases down the group. Hence correct order of solubility is : Mg > Ca > Sr > Ba

4. **Sol.** Fact

5. **Sol.** Carbonate of Mg is basic in nature (many times occurs as $MgCO_3.Mg(OH)_2$) but carbonate of Li is not.

6. **Sol.** $\underset{\text{Cold \& dil.}}{Cl_2 + 2NaOH} \longrightarrow Cl^- + ClO^- + Na^+ + H_2O$

Disproportionation reaction.

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. **Sol.** For alkaline earth metal hydroxides, down the group the basic strength increases due to increase in metallic character. So down the group, hydroxides easily get dissolved producing OH^- ions. So down the group with increasing atomic number, the solubility of their hydroxides increase.

2. **Sol.** Down the group the effective nuclear charge remains almost constant. But down the group with increasing atomic number the number of atomic orbits increases and there by atomic size increases. As a result, the distance of valence shell electron from nucleus increases and attraction between them decreases and therefore ionization energy decreases.

3. **Sol.** Alkali metals dissolves in liquid ammonia to give ammoniated cations and ammoniated electrons, the blue colour of the solution is due to ammoniated electrons.

$$M + (m + n)NH_3 \rightarrow [M(NH_3)_n]^+ + [e(NH_3)_m]^-$$

The conductivity of solution is due to both the ions.

Additional Problems For Self Practice (APSP)

PART - I : PRACTICE TEST PAPER

JEE(Main) Pattern Practice paper (30 SCQ, 1 hr, 120 Marks).

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

Max. Marks : 120 **Max. Time : 1 Hr.**

Important Instructions

1. The test is of **1 hour** duration.

2. The Test Booklet consists of **30** questions. The maximum marks are **120.**

3. Each question is allotted **4 (four)** marks for correct response.

4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question.
¼ **(one fourth)** marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.

5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

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1. **Sol.** Down the group size increases and therefore, attraction between valence shell electron and nucleus decreases and thus ionisation energy decreases.

2.
Sol. (1) Down the group, the atomic size increases with increasing atomic number and so attraction for shared pair of electrons decreases. Hence electronegativity decreases.
(2) Down the group, the atomic size increases with increasing atomic number and so attraction between valence electron and nuclear decreases. Hence ionization energy decreases.
(3) Down the group atomic size increases with increase in number of atomic shells while effective nuclear charge remains constant.
(4) Down the group atomic size increases with increase in number of atomic shells and therefore, the strength of metallic bond decreases. So melting point decreases.

3.
Sol. Alkali metals have low ionisation energy.

4. **Sol.** All are wrong. The solution has strong reducing nature and coloured due to ammoniated electron. Dilute solution is paramagnetic whereas concentrated solution is diamagnetic.

5.
Sol. (2) Smaller cation and higher charge attracts more numbers of water molecules.
(3) Periodic property

(4) Except Li^+, due to bigger size of ions they have low hydration enthalpies. Hence except lithium, all alkali metal halides do not form hydrates.

6. **Sol.** **S_1 :** Li^+ being smaller have high polarising power and I^- being larger have high polarisability. So it is most covelent among alkali metal halides according to Fajan's rule.

S_2 : The IE1 of potussium atom is less then sodium atom.

S_3 : The presence of transition metals like iron and other impurities catalyses the decompositon of deep blue
solution forming amide and liberating H_2.

S_4 : Two opposing tendencies exists. With greater charge and smaller size of cation, lattice energy increases which tends to increase the melting point ; while increase in covalent character causes a decrease in melting point. Hence, no unique generalised trend may be stated for melting points. (Students need not worry about or memorise such experimental data).

7. **Sol.** The reaction of alkali metals with water becomes increasingly violent on descending the group on account of their decreasing ionisation energies with increasing atomic size. So, the order of reactivity is :
Li < Na < K < Rb.

8. **Sol.** $2Na + O_2 \longrightarrow Na_2O_2$

9. **Sol.** They have weak metallic bond because of one valence electron per atom. So they have low melting points.

10. **Sol.** They easily lose valence shell electron because of their low ionisation energies, on account of their bigger atomic sizes. So they behave as strong reducing agents.

11.
Sol. (1) Factual

(2) Hydration energy $\propto \frac{1}{\text{size of cation}}$.

(3) Both are diagonally related ; because of more positive charge on Mg, Mg^{2+} is smaller than Li^+.
$Li^+ = 76$ pm, $Mg^{2+} = 72$ pm.

(4) Salt of weak base and strong acid, thus easily hydrolysed in water giving acidic solution.

12. **Sol.** $Be + Air \xrightarrow{T>1000°C} BeO + Be_3N_2$ (white powder)

$Be_3N_2 + 6H_2O \longrightarrow 3Be(OH)_2$ (white precipitate) + $2NH_3$ (Colourless gas)

13. **Sol.** $KNO_3 \xrightarrow{Heat} KNO_2 + \frac{1}{2}O_2$

$C + O_2 \longrightarrow CO_2$

14. **Sol.** $2Na + O_2 \xrightarrow{Heat} Na_2O_2$; $2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$.

15. **Sol.** $K_2O + H_2O \longrightarrow 2\ KOH \longrightarrow K^+ + OH^-$.
The resulting solution is basic due to the presence of OH^-.

16. **Sol.** $K + O_2 \xrightarrow{\text{burning}} KO_2$

17. **Sol.** Sodium hydroxide is manufactured by the electrolysis of brine using Castner-Kellner cell.

18. **Sol.** (1) $Na_2O + H_2O$ 2 NaOH

(2) $2\ Na/Hg + 2\ H_2O \longrightarrow$ (Castner-Kellner cell) $\longrightarrow 2NaOH + 2\ Hg + H_2$.

(3) $Na_2O_2 + 2H_2O \longrightarrow 2\ NaOH + H_2O_2$

(4) $Na_2CO_3 + 2H_2O \rightleftharpoons 2NaOH + H_2CO_3$

19. **Sol.** (1), (2) & (3) reacts with water being more basic than water.

20. **Sol.** Isoelectronic species have same number of electrons.

21. **Sol.** All alkali metal hydrides are ionic in nature and react with water according to the reaction ;
$NaH + H_2O \longrightarrow NaOH + H_2$.

22. **Sol.** $Mg_3N_2 + 6H_2O \longrightarrow 3\ Mg(OH)_2 + 2NH_3$

23. **Sol.** True statement. The CsI, because of bigger cation (Cs^+) and bigger anion (I^-), has smaller hydration enthalpy. As a result, it does not exceed its lattice energy ; so CsI is insoluble in water.

(Source : NCERT)

24. **Sol.** (1) Lithium show exceptional behavior in reaction directly with nitrogen of air to form the nitride, Li_3N.

(2) Smaller cation (Li^+) polarises bigger anion (CO_3^{2-}) liberating CO_2 gas. So it has the lowest thermal stability.

(3) The solubility of the alkali metal hydroxides 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 decreases but the change in lattice energy is more as compare to that of hydration energy.

25. **Sol.** $NaNO_3$ is not used as gun powder because it is hygroscopic in nature and becomes wet by absorbing water molecules from the atmosphere. Therefore, (1) option is correct.

27. **Sol.** Baking powder used to make cake is a mixture of starch, $NaHCO_3$ and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is being acidic in nature and gives CO_2 when moistened with $NaHCO_3$.

28. **Sol.** $Ba(NO_3)_2$ results a neutral solution as it is the salt of strong acid, HNO_3 and strong base, $Ba(OH)_2$.

29. **Sol.** Methanides give CH_4 on reaction with H_2O.
$Al_4C_3 + 12H_2O \longrightarrow 4Al\ (OH)_3 + 3CH_4$; $Be_2C + 4H_2O \longrightarrow 2Be\ (OH)_2 + CH_4$

30. **Sol.** Factual.

PART - II : PRACTICE QUESTIONS

13. **Sol.** Solution of sodium in liquid ammonia acts as powerful reducing agent.

$$O_2 + e^- \longrightarrow O_2^-$$

$$[Ni(CN)_4]^{2-} + 2e^- \longrightarrow [Ni(CN)_4]^{4-}$$

14. **Sol.** (1) Pure sodium metal can be produced by the electrolysis of molten NaCl.
(2) CsOH has the maximum basicity and maximum solubility among all alkali metal hydroxides.
(3) Potassium carbonate can not be prepared because $KHCO_3$ is more soluble than $NaHCO_3$.

15. **Ans.** $BeCl_2 + 4H_2O \rightleftharpoons [Be(H_2O)_4]^{+2} + 2Cl^-$

16. **Sol.** Covalent character in ionic compounds is governed by Fazan's rules.

Covalent character $\propto \frac{1}{\text{size of cation}}$; Covalent character $\propto$ charge on cation.
Hence the increasing order of covalent character is NaCl < LiCl < $BeCl_2$.

17. **Sol.** As basic character of metals increases, the basic character of their hydroxides also increases. The basic character of the metals depend on their ionization energies and it is inversely proportionate to ionization energy. Magnesium has highest ionization energy so it is least basic and it's hydroxide is a weakest base.

18. **Sol.** KI has lower melting point because of more covalent character on account of higher polarisability of bigger I^- ion.

19. **Sol.** The enthalpies of formation for the chlorides become more negative on descending the group.Thus the correct order of stability of alkali metal chlorides follows the order CsCl > KCl > NaCl > LiCl.

20. **Sol.** As non-metallic character of element attached to oxygen atom increases, the difference between the electronegativity values of element and oxygen decreases and the acid character of oxides increases and vice-versa. Hence the correct order is MgO > Al_2O_3 > SO_3 > Cl_2O_7.

21. **Sol.** In the electrolysis of brine :
Anode : $2Cl^- \longrightarrow Cl_2 + 2e$

Cathode : $\begin{cases} Na^+ + e^- \rightarrow Na \\ 2Na + 2H_2O \rightarrow 2NaOH + H_2 \end{cases}$

22. **Sol.** **Plaster of Paris** at 200°C becomes anhydrous i.e. $CaSO_4$. The anhydrous form is known as **burnt plaster or dead plaster.**

23. **Sol.** Mg can't decompose water as last as Li
Mg can't react readily with liquid Bromine as last as Li

24. **Sol.** **S_1 :** $LiHCO_3$ exist in solutions but does not exist in solid state, because smaller cation polarises bigger HCO_3^-.

S_2 : Because $MgCl_2$ and $CaCl_2$ are deliquescent in nature.

S_3 : BeO dissolves in bases as well as in acids forming salts and water.