10 The s-Block Elements

I. Multiple Choice Questions (Type-I)

1. The alkali metals are low melting. Which of the following alkali metals is expected to melt if the room temperature rises to 30°C?
   (*i*) Na (*ii*) K
   (*iii*) Rb (*iv*) Cs

Ans. (*iv*)

Explanation: The melting point decreases down the group because the size increases and the forces in metallic bonding decreases. Melting point of Cs = 302K.

2. Alkali metals react with water vigorously to form hydroxides and dihydrogen. Which of the following alkali metals reacts with water least vigorously?
   (*i*) Li (*ii*) Na
   (*iii*) K (*iv*) Cs

Ans. (*i*)

Explanation: Li has very high enthalpy of hydration, therefore the reaction between Li and water is highly exothermic but the energy evolved is consumed in fusion, vaporisation, and ionisation as a result reaction with water proceeds slowly.

3. The reducing power of a metal depends on various factors. Suggest the factor which makes Li, the strongest reducing agent in aqueous solution.
   (*i*) Sublimation enthalpy (*ii*) Ionisation enthalpy
   (*iii*) Hydration enthalpy (*iv*) Electron-gain enthalpy

Ans. (*iii*)

Explanation: $E^{\ominus}_{red}$ is a measure of tendency of an element to lose electron in aqueous solution. Higher the negative $E^{\ominus}$, greater is the ability to lose electrons and strong reducing character in aqueous solution.

4. Metal carbonates decompose on heating to give metal oxide and carbon dioxide. Which of the metal carbonates is most stable thermally?
   (*i*) $MgCO_3$ (*ii*) $CaCO_3$
   (*iii*) $SrCO_3$ (*iv*) $BaCO_3$

Ans. (*iv*)

Explanation: Thermal stability of MCO_3 Group 2 depends on the MO. If MO is stable MCO_3 is thermally unstable and vice versa.
$MCO_3 \rightarrow MO + CO_2$. Thermal stability of MO decreases as the size of M increases. Therefore, BaO is least stable and $BaCO_3$ is most stable.

5. Which of the carbonates given below is unstable in air and is kept in CO_2 atmosphere to avoid decomposition?

(*i*) $BeCO_3$ (*ii*) $MgCO_3$
(*iii*) $CaCO_3$ (*iv*) $BaCO_3$

Ans. (*i*)

Explanation: $BeCO_3$ is stable only in atmosphere of CO_2. It is unstable due to strong polarizing effect of small size of Be^{2+} ion.

6. Metals form basic hydroxides. Which of the following metal hydroxides is the least basic?

(*i*) $Mg(OH)_2$ (*ii*) $Ca(OH)_2$
(*iii*) $Sr(OH)_2$ (*iv*) $Ba(OH)_2$

Ans. (*i*)

Explanation: Basic character of the hydroxide increases down the group as the size of metal increases. Solubility of hydroxide increases and hydroxide of Be and Mg are almost insoluble.

7. Some of the Group 2 metal halides are covalent and soluble in organic solvents. Among the following metal halides, the one which is soluble in ethanol is

(*i*) $BeCl_2$ (*ii*) $MgCl_2$
(*iii*) $CaCl_2$ (*iv*) $SrCl_2$

Ans. (*i*)

Explanation: $BeCl_2$ has covalent character because of small size and high effective nuclear charge. Being covalent in nature it is dissolved in ethanol.

8. The order of decreasing ionisation enthalpy in alkali metals is

(*i*) Na > Li > K > Rb (*ii*) Rb < Na < K < Li
(*iii*) Li > Na > K > Rb (*iv*) K < Li < Na < Rb

Ans. (*iii*)

Explanation: As the size of atom increases, effective nuclear charge decreases and ionization enthalpy decreases down the group.

9. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of LiF in water is due to

(*i*) Ionic nature of lithium fluoride
(*ii*) High lattice enthalpy
(*iii*) High hydration enthalpy for lithium ion
(*iv*) Low ionisation enthalpy of lithium atom

Ans. (*ii*)

Explanation: Solubility of metal halides in water depends on lower lattice enthalpy and high hydration enthalpy. In case of LiF, the lowest solubility is due to its very high lattice enthalpy.

10. Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?

(*i*) $Be(OH)_2$ (*ii*) $Mg(OH)_2$
(*iii*) $Ca(OH)_2$ (*iv*) $Ba(OH)_2$

Ans. (*i*)

Explanation: $Be(OH)_2$ is insoluble in water due to its very high lattice enthalpy and high hydration enthalpy. It reacts with acid to give salt and water, and with base to give beryllate and water.

$$Be(OH)_2 + 2HCl \rightarrow BeCl_2 + 2H_2O$$
$$Be(OH)_2 + 2NaOH \rightarrow Na_2BeO_2 + 2H_2O$$

11. In the synthesis of sodium carbonate, the recovery of ammonia is done by treating NH_4Cl with $Ca(OH)_2$. The by-product obtained in this process is

(*i*) $CaCl_2$ (*ii*) NaCl
(*iii*) NaOH (iv) $NaHCO_3$

Ans. (*i*)

Explanation: In solvay ammonia soda process, Na_2CO_3 is manufactured. The reactions involved in the synthesis are:

$$NH_3 + H_2O + CO_2 \rightarrow NH_4HCO_3$$
$$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$$
$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O$$

NH_3 is recovered from NH_4HCO_3 and NH_4Cl and in this process $CaCl_2$ is formed as a by product according to the following reactions:

$$NH_4HCO_3(\text{on heating}) \rightarrow NH_3 + H_2O + CO_2$$
$$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + 2H_2O + CaCl_2$$

12. When sodium is dissolved in liquid ammonia, a solution of deep blue colour is obtained. The colour of the solution is due to

(*i*) ammoniated electron (*ii*) sodium ion
(*iii*) sodium amide (*iv*) ammoniated sodium ion

Ans. (*i*)

Explanation: Alkali metals are dissolved in liquid ammonia and give deep blue highly conducting liquid. The colour of the solution is due to ammoniated electrons which excite to higher energy level by absorbing red wavelength and transmitted blue colour.

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

13. By adding gypsum to cement

(*i*) setting time of cement becomes less.
(*ii*) setting time of cement increases.
(*iii*) colour of cement becomes light.
(*iv*) shining surface is obtained.

Ans. (*ii*)

Explanation: Gypsum ($CaSO_4.5H_2O$) is added to cement to increase the setting time of cement so that it gets hardened. Setting of cement is an exothermic process.

14. Dead burnt plaster is

(*i*) $CaSO_4$ (*ii*) $CaSO_4.\frac{1}{2}H_2O$

(*iii*) $CaSO_4.H_2O$ (*iv*) $CaSO_4.2H_2O$

Ans. (*i*)

Explanation: Plaster of paris ($CaSO_4.\frac{1}{2}H_2O$) on heating at 200°C changes into anhydrous $CaSO_4$.

15. Suspension of slaked lime in water is known as

(*i*) lime water (*ii*) quick lime

(*iii*) milk of lime (*iv*) aqueous solution of slaked lime

Ans. (*iii*)

Explanation: Slaked lime $Ca(OH)_2$ is sparingly soluble in water. It gives white suspension in water when CaO is soaked in water and the reaction is highly exothermic. White suspension is called milk of lime and it is used for white washing.

16. Which of the following elements does not form hydride by direct heating with dihydrogen?

(*i*) Be (*ii*) Mg

(*iii*) Sr (*iv*) Ba

Ans. (*i*)

Explanation: Only BeH_2 cannot be prepared by direct combination with H_2 in group II. It is prepared by reacting $BeCl_2$ with $LiAlH_4$.

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

17. The formula of soda ash is

(*i*) $Na_2CO_3.10H_2O$ (*ii*) $Na_2CO_3.2H_2O$

(*iii*) $Na_2CO_3.H_2O$ (*iv*) Na_2CO_3

Ans. (*iv*)

Explanation: Washing soda ($Na_2CO_3.10H_2O$) loses water of crystallization above 373K. It becomes white anhydrous powder called soda ash.

$$Na_2CO_3.10H_2O \rightarrow Na_2CO_3 + 10H_2O$$

18. A substance which gives brick red flame and breaks down on heating to give oxygen and a brown gas is

(*i*) Magnesium nitrate (*ii*) Calcium nitrate

(*iii*) Barium nitrate (*iv*) Strontium nitrate

Ans. (*ii*)

Explanation: $Ca(NO_3)_2 \xrightarrow{\text{Heat}} CaO + NO_2 + O_2$.

Ca imparts brick red colour, NO_2 is a brown gas.

19. Which of the following statements is true about $Ca(OH)_2$?

(*i*) It is used in the preparation of bleaching powder.

(*ii*) It is a light blue solid.

(*iii*) It does not possess disinfectant property.

(*iv*) It is used in the manufacture of cement.

Ans. (*i*)

Explanation: $Ca(OH)_2$ reacts with Cl_2 to give bleaching powder.

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

20. A chemical **A** is used for the preparation of washing soda to recover ammonia. When CO_2 is bubbled through an aqueous solution of **A**, the solution turns milky. It is used in white washing due to disinfectant nature. What is the chemical formula of **A**?

(*i*) $Ca(HCO_3)_2$ (*ii*) CaO

(*iii*) $Ca(OH)_2$ (*iv*) $CaCO_3$

Ans. (*iii*)

Explanation: To recover NH_3 in solvay ammonia soda process, $Ca(OH)_2$ is used. It is treated with NH_4Cl.

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

On passing CO_2 through $Ca(OH)_2$, lime water, which is colourless, turns milky due to the formation of $CaCO_3$.

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

$Ca(OH)_2$ is used for white washing also.

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

(*i*) act as dehydrating agent

(*ii*) can absorb moisture from air

(*iii*) Tendency to form hydrate decreases from calcium to barium

(*iv*) All of the above

Ans. (*iv*)

Explanation: Chlorides of alkaline earth metals are hydrated. These are hygroscopic in nature.

II. Multiple Choice Questions (Type-II)

In the following questions two or more options may be correct.

22. Metallic elements are described by their standard electrode potential, fusion enthalpy, atomic size, etc. The alkali metals are characterised by which of the following properties?

(*i*) High boiling point

(*ii*) High negative standard electrode potential

(*iii*) High density

(*iv*) Large atomic size

Ans. (*ii*) and (*iv*)

Explanation: Alkali metals have largest size and low density and have low boiling point. These metals lose *ns* electrons easily due to less effective nuclear charge and have high negative standard electrode potential.

23. Several sodium compounds find use in industries. Which of the following compounds are used for textile industry?

(*i*) Na_2CO_3 (*ii*) $NaHCO_3$

(*iii*) NaOH (*iv*) NaCl

Ans. (*i*) and (*iii*)

Explanation: Na_2CO_3 is used in manufacture of soap powders, in laundry and textile industry. NaOH is used in Soap industry, Paper industry.

24. Which of the following compounds are readily soluble in water?

(*i*) $BeSO_4$ (*ii*) $MgSO_4$

(*iii*) $BaSO_4$ (*iv*) $SrSO_4$

Ans. (*i*) and (*ii*)

Explanation: Hydration energy of Be^{+2} and Mg^{+2} is high, it decreases down the group as the size increases. Therefore, $BeSO_4$ and $MgSO_4$ are easily soluble.

25. When Zeolite, which is hydrated sodium aluminium silicate is treated with hard water, the sodium ions are exchanged with which of the following ion(*s*)?

(*i*) H^+ ions (*ii*) Mg^{2+} ions

(*iii*) Ca^{2+} ions (*iv*) SO_4^{2-} ions

Ans. (*ii*) and (*iii*)

Explanation: Zeolite is used to remove hardness of water. Zeolite is sodium alumino silicate. It has a property to exchange Ca^{2+} and Mg^{2+} ions from hard water by Na^+ ion of zeolite.

26. Identify the correct formula of halides of alkaline earth metals from the following:

(*i*) $BaCl_2.2H_2O$ (*ii*) $BaCl_2.4H_2O$

(*iii*) $CaCl_2.6H_2O$ (*iv*) $SrCl_2.4H_2O$

Ans. (*i*) and (*iii*)

Explanation: Chlorides of alkaline earth metals are hydrated and extent of hydration decreases down the group.

27. Choose the correct statements from the following:

(*i*) Beryllium is not readily attacked by acids because of the presence of an oxide film on the surface of the metal.

(*ii*) Beryllium sulphate is readily soluble in water as the greater hydration enthalpy of Be^{2+} overcomes the lattice enthalpy factor.

(*iii*) Beryllium exhibits coordination number more than four.

(*iv*) Beryllium oxide is purely acidic in nature.

Ans. (*i*) and (*ii*)

Explanation: Be resembles Al (diagonal relation) and form protective film of oxide and not attacked readily by acids. $BeSO_4$ is soluble in water due to high hydration enthalpy of Be^{2+}.

28. Which of the following are the correct reasons for anomalous behaviour of lithium?

(*i*) Exceptionally small size of its atom

(*ii*) Its high polarising power

(*iii*) It has high degree of hydration

(*iv*) Exceptionally low ionisation enthalpy

Ans. (*i*) and (*ii*)

Explanation: In the family of alkali metals, Li has small size because size increases down the group. On account of small size and high nuclear charge it shows high polarizing power.

III. Short Answer Type

29. How do you account for the strong reducing power of lithium in aqueous solution?

Ans. Li, being member of group 1 and first element of the family has highest enthalpy of ionization but also have high enthalpy of hydration, which predominates, and in aqueous solution, Li loses electrons and has good reducing power.

$$Li(s) \rightarrow Li(g) \text{(Sublimation enthalpy)}$$
$$Li(g) \rightarrow Li^{+}(g) + 1e^{-} \text{(Enthalpy of ionization)}$$
$$Li^{+}(g) + H_2O \rightarrow Li^{+}(aq) \quad \text{(Enthalpy of hydration)}$$

Due to small size of Li ion, it has strongest enthalpy of hydration among all alkali metals.

30. When heated in air, the alkali metals form various oxides. Mention the oxides formed by Li, Na and K.

Ans. Alkali metals react with O_2 and reactivity increases down the group. These elements give three types of oxides—normal oxides, peroxides and superoxides.

$4\,Li + O_2 \rightarrow 2Li_2O$ (lithium oxide)

$6Na + 2O_2 \rightarrow Na_2O_2$ (sodium peroxide) $+ 2Na_2O$ (sodium oxide)

$8K + 2O_2 \rightarrow KO_2$ (superoxide) $+ K_2O_2$ (peroxide) $+ K_2O$ (normal oxide)

31. Complete the following reactions

(*i*) $O_2^{2-} + H_2O \rightarrow$ (*ii*) $O_2^{-} + H_2O \rightarrow$

Ans. (*i*) $O_2^{2-} + 2H_2O \rightarrow 2OH^{-} + H_2O_2$

(*ii*) $2O_2^{-} + 2H_2O \rightarrow 2OH^{-} + H_2O_2 + O_2$

32. Lithium resembles magnesium in some of its properties. Mention two such properties and give reasons for this resemblance.

Ans. Atomic radii: Li = 152 pm, Mg = 160 pm; ionic radii : Li^{+} = 76 pm, Mg^{2+} = 72 pm. The main points of similarity is due to similar ionic radii. Two points of resemblance are:

(*i*) Lithium and magnesium react slowly with water. Their oxides and hydroxides are much less soluble and their hydroxides decompose on heating.

$$2LiOH(\text{on heating}) \rightarrow Li_2O + H_2O$$
$$2Mg(OH)_2(\text{on heating}) \rightarrow Mg_2O + 2H_2O$$

(*ii*) Both form nitride, Li_3N and Mg_3N_2, by direct combination with nitrogen

$$6Li + N_2 \rightarrow 2Li_3N,$$
$$3Mg + N_2 \rightarrow Mg_3N_2$$

33. Name an element from Group 2 which forms an amphoteric oxide and a water soluble sulphate.

Ans. Beryllium is an element from group 2 which gives an amphoteric oxide BeO and water soluble sulphate $BeSO_4$.

$$Be(OH)_2 + 2OH^- \rightarrow \underset{\text{Beryllate ion}}{[Be(OH)_4]^{2-}}$$

$$Be(OH)_2 + 2HCl + 2H_2O \rightarrow [Be(OH)_4]Cl_2$$

$BeSO_4$ is soluble in water due to highest hydration energy. It is much more than lattice energy.

34. Discuss the trend of the following:

(*i*) Thermal stability of carbonates of Group 2 elements.

(*ii*) The solubility and the nature of oxides of Group 2 elements.

Ans. (*i*) Thermal stability increases down the group. On heating, these carbonates give CO_2 and oxide of the respective element of group 2. $BeCO_3$ is unstable and made stable in the atmosphere of CO_2.

$$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$$
$$MCO_3(\text{on heating}) \rightarrow MO + CO_2$$

(*ii*) All oxides are basic and ionic in nature except BeO which is amphoteric and covalent. Lattice energy of oxides decreases as the size of cation increases in oxide. Basic nature increases down the group. BeO < MgO < CaO < SrO < BaO. Except BeO and MgO, all are soluble in water and on dissolving produce large amount of heat. BeO and MgO, due to high lattice energy, are insoluble in water.

35. Why are $BeSO_4$ and $MgSO_4$ readily soluble in water while $CaSO_4$, $SrSO_4$ and $BaSO_4$ are insoluble?

Ans. Solubility of sulphates of group 2 elements depends on their hydration energy which decreases down the group. The lattice energy of group 2 sulphates is almost same. Very high hydration enthalpy Be^{+2} and Mg^{+2} ions overcome the lattice enthalpy and their sulphates are soluble. However, the hydration enthalpy of Ca^{2+}, Sr^{2+} and Ba^{2+} cannot overcome their lattice enthalpy and remain insoluble in water.

36. All compounds of alkali metals are easily soluble in water but lithium compounds are more soluble in organic solvents. Explain.

Ans. Smallest size of Li^+ ion and high polarizing power give it the covalent character therefore, lithium compounds are covalent and soluble in organic solvents whereas, other alkali metal compounds are ionic and soluble in water.

37. In the Solvay process, can we obtain sodium carbonate directly by treating the solution containing $(NH_4)_2CO_3$ with sodium chloride? Explain.

Ans. $(NH_4)_2CO_3$ reacts with NaCl and the products are Na_2CO_3 and NH_4Cl. Both the products are highly soluble in water and equilibrium cannot shift in forward direction. That's why Na_2CO_3 cannot be prepared directly.

38. Write Lewis strucure of O_2^- ion and find out oxidation state of each oxygen atom? What is the average oxidation state of oxygen in this ion?

Ans. The Lewis structure of O_2^- is $O - O^-$. Oxygen atom having no charge has 6 electrons so its oxidation number is zero, but the other oxygen atom carrying –1 charge has 7 electrons so its oxidation number is –1. Hence, the average oxidation state of oxygen is $-\frac{1}{2}$.

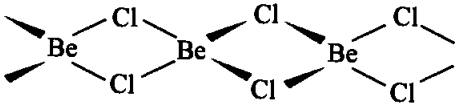
39. Why do beryllium and magnesium not impart colour to the flame in the flame test?

Ans. Except Be and Mg, all alkaline earth metals impart characteristic colours to the flame of Bunsen burner. These two metals have very small atomic radii and electrons are more strongly bind due to high effective nuclear charge. Energy of Bunsen flame is not sufficient to excite the electrons. Hence, these elements do not impart colour to the flame.

40. What is the structure of $BeCl_2$ molecule in gaseous and solid state?

Ans. In gaseous state above 1200 K, $BeCl_2$ exists as a monomer having linear structure and with zero dipole moment. Cl—Be—Cl.

In solid state, it exists in polymeric chain structure in which each Be atom is surrounded by 4 Cl atoms. 2 Cl atoms through covalent bonds and other 2 Cl atoms through coordinate bonds and give bridge structure.



IV. Matching Type

In the following questions more than one option of Column I and II may be correlated.

41. Match the elements given in Column I with the properties mentioned in Column II.

Column I	Column II
(*i*) Li	(*a*) Insoluble sulphate
(*ii*) Na	(*b*) Strongest monoacidic base
(*iii*) Ca	(*c*) Most negative $E^\ominus$ value among alkali metals
(*iv*) Ba	(*d*) Insoluble oxalate
	(*e*) $6s^2$ outer electronic configuration

Ans. (*i*) → (*c*); (*ii*) → (*b*); (*iii*) → (*d*); (*iv*) → (*a*), (*e*)

Explanation:

Column I	Column II
(*i*) Li	Due to very high hydration enthalpy, E° is most negative.
(*ii*) Na	Na gives NaOH (strong base). One mole of it replaces 1 mol H^+ from acid therefore it is strongest monoacidic base.
(*iii*) Ca	Hydration energy is very low therefore, calcium oxalate is insoluble.
(*iv*) Ba	Hydration energy is low as the size Ba^{2+} is large therefore barium sulphate is insoluble. $6s^2$ is valence shell electronic configuration.

42. Match the compounds given in Column I with their uses mentioned in Column II.

Column I	Column II
(*i*) $CaCO_3$	(*a*) Dentistry, ornamental work
(*ii*) $Ca(OH)_2$	(*b*) Manufacture of sodium carbonate from caustic soda
(*iii*) CaO	(*c*) Manufacture of high quality paper
(*iv*) $CaSO_4$	(*d*) Used in white washing

Ans. (*i*) → (*c*); (*ii*) → (*d*); (*iii*) → (*b*); (*iv*) → (*a*)

Explanation:

Column I	Column II
(*i*) $CaCO_3$	Specially precipitated $CaCO_3$ is used in the manufacture of high quality paper.
(*ii*) $Ca(OH)_2$	It is used in white wash due to its disinfectant nature and sparingly soluble in water.
(*iii*) CaO	It is used in the manufacture of Na_2CO_3 from NaOH.
(*iv*) $CaSO_4$	It is used in dentistry and ornamental work.

43. Match the elements given in Column I with the colour they impart to the flame given in Column II.

Column I	Column II
(*i*) Cs	(*a*) Apple green
(*ii*) Na	(*b*) Violet
(*iii*) K	(*c*) Brick red
(*iv*) Ca	(*d*) Yellow
(*v*) Sr	(*e*) Crimson red
(*vi*) Ba	(*f*) Blue

Ans. (*i*) → (*f*); (*ii*) → (*d*); (*iii*) → (*b*); (*iv*) → (*c*); (*v*) → (*e*); (*vi*) → (*a*)

Explanation: This is 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 and give characteristic colour to the Bunsen flame.

V. Assertion and Reason Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

44. Assertion (A) : The carbonate of lithium decomposes easily on heating to form lithium oxide and CO_2.

Reason (R) : Lithium being very small in size polarises large carbonate ion leading to the formation of more stable Li_2O and CO_2.

(*i*) Both A and R are correct and R is the correct explanation of A.

(*ii*) Both A and R are correct but R is not the correct explanation of A.

(*iii*) Both A and R are not correct

(*iv*) A is not correct but R is correct.

Ans. (*i*)

Explanation: Li_2CO_3 is unstable and decomposes on heating. Due to small size of Li^+, it has strong polarizing power to distort electron cloud of CO_3^{-2}. Lattice energy of Li_2O is higher than Li_2CO_3.

45. Assertion (A) : Beryllium carbonate is kept in the atmosphere of carbon dioxide.

Reason (R) : Beryllium carbonate is unstable and decomposes to give beryllium oxide and carbon dioxide.

(*i*) Both A and R are correct and R is the correct explanation of A.

(*ii*) Both A and R are correct but R is not the correct explanation of A.

(*iii*) Both A and R are not correct.

(*iv*) A is not correct but R is correct

Ans. (*i*)

Explanation: BeO is more stable due to small size and strong polarizing power of Be^{2+}. As BeO is stable and $BeCO_3$ is unstable. When it is kept in the atmosphere of CO_2 a reversible process occurs and stability of $BeCO_3$ increases.

VI. Long Answer Type

46. The s-block elements are characterised by their larger atomic sizes, lower ionisation enthalpies, invariable +1 oxidation state and solubilities of their oxosalts. In the light of these features describe the nature of their oxides, halides and oxosalts.

Ans. The atom of Alkali metals have large size and due to this they readily form cations and so their compounds are ionic in nature. Alkali metals have

+1 oxidation state and give ionic compounds. Alkali metals give three types of oxides—Normal oxides (M_2O), Peroxides (M_2O_2) and super oxides (MO_2). Basic character of normal oxides increases from Li_2O to Cs_2O due to increase in their ionic character. Halides of alkali metals MX are also ionic except LiX, which is covalent because of small size and high polarizing power. Ionic character increases from Li to Cs.

Oxosalts of alkali metals M_2CO_3, $MHCO_3$, MNO_3 are solid water soluble ionic compounds. Oxosalts of lithium show different properties due to small size of Li and its high polarizing power.

47. Present a comparative account of the alkali and alkaline earth metals with respect to the following characteristics:

(*i*) Tendency to form ionic / covalent compounds

(*ii*) Nature of oxides and their solubility in water

(*iii*) Formation of oxosalts

(*iv*) Solubility of oxosalts

(*v*) Thermal stability of oxosalts

Ans. (*i*) Alkaline earth metals give ionic compounds but these compounds are less ionic than alkali metals because of more effective nuclear charge and small size.

(*ii*) Oxides of alkaline earth metals are less basic than the oxides of alkali metals. These oxides are water soluble and the reactions are highly exothermic. Hydroxides of alkaline earth metals are less basic than hydroxides of alkali metals.

(*iii*) Alkaline earth metals give oxosalts with oxoacids but reactivity of alkali metals is faster. The reactivity of alkaline earth metals is less due to small size and more nuclear charge.

(*iv*) Oxosalts of alkaline earth metals are more soluble than oxosalts of alkali metals because of small size of cation and high hydration enthalpy.

(*v*) Thermal stability of oxosalts of alkali metals is more than oxosalts of alkaline earth metals. Na_2CO_3 is stable towards heat but $MgCO_3$ on heating is decomposed into MgO and CO_2.

48. When a metal of group 1 was dissolved in liquid ammonia, the following observations were obtained:

(*i*) Blue solution was obtained initially.

(*ii*) On concentrating the solution, blue colour changed to bronze colour.

How do you account for the blue colour of the solution? Give the name of the product formed on keeping the solution for some time.

Ans. (*i*) Alkali metals dissolve in liquid ammonia and give blue solution because of ammoniated electrons. These electrons absorb energy

in the visible region of light and impart blue colour to the solution.

$M + (x+y)NH_3 \rightarrow [M(NH_3)x]^+ + [e(NH_3)y]^-$ Ammoniated electrons.

(*ii*) In concentrated solution, the blue colour changes to bronze colour due to the formation of clusters of metal ion, on standing, blue solution librates H_2 gas with the formation of amide.

$$M^+_{(am)} + e^- + NH_3(l) \rightarrow MNH_{2(am)} + \frac{1}{2}H_2(g)$$

49. The stability of peroxide and superoxide of alkali metals increase as we go down the group. Explain giving reason.

Ans. The stability of peroxides and superoxides increases as the size of metal ion increases. $KO_2 < RbO_2 < CsO_2$. Li gives only monoxide, Na gives peroxide and K, Rb and Cs give superoxide also. Peroxide ion and superoxide ion combine with large size of alkali metals. Stability increases as the size of cation increases. $O^{-2} < O_2^{-2} < O_2^-$.

$$4Li + O_2 \rightarrow 2Li_2O(\text{oxide})$$
$$2Na + O_2 \rightarrow Na_2O_2(\text{peroxide})$$
$$M + O_2 \rightarrow MO_2(\text{superoxide})$$
$$(M = K, Rb, Cs)$$

50. When water is added to compound (A) of calcium, solution of compound (B) is formed. When carbon dioxide is passed into the solution, it turns milky due to the formation of compound (C). If excess of carbon dioxide is passed into the solution milkiness disappears due to the formation of compound (D). Identify the compounds A, B, C and D. Explain why the milkiness disappears in the last step.

Ans. Solution B turns milky on passing CO_2, it is lime water $Ca(OH)_2$ and compound C which gives milky appearance is $CaCO_3$. On passing excess of CO_2 milkiness disappears due to the formation of compound D that is $Ca(HCO_3)_2$. Compound A reacts with water and gives B. It is CaO. The reactions are:

$$CaO(A) + H_2O \rightarrow Ca(OH)_2(B) \text{ lime water}$$
$$Ca(OH)_2(B) + CO_2 \rightarrow CaCO_3(C) \text{ calcium carbonate} + H_2O$$
$$Ca(OH)_2(B) + CO_2 + H_2O \rightarrow Ca(HCO_3)_2 \text{ (D) calcium bicarbonate}$$

51. Lithium hydride can be used to prepare other useful hydrides. Beryllium hydride is one of them. Suggest a route for the preparation of beryllium hydride starting from lithium hydride. Write chemical equations involved in the process.

Ans. Beryllium hydride cannot be prepared directly by reaction with H_2. It is prepared by reacting with $LiAlH_4$. Following reactions take place:

$$8\ LiH + Al_2Cl_6 \rightarrow 2\ LiAlH_4 + 6\ LiCl$$
$$2\ BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$$

52. An element of group 2 forms covalent oxide which is amphoteric in nature and dissolves in water to give an amphoteric hydroxide. Identify the element and write chemical reactions of the hydroxide of the element with an alkali and an acid.

Ans. In group 2, Be is the only element which gives covalent oxide BeO, which is amphoteric in nature. The rest elements of this group give ionic oxides which are basic in nature. BeO dissolves in water and gives sparingly soluble hydroxide which reacts with acid and base to give salt.

$$BeO + H_2O \rightarrow Be(OH)_2$$

$$Be(OH)_2 + 2OH^- \rightarrow \underset{\text{Beryllate ion}}{[Be(OH)_4]^{2-}}$$

$$Be(OH)_2 + 2HCl + 2H_2O \rightarrow [Be(OH)_4]Cl_2$$

53. Ions of an element of group 1 participate in the transmission of nerve signals and transport of sugars and aminoacids into cells. This element imparts yellow colour to the flame in flame test and forms an oxide and a peroxide with oxygen. Identify the element and write chemical reaction to show the formation of its peroxide. Why does the element impart colour to the flame?

Ans. Na^+ ions participate in the transmission of nerve signals and gives oxide and peroxide.

$$4\,Na + O_2 \rightarrow 2Na_2O$$

$$2\,Na + O_2 \rightarrow Na_2O_2$$

$$2Na_2O + O_2 \rightarrow 2Na_2O_2$$

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