Chapter – 5

Alkali and Alkaline Earth Metals

I. Choose the Correct Answer:

Question 1.
For alkali metals, which one of the following trends are incorrect?
(a) Hydration energy : Li > Na > K > Rb
(b) Ionization energy : Li > Na > K > Rb
(c) Density : Li < Na < K < Rb
(d) Atomic size : Li < Na < K < Rb

Answer:
(c) Density : Li < Na < K < Rb
Potassium is lighter than sodium. The correct order of density is
Li < K< Na < Rb < Cs
0.54 < 0.86 < 0.97< 1.53< 1.90 (in g cm^3).

Question 2.
Which of the following statements are incorrect?
(a) Li+ has minimum degree of hydration among alkali metal cations.
(b) The oxidation state of K in KO_2 is +1.
(c) Sodium is used to make Na/Pb alloy.
(d) $MgSO_4$ is readily soluble in water.

Answer:
(a) Li+ has minimum degree of hydration among alkali metal cations.
Li+ has maximum degree of hydration among alkali metal cations.
$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

Question 3.
Which of the following compounds will not evolve H_2 gas on reaction with alkali metals?
(a) ethanoic acid
(b) ethanol
(c) phenol
(d) none of these

Answer:
(d) none of these
Hint:
All these compounds reacts with alkali metals to evolve hydrogen gas.

Question 4.
Which of the following has the highest tendency to give the reaction Aqueous –
$M^+(g) \xrightarrow[\text{Medium}]{\text{Aqueous}} M^+(aq)$
(a) Na
(b) Li
(c) Rb
(d) K

Answer:
(b) Li.
Hint:
Hydration energy of Li^+ is more and hence Li^+ is stabilized in aqueous medium.

Question 5.
Sodium is stored in …….
(a) alcohol
(b) water
(c) kerosene
(d) none of these

Answer:
(c) kerosene

Question 6.
RbO_2 is ……
(a) superoxide and paramagnetic
(b) peroxide and diamagnetic
(c) superoxide and diamagnetic
(d) peroxide and paramagnetic

Answer:
(a) superoxide and paramagnetic
Hint:
RbO_2 is a super oxide which contains Rb^+ and O_{2-} ions. O_{2-} contains one unpaired electron and hence it is paramagnetic.

Question 7.
Find the wrong statement ……
(a) sodium metal is used in organic qualitative analysis
(b) sodium carbonate is soluble in water and it is used in inorganic qualitative analysis
(c) potassium carbonate can be prepared by Solvay process
(d) potassium bicarbonate is acidic salt

Answer:
(c) Potassium carbonate can be prepared by Solvay process
Hint:
Potassium carbonate cannot be prepared by Solvay process. Potassium bicarbonate is fairly soluble in water and does not precipitate out.

Question 8.
Lithium shows diagonal relationship with
(a) sodium
(b) magnesium
(c) calcium
(d) aluminium

Answer:
(b) magnesium (diagram pending)

Question 9.
In case of alkali metal halides, the ionic character increases in the order
(a) MF < MCl < MBr < MI
(b) MI < MBr < MCl < MF
(c) MI < MBr < MF < MCl
(d) none of these

Answer:
(b) MI < MBr < MCl < MF

Hint:
Ionic character (difference in electronegativity) MI < MBr < MCl < MF

Question 10.
In which process, fused sodium hydroxide is electrolysed for extraction of sodium?
(a) Castner's process
(b) cyanide process
(c) Down process
(d) All of these

Answer:
(a) Castners process Castner's process
$NaOH \rightleftharpoons Na^+ + OH^-$
Cathode : $Na^+ + e^- \rightarrow Na$
Anode : $2OH^- \rightarrow H_2O + 1/2\ O_2 + 2e^-$

Question 11.
The product obtained as a result of a reaction of nitrogen with CaC_2 is (NEET – Phase I)
(a) $Ca(CN)_3$
(b) CaN_2
(c) $Ca(CN)_2$
(d) Ca_3N_2

Answer:
(c) $Ca(CN)_2$

Hint:
$$CaC_2 + N_2 \xrightarrow{300-350^\circ C} \underset{\text{Calcium cyanide}}{Ca(CN)_2}$$

Question 12.
Which of the following has highest hydration energy?
(a) $MgCl_2$
(b) $CaCl_2$
(c) $BaCl_2$
(d) $SrCl_2$

Answer:
(a) $MgCl_2$

Hint:
The order of hydration energy of alkaline earth metal is $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$

Question 13.
Match the flame colours of the alkali and alkaline earth metal salts in the bunsen burner
(p) Sodium – (1) Brick red
(q) Calcium – (2) Yellow
(r) Barium – (3) Violet
(s) Strontium – (4) Apple green
(t) Cesium – (5) Crimson red
(u) Potassium – (6) Blue

(a) p – 2, q – 1, r- 4, s – 5, t- 6, u – 3
(b) p – 1, q – 2, r – 4, s – 5, t – 6, u – 3
(c) p – 4, q – 1, r – 2, s – 3, t – 5, u – 6
(d) p – 6, q – 5, r – 4, s – 3, t – 1,u – 2

Answer:
(a) p – 2, q – 1, r – 4, s – 5, t – 6, u – 3
(p) sodium – yellow (2)
(p) calcium – brick red (1)
(r) barium – apple green (4)
(s) strontium – crimson red (5)
(t) cesium – blue (6)
(u) potassium – violet (3)

Question 14.
Assertion : Generally alkali and alkaline earth metals form superoxides
Reason : There is a single bond between O and O in superoxides.

(a) both assertion and reason are true and reason is the correct explanation of assertion
(b) both assertion and reason are true but reason is not the correct explanation of assertion

(c) assertion is true but reason is false
(d) both assertion and reason are false

Answer:
(d) both assertion and reason are false

Hint:
Among alkali and alkaline earth metals, K, Rb and Cs alone forms superoxides. Superoxide O_{2^-} has 3 electron bond.

Question 15.
Assertion : $BeSO_4$ is soluble in water while $BaSO_4$ is not
Reason: Hydration energy decreases down the group from Be to Ba and lattice energy remains almost constant.

(a) both assertion and reason are true and reason is the correct explanation of assertion
(b) both assertion and reason are true but reason is not the correct explanation of assertion
(c) assertion is true but reason is false
(d) both assertion and reason are false

Answer:
(a) both assertion and reason are true and reason is the correct explanation of assertion

Question 16.
Which is the correct sequence of solubility of carbonates of alkaline earth metals?
(a) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$
(b) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
(c) $CaCO_3 > BaCO_3 > SrCO_3 > MgCO_3$
(d) $BaCO_3 > CaCO_3 > SrCO_3 > MgCO_3$

Answer:
(b) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
Hint:
Solubility of carbonates decreases down the group.

Question 17.
In context with beryllium, which one of the following statements is incorrect?
(a) It is rendered passive by nitric acid
(b) It forms Be_2C
(c) Its salts are rarely hydrolyzed
(d) Its hydride is electron deficient and polymeric

Answer:
(c) Its salts are rarely hydrolyzed
Hint:
Correct statement is beryllium salts are easily hydrolyzed

Question 18.
The suspension of slaked lime in water is known as (NEET Phase – II)
(a) lime water
(b) quick lime
(c) milk of lime
(d) aqueous solution of slaked lime

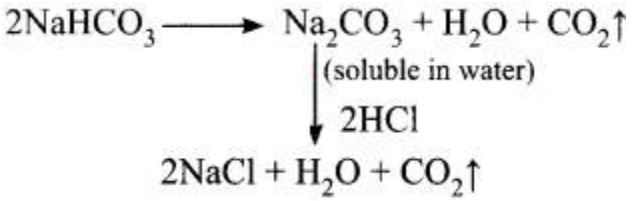
Answer:
(c) milk of lime

Hint:
Slaked lime $Ca(OH)_2$. The suspension is called milk of lime and the clear solution is called lime water

Question 19.
A colourless solid substance (A) on heating evolved CO_2 and also gave a white residue, soluble in water. Residue also gave CO_2 when treated with dilute HCl.
(a) Na_2CO_3
(b) $NaHCO_3$
(c) $CaCO_3$
(d) $Ca(HCO_3)_2$

Answer:
(b) $NaHCO_3$

Hint:



Question 20.

The compound (X) on heating gives a colourless gas and a residue that is dissolved in water to obtain (B). Excess of CO_2 is bubbled through aqueous solution of B, C is formed. Solid (C) on heating gives back X. (B) is …….

(a) $CaCO_3$

(b) $Ca(OH)_2$

(c) Na_2CO_3

(d) $NaHCO_3$

Answer:

(b) $Ca(OH)_2$

Solution:

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

$CaO + H_2O \rightarrow Ca(OH)_2$

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

Question 21.

Which of the following statement is false ? (NEET – Phase -1)

(a) Ca^{2+} ions are not important in maintaining the regular beating of the heart

(b) Mg^{2+} ions are important in the green parts of the plants

(c) Mg^{2+} ions form a complex with ATP

(d) Ca^{2+} ions are important in blood clotting

Answer:

(a) Ca^{2+} ions are not important in maintaining the regular beating of the heart

Hint:

Ca^{2+} ion plays an important role in maintaining regular heart beat.

Question 22.
The name 'Blue John' is given to which of the following compounds?
(a) CaH_2
(b) CaF_2
(c) $Ca_3(PO_4)_2$
(d) CaO

Answer:
(b) CaF_2

Hint:
'Blue john' – CaF_2 (A variety of fluorite)

Question 23.
Formula of gypsum is ……..
(a) $CaSO_4.2H_2O$
(b) $CaSO_4.$ ½$2H_2O$
(c) $3CaSO_4.H_2O$
(d) $2CaSO_4.2H_2O$

Answer:
(a) $CaSO_4.2H_2O$

Question 24.
When CaC_2 is heated in atmospheric nitrogen in an electric furnace the compound formed is
(a) $Ca(CN)_2$
(b) CaNCN
(c) CaC_2N_2
(d) $CaNC_2$

Answer:
(b) CaNCN

Solution:

$$CaC_2 + N_2 \xrightarrow{1\ atm} \underset{\substack{\text{Nitrolium (or)}\\ \text{calcium cyanamide}}}{CaNCN}$$

Question 25.
Among the following the least thermally stable is
(a) K_2CO_3
(b) Na_2CO_3
(c) $BaCO_3$
(d) Li_2CO_3

Answer:
(d) Li_2CO_3
Hint:
Li_2CO_3 is the least stable.

II. Write a brief answer to the following questions.

Question 26.
Why sodium hydroxide is much more water-soluble than chloride?

Answer:

1. Sodium hydroxide is a stronger base whereas sodium chloride is a salt.
2. Sodium hydroxide dissolves freely in water with the evolution of much heat on account of intense hydration.
3. In other words, when the Na^+ and OH^- ions break up, the OH^- ions are much smaller than Cl^- ions and are able to form a hydrogen bond with water.
4. Thus sodium hydroxide dissolves easily in water.

Question 27.
Write the chemical equations for the reactions involved in Solvay process of preparation of sodium carbonate.

Answer:
Solvay process:
The Solvay process is represented by the below chemical equations:

(*i*) $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$
Ammonium carbonate

(*ii*) $(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$
Ammonium bicarbonate

(*iii*) $NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$
Ammonium chloride

(*iv*) $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$
Sodium carbonate

Question 28.
An alkali metal (x) forms a hydrated sulphate, X_2SO_2. $10H_2O$. Is the metal more likely to he sodium (or) potassium.

Answer:
Sodium: Because hydration is favoured by high charge density cations and of the two mono positive ions, sodium is smaller and will have higher charge density. Thus, $Na_2SO_4.10H_2O$ is more readily formed.

Question 29.
Write balanced chemical equation for each of the following chemical reactions.
(i) Lithium metal with nitrogen gas
(ii) Heating solid sodium bicarbonate
(iii) Rubidium with oxygen gas
(iv) Solid potassium hydroxide with CO_2
(v) Heating calcium carbonate
(vi) Heating calcium with oxygen

Answer:

(*i*) $6Li_{(s)} + 3N_{2(g)} \rightarrow 2Li_3N_{(s)}$
Lithium Nitrogen Lithium nitride

(*ii*) $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2\uparrow + H_2O$
Sodium bicarbonate Sodium carbonate

(*iii*) $Rb + O_2 \rightarrow RbO_2$
Rubidium Rubidium superoxide

(*iv*) $2KOH_{(s)} + CO_2 \rightarrow K_2CO_3 + H_2O$
Potassium hydroxide Potassium carbonate

(v) $\underset{\text{Calcium carbonate}}{CaCO_3} \xrightarrow{\Delta} \underset{\text{Quick lime}}{CaO_{(s)}} + CO_2\uparrow$

(vi) $\underset{\text{Calcium}}{2Ca_{(s)}} + O_{2(g)} \rightarrow \underset{\text{Calcium oxide}}{2CaO_{(s)}}$

Question 30.
Discuss briefly the similarities between beryllium and aluminium.

Answer:

1. Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms a polymeric chain structure in addition to the dimer. Both are soluble in organic solvents and are strong Lewis acids.

2. Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[Be(OH)_4]^{2-}$ and hydrogen as aluminium hydroxide which gives aluminate ion, $[Al(OH)_4]^{2-}$.

3. Beryllium and aluminium ions have a strong tendency to form complexes, BeF_4^{2-}, AlF_6^{3-}.

4. Both beryllium and aluminium hydroxides are amphoteric in nature.
5. Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.

6. Both beryllium and aluminium are rendered passive by nitric acid.

Question 31.
Give the systematic names for the following:

1. milk of magnesia
2. lye
3. lime
4. caustic potash
5. washing soda
6. soda ash and
7. trona.

Answer:

1. Milk of magnesia – $Mg(OH)_2$ – Magnesium hydroxide
2. Lye – NaOH – Sodium hydroxide
3. Lime – $Ca(OH)_2$ Calcium hydroxide
4. Caustic potash – KOH – Potassium hydroxide
5. Washing soda – Na_2CO_3. $10H_2O$ – Sodium carbonate decahydrate
6. Soda ash – Na_2CO_3 – Sodium carbonate (anhydrous)
7. Trona – $NaCO_3.NaHCO_3.2H_2O$ – Sodium sesqui carbonate

Question 32.
Substantiate Lithium fluoride has the lowest solubility among group one metal fluorides.

Answer:
Lithium fluoride has the lowest solubility among alkali metal fluoride due to its small size of Li^+ and F^- ions, lattice enthalpy is much higher than that of hydration enthalpy.

Question 33.
Mention the uses of Plaster of Paris.

Answer:

- The largest use of Plaster of Paris is in the building industry as well as plasters.
- It is used for immobilizing the affected part of organ, where there is a bone fracture or sprain.
- It is also employed in dentistry, in ornamental work and for making casts of statues and busts.

Question 34.
Beryllium halides are covalent whereas magnesium halides are ionic why?

Answer:
Halogens are non-metals and beryllium is also non-metal. Since non-metals always form covalent bonds with each other due to almost similar ionization

potential and electronegativity. And Beryllium is smaller in size and has high polarizing power therefore, beryllium halides are covalent.

Magnesium is a metal and metals mostly form ionic bonds with non-metals due to vast differences in their ionization potential and electronegativity, therefore magnesium halides are always ionic.

Question 35.
Alkaline earth metal (A), belongs to 3rd period reacts with oxygen and nitrogen to form compound (B) and (C) respectively. It undergo metal displacement reaction with $AgNO_3$ solution to form compound (D).

Answer:

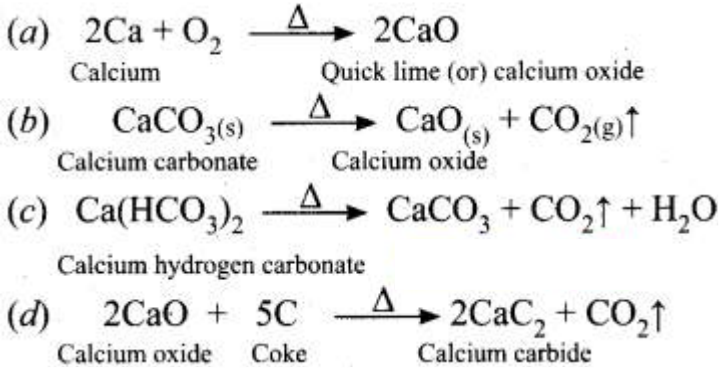
1. An alkaline earth (A) metal belongs to third period is magnesium (Mg).
2. Magnesium reacts with oxygen to form magnesium oxide (MgO) (B).
   $$2Mg + O_2 \rightarrow \underset{\text{Magnesium oxide}}{2MgO}$$
3. Magnesium reacts with nitrogen to form magnesium nitride Mg_3N_2 (C).
   $$3Mg + N_2 \rightarrow \underset{\text{Magnesium nitride}}{Mg_3N_2}$$
4. Magnesium undergoes metal displacement reaction with $AgNO_3$ solution to form magnesium nitrate $Mg(NO_3)_3$ (D).
   $$Mg + 2AgNO_3 \rightarrow \underset{\text{Magnesium nitrate}}{Mg(NO_3)_2} + 2Ag$$

A	Magnesium	Mg
B	Magnesium oxide	MgO
C	Magnesium nitride	Mg_3N_2
D	Magnesium nitrate	$Mg(NO_3)_2$

Question 36.
Write balanced chemical equation for the following processes:
(a) heating calcium in oxygen
(b) heating calcium carbonate
(c) evaporating a solution of calcium hydrogen carbonate

(d) heating calcium oxide with carbon

Answer:



Question 37.

Explain the important common features of group 2 elements. Important common features of group 2 elements.

Answer:

1. Group 2 is known as alkaline earth metals. It contains soft, silver metals that are less metallic in character than the Group 1 elements. Although many characteristics are common throughout the group, the heavier metals such as Ca, Sr, Ba, and Ra are almost as reactive as the Group 1 Alkali Metals.

2. General electronic configuration can be represented as [Noble gas] ns^2 where 'n' represents the valence shell.

3. All the elements in Group 2 have two electrons in their valence shells, giving them an oxidation state of +2. This enables the metals to easily lose electrons, which increases their stability and allows them to form compounds via ionic bonds.

4. The atomic and ionic radii of alkaline earth metals are smaller than the corresponding members of the alkali metals.

5. On moving down the group, the radii increases due to gradual increase in the number of the shells and the screening effect.

6. Down the group the ionisation enthalpy decreases as atomic size increases. They are less electropositive than alkali metals.

7. Compounds of alkaline earth metals are more extensively hydrated than those of alkali metals because the hydration enthalpies of alkaline earth metal ions are larger than those of alkali metal ions.

Question 38.
Discuss the similarities between beryllium and aluminium.

Answer:
Similarities between Beryllium and Aluminium:

1. Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms a polymeric chain structure in addition to the dimer. Both are soluble in organic solvents and are strong Lewis acids.

2. Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[Be(OH)_4]^{2-}$and hydrogen as aluminium hydroxide which gives aluminate ion, $[Al(OH)_4]^-$.
3. Beryllium and aluminium ions have a strong tendency to form complexes, BeF_4^{2-}, AlF_6^{3-}.

4. Both beryllium and aluminium hydroxides are amphoteric in nature.

5. Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.

6. Both beryllium and aluminum are rendered passive by nitric acid.

Question 39.
Why alkaline earth metals are harder than alkali metals?

Answer:

1. The strength of metallic bond in alkaline earth metals is higher than alkali

metals due to the presence of 2 electrons in its outermost shell as compared to alkali metals, which have only 1 electron in valence shell. Therefore, alkaline earth metals are harder than alkali metals.

2. The alkaline earth metals have greater nuclear charge and more valence electrons, thus metallic bonding is more effective. Due to this they are harder than alkali metals.

Question 40.
How is plaster of paris prepared?

Answer:
Plaster of paris is a hemihydrate of calcium sulphate $CaSO_4$. H_2O. It is obtained by heating gypsum at 393 K.

$$\underset{\text{Gypsum}}{2CaSO_4.2H_2O_{(s)}} \xrightarrow{\Delta} \underset{\text{Plaster of paris}}{2CaSO_4.H_2O} + 3H_2O$$

Question 41.
Give the uses of gypsum.

Answer:

1. Gypsum is used in making drywalls or plasterboards. Plasterboards are used as the finish for walls and ceilings, and for partitions.

2. Another important use of gypsum in the production of plaster of Paris. Gypsum is heated to about 300 degrees Fahrenheit to produce plaster of Paris, which is also known as gypsum plaster. It is mainly used as a sculpting material.

3. Gypsum is used in making surgical and orthopedic casts, such as surgical splints and casting moulds.

4. Gypsum plays an important role in agriculture as a soil additive, conditioner, and fertilizer. It helps loosen up compact or clay soil and provides calcium and sulphur, which are essential for the

healthy growth of a plant. It can also be used for removing sodium from soils having excess salinity.

5. Gypsum is used in toothpaste, shampoos, and hair products, mainly due to its binding and thickening properties.

6. Gypsum is a component of Portland cement, where it acts as a hardening retarder to control the speed at which concrete sets.

Question 42.
Describe briefly the biological importance of calcium and magnesium.

Answer:

1. An adult body contains about 25 g of Mg and 1200 g of Ca. The daily requirement in the human body has been estimated to be 200-300 mg.

2. Magnesium is the co-factor of all enzymes that utilize ATP in phosphate transfer and energy release.
3. The main pigment for the absorption of light in plants is chlorophyll which contains magnesium.

4. About 99% of body calcium is present in bones and teeth.

5. Calcium plays important roles in neuromuscular function, interneuronal transmission, cell membrane integrity and blood coagulation.

6. The calcium concentration in plasma is regulated at about 100 mgL^{-1}. It is maintained by two hormones: calcitonin and parathyroid hormone.

7. Deficiency of magnesium results into convulsion and neuromuscular irritation.

8. 2% of adult weight is made up of calcium. Calcium phosphate is present in teeth and Calcium carbonate is present in bones. They

make the teeth and bone hard.

9. Water in the human body such as inside the cell and in the blood contain dissolved calcium ions. These ions are involved in making muscles move and in sending electricity around the brain and along the nerves.
10. Magnesium is an essential element in both plant and animal life.

Question 43.
Which would you expect to have a higher melting point, magnesium oxide or magnesium fluoride? Explain your reasoning.

Answer:

- Magnesium fluoride – 1263°C
- Magnesium oxide – 2852°C
- The strength of ionic bonds usually depends on two factors – ionic radius and charge. Mg^{2+} and O^{2-} have charges of +2 and -2 respectively. This is larger than the charge of other ions.
- Magnesium ions and oxygen ions also have a small ionic radius.
- Oxygen ion is smaller than fluoride
- The smaller the ionic radii, the smaller the bond length and the stronger the bond. Therefore the ionic bond between magnesium and oxygen is very strong.