UNIT-5 ALKALI AND ALKALINE EARTH METALS

MY REVISION TIMELINE:-

SUMMARY:-

- s-block elements consists of group 1 and 2 elements and are commonly known as alkali and alkaline Earth metals respectively.
- General characteristics of alkali metals:
  - Highly reactive.
  - General electronic configuration – ns^1.
  - Oxidation state is +1.
  - On moving down the group atomic and ionic radii increases.
  - M^+ ions are smaller than the respective parent atoms.
  - Lowest ionisation enthalpy and electronegativity compared to other elements in the respective period.
  - Second ionisation enthalpy is very high.
  - Lithium salts are more stable than the salts of other metals of group 1.
  - Alkali metal salts show characteristic coloured flame.
  - Lithium shows some distinctive behaviour when compared to other elements of the group.
  - Lithium shows diagonal relationship with group 2 magnesium.
- Alkali metals are highly reactive towards more electronegative elements such as oxygen and halogen.
- Important compounds of alkali metals:
  - Sodium carbonate (washing soda) $Na_2CO_3.10H_2O$
  - Sodium chloride (table salt) NaCl
- Sodium-potassium plays an important role in transmitting nerve signals.
- General characteristics for alkaline Earth metals:
  - Electronic configurations – ns^1
  - Atomic and ionic radii of alkaline Earth metals are smaller than the corresponding alkali metals and increases on moving down the group.
  - Common oxidation state is -2.
  - Low ionisation enthalpies compared to p-block elements. Down the group ionisation enthalpy decreases.
  - They are less electropositive than alkali metals.
  - IE_1 values of alkaline Earth metals are higher than that of alkali metals. IE_2 values of alkaline Earth metals are much smaller those of alkali metals.

- Hydration enthalpy order: Be > Mg > Ca > Sr > Ba
- Electronegativity decreases as we go down the group.
- They show characteristic coloured flame.
- Beryllium shows anomalous property due to
  - Small size
  - High electronegativity
  - High ionisation energy
  - High polarising power
- Shows diagonal relationship with aluminium.

➢ Chemical properties of alkaline Earth metals: It reacts with halogen and hydrogen to give corresponding halides and hydrides respectively.

TEXTBOOK EVALUATION

Multiple choice questions:-

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

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.

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**

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

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

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

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

8. Lithium shows diagonal relationship with

(a) sodium **(b) magnesium**

(c) calcium (d) aluminium

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

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

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

Explanation:

$$CaC_2 + N_2 \xrightarrow{300-350^{\circ}C} Ca(CN)_2$$

12. Which of the following has highest hydration energy?

(a) $MgCl_2$ (b) $CaCl_2$

(c) $BaCl_2$ (d) $SrCl_2$

Explanation:

$Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$

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

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

Explanation:

K, Rb and Cs form superoxides. O_2^- - 3 electron bond.

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

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) $BaCO_3 > CaCO_3 > SrCO_3 > MgCO_3$

Explanation:

Beryllium salts are hydrolysed.

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

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

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) $Ca(HCO_3)_2$

Explanation:

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2\uparrow$ (soluble in water) $\xrightarrow{2HCl} 2NaCl + H_2O + CO_2\uparrow$

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) $NaHCO_3$

Explanation:

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow \xrightarrow{H_2O} Ca(OH)_2 \xrightarrow{CO_2} Ca(HCO_3)_2 \xrightarrow{\Delta CO_2} CaCO_3$

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

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

23. Formula of gypsum is …….

(a) $CaSO_4.2H_2O$ (b) $CaSO_4.\ ½2H_2O$

(c) $3CaSO_4.H_2O$ (d) $2CaSO_4.2H_2O$

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) $CaNC_2$

Explanation:

$$CaC_2 + N_2 \xrightarrow{1\ atm} CaNCN$$

25. Among the following the least thermally stable is

(a) K_2CO_3 (b) Na_2CO_3

(c) $BaCO_3$ **(d) Li_2CO_3**

Write brief answers to the following questions:-

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

- The solubility product of **NaCl** is **lower** than that of NaOH.
- The more soluble a substance is, the **higher the K_{SP}** value it has.
- In aqueous solution NaOH gives **OH^-** ions.
- It can be solvated by establishing **H-bonds** with water molecules. So it is more soluble in water.

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

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

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

(*iii*) $NH_4HCO_3 + NaCl \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl} + NaHCO_3$

(*iv*) $2NaHCO_3 \rightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3} + CO_2 + H_2O$

28. An alkali metal (x) forms a hydrated sulphate, $X_2SO_4.10H_2O$. Is the metal more likely to be sodium (or) potassium.

- It is **$Na_2SO_4.10H_2O$**
- Metal is **Na**
- Salt – **washing soda**

29. Write balanced chemical equation for each of the following chemical reactions.

(i) Lithium metal with nitrogen gas

(ii) Heating solid sodium bicarbonate

(iii) Rubidum with oxygen gas

(iv) Solid potassium hydroxide with CO2

(v) Heating calcium carbonate
(vi) Heating calcium with oxygen

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

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

30. Discuss briefly the similarities between beryllium and aluminium.

- Beryllium chloride $BeCl_2$ and Aluminium chloride $AlCl_3$ forms **dimeric structure**. Both are soluble in organic solvents and are **strong Lewis acids**.
- Beryllium and aluminium have **same electronegativity** values.
- Beryllium hydroxide [$Be(OFI)_2$] and Aluminium hydroxide [$Al(OH)_3$] **dissolves** in **excess alkali** to give **beryllate ion** $[Be(OH)_4]^{2-}$ and **aluminate ion** $[Al(OH)_4]^-$, respectively.
- Be and Al ions have **strong tendency** to **form complexes**, e.g. BeF_4^{2-} and AlF_6^{3-}
- Both Beryllium hydroxide [$Be(OFI)_2$] and Aluminium hydroxide [$Al(OH)_3$] are **amphoteric** in nature.
- Carbide of Be – beryllium carbide (Be_2C) and Al – aluminium carbide (Al_4C_3) give **methane** on **hydrolysis**.
- Both beryllium and aluminium are **rendered passive** by **nitric acid**.

31. Give the systematic names for the following
(i) milk of magnesia (ii) lye (iii) lime (iv) Caustic potash (v) washing soda (vi) soda ash (v) trona

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

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

The **lattice energy** of LiF is **higher** due to the **smaller size of Li^+** and **F^-**. So LiF has lower solubility.

33. Mention the uses of plaster of paris.

- The **building industry** as well as **plasters**.
- For **immobilizing** the **affected part of organ** where there is a bone fracture or sprain.

- Employed in **dentistry**, in **ornamental work** and for making **casts of statues** and **busts**.

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

In case of **Beryllium**, the ionisation energy and electronegativity of the **halides** are **almost similar** but there is a **vast difference** in ionisation energy and electronegativity between **Magnesium** and **halides**.

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).

- An alkaline earth (A) metal belongs to third period is magnesium (Mg).
- Magnesium reacts with oxygen to form magnesium oxide (MgO) (B).

  $2Mg + O_2 \rightarrow 2MgO$
- Magnesium reacts with nitrogen to form magnesium nitride Mg_3N_2 (C).

  $3Mg + N_2 \rightarrow Mg_3N_2$
- Magnesium undergoes metal displacement reaction with $AgNO_3$ solution to form magnesium nitrate

  $Mg + 2AgNO_3 \rightarrow Mg(NO_3)_2 + 2Ag$

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

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

(a) $2Ca + O_2 \xrightarrow{\Delta} 2CaO$
Calcium — Quick lime (or) calcium oxide

(b) $CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}\uparrow$
Calcium carbonate — Calcium oxide

(c) $Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + CO_2\uparrow + H_2O$
Calcium hydrogen carbonate

(d) $2CaO + 5C \xrightarrow{\Delta} 2CaC_2 + CO_2\uparrow$
Calcium oxide — Coke — Calcium carbide

37. Explain the important common features of Group 2 elements.

- Group 2 contains **Be, Mg, Ca, Sr, Ba** and **Ra**.
- Group 2 elements **except beryllium** are commonly known as **alkaline earth metals** because their oxides and hydroxides are alkaline in nature and these metal oxides are found in the **Earth's crust**.
- **Radium** is **radioactive**.
- Beryllium is the **rare element** and Radium is the **rarest**

- Many alkaline earth metals are used in creating **colours** and **used in fireworks**.
- Their general electronic configuration is **ns^2**.
- Atomic and ionic radii of alkaline earth metals are smaller than alkali metals, on **moving down the group**, the **radii increases**.
- These elements exhibit **+2 oxidation state** in their compounds.
- Alkaline earth metals have **higher ionization enthalpy** values **than alkali metals**.
- They are **less electropositive than alkali metals**.
- **Hydration enthalpies** of alkaline earth metals **decreases** as we go **down the group**.
- **Electronegativity** values of alkaline earth metals **decrease down the group**.
- Alkaline earth metal salts moistened with **concentrated hydrochloric acid** gave a characteristic **coloured flame**, when heated on a **platinum wire** in a flame.
- All elements except Beryllium combine with hydrogen to **form hydrides** of formula **MH_2**.

38. Discuss the similarities between beryllium and aluminium.

- Beryllium chloride $BeCl_2$ and Aluminium chloride $AlCl_3$ forms **dimeric structure**. Both are soluble in organic solvents and are **strong Lewis acids**.
- Beryllium and aluminium have **same electronegativity** values.
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- Both beryllium and aluminium are **rendered passive** by **nitric acid**.

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

- Alkali metals have **one electron** in their outer most shell.
- Alkaline Earth metals have **two electrons** in their outer most shell.
- More **valence electrons** and more **positively charged nuclei** leads to greater opportunity for **metallic bonding**.

40. How is plaster of paris prepared?

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

$$2CaSO_4.2H_2O_{(s)} \xrightarrow{\Delta} 2CaSO_4.H_2O + 3H_2O$$

Gypsum — Plaster of paris

41. Give the uses of gypsum.

- Gypsum is used in making **dry walls** or **plaster boards**.
- Gypsum is used in the production of **Plaster of Paris**, which is used as a sculpting material
- Gypsum is used in making **surgical** and **orthopedic** casts, such as surgical splints and casting moulds.
- It plays an important role in **agriculture** as a soil additive, conditioner and fertilizer.
- Gypsum is used in **toothpaste**, **shampoo** and **hair products**.

- Gypsum is a component of **Portland cement**, where it acts as a hardening retarder to control the speed at which concrete sets.
- Gypsum is used to give **colour** to **cosmetics** and **drugs**.
- Gypsum plays a very important role in **wine** making.

42. Describe briefly the biological importance of Calcium and magnesium.

- An adult body contains about **25g** of **Mg** and **1200g** of **Ca**.
- Magnesium plays an important role in many biochemical reactions catalysed by **enzymes**. It is the co-factor of all enzymes that utilize **ATP** in phosphate transfer and energy release.
- Magnesium is also essential for **DNA synthesis** and is responsible for the stability and proper functioning of DNA.
- Magnesium is also used for **balancing electrolytes** in our body.
- The main pigment that is responsible for photosynthesis, chlorophyll, contains magnesium which plays an important role in **photosynthesis**.
- Deficiency of magnesium results into **convulsion** and **neuromuscular irritation**.
- Calcium is a major component of **bones** and **teeth**.
- Calcium is also present in in **blood** and its concentration is maintained by **hormones** (calcitonin and parathyroid hormone).
- Calcium is also important for **muscle contraction**.
- Deficiency of calcium in blood causes it to take **longer time to clot**.

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

- Magnesium oxide is having **higher melting point**.
- The lattice energy of MgO & MgF_2 are **3938** and **2957** respectively.
- MgO results in larger amount of lattice energy since it has **higher charge**.
- The strong attraction cause most ionic material to be **hard** and **brittle** and have high melting points.