Chapter 5

Hydrogen and Its Compounds and S-Block Elements

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Key Concepts

HYDROGEN

Hydrogen is the first element of the periodic table. Its electronic configuration is $1s^1$ and it behaves like an alkali metal as well as a halogen. There are three isotopes of hydrogen namely, hydrogen ($_1H^1$), deuterium ($_1H^2$ or D) and tritium ($_1H^3$ or T).

Based on the spinning of two nuclei in dihydrogen, two types of dihydrogen may be distinguished. Ortho-dihydrogen involves parallel spinning while para-dihydrogen involves antiparallel spinning of the two nuclei.

Dihydrogen is relatively inactive (because of high enthalpy 435.kJ Mol^{-1}) at ordinary temperature but quite reactive at high temperature or in the presence of catalysts.

HYDRIDES

These are classified as follows:

- *Ionic Hydrides:* When elements of Groups 1 and 2 (except Be and Mg) and lanthanides, (electronegativity in the range 0.9 to 1.2) from compounds with hydrogen, they are called ionic hydrides. These hydrides are crystalline solids with higher melting points. The stability of hydrides decreases with increase in atomic number of the element in a group. Examples are NaH, CaH_2 etc.
- *Covalent Hydrides:* When element of p-block from compound with hydrogen, they are called covalent hydrides. Examples are NH_3, H_2O etc. These are generally gaseous compound. Their stability with increase in atomic number of elements within group decreases.
- *Interstitial Hydrides:* These are formed by some of the transition metals with electronegativity ranging from 1.2 to 1.4. Mostly these are non-stoichiometric solids and may be considered as interstitial compounds. Varying temperature and pressure may vary the proportion of hydrogen in the compound. Examples are $TiH_{1.73}$, $ZrH_{1.92}$, $VH_{0.6}$ etc.
- *Polymeric Hydrides:* Some elements with electronegativity in the range 1.4 to 2.0 form polymeric hydrides. These are solids containing molecules linked by hydrogen-bridged bonds. Examples include $(BeH_2)_n$, $(MgH_2)_n$ and $(AlH_3)_n$

  Hydrogen finds many uses. For example, for the preparation of NH_3, CH_3OH, synthetic petrol, acetylene, vegetable ghee, $H_2 - F_2$ flame, an oxy-hydrogen flame etc.

WATER

Water (H_2O) is the most abundant liquid i.e., 75% of the earth's surface is full oceans, lakes and rivers. It has bent angular structure with H-O-H bond angle of 104.5°. Because of hydrogen bondings, water unusually has high

melting and boiling points. Because of these bonds, ice is less dense than liquid water. When ice (density = 0.917 g cm^{-3}) is heated, its density increases to 1 g cm^{-3} at 4°C followed by decrease in density as the temperature is further increased.

Water is termed as soft water if it is free from calcium or magnesium salts. If these salts are present, it is termed as hard water. The latter is not useful for washing purposes as soap forms insoluble scum of calcium or magnesium state in hard water.

Temporary hardness in water is due to dissolved bicarbonates of calcium or magnesium. It can removed by boiling water when carbonates are precipitated out. Permanent hardness is due to soluble chloride or sulphate of calcium or magnesium. This hardness can be removed by adding sodium hydroxide, carbonate or sodium phosphate. Ion exchange resins are also used to soften the water.



HYDROGEN PEROXIDE

The two O-H groups in hydrogen peroxide (H_2O_2) do not lie in the same plane. The angle between two planes is 111.5° and it reduces to 90.2° in the crystalline phase. The O-O-H bond on the other hand changes from 94.8° to 101.9°.

Hydrogen peroxide is a strong oxidizing agent. It oxidizes ferrous to ferric, iodide to iodine, lead sulphide to lead sulphate, potassium ferrocyanide to potassium ferricyanide (in acidic medium) and manganese (II) to manganese (IV).

Hydrogen peroxide also acts as a reducing agent. It reduces permanganate to manganese (II), iron (III) to iron (II), ferricyanide to ferrocyanide (in alkaline medium), periodate to iodate, ozone to oxygen and silver to metallic.

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SUMMARY OF PREPARATION AND PROPERTIES OF DIHYDROGEN

H_2
DIHYDROGEN

PREPARATION

From water (H_2O)

(a) By reaction with metals

- Active metals (Na, K, Ca) react at room temperature
- Metals like Mg, Zn, Al react on heating
- Metals like Fe, Ni, Sn react with steam

$H_2O + Na \longrightarrow NaOH + H_2$

$H_2O + 2Mg \longrightarrow 2MgO + H_2$

$4H_2O + 3Fe \xrightleftharpoons{1000k} Fe_3O_4 + 4H_2$

(b) Electrolysis of acidic or alkaline water

$2H_2O \xrightarrow{\text{Electricity}} O_2 + 2H_2$

From Acids by reaction with active metals

$2HCl + Mg \longrightarrow MgCl_2 + 2H_2$

$H_2SO_4 + Zn \longrightarrow ZnSO_4 + H_2$

From Conc. Alkalies by reaction with elements like

Zn, Sn, Al, Be, B, Si etc.

$2Al + 2NaOH + 2H_2O \longrightarrow NaAlO_2 + 3H_2$

$Sn + 2NaOH + H_2O \longrightarrow Na_2SnO_3 + 2H_2$

Laboratory Preparation

$H_2SO_4 + Zn \longrightarrow ZnSO_4 + H_2$ (dil.)

Uses

- In Preparation of ammonia
- Hydrogenation of oils
- In oxy-hydrogen and atomic hydrogen torch
- Liquid H_2 is used as prospective fuel.

PROPERTIES

Physical Properties

- Colourless
- Tasteless
- Odourless
- Highly combustible
- High value of $\Delta H_{H\text{-}H}$ (436 KJ mol^{-1})

Chemical Properties

Metals react to form respective hydrides

$H_2 + 2Na \xrightarrow{525K} 2NaH$

$H_2 + Ca \xrightarrow{525K} CaH_2$

Non-Metals form respective hydrides

$2H_2(g) + O_2(g) \xrightarrow[\text{or sunlight}]{970K} 2H_2O$

$3H_2(g) + N_2(g) \xrightarrow{Fe/Mo,\ 770K} 2NH_3$

$H_2(g) + S(I) \longrightarrow H_2S$

$2H_2(g) + 2C(s) \xrightarrow{1275K} C_2H_2$

$H_2(g) + X_2(g) \xrightarrow[3000K]{\text{Electric arc}} 2HX(X = F,Cl,Br\ I)$

Metals Oxides are reduced to metals

$H_2 + PbO \longrightarrow Pb + H_2O$

$2H_2 + CO \xrightarrow[ZnO/Cr_2O_3]{700K,\ 200atm.} CH_3OH$

Unsaturated hydrocarbons get hydrogenated

$H_2 + CH_2 = CH_2 \xrightarrow{Pt} CH_3\text{-}CH_3$

$2H_2 + CH \equiv CH \xrightarrow{Pt} CH_3\text{-}CH_3$

$H_2 + \text{Vegetable oils} \xrightarrow{Ni} \text{Fats}$

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H_2O WATER

Physical Properties

- The composition of hydrogen and oxygen elements by mass is 1:8 and by volume it is 2:1.
- It is a covalent compound with bent structure. The O-H bonds are sp^3-sσ - bonds and angle around O is 104.5°.
- Its dipole moment is 1.83D and dielectric constant is 82.5.
- Excellent solvents for large number of ionic as well as covalent substances.
- Interpartical forces in **water** and **ice** are **H-bonds.**
- Density of ice is less than water because of open cage like structure of ice.
- Density of water is maximum (1.0 g cm^{-3}) at 277 K.
- Dissociation constant (K_w) of water at 25° C is 1×10^{-14} and $pK_w = 14$.

Chemical Properties

Dissociation of water

$$H_2O \xrightarrow{\text{High temp.}} H_2 + \frac{1}{2}O_2$$

Dissociation is 0.2% even at 1500 K

Amphoteric nature of water

$$H_2O + NH_3 \rightleftharpoons NH_4^+ + OH^-$$

Acid

$$H_2O + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

Base

Self ionization of water

$$H_2O + H_2O \longrightarrow H_3O^+ + OH^-$$

Active metals decompose water to liberate H_2

$$H_2O + 2Na \longrightarrow 2NaOH + H_2$$

$$H_2O + Zn \xrightarrow{\text{Heat}} ZnO + H_2$$

In these reactions H_2O acts as a weak oxidant. It can reduce highly electronegative elements such as halogens, carbon, etc.

$$2H_2O + 2Cl_2 \longrightarrow 4HCl + O_2$$

$$C + H_2O(g) \longrightarrow CO + H_2$$

Red Hot Coke

Hydrolytic Reactions

$$3H_2O + PBr_3 \longrightarrow H_3PO_3 + 3HBr$$

$$2H_2O + SiCl_4 \longrightarrow SiO_2 + 4HCl$$

$$6H_2O + Ca_3P_3 \longrightarrow Ca(OH)_2 + 2PH_3$$

$$2H_2O + CaH_2 \longrightarrow Ca(OH)_2 + H_2$$

$$2H_2O + CaC_2 \longrightarrow Ca(OH)_2 + C_2H_2$$

$$12H_2O + Al_4C_3 \longrightarrow 4Al(OH)_3 + 3CH_4$$

$$H_2O + CaNCN \longrightarrow CaCO_3 + 2NH_3$$

$$6H_2O + Mg_3N_2 \longrightarrow 3Mg(HO)_2 + 2NH_3$$

Hydrate Reactions

$$CuSO_4(s) + 5H_2O \longrightarrow CuSO_4.5H_2O(s)$$

$$AlCl_3 + 6H_2O \longrightarrow AlCl_3.6H_2O$$

$$BeCl_2 + 2H_2O \longrightarrow BeCl_2.2H_2O$$

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H_2O_2 HYDROGEN PEROXIDE

PREPARATION

- **Merck's method**

$Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$

- **From Barium peroxide**

$BaO_2.8H_2O + H_2SO_4 \longrightarrow BaSO_4\downarrow + 8H_2O + H_2O_2$

$BaO_2.8H_2O + H_3PO_4 \longrightarrow Ba_3(PO_4)_2\downarrow + 8H_2O + 3H_2O_2$

- **Electrolysis 50% H_2SO_4**

$H_2SO_4 \longrightarrow H^+ + HSO_4$

Cathode:- Anode:-

$2H^+ + 2e^- \longrightarrow H_2$ $2HSO_4^- \longrightarrow H_2S_2O_8 + 2e$

$H_2S_2O_8 + H_2O \longrightarrow 2H_2O_2 + H_2SO_4$

- **Electrolysis of $(NH_4)_2SO_4$ (H_2SO_4 mixture)**

$(NH_4)_2SO_4 + H_4SO_4 \longrightarrow 2NH_4HSO_4$

$NH_4SO_4^- + H^+ \longleftarrow$

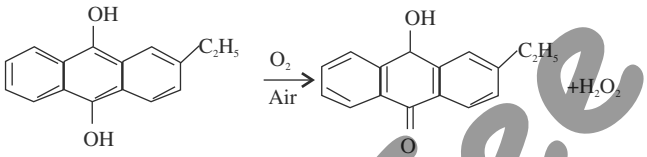
Cathode:- Anode:-

$2H^+ + 2e^- \longrightarrow H_2$ $2NH_4SO_4^- \longrightarrow (NH_4)_2S_2O_8 + 2e^-$

$(NH_4)_2S_2O_8 + H_2O \longrightarrow 2NH_4HSO_4 + H_2O_2$

Amm. Persulphate

- **Air oxidation of 2-enthraquinol**



Concentration

Dilute solution of H_2O_2 is concentrated by various steps like slow evaporation on water bath, evaporation in vacuum decicator, distillation under reduced pressure and finally freezing.

Storage: It is stored in a dark bottle and its decomposition is retarded by stabilizers like glycerol, acetanilide, uric acid, barbituric acid, etc.

PROPERTIES

Physical Properties

- Colourless, syrupy liquid with odour like nitric acid
- Soluble in alcohol, ether
- Density 1.44 g/cm^3
- BP = 423K at 670 mm; 358K at 68 mm

Chemical Properties

- **Decomposition**

$2H_2O_2 \longrightarrow 2H_2O + O_2$; $\Delta H = -196$ kJ

Decomposition is felicitated by Pt carbon

- **Acidic Nature** ($Ka = 1.5 \times 10^{-12}$)

$H_2O_2 + 2NaOH \longrightarrow Na_2O_2 + 2H_2O$

$H_2O_2 + NaCO_3 \longrightarrow Na_2O_2 + H_2O + CO_2$

- Oxidising behaviour

$4H_2O_2 + PbS \longrightarrow PbSO_4 + 4H_2O$

$H_2O_2 + NO_2^- \longrightarrow NO_3^- + H_2O$

$H_2O_2 + 2I^- + 2H^+ \longrightarrow I_2 + H_2O$

$H_2O_2 + 2Fe^{2+} + 2H^+ \longrightarrow 2Fe^{3+} + 2H_2O$

$H_2O_2 + AsO_3^{3-} \longrightarrow AsO_4^{3-} + H_2O$

$H_2O_2 + 2[Fe(CN)_6]^{4-} \longrightarrow 2[Fe(CN)_6]^{3-} + 2H_2O$

$4H_2O_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow CrO_5 + H_2O$

- Reducing Nature

$H_2O_2 + Ag_2O \longrightarrow 2Ag + H_2O + O_2$

$H_2O_2 + PbO_2 \longrightarrow PbO + H_2O + O_2$

$H_2O_2 + O_3 \longrightarrow H_2O + 2O_2$

$5H_2O_2 + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

$H_2O_2 + Cl_2 \longrightarrow 2HCl + O_2$

$H_2O_2 + 2[Fe(CN)_6]^{3-} \xrightarrow{2OH^-} 2[Fe(CN)_6]^{4-} + 2H_2O + O_2$

$H_2O_2 + NaOBr \longrightarrow NaBr + H_2O + O_2$

$H_2O_2 + CaOCl_2 \longrightarrow CaCl_2 + H_2O + O_2$

Bleaching action H_2O_2: H_2O_2 is used to bleach delicate articles like ivory silk, feather, wool, etc. The bleaching action is due to its ability to oxidise the colouring matter.

$H_2O_2 \longrightarrow H_2O + O$

Coloring matter + (O) $\longrightarrow$ Oxidised matter (Colourless)

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S-Block Elements

(a) Element of group 1 (or I A) and 2(or II A) are known as s-block elements.
(b) General electronic configuration are
Group 1 [Inert gas]ns^1 Alkali metals
Group 2 [Inert gas]ns^2 Alkaline Earth metals

Property	Alkali metal	Alkaline earth metal
Physical state	(a) All are silvery white.	(a) All are grayish white.
	(b) Light soft, malleable and ductile metals with metallic luster.	(b) Relatively harder.
	(c) Both are diamagnetic and colourless.	
Flame colour	(a) Both produce characteristic colours in Bunsen flame due to easy excitation of electron to higher energy levels.	(a) Be and Mg do not show any colour as their electrons are more strongly bound.
	(b) Characteristic flame colours are Li – Crimson, Na – Golden Yellow, K – Pale violet, Rb and Cs – Violet	(b) Ca – Brick red, Sr - Crimson Ba – apple green, Ra - Crimson
	(c) Energy released $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$	(c) Be and Mg atoms due to their small size, bind their electrons more strongly because of higher effective nuclear charge. Hence these posses high excitation energy and are not excited by the flame energy and do not show any colour.
	(d) The flame energy cause an excitation of the outermost electron which on reverting back to its initial position gives out the absorbed energy as visible light.	
Ionisation energy	(a) Due to unpaired lone electrons in ns sub shell as well as due to their larger size, the outermost electron is far from the nucleus, the removal of electron is easier and these have low values of ionization potential.	(a) Due to smaller size, electrons are tightly held as compared to alkali metal.
	(b) IP of these metals decreases from Li to Cs	(b) The IP value decreases with increase of atomic radii from Be to Ba.
Hydration of ions	(a) Hydration represents for the dissolution of a substance in water to absorb water molecule by weak valency forces. Hydration of ions in the process when ions on dissolution in water get hydrated.	
	(b) Smaller the cation greater is the degree of hydration. Hydration energy- $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$	(b) Hydration energy- $Be^{+2} > Mg^{+2} > Ca^{+2} > Sr^{+2} > Ba^{+2}$
	(c) Li^+ being smallest in size has maximum Degree of hydration and that is why lithium Salts are mostly hydrated and moves very slowly under the influence of electric field.	

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Property	Alkali metal	Alkaline earth metal
Oxidation numbers and valency	These metals easily form univalent +ve ion by losing solitary ns^1 electron due to low IP value.	The IP_1 of these metals are much lower than IP_2 and thus it appears that these metals should form univalent ion rather than bivalent ions but in actual practice, all these give bivalent ions.
Electro negativity	(a) These metals are highly electropositive thereby posses low values of electro-negativities	(a) Their electro negativities are also small but are higher than of alkali metals.
	(b) Electro-negativity of alkali metals decreases down the group Li > Na > K > Rb > Cs	(b) Electro-negativity decrease form Be to Ba.
Standard oxidation potentials are reducing properties	(a) Since alkali metals easily loose ns^1 electron they have high value of oxidation potential i.e., $M \longrightarrow M^+_{(aq)} + e^-$	(a) They lose two electrons to give M^{+2} ion.
	(b) Standard oxidation potential are listed below Li Na K Rb Cs 3.05 2.71 2.93 2.99 2.99	(b) Standard oxidation potential are Be Mg Ca Sr 1.69 2.35 2.87 2.90
	(c) Li have greatest reducing nature due to maximum hydration energy of Li^+ ion.	
Action with air	(a) On exposure to moist air, all alkali metals except lithium tarnish quickly.	(a) Except beryllium these metals are easily tarnish in air as a layer of oxide is formed on their surface.
	(b) They generally form oxides and peroxides. $M + O_2 \xrightarrow{O_2} M_2O \xrightarrow{O_2} M_2O_2 \longrightarrow MO_2$	(b) They give oxides of ionic nature $M^{+2}O^{-2}$ which are crystalline in nature.
Action with water	(a) Alkali metals decompose water with the evolution of hydrogen $2M + 2H_2O \rightarrow 2MOH + H_2$	(a) Ca, Sr, Ba and Ra decompose cold water readily with evolution of hydrogen. $2M + 2H_2O \rightarrow 2M(OH)_2 + H_2$
	(b) Li decompose water slowly, sodium reacts water quickly. K, Rb and Cs react with water vigorously.	(b) Magnesium decomposes boiling water beryllium is not attacked even at high temperatures.
	(c) Alkali metals react with alcohols forming alkoxides with the evolution of hydrogen: $2Li + 2C_2H_5OH \longrightarrow 2C_2H_5OLi + H_2$ Ethy alcohol Lithium ethoxide	
Hydride	(a) These metals combine with H_2 to give white crystalline ionic hydrides of the general formula MH.	(a) Except Be, all alkaline earth on heating directly with H_2.
	(b) The metal hydrides react with water to give MOH and H_2: $MH + H_2O \longrightarrow MOH + H_2$	(b) BeH_2 is prepared by the action of $LiAlH_4$ on $BeCl_2$: $BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$
		(c) The ionic hydrides of Ca, Sr, Ba liberate H_2 at anode and metal at cathode.

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Property	Alkali metal	Alkaline earth metal
Carbonates And bicarbonates	(a) The carbonates (M_2CO_3) and bicarbonates ($MHCO_3$) are highly stable to heat, where M stands for alkali metals	(a) All these metal carbonates MCO_3 are insoluble in neutral medium but soluble in acids and decompose on heating.
	(b) The stability of these salts increases with the increasing electropositive character from Li To Cs. Therefore Li_2CO_3 decompose on heating.	(b) The stability of carbonates increase in electropositive character metal.
	(c) Bicarbonates are decomposed at relatively high temperature. $2MHCO_3 \xrightarrow{300°C} M_2CO_3 + H_2O + CO_2$	(c) Bicarbonates of alkaline earth metals do not exit in solid state but are known in solution only on heating their solution bicarbonate decomposed to liberate: $M(HCO_3)_2 \longrightarrow MCO_3 + CO_2 + H_2O$
Halides	(a) Alkali metals combine directly with halogens to from ionic halide MX.	(a) The alkaline earth metals directly combine with halogens on heating to give metal halides MX_2.
	(b) The ease with which the alkali metals form halides increases form Li to Cs due to increase in electropositive character.	(b) The ionic character of halides increases from Be to Ra.
	(c) LiX has more covalent character.	(c) Beryllium halides have covalent Character due to size and high effective nuclear charge and thus do not conduct electricity in molten state.
	(d) Halides having ionic nature high melting point and are good conductor of current in fused state. These are readily soluble in water.	(d) The solubility of halides in water decreases down the group. Except fluorides, all are fairly soluble in water.
	(e) Halides of potassium, rubidium and ceasium have property of combining with extra halogen atoms forming polyhalides: $KI + I_2 - KI_3$	(e) The decrease is solubility of halide down the group is due to decreas in hydration energy because of increasing size of metal cation. Solubility OH increase down the group
		(f) The halides are hygroscopic and readily form hydrates $CaCl_2.6H_2O$, $BaCl_2.2H_2O$ Otherwise down the group lattice and hydration energy incomplete
Sulphates	(a) All these form sulphates of type M_2SO_4.	(a) MSO_4
	(b) Except Li_2SO_4 rest are soluble in water. Down the group stability and solubility increases.	(b) The solubility of sulphates decreases on moving down the group. $BeSO_4$ is soluble in water while $BaSO_4$ is completely insoluble
Nitrates	(a) Nitrates of both are soluble in water and decompose on heating.	
	(b) $LiNO_3$ decompose to give NO_2 and O_2 rest all give nitrites and oxygen. $2MNO_3 \rightarrow 2MNO_2 + O_2$ (except Li) $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$	(b) On heating they decompose into their corresponding oxides with evolution of a mixture of nitrogen dioxide and oxygen $M(NO_3)_2 \rightarrow MO + 2NO_2 + \frac{1}{2}O_2$
Solution of Liquid NH_3	Forms deep blue solution with liquid Ammonia which is conducting and paramagnetic in nature.	Except Be and Mg, all others form a deep blue-black solution with liquid ammonia.

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Solved Examples

1. Incorrect statement for H_2O_2 is:

(a) Decomposition of H_2O_2 is a disproportionation reaction.

(b) Aqueous solution of H_2O_2 is weakly acidic.

(c) Bleaching action of H_2O_2 is due to its reducing nature.

(d) H_2O_2 is used in refreshing old lead paintings PbS (black) converts into $PbSO_4$ (white) in presence of H_2O_2.

Sol. (c) $2H_2O_2 \rightarrow 2H_2O + O_2$ (disproportionation)

H_2O_2 is very good oxidizing and poor reducing agent. Its bleaching action is due to its oxidising nature.

$PbS + H_2O_2 \rightarrow PbSO_4 + H_2O$
(black) (white)

2. In which property listed below hydrogen does not resemble alkali metals?

(a) Tendency to form cation

(b) Nature of oxide

(c) Combination with halogens

(d) Reducing character

Sol. (b) H_2O is neutral while alkali metal oxides are basic in nature.

3. Calgon causes the softening of hard water by:

(a) Sequestraction of Ca^{2+} and Mg^{2+} ion

(b) Sequestraction of Cl^- and SO_4^{2-} ion

(c) Precipitation the Ca^{2+} and Mg^{2+} ions as phosphates

(d) Precipitation the Ca^{2+} and Mg^{2+} ions as sulphates

Sol. (a) Calgon is sodium hexametaphosphate $Na_6(PO_3)_6$ or $Na_2[Na_4(PO_3)_6]$

$2Ca^{+2} + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Ca_2(PO_3)_6] + 4Na^+$
Soluble complex

It is sequestraction of Ca^{+2} and Mg^{+2}

4. Which elements out of the following do not produce hydrogen on treatment with caustic soda?

A (Zn); B (Sn); C (Mg); D (Cu); E (Al)

(a) A, E (b) C, D (c) D, E (d) B, D

Sol. (b) Mg and Cu do not produce hydrogen on treatment with caustic soda (NaOH)

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2 \uparrow$

$Sn + 2NaOH + H_2O \rightarrow Na_2SnO_3 + 2H_2 \uparrow$

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2 \uparrow$

5. In which reaction, hydrogen peroxide neither acts as oxidizing agent nor reducing agent?

(a) $Na_2CO_3 + H_2O_2 \rightarrow$

(b) $PbS + H_2O_2 \rightarrow$

(c) $Cr_2O_7^{2-} + H^+ + H_2O_2 \rightarrow$

(d) $SO_3^{2-} + H_2O_2 \rightarrow$

Sol. (a) $Na_2CO_3 + H_2O_2 \rightarrow Na_2O_2 + CO_2 + H_2O$
Here, H_2O_2 acts as acid.

6. Alkali metals dissolve in liquid ammonia to give a blue colored solution which is due to the presence of –

(a) M – atoms (b) M^+ ions

(c) Solvated anions (d) Solvated electrons

Sol. (d) The blue colored solutions of an alkali metal in ammonia is explained on the basis of formation of ammoniated (solvated) metal cations and ammoniated (solvated) electrons in the metal ammonia solution in the following way:

$M \longrightarrow M^+ + e^-$

$M^+ + xNH_3 \longrightarrow [M(NH_3)_x]^+$

$e^- + yNH_3 \longrightarrow [e(NH_3)_y]^-$

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

(Solvated metal cation) (solvated electron)

The blue colour of the solution is due to excitation of free electrons to higher energy levels. The absorption of photons takes place in the red region of the spectrum and hence, the solution appears blue in the transmitted light. As the concentration of the alkali metal increases, the metal ion cluster formation takes place and at very high concentration the solution becomes colored like that of metallic copper.

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7. Which of the following is an incorrect statement?
(a) Sodium oxide is more basic then magnesium oxide.
(b) Beryllium oxide is amphoteric.
(c) The thermal stability of beryllium carbonate is more than of calcium carbonate.
(d) Beryllium is amphoteric.

Sol. (c) The thermal stability of calcium carbonate is more as compared to that of beryllium carbonate. The ionic potential (Φ) value of Be^{2+} is more than that Ca^{2+}. So Be^{2+} attracts the oxygen of CO_3^{2-} more and on heating beryllium carbonate looses CO_2 more easily.

8. In the Solvay process of manufacture of sodium carbonate, the raw materials used are:
(a) aqueous NaOH, NH_3 and CO_2
(b) molten NaOH, NH_3 and CO
(c) brine NaCl, NH_3 and CO
(d) brine NaCl, NH_3 and CO_2

Sol. (d) The chemical reactions involved in Solvay process are as below:

$$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$$

$$NH_4HCO_3 + NaCl \xrightarrow{30°C} NaHCO_3\downarrow + NH_4Cl$$

$$2NaHCO_3 \xrightarrow{250°C} Na_2CO_3 + H_2O + CO_2$$
(used again)

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3$$
Slaked lime (used again)

9. The ion of which of the following metals has least ionic conductivity in the aqueous solution?
(a) Lithium (b) Sodium
(c) Potassium (d) Rubidium

Sol. (a) Li^+ forms $[Li(H_2O)_4]^+$ in water because of its smallest size and highest charge to size ratio. The size of this hydrated ion is biggest and thus ionic conductivity is least.

10. The compound X on heating gives a colorless gas. The residue is dissolved in water to obtain Y. Excess of CO_2 is bubbled through aqueous solutions of Y and Z is formed. Z on gentle heating gives back X. The compound X is:
(a) $CaCO_3$ (b) Na_2CO_3
(c) $CaSO_4.2H_2O$ (d) K_2CO_3

Sol. (a) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
[X]

$$CaO + H_2O \longrightarrow Ca(OH)_2$$
[Y]

$$Ca(OH)_2 + CO_2 \longrightarrow Ca(HCO_3)_2$$
[Y] (excess) [Z]

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + H_2O + CO_2$$
[Y] [X]

11. Number of crystal water in Gypsum, Plaster of Paris and Epsom salt respectively are:
(a) 2, 0.5, 7 (b) 7, 2,1
(c) 7, 0.5, 2 (d) 3, 4, 2

Sol. (a) The formulae of Gypsum, Plaster of Paris and Epsom salt are-

$CaSO_4.2H_2O$, $CaSO_4.0.5H_2O$ and $MgSO_4.7H_2O$

12. Nitrolim (a nitrogenous fertilizer) is a mixture of:
(a) Calcium carbide and calcium cyanamide
(b) Calcium oxide and calcium carbide
(c) Calcium cyanamide and carbon
(d) Calcium oxide and carbon

Sol. (c) $CaC_2 + N_2 \xrightarrow{1000°c} CaCN_2 + C$
Cal. Cynamide
Nitrolim

13. On exposure to air, sodium hydroxide becomes liquid and after sometimes it changes to whites powder. Why?

Sol. Sodium hydroxide continuously absorbs carbon dioxide of atmosphere and is converted into sodium carbonate. A stage reaches when the solution becomes saturated and the crystals are formed. These crystals, with the crystallization (efflorescence) and crumble to white powder.

14. An aqueous solution of iodine becomes colourless on adding excess of sodium hydroxide solution. Why?

Sol. Iodine reacts with NaOH forming colourless compounds. Thus, the color of iodine disappears on addition of NaOH.

$$2NaOH + I_2 \longrightarrow NaI + NaIO + H_2O$$
Colourless products

15. The addition of NaOH solution to a solution of $ZnCl_2$ produces a white precipitate which dissolves on further addition of NaOH. Why?

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Sol. $ZnCl_2$ reacts with NaOH to gives white precipitate of $Zn(OH)_2$ which later on gets dissolved in excess of NaOH because of formation of soluble sodium zincate.

$$ZnCl_2 + 2NaOH \longrightarrow \underset{\text{(Insoluble)}}{2NaCl + Zn(OH)_2}$$

$$Zn(OH)_2 + 2NaOH \longrightarrow \underset{\text{(Soluble)}}{Na_2ZnO_2 + 2H_2O}$$

16. NaCl in earlier days used to manufacture NaOH and Cl_2 involving following steps. Identify (A) to (I) in the following:

$$NaCl + \text{conc. } H_2SO_4 \xrightarrow{\Delta} (A) + (B)\ (gas)$$

$$(B)\ gas \xrightarrow{MnO_2} (C)\ gas$$

$$(A) + NaCl \xrightarrow{\Delta} (D) + (C)\ gas$$

$$(D) + carbon + CaCO_3 \longrightarrow (E) + (F)$$

$$CaCO_3 \xrightarrow{\Delta} (G) + (H)\ gas$$

$$(G) + H_2O \longrightarrow (I)$$

$$(I) + (E) \longrightarrow NaOH + CaCO_3$$

Sol. $NaCl + \text{conc.}H_2SO_4 \longrightarrow \underset{(A)\quad(B)}{NaHSO_4 + HCl}$

$$\underset{(B)}{HCl} \xrightarrow{MnO_2} Cl_2$$

$$\text{Or } \underset{(B)}{MnO_2} + 4HCl \xrightarrow{\Delta} \underset{(C)}{MnCl_2} + Cl_2 + 2H_2O$$

$$\underset{(A)}{NaHSO_4} + NaCl \xrightarrow{\Delta} \underset{(D)}{Na_2SO_4} + HCl$$

$$\underset{(D)}{Na_2SO_4} + carbon + CaCO_3 \xrightarrow{\Delta} \underset{(E)}{Na_2CO_3} + \underset{(F)}{CaSO_4}$$

$$\underset{(G)}{CaCO_3} \xrightarrow{\Delta} CaO + \underset{(H)}{CO_2}$$

$$\underset{(G)}{CaO} + H_2O \longrightarrow \underset{(I)}{Ca(OH)_2}$$

$$\underset{(I)}{Ca(OH)_2} + \underset{(E)}{Na_2CO_3} \longrightarrow 2NaOH + CaCO_3$$

17. Magnesium metal burns in air to give a white ash. When ash is treated with water, the odour of ammonia can be detected. What is the reason?

Sol. Mg burns in air to form MgO and Mg_3N_2. It is the Mg_3N_2 which on hydrolysis gives NH_3

$$2Mg + O_2 \longrightarrow 2MgO$$

$$3Mg + N_2 \longrightarrow Mg_3N_2$$

$$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$$

18. Element (A) burns in nitrogen to give an ionic compound, (B) reacts with water to give (C) and (D). A solution of (C) becomes milky on bubbling carbon dioxide. Identify (A), (B), (C) and (D).

Sol. (a) Since element (A) burns in nitrogen to give an ionic compound, therefore (B) must be a metal nitride

(b) Since (B), a metal nitride reacts with water, (B) is ionic nitride and the product formed, i.e., (C) and (D) are metal hydroxides and ammonia, (NH_3)

(c) Since (C) become milky on bubbling CO_2, (C) must by calcium hydroxide, $Ca(OH)_2$.

All reactions involved in the question can be explained as follows:

$$\underset{(A)}{3Ca_{(s)}} + \underset{(B)}{N_{2(g)}} \xrightarrow{\Delta} \underset{\text{Calcium nitride}}{Ca_3N_{2(s)}}$$

$$\underset{(B)}{Ca_3N_2} + 6H_2O \longrightarrow \underset{\text{Calcium Hydroxide(C)}}{3Ca(OH)_2} + \underset{\text{Ammonia (D)}}{2NH_3(g)}$$

$$Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{Calcium Carbonate (milkiness) (D)}}{CaCO_3\downarrow} + H_2O$$

Thus, (A) = Ca, (B) = Ca_3N_2, (C) = $Ca(OH)_2$ (D) = NH_3

19. An aqueous compound of an inorganic compound (X) shows the following reactions:

(a) It decolourises an acidified $KMnO_4$ solution accompanied by the evolution of oxygen.

(b) It liberates I_2 from an acidified KI solution.

(c) It gives a brown precipitate with alkaline $KMnO_4$ solution with evolution of oxygen.

(d) It removes black stains from old oil paintings.

Identify X and give chemical equation for the reactions at steps (a) to (d).

Sol. (X) is H_2O_2.

a. $2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \longrightarrow$

$\underset{\text{Purple Coloured}}{\quad} K_2SO_4 + \underset{\text{Colourless}}{2MnSO_4} + 8H_2O + 5O_2$

b. $2KI + H_2SO_4 + H_2O_2 \longrightarrow K_2SO_4 + I_2 + 2H_2O$

c. $2KMnO_4 + 3H_2O_2 \longrightarrow$

$2KOH + \underset{\text{Brown}}{2MnO_2} + 2H_2O + 3O_2$

d. $\underset{\text{Black}}{PbS} + 4H_2O_2 \longrightarrow \underset{\text{White}}{PbSO_4} + 4H_2O$

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20. Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce gas A and alkaline solution. The solution on exposure to air produces a thin solid layer of on the surface. Identify the compounds A and B.

Sol. $Ca + N_2 \xrightarrow{\Delta}$ white powder

$\downarrow H_2O$

Gas (A) + alkaline solution

$\downarrow$ Air

thin solid layer

(B)

Ca on heating with N_2 produces calcium nitride, Ca_3N_2, a white powder. Ca_3N_2 on reacting with water produces ammonia gas NH_3, i.e. A and alkaline solution, atmospheric CO_2 to give insoluble $CaCO_3$.

$$3Ca + N_2 \xrightarrow{\Delta} Ca_3N_2$$

$$Ca_3N_2 + 6H_2O \longrightarrow \underset{\substack{\text{Calcium}\\ \text{hydroxide}\\ \text{(alkaline solution)}}}{3Ca(OH)_2} + 2NH_3$$

$$\underset{\text{(air)}}{Ca(OH)_2 + CO_2} \longrightarrow \underset{\text{(B)}}{CaCO_3\downarrow} + H_2O$$

Exercise

LEVEL I

1. Which pair of species can undergo chemical reaction with each other?
(a) CO and NO
(b) LiH and H_2O
(c) CO_2 and HCl
(d) CaH_2 and SiH_4

2. Which type of element forms ionic hydrides?
(a) Transition elements
(b) Metalloids
(c) Elements with high electronegativity
(d) Elements with high electropositivity

3. The three isotopes of hydrogen differ from one another in:
(a) Atomic number
(b) Number of protons
(c) Nuclear charge
(d) Nuclear mass

4. Electrolysis of which of the following liberates hydrogen gas at anode?
(a) Aq. H_2SO_4
(b) Aq. $CuSO_4$
(c) Molten calcium hydride
(d) Aq. barium hydroxide

5. Which of the following operation would cause removal of temporary hardness of water?
(a) passing CO_2 gas through it
(b) passing SO_2 gas through it
(c) adding calculated amount of $Ca(OH)_2$
(d) adding calculated amount of sodium hypophosphate.

6. When temporary hard water containing $Mg(HCO_3)_2$ is boiled the percipitate formed is of:
(a) $MgCO_3$
(b) MgO
(c) $Mg(OH)_2$
(d) None of these

7. In which of the following reactions hydrogen act as oxidizing agent?
(a) $Ca + H_2 \rightarrow$
(b) $H_2 + O_2 \rightarrow$
(c) $H_2 + F_2 \rightarrow$
(d) $CuO + H_2 \rightarrow$

8. Which forces of attraction are responsible for liquefication of H_2?
(a) Dispersion forces
(b) Hydrogen bonding
(c) Dipole force
(d) All of these

9. Adsorbed hydrogen by Palladium is known as:
(a) Atomic (b) Nascent
(c) Occuluded (d) Heavy

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10. Which of the following is not a peroxide?

(a) Na_2O_2 (b) BaO_2

(c) PbO_2 (d) H_2O_2

11. The ortho and para-hydrogens possess:

(a) Same physical properties but different chemical properties

(b) Different physical properties but same chemical properties

(c) Same chemical and physical properties

(d) Different physical and chemical properties

12. Which is correct about the reaction between H_2O_2 and O_3?

(a) It is a case of mutual reduction

(b) O_3 will oxidise H_2O_2 into O_2

(c) It is not a redox reaction

(d) H_2O_2 being a stronger oxidizing agent will decompose ozone into oxygen

13. Alkali metal superoxides contain the (O_2^-) ion. They are:

(a) Paramagnetic

(b) Coloured compounds

(c) Oxidizing agents

(d) All of these

14. On heating sodium metal in the current of dry ammonia leads to the formation of which gas?

(a) $NaNH_2$ (b) NaN_3

(c) NH_3 (d) H_2

15. Which of the following s-block elements react with NaOH to give water soluble complex?

(a) Al (b) Ca

(c) Be (d) Li

16. Which of the following element is common in microcosmic salt and Glauber's salt?

(a) N (b) Na

(c) K (d) Both (a) and (b)

17. Which of the following elements does not form hydride by direct heating with dihydrogen?

(a) Be (b) Mg

(c) Sr (d) Ba

18. A metal chloride, when placed on a platinum wire in Bunsen flame, does not produce any distinctive colour. The cation of chloride is:

(a) Li^+ (b) Mg^{2+}

(c) Na^+ (d) Ca^{2+}

19. Which of the following properties of IA group metals increases as the atomic number rises?

(I) Metallic character

(II) Ionic radius

(III) Melting point

(IV) Density

(V) Ionization potential

(a) I, II, III (b) I, II

(c) III, IV, V (d) All

20. Which of the following statements is not true about the dilute solutions of alkali metals in liquid ammonia?

(a) They are deep blue coloured solutions

(b) They are highly conducting in nature

(c) They are diamagnetic in nature

(d) Ammoniated cation and ammoniated anion are formed in the solution.

21. Which of the following equations is not involved in the Solvay process?

(a) $CaCO_3 \rightarrow CaO + CO_2$

(b) $NaCl + NH_3 + H_2O + CO_2 \rightarrow NH_4Cl + NaHCO_3$

(c) $CaO + 2NH_4Cl \rightarrow 2NH_3 + H_2O + CaCl_2$

(d) $Na_2CO_3 + CO_2 + H_2O \rightarrow 2NaHCO_3$

22. Which of the following property of alkaline earth metals increases with increasing atomic number?

(a) Ionization potential

(b) Solubility of hydroxides

(c) Solubility of sulphates

(d) Density

23. Among the carbonates of alkali metals which one has highest thermal stability?

(a) Cs_2CO_3 (b) Rb_2CO_3

(c) K_2CO_3 (d) Na_2CO_3

24. A solution of sodium in liquid ammonia is blue in colour due to:

(a) The presence of ions Na^+

(b) The presence of ammoniated electron

(c) The formation of $NaNH_2$

(d) The formation of sodium hydride

25. The order of basic strength of the hydroxides of alkali metals is:

(a) Li > Na > Rb > Cs

(b) Na > Li > Rb > Cs

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(c) Cs > Rb > Na > Li
(d) Rb > Cs > Na > Li

26. Which of the following compounds liberate(s) oxygen on heating?
(a) Li_2CO_3 (b) LiOH
(c) $LiNO_3$ (d) NaOH

27. When $MgCl_2.6H_2O$ is strongly heated, then it forms:
(a) MgO (b) $Mg(OH)_2$
(c) Mg(OH)Cl (d) $MgCl_2$

28. Magnesium liberates H_2 on reaction with:
(a) dil. HCl
(b) dil. H_2SO_4
(c) very dil. HNO_3
(d) all of these

29. Calcium hydride on hydrolysis forms:
(a) $CaO + H_2$
(b) $Ca(OH)_2$ only
(c) $Ca(OH)_2 + H_2$
(d) Only CaO

30. Which one on reaction with NaOH solution gives inflammable gas?
(a) S (b) Zn
(c) NH_4Cl (d) I_2

31. Which of the following is the most important factor in making lithium metal, the strongest reducing agent?
(a) Ionization energy
(b) Hydration energy
(c) Heat of sublimation
(d) None of these

32. Compound having highest melting point:
(a) LiCl (b) CsCl
(c) NaCl (d) KCl

33. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of LiF in water is due to:
(a) Ionic nature of lithium fluoride
(b) High lattice enthalpy of lithium and fluoride ion
(c) High hydration enthalpy of lithium ion
(d) Low ionisation enthalpy of lithium atom

34. Which of the following compound is consumed during the preparation of Na_2CO_3 by Solvay's Process?
(a) $NH_3 + CaCO_3 + NaCl$
(b) $NH_4Cl + CaO + NaCl$
(c) $CaCO_3 + NaCl$
(d) $NaCl + NH_4HCO_3$

35. Select the correct statement:
(a) Be and Al show diagonal relationship
(b) Be forms tetrahedral complexes $[Be(C_2O_4)_2]^{2-}$
(c) Al forms AlF_6^{-3}, an octahedral complex
(d) All are correct statements

LEVEL II

1. When a mixture of ammonium sulphate and 50% H_2SO_4 is electrolysed the products formed at anode and cathode are:
(a) H_2 and H_2O_2
(b) $(NH_4)_2S_2O_8$ and H_2
(c) H_2 and NH_4HSO_4
(d) H_2O_2 and H_2

2. When H_2O_2 is added to ice cold solution of acidified potassium dichromate containing ether. The contents are shaken and allowed to stand then
(a) a blue colour is obtained in ether due to formation of $Cr_2(SO_4)_3$
(b) a blue colour is obtained in ether due to formation of CrO_5
(c) CrO_3 is formed which dissolves in ether to give blue colour
(d) Chromyl chloride is formed.

3. Which of the following species is reduced by H_2O_2?
(a) $[Fe(CN_6)]^{4-}$
(b) $[Fe(CN_6)]^{3-}$ in alkaline medium
(c) NO_2^-
(d) I⁻/HCl

4. Which of the following on oxidation gives H_2O_2?
(a) 2-Ethylanthraquinol
(b) 2-Ethylanthraquinone
(c) Anthracene
(d) 2-Ethylanthracene

5. One of the following is an incorrect statement. Point out the incorrect one:

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(a) Hardness of water depends upon its soap consuming power
(b) Temporary hardness is due to bicarbonates of calcium and magnesium
(c) Permanent hardness is due to soluble sulphates and chlorides of Ca and Mg
(d) Permanent hardness can be removed by boiling water.

6. Incorrect statement about ortho and para hydrogen:
(a) Para hydrogen is present in pure state at low temperature (zero kelvin)
(b) The ratio of ortho : para hydrogen at room temperature is 3:1
(c) Entropy of ortho hydrogen is more than para hydrogen at high temperature.
(d) 100% pure ortho hydrogen may be obtained at high temperature

7. Which of the following is an incorrect statement for heavy water?
(a) It is used as moderator in nuclear reactor
(b) It gives deuteromathane when react with Al_4C_3
(c) Ionic compounds are more soluble in D_2O than in H_2O
(d) Bond energy of D_2O is higher than that of H_2O

8. In which of the following reaction hydrogen peroxide is a reducing agent?
(a) $2FeCl_2 + 2HCl + H_2O_2 \rightarrow 2FeCl_3 + 2H_2O$
(b) $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$
(c) $HI + H_2O_2 \rightarrow 2H_2O + I_2$
(d) $H_2SO_3 + H_2O_2 \rightarrow H_2SO_4 + H_2O$

9. Which one of the following removes temporary hardness of water?
(a) Slaked lime
(b) Plaster of Paris
(c) $CaCO_3$
(d) Hydrolith

10. Which physical constant for H_2O has higher magnitude than D_2O?
(a) Boiling point
(b) Temperature of maximum density
(c) Dielectric constant
(d) Bond dissociation energy

11. Identify incorrect statement regarding H_2O_2:
(a) It can be prepared by acidifying BaO_2 and hydrolyzing $H_2S_2O_8$ and H_2SO_5.
(b) It is thermodynamically stable.
(c) It has non planar structure.
(d) It is oxidizing as well as reducing agent.

12. In which of the following method of the removal of hardness, Ca^{+2} and Mg^{2+} are not separated from sample of hard water?
(a) By boiling of temporary hard water
(b) Addition of sodium carbonate
(c) Using sodium hexametaphosphate
(d) Synethetic resins and zeolite method.

13. Which of the following statement is not correct regarding the diagonal relationship between Al and Be?
(a) BeO and Al_2O_3 are amphoteric in nature.
(b) Al_4C_3 and Be_2C give same gas on hydrolysis.
(c) Both can from complexes with same maximum co-ordination.
(d) Both form electron deficient and covalent hydride.

14. $A+H_2O \rightarrow NaOH$

$B+H_2O \rightarrow NaOH+O_2$; A and B are respectively:
(a) Na_2O_2 and Na_2O
(b) Na_2O and Na_2O_2
(c) NaO_2 and Na_2O_2
(d) Na_2O and NaO_2

15. Which of the following pair of metal form nitride on reaction with Nitrogen?
(a) Li, Mg (b) Mg, Na
(c) Al, K (d) Al, Na

16. Which gas responsible for leaving holes in cakes or pastries and making them light and fluffy?
(a) O_2 (b) CO_2
(c) H_2 (d) CH_4

17. When sodium is placed in moist air, finally change into:
(a) NaOH (b) Na_2O_2
(c) Na_2O (d) Na_2CO_3

18. Which of the following statement is not correct?
(a) $AlCl_3$ is soluble in excess NaOH and form soluble complex.

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(b) $LiHCO_3$ is not found in solid state.

(c) K_2O_2 is diamagnetic but KO_2 is paramagnetic.

(d) Hydrated $MgCl_2$ gives anhydrous $MgCl_2$ on heating in dry air.

19. Which of the following statement is not correct?

(a) BeF_2 forms complex ion with NaF in which Be goes with cation.

(b) $BeCO_3$ is kept in the atmosphere of CO_2 since it is least thermally stable.

(c) Be dissolves in alkali forming $[Be(OH)_4]^{-2}$.

(d) BeH_2 can exist as planar dimer in vapour state.

20. CO_2 gas along with solid Y is obtained when sodium salt X is heated, X is again obtained when CO_2 gas is passed into aqueous solution of Y. X and Y are:

(a) Na_2CO_3, Na_2O

(b) Na_2CO_3, NaOH

(c) $NaHCO_3$, Na_2CO_3

(d) Na_2CO_3, $NaHCO_3$

21. Which of the following statement is not correct?

(a) Lithium halide are most covalent among alkali metal halides.

(b) Li_2O is more thermal stable than Li_2CO_3.

(c) Except Be halides, all other halides of II A metals are ionic in nature.

(d) Charge and size ratio for Be^{+2} and Al^{+3} is nearly same.

22. $NH_3 + H_2O + CO_2 \rightarrow A$;

$A + H_2O + CO_2 \rightarrow B$

$B + NaCl \rightarrow C + NH_4Cl$;

$C \rightarrow D + H_2O + CO_2$.

Which of the following is incorrect statement?

(a) A is $(NH_4)_2CO_3$

(b) D is Na_2CO_3

(c) C is $NaHCO_3$

(d) B is $(NH_4)_2C_2O_4$

23. When powered Be is heated with air, it form A and B. Compound A gives C after reductive chlorination. C produces white fumes in presence of moisture and forms D. Then A, B, C and D, respectively, are:

(a) BeO, Be_3N_2, $BeCl_2$, $Be(OH)_2$

(b) Be_3N_2, BeO, $BeCl_4^{-2}$, $Be(OH)_2$

(c) BeO, $Be(OH)_2$, Be_3N_2, $BeCl_2$

(d) BeO, Be_3N_2, Be, $Be(OH)_2$

24. A solid compound X on heating gives CO_2 gas and a residue. The residue mixed with water forms Y on passing an excess of CO_2 through Y in water, a clear solution, Z is obtained. On boiling Z compound X is reformed. The compound X is:

(a) $CaCO_3$ (b) Na_2CO_3

(c) K_2CO_3 (d) $Ca(HCO_3)_2$

25. Select the incorrect choice:

(a) Solubility of alkaline earth metal's carbonates, sulphates and chromates decreases from Be to Ba.

(b) Solubility of alkaline earth metal's hydroxides is less than alkali metal hydroxides.

(c) Solubility of alkaline earth Metal's oxides decreases from Be to Ba.

(d) SO_2 on passing in lime water turns lime water milky.

26. Which of the following statement is not correct?

(a) All alkali-metal salts impart a characteristic colour to the Bunsen flame.

(b) The correct order of increasing thermal stability of the carbonates of alkali metals is $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$.

(c) Among the alkali metal's cesium is the most reactive

(d) The reducing character of the alkali metal hydrides follow the order:
LiH > NaH > KH > RbH > CsH.

27. Identify the product A,B,C,D of reaction sequence respectively:

X $NaCl \rightarrow A + B + Cl_2$

$\downarrow Al$

$NaAlO_2 + B_{(g)}$

Y $A + Cl_2 \rightarrow C + D + H_2O$

(a) NaOH, NaCl, NaClO, H_2O

(b) Na_2CO_3, H_2, NaCl, $NaClO_3$

(c) NaOH, H_2, NaCl, $NaClO_3$

(d) Na, H_2, $NaClO_3$, NaCl

28. Which of the following metal, on burning in moist air, does not give smell of ammonia?

(a) Mg (b) Ca

(c) K (d) Li

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29. Mg_2C_3 reacts with water forming propyne gas. C_3^{4-} ions has:
(a) Two sigma and two pi bonds
(b) Three sigma and one pi bond
(c) Two sigma and one pi bond
(d) Two sigma and three pi bonds

30. The fluoride which is most soluble in water is:
(a) CaF_2 (b) BaF_2
(c) SrF_2 (d) BeF_2

31. Amongst the following hydroxides, the one which has the highest value of Ksp at ordinary temperature?
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Sr(OH)_2$ (d) $Ba(OH)_2$

32. At high temperature, nitrogen combines with CaC_2 to give:
(a) Calcium cyanide
(b) Calcium cyanamide
(c) Calcium carbonate
(d) Calcium nitride

33. Which metal bicarbonates does not exist in solid state?
(i) $LiHCO_3$ (ii) $Ca(HCO_3)_2$
(iii) $Zn(HCO_3)_2$ (iv) $AgHCO_3$
(a) i, ii, iii, iv (b) i, ii, iii
(c) i, ii, iv (d) ii, iii, iv

34. The reaction of sodium highly exothermic with water. The rate of reaction is lowered by:
(a) Lowering the temperature
(b) Mixing with alcohol
(c) Mixing with acetic acid
(d) Making an amalgam

35. The alkali metals dissolve in liquid NH_3, it is found that:
(a) The dilute solution are blue but the colour changes to bronze with increasing concentration.
(b) The blue solutions is due to the presence of solvated electrons.
(c) The blue solutions are paramagnetic but the bronze coloured solutions are diamagnetic.
(d) All the facts given above are found.

LEVEL III

ONE OR MORE THAN ONE CORRECT TYPE

1. The reagent(s) used for softening the temporary hardness of water is (are):
(a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$
(c) Na_2CO_3 (d) NaOCl

2. The oxidation states of the most electronegative element in the products of the reaction between BaO_2 with dilute H_2SO_4 are:
(a) -1 (b) +1
(c) -2 (d) 0

3. Which of the following reaction(s) is/are correct?
(a) $Cl_2 + NaOH \rightarrow NaCl + NaClO_3 + H_2O$
(b) $P_4 + NaOH + H_2O \rightarrow NaH_2PO_2 + PH_3$
(c) $S + NaOH \xrightarrow{\Delta} Na_2S_2O_3 + Na_2S + H_2O$
(d) $Si + NaOH \xrightarrow{\Delta} Na_2SiO_3 + H_2$

4. Which of the following is/are correct?
(a) Sodium thiosulphate is called hypo.
(b) Sodium peroxide is called oxone.
(c) Potassium carbonate is called pearl ash.
(d) Sodium nitrate is called Indian nitre.

5. Which of the following is/are found in the solid state?
(a) $LiHCO_3$ (b) $KHCO_3$
(c) $NaHCO_3$ (d) NH_4HCO_3

6. Which of the following compound(s) will impart a golden yellow colour to the Bunsen flame?
(a) KCl (b) K_2CO_3
(c) NaCl (d) Na_2CO_3

7. Nitrogen dioxide cannot be obtained by heating:
(a) KNO_3 (b) $NaNO_3$
(c) $AgNO_3$ (d) $Cu(NO_3)_2$

8. Which of the following metals dissolve in liquid ammonia?
(a) Sr (b) Ca
(c) Ba (d) Be

9. In which of the following, hydration enthalpy is greater than the lattice enthalpy?
(a) $BaSO_4$ (b) $BaCO_3$
(c) Na_2SO_4 (d) Na_2CO_3

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PASSAGE BASED QUESTIONS

Passage # 1 (Q. 10 and 11)

Hydrogen peroxide is a powerful oxidizing agent, both in the acidic and alkaline medium.

In acidic medium: $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$

In alkaline medium: $H_2O_2 + 2e^- \rightarrow 2^-OH$

Hydrogen peroxide acts as a reducing agent towards powerful oxidizing agents.

In acidic medium: $H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$

In alkaline medium, however, its reducing nature is more effective.

$H_2O_2 + 2OH^- \rightarrow 2H_2O + O_2 + 2e^-$

10. On addition of H_2O_2 to acidified $KMnO_4$, $KMnO_4$ gets decolourised due to:
(a) Oxidation of $KMnO_4$
(b) Reduction of $KMnO_4$
(c) Both oxidation and reduction
(d) None of the above of $KMnO_4$

11. H_2O_2 behaves as a bleaching agent due to:
(a) Oxidizing nature
(b) Reducing nature
(c) Acidic nature
(d) Unstable nature

Passage # 2 (Q. 12 to 14)

$$\text{Red hot coke + Steam} \xrightarrow{1000^\circ c} (X) \xrightarrow[500^\circ c \text{ catalyst (y)}]{\text{Steam}} (Z) + H_2.$$

12. 'X' is:
(a) Water gas (b) Producer gas
(c) Coal gas (d) Oil gas

13. Catalyst 'Y' is:
(a) V_2O_5 (b) Cr_2O_3
(c) Fe_2O_3 (d) $Fe_2O_3 + Cr_2O_3$

14. 'Z' is removed by passing the gaseous mixture through
(a) acidic solution
(b) alkaline solution
(c) water under high pressure of 25 atm
(d) an organic solvent

Passage # 3 (Q. 15 and 16)

On exposure to air, alkali metals get tarnished due to formation of oxides, hydroxides and carbonates on their surface. When heated in air or oxygen they burn vigorously forming different types of oxides depending upon the nature of the metal.

The formation and stability of these metals can be explained on the basis of size of alkali metal ion and the anion. Peroxides are colourless, while superoxides are coloured. The normal oxides are basic while peroxides and superoxides. Act as oxidizing agents.

15. On heating in excess of oxygen, lithium gives:
(a) Li_2O (b) LiO
(c) Li_2O_2 (d) LiO_2

16. On heating excess of oxygen, potassium gives:
(a) K_2O (b) KO
(c) K_2O_2 (d) KO_2

Passage # 4 (Q. 17 and 18)

According to Fajan's rules, the percentage of covalent character in an ionic compound increases if the cation is highly charged or small in size and the anion is large or cation has pseudo inert gas configuration. As a result of the increased covalent character, solubility in less polar solvent increases and the melting point decreases.

17. Which of the following has the lowest melting point?
(a) KCl (b) LiCl
(c) CsCl (d) RbCl

18. The correct order of increasing ionic character is:
(a) $BeCl_2 < MgCl_2 < CaCl_2 < BaCl_2$
(b) $BeCl_2 < MgCl_2 < BaCl_2 < CaCl_2$
(c) $BeCl_2 < BaCl_2 < MgCl_2 < CaCl_2$
(d) $BaCl_2 < CaCl_2 < MgCl_2 < BeCl_2$

INTEGER VALUE TYPE QUESTIONS

19. What is the sum of protons, electrons and neutrons in the lightest isotope of hydrogen?

20. How many moles of phosphine are produced when one mole of the calcium phosphide reacts with water?

21. Potassium iodide reacts with acidified $K_2Cr_2O_7$. How many moles of KI are required for one mole of $K_2Cr_2O_7$?

22. How many water molecules are associated with washing soda?

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MATCH THE COLUMN TYPE QUESTIONS

23.

Column I		Column II	
A	Calgon	1.	More reactive form of hydrogen as compared to H_2
B	D_2O	2.	Open book-type structure
C	Nascent hydrogen	3.	Sodium polymetaphosphate
D	H_2O_2	4.	Heavy water

24.

Column I		Column II	
A	Sodium ion in zeolite gets exchanged with	1.	Ca^{2+}
B	Hardness	2.	Mg^{2+}
C	Temporary hardness	3.	$Ca(HCO_3)_2$
D	Permanent hardness	4.	$MgSO_4$

25.

Column I		Column II	
A	Gives CO_2 on heating	1.	Na
B	Pink-violet flame colouration	2.	Cs
C	Forms superoxide on heating With O_2	3.	K_2CO_3
D	Used in photoelectric cells	4.	$NaHCO_3$
E	Form monoxide on heating with oxygen	5.	K
F	Forms peroxide on heating with oxygen	6.	Li

PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. **Statement-1:** Alkali metals dissolve in liquid ammonia to give blue solutions.

   Statement-2: Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$

   (M = alkali metals).

   (a) Statement-1: is True, statement-2 is True; Statement-2 is a correct explanation for statement-1.

   (b) Statement-1: is True, statement-2 is True; Statement-2 is not a correct explanation for statement-1.

   (c) Statement-1 is True, statement-2 is False

   (d) Statement-1 is False, statement-2 is True

   [IIT-2007]

2. The reagent(s) used for softening the temporary hardness of water is (are):

   (a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$

   (c) Na_2CO_3 (d) NaOCl **[IIT-2010]**

3. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a:

   (a) Reducing agent, oxidizing agent

   (b) Reducing agent, reducing agent

   (c) Oxidizing agent, oxidizing agent

   (d) Oxidizing agent, reducing agent

   [JEE Advanced - 2014]

4. A piece of magnesium ribbon was heated to redness in an atmosphere of nitrogen and on cooling water was added, the gas evolved was-

   (a) Ammonia (b) Hydrogen

   (c) Nitrogen (d) Oxygen

   [AIEEE - 2005]

5. The ionic mobility of alkali metal ions in aqueous solution is maximum for-

   (a) Rb^+ (b) Li^+

   (c) Na^+ (d) K^+

   [AIEEE - 2006]

6. In context with the industrial preparation of hydrogen from water gas ($CO+H_2$), which of the following is the correct statement?

   (a) CO is removed by absorption in aqueous Cu_2Cl_2 solution

   (b) H_2 is removed through occlusion with Pd

   (c) CO is oxidized to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali

   (d) CO and H_2 are fractionally separated using difference in their densities

   [AIEEE - 2008]

7. The products obtained on the heating $LiNO_3$ will be-

   (a) $Li_2O + NO_2 + O_2$

   (b) $Li_3N + O_2$

   (c) $Li_2O + NO + O_2$

   (d) $LiNO_2 + O_2$

   [AIEEE - 2011]

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8. What is the best description of the change that occurs when $Na_2O(s)$ is dissolved in water?

(a) Oxide ion accepts a pair of electrons

(b) Oxide ion donates a pair of electrons

(c) Oxidation number of oxygen increases

(d) Oxidation number of sodium decreases

[AIEEE - 2011]

9. Which of the following on thermal decomposition yields a basic as well as an acidic oxide?

(a) $KClO_3$ (b) $CaCO_3$

(c) NH_4NO_3 (d) $NaNO_3$

[AIEEE - 2012]

10. Pure hydrogen (99.9%) can be made by which of the following processes?

(a) Mixing natural hydrocarbons of high molecular weight

(b) Electrolysis of water

(c) Reaction of slat like hydrides with water

(d) Reaction of methane with steam

[AIEEE - 2012]

11. The solubility order for alkali metal fluoride in water is-

(a) LiF < RbF < KF < NaF

(b) RbF < KF < NaF < LiF

(c) LiF > NaF > KF > RbF

(d) LiF < NaF < KF < RbF

[JEE Main Online - 2013]

12. In which of the following reactions H_2O_2 acts as a reducing agent?

(i) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$

(ii) $H_2O_2 - 2e^- \rightarrow O_2 + 2H^+$

(iii) $H_2O_2 + 2e^- \rightarrow 2OH^-$

(iv) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + 2H_2O$

(a) (iii), (iv) (b) (i), (iii)

(c) (ii), (iv) (d) (i), (ii)

[JEE Main - 2014]

Answer Key

LEVEL I

1. (b)	2. (d)	3. (d)	4. (c)	5. (c)	6. (a)	7. (a)	8. (a)	9. (c)	10. (c)
11. (b)	12. (b)	13. (d)	14. (d)	15. (c)	16. (b)	17. (a)	18. (b)	19. (b)	20. (c)
21. (d)	22. (b)	23. (a)	24. (b)	25. (c)	26. (c)	27. (a)	28. (d)	29. (c)	30. (b)
31. (b)	32. (c)	33. (b)	34. (c)	35. (d)					

LEVEL II

1. (b)	2. (b)	3. (b)	4. (b)	5. (d)	6. (d)	7. (c)	8. (b)	9. (a)	10. (c)
11. (b)	12. (c)	13. (c)	14. (b)	15. (a)	16. (b)	17. (d)	18. (d)	19. (a)	20. (c)
21. (c)	22. (d)	23. (a)	24. (a)	25. (c)	26. (d)	27. (c)	28. (c)	29. (a)	30. (d)
31. (d)	32. (b)	33. (a)	34. (d)	35. (d)					

LEVEL III

1. (b, c, d)	2. (a, c)	3. (a, b, c, d)	4. (a, b, c)	5. (b, c, d)	6. (c, d)	7. (a, b)	8. (a, b, c)
9. (c, d)	10. (b)	11. (a)	12. (a)	13. (d)	14. (c)	15. (a)	16. (d)
17. (b)	18. (a)	19. (2)	20. (2)	21. (6)	22. (10)		

23. (A → 3; B → 4; C → 1; D → 2)

24. (A → 1, 2; B → 1, 2; C → 3; D → 4)

25. (A → 4; B → 3; C → 2, 5; D → 2; E → 1,2,5, 6; F → 1)

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PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. (a) 2. (b, c, d) 3. (a) 4. (a) 5. (a) 6. (c) 7. (a) 8. (b) 9. (b) 10. (c)
11. (d) 12. (c)

Hints and Solutions

LEVEL I

1. (b) $LiH + H_2O \rightarrow LiOH + H_2$

2. (d) Highly electropositive elements (s-block metals) can form ionic hydrides.

3. (d) Isotopes have different nuclear mass.

4. (c) CaH_2 (Molten) $\rightarrow Ca^{+2} + 2H^-$

at anode:- $2H^- \rightarrow H_2\uparrow + 2e^-$

5. (c) Temporary hardness of water can be removed by adding calculated amount of $Ca(OH)_2$.

6. (a) $Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + CO_2\uparrow + H_2O$

7. (a) $Ca + H_2 \rightarrow CaH_2$

R.A O.A

8. (a) Intermolecular interaction present in H_2 is dispersion forces.

9. (c) Adsorption of H_2 by various metals is also known as occulusion.

10. (c) In PbO_2, oxidation state of 'O' is '-2'.

11. (b) Ortho and para – hydrogen possess different physical properties but same chemical properties.

12. (b) O_3 is a stronger oxidizing agent than H_2O_2. O_3 will oxidize H_2O_2 into O_2

13. (d) Due to presence of unpaired e- in superoxide ion, they are paramagnetic, coloured and oxidizing agents.

14. (d) $Na + NH_3 \xrightarrow{\Delta} NaNH_2 + \frac{1}{2} H_2\uparrow$

15. (c) $Be + 2NaOH \rightarrow \underset{\text{water soluble}}{Na_2BeO_2} + H_2$

16. (b) Microcosmic salt is $Na(NH_4)HPO_4.4H_2O$

Glauber's salt is $Na_2SO_4.10H_2O$

17. (a) Be is less reactive s-block metal. It does not form hydride by direct heating with H_2.

18. (b) Due to high ionisation energy, salts of Be^{+2} and Mg^{+2} do not give flame test.

19. (b) In alkali metals (IA), metallic character and ionic radius increases as the atomic number rises.

20. (c) Solutions of alkali metals in liquid ammonia are paramagnetic in nature.

21. (d) $Na_2CO_3 + CO_2 + H_2O \rightarrow NaHCO_3$

(this reaction is not possible)

The actual reaction is,

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

22. (b) Order of solubility of hydroxides:-

$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

23. (a) Order of thermal stability:-

$Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

24. (b) Cause of blue colour is presence of ammoniated electron.

25. (c) Down the group, basic strength of hydroxides increases.

26. (c) $2LiNO_3 \xrightarrow{\Delta} Li_2O + 2NO_2\uparrow + \frac{1}{2} O_2\uparrow$

27. (a) $MgCl_2.6H_2O \xrightarrow{\Delta} MgO + HCl\uparrow$

28. (d) Mg displaces H_2 from acids

29. (c) $CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$

30. (b) $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2\uparrow$ (Inflammable gas)

31. (b) Li is the strongest reducing agent because Li^+ has exceptionally high hydration energy.

32. (c) Order of melting point is,

$NaCl > KCl > CsCl > LiCl$

33. (b) Both Li^+ and F^- ions are very small in size. Hence, lattice energy of LiF is very high and it has lowest solubility in water amongst alkali metal fluorides.

34. (c) Raw materials used in Solvay process are $CaCO_3$, NH_3 and NaCl but only $CaCO_3$ and NaCl are consumed during the preparation of Na_2CO_3.

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35. (d) Be and Al show diagonal relationship. Maximum co-ordination number of Be is 4 while that of Al is 6.

LEVEL II

1. (b) at anode, $(NH_4)_2S_2O_8$ is formed.
at cathode, H_2 is formed.

2. (b) a blue colour is obtained due to formation of chromic peroxide, CrO_5 or $CrO(O_2)_2$.

3. (b) $[Fe(CN)_6]^{3-}$ is reduced into $[Fe(CN)_6]^{4-}$

4. (b) 2-Ethylanthraquinol on oxidation give H_2O_2

5. (d) Permanent hardness can not be removed by boiling water. Only temporary hardness can be removed by boiling water.

6. (d) 100% pure orthohydrogen can not be obtained even at high temperature.

7. (c) Ionic compounds are more soluble in polar solvents having higher value of dielectric constant. H_2O has higher dielectric constant than D_2O.

8. (b) Cl_2 acts as oxidizing agent and H_2O_2 acts as reducing agent.

9. (a) $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$
(Hardness) (Slaked lime)

10. (c) H_2O has higher dielectric constant than D_2O.

11. (b) It is thermodynamically unstable.
$2H_2O_2 \longrightarrow 2H_2O + O_2$

12. (c) Sodium hexametaphosphate (Calgon) forms soluble complex with Ca^{+2} and Mg^{+2}.
$Na_2[Na_4(PO_3)_6] + 2Ca^{+2} \longrightarrow Na_2[Ca_2(PO_3)_6] + 4Na^+$

13. (c) Be shows maximum co-ordination number 4 while due to pressence of vacant d-orbitals Al shows maximum co-ordination number 6.

14. (b) $Na_2O + H_2O \longrightarrow NaOH$
(A)
$Na_2O_2 + H_2O \longrightarrow NaOH + O_2$
(B)

15. (a) Na, K, Rb and Cs do not form nitride on reaction with nitrogen.
Li and Mg form nitride with nitrogen.

16. (b) In cakes or pastries, $NaHCO_3$ (baking soda) is added. During baking of cake, CO_2 gas is released which makes cake light and fluffy.

17. (d) $Na + O_2 \longrightarrow Na_2O$
$Na_2O + H_2O \longrightarrow NaOH$
$NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

18. (d) Hydrated $MgCl_2$ ($MgCl_2.6H_2O$) gives MgO on heating in dry air.

19. (a) $BeF_2 + 2NaF \longrightarrow Na_2[BeF_4]$
In this complex, Be present in anionic part.

20. (c) Salt (X) is $NaHCO_3$.
$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2\uparrow + H_2O$
(Y)

21. (c) Halides of Mg are also covalent.

22. (d) B is NH_4HCO_3.

23. (a) $Be + air \xrightarrow{\Delta} \underset{(A)}{BeO} + \underset{(B)}{Be_3N_2}$
$BeO + chlorination \longrightarrow \underset{(C)}{BeCl_2}$
$BeCl_2 + moisture \longrightarrow \underset{(D)}{Be(OH)_2}$

24. (a) $\underset{(X)}{CaCO_3} \xrightarrow{\Delta} CaO + CO_2$
$CaO + H_2O \longrightarrow \underset{(Y)}{Ca(OH)_2}$
$Ca(OH)_2 + excess\ CO_2 \longrightarrow \underset{(Z)}{Ca(HCO_3)_2}$

25. (c) Order of solubility :
$BeO < MgO < CaO < SrO < BaO$

26. (d) Correct order of reducing character :
$LiH < NaH < KH < RbH < CsH$

27. (c)
$NaCl_{(aq)} \xrightarrow{Electrolysis} \underset{(A)}{NaOH} + \underset{(B)}{H_2} + Cl_2$
$\downarrow Al$
$NaAlO_2 + \underset{(B)}{H_2}$
$NaOH + Cl_2 \longrightarrow NaCl + NaClO_3 + H_2O$

28. (c) Potassium (K) does not form nitride on burrning in air.

29. (a) Structure of C_3^{4-} is,
$^{-}C \equiv C - C^{-3}$
It has 2 sigma and 2 pi bonds.

30. (d) Order of solubility in water :
$BeF_2 > BaF_2 > SrF_2 > CaF_2$

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31. (d) $K_{sp} \propto$ solubility

Order of solubility :

$Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

32. (b) $CaC_2 + N_2 \xrightarrow{\Delta} \underset{\text{(Calcium cyanamide)}}{CaCN_2}$

33 (a) Only bicarbonates of Na^+, K^+, Rb^+ and Cs^+ exist is solid state.

34 (d) Hg is less reactive metal. Hence, by making an amalgam the rate of reaction of Na with water is lowered.

35 (d) The alkali metals dissolve in liquid NH_3. This solution is blue coloured due to solvated electrons. As concentration of metal increases, colour changes to bronze.

LEVEL III

1.(b, c, d)

$Ca(OH)_2$ (slaked lime), Na_2CO_3 (washing soda) and NaOCl are used for softening the temporary hardness.

$NaOCl + H_2O \rightarrow NaOH + HOCl$

$OH^- + HCO_3^- \rightarrow CO_3^{2-} + H_2O$

2.(a, c) $BaO_2 + H_2SO_{4\,(dilute)} \rightarrow BaSO_4 + H_2O_2$

The most electronegative element in products is oxygen. In H_2O_2, oxidation state of 'O' is –1 and in $BaSO_4$, oxidation state of 'O' is –2.

3. (a, b, c, d)

All reactions are correct.

4. (a, b, c)

Indian nitre is potassium nitrate (KNO_3)

5. (b, c, d)

$LiHCO_3$ exists only in solution.

6. (c, d) Na^+ will impart a golden yellow colour to the Bunsen flame.

7. (a, b) Nitrates of Na^+, K^+, Rb^+ Cs^+ do not release NO_2 gas by heating.

8. (a, b, c)

In s-block, Be and Mg do not dissolve in liquid ammonia.

9.(c, d) For salts, which are soluble in water, hydration enthalpy is greater than the lattie enthalpy.

Na_2SO_4 and Na_2CO_3 are soluble in water.

10. (b) With H_2O_2, $KMnO_4$ behaves as oxidising agent.

11. (a) H_2O_2 behaves as a bleaching agent due to its oxidizing nature.

12. (a) Red hot coke + steam $\xrightarrow{\Delta} \underbrace{CO + H_2}_{\substack{\text{Water gas}\\(X)}}$

$\xrightarrow[\text{Catalyst}]{\text{Steam}} \underset{(Z)}{CO_2 + H_2}$

13. (d) Catalyst 'Y' is $Fe_2O_3 + Cr_2O_3$

14. (c) CO_2 is removed by passing the gaseous mixture through water under high pressure of 25 atm.

$CO_2 + H_2O \longrightarrow H_2CO_3$

15. (a) $Li + O_{2(excess)} \xrightarrow{\Delta} Li_2O$

16. (d) $K + O_{2(excess)} \xrightarrow{\Delta} KO_2$

17. (b) Order of melting point:

KCl > RbCl > CsCl > LiCl

18. (a) Covalent character $\propto$ polarising power of cation.

Order of ionic character is reverse of order of covalent character.

19. Lightest isotope of hydrogen is protium. It has 1 proton, 1 electron and zero neutron.

20. $Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$

1 mole 2 moles

21. $K_2Cr_2O_7 + 7H_2SO_4 + 6KI \rightarrow Cr_2(SO_4)_3 + 3I_2 + 7H_2O + 4K_2SO_4$

1 mole 6 moles

22. Washing soda is $Na_2CO_3.10H_2O$

23. (A $\rightarrow$3; B $\rightarrow$4 ; C $\rightarrow$1; D $\rightarrow$ 2)

24. (A $\rightarrow$1, 2; B $\rightarrow$1, 2 ; C $\rightarrow$3; D $\rightarrow$4)

25. (A $\rightarrow$4; B $\rightarrow$3 ; C $\rightarrow$2, 5 ; D $\rightarrow$2 ; E $\rightarrow$1, 2, 5, 6; F $\rightarrow$1]

PREVIOUS YEARS' QUESTIONS FOR JEE (MAIN AND ADVANCED)

1. (b) Both statements are correct but blue colour is due to presence of solvated e^-.

2. (b, c, d)

$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$

$Na_2CO_3 + Ca(HCO_3)_2 \longrightarrow CaCO_3\downarrow + 2NaHCO_3$

$NaOCl + H_2O \longrightarrow NaOH + HOCl$

$OH^- + HCO_3^- \longrightarrow CO_3^{-2} + H_2O$

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3. (a) $\overset{+7}{KIO_4} + \underset{\text{Reducing agent}}{H_2O_2} \rightarrow \overset{+5}{KIO_3} + H_2O + O_2$

$\overset{-1}{NH_2}OH + \underset{\text{Oxidizing agent}}{H_2O_2} \rightarrow \overset{+3}{N_2}O_3 + H_2O$

4. (a) $3Mg + N_2 \xrightarrow{\Delta} Mg_3N_2$

$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3\uparrow$

5. (a) Hydrated ion of Rb^+ is smallest among these four.

6. (c) $CO + H_2 \xrightarrow{\text{Steam, Catalyst}} \underset{\downarrow}{CO_2} + H_2$

absorption in alkali

7. (a) $2LiNO_3 \xrightarrow{\Delta} Li_2O + 2NO_2\uparrow + \frac{1}{2}O_2\uparrow$

8. (b) $Na_2O + H_2O \longrightarrow 2NaOH$

$O^{-2} + H^+ \longrightarrow OH^-$

Oxide ion (O^{-2}) donates a pair of electrons

9. (b) $CaCO_3 \xrightarrow{\Delta} \underset{\text{(Basic)}}{CaO} + \underset{\text{(acidic)}}{CO_2}$

10. (c) $NaH + H_2O \longrightarrow NaOH + H_2\uparrow$

11. (d) Order of solubility in water:

$LiF < NaF < KF < RbF$

12. (c) Removal of e^- is known as oxidation.

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