Chapter – 10 (The s- Block Elements)

Exercise Questions:

Question: 1 What are the common physical and chemical features of alkali metals?

Answer:

Physical properties of alkali metals:

i.) Akali metals have low ionisation enthalpies.

ii.) Alkali metals are highly electropositive in nature.

iii.) Alkali metals exhibit +1 oxidation states in their compound.

iv.) Alkali metals impart characteristics colour in nature.

Chemical properties of alkali metals:

i.) Alkali metals are highly reactive in nature.

ii.) Alkali metals hydroxide are highly basic in nature.

iii.) Alkali metals dissolve in liquid ammonia to form blue and conducting solution.

Question: 2 Discuss the general characteristics and gradation in properties of the alkaline earth metals.

Answer:

- Atomic size goes on increasing down the group.
- Ionisation energy goes on decreasing down the group.
- They are harder than alkali metals.
- They are less electropositive than alkali metals.
- Electropositive character increases on going down the group.

Question: 3 Why are alkali metals not found in nature?

Answer:

Alkali metals are highly reactive in nature. That's why they always exist in combine state in nature.

Question: 4 Find out the oxidation state of sodium in Na_2O_2.

Answer:

Let x be the oxidation state of Na in Na2O2 2x + 2(-1) = 0, 2x = 2x = +1

Question: 5 Explain why sodium is less reactive than potassium?

Answer:

It is because ionization enthalpy ΔH_I of potassium = 419kJ / mol.

Ionisation enthalpy of sodium = 496 KJ / mol. Since ionization enthalpy of potassium is less than that of sodium, potassium is more reactive than sodium.

Question: 6 Compare the alkali metals and alkaline earth metals with respect to:

i.) Ionization enthalpy

ii.) Basicity of oxides

iii.) Solubility of hydroxides.

Answer:

(i). **Ionization enthalpy**: Because of high nuclear charge the ionization enthalpy of alkaline earth metals are higher than those of the corresponding alkali metals.

(ii). **Basicity of oxides**: Basicity of oxides of alkali metals are higher than that of alkaline earth metals.

(iii). **Solubility of hydroxides**: Solubility of hydroxides of alkali metals are higher than that of alkaline earth metals. Alkali metals due to lower ionization enthalpy are more electropositive than the corresponding group 2 elements.

Question: 7 In what ways lithium shows similarities to magnesium in its chemical behaviour?

Answer:

- Both react with nitrogen to form nitrides.
- Both react with O2 to form monoxides.
- Both the elements have the tendency to form covalent compounds.
- Both can form complex compounds.

Question: 8 Explain why can alkali and alkaline earth metals not be obtained by chemical reduction method.

Answer:
Alkali and alkaline earth metals are themselves better reducing agents, and reducing agents better than alkali metals are not available. That is why these metals are not obtained by chemical reduction methods.

Question: 9 Why are potassium and caesium, rather than lithium used in photoelectric cells?

Answer:
Potassium and caesium have much lower ionisation enthalpy than that of lithium. As a result, these metals easily emit electrons on exposure to light. Due to this, K and Cs are used in photoelectric cells rather than lithium.

Question: 10 When alkali metal dissolves in liquid ammonia, the solution can acquire different colours. Explain the reason for this type of colour change.

Answer:
When an alkali metal dissolve in liquid ammonia, the solution can acquire different colours, means dilute solutions of alkali metals in liquid ammonia exhibit dark blue colour this is because of ammoniated electrons absorb energy in the visible region of light.
e.g., M + (x + y)NH3 → [M(NH3)x]^+ + [e-(NH3)y]{ammoniated electrons}

However, if the concentration increases above 3M, the colour changes to copper -bronze and it becomes diamagnetic in nature.

Question: 11 Beryllium and magnesium do not give colour to flame whereas other alkaline earth metals do so. Why?

Answer:
Due to the small size, the ionisation enthalpies of Be and Mg are much lighter than those of other alkaline earth metals. Therefore, a large amount of energy is needed to excite their valence electrons, and that's why they do not impart colour to the flame.

Question: 12 Discuss the various reactions that occur in the Solvay process.

Answer:
Solvay process is used to prepare sodium carbonate.
When carbon dioxide gas is bubbled through a brine solution saturated with ammonia, sodium hydrogen carbonate is formed. This sodium hydrogen carbonate is then converted to sodium carbonate.

Step 1: Brine solution is saturated with ammonia.

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

This ammoniated brine is filtered to remove any impurity.

Step 2: Carbon dioxide is reacted with this ammoniated brine to result in the formation of insoluble sodium hydrogen carbonate.

$NaCl + NH_4HCO_3 \rightarrow NaHCO_3 + NH_4Cl$

Step 3: The solution containing crystals of $NaHCO_3$ is filtered to obtain $NaHCO_3$.

Step 4: $NaHCO_3$ is heated strongly to convert it into $NaHCO_3$.

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

Step 5: To recover ammonia, the filtrate (after removing $NaHCO_3$) is mixed with $Ca(OH)_2$ and heated.

The overall reaction taking place in Solvay process is $2NaCl + CaCO_3 \rightarrow Na_2CO_3 + CaCl_2$

Question: 13 Potassium carbonate cannot be prepared by Solvay process. Why?

Answer:

Potassium carbonate being more soluble than sodium bicarbonate does not get precipitated when CO_2 is passed through a concentrated solution of KCl saturated with ammonia.

Question: 14 Why is Li_2CO_3 decomposed at a lower temperature whereas Na_2CO_3 at higher temperature?

Answer:

Li_2CO_3 is a covalent compound whereas Na_2CO_3 is an ionic compound. Therefore, lattice energy of Na_2CO_3 is higher than that of Li_2CO_3. Thus, $LiCO_3$ is decomposed at a lower temperature.

Question: 15 Compare the solubility and thermal stability of the following compounds of the alkali metals with those of the alkaline earth metals.

a.) Nitrates

b.) Carbonates

c.) Sulphates

Answer:

(i) Nitrates

Thermal stability

Nitrates of alkali metals, except $LiNO_3$, decompose on strong heating to form nitrites.

$2KNO_3(s) \rightarrow 2KNO_2(s) + O_2(g)$

$LiNO_3$, on decomposition, gives oxide.

$2LiNO_3(s) \quad Li_2O(s) + 2NO_2(g) + O_2(g)$

Similar to lithium nitrate, alkaline earth metal nitrates also decompose to give oxides.

$2Ca(NO_3)(s) \quad 2CaO(s) + 4NO_2(g) + O_2(g)$

As we move down group 1 and group 2, the thermal stability of nitrate increases.

Solubility

Nitrates of both group 1 and group 2 metals are soluble in water.

(ii) Carbonates

Thermal stability

The carbonates of alkali metals are stable towards heat. However, carbonate of lithium, when heated, decomposes to form lithium oxide. The carbonates of alkaline earth metals also decompose on heating to form oxide and carbon dioxide.

Solubility

Carbonates of alkali metals are soluble in water with the exception of Li_2CO_3. Also, the solubility increases as we move down the group. Carbonates of alkaline earth metals are insoluble in water.

(iii) Sulphates

Thermal stability

Sulphates of both group 1 and group 2 metals are stable towards heat.

$$Na_2CO_3 \xrightarrow{\Delta} \text{No effect}$$

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

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$$

Solubility

Sulphates of alkali metals are soluble in water. However, sulphates of alkaline earth metals show varied trends.

$BeSO_4$ Fairly soluble

$MgSO_4$ Soluble

$CaSO_4$ Sparingly soluble

$SrSO_4$ Insoluble

$BaSO_4$ Insoluble

In other words, while moving down the alkaline earth metals, the solubility of their sulphates decreases.

Question: 16 Starting with sodium chloride how would you proceed to prepare.

i.) Sodium metal

ii.) Sodium hydroxide

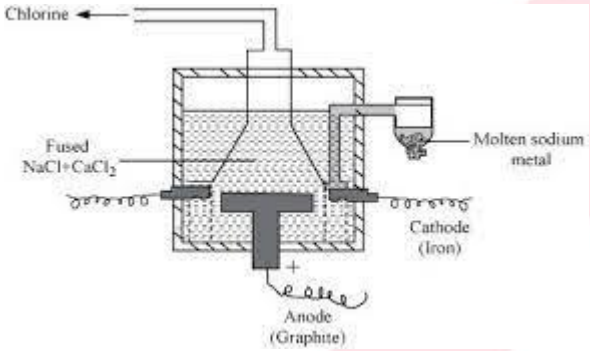
iii.) Sodium peroxide

iv.) Sodium carbonates?

Answer:

(a) Sodium can be extracted from sodium chloride by Downs process.

This process involves the electrolysis of fused NaCl (40%) and CaCl2(60 %) at a temperature of 1123 K in Downs cell.



Steel is the cathode and a block of graphite acts as the anode. Metallic Na and Ca are formed at cathode. Molten sodium is taken out of the cell and collected over kerosene.

$NaCl \xrightarrow{Electrolysis} Na^+ + Cl^-$

Molten

At Cathode: $Na^+ + e^- \rightarrow Na$

At Anode: $Cl^- + e^- \rightarrow Cl$

$Cl + Cl \rightarrow Cl2$

(b) Sodium hydroxide can be prepared by the electrolysis of sodium chloride. This is called Castner-Kellner process. In this process, the brine solution is electrolysed using a carbon anode and a mercury cathode.

The sodium metal, which is discharged at cathode, combines with mercury to form an amalgam.

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

Anode: $Cl^- \rightarrow \frac{1}{2} Cl2 + e^-$

(c) Sodium peroxide First, NaCl is electrolysed to result in the formation of Na metal (Downs process). This sodium metal is then heated on aluminium trays in air (free of CO2) to form its peroxide.

$2Na + O2(air) \longrightarrow Na2O2$

(d) Sodium carbonate is prepared by Solvay process. Sodium hydrogen carbonate is precipitated in a reaction of sodium chloride and ammonium hydrogen carbonate.

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

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

$NH_4HCO_3 + NaCl \longrightarrow NH_4Cl + NaHCO_3$

Question: 17 What happens when:

i.) Magnesium is burnt in air,

ii.) Quick lime is heated with silica

iii.) Chlorine reacts with saked lime

iv.) Calcium nitrate is heated?

Answer:

i.) $2Mg(s) + O_2(g) \xrightarrow{heat} 2MgO(s)$

ii.) $CaO(s) + SiO_2(s) \xrightarrow{heat} CaSiO_3(s)$

iii.) $2Ca(OH)_2 + 2Cl_2 \rightarrow CaCl_2 + Ca(OCl_02 + 2H_2O$

iv.) $2Ca(NO_3)_2(s) \xrightarrow{heat} 2CaO(s) + 4NO_2(g) + O_2(g)$

Question: 18 Describe two important uses of each of the following:

i.) Caustic soda

ii.) Sodium carbonate

iii.) Quick lime.

Answer:

Uses of caustic soda:

(a) Manufacture of soap, artificial silk, paper and other chemicals.

(b) The textile industry for mercerizing cotton fabrics.

Uses of sodium carbonate:

(a) Softening hard water.

(b) Washing purposes in the laundry.

Uses of quicklime:

(a) In the manufacture of sodium carbonate from NaOH.

(b) As a flux in metallurgy.

Question: 19 Draw the structure of:

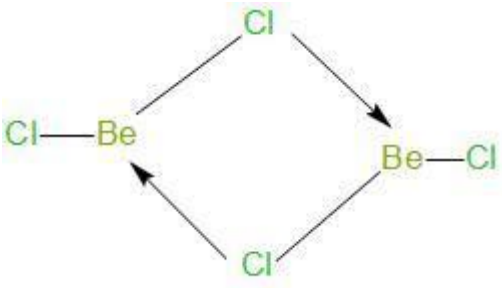
i.) $BeCl_2$(vapour)

ii.) $BeCl_2$(solid).

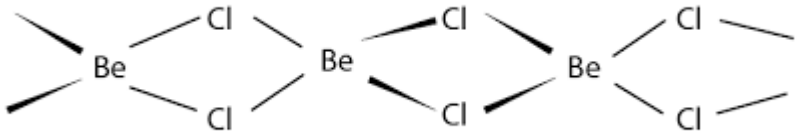
Answer:

BeCl2(vapour)

In the vapour state, it exists as a chlorobridge dimer.



BeCl2(solid)



Question: 20 The hydroxide and carbonates of sodium and potassium are easily soluble in water while the corresponding salts of magnesium and calcium are sparingly soluble in water. Explain.

Answer:

Since group 1 hydroxides and carbonates due to large size contain higher hydration energy than the lattice energy so, they are easily soluble in water. Whereas, in magnesium and calcium due to small size, their lattice energy dominates over hydration energy. Hence, they are springily soluble in water.

Question: 21 Describe the importance of the following:

i.) Limestone

ii.) Cement

iii.) Plaster of paris.

Answer:

(i) Limestone is used:

(a) As a building material in the form of marble.

(b) In the preparation of quicklime.

(c) As a raw material in ammonia soda process for the manufacture of sodium carbonate.

(d) As a constituent of toothpaste.

(e) As a filler in cosmetics.

(ii) Cement is used in:

(a) Concrete and reinforced concrete.

(b) Plastering.

(c) The construction of buildings, bridges , dams, etc.

(iii) Plaster of paris is used:

(a) In building industry.

(b) In plasters.

(c) For making statues, models and other decorative materials.

(d) In surgical bandages (plasters) for immobilizing the fractured base in the body.

Question: 22 Why are lithium salts commonly hydrated and those of the other alkali metal ions usually anhydrous?

Answer:

Due to smallest size, Li^+ can polarize water molecules easily than the other alkali metal ions.

Question: 23 Why LiF almost insoluble in water whereas LiCl soluble not only in water but also in acetone?

Answer:

It is done to high lattice energy of LiF as compared to LiCl.

LiCl is soluble in water because its hydration energy is higher than its lattice energy.

Question: 24 Explain the significance of sodium, potassium, magnesium and calcium in biological fluids.

Answer:

Significance of sodium potassium, magnesium and calcium in biological fluids-

Sodium-

- It is mainly found in blood plasma and also in the interstitial fluid which surrounds the cell.
- Na^{+} ions help in the transmission of nerve signals also for the regulating water in the plasma membrane.
- Also for the transport of sugars and amino acids into the cells.

Potassium-

- These ions are highly present within cell fluids.
- Helps in activating many enzymes

- To produce ATP it oxidises the glucose molecule.
- Also helps in the transmission of nerve signals.

Magnesium and calcium-

- Plays an important role in neuromuscular function (by magnesium), interneuronal transmission, cell membrane integrity and blood coagulation(by calcium)
- Mg helps in maintains normal blood circulation in our body.

Question: 25 What happens when:

i.) Sodium metal is dropped in water?

ii.) Sodium metal is heated in free supply of air?

iii.) Sodium peroxide dissolves in water?

Answer:

i.) $2Na + 2H2O \rightarrow 2NaOH + H2$

ii.) $2Na + O32 \rightarrow Na2O2$

iii.) $Na2O2 + 2H2O \rightarrow 2NaOH + H2O2$

Question: 26 Comment on each of the following observations:

a.) The mobilities of the alkali metal ions in aqueous solution are $Li < Na^+ < K^+ < Rb^+ < Cs^+$

b.) Lithium is the only alkali metal to form a nitride directly.

c.) E^0 for $Mn^{2+}(aq) + 2e^- \rightarrow M(s)$ (where M = Ca, Sr, or Ba) is nearly constant.

Answer:

(a) On moving down the alkali group, the ionic and atomic sizes of the metals increase. The given alkali metal ions can be arranged in the increasing order of their ionic sizes as:

Li+ < Na+ < K+ < Rb+ < Cs+

Smaller the size of an ion, the more highly is it hydrated. Since Li+ is the smallest, it gets heavily hydrated in an aqueous solution. On the other hand, Cs+ is the largest and so it is the least hydrated. The given alkali metal ions can be arranged in the decreasing order of their hydrations as:

Li+ > Na+ > K+ > Rb+ > Cs+

Greater the mass of a hydrated ion, the lower is its ionic mobility. Therefore, hydrated Li+ is the least mobile and hydrated Cs+ is the most mobile. Thus, the given alkali metal ions can be arranged in the increasing order of their mobilities as:

Li+ < Na+ < K+ < Rb+ < Cs+

(b) Unlike the other elements of group 1, Li reacts directly with nitrogen to form lithium nitride. This is because Li+ is very small in size and so its size is the most compatible with the N3- ion. Hence, the lattice energy released is very high. This energy also overcomes the high amount of energy required for the formation of the N3- ion.

(c) Electrode potential (E°) of any M2+/M electrode depends upon three factors:
(i) Ionisation enthalpy
(ii) Enthalpy of hydration
(iii) Enthalpy of vaporisation
The combined effect of these factors is approximately the same for Ca, Sr, and Ba. Hence, their electrode potentials are nearly constant.

Question: 27 State as to why:

a.) a solution of Na2CO3 is alkaline?

b.) Alkali metals are prepared by electrolysis of their fused chlorides?

c.) Sodium is found to be more useful than potassium?

Answer:
(a) Hydrolysis of sodium carbonate in aqueous solution gives hydroxide ions. Hence, the solution is alkaline.

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

(b) During electrolysis of aqueous solution of alkali metal chlorides, hydrogen (having lower discharge potential) is preferentially evolved than alkali metal at cathode. Hence, Electrolysis of fused alkali metal chlorides is carried out to prepare alkali metals.

(c) Sodium ions are present in blood plasma and interstitital fluids which surround the cell. Potassium ions are present in intracellular fluids. Sodium ions help in transmission of nerve signals, regulate water flow across cell membranes. Hence, sodium is more useful than potassium.

Question: 28 Write the balanced equations for reactions between.

a.) Na2O2 and water

b.) KO2 and water

c.) Na2O and CO2

Answer:

a.) $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

b.) $2KO_2 + 2H_2O \rightarrow 2KOH + O_2 + H_2O_2$

c.) $Na_2O + CO_2 \rightarrow Na_2CO_3$

Question: 29 How would you explain the following observations?

i.) **BeO is almost insoluble but BeSO4 is soluble in water.**

ii.) **BaO is soluble but BaSO4 is insoluble in water.**

iii.) **LiI is more soluble than KI in ethanol.**

Answer:

(i). Lattice energy of BeO is comparatively higher than the hydration energy. Therefore, it is almost insoluble in water. Whereas BeSO4 is ionic in nature and its hydration energy dominates the lattice energy.

(ii). Both BaO and BaSO4 are ionic compounds but the hydration energy of BaO is higher than the lattice energy, therefore it is soluble in water.

(iii). Since the size of Li+ ion is very small in comparison to K+ ion, it polarises the electrone cloud of I- ion to a great extent. Thus LiI dissolves in ethanol more easily than the KI.

Question: 30 Which of the alkali metal is having least melting point?

a.) Na

b.) K

c.) Rb

d.) Cs.

Answer:

Size of Cs is the biggest thus, its melting point is the lowest, (d) is correct.

Question: 31 Which one of the following alkali metals give hydrated salts?

a.) Li

b.) Na

c.) K

d.) Cs

Answer:

Li^+ is the smallest. Thus, it has highest change density and hence attracts the water molecules more strongly.

Question: 32 Which one of the following alkaline earth metal carbonates is thermally most stable?

a.) MgCO3

b.) CaCO3

c.) SrCO3

d.) BaCO3

Answer:

(d.) BaCO3.