

NCERT Solutions for Class 11 Chemistry Chapter 10 The s-Block Elements

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

Answer :

Physical and chemical features of alkali metals-

Physical features-

- All the alkali metals are silvery white, soft and light metals. Because of the large size, these elements have a low density which increases down the group from Li to Cs. However, **potassium is lighter than sodium** .
- The melting and boiling points of the alkali metals are low indicating **weak metallic bonding due to the presence of only a single valence** electron in them.
- The alkali metals and their salts **impart characteristic colour** to an oxidizing flame.

Chemical features-

- Due to low ionisation enthalpy, they are highly reactive. As we move down the group reactive nature increases.
- The alkali metals tarnish in dry air due to the formation of their oxides which in turn react with moisture to form hydroxides. They burn vigorously in oxygen forming oxides. Lithium forms monoxide, sodium forms peroxide, the other metals form superoxides. The superoxide O^{2-} ion is stable only in the presence of large cations such as K, Rb, Cs.
- The alkali metals react with water to form hydroxide and dihydrogen.

Question 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-

- General electronic configuration is [noble gas] ns^2 .
- Have two electrons to lose and attain their nearest noble gas configuration.
- have smaller atomic and ionic radii than corresponding alkali metals in the same periods.
- First IE is higher than those elements of group 1
- electropositive nature increase down the group from Be to Ba.
- they give a positive flame test by imparting different colours.(except Be and Mg)

Chemical properties-

- Be and Mg are inert to oxygen and water. this is because of the formation of a thin layer of oxide on their surface.(powdered Be give BeO and Be_3N_2 .
- React with halogens at high temperature to form halogen halides. $[M + X_2 \rightarrow MX_2]$ here M = alkaline metals and X = halogen elements
- All alkaline metals react with hydrogen and form hydrides except for Beryllium
- React with acids to form salts and produce dihydrogen gas. $[M + 2HCl \rightarrow MCl_2 + H_2(g)]$
- Act as a reducing agent but not as powerful as alkali metals. Down the group reducing power decreases.
- Also, dissolve in liquid ammonia and give the deep blue coloured solution. $M + (x + y)NH_3 \rightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$

Question 10.3 Why are alkali metals not found in nature ?

Answer :

Electronic Configuration All the alkali metals have one valence electron, outside the noble gas core. The loosely held s electron in the outermost valence shell of these elements makes them the most electropositive metals. They readily lose an electron to give monovalent M^+ ions. Hence they are never found in the free or native state in nature.

Question 10.4 Find out the oxidation state of sodium in Na_2O_2

Answer :

Let suppose the oxidation state of Na is to be x.

In the case of peroxide, the oxygen has -1 oxidation state.

So, now

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

$$2x = 2$$

$$x = 1$$

Question 10.5 Explain why is sodium less reactive than potassium

Answer :

As we know that in alkali metals, as we go down the group the atomic size increases and also the effective nuclear charge decreases. So, therefore, the outermost electron of potassium is easily removed. Electronic configuration

of (K =) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$

(Na =) $1s^2, 2s^2, 2p^6, 3s^1$ Hence the reactivity of sodium is less than of potassium.

Question 10.6 Compare the alkali metals and alkaline earth metals with respect to (i) ionisation enthalpy (ii) basicity of oxides and (iii) solubility of hydroxides

Answer :

(i) Ionisation enthalpy-

Alkali metals have low first IE as compare to alkaline earth metals because of having a large atomic size also after losing one electron they attain noble gas configuration. In alkaline earth metals, their first IE is higher than alkali metals because they have high effective nuclear charge and small in size as compare to group 1st element. However, they have low second IE as compare to alkali metals.

(ii) Basicity of oxides-

Alkali metal oxides are more basic than alkaline earth metal oxides. this is because alkali metals are highly electropositive which makes them highly ionic, so they readily dissociate into hydroxide ions in water than alkaline metals.

(iii) The solubility of Hydroxide-

Alkali metal hydroxide is more soluble in water than alkaline earth metals. This is because of the high lattice energy of alkaline earth metals.

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

Answer :

Chemical similarities between lithium and magnesium-

1. *Li* and *Mg* slowly react with water and their hydroxide and oxides are also less soluble in water. On heating, their hydroxide decomposes. Both the element form nitride Mg_3N_2 and Li_3N by direct reaction with nitrogen.
2. Li_2O and MgO do not give superoxide on reacting with an excess of oxygen.
3. Lithium and Magnesium carbonates easily decompose into their oxides and carbon dioxide.
4. Chlorides of both element soluble in ethanol.
5. Both chlorides can crystallise from their aqueous solution as hydrates, $LiCl \cdot 2H_2O$ and $MgCl_2 \cdot 8H_2O$

Question 10.8 Explain why can alkali and alkaline earth metals not be obtained by chemical reduction methods?

Answer :

Alkali and alkaline earth metals not be obtained by chemical reduction methods because to reduce their oxides we need to use a strong reducing agent, but there is no other reducing agent which is stronger than them.

Question 10.9 Why are potassium and cesium, rather than lithium used in photoelectric cells?

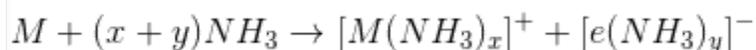
Answer :

It is because of the low ionisation energy of K and Cs. They lose electron easily. On the other hand, Lithium is smaller in size as compared to caesium and lithium, it requires high energy to lose an electron. Therefore, lithium is not used in a photoelectric cell.

Question 10.10 When an alkali metal dissolves in liquid ammonia the solution can acquire different colours. Explain the reasons for this type of colour change.

Answer :

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



The blue colour of the solution is due to the ammoniated electron which absorbs energy in the visible region of light and thus imparts blue colour to the solution. The solutions are paramagnetic.

In concentrated solution, the blue colour changes to bronze colour and becomes diamagnetic

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

Answer :

When the alkaline earth metals are heated the electrons are excited to higher energy levels and when they drop back to the ground state, energy is emitted in the form of visible light. Hence the colour is observed. The electrons in beryllium and magnesium are too strongly bound to get excited by flame. Hence, these elements do not impart any colour.

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

Answer :

Solvay process is used to prepare sodium carbonate. Reactions occurs in solvay process are -

1. $2NH_3 + H_2O \rightarrow (NH_4)_2CO_3$
2. $(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$
3. $NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$
4. $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

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

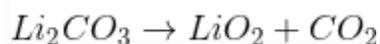
Answer :

Solvay process cannot be used to prepare potassium carbonate because unlike sodium bicarbonate, $KHCO_3$ is fairly soluble in water and does not precipitate out.

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

Answer :

As we go down the group the electropositive nature of alkali metals increases. And because of that, there is an increase of stability of carbonates. But carbonates of lithium is not stable because lithium carbonate is covalent. Lithium-ion is smaller in size so it can polarise the negative carbonate ion, leading to the formation of more stable lithium oxide. therefore, Lithium decomposes at the lower temperature while sodium carbonate decomposes at a higher temperature.

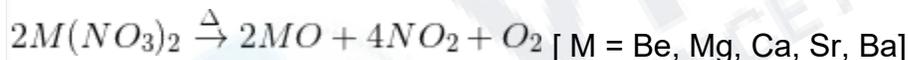
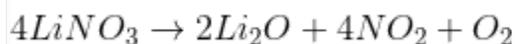


Question 10.15 Compare the solubility and thermal stability of the following compounds of the alkali metals with those of the alkaline earth metals. (a) Nitrates (b) Carbonates (c) Sulphates.

Answer :

(a) Nitrates-

Alkali and alkaline earth metal nitrates are soluble in water. Down the group thermal stability of nitrates increases. Nitrates of alkaline and alkali metals give corresponding nitrites except for lithium nitrate, it gives lithium oxides.



(b) Carbonates-

Alkaline earth metal carbonates decompose on heating gives carbon dioxide and oxide. On the other hand carbonates of alkali metals are stable towards heat. The solubility of carbonates increases down the group in alkali metals (except Li_2CO_3). But carbonates of alkaline earth metals are insoluble in water.

(c) Sulphate-

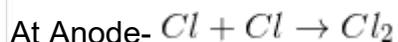
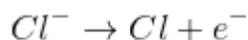
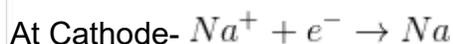
thermal stability is good for both alkali and alkaline earth metals. Alkali metal sulphates are more soluble in water than alkaline earth metals. Solubility decrease down the group from $CaSO_4$ to $BaSO_4$. sulphate of Be and Mg are readily soluble in water.

Question 10.16 Starting with sodium chloride how would you proceed to prepare (i) sodium metal (ii) sodium hydroxide (iii) sodium peroxide (iv) sodium carbonate ?

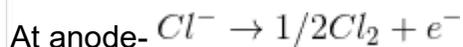
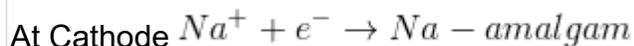
Answer :

(i) Sodium metal can be extracted from sodium chloride. In this process electrolysis of fused $NaCl$ (40%) and $CaCl_2$ (60%) at a temp. of 1123K in Downs cell.

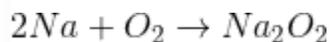
steel cathode and graphite block is act as anode. sodium and calcium deposit at cathode .



(ii) $NaOH$ can be prepared by the electrolysis of sodium chloride. By Castner- Kellner process. A brine solution is electrolysed using a mercury cathode and a carbon anode. Sodium metal discharged at the cathode combines with mercury to form sodium amalgam. Chlorine gas is evolved at the anode.

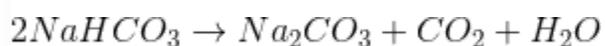


(iii) $NaCl$ is electrolysed for the formation of Na metal (in Downs process). this sodium metal is then heated on aluminium trays in air to form sodium peroxide.



(iv) Sodium carbonate is prepared by solvay process. $NaHCO_3$ is precipitated in a reaction of sodium chloride and ammonium hydrogen carbonate.

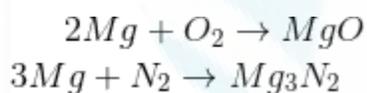
this $NaHCO_3$ crystals are heated to give sodium carbonate.



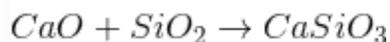
Question 10.17 What happens when (i) magnesium is burnt in air (ii) quick lime is heated with silica (iii) chlorine reacts with slaked lime (iv) calcium nitrate is heated ?

Answer :

(i) Magnesium is more electropositive and burns with dazzling brilliance in the air to give MgO and Mg_3N_2 .



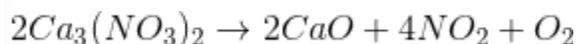
(ii) Quick lime combined with silica to form calcium silicate which is used as slag.



(iii) when chlorine reacts with slaked lime it produces bleaching powder.



(iv) when calcium nitrate is heated is decomposed to give calcium



Question 10.18 Describe two important uses of each of the following : (i) caustic soda
(ii) sodium carbonate (iii) quicklime.

Answer :

(i) Caustic Soda The chemical name is sodium hydroxide ($NaOH$). Sodium hydroxide is generally prepared commercially by the electrolysis of sodium chloride in Castner-Kellner cell.

Uses-

- the manufacture of soap, paper, artificial silk and a number of chemicals
- in the purification of bauxite,
- in the textile industries for mercerising cotton fabrics
- for the preparation of pure fats and oils, and
- as a laboratory reagent.

(ii) Sodium Carbonate-

The common name is washing soda (Na_2CO_3). Sodium carbonate is generally prepared by Solvay Process.

Uses-

- It is used in water softening, laundering and cleaning.
- It is used in the manufacture of glass, soap, borax and caustic soda.
- It is used in paper, paints and textile industries.

- It is an important laboratory reagent both in qualitative and quantitative analysis

(iii) Quick lime-

The chemical name is calcium oxide and the formula is CaO . It is prepared on a commercial scale by heating limestone ($CaCO_3$) in a rotary kiln at 1070-1270 K
 ($CaCO_3 \rightleftharpoons CaO + CO_2$)

Uses-

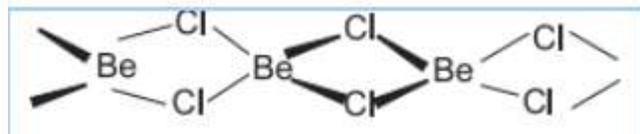
- It is an important primary material for manufacturing cement and is the cheapest form of alkali.
- It is used in the manufacture of sodium carbonate from caustic soda.
- It is employed in the purification of sugar and in the manufacture of dye stuffs.

Question 10.19 Draw the structure of (i) $BeCl_2$ (vapour) (ii) $BeCl_2$ (solid).

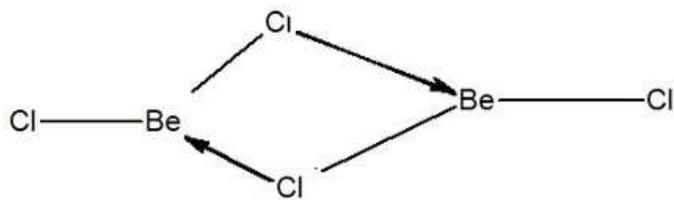
Answer :

Answer-

structure of $BeCl_2$ in solid phase-



In Gaseous phase-



Question 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 :

The atomic size of sodium and potassium is larger than the magnesium and calcium. So, the lattice energy of carbonates and oxides formed by sodium and potassium are less than that of calcium and magnesium. Therefore the carbonates and oxides of Na and K dissolve readily in water and Mg and Ca are sparingly soluble in water.

Question 10.21 Describe the importance of the following : (i) limestone (ii) cement (iii) plaster of paris.

Answer :

(i) Limestone-

The chemical formula is $CaCO_3$.

Importance of limestone is-

- It is used as a building material in the form of marble and in the manufacture of quick lime

- Calcium carbonate along with magnesium carbonate is used as a flux in the extraction of metals such as iron.
- It is also used as an antacid, mild abrasive in tooth paste, a constituent of chewing gum, and a filler in cosmetics.

(ii) Cement-

Cement is an important building material. It is a mixture of tricalcium silicate (Ca_3SiO_5) and tricalcium aluminate ($Ca_3Al_2O_6$).

Importance of cement-

It is used in concrete and reinforced concrete, in plastering and in the construction of bridges, dams and buildings

(iii) Plaster of Paris-

It is a hemihydrate of calcium sulphate. It is obtained when gypsum, $CaSO_4 \cdot 2H_2O$, is heated to 393 K.

Importance of POP-

It is used in medicine as surgical bandages and also it is used for making casts and moulds.

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

Answer :

Lithium-ion is the smallest among the other alkali metal ions. Hence it has higher polarising power than others and so it can polarise water molecule more easily than other alkali metals. Hence the water molecules are more attracted towards Li salts as the water of crystallisation. Li^+ has a maximum degree of hydration and for this reason, lithium salts are mostly hydrated, e.g., $\text{LiCl} \cdot 2\text{H}_2\text{O}$

As the down the group size of ions increase, their polarising power decreases. Hence other alkali metal ions usually form anhydrous salts.

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

Answer :

Both Li^+ ion and F^- ion are smaller in size. So their size compatibility is very high. Hence lattice energy during formation is very high and it is not overcome by the hydration energy. Therefore LiF is almost insoluble in water. On the other hand, Li^+ and Cl^- have comparable size differences, therefore they have low lattice energy and because of small in size, lithium ion has high polarising power as a result it distorts the electron cloud of chloride anion. As a result, there is some covalent character in LiCl . So, it is soluble in water but also in acetone.

Question 10.24 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 10.25 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 ?

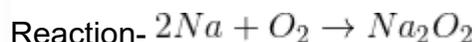
Answer :

(i) When sodium metal dropped into water it reacts rapidly and forms sodium hydroxide and hydrogen gas.

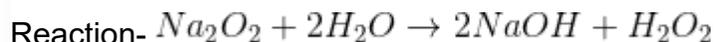
the chemical reaction is - $2Na + 2H_2O \rightarrow 2NaOH + H_2$

(ii) sodium metal heated in the free supply of water-

Sodium reacts vigorously with oxygen and forming sodium peroxides.



(iii) when sodium peroxide dissolved in water it hydrolysed and produce sodium hydroxide and hydrogen peroxide.



Question 10.26 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 $M^{2+}(aq) + 2e^- \rightarrow M(s)$ (where $M = Ca, Sr$ or Ba) is nearly constant.

Answer :

(a) As we know that down the group ionic size increases. Lithium-ion is the smallest in size and we know smaller the size of ion, the more hydrated it is. So lithium ion is most hydrated and ion is bigger in size so it is least hydrated.

Greater the size of hydrated ion less is mobility. So that the order of mobility of ions $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$

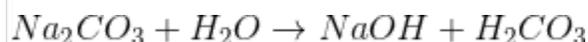
(b) Lithium unlike other alkali metals directly react with nitrogen and forms lithium nitride (Li_3N). This is because lithium-ion is the smallest in size and therefore it has very high size compatibility with N^{3-} . Hence the lattice energy released is very high.

(c) Electrode potential (E^0) for M^{2+} is depend on mainly three-factor- (i) ionisation enthalpy (ii) hydration enthalpy (iii) enthalpy of vaporisation. But we consider the overall effect of these three factors that should be the same for all Ca, Sr, Ba . Hence their electrode potential is constant.

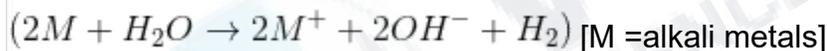
Question 10.27 State as to why (a) a solution of Na_2CO_3 is alkaline ? (b) alkali metals are prepared by electrolysis of their fused chlorides ? (c) sodium is found to be more useful than potassium ?

Answer :

(a) when sodium bicarbonate is added to water it gives sodium hydroxide (strong bas). As a result, the solution becomes alkaline in nature.



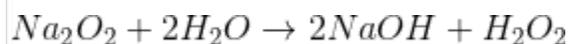
(b) Because their oxides are themselves are a very strong reducing agent in nature. So, by chemical reduction, we cannot obtain alkali metals. Also, we cannot use electrolysis of the aqueous solution method because after liberating the metals they again react with water.(



Question 10.28 Write balanced equations for reactions between (a) Na_2O_2 and water (b) KO_2 and water (c) Na_2O and CO_2 .

Answer :

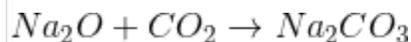
(a)The balanced reaction between Na_2O_2 and water-



(b) the reaction between water and KO_2 -



(c) reaction between Na_2O and CO_2 -



Question 10.29 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) Be^{2+} is small in size so it has high polarising power and O^{2-} is also small in size. Compatibility of both the cation and anion are very high. So their lattice energy is also very high. When BeO is dissolved in water its hydration energy is not sufficient to overcome its lattice energy. So, therefore, it is insoluble in water.

On the other hand, SO_4^{2-} ions are large in size. Hence Be^{2+} ion can easily polarise SO_4^{2-} ions and making it unstable and because of that lattice energy of $BeSO_4$ is not very high and so it is soluble in water.

(ii) BaO is soluble because Ba^{2+} cation is large in size as compare to O^{2-} anion. Size compatibility between them is not good. Therefore BaO is unstable. Hence lattice energy during the formation of their lattice is not high So it can be easily overcome by hydration energy. Therefore BaO is soluble in water. In case of $BaSO_4$, we know that down the group hydration enthalpy decreases and both the anion and cation have very good size compatibility. So, lattice energy cannot be overcome by hydration energy. As a result, $BaSO_4$ is not soluble in water.

(iii) The Li^+ ion has high polarising power. It is very small in size as compare to K^+ ion. So, it has a high tendency to distort the electron cloud around the negative iodide (I^-) ion. As a result of high polarizability, it has high covalent character than. KI Hence it is more soluble in methanol.

Question 10.30 Which of the alkali metal is having least melting point ? (a) Na (b) K (c) Rb (d) Cs

Answer :

The strength of metallic bond decreases down the group in the periodic table because as the size of cation increases the binding energies of their atoms in the crystal lattice decreases.

order of melting point $Na > K > Rb > Cs$

So, ans is (a) Na

Question 10.31 Which one of the following alkali metals gives hydrated salts ? (a) Li (b) Na (c) K (d) Cs

Answer :

The smaller the size of ion higher is the charge density and high polarising power. And among the alkali metals, lithium-ion is the smallest in size and has the power to attract the water molecules.

Ans is (a) Li

Question 10.32 Which one of the alkaline earth metal carbonates is thermally the most stable ? (a) $MgCO_3$ (b) $CaCO_3$ (c) $SrCO_3$ (d) $BaCO_3$ \

Answer :

Thermal stability \propto size of the cation in carbonates

increasing order of cationic size in alkaline earth metal is $Mg < Ca < Sr < Ba$

Therefore the most thermal stable carbonates are of Barium

Ans. (d) $BaCO_3$

