CHAPTER 10 THE S-BLOCK ELEMENTS

Problem 10.1

What is the oxidation state of K in KO_2?

Answer:

The superoxide species is represented as O_2^-; the oxidation state of potassium is $+1$ because the molecule is neutral.

Problem 10.2

The E^- for Cl_2 / Cl^- is $+1.36$, for I_2 / I^- is $+0.53$, for Ag^+ / Ag is $+0.79$, Na^+ / Na is -2.71 and for Li^+ / Li is -3.04. Arrange the following ionic species in decreasing order of reducing strength:

I^-, Ag, Cl^-, Li, Na

Answer:

The order is Li > Na > I^- > Ag > Cl^-

Problem 10.3

Why is KO_2 paramagnetic?

Answer:

Due to one unpaired electron in the $\pi^2 2p$ molecular orbital, the superoxide O_2^- is paramagnetic.

Problem 10.4

Why does the solubility of alkaline earth metal hydroxides in water increase down the group?

Answer:

Because the anion is so prevalent in alkaline earth metal hydroxides, the cationic radius will affect the lattice enthalpy. With increasing ionic size, the lattice enthalpy reduces considerably more than the hydration enthalpy, hence the solubility increases.

Problem 10.5

Why does the solubility of alkaline earth metal carbonates and sulphates in water decrease down the group?

Answer:

Due to the fact that anions are substantially larger than cations, the lattice enthalpy will be nearly constant throughout a group. Solubility decreases as hydration enthalpies fall down the group, as shown in alkaline earth metal carbonates and sulphates.

Exercises

10.1 What are the common physical and chemical features of alkali metals?

Answer: Physical properties of alkali metals are as follows:

- Alkali metals has lowIonization enthalpies.

- Alkali metals are strongly electropositive in nature.

- Alkali metal compounds have $+1$ oxidation states.

- Alkali metals provide distinct colours to the flame.

Chemical properties of alkali metals are as follows:

- In nature, alkali metals are very reactive.

- Alkali metal hydroxides have a high basicity.

- When alkali metals dissolve in liquid ammonia, they generate a blue, conducting Answer.

10.2 Discuss the general characteristics and gradation in properties of alkaline earth metals.

Answer: The general characteristics and gradation in properties of alkaline earth metals are as follows:

-Atomic size increases as one moves down the group.

- Ionization energy decreases as one moves along the group.

- They are more durable than alkali metals.

- They have a lower electropositive potential than alkali metals.

10.3 Why are alkali metals not found in nature?

Answer: In nature, alkali metals are extremely reactive. That is why they are usually found in a combined condition in nature.

10.4 Find out the oxidation state of sodium in Na_2O_2.

Answer: Assume that x be the oxidation state of Na in Na_2O_2,

$2x + 2(-1) = 0,$

$2x - 2 = 0,$

$2x = 2x = +1$

10.5 Explain why is sodium less reactive than potassium.

Answer: It is because ionization enthalpy ΔH_i of potassium = $419\,kJ\,mol^{-1}$.

Ionization enthalpy of sodium $= 496KJ$ mol.

Because potassium's ionisation enthalpy is lower than that of sodium, potassium is more reactive than sodium.

10.6 Compare the alkali metals and alkaline earth metals with respect to

(i) ionization enthalpy,

Answer: Because of their large nuclear charge, alkaline earth metals have a greater ionisation enthalpy than alkali metals.

(ii) basicity of oxides,

Answer: The basicity of alkali metal oxides is greater than that of alkaline earth metals.

(iii) solubility of hydroxides.

Answer: The solubility of alkali metal hydroxides is greater than that of alkaline earth metals. Because of their lower ionisation enthalpy, alkali metals are more electropositive than group 2 elements.

10.7 In what ways lithium shows similarities to magnesium in its chemical behaviour?

Answer: In several ways lithium shows similarities to magnesium in its chemical behavior, some are as follows:

- When combined with nitrogen, they create nitrides.

- Both react with O_2 to produce monoxides.

- Both elements have a tendency to create covalent compounds.

- Both can combine to generate complex molecules.

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

Answer: Alkali and alkaline earth metals are superior reducing agents in and of themselves, and better reducing agents than alkali metals are not accessible. As a result, chemical reduction procedures are not used to acquire these metals.

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

Answer: The ionisation enthalpy of potassium and caesium is substantially lower than that of lithium. As a result, when exposed to light, certain metals easily emit electrons. As a result, rather of lithium, K and Cs are employed in photoelectric cells.

10.10 When alkali metal dissolves in liquid ammonia, the Answer can acquire different colours. Explain the reason for this type of colour change.

Answer: As ammoniated electrons absorb energy in the visible spectrum of light and contribute blue colour, alkali metals dissolve in liquid ammonia and produce deep blue Answers that are naturally conducting.

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

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

Answer: As of their tiny size, Be and Mg have substantially greater ionisation enthalpies than other alkaline earth metals. As a result, it takes a lot of energy to excite their valence electrons, which is why they don't provide colour to the flame.

10.12 Discuss the various reactions that occur in the Solvay process.

Answer:

$$CaCO_3(s) \xrightarrow{heat} CaO + CO_2$$
$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$
$$NaCl + NH_4OH + CO_2 \rightarrow NaHCO_3 + NH_4Cl_2$$
$$NaHCO_3(s) \xrightarrow{heat} Na_2CO_3 + CO_2 + H_2O$$
$$Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3 \cdot 10H_2O$$

10.13 Potassium carbonate cannot be prepared by Solvay process. Why?

Answer: As potassium carbonate is more soluble than sodium bicarbonate, it does not precipitate when CO_2 is passed through a concentrated Answer of ammonia-saturated KCl.

10.14 Why is Li_2CO_3 decomposed at a lower temperature whereas Na_2CO_3 at higher temperature?

Answer: Li_2CO_3 is covalent compound and Na_2CO_3 is ionic compound. As a result, Lattice energy of Na_2CO_3 is grater as compared to that of Li_2CO_3. As a result, $LiCO_3$ is decomposed at a lower temperature.

10. 15 Compare the solubility and thermal stability of the following compounds of the alkali metals with those of the alkaline earth metals.

(a) Nitrates

Answer: Nitrates from both groups 1 and 2 elements are soluble in water because the hydration energy exceeds the lattice energy. Nitrates of both group 1 and group 2 elements are thermally unstable, but breakdown differently with the exception of $LiCO_3$.

$$2NaNO_3 \xrightarrow{heat} 2NaNO_2 + O_2$$

$$2KNO_3 \xrightarrow{\Delta} 2KNO_2 + O_2$$

$$4LiNO_3 \xrightarrow{\Delta} 2LiO_2 + 4NO_2 + O_2$$

$$2Mg(NO_3)_2 \xrightarrow{\Delta} 2MG + 4NO_2 + O_2$$

(b) Carbonates

Answer: Except for Li_2CO_3, carbonates of group 1 elements are soluble in water. They are also thermally stable, with the exception of

$$Li_2CO_3Li_2CO_3 \xrightarrow{\Delta} i_2O + CO_2$$

Because their Lattice energy is greater than their hydration energy, Group 2 carbonates are insoluble in water.

Because lattice energy does not rise with increasing ionic character, the thermal stability of carbonates in group 2 increases along the group.

(c) Sulphates

Answer: Except for Li_2SO_4, sulphates in group 1 are soluble in water. They have a high thermal stability.

Because Lattice energy predominate over hydration energy, the solubility of sulphates in group 2 falls along the group. Sulphates of group 2 elements are thermally stable and rise down the group as Lattice energy increases.

10.16 Starting with sodium chloride how would you proceed to prepare.

(i) Sodium metal

Answer: Sodium metal is produced by electrolysis of a fused mass of $NaCl$ 40% and $CaCl_2$ 60% in Down's cell at $873K$, using iron as cathode and graphite as anode. At the cathode, Na is freed.

At cathode:

$$Na^+ + e^- \rightarrow Na(l)$$

At anode:

$$2Cl^-(melt) \rightarrow Cl_2(g) + 2e^-$$

(ii) Sodium hydroxide

Answer: It is prepared by electrolysis of an aqueous Answer of $NaCl$ (brine) in Castner-Kellner cell.

At cathode:

$$Na^{+} + e^{-} \rightarrow Na$$

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

At anode:

$$Cl^{-} - e^{-} \rightarrow Cl$$
$$Cl + Cl \rightarrow Cl_2$$

(iii) Sodium peroxide

Answer: $4Na + 2O_2 \rightarrow 2Na_2O + O_2$

(iv) Sodium carbonate

Answer: It is prepared by Solvay ammonia process.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 \downarrow + NH_4COl$$
$$2NaHCO_3 \xrightarrow{A} Na_2CO_3 + CO_2 + H_2O$$

10.17 What happens when

(i) magnesium is burnt in air,

Answer: $2Mg(s) + O_2(g) \xrightarrow{\Delta} 2MgO(s)$

(ii) Quick lime is heated with silica

Answer: $CaO(s) + SiO_2(s) \xrightarrow{\Delta} CaSiO_2(s)$

(iii) chlorine reacts with slaked lime

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

(iv) calcium nitrate is heated?

Answer: $2Cs\left(ON_3\right)_2(s) \xrightarrow{\Delta} 2CaO(s) + 4NO_2(g) + O_2(g)$

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

(i) caustic soda

Answer: Two important uses of caustic soda are:

(a) It is utilised in the production of soap paper, artificial silk, and other products.

(b) It is employed in the textile industry.

(ii) sodium carbonate

Answer: Two important uses of sodium carbonate are:

(a) It is used in the softening of water, as well as in laundry and cleaning.

(b) It is utilised in the production of glass.

(iii) quick lime

Answer: Two important uses of quick lime are:

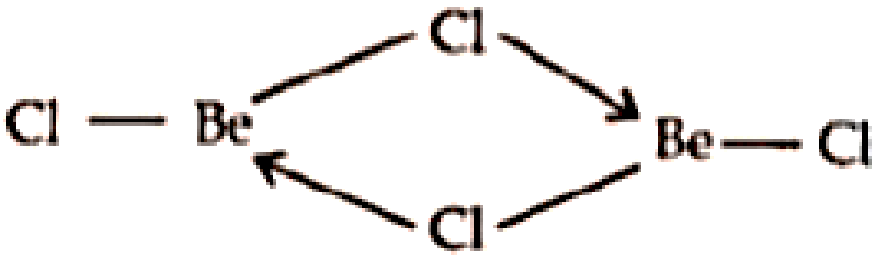
(a) It's utilised in the manufacture of bleaching powder.

(b) Used in the purification of sugar and the production of cement.

10.19 Draw the structure of

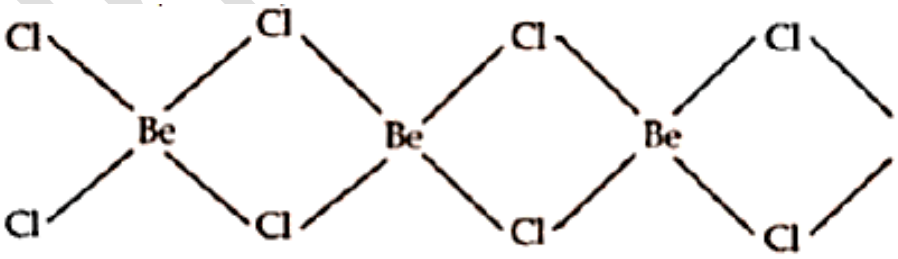
(i) $BeCl_2$ (vapour),

Answer:



(ii) $BeCl_2$ (solid).

Answer:



10.20 The hydroxides 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: As group 1 hydroxides and carbonates have a greater hydration energy than the lattice energy due to their big size, they are easily soluble in water. Whereas with magnesium and calcium,

because to their tiny size, lattice energy outweighs hydration energy. As a result, they are only marginally soluble in water.

10.21 Describe the importance of the following:

(i) Limestone

Answer: It is widely utilised in the production of high-quality paper. In toothpaste, it is also used as a mild abrasive. In cosmetics, it acts as a filler.

Finally, it was used as an antacid.

(ii) Cement

Answer: It is a vital construction material. In addition, it is used in concrete and reinforced cement.

(iii) Plaster of Paris.

Answer: It is found in plasters. Also used in dentistry and decorative work on sculptures.

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

Answer: Because of its tiny size, Li^+ may more easily polarise water molecules than the other alkali metal ions.

10.23: Why is **LiF** almost insoluble in water whereas **LiCl** soluble not only in water but also in acetone?

Answer: It is because LiF has a higher lattice energy than $LiCl$.

Because its hydration energy is greater than its lattice energy, is soluble in water.

10.24 Explain the significance of sodium, potassium, magnesium and calcium in biological fluids.

Answer:

Sodium ions:

- Na^+ ions have a role in nerve signal transmission and in controlling the flow of water across cell membranes.

- Sugar and amino acid transfer into the cell.

Potassium ions:

They participate in the oxidation of glucose to create ATP by activating numerous enzymes.

Magnesium ions:

All enzymes that use ATP to transfer phosphates require magnesium as a cofactor, and Mg is the primary pigment in plants for light absorption.

Calcium:

- Ca^{2+} ions are present in bones and performs a very specific function in neuromuscular function.

10.25 What happens when

(i) Sodium metal is dropped in water?

Answer: $2Na + 2H_2O \rightarrow 2NaOH + H_2$

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

Answer: $2Na + O_2 \rightarrow Na_2O_2$

(iii) Sodium peroxide dissolves in water?

Answer: $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

10.26 Comment on each of the following observations:

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

Answer: The smaller the ion, the more intensely hydrated it is, and hence the higher the mass of the hydrated ion, and so the lower the ionic mobility. The degree of hydration reduces as the sequence progresses.

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

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

Answer: Because of its tiny size, lithium may immediately produce nitride.

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

Answer: This is due to the fact that reduction potential is dependent on sublimation energy, ionisation energy, and hydration energy. For these ions, the outcome is nearly constant.

10.27 State as to why

(a) a Answer of Na_2CO_3 is alkaline?

Answer: Na_2CO_3 is a salt of a weak acid, carbonic acid (H_2CO_3) and a strong base $NaOH$. Thus it undergoes hydrolysis to produce strong base $NaOH$ and its aqueous Answer is alkaline in nature.

$Na_2CO_3(s) + H_2O(l) \rightarrow 2NaOH$

(b) alkali metals are prepared by electrolysis of their fused chlorides?

Answer: Because the discharge potential of alkali metals is substantially greater than that of hydrogen, when an aqueous Answer of any alkali metal chloride is electrolyzed, H_2 is created at the cathode

instead of the alkali metal. As a result, alkali metals are synthesised by electrolysis of their fused chlorides.

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

Answer: Because potassium is more reactive than sodium and is present to a lesser amount in nature than Na, it is discovered to be more beneficial.

10.28 Write balanced equations for reactions between.

(a) Na_2O_2 and water

Answer: $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

(b) KO_2 and water

Answer: $2KO_2 + 2H_2O \rightarrow 2KOH + O_2 + H_2O_2$

(c) Na_2O and CO_2

Answer: $Na_2O + CO_2 \rightarrow Na_2CO_3$

10.29 How would you explain the following observations?

(i) BeO is almost insoluble but $BeSO_4$ is soluble in water.

Answer: The lattice energy BeO is larger than the hydration energy. As a result, it is nearly insoluble in water. In contrast, $BeSO_4$ is ionic in nature, and its hydration energy dominates the lattice energy.

(ii) BaO is soluble but $BaSO_4$ is insoluble in water.

Answer: Both BaO and $BaSO_4$ are ionic compounds, but since the hydration energy of BaO is greater than the lattice energy, it is soluble in water.

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

Answer: Because the size of Li^+ ion is so tiny in contrast to K^+ ion, it greatly polarises the electron cloud I^- ion. As a result, LiI dissolves more easily in ethanol than KI.

10.30 Which of the alkali metal is having least melting point?

(a) Na

(b) K

(c) Rb

(d) Cs

Answer: Obtion (d) is correct.

10.31 Which one of the following alkali metals give hydrated salts?

(a) Li

(b) Na

(c) K

(d) Cs

Answer: Obtion (a) is correct.

10.32 Which one of the following alkaline earth metal carbonates is thermally most stable?

(a) $MgCO_3$

(b) $CaCO_3$

(c) $SrCO_3$

(d) $BaCO_3$

Answer: Obtion (d) is correct.