

Q 10.1

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

Ans 10.1

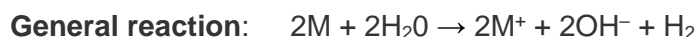
Physical properties:

- (1) The alkali metal is soft and so we can cut them easily. We can able to cut the sodium metal even by using the knife.
- (2) Generally, the alkali metal is lightly coloured and mostly they appear as silvery white.
- (3) Its atomic size is larger and so their density is low. The density of the alkali metal increases down in the group from Li to Cs except for K which has low density than sodium.
- (4) Alkali metal is weak in its metallic bonding and so they are having low boiling and melting points.
- (5) The salts present in alkali metals exposes colour to flames because the heat of the flame excites electron which is located on the outer orbital to higher energy level. In this excited state of electron getting reversed back to the ground level, the emission of excess energy in the form of radiation falls in visible region.
- (6) Metals like K and Cs loses electrons when they get irradiated with light and also displays photoelectric effect.

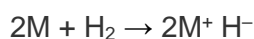
Chemical properties:

(1) Alkali metal reacts with water and forms oxides and hydroxides. So, the reaction will be more spontaneous while moving down the group.

(2) Alkali metal reacts with water and forms dihydrogens and hydroxides.



(3) Dihydrogen reacts with alkali metals and forms metal hydrides. The hydrides from this have higher melting points and they are solids which are ionic.



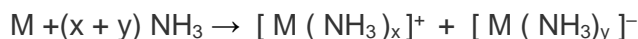
(4) Alkali metals directly reacts with halogens and forms ionic halides except Li.



It has the ability to easily distort the cloud of the electron which is around the -ve halide ion because, lithium ion is smaller in size. Hence, Lithium halide is naturally covalent.

(5) Alkali metals are very stronger reducing agents. This increases as we move down the group except lithium. Due to its high hydration energy it results in strong reducing agent among all alkali metals.

(6) To result in blue coloured solution(deep blue) which are naturally conducting, they get dissolved in liquid ammonia.



Q10.2

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

Ans 10.2

General characteristics:

- (i) (Noble gas) ns^2 is the electronic configuration of alkaline earth metal.
- (ii) To occupy the nearest inert gas configuration, these metals lose two of their electrons; and so its oxidation state is +2.
- (iii) The ionic radii and atomic radii is smaller than alkali metals. When they moved down towards the group, there is an increase in ionic radii and atomic radii due to decrease in effective nuclear charge.
- (iv) The ionization enthalpy is low because the alkaline earth metals are larger in size. The first ionization enthalpy is higher than metals of group 1.
- (v) They appear in lustrous and silvery white. They are soft as alkali metals.
- (vi) Factors that cause alkaline earth metals to contain high boiling point and melting point:
 - (*) Atoms of alkali metals are larger than that of alkaline earth metals.
 - (*) The strong metallic bonds are formed by two valence electrons.
- (vii) Ca- brick red, Sr- crimson red, Ba-apple green results in colours to flames.

Electrons are bounded strongly to get excited in Be and Mg. Therefore, they do not expose any colours to the flame.

The alkali metals are more reactive than alkaline earth metals.

Chemical properties:

- (i) Reaction with water air and: Due to the formation of oxide layer on their surface, beryllium and Mg are most inert to water and air.
- (a) Beo and $Be_3 N_2$ is formed when powdered Be is burnt in air.
- (b) For the formation of MgO and $Mg_3 N_2$, Mg is burnt in the air with dazzling sparkle. Since Mg is more electropositive.
- (c) The formation of respective nitrides and oxides is by instant reaction of Sr, Ca, and Ba with air.
- (d) Ca, Sr, and Ba can able to react vigorously even with water which is cold.
- (ii) when they react with halogens, halides are formed at high temperature.
 $M + X_2 \rightarrow MX_2$ (X = F, Cl, Br, I)
- (iii) Except Be, all the alkaline earth metals react with hydrogen to form hydrides.
- (iv) alkaline earth metals instantly react with acids to form salts with the liberation of hydrogen gas.
 $M + 2HCl \rightarrow MCl_2 + H_2(x)$

Q 10.3

Why are alkali metals not found in nature?

Ans 10.3

Sodium, cesium, lithium, francium, potassium, rubidium all together comprise the alkali metals. They consist of only one electron on its valence shell, which gets loose easily due to their low ionizing energies. So, alkali metals are not found naturally in their elemental state as they are highly reactive.

Q 10.4

Find out the oxidation state of sodium in Na_2O_2 .

Ans 10.4

Let the oxidation state of Na be y.

In case of peroxides, the oxidation state of oxygen is -1.

Therefore,

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

$$2y - 2 = 0$$

$$2y = 2$$

$$y = +1$$

Therefore, the oxidation state of Na is +1.

Q 10.5

Explain why is sodium less reactive than potassium.

Ans 10.5

On moving down the group in the alkali metals, the size of the atom increases and the effect of the nuclear charge gets decreased. Due to these factors, the electron of potassium which is located outer gets lost easily as compared to Na. Therefore, potassium is highly reactive than sodium.

Q 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.

Ans 10.6

Sr. No	Alkaline earth metals	Alkali Metals
a)	Solubility of hydroxide: They are less soluble compared to alkali metals as it has high lattice energy and is having higher charge densities account for higher lattice.	Solubility of hydroxide: They are more soluble compared to alkaline earth metals.

b)	<p>Ionization Enthalpy: They have smaller atomic size and higher effective nuclear charge compared to alkali metals, which causes their 1st ionization enthalpy higher than that in alkali metals, but the 2nd ionization enthalpy is less than that of alkali metals</p>	<p>Ionization Enthalpy: They have large atomic size compared to alkaline earth metals, so they are having less 1st ionization enthalpy, so they lose valence electrons very easily.</p>
c)	<p>Basicity of oxides: Their oxides are quite basic but less as compared to those of alkali metals as they are less electro positive than alkali metals.</p>	<p>Basicity of oxides: Their oxides are basic in nature as they are highly electropositive, which makes their oxides highly ionic.</p>

Q 10.7

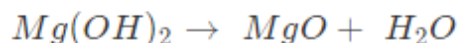
In what ways lithium shows similarities to magnesium in its chemical behaviour?

Ans 10.7

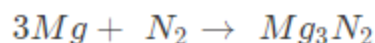
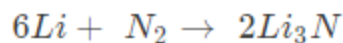
Similarities between lithium and magnesium:

(i) lithium and magnesium react slow with cold water.

(ii) oxides of lithium and magnesium are less soluble in H₂O. also the hydroxides of both decompose at high temperature.

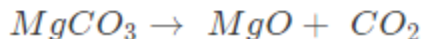


(iii) Nitrides is formed from both the lithium and magnesium when they react with N₂.



(iv) Neither Li nor Mg form superoxides or peroxides.

(v) Both the carbonates of lithium and magnesium are naturally covalent. They decomposes on heating.



(vi) They do not form bicarbonates which are solid.

(vii) Both $MgCl_2$ and $LiCl$ are soluble in ethanol because they are naturally covalent.

(viii) Both $MgCl_2$ and $LiCl$ are naturally deliquescent. They crystallize as hydrates from aqueous solutions.

Eg.,



Q 10.8

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

Ans 10.8

By using a stronger reducing agent, the oxides of metals get reduced by the process called chemical reduction. Alkaline earth metals and alkali metals are strong among the reducing agents. No stronger reducing agent is available than them. Therefore alkaline earth metals and alkali cannot be obtained by chemical reduction of their oxides.

Q 10.9

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

Ans 10.9

Lithium, potassium, and cesium, are all alkali metals. But still, potassium and cesium are used in photoelectric cell and not Lithium because Li is smaller in size when compared to the other two.

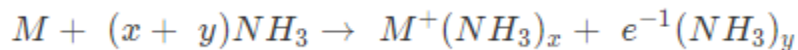
On the other hand, cesium and potassium have low ionization energy. Therefore, they lose electrons easily. This property is utilized in photoelectric cells.

Q 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.

Ans 10.10

When the alkali metal is dissolved in liquid ammonia, a deep blue coloured solution is formed.



The ammoniated electrons absorb energy corresponding to red region of visible light. Therefore, the transmitted light is deep blue in colour.

Clusters of metal ions are formed at higher concentration (3M) which causes the solution to attain a copper-bronze colour and a metallic lustre.

Q 10.11

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

Ans 10.11

The valence electrons get excited to a higher energy level when an alkaline earth metal is heated.

It radiates energy which belongs to the visible region when this excited electron comes back to its energy level which is low. The colour is observed here. The electrons are strongly bound in the beryllium and magnesium. The energy required to excite these electrons is very high. When the electron reverts back to its original position, the energy released does not fall in the visible region. Hence, no colour is seen in the flame.

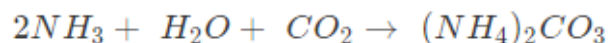
Q 10.12

Discuss the various reactions that occur in the Solvay process.

Ans 10.12

The process of preparing sodium carbonate is called Solvay process. Sodium hydrogen carbonate is formed when carbon dioxide gas is bubbled through a brine solution saturated with ammonia. The obtained sodium hydrogen carbonate is then converted into sodium carbonate.

(i) Brine solution is saturated with ammonia.



This ammoniated brine is filtered for purity removal.

(ii) When carbondioixide reacts with ammoniated brine, it results in the formation of insoluble sodium hydrogen carbonate.

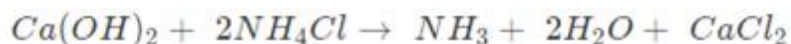


(iii) NaHCO_3 is obtained by the solution which contains crystals of NaHCO_3 is filtered.

(iv) NaHCO_3 is heated strongly to convert it into Na_2CO_3 .



(v) Ammonia is recovered when the filtrate which is removed after NaHCO_3 is mixed with Ca(OH)_2 and heated.



The overall reaction taking place in Solvay process is



Q 10.13

Potassium carbonate cannot be prepared by Solvay process. Explain why?

Ans 10.13

Solvay process is not applicable for the preparation of potassium carbonate because potassium carbonate is soluble in water and it doesn't precipitates out like sodium bicarbonate.

Q 10.14

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

Ans 10.14

The electropositive character increases while moving down in the group of alkali metal which results in an increase in stability of alkali carbonates. Generally, lithium carbonate is not stable when it reacts to heat because lithium carbonate is covalent. Due to the smaller size of lithium ion it polarizes large carbonate ion which results in the formation of stable lithium oxide.



This is why sodium carbonate decomposes at high temperature and lithium carbonate decomposes at low temperature.

Q 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.

Ans 10.15

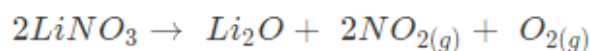
(a) Nitrates

Thermal stability

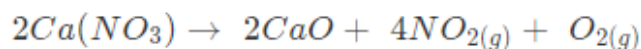
Except LiNO_3 , the nitrates of alkali metals gets decomposed while heating strong which results in the formation of nitrites.



LiNO_3 , on decomposition, gives oxide.



Like lithium nitrate, alkaline earth metal nitrates also decomposes to give oxides.



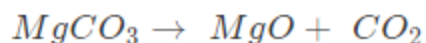
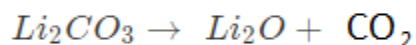
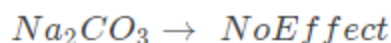
Solubility

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

(b) Carbonates

Thermal stability

The alkali metals carbonates are very stable to heat. But carbonates of lithium decomposes and results in the formation of lithium oxide while heating. The carbonates of alkaline earth metals also decompose which results in the formation of carbon dioxide and oxide while heating.



Solubility

Exception of Li_2CO_3 , the carbonates of alkali metals are soluble in water and also while we move down the group, the solubility increases. Carbonates of alkaline earth metals are insoluble in water.

(c) Sulphates

Thermal stability

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

Solubility

Sulphates of alkali metals are soluble in water. But the sulphates of alkaline earth metals shows various activities,

CaSO_4 Sparingly soluble

BaSO_4 Insoluble

BeSO_4 Fairly soluble

SrSO_4 Insoluble

MgSO_4 Soluble

Q 10.16

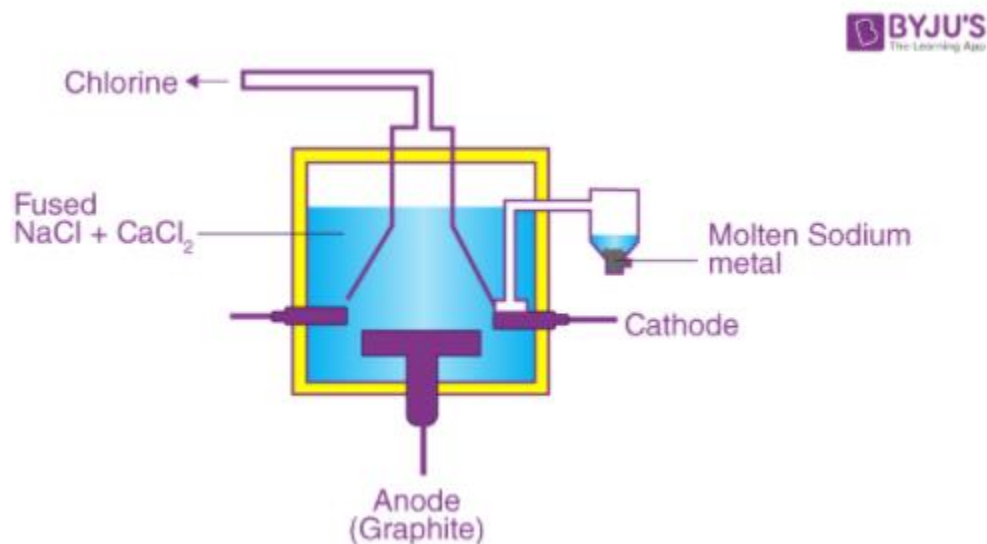
Starting with sodium chloride how would you proceed to prepare (i) sodium metal (ii) sodium hydroxide (iii) sodium peroxide (iv) sodium carbonate?

Ans 10.16

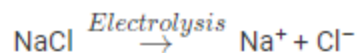
(i) Sodium metal

Sodium chloride can be converted into sodium by Downs process.

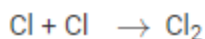
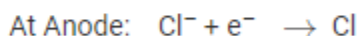
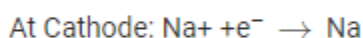
It can be achieved by electrolysis of fused CaCl_2 (60 %) and NaCl (40%) at 1123 K in a special apparatus (Downs cell).



A graphite block is the anode while steel is made the cathode. Metallic Ca and Na are formed at the cathode. Molten Na is supported by dipping in kerosene.



(Molten)

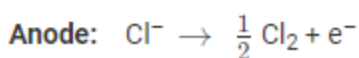
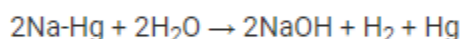
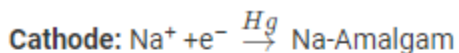


(ii) Sodium hydroxide

By electrolyzing a solution of sodium chloride, we can get Sodium hydroxide. This process is commonly known as Castner- Kellner process.

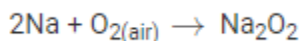
The process is carried out using a mercury cathode and a carbon anode.

Sodium metal, deposited at cathode forms an Amalgam by combining with Mercury.



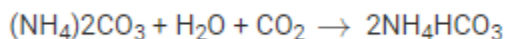
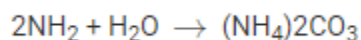
(iii) Sodium peroxide

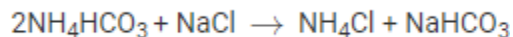
After Na metal is gotten from Downs process, it is heated on Aluminium trays in presence of air (without CO_2) to form Sodium peroxide.



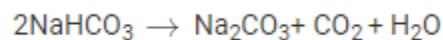
(iv) Sodium carbonate

Sodium hydrogen carbonate is obtained as a precipitate by reacting sodium chloride with ammonium hydrogen carbonate. The resultant crystals can be heated to obtain Sodium Carbonate.





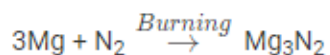
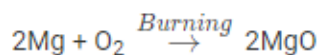
The resultant crystals can be heated to obtain Sodium Carbonate.

**Q 10.17**

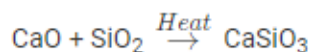
What happens when (i) magnesium is burnt in air (ii) quick lime is heated with silica (iii) chlorine reacts with slaked lime (iv) calcium nitrate is heated?

Ans 10.17

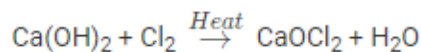
(i) When Magnesium is burnt in air, it does so with a dazzling bright light resulting in the formation of Mg_3N_2 and MgO .



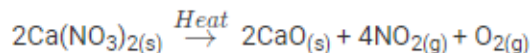
(ii) Silica (SiO_2) combines with Quick lime (CaO) resulting in formation of Slag.



(iii) Bleaching powder is formed when chlorine is made to react with slaked lime.



(iv) Calcium nitrate, when heated, undergoes decomposition to form calcium oxide.

**Q 10.18**

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

Ans 10.18

(i) Caustic soda

(a) Heavily used in soap industries.

(b) Common reagent in laboratories.

(ii) Sodium carbonate

(a) Finds uses in both soap and glass industries.

(b) Also finds use as a water softener.

(iii) Quick lime

(a) Finds use as a primary material for manufacturing slaked lime.

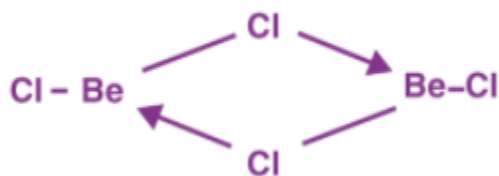
(b) It helps in the manufacture of cement and glass.

Q 10.19

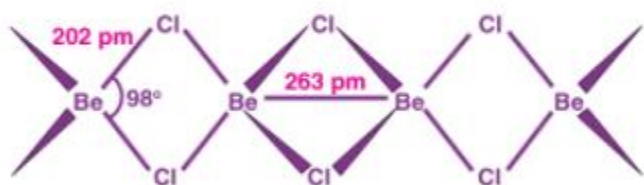
Draw the structure of (i) BeCl_2 (vapour) (ii) BeCl_2 (solid).

Ans 10.19

(i) BeCl_2 has a linear structure and exists as a monomer in the vapour state.



(ii) In the solid phase, BeCl_2 is a polymer.



Q 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.

Ans 10.20

Since the atomic sizes of magnesium and calcium are smaller than that of sodium and potassium, calcium and magnesium form carbonates and hydroxides with higher lattice energies. Thus, they are only sparingly soluble whereas those of potassium and sodium are readily soluble due to low lattice energies.

Q 10.21

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

Ans 10.21

Uses of cement:

- Bridge construction
- Plastering
- Most important ingredient in concrete

Uses of Plaster of Paris:

- Used to make casts and moulds
- Used to make surgical bandages

Uses of limestone:

- Preparation of cement and lime
- As a flux in iron ore smelting

Q 10.22

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

Ans 10.22

Since Lithium has the smallest size among all the alkali metals, it can easily polarize water molecules. Thus, smaller the size of the ion, greater is its ability to polarize water molecules.

Hence, trihydrated Lithium Chloride and other Lithium salts can be easily polarized. Due to this reason, other alkali metal ions can only form anhydrous salts.

Q 10.23

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

Ans 10.23

LiF has a greater ionic character than LiCl which disturbs the balance between hydration energy and lattice energy. This balance is crucial for the solvability of ions in solution. Due to greater covalent character and lower lattice energy, dissolution of LiCl is more exothermic in nature than that of LiF.

Q 10.24

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

Ans 10.24**Sodium (Na):**

They are found in our blood plasma and the interstitial fluids around the cells. They help in

- (a) Transmission of nerve signals.
- (b) They regulate the flow of water across the membranes of the neighboring cells.
- (c) Transport sugars and amino acids from and to cells.

Potassium (K):

They are found mostly in the cell fluids in greater quantities.

They help in

- (a) Activating enzymes.
- (b) Oxidising glucose to form ATP.
- (c) Transmitting nerve signals.

Magnesium (Mg) and calcium (Ca):

They are also called as macro-minerals named so because of their abundance in our body. Mg helps in

- (a) Relaxing nerves and muscles.
- (b) Building and strengthening bones.
- (c) Maintaining blood circulation in our body.

Ca helps in

- (a) coagulation of blood
- (b) Maintaining homeostasis.

Q 10.25

What happens when:

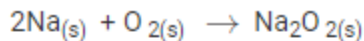
- (i) Sodium metal is immersed in water?**
- (ii) Sodium metal is heated in abundance of air?**
- (iii) Sodium peroxide gets dissolved in water?**

Ans 10.25

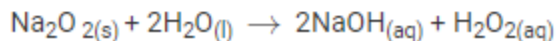
(i) Sodium reacts to form NaOH and H₂ gas when it is dropped in water. The reaction occurs as shown below:



(ii) Sodium peroxide is formed when sodium reacts with oxygen while heating it in presence of air. The reaction proceeds as shown below:



(iii) NaOH and water are formed as a result of hydrolysis of Sodium peroxide when it is dissolved in water.



Q 10.26

Comment on each of the following observations:

(a) The mobilities of the alkali metal ions in aqueous solution are



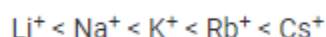
(b) Lithium is the only metal to form a nitride directly.

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

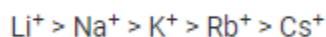
Ans 10.26

(a) The ionic and atomic sizes of the metals tend to increase while going down the alkali group.

The increasing order of the ionic sizes of the alkali metal ions is as shown below:

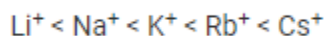


Smaller the size of an ion, greater is its ability to get hydrated. Li^+ ion gets heavily hydrated since it is the smallest in size whereas Cs^+ has the largest size and is the least hydrated ion. The alkali metal ions when arranged in the decreasing order of their hydrations is as shown below:



Higher the mass of a hydrated ion, the lesser is its ionic mobility. Thus, hydrated Li^+ is the least mobile ion whereas hydrated Cs^+ is the most mobile ion.

The ionic mobility of the alkali metal ions are in the following order:



(b) The only metal that can form a nitride directly is Lithium because Li^+ has a smaller size and is easily compatible with the N^{3-} ion. Thus, the lattice energy released is very high which is enough to overcome the amount of energy needed to form N^{3-} ion.

(c) Electrode potential (E°) of any M^{2+}/M electrode is decided by three factors:

(i) Enthalpy of hydration

(ii) Enthalpy of vaporisation

(iii) Ionisation enthalpy

The cumulative effect of these factors on Ba, Sr, and Ca is almost the same.

As a result, their electrode potentials are also same.

Q 10.27

State as to why

- (a) a solution of Na_2CO_3 alkaline in nature?
- (b) alkali metals are prepared by electrolysis of their fused chlorides?
- (c) Sodium is found to be more useful than potassium?

Ans 10.27

(a) Sodium bicarbonate and sodium hydroxide are the end products when Na_2CO_3 is hydrolyzed. Since, the product are alkaline in nature, a solution of Na_2CO_3 is considered to be alkaline in nature.

(b) Chemical reduction cannot be used to prepare alkali metals since they themselves are reducing in nature. Alkali metals are highly electropositive and thus cannot be prepared by displacement reactions. Since they also react with water, these alkali metals cannot be prepared by electrolysis of their aqueous solutions. Thus, alkali metals are mostly prepared by electrolysis of their fused chlorides.

(c) Sodium ions are primarily found in the Blood plasma and the interstitial fluids around the cells whereas Potassium ions are found within the cell fluids. Sodium ions help in the transmission of nerve signals and also regulate the flow of water and transport sugars and amino acids into the cells.

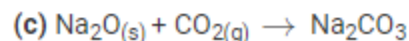
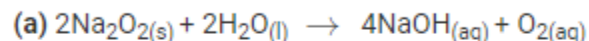
Thus, Sodium is more important for our survival than potassium.

Q 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

Ans 10.28



Q 10.29

How would you explain the following observations?

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

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

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

Ans 10.29

(i) The sizes of Be²⁺ and O²⁻ are small and are highly compatible with each other. Due to this, a high amount of lattice energy is released during its formation. The hydration energy, when it is made to dissolve in water, is not enough to overcome the lattice energy. Thus, BeO is almost insoluble in water.

Whereas the size of an SO₄²⁻ is large compared to Be²⁺ and there is lesser compatibility and lattice energy which can be easily overcome by the hydration energy. Thus, BeSO₄ is easily soluble in water.

(ii) The sizes of Ba²⁺ and SO₄²⁻ are large and are highly compatible with each other. Due to this, a high amount of lattice energy is released during its formation. The hydration energy, when it is made to dissolve in water, is not enough to overcome the lattice energy. Thus, BaSO₄ is insoluble in water.

Whereas the size of an O²⁻ is small compared to Be²⁺ and there is lesser compatibility and lattice energy which can be easily overcome by the hydration energy. Thus, BaO is easily soluble in water.

(iii) The lithium-ion has a smaller size and as a result of that, it has a higher polarizing capability. This enables it to polarize the electron cloud around an iodide ion thus resulting in a greater covalent character in LiI than KI. Thus, LiI is easily soluble in ethanol.

Q 10.30

Which of the following alkali metals has the least melting point?

(a) Na (b) K (c) Rb (d) Cs

Ans 10.30

(d) Cs

Cs has the least melting point of the given alkali metals since it has the largest size. Due to a larger size, the binding capability of Cs is limited and the lattice energy released during the formation of its compounds is less and can be easily broken.

Q 10.31

Which one of the following alkali metals gives hydrated salts?

(a) Li (b) Na (c) K (d) Cs

Ans 10.31

(a) Li

Li is capable of forming hydrated salts because of its size. Since it is smaller in size, it has a higher charge density and can easily attract water molecules around it and form hydrated salts like LiCl·2H₂O. The other alkali metals have a bigger size and lesser charge density and thus aren't capable of forming hydrated salts.

Q 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

Ans 10.32

(d) BaCO_3

Thermal stability is directly proportional to the size of the cation i.e., larger the size of the atom, greater is its thermal stability. The biggest cation among the given compounds is Ba.

Thus, BaCO_3 will be the most thermal carbonate among the given compounds followed by SrCO_3 , CaCO_3 and MgCO_3 .

