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Part-2

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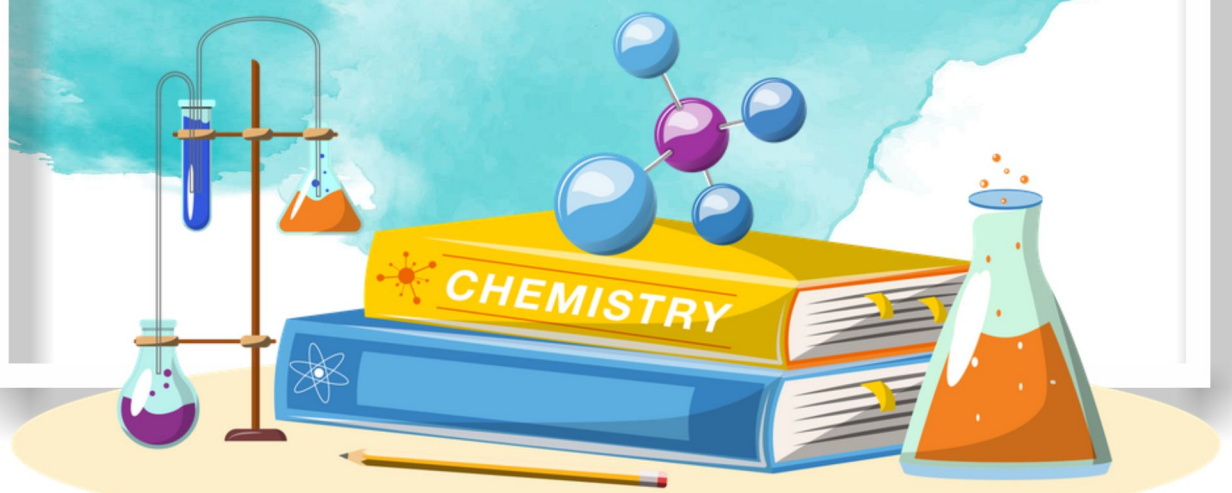

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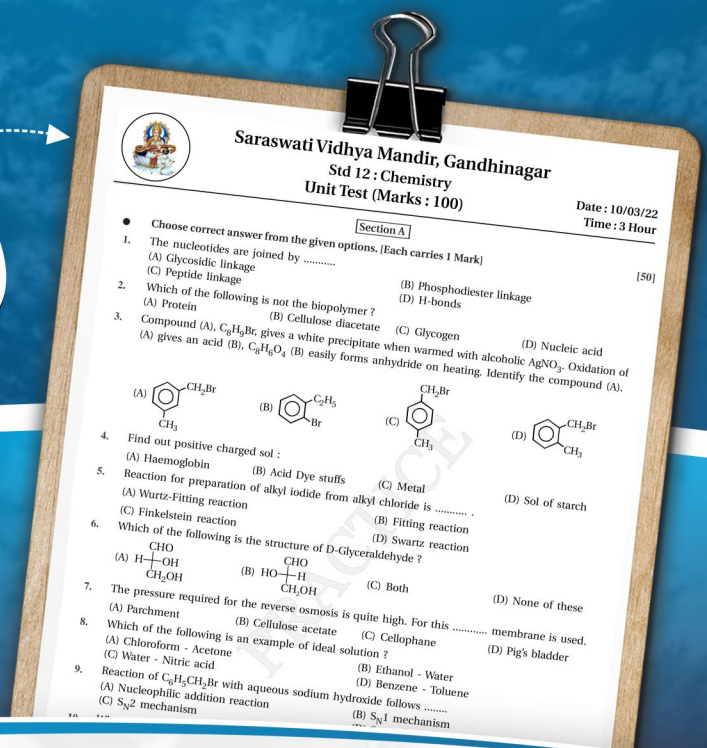

Saraswati Vidhya Mandir, Gandhinagar
Std 12 : Chemistry
Unit Test (Marks : 100)
Date : 10/03/22
Time : 3 Hour

Section A

• Choose correct answer from the given options. [Each carries 1 Mark] [50]

1. The nucleotides are joined by .....
(A) Glycosidic linkage (B) Phosphodiester linkage
(C) Peptide linkage (D) H-bonds

2. Which of the following is not the biopolymer ?
(A) Protein (B) Cellulose diacetate (C) Glycogen (D) Nucleic acid

3. Compound (A), C_8H_9Br, gives a white precipitate when warmed with alcoholic $AgNO_3$. Oxidation of (A) gives an acid (B), $C_8H_6O_4$ (B) easily forms anhydride on heating. Identify the compound (A).
(A) (B) (C) (D)

4. Find out positive charged sol :
(A) Haemoglobin (B) Acid Dye stuffs (C) Metal (D) Sol of starch

5. Reaction for preparation of alkyl iodide from alkyl chloride is ..... .
(A) Wurtz-Fitting reaction (B) Fitting reaction
(C) Finkelstein reaction (D) Swartz reaction

6. Which of the following is the structure of D-Glyceraldehyde ?
(A) (B) (C) Both (D) None of these

7. The pressure required for the reverse osmosis is quite high. For this ..... membrane is used.
(A) Parchment (B) Cellulose acetate (C) Cellophane (D) Pig's bladder

8. Which of the following is an example of ideal solution ?
(A) Chloroform - Acetone (B) Ethanol - Water
(C) Water - Nitric acid (D) Benzene - Toluene

9. Reaction of $C_6H_5CH_2Br$ with aqueous sodium hydroxide follows .....
(A) Nucleophilic addition reaction (B) S_N1 mechanism
(C) S_N2 mechanism

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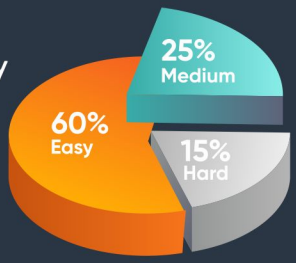

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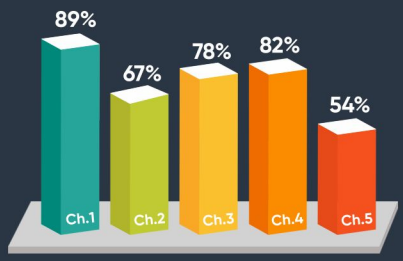

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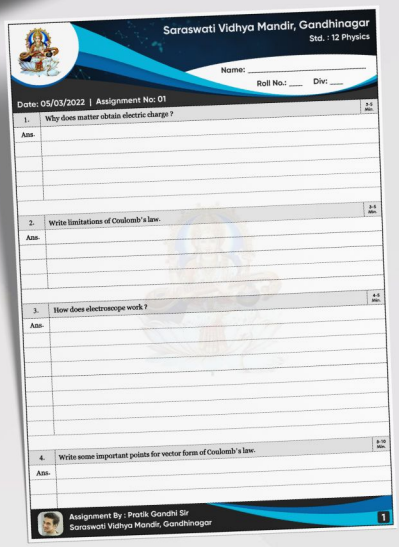

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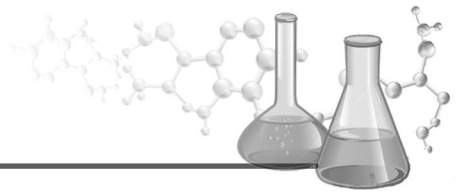
9 Hydrogen



Section-A Questions

9.1 Position of Hydrogen in the Periodic Table

1)* Justify the position of hydrogen in the periodic table on the basis of its electronic configuration. (Exercise - 9.1)

OR

Discuss the position of hydrogen in the modern periodic Table.

- Hydrogen is the first element in the periodic table. However, its placement in the periodic table has been a subject of discussion in the past.
- Hydrogen has electronic configuration $1s^1$ on one hand, its electron configuration is similar to the outer electronic configuration II (ns^1) of alkali metals, which belong to the first group of the periodic table.
- On the other hand, like halogens, it is short by, one electron to the corresponding noble gas configuration.
- Hydrogen, therefore has resemblance to alkali metals, which lose one electron to form unipositive ions. Like alkali metals hydrogen forms oxides, halides and sulphides.
- However, unlike alkali metals, it has a very high ionization enthalpy and does not possess metallic characteristics under normal conditions. $\Delta_i H$ of Li is 520 kJ mol^{-1} , F is 1680 kJ mol^{-1} and that of H is 1312 kJ mol^{-1}.
- Like halogens, hydrogen forms a diatomic molecule, combines with elements to form hydrides and a large number of covalent compounds. However, in terms of reactivity, it is very low as compared to halogens.
- Inspite of the fact that hydrogen, to a certain extent resembles both with alkali metals and Halogens, it differs from them as well. Loss of the electron from Hydrogen atom results in nucleus (H^+) of ~ 1.5×10^{-3} pm size.
- This is extremely small as compared to normal atomic and ionic sizes of 50 to 200 pm.
- As a consequence, H^+ does not exist freely and is always associated with other atoms or molecules.

Thus, it is unique in behaviour and is, therefore, best placed separately in the periodic table

2)* Why does hydrogen occur in a diatomic form rather than in a monoatomic form under normal conditions ? (Exercise - 9.3)

- Hydrogen atom has only one electron and this has one electron less than the stable inert gas configuration of helium. Therefore to attain stable inert gas configuration of helium, it shares its single electron with electron of other hydrogen atom to form a stable diatomic molecule

9.2 Dihydrogen, (H_2)

3) Write short note on Dihydrogen.

- Occurrence of dihydrogen :

(i) Dihydrogen is the most abundant element in the universe and is the principal element in the solar atmosphere.

(ii) However, due to its light nature, it is much less abundant (0.15 % by mass) in the earth's atmosphere.

(iii) In the combined form it constitutes 15.4% of the earth's crust and the oceans.

4)* Write the names of isotopes of hydrogen what is the mass ratio of these isotopes ? (Exercise - 9.2)

OR

Explain Isotopes of Hydrogen in short.

- Hydrogen has three isotopes: protium, (^1_1H) , Deuterium, (^2_1H or D) and tritium, (^3_1H or T).
- These isotopes differ from one another in respect of the presence of neutrons.

- Ordinary hydrogen, protium, has no neutrons, deuterium (also known as heavy hydrogen) has one and tritium has two neutrons in the nucleus.
- In the year 1934, an American scientist, Harold C. Urey, got Nobel Prize for separating hydrogen isotope of mass number 2 by physical methods.
- The predominant form is protium. Terrestrial hydrogen contains 0.0156% of deuterium mostly in the form of HD.
- The tritium concentration is about one atom per 10^{18} atoms of protium. Of these isotopes, only tritium is radioactive and emits low energy β^- particles. Its half life period is $\left(t_{\frac{1}{2}} = 12.33 \text{ years}\right)$
- Since the isotopes have the same electronic configuration, they have almost the same chemical properties.
- The only difference is in their rates of reactions, mainly due to their different enthalpy of bond dissociation.
- However, in physical properties these isotopes differ considerably due to their large mass differences.

Atomic and Physical Properties of Hydrogen

Property	Hydrogen	Deuterium	Tritium
Relative abundance (%)	99.985	0.0156	10^{-15}
Relative atomic mass (g mol^{-1})	1.008	2.014	3.016
Melting point / (K)	13.96	18.73	20.62
Boiling point / (K)	20.39	23.67	25.0
Density / (gL^{-1})	0.09	0.18	0.27
Enthalpy of fusion / (kJ mol^{-1})	0.117	0.197	–
Enthalpy of vaporization / (kJ mol^{-1})	0.904	1.226	–
Enthalpy of bond dissociation / (kJ mol^{-1} at 298 K)	435.88	443.35	–
Internuclear distance / (pm)	74.14	74.14	–
Ionization enthalpy / (kJ mol^{-1})	1312	–	–
Electron gain enthalpy / (kJ mol^{-1})	–73	–	–
Covalent radius / (pm)	37	–	–
Ionic radius (H^-) / (pm)	208	–	–

9.3 Preparation of Dihydrogen, (H_2)

5) Explain Laboratory Preparation of Dihydrogen.

- It is usually prepared by the reaction of granulated zinc with dilute hydrochloric acid.

$$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$$

- It can also be prepared by the reaction of zinc with aqueous alkali.

$$Zn + 2NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2$$

6)* How can the production of dihydrogen, obtained from 'coal gasification' be increased ? (Exercise - 9.4)

OR

*** Describe the bulk preparation of dihydrogen by electrolytic method what is the role of an electrolyte in this process ? (Exercise - 9.5)**

OR

Explain commercial production of Dihydrogen.

(i) Electrolysis of acidified water using platinum electrodes gives hydrogen.

$$2H_2O_{(l)} \xrightarrow[\text{Traces of acid / base}]{\text{Electrolysis}} 2H_{2(g)} + O_{2(g)}$$

(ii) High purity (> 99.95 %) dihydrogen is obtained by electrolysing warm aqueous barium hydroxide solution between nickel electrodes.

(iii) It is obtained as a byproduct in the manufacture of sodium hydroxide and chlorine by the electrolysis of brine solution. During electrolysis, the reactions that take place are :

at anode : $2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$

at cathode : $2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$

The overall reaction is :

$$2Na^+_{(aq)} + 2Cl^-_{(aq)} + 2H_2O_{(l)} \downarrow$$

$$Cl_{2(g)} + H_{2(g)} + 2Na^+_{(aq)} + 2OH^-_{(aq)}$$

➠(iv) Reaction of steam on hydrocarbons or coke at high temperatures in the presence of catalyst yields hydrogen.

$$C_nH_{2n+2} + nH_2O \xrightarrow[Ni]{1270\,K} nCO + (2n+1)\,H_2$$

e. g., $CH_{4(g)} + H_2O_{(g)} \xrightarrow[Ni]{1270\,K} \underbrace{CO_{(g)} + 3H_{2(g)}}_{\text{water gas}}$

➠ The mixture of CO and H_2 is called water gas. As this mixture of CO and H_2 is used for the synthesis of methanol and a number of hydrocarbons, it is also called synthesis gas or 'syngas'.

➠ Nowadays 'syngas' is produced from sewage, saw-dust, scrap wood, newspapers etc.

➠ The process of producing 'syngas' from coal is called 'coal gasification'.

$$C_{(s)} + H_2O_{(g)} \xrightarrow{1270\,K} CO_{(g)} + H_{2(g)}$$

➠ The production of dihydrogen can be increased by reacting carbon monoxide of syngas mixtures with steam in the presence of iron chromate as catalyst.

$$CO_{(g)} + H_2O_{(g)} \xrightarrow[catalyst]{673\,K} CO_{2(g)} + H_{2(g)}$$

➠ This is called water-gas shift reaction. Carbon dioxide is removed by scrubbing with sodium arsenite solution.

➠ Presently ~ 77% of the industrial dihydrogen is produced from petro-chemicals, 18% from coal, 4% from electrolysis of aqueous solutions and 1% from other sources.

7)* Complete the following reactions. (Exercise - 9.6)

(i) $H_{2(g)} + M_mO_{o(s)} \xrightarrow{\Delta}$

(ii) $CO_{(g)} + H_{2(g)} \xrightarrow[catalyst]{\Delta}$

(iii) $C_3H_{8(g)} + 3H_2O_{(g)} \xrightarrow[catalyst]{\Delta}$

(iv) $Zn_{(s)} + NaOH_{(aq)} \xrightarrow{heat}$

➠**(i)** $H_{2(g)} + M_mO_{o(s)} \xrightarrow{\Delta} mM_{(s)} + {}_oH_2O$

➠**(ii)** $CO_{(g)} + 2H_{2(g)} \xrightarrow[catalyst]{\Delta} \underset{\text{methanol}}{CH_3OH_{(l)}}$

➠**(iii)** $C_3H_{8(g)} + 3H_2O_{(g)} \xrightarrow{Ni,\ 1270K} 3CO_{(g)} + 7H_{2(g)}$

➠**(iv)** $Zn_{(s)} + 2NaOH_{(aq)} \xrightarrow{heat} \underset{\text{Sodium zincate}}{Na_2ZnO_{2(aq)}} + H_{2(g)}$

9.4 Properties of Dihydrogen

8) Write physical properties of Hydrogen.

➠ (i) Dihydrogen is a colourless, odourless, tasteless, combustible gas.

(ii) It is lighter than air and insoluble in water.

9)* Discuss the consequence of high enthalpy of H – H bond in terms of chemical reactivity of dihydrogen. OR (Exercise - 9.7) Explain chemical properties of Hydrogen.

➠ The chemical behaviour of dihydrogen is determined, to a large extent, by bond dissociation enthalpy.

➠ The H–H bond dissociation enthalpy is the highest for a single bond between two atoms of any element.

➠ The dissociation of dihydrogen into its atoms is only ~ 0.081% around 2000K which increases to 95.5% at 5000K.

➠ It is relatively inert at room temperature due to the high H–H bond enthalpy. Thus, the atomic hydrogen is produced at a high temperature in an electric arc or under ultraviolet radiations.

➠ Since its orbital is incomplete with $1s^1$ electronic configuration, it does combine with almost all the elements.

➠ It accomplishes reactions by (i) loss of the only electron to give H^+. (ii) gain of an electron to form H^+, and (iii) sharing electrons to form a single covalent bond.

➠ **Reaction with halogens :** It reacts with halogens, X_2 to give hydrogen halides, HX,

$H_{2(g)} + X_{2(g)} \longrightarrow 2HX_{(g)}$ [X = F, Cl, Br, I]

While the reaction with fluorine occurs even in the dark, with iodine it requires a catalyst.

➠ **Reaction with dioxygen :** It reacts with dioxygen to form water. The reaction is highly exothermic.

$$2H_{2(g)} + O_{2(g)} \xrightarrow[heating]{Cytalyst\ or} 2H_2O_{(l)}$$

$\Delta H^\ominus = -285.9$ kJ mol^{-1}

➠ **Reaction with dinitrogen :** With dinitrogen it forms ammonia.

$$3H_{2(g)} + N_{2(g)} \xrightarrow[Fe]{673K,\ 200\ atm} 2NH_{3(g)}$$

$$\Delta H^{\ominus} = -92.6\ kJ\ mol^{-1}$$

This is the method for the manufacture of ammonia by the Haber process.

➠ **Reactions with metals :** With many metals it combines at a high temperature to yield the corresponding hydrides.

$H_{2(g)} + 2M_{(g)} \longrightarrow 2MH_{(s)}$;
where M is an alkali metal.

➠ **Reactions with metal ions and metal oxides :**

It reduces some metal ions in aqueous solution and oxides of metals (less active than iron) into corresponding metals.

$H_{2(g)} + Pd^{2+}_{(aq)} \longrightarrow Pd_{(s)} + 2H^{+}_{(aq)}$

$yH_{2(g)} + M_xO_{y(s)} \longrightarrow xM_{(s)} + yH_2O_{(l)}$

➠ **Reactions with organic compounds :** It reacts with many organic compounds in the presence of catalysts to give useful hydrogenated products of commercial importance.

For example :

(i) Hydrogenation of vegetable oils using nickel as catalyst gives edible fats (margarine and vanaspati ghee).

(ii) Hydroformylation of olefins yields aldehydes which further undergo reduction to give alcohols.

$H_2 + CO + RCH = CH_2 \longrightarrow RCH_2CH_2CHO$

$H_2 + RCH_2CH_2CHO \longrightarrow RCH_2CH_2CH_2OH$

[1] Comment on the reactions of dihydrogen with (i) chlorine, (ii) sodium, and (iii) copper (II) oxide (Text Book Problem-9.1)

➠ **(i)** Dihydrogen reduces chlorine into chloride (Cl^-) ion and itself gets oxidised to H^+ ion by chlorine to form hydrogen chloride. An electron pair is shared between H and Cl leading to the formation of a covalent molecule.

➠ **(ii)** Dihydrogen is reduced by sodium to form NaH. An electron is transferred from Na to H leading to the formation of an ionic compound, Na^+H^-.

➠ **(iii)** Dihydrogen reduces copper(II) oxide to copper in zero oxidation state and itself gets oxidised to H_2O, which is a covalent molecule.

10) Give uses of Dihydrogen.

➠ The largest single use of dihydrogen is in the synthesis of ammonia which is used in the manufacture of nitric acid and nitrogenous fertilizers.

➠ Dihydrogen is used in the manufacture of vanaspati fat by the hydrogenation of polyunsaturated vegetable oils like soyabean, cotton seeds etc.

➠ It is used in the manufacture of bulk organic chemicals, particularly methanol.

$$CO_{(g)} + 2H_{2(g)} \xrightarrow[catalyst]{cobalt} CH_3OH_{(l)}$$

➠ It is widely used for the manufacture of metal hydrides. It is used for the preparation of hydrogen chloride, a highly useful chemical. (In metallurgical processes, it is used to reduce heavy metal oxides to metals.

➠ Dihydrogen is used in fuel cells for generating electrical energy. It has many advantages over the conventional fossil fuels and electric power.

➠ It does not produce any pollution and releases greater energy per unit mass of fuel in comparison to gasoline and other fuels.

***Sub. Que. : How does the atomic hydrogen or oxyhydrogen torch function for cutting and welding purposes ? Explain (Exercise - 9.13)**

➠ Atomic hydrogen and oxy-hydrogen torches find use for cutting and welding purposes. Atomic hydrogen atoms (produced by dissociation of dihydrogen with the help of an electric arc) are allowed to recombine on the surface to be welded to generate the temperature of 4000 K.

➠ It is used as a rocket fuel in space research.

9.5 Hydrides

11)* Saline hydrides are known to react with water violently producing fire can CO_2, a well known fire extinguisher be used in this case ? Explain. (Exercise - 9.15)

➠ Saline hydrides react violently with water producing dihydrogen gas

$$NaH_{(s)} + H_2O_{(aq)} \longrightarrow NaOH_{(aq)} + H_{2(g)}$$

➠ But A well known fire extinguisher CO_2 is used then following red will be obtained

$$NaH + CO_2 \longrightarrow HCOONa$$

12) What is Hydrides ? Give its types and Explain.

OR

Explain Ionic Hydrides (Saline Hydrides) covalent (molecular hydrides), Metal (hydrides) or (non stoichiometric hydrides) by Examples.

➠ Dihydrogen, under certain reaction conditions, combines with almost all elements, except noble gases, to form binary compounds, called hydrides.

➠ If 'E' is the symbol of an element then hydride can be expressed as EH_x (e.g., MgH_2) or E_mH_n (e.g., B_2H_6).

➠ The hydrides are classified into three categories :

(i) Ionic or saline or saltlike hydrides

(ii) Covalent or molecular hydrides

(iii) Metallic or non-stoichiometric hydrides

13) Write short note on Ionic or Saline Hydrides.

➠ These are stoichiometric compounds of dihydrogen formed with most of the *s*-block elements which are highly electropositive in character. Such as LiH, BeH_2 and MgH_2.

➠ In fact BeH_2 and MgH_2 are polymeric in structure.

➠ The ionic hydrides are crystalline, non-volatile and non-conducting in solid state. However, their melts conduct electricity and on electrolysis liberate dihydrogen gas at anode, which confirms the existence of H^- ion.

$$2H^-\ (melt) \xrightarrow{anode} H_{2(g)} + 2e^-$$

*** Sub. Que. : How can saline hydrides remove traces of water from organic compounds ?**

(Exercise - 9.32)

➠ Saline hydrides react violently with water producing dihydrogen gas.

$$NaH_{(s)} + H_2O_{(aq)} \longrightarrow NaOH_{(aq)} + H_{2(g)}$$

➠ Lithium hydride is rather unreactive at moderate temperatures with O_2 or Cl_2. It is, therefore, used in the synthesis of other useful hydrides,

e.g., $8LiH + Al_2Cl_6 \longrightarrow 2LiAlH_4 + 6LiCl$

$2LiH + B_2H_6 \longrightarrow 2LiBH_4$

14)* Arrange the following (Exercise - 9.16)

(i) CaH_2, BeH_2 and TiH_2 in order of increasing electrical conductance.

(ii) LiH, NaH and CsH in order of increasing ionic character.

(iii) H - H, D - D and F - F in order of increasing bond dissociation enthalpy.

(iv) NaH, MgH_2 and H_2O in order of increasing reducing property.

➠ (i) $BeH_2 < CaH_2 < TiH_2$

(ii) LiH < NaH < CsH

(iii) F – F < H – H < D – D

(iv) $H_2O < MgH_2 < NaH$

15)* What do you expect the nature of Hydrides is, if formed by elements of atomic numbers 15, 19, 23 and 44 with dihydrogen ? Compare their behaviour towards water. (Exercise - 9.33)

➠ (i) The element (Z = 15) is a *p*-block element so it form covalent hydride, e.g. PH_3.

(ii) The element (Z = 19) is a *s*-block element so, it form ionic hydride, e.g. KH.

(iii) The element (Z = 23) is *d*-block element. So it form nonstoichiometric hydride, e.g. $VH_{1.6}$.

(iv) The element (Z = 44) is from *d*-block and 8 group. So it does not form hydride.

➠ Above four hydride, only H_2 is obtained in reaction of KH with H_2O.

$$KH + H_2O \longrightarrow KOH + H_2$$

16)* What do you understand by (i) electron deficient (ii) electron precise and (iii) electron rich compounds of hydrogen ? Provide justification with suitable examples.

OR (Exercise - 9.8)

*** What characteristics do you expect from an electron deficient hydride with respect an electron deficient hydride with respect to its structure and chemical reactions ?**

OR (Exercise - 9.9)

Write note on covalent or molecular hydrides.

➠ Dihydrogen forms molecular compounds with most of the *p*-block elements. Most familiar examples are CH_4, NH_3, H_2O and HF.

- For convenience hydrogen compounds of non-metals have also been considered as hydrides. Being covalent, they are volatile compounds.
- Molecular hydrides are further classified according to the relative numbers of electrons and bonds in their Lewis structure into :
  (i) electron-deficient,
  (ii) electron-precise,
  (iii) electron - rich hydrides.
- An electron-deficient hydride, as the name suggests, has too few electrons for writing its conventional Lewis structure.
  Example : Diborane (B_2H_6)
- In fact all elements of group 13 will form electron-deficient compounds. They act as Lewis acids i.e., electron acceptors.
- Electron-precise compounds have the required number of electrons to write their conventional Lewis structures. All elements of group 14 form such compounds (e.g., CH_4) which are tetrahedral in geometry.
- Electron-rich hydrides have excess electrons which are present as lone pairs.
  Example : Elements of group 15-17 form such compounds. (NH_3 has 1-lone pair, H_2O – 2 and HF –3 lone pairs).
- They will behave as Lewis bases i.e., electron donors. The presence of lone pairs on highly electronegative atoms like N, O and F in hydrides results in hydrogen bond formation between the molecules. This leads to the association of molecules.

[2] Would you expect the hydrides of N, O, and F to have lower boiling points than the hydrides of their subsequent group members ? Give reasons. OR (Text Book Problem -9.2)

*** Among NH_3, H_2O and HF, which would you expect to have highest-magnitude of hydrogen bonding and why ? (Exercise - 9.14)**

- On the basis of molecular masses of NH_3, H_2O and HF, their boiling points are expected to be lower than those of the subsequent group member hydrides.
  However, due to higher electronegativity of N, O and F, the magnitude of hydrogen bonding in their hydrides will be quite appreciable. Hence, the boiling points NH_3, H_2O and HF will be higher than the hydrides of their subsequent group members.

17)* What do you understand by the form non-stoichiometric hydrides ? Do you expect this type of the hydrides to be formed by alkali metals ? Justify your answer.

OR (Exercise - 9.11)

*** How do you expect the metallic hydrides to be useful for hydrogen storage ? Explain.**

OR (Exercise - 9.12)

Write note on Metallic or non stoichiometric hydrides.

- The Metallic hydride are formed by many *d*-block and *f*-block elements.
- However, the metals of group 7, 8 and 9 do not form hydride. Even from group 6, only chromium forms CrH. These hydrides conduct heat and electricity though not as efficiently as their parent metals do.
- Unlike saline hydrides, they are almost always non-stoichiometric, being deficient in hydrogen.
  For example : $LaH_{2.87}$, $YbH_{2.55}$, $TiH_{1.5\ -\ 1.8}$, $ZrH_{1.3\ -\ 1.75}$, $VH_{0.56,}$ $NiH_{0.6\ -\ 0.7}$, $PdH_{0.6\ -\ 0.8}$ etc. In such hydrides, the law of constant composition does not hold good.
- In these hydrides, hydrogen occupies interstitial space in the metal lattice producing distortion without any change in its type. Consequently, they were termed as interstitial hydrides.
- The except for hydrides of Ni, Pd, Ce and Ac, other hydrides of this class have lattice different from that of the parent metal.
- The property of absorption of hydrogen on transition metals is widely used in catalytic reduction / hydrogenation reactions for the preparation of large number of compounds.
- Some of the metals (e.g., Pd, Pt) can accommodate a very large volume of hydrogen and, therefore, can be used as its storage media.
- This property has high potential for hydrogen storage and as a source of energy.

18)* Do you expect the carbon hydrides of the type C_nH_{2n+2} to act as 'Lewis' acid or base ? Justify your answer. (Exercise - 9.10)

➠ Carbon hydrides of type (C_nH_{2n+2}) are electron precise hydrides. In other words, they have exact number of electrons required to form covalent bonds. Therefore, they do not have any tendency to either gain or lose electrons and hence they neither act as lewis acids nor lewis bases.

[3] Can phosphorus with outer electronic configuration $3s^2$, $3p^3$ form PH_5 ? (Text Book Problem -9.3)

➠ Although phosphorus exhibits +3 and +5 oxidation states, it cannot form PH_5. Besides some other considerations, high Δ_aH value of dihydrogen and $\Delta_{eg}H$ value of hydrogen do not favour to exhibit the highest oxidation state of P, and consequently the formation of PH_5.

9.6 Water

19)* Describe the usefulness of water in biosphere and biological system. (Exercise - 9.28)

OR

Give general information about water (H_2O)

OR

Give importance of water for living organisms and write.

➠ A major part of all living organisms is made up of water. Human body has about 65% and some plants have as much as 95% water.

➠ It is a crucial compound for the survival of all life forms.

➠ It is a solvent of great importance.

➠ The distribution of water over the earth's surface is not uniform. The estimated world water supply is given in following Table.

➠ The high heat of vaporisation and heat capacity are responsible for moderation of the climate and body temperature of living beings.

➠ It is an excellent solvent for transportation of ions and molecules required for plant and animal metabolism.

Estimated World Water Supply

Source	% of Total
Oceans	97.33
Saline lakes and inland seas	0.008
Polar ice and glaciers	2.04
Ground water	0.61
Lakes	0.009
Soil moisture	0.005
Atmospheric water vapour	0.001
Rivers	0.0001

20)* What properties of water make it useful as a solvent ? What types of compound can it (i) dissolve and (ii) hydrolyse ? (Exercise - 9.29)

OR Physical properties of water.

➠ Water is a colourless and tasteless liquid. The unusual properties of water in the condensed phase (liquid and solid states) are due to the presence of extensive hydrogen bonding between water molecules.

➠ This leads to high freezing point, high boiling point, high heat of vaporisations and high heat of fusion in comparison to H_2S and H_2Se.

➠ In comparison to other liquids, water has a higher specific heat, thermal conductivity, surface tension, dipole moment and dielectric constant, etc.

➠ These properties allow water to play a key role in the biosphere.

➠ It is an excellent solvent for transportation of ions and molecules required for plant and animal metabolism.

➠ Due to hydrogen bonding with polar molecules, even covalent compounds like alcohol and carbohydrates dissolve in water.

Physical properties of H_2O and D_2O

Physical Properties of H_2O and D_2O

Property	H_2O	D_2O
Molecular mass (g mol^{-1})	18.0151	20.0276
Melting point / K	273.0	276.8
Boiling point / K	373.0	374.4
Enthalpy of formation / kJ mol^{-1}	–285.9	–294.6
Enthalpy of vaporisation (373 K) / kJ mol^{-1}	40.66	41.61

Enthalpy of fusion/ kJ mol^{-1}	6.01	–
Temp of max. density / K	276.98	284.2
Density (298K) / g cm^{-3}	1.0000	1.1059
Viscosity / centipoise	0.8903	1.107
Dielectric constant / C^2 / $N.m^2$	78.39	78.06
Electrical conductivity (293 K/$ohm^{-1}cm^{-1}$)	5.7×10^{-8}	–

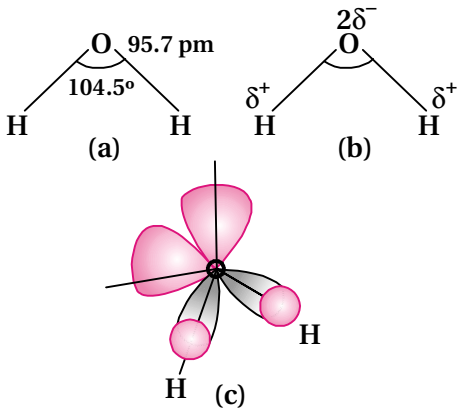
21)* Compare the structures of H_2O and H_2O_2.

OR (Exercise - 9.17)

Explain structure of water. OR

Write bond angle and hybridisation type of water molecule

➠ In the gas phase water is a bent molecule with a bond angle of 104.5°, and O–H bond length of 95.7 pm as shown in fig.



H_2O molecule

(a) The bent structure of water (b) the water molecule as a dipole and (c) the orbital overlap picture in water molecule

➠ It is a highly polar molecule. Its orbital overlap picture is shown in figure.

➠ In the liquid phase water molecules are associated together by hydrogen bonds. The crystalline form of water is ice. At atmospheric pressure ice crystallises in the hexagonal form, but at very low temperatures it condenses to cubic form.

➠ Density of ice is less than that of water. Therefore, an ice cube floats on water.

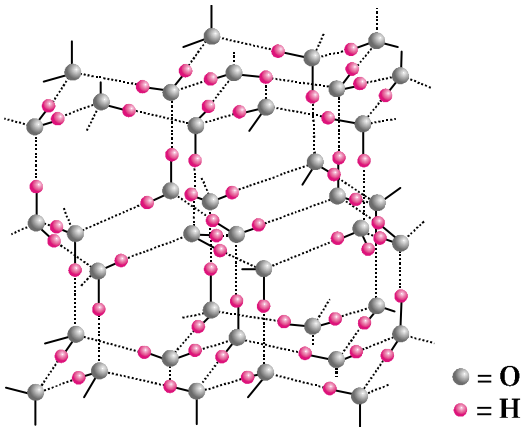
➠ In winter season ice formed on the surface of a lake provides thermal insulation which ensures the survival of the aquatic life.

22)* Describe the structure of the common form of ice. OR (Exercise - 9.21)

Explain structure of ice.

➠ Ice has a highly ordered three dimensional hydrogen bonded structure as shown in figure. Examination of ice crystals with X-rays shows that each oxygen atom is surrounded tetrahedrally by four other oxygen atoms at a distance of 276 pm.

➠ Hydrogen bonding gives ice a rather open type structure with wide holes. These holes can hold some other molecules of appropriate size interstitially.



The structure of ice

23) Give chemical properties of water.

➠ Water reacts with a large number of substances some of the important reactions are given below.

*** Sub. Que. : Write chemical reactions to show the amphoteric nature of water. (Exercise - 9.24)**

➠ **(i) Amphoteric Nature :** It has the ability to act as an acid as well as a base i.e., it behaves as an amphoteric substance. In the Brönsted sense it acts as an acid with NH_3 and a base with H_2S.

$$H_2O_{(l)} + NH_{3(aq)} \rightleftharpoons OH^-_{(aq)} + NH^+_{4(aq)}$$

$$H_2O_{(l)} + H_2S_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + HS^-_{(aq)}$$

*** Sub. Que. : What do you understand by the term 'auto protolysis' of water ? What is its significance ? (Exercise - 9.18)**

➠ The auto-protolysis (self-ionization) of water takes place as follows :

$$\underset{\text{acid-1 (acid)}}{H_2O_{(l)}} + \underset{\text{base-2 (base)}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{acid-2 (conjugate acid)}}{H_3O^+_{(aq)}} + \underset{\text{base-1 (conjugate base)}}{OH^-_{(aq)}}$$

➠**(ii) Redox Reactions Involving Water :** Water can be easily reduced to dihydrogen by highly electropositive metals.

$2H_2O_{(l)} + 2Na_{(s)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$

➠ Thus, it is a great source of dihydrogen. Water is oxidised to O_2 during photosynthesis.

$6CO_{2(g)} + 12H_2O_{(l)} \rightarrow C_6H_{12}O_{6(aq)} + 6H_2O_{(l)} + 6O_{2(g)}$

➠ With fluorine also it is oxidised to O_2

$2F_{2(g)} + 2H_2O_{(l)} \longrightarrow 4H^+_{(aq)} + 4F^-_{(aq)} + O_{2(g)}$

*** Sub. Que. : What is the difference between the forms 'hydrolysis' and 'hydration.**

(Exercise - 9.31)

➠**(iii) Hydrolysis Reaction :** Due to high dielectric constant, it has a very strong hydrating tendency. It dissolves many ionic compounds. However, certain covalent and some ionic compounds are hydrolysed in water.

$P_4O_{10(s)} + 6H_2O_{(l)} \longrightarrow 4H_3PO_{4(aq)}$

$SiCl_{4(l)} + 2H_2O_{(l)} \longrightarrow SiO_{2(s)} + 4HCl_{(aq)}$

$N^{3-}_{(s)} + 3H_2O_{(l)} \longrightarrow NH_{3(g)} + 3OH^-_{(aq)}$

➠**(iv) Hydrates Formation :** From aqueous solutions many salts can be crystallised as hydrated salts. Such an association of water is of different types viz.,

(i) coordinated water e.g., $[Cr(H_2O)_6]^{3+}\ 3Cl^-$

(ii) interstitial water e.g., $BaCl_2 . 2H_2O$

(iii) hydrogen-bonded water

e.g., $[Cu(H_2O)_4]^{2+}\ SO_4^{2-} \cdot H_2O$ in $CuSO_4 \cdot 5H_2O$

24)* Consider the reaction of water with F_2 and suggest in terms of oxidation and reduction, which species are oxidised reduced.

(Exercise - 9.19)

➠ $2F_{2(g)} + 2H_2O_{(l)} \longrightarrow O_{2(g)} + 4H^+_{(aq)} + 4F^-_{(aq)}$

Reduction / oxidation

➠ In above reaction water act as a reducing agent so, it accept oxygen while fluorine act a oxidising agent. It release Fluorine ion (F^-).

25)* Complete the following chemical reactions : **(Exercise - 9.20)**

(i) $PbS_{(s)} + H_2O_{2(aq)} \rightarrow$

(ii) $MnO^-_{4(aq)} + H_2O_{2(aq)} \rightarrow$

(iii) $CaO_{(s)} + H_2O_{(g)} \rightarrow$

(iv) $AlCl_{3(g)} + H_2O_{(l)} \rightarrow$

(v) $Ca_3N_{2(s)} + H_2O_{(l)} \rightarrow$

Classify the above into (a) hydrolysis, (b) redox and (c) hydration reactions.

➠**(i)** $PbS_{(s)} + 4H_2O_{2(aq)} \longrightarrow PbSO_{4(s)} + 4H_2O_{(l)}$

(redox reaction)

➠**(ii)** $2MnO^-_{4(aq)} + 5H_2O_{2(l)} + 6H^+_{(aq)} \longrightarrow 2Mn^{2+}_{(aq)} + 8H_2O_{(l)} + 5O_{2(g)}$

(redox reaction)

➠**(iii)** $CaO_{(s)} + H_2O_{(g)} \longrightarrow Ca(OH)_{2(aq)}$

(hydrolysis reaction)

➠**(iv)** $AlCl_{3(g)} + 6H_2O_{(l)} \rightarrow [Al(OH_2)_6]^{3+}_{(aq)} + 3Cl^-_{(aq)}$

(hydration reaction)

➠**(v)** $Ca_3N_{2(s)} + 6H_2O_{(l)} \longrightarrow 3Ca(OH)_{2(aq)} + 2NH_{3(aq)}$

(hydrolysis reaction)

[4] How many hydrogen-bonded water molecule(s) are associated in $CuSO_4 \cdot 5H_2O$?

(Text Book Problem - 9.4)

➠ Only one water molecule, which is outside the brackets (coordination sphere), is hydrogen-bonded. The other four molecules of water are coordinated.

26)* What is meant by 'demineralised' water and how can it be obtained ? **(Exercise - 9.22)**

OR Explain Hard and Soft water

➠ Rain water is almost pure, Being a good solvent, when it flows on the surface of the earth, it dissolves many salts.

➠ Presence of calcium and magnesium salts in the form of hydrogencarbonate, chloride and sulphate in water makes water 'hard'.

➠ Hard water does not give lather with soap. Water free from soluble salts of calcium and magnesium is called Soft water. It gives lather with soap easily.

➠ Hard water forms scum/precipitate with soap. Soap containing sodium stearate ($C_{17}H_{35}COONa$). Reacts with hard water to precipitate out Ca/Mg stearate.

$2C_{17}H_{35}COONa_{(aq)} + M^{2+}_{(aq)} \longrightarrow (C_{17}H_{35}COO)_2\ M \downarrow + 2Na^+_{(aq)}$;

M is Ca/Mg

➠ It is, therefore, unsuitable for laundry. It is harmful for boilers as well, because of deposition of salts in the form of scale. This reduces the efficiency of the boiler. The hardness of water is of two types: (i) temporary hardness, and (ii) permanent hardness.

27) Describe methods to remove the temporary Hardness of water (i) Boiling (ii) Clark's is method.

➠**(i) Boiling :** During boiling, the soluble $Mg(HCO_3)_2$ is converted into insoluble $Mg(OH)_2$ and $Ca(HCO_3)_2$ is changed to insoluble $CaCO_3$. It is because of high solubility product of $Mg(OH)_2$ as compared to that of $MgCO_3$, that $Mg(OH)_2$ is precipitated. These precipitates can be removed by filtration. Filtrate thus obtained will be soft water.

$$Mg(HCO_3)_2 \xrightarrow{\text{heating}} Mg(OH)_2 \downarrow + 2CO_2 \uparrow$$

$$Ca(HCO_3)_2 \xrightarrow{\text{heating}} CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

➠**(ii) Clark's method :** In this method calculated amount of lime is added to hard water. It precipitates out calcium carbonate and magnesium hydroxide which can be filtered off.

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

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

28) Describe method to remove the permanent hardness of water. OR

*** What is meant by 'demineralised' water and how can it be obtained ? (Exercise - 9.26)**

OR

*** Is demineralised or distilled water useful for drinking purposes ? If not, how can it be made useful ? OR (Exercise - 9.27)**

➠ Permanent hardness is due to the presence of soluble salts of magnesium and calcium in the form of chlorides and sulphates in water.

➠ Permanent hardness is not removed by boiling. It can be removed by the following methods.

➠**(i) Treatment with washing soda (sodium carbonate) :** Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates.

$$MCl_2 + Na_2CO_3 \longrightarrow MCO_3\downarrow + 2NaCl \ (M = Mg, Ca)$$

$$MSO_4 + Na_2CO_3 \longrightarrow MCO_3 \downarrow + Na_2SO_4$$

➠**(ii)** Calgon's method: Sodium hexametaphosphate ($Na_6P_6O_{18}$), commercially called 'calgon', when added to hard water, the following reactions take place.

$$Na_6P_6O_{18} \longrightarrow 2Na^+ + Na_4P_6O^{2-}{}_{18}$$

$$M^{2+} + Na_4P_6O^{2-}{}_{18} \longrightarrow [Na_2MP_6O_{18}]^{2-} + 2Na^+ \ (M = Mg, Ca)$$

➠ The complex anion keeps the Mg^{2+} and Ca^{2+} ions in solution.

*** Sub. Que. : Discuss the principle and method of softening of hard water by synthetic ion exchange resins. (Exercise - 9.23)**

➠**(iii) Ion-exchange method :** This method is also called zeolite/permutit process. Hydrated sodium aluminium silicate is zeolite/permutit.

➠ For the sake of simplicity, sodium aluminium silicate ($NaAlSiO_4$) can be written as NaZ. When this is added in hard water, exchange reactions take place.

$$2NaZ_{(s)} + M^{2+}{}_{(aq)} \longrightarrow MZ_{2(s)} + 2Na^+{}_{(aq)} \ (M = Mg, Ca)$$

➠ Permutit/zeolite is said to be exhausted when all the sodium in it is used up. It is regenerated for further use by treating with an aqueous sodium chloride solution.

$$MZ_{2(s)} + 2NaCl_{(aq)} \longrightarrow 2NaZ_{(s)} + MCl_{2(aq)}$$

➠**(iv) Synthetic resins method :** Nowadays hard water is softened by using synthetic cation exchangers. This method is more efficient than zeolite process.

➠ Cation exchange resins : It contain large organic molecule with $-SO_3H$ group and are water insoluble. Ion exchange resin (RSO_3H) is changed to RNa by treating it with NaCl.

➠ The resin exchanges Na^+ ions with Ca^{2+} and Mg^{2+} ions present in hard water to make the water soft. Here R is a resin anion.

$$2RNa_{(s)} + M^{2+}{}_{(aq)} \longrightarrow R_2M_{(s)} + 2Na^+{}_{(aq)}$$

➠ The resin can be regenerated by adding aqueous NaCl solution.

➠ Pure de-mineralised (de-ionized) water free from all soluble mineral salts is obtained by passing water successively through a cation exchange (in the H^+ form) and an anion-exchange (in the OH^- form) resins.

$$2RH_{(s)} + M^{2+}{}_{(aq)} \rightleftharpoons MR_{2(s)} + 2H^+{}_{(aq)}$$

➠ In this cation exchange process, H^+ exchanges for Na^+, Ca^{2+}, Mg^{2+} and other cations present in water.

➠ This process results in proton release and thus makes the water acidic.

➠ **Anion exchange process :**

$RNH_{2(s)} + H_2O_{(l)} \rightleftharpoons RNH_3^+ . OH^-_{(s)}$

$RNH_3^+ \cdot OH^-_{(s)} + X^-_{(aq)} \rightleftharpoons RNH_3^+ \cdot X^-_{(s)} + OH^-_{(aq)}$

➠ OH^- exchanges for anions like Cl^-, HCO_3^-, SO_4^{2-} etc. present in water. OH^- ions, thus, liberated neutralise the H^+ ions set free in the cation exchange.

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

➠ The exhausted cation and anion exchange resin beds are regenerated by treatment with dilute acid and alkali solutions respectively.

9.7 Hydrogen Peroxide (H_2O_2)

29) Write preparation of Hydrogen peroxide.

➠ **(i)** Acidifying barium peroxide and removing excess water by evaporation under reduced pressure gives hydrogen peroxide.

$$BaO_2 \cdot 8H_2O_{(s)} + H_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + H_2O_{2(aq)} + 8H_2O_{(l)}$$

➠ **(ii)** Peroxodisulphate, obtained by electrolytic oxidation of acidified sulphate solutions at high current density, on hydrolysis yields hydrogen peroxide.

$$2HSO^-_{4(aq)} \xrightarrow{\text{Electrolysis}} HO_3SOOSO_3H_{(aq)}$$

$$\xrightarrow{\text{Hydrolysis}} 2HSO^-_{4(aq)} + 2H^+_{(aq)} + H_2O_{2(aq)}$$

➠ This method is now used for the laboratory preparation of D_2O_2.

$$K_2S_2O_{8(s)} + 2D_2O_{(l)} \longrightarrow 2KDSO_{4(aq)} + D_2O_{2(l)}$$

➠ **(iii)** Industrially it is prepared by the auto-oxidation of 2-alklylanthraquinols.

$$\begin{pmatrix}\text{2-ethyl}\\ \text{anthraquinol}\end{pmatrix} \underset{H_2/Pd}{\overset{O_2\,(air)}{\rightleftharpoons}} H_2O_2 + \begin{pmatrix}\text{Oxidised}\\ \text{product.}\end{pmatrix}$$

➠ In this case 1% H_2O_2 is formed. It is extracted with water and concentrated to ~30% (by mass) by distillation under reduced pressure.

➠ It can be further concentrated to ~85% by careful distillation under low pressure. The remaining water can be frozen out to obtain pure H_2O_2.

30) Write physical properties of Hydrogen peroxide.

➠ In the pure state H_2O_2 is an almost colourless (very pale blue) liquid.

➠ H_2O_2 is miscible with water in all proportions and forms a hydrate $H_2O_2 \cdot H_2O$ (mp 221K).

➠ A 30% solution of H_2O_2 is marketed as '100 volume' hydrogen peroxide. It means that one millilitre of 30% H_2O_2 solution will give 100 mL of oxygen at STP. Commercially marketed sample is 10 V, which means that the sample contains 3% H_2O_2.

Physical Properties of Hydrogen Peroxide

Melting point/K	272.4
Density (liquid at 298 K)/g cm^{-3}	1.44
Boiling point (exrapolated)/ K	423
Viscosity (290K)/centipoise	1.25
Vapour pressure(298K)/mmHg	1.9
Dielectric constant (298K)/ C^2 / Nm^2	70.7
Density (solid at 268.5K)/g cm^{-3}	1.64
Electrical conductivity (298 K) / Ω^{-1} cm^{-1}	5.1×10^{-8}

[5] Calculate the strength of 10 volume solution of hydrogen peroxide. (Text Book Problem - 9.5)

➠ 10 volume solution of H_2O_2 means that 1L of this H_2O_2 solution will give 10 L of oxygen at STP

$2H_2O_{2(l)} \longrightarrow O_{2(g)} + H_2O_{(l)}$

$2 \times 34g$ 22.7 L at STP

68g

On the basis of above equation 22.7 L of O_2 is produced from 68 g H_2O_2 at STP

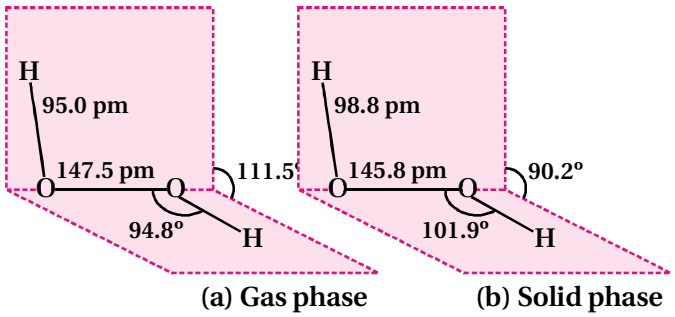
10 L of O_2 at STP is produced from

$\frac{68 \times 10}{22.4}$ g = 29.9 g ≈ 30 g H_2O_2

Therefore, strength of H_2O_2 in 10 volume H_2O_2 solution = 30 g/L = 3% H_2O_2 solution

31) Write structure of Hydrogen peroxide.

➠ Hydrogen peroxide has a non-planar structure.



(a) Gas phase (b) Solid phase

➠ (a) H_2O_2 structure in gas phase, dihedral angle is 111.5°. (b) H_2O_2 structure in solid phase at 110 K, dihedral angle is 90.2°.

32)* Write chemical reactions to justify that hydrogen peroxide can function as an oxidising as well as reducing agent. (Exercise - 9.25)

OR

Write chemical properties of hydrogen peroxide.

➠ Hydrogen peroxide act as an oxidising as well as reducing agent in both acidic and alkaline media. Simple reactions are described below.

➠**(i) Oxidising effect in acidic medium :**

$$2Fe^{2+}_{(aq)} + 2H^+_{(aq)} + H_2O_{2(aq)} \longrightarrow 2Fe^{3+}_{(aq)} + 2H_2O_{(l)}$$

$$PbS_{(s)} + 4H_2O_{2(aq)} \longrightarrow PbSO_{4(s)} + 4H_2O_{(l)}$$

➠**(ii) Reducing effect in acidic medium :**

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

$$HOCl + H_2O_2 \longrightarrow H_3O^+ + Cl^- + O_2$$

➠**(iii) Oxidising effect in basic medium :**

$$2Fe^{2+} + H_2O_2 \longrightarrow 2Fe^{3+} + 2OH^-$$

$$Mn^{2+} + H_2O_2 \longrightarrow Mn^{4+} + 2OH^-$$

➠**(iv) Reducing effect in basic medium :**

$$I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$$

$$2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$$

33) How the H_2O_2 should be store ?

➠ H_2O_2 decomposes slowly on exposure to light.

$$2H_2O_{2(l)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$

➠ In the presence of metal surfaces or traces of alkali (present in glass containers), the above reaction is catalysed.

➠ It is, therefore, stored in wax-lined glass or plastic vessels in dark.

➠ Urea can be added as a stabiliser. It is kept away from dust because dust can induce explosive decomposition of the compound.

34)* How does H_2O_2 behave as a bleaching agent ?

OR (Exercise - 9.35)

Give uses of Hydrogen peroxide.

➠(i) In daily life it is used as a hair bleach and as a mild disinfectant. As an antiseptic it is sold in the market as perhydrol.

➠(ii) It is used to manufacture chemicals like sodium perborate and per-carbonate, which are used in high quality detergents.

➠(iii) It is used in the synthesis of hydroquinone, tartaric acid and certain food products and pharmaceuticals (cephalosporin) etc.

➠(iv) It is employed in the industries as a bleaching agent for textiles, paper pulp, leather, oils, fats, etc.

➠(v) Nowadays it is also used in Environmental (Green) Chemistry. For example, in pollution control treatment of domestic and industrial effluents, oxidation of cyanides, restoration of aerobic conditions to sewage wastes, etc.

[6] What is the volume of 1.5 N H_2O_2 ?

➠ Normality of $H_2O_2 = \dfrac{H_2O_2 \text{ volume strength}}{5.6}$

$\therefore$ Volume strength = $1.5 \times 5.6 = 8.4$ H_2O_2

[7] Calculate volume strength of 30.36g / litre H_2O_2 solution.

➠ $V = \dfrac{aml \times 22.4}{68}$

$= \dfrac{30.36 \times 22.4}{68} = 10.0009$

[8] ..... is strength in %W/V of 40 volume containing H_2O_2 solution.

➠ $2H_2O_2 \longrightarrow 2H_2O + O_2$

68gm volume at 1 mol STP = 22.4 litre

1 mol O_2 at STP = 1 mol H_2O_2

$\therefore$ 22.4 litre O_2 from 68 gm H_2O_2

$\therefore$ 40 litre O_2 x gm

$\therefore \dfrac{22.4}{40} = \dfrac{68}{x}$

$\therefore x = \dfrac{68 \times 40}{22.4} = 121.42$ gm/L H_2O_2

$\therefore$ H_2O_2 %W/V $= \dfrac{121.42}{10} = 12.14$

❖ Try Your Self ❖

(1) **Calculate molarity and % W/V of 40 volume of H_2O_2.** **(Ans. : 12.14)**

(2) **The concentration of commercial H_2O_2 is 3.125 M than its grade is ..... volume.** **(Ans. : 35 Volume)**

(3) **12 L H_2O_2 solution contain 680 gm H_2O_2 then % W/V and volume of the solution is respectively ..... and ..... .** **(Ans. : 5.66, 18.7)**

(4) **The strength of H_2O_2 sample available form market is 8.32% W/V. The volume and molar concentration of this sample are ..... and ..... respectively** **(Ans. : 27.4, 2.447)**

9.8 Heavy Water, (D_2O)

35)* Knowing the properties of H_2O and D_2O. Do you think that D_2O can be used for drinking purpose ? **(Exercise - 9.30)**

OR

What is heavy water ? Give uses of it.

- Heavy water is injurious to human beings, plants and animals since it slows down the rates of reactions occurring in them. Thus heavy water does not support life so it is not used for drinking.
- Heavy water (D_2O) is a oxide of deuterium, the isotope of Hydrogen.
- Heavy water is extensively used as a moderator in nuclear reactors and in exchange reactions for the study of reaction mechanisms.
- It can be prepared by exhaustive electrolysis of water or as a by product in some fertilizer industries.

$$CaC_2 + 2D_2O \longrightarrow C_2D_2 + Ca(OD)_2$$

$$SO_3 + D_2O \longrightarrow D_2SO_4$$

$$Al_4C_3 + 12D_2O \longrightarrow 3CD_4 + 4Al(OD)_3$$

9.9 Dihydrogen as a Fuel

36) Give uses of Dihydrogen as a fuel.

- Dihydrogen releases large quantities of heat on combustion. Dihydrogen can release more energy than petrol (about three times).
- The only pollutants will be the oxides of dinitrogen (due to the presence of dinitrogen as impurity with dihydrogen).
- A cylinder of compressed dihydrogen weighs about 30 times as much as a tank of petrol containing the same amount of energy.
- Tanks of metal alloy like $NaNi_5$, Ti–TiH_2, Mg–MgH_2 etc. are in use for storage of dihydrogen in small quantities.
- The basic principle of hydrogen economy is the transportation and storage of energy in the form of liquid or gaseous dihydrogen.
- Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power.

- The Energy Released by Combustion of Various Fuels in Moles, Mass and Volume

Energy released on combustion in kJ state)	Dihydrogen (in gaseous state)	Dihydrogen (in liquid)	LPG	CH_4 gas	Octane (in liquid state)
per mole	286	285	2220	880	5511
per gram	143	142	50	53	47
per litre	12	9968	25590	35	34005

37)* Do you expect different products in solution when aluminium (III) chloride and potassium chloride treated separately with (i) normal water (ii) acidified water and (iii) alkaline water ? Write equations wherever necessary.

(Exercise - 9.34)

➠ **$AlCl_3$:** The aqueous solution containing acidic nature.

(i) $AlCl_{3(s)} + H_2O_{(l)} \rightarrow Al(OH)_{3(s)} + 3H^+_{(aq)} + 3Cl^-_{(aq)}$

(ii) In acidified water H^+ ion react with $Al(OH)_3$ and give Al^{3+} in and H_2O. Thus the Al^{3+} and Cl^- ion obtain from $AlCl_3$ in acidified water.

(iii) $AlCl_{3(s)} \xrightarrow[\text{water}]{\text{Basic}} [Al(OH)_4]^-_{(aq)} + 3Cl^-_{(aq)}$

$[Al(OH)_4]^-_{(aq)} \longrightarrow AlO^-_2 + 2H_2O_{(l)}$

➠ **KCl :** KCl is a salt of strong acid and strong base and reacts with H_2O. The K^+ and Cl^- obtain by only dissociation reaction.

$$KCl_{(s)} \xrightarrow{H_2O} K^+_{(aq)} + Cl^-_{(aq)}$$

➠ The aqueous solution of KCl is neutral. There is no reaction between ions in acidic/basic solution of KCl.

38)* What do you understand by the terms :

(i) Hydrogen economy (ii) Hydrogenation

(iii) Syngas

(iv) Water-gas shift reaction

(v) Fuel-cell ? **(Exercise - 9.36)**

➠**(i) Hydrogen - economy :** The basic principle of hydrogen - economy is the transportation and storage of energy in the form of liquid or gaseous dihydrogen.

➠**(ii) Hydrogenation :** Hydrogenation of vegetable oils using nickel as catalyst gives edible fats (margarine and vanaspati ghee)

➠**(iii) Syngas :** The mixture of CO and H_2 is used for the synthesis of methanol and a number of hydrocarbons so it is called synthesis gas or syngas.

➠**(iv) Water gas shift reaction :** The production of dihydrogen can be increased by reacting carbon monoxide of syngas mixture with steam in the presence of iron chromate as catalyst.

$$\underbrace{CO_{(g)} + H_2O_{(g)}}_{\text{Water–gas}} + \xrightarrow[\text{steam catalyst}]{673K} CO_{2(g)} + H_{2(g)}$$

$FeCrO_4$

➠**(v) Fuel-cell :** Fuel-cell is a device which converts, the energy produced during the combustion of a fuel directly into electrical energy Dihydrogen is used in Hydrogen-Oxygen fuel-cells for generating electrical energy. In this 70 – 85% combustion energy is converted into electrical energy.

Section-B Objective Questions

Short Questions

1) Which block elements form the interstitial hydrides compound ?

➠ *d*-block and *f*-block elements form interstitial hydride compound.

2) What is "Calgon" ? Give its molecular formula.

➠ Sodium hexametaphosphate commercialy called 'calgon'. Its molecular formula is $Na_6P_6O_{18}$.

3) Which is act as an oxidising agent in the following reaction ?

$2H_2O_{(l)} + 2Na_{(s)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$

➠ H_2 is obtained by reduction of H^+ in H_2O. Therefore it act as an oxidizing agent.

4) Which compound is used to remove the temporary hardness of water in Clark's method.

➠ In clark's method, the lime water ($Ca(OH)_2$) is used to remove the temporary hardness.

5) What will be obtained by reaction of calcium carbide with heavy water ? Give its chemical reaction.

➠ Procuct : $Ca(OD)_2$ and C_2D_2

Reaction : $CaC_2 + 2D_2O \rightarrow Ca(OD)_2 + C_2D_2$

6) Write bond angle and types of hybridization of water molecule.

➠ In water molecule, the bond angle of H – O – H is 104.5° and the oxygen atom containing sp^3 hybridization.

7) Why the boiling point of H_2O is higher than the H_2S ?

➠ The boiling point of H_2O is higher than the H_2S because of H-bond in H_2O.

8) What is the half life period of tritium ?

➠ The half life period of tritium is 12.33 years.

9) How the crystal form of ice will be examine ?

➠ The examination of ice crystals is done with X-rays.

10) How many isotopes Hydrogen has ? Give its Names.

➠ Hydrogen has three isotopes :

(i) protium $\left({}_1^1H\right)$,

(ii) deuterium $\left({}_1^2H \text{ and } D\right)$ and

(iii) tritium $\left({}_1^3H \text{ or } T\right)$

11) Hydrogen forms stable diatomic molecule like which elements ?

➠ Hydrogen forms stable diatomic molecule like halogen elements.

12) Complete the reaction : $8\,LiH + Al_2Cl_6 \rightarrow (?)$

➠ $8\,LiH + Al_2Cl_6 \rightarrow 2\,LiAlH_4 + 6\,LiCl$.

13) Give reaction of I_2 with H_2O_2 in presence of basic medium ?

➠ $I_{2(s)} + H_2O_{2(aq)} + 2OH^-_{(aq)} \rightarrow 2I^-_{(aq)} + 2H_2O_{(l)} + O_{2(g)}$

14) From which source maximum hydrogen is obtained ?

➠ Maximum Hydrogen is obtained from petrochemicals.

15) Which isotope of hydrogen emitted β-particle ?

➠ The tritium isotope of hydrogen emitted the β-particles.

16) Reaction $HO_3\,SOOSO_3\,H_{(aq)} \xrightarrow[H_2O]{\text{Hydrolysis}} 2H_2SO_4 + x$. What is product x ?

➠ The product x will be H_2O_2.

17) Which element accept one electron and get noble gas like configuration ?

➠ Hydrogen element accepts one electron and gets noble gas like configuration.

18) In synthesis of which compound, the water gas is used ?

➠ Water gas is used in synthesis of CH_3OH (methanol).

19) What is the – O – O – H bond angle in solid form of H_2O_2 ?

➠ In solid form of H_2O_2 – O – O – H bond angle is 101.9°.

20) The correct reactivity order of halogen with hydrogen is ?

➠ $F_2 > Cl_2 > Br_2 > I_2$

21) Give reason : The Density of water is higher than density of ice.

➠ The Density of water is higher then density of ice because of the hydrogen bonding.

22) Which pairs of ions are responsible for hardness of water ?

➠ Ca^{2+} and Mg^{2+} like pairs of ions are responsible for hardness of water.

23) Give reason : The hard water is not suitable for washing of clothes.

➠ The hard water is not suitable for washing of clothes because the hard water create precipitate with soup.

Fill in the Blanks

24) H_2O_2 act as an antiseptic then it is known as ..... in market.

➠ perhydrol

25) Cation exchange resin is ..... group containing organic molecule.

➠ SO_3H

26) The ionic radius of H^+ ions and that of other ions is ..... pm and ..... pm respectively.

➠ 1.5×10^{-3} pm, 50 – 200 pm

27) ..... group elements give saltlike hydride.

➠ *s* group.

28) Only ..... element of group-6 forms hydride.

➠ Cr

29) ..... is used in moderator in nuclear reactors.

➠ D_2O

30) The three dimensional arrangement occurs by ..... bond in ice.

➠ hydrogen

31) ..... method is used to obtain H_2O_2 from 2-ethylanthraquinol.

➠ Oxidation

32) In crystal structure of ice, the oxygen atom is at ..... distance from four hydrogen atoms.

➠ 276 pm

33) ..... is the relative proportion of tritium and protium.

➠ $1 : 10^{18}$

State True Or False For The Following Statements

34) Metals of group 7, 8 and 9 form non-stoichiometric hydride.

➠ False

35) The pure dihydrogen is obtained by heating of hydrocarbon with H_2O vapour in presence of Fe catalyst at 1270K temp.

➠ False

36) The ionization enthalpy of hydrogen is more than Alkali metals.

➠ True

37) Some chemical properties of hydrogen is like metal and nonmetal.

➠ True

38) The metal and non metal elements of *d*-block are react with hydrogen and give molecular hydrides.

➠ False

39) At normal temp. dihydrogen reacts violently with dioxygen.

➠ True

Match the Following

40) Match the correct option from Column-A and Column-B.

Column-A	Column-B
(1) H_2O_2	(p) As moderator
(2) D_2O	(q) As fuel
(3) liquid H_2	(r) For to make hard water soft
(4) Zeolite	(s) As disinfectant

➠ (1 → s); (2 → p); (3 → q); (4 → r)

41) Match the correct option from Column-A and Column-B.

Column-A	Column-B
(1) Calgon	(a) D_2O
(2) perhydrol.	(b) Zeolite
(3) Heavy water	(c) Sodium metahexametaphosphate
(4) Aluminosyliate	(d) Commercial name of Hydrogen peroxide

➠ (1 → c); (2 → d); (3 → a); (4 → b)

42) Match the correct option from Column-A and Column-B.

Column-A	Column-B
(1) Ionic hydride	(p) BeH_2
(2) Interstitial hydride	(q) TiH
(3) Electron-precise hydride	(r) CH_4
(4) Electron-rich hydride	(s) H_2O
	(t) B_2H_6

➠ (1 → p); (2 → t); (3 → r); (4 → s)

43) Match the correct option from Column-A and Column-B.

Column-A	Column-B
(1) VH	(a) Ionic hydride
(2) HF	(b) Metallic hydride
(3) Magnesium hydrides	(c) Electron precise hydride
(4) B_2H_6	(d) Molecular hydride

➠ (1 → b); (2 → d); (3 → a); (4 → c)

Assertion And Reason Type Questions

(A) Both (A) and (R) are true and Reason (R) is the correct explanation of (A).

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) (A) is true but (R) is false.

(D) (A) and (R) both are false.

44) Assertion : Hydrogen atom combines with other element by exchange and sharing of electron.

Reason : Hydrogen can be form electrovalent or covalent bond with other elements.

Ans. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).

45) Assertion : H_2 act as a reducing agent and react with many organic compounds in presence of catalyst and give hydrogenated product.

Reason : $CH_2 = CH_2 + H_2 \xrightarrow[390\,K]{[Ni]} CH_3 - CH_3$

Ans. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).

46) Assertion : In metallic hydrides hydrogen occupies interstices in the metal lattice producing distortion without any change in its type.

Reason : Metallic hydride is also known as Interstitial hydride.

Ans. (B) Both (A) and (R) are true but (R) is not the correct explanation of (A).

47) Assertion : Saline hydrides react violently with water producing dihydrogen gas.

Reason : The metals of group 6, 7, 8 and 9 do not from hydride.

Ans. (C) Assertion is true but (B) is false.

48) Assertion : H_2O has high melting point and boiling point than H_2S, H_2Se .

Reason : H_2O containing hydrogen bond.

Ans. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).

Section-C NCERT Exemplar Solution

Multiple Choice Questions (MCQs)

1) Hydrogen resembles halogens in many respects for which several factors are responsible. Of the following factors which one is most important in this respect ?

(A) Its tendency to lose an electron to form a cation.

(B) Its tendency to gain a single electron in its valence shell to attain stable electronic configuration.

(C) Its low negative electron enthalpy value.

(D) Its small size.

Ans. **(B)** Its tendency to gain a single electron in its valence shell to attain stable electronic configuration.

➠ Hydrogen resembles halogen in many respects. In its one main tendency is to gain a single electron in its valence shell to attain stable electronic configuration.

2) Why does H^+ ion always get associated with other atoms or molecules ?

(A) Ionisation enthalpy of hydrogen resembles that of alkali metals.

(B) Its reactivity is similar to halogens.

(C) It resembles both alkali metals and halogens

(D) Loss of an electron from hydrogen atom results in a nucleus of very small size as compared to other atoms or ions. Due to small size it cannot exist free.

Ans. **(D)** Loss of an electron from hydrogen atom results in a nucleus of very small size as compared to other atoms or ions. Due to small size it cannot exist free.

➠ H^+ ion immediately combine with any neutral molecule or atom as after losing one electron it is very small in size. So such small ion can't remain stable in free state.

3) Metal hydrides are ionic, covalent or molecular in nature. Among LiH, NaH, KH, RbH and CsH, the correct order of increasing ionic character is

(A) LiH > NaH > CsH > KH > RbH

(B) LiH < NaH < KH < RbH < CsH

(C) RbH > CsH > NaH > KH > LiH

(D) NaH > CsH > RbH > LiH > KH

Ans. **(B)** LiH < NaH < KH < RbH < CsH

➠ Ionic character increase as the size of the atom increases or the electronegativity of the atom decreases :

LiH < NaH < KH < RbH < CsH

4) Which of the following hydrides is electron-precise hydride ?

(A) B_2H_6 (B) NH_3 (C) H_2O (D) CH_4

Ans. **(D)** CH_4

➠ Electron precise hydrides contain exact number of electron to form normal covalent bonds. The shape of CH_4 is Tetrahedral.

5) Radioactive elements emit α, β and γ are characterised by their half-lives. The radioactive isotope of hydrogen is

(A) Protium (B) deuterium

(C) tritium (D) hydronium

Ans. **(C)** tritium

➠ The radioactive isotope of hydrogen is tritium. Because in tritium (n = 3, p = 1), so, n/p (neutron/proton) ration is 3 and this ratio > 1.5 are usually radioactive.

6) Consider the reactions

(i) $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$

(ii) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$

Which of the following statements is correct about H_2O_2 with reference to these reactions ? Hydrogen peroxide is ..... .

(A) an oxidising agent in both (i) and (ii)

(B) an oxidising agent in (i) and reducing agent in (ii)

(C) a reducing agent in (i) and oxidising agent in (ii)

(D) a reducing agent in both (i) and (ii)

Ans. **(B)** an oxidising agent in (i) and reducing agent in (ii)

Reduction

➠ (i) $H_2O_2^{-1} + 2HI^{-1} \rightarrow I_2^0 + 2H_2O^{-2}$

Oxidation

In above Reduction H_2O_2 acts as an Oxidation agent and convert HI into I_2.

Reduction

➠ (ii) $HOCl^{+1} + H_2O_2^{-1} \rightarrow H_3O^+ + Cl^- + H_2O_2^0$

Oxidation

In above reduction H_2O_2 acts as a Reducing agent and convert HOCl into Cl^{-1}.

7) The oxide that gives H_2O_2 on treatment with dilute H_2SO_4 is

(A) PbO_2 (B) $BaO_2 \cdot 8H_2O + O_2$

(C) MnO_2 (D) TiO_2

Ans. **(B)** $BaO_2 \cdot 8H_2O + O_2$

➠ Oxides such as BaO_2, Na_2O_2 etc. which contain peroxide linkage (i.e., – O – O or O_2^{2-}) on treatment with dilute H_2SO_4 give H_2O_2 but dioxides (O = M = O, where M is the metal atom) such as PbO_2, MnO_2, TiO_2 do not give H_2O_2 on treatment with dilute H_2SO_4.

$BaO_2 \cdot 8H_2O_{(s)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + H_2O_{2(aq)} + 8H_2O_{(l)}$

8) Which of the following equations depict the oxidising nature of H_2O_2 ?

(A) $2MnO^-_4 + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

(B) $2Fe^{3+} + 2H + H_2O_2 \rightarrow 2Fe^{2+} + 2H_2O + O_2$

(C) $2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$

(D) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

Ans. **(C)** $2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$

➠ In this reaction reduction of H_2O_2 is occurs e.g. in reaction the oxidation no. of oxygen atom is become –1 to –2 so its indicate the oxidising nature.

Reduction

$2I^- + 2H^+ + H_2O_2^{-1} \rightarrow I_2^0 + 2H_2O^{-2}$

Oxidation

9) Which of the following equation depicts reducing nature of H_2O_2 ?

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

(B) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

(C) $Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2OH^-$

(D) $Pbs + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

Ans. **(B)** $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

➠ H_2O_2 acts as a oxidising agent and reducing agent in alkaline following reaction indicate its reducing nature in basic medium.

$I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

$2MnO^-_4 + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$

10) Hydrogen peroxide is ..... .

(A) an oxidising agent

(B) a reducing agent

(C) both an oxidising and a reducing agent

(D) neither oxidising nor reducing agent

Ans. **(C)** both an oxidising and a reducing agent

➠ Hydrogen peroxide act as an oxidising and reducing agent in both acidic and basic medium.

11) Which of the following reactions increases production of dihydrogen from synthesis gas ?

(A) $CH_{4(g)} + H_2O_{(g)} \xrightarrow[Ni]{1270\ K} CO_{(g)} + 3H_{2(g)}$

(B) $C_{(s)} + H_2O_{(g)} \xrightarrow{1270\ K} CO_{(g)} + H_{2(g)}$

(C) $CO_{(g)} + H_2O_{(g)} \xrightarrow[Catalyst]{673\ K} CO_{2(g)} + H_{2(g)}$

(D) $C_2H_6 + 2H_2O \xrightarrow[Ni]{1270\ K} 2CO + 5H_2$

Ans. **(C)** $CO_{(g)} + H_2O_{(g)} \xrightarrow[Catalyst]{673\ K} CO_{2(g)} + H_{2(g)}$

➠ To increase the production of H_2 from synthesis gas CO is oxidised to CO_2 by passing it over steam at 673K in presence of a catalyst.

$CO_{(g)} + H_2O_{(g)} \xrightarrow{673\ K} CO_{2(g)} + H_{2(g)}$

12) When sodium peroxide is treated with dilute sulphuric acid, we get ..... .

(A) sodium sulphate and water

(B) sodium sulphate and oxygen

(C) sodium sulphate hydrogen and oxygen

(D) sodium sulphate and hydrogen peroxide

Ans. **(D)** sodium sulphate and hydrogen peroxide

➠ When sodium peroxide is react with dilute sulphuric acid, we get sodium sulphate and hydrogen peroxide.

$$Na_2O_2 + \text{dil. } H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$$

13) Hydrogen peroxide is obtained by the electrolysis of ..... .

(A) water (B) sulphuric acid

(C) hydrochloric acid

(D) fused sodium peroxide

Ans. **(B)** sulphuric acid

➠ When electrolysis of acidic sulphate salt and form peroxodisulphate and then its hydrolysis obtain H_2O_2.

$$2HSO_{4(aq)}^- \xrightarrow{\text{electrolysis}} HO_3SOOSO_3H_{(aq)}$$

$$\xrightarrow{\text{hydrolysis}} 2HSO_{4(aq)}^- + 2H^+_{(aq)} + H_2O_{2(aq)}$$

14) Which of the following reactions is an example of use of water gas in the synthesis of other compounds ?

(A) $CH_{4(g)} + H_2O_{(g)} \xrightarrow[\text{Ni}]{1270\text{ K}} CO_{(g)} + H_{2(g)}$

(B) $CO_{(g)} + H_2O_{(g)} \xrightarrow[\text{Catalyst}]{673\text{K}} CO_{2(g)} + H_{2(g)}$

(C) $C_nH_{2n} + nH_2O_{(g)} \xrightarrow[\text{Ni}]{1270\text{ K}} nCO + (2n+1)\,H_2$

(D) $CO_{(g)} + 2H_{2(g)} \xrightarrow{[CO]} CH_3OH_{(l)}$

Ans. **(D)** $CO_{(g)} + 2H_{2(g)} \xrightarrow{[CO]} CH_3OH_{(l)}$

➠ The mixture of carbon monoxide and Hydrogen gas is known as water gas.

$$CO_{(g)} + 2H_{2(g)} \xrightarrow{[CO]} CH_3OH_{(l)}$$

This equation indicate the use of water gas is in prep. of methanol.

15) Which of the following ions will cause hardness in water sample ?

(A) Ca^{+2} (B) Na^+ (C) Cl^- (D) K^+

Ans. **(A)** Ca^{+2}

➠ Bicarbonates, chlorides and sulphates of Ca and Mg are responsible for the hardness of water.

16) Which of the following compounds is used for water softening ?

(A) $Ca_3(PO_4)_2$ (B) Na_3PO_4

(C) $Na_6P_6O_{18}$ (D) Na_2HPO_4

Ans. **(C)** $Na_6P_6O_{18}$

➠ The sodium hexametaphosphate is used for water softening. Its molecular formula is

$$Na_2[Na_4(PO_3)_6] = Na_6P_6O_{18}$$

$$2CaCl_2 + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Ca_2(PO_3)_6] + 4NaCl$$

17) Elements of which of the following group(s) of periodic table do not form hydrides ?

(A) Groups 7, 8, 9 (B) Groups 13

(C) Groups 15, 16, 17 (D) Groups 14

Ans. **(A)** Groups 7, 8, 9

➠ Hydrogen gas form hydrides with all elements of *p*-group its general examples CH_4, NH_3, H_2O and HF. For understanding the compound of hydrogen with non-metal also are hydrides we say.

18) Only one element of ..... forms hydride.

(A) group-6(B) group-7(C) group-8 (D) group-9

Ans. **(A)** group-6

➠ Only one element of group 6 i.e. Cr forms hydride. It is CrH.

Note : Many elements of *d*-block and *f*-block are form metallic hydrides while the elements of group 7, 8, and 9 are not form hydride and only one element Cr of group-6 can form hydride.

Multiple Choice Questions (MCQs)
(More than one correct answer)

19) Which of the following statements are not true for hydrogen ?

(A) It exists as diatomic molecule.

(B) It has one electron in the outermost shell.

(C) It can lose an electron to form a cation which can freely exist.

(D) It forms a large number of ionic compounds by losing an electron.

Ans. **(C, D)**

➠ H^+ is never remain free because its always in small size so it easily combine with any atom or molecules. It is easily form oxide, halides and sulphide like alkali metal but its high ionisation enthalpy its not contain metallic character in normal case.

20) Dihydrogen can be prepared on commercial scale by different methods. In its preparation by the action of steam on hydrocarbons, a mixture of CO and H_2 gas is formed. It is known as ..... .

(A) water gas (B) syn gas

(C) producer gas (D) industrial gas

Ans. (A, B)

➠ Hydrogen gas is formed by many method. A mixture of CO + H_2 is called water gas or syn gas.

$$C_nH_{2n+2} + nH_2O \xrightarrow[[Ni]]{1270\,K} nCO_2 + (2n + 1)H_2$$

$$CH^+_{4(g)} + H_2O_{(g)} \xrightarrow[[Ni]]{1270\,K} CO_{(g)} + 3H_2$$

➠ The mixture of CO and H_2 is known as water gas and it is useful in synthesis of methanol and other hydrocarbons. So it is called synthetic gas.

21) Which of the following statement(s) is/are correct in the case of heavy water ?

(A) Heavy water is used as a moderator in nuclear reactor.

(B) Heavy water is more effective as solvent than ordinary water.

(C) Heavy water is more associated than ordinary water.

(D) Heavy water has lower boiling point than ordinary water.

Ans. (A, C)

➠ Heavy water is used as moderator in nuclear reactor and its boiling point is higher than normal water and it is a not good solvant than normal water because its dielectric constant is low.

22) Which of the following statements about hydrogen are correct ?

(A) Hydrogen has three isotopes of which protium is the most common.

(B) Hydrogen never acts as cation in ionic salts.

(C) Hydrogen ion, H^+, exists freely in solution.

(D) Dihydrogen does not act as a reducing agent.

Ans. (A, B)

➠ Hydrogen has three isotopes However H^+ being small never exists as cation in ionic compounds.

23) Some of the properties of water are described below. Which of them is/are not correct ?

(A) Water is known to be a universal solvent

(B) Hydrogen bonding is present to a large extent in liquid water.

(C) There is no hydrogen bonding in the frozen state of water.

(D) Frozen water is heavier than liquid water.

Ans. (C, D)

➠ There is H-bonding in frozen water so, ice is lighter than liquid water.

➠ The crystalline form of water is ice. At atmospheric pressure, ice crystallises in the hexagonal form, but at very low temperatures it condenses to cubic form. Density of ice is less than that of water. Therefore, an ice cube floats on water.

24) Hardness of water may be temporary or permanent. Permanent hardness is due to the presence of....

(A) chlorides of Ca and Mg in water.

(B) sulphates of Ca and Mg in water.

(C) hydrogen carbonates of Ca and Mg in water.

(D) carbonates of alkali metals in water.

Ans. (A, B)

➠ Permanent hardness of water is due to chlorides and sulphates of Ca^2 and Mg^{2+} and its not removed by heating.

25) Which of the following statements is correct ?

(A) Elements of group 15 form electron deficient hydrides.

(B) All elements of group 14 form electron precise hydrides.

(C) Electron precise hydrides have tetrahedral geometries.

(D) Electron rich hydrides can act as Lewis acids.

Ans. (B, C)

➠ Elements of group 14 form electron-precise hydrides which have tetrahedral structures.

26) Which of the following statements is correct ?

(A) Hydrides of group 13 act as Lewis acids.

(B) Hydrides of group 14 are electron deficient hydrides.

(C) Hydrides of group 14 act as Lewis acids.

(D) Hydrides of group 15 act as Lewis bases.

Ans. **(A, D)**

➠ Hydrides of group 13 i.e. BF_3, $AlCl_3$ etc. act as lewis acid while those of group 15 such as NH_3 act at lewis base.

➠ In all hydride of group 14 sufficient electrons are there.

➠ In all hydrides of group 15 the excess electron acts as non bonding electron pair so it is lewis base.

27) Which of the following statements is correct?

(A) Metallic hydrides are deficient of hydrogen.

(B) Metallic hydrides conduct heat and electricity.

(C) Ionic hydrides do not conduct electricity in solid state.

(D) Ionic hydrides are very good conductors of electricity in solid state.

Ans. **(A, B, C)**

➠ The ionic hydrides are crystalline and electricity non-conducting in solid state but it conduct electricity in liquid state.

Short Answer Type Questions

28) How can production of hydrogen from water gas be increased by using water gas shift reaction ?

➠ Water gas is produced when superheated steam is passed over red hot coke or coal at 1270 K in presence of nickel as catalyst.

$$\underset{\text{Coke}}{C_{(s)}} + \underset{\text{Steam}}{H_2O_{(g)}} + 121.3kJ \xrightarrow[[Ni]]{1270\,K} \underbrace{CO_{(g)} + H_{2(g)}}_{\text{water gas}}$$

➠ It is difficult to obtain pure H_2 from water gas as CO is difficult to remove. Therefore, to increase the production of H_2 from water gas, CO is oxidised to CO_2 by mixing it with more steam and passing the mixture over $FeCrO_4$ catalyst at 673 K.

$$\underbrace{CO_{(g)} + H_{2(g)}}_{\text{water gas}} + \underset{\text{steam}}{H_2O_{(g)}} \xrightarrow[FeCrO_4]{673K} CO_{2(g)} + 2H_{2(g)}$$

➠ The chemical reaction in which CO of water gas reacts with steam to form CO_2 and more H_2 is called water gas shift reaction. (WGSIQ).

➠ CO_2 from syngas this produced can be removed either by scrubbing the mixture with sodium arsenite solution or by passing the mixture through water under 30 atm pressure when CO_2 dissolves leaving behind H_2, which is collected.

29) What are metallic/interstitial hydrides ? How do they differ from molecular hydrides ?

➠ Metallic/Interstitial hydride make many *d*-block and *f*-block metals.

➠ These hydrides are good conductor of electricity.

➠ These hydrides are non-stoichiometric except saline hydride and e.g. being deficient in hydrogen. e.g., $LaH_{2.87}$ $YbH_{2.55}$, $TiH_{1.5\,-\,1.8}$, $VH_{0.56}$, $NiH_{0.6\,-\,0.7}$, $PdH_{0.6\,-\,0.8}$ etc. In these hydrides law of constant composition does not hold good.

Molecular Hydrides	Metallic Hydrides
(1) These are mainly formed *p*-block and some *s*-block elements (Be, Mg).	(1) These are mainly formed 3, 4, 5, 10, 11, 12, and *f*-block elements.
(2) These are formed unstable comp. Its melting point and boiling point are low.	(2) Its form hard comp. and partially contain metallic tendency.
(3) These are good conductor of electricity.	(3) These are non-conductor of electricity.

30) Name the classes of hydrides to which H_2O, B_2H_6 and NaH belong.

➠ H_2O : Covalent or molecular Hydride (electron rich hydride).

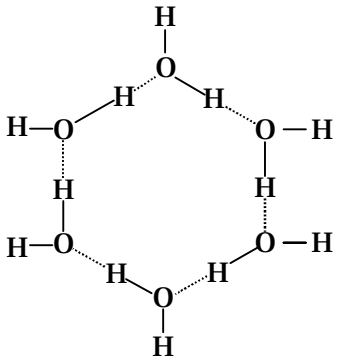
B_2H_6 : Covalent or molecular Hydride (electron deficient hydride).

NaH : Ionic or saline hydride.

31) If same mass of liquid water and a piece of ice is taken, then why is the density of ice less than that of liquid water ?

➠ The mass per unit volume (i.e. mass volume) is called density since water expands on freezing,

therefore, volume of ice for the same mass of water is more than liquid water. In other words, the density of ice is lower than liquid water and hence ice floats on water.



Hexagonal honey comb structure of ice

32) Complete the following equations :

(i) $PbS_{(s)} + H_2O_{2(aq)} \rightarrow$

(ii) $CO_{(g)} + 2H_{2(g)} \xrightarrow[\text{Catalyst}]{\text{Cobalt}}$

➠ **(i)** When PbS reacts with hydrogen peroxide and formed $PbSO_4$ water.

$$PbS_{(s)} + 4H_2O_{2(aq)} \rightarrow PbSO_4 + 4H_2O$$

➠ **(ii)** Methanol is formed by reaction of carbon monoxide with H_2 gas in presence of Co catalyst.

$$CO_{(g)} + 2H_{2(g)} \xrightarrow{\text{cobalt catalyst}} CH_3OH_{(l)}$$

33) Give reasons.

(i) Lakes freeze from top towards bottom

(ii) Ice floats on water.

➠ **(i)** During winter, the temperature of lake water keeps on decreasing. Since, cold water is heavier, therefore, of keeps on going into the interior of the lake while warm water from inside the lake keeps on coming to the surface of the lake. This process continues till the temperature of entire water of two lakes becomes 277 K Therefore, any further decrease in the temperature of the surface water will less its density.

➠ **(ii)** Density of ice is less than that of liquid water, so it floats over water.

34) What do you understand by the term 'auto-protolysis' of water? What is its significance ?

➠ Auto-protolysis means self ionisation of water. It may be represented as

$$\underset{\text{Acid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{H_2O_{(l)}} \rightleftharpoons \underset{\text{Acid}_2}{H_3O^+_{(aq)}} + \underset{\text{Base}_1}{OH^-_{(aq)}}$$

➠ Due to auto-protolysis, water is amphoteric in nature. i.e. it reacts with both acids and bases. If acts as a base towards acids stronger than itself and as an acid towards base stronger then itself. For example :

$$\underset{\text{Acid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{NH_{3(aq)}} \longrightarrow \underset{\text{Acid}_2}{NH^+_{4(aq)}} + \underset{\text{Base}_1}{OH^-_{(aq)}}$$

$$\underset{\text{Base}_1}{H_2O_{(l)}} + \underset{\text{Acid}_2}{H_2S_{(aq)}} \longrightarrow \underset{\text{Acid}_1}{H_3O^+} + \underset{\text{Base}_2}{HS^-}$$

35) Discuss briefly de-mineralisation of water by ion exchange resin.

➠ **Synthetic resins method :** Nowadays hard water is softened by using synthetic cation exchangers. This method is more efficient than zeolite process.

➠ Cation exchange resins : It contain large organic molecule with $-SO_3H$ group and are water insoluble. Ion exchange resin (RSO_3H) is changed to RNa by treating it with NaCl.

➠ The resin exchanges Na^+ ions with Ca^{2+} and Mg^{2+} ions present in hard water to make the water soft. Here R is resin anion.

$$2RNa_{(s)} + M^{2+}_{(aq)} \longrightarrow R_2M_{(s)} + 2Na^+_{(aq)}$$

➠ The resin can be regenerated by adding aqueous NaCl solution.

➠ Pure de-mineralised (de-ionized) water free from all soluble mineral salts is obtained by passing water successively through a cation exchange (in the H^+ form) and an anion-exchange (in the OH^- form) resins.

$$2RH_{(s)} + M^{2+}_{(aq)} \rightleftharpoons MR_{2(s)} + 2H^+_{(aq)}$$

➠ In this cation exchange process, H^+ exchanges for Na^+, Ca^{2+}, Mg^{2+} and other cations present in water.

➠ This process results in proton release and thus makes the water acidic.

➠ **Anion exchange process :**

$$RNH_{2(s)} + H_2O_{(l)} \rightleftharpoons RNH^+_3 \,.\, OH^-_{(s)}$$

$$RNH^+_3 \cdot OH^-_{(s)} + X^-_{(aq)} \rightleftharpoons RNH^+_3 \cdot X^-_{(s)} + OH^-_{(aq)}$$

➠ OH^- exchanges for anions like Cl^-, HCO^-_3, SO^{2-}_4 etc. present in water. OH^- ions, thus,

liberated neutralise the H^+ ions set free in the cation exchange.

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

➠ The exhausted cation and anion exchange resin beds are regenerated by treatment with dilute acid and alkali solutions respectively.

36) Molecular hydrides are classified as electron deficient, electron precise and electron rich compounds. Explain each type with two examples.

➠ Molecular hydrides are classified according to the relative numbers of electrons and bonds, in their lewis structure as follow.

➠ **(i) Electron deficient hydrides :** In these hydrides there are less than eight electrons present arround the central atom.

➥ Group-13 elements make these type of hydrides. e.g., BH_3, AIH_3, etc.

➥ These hydrides are lewis acid in nature.

➠ **(ii) Electron precise hydrides :** In this type of hydrides central atom have eight electrons. Group-14 elements, give these type of hydrides e.g. CH_4, SiH_4.

➠ **(iii) Electron rich hydrides :** In these type of hydrides central atom have than 8 electron.

Group - 15, 16 and 17 elements gave this type of hydrides. e.g., NH_3, H_2O, HF, etc.

37) How is heavy water prepared ? Compare its physical properties with those of ordinary water.

➠ Heavy water is prepared by prolonged electrolysis of water. Its physical properties are as under :

Property	H_2O	D_2O
➠ Molecular mass (g mol^{-1})	18.0151	20.0276
➠ Melting point (K)	273.0	276.8
➠ Boiling point (K)	373.0	374.4
➠ Enthalpy of formation (kJ mol^{-1})	–285.9	–294.6
➠ Enthalpy of vaporisation – 373 K (kJ mol^{-1})	40.66	41.61
➠ Enthalpy of fusion (kJ Mol^{-1})	6.01	–
➠ Temperature of max. density (K)	276.98	284.2
➠ Density at 298 K (g cm^{-3})	1.0000	1.1059
➠ Viscosity (centipoise)	0.8903	1.107
➠ Dielectric constant (C^2 /Nm^2)	78.39	78.06
➠ Electrical conductivity at 298K (ohm^{-1} cm^{-1})	5.7×10^{-8}	–

38) Write one chemical reaction for the preparation of D_2O_2.

➠ By the action of D_2SO_4 dissolved in water over BaO_2.

$$BaO_2 + D_2SO_4 \rightarrow BaSO_4 + D_2O_2$$

39) Calculate the strength of 5 volumes H_2O_2 solution.

➠ According to definition, 5 volumes H_2O_2 solution means that 1 L of 5 volume H_2O_2 solution on decomposition produces 5 L of O_2 at STP

Reaction : $2H_2O_2 \rightarrow 2H_2O + O_2$

2×34gm $\rightarrow$ 22.7 L volume at STP

Now,

22.7 L O_2 at STP will be obtained H_2O_2 = 68 g.

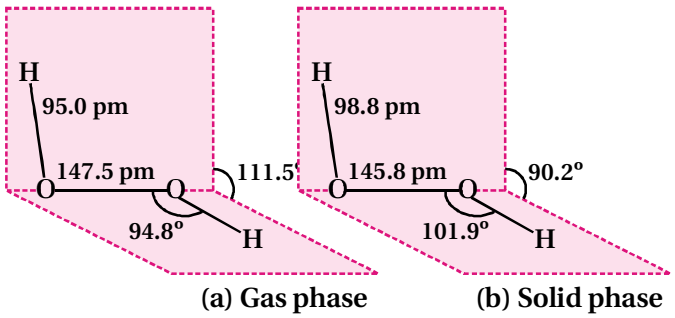
$\therefore$ 5 L of O_2 at STP will be obtained from H_2O_2 = ?

$$\therefore \quad \frac{5 \times 68}{22.7} \text{ gm} = 14.98 \text{ gm} \approx 15 \text{ gm}$$

40) (i) Draw the gas phase and solid phase structure of H_2O_2 .

(ii) H_2O_2 is a better oxidising agent than water. Explain.

➠**(i)** H_2O_2 has a non-planar structure.



(a) Gas phase **(b) Solid phase**

➠**(ii)** H_2O_2 is a better oxidising agent then water its

reasons are of follow H_2O_2 oxidises an acidified solution of KI to give I_2 which gives blue colour with starch solution but H_2O does not.

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

➠ H_2SO_4 turns black PbS to white $PbSO_4$ but H_2O does not.

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

41) Melting point, enthalpy of vaporisation and viscosity data of H_2O and D_2O is given below.

	H_2O	D_2O
Melting point/K	373.0	374.4
Enthalpy of vaporisation at (373 k) mol^{-1}	40.66	41.61
Viscosity/centipoise	0.8903	1.107

On the basis of this data explain in which of these liquids intermolecular forces are stronger ?

➠ The melting point, enthalpy of vaporization and viscosity value of all these items depend upon the intermolecular forces of attraction. So their values are higher for D_2O as compared to those of H_2O therefore, intermolecular forces of attraction are stronger in D_2O than in H_2O.

42) Dihydrogen reacts with dioxygen (O_2) to form water. Write the name and formula of the product when the isotope of hydrogen which has one proton and one neutron in its nucleus is treated with oxygen. Will the reactivity of both the isotopes be the same towards oxygen ? Justify your answer.

➠ The isotope of hydrogen which contains on proton and one neutron is deuterium. Thus, when dideuterium reacts with dioxygen, deuterium oxide. i.e. heavy water is obtained.

$$\underset{\text{Dideuterium}}{2D_{2(g)}} + \underset{\text{Dioxygen}}{O_{2(g)}} \xrightarrow{\text{Heat}} \underset{\text{Deuterium oxide}}{2D_2O}$$

The reactivity of H_2 and D_2 towards oxygen will be different since the D-D bond is stronger than H-H bond therefore, H_2 is more reactive then D_2 towards reaction with oxygen.

43) Explain why HCl is a gas and HF is a Liquid ?

➠ Due to greater electronegativity of F over Cl, F forms stronger H-bond as compared to Cl. As a result, more energy is required to break the H-bonds in HF than HCl and hence the boiling point of HF is higher than that of HCl. Consequently, HF is liquid while HCl is a gas at room temperature.

44) When the first element of the periodic table is treated with dioxygen, it gives a compound whose solid state floats on its liquid state. This compound has an ability to act as an acid as well as a base. What products will, be formed when this compound undergoes autoionisation ?

➠ The first element of the periodic table is hydrogen and its molecular form is dihydrogen (H_2). When dihydrogen reacts with dioxygen water is formed. Water is a liquid at room temperature. When liquid water freezes, it expands to form ice. In other words density of ice is lower than that of liquid water and hence ice floats over water.

Water is amphoteric in nature. It acts as an acid in presence of strong bases and as a base in presence of strong acids.

$$\underset{\text{Base}_1}{H_2O_{(l)}} + \underset{\text{Acid}_2}{H_2S_{(aq)}} \longrightarrow \underset{\text{Acid}_1}{H_3O^+_{(aq)}} + \underset{\text{Base}_2}{HS^-_{(aq)}}$$

$$\underset{\text{Acid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{NH_{3(aq)}} \longrightarrow \underset{\text{Acid}_2}{NH^+_{4(aq)}} + \underset{\text{Base}_1}{OH^-_{(aq)}}$$

➠ Due to amphoteric character, water undergoes self ionisation as following

$$\underset{\text{Acid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{H_2O_{(aq)}} \rightleftharpoons \underset{\substack{\text{Acid}_2\\(\text{Conjugate acid})}}{H_3O^+_{(aq)}} + \underset{\substack{\text{Base}_1\\(\text{Conjugate acid})}}{OH^-_{(aq)}}$$

This self ionisation of water is called auto-protolysis.

45) Roshan heard that instructions were given to the laboratory attendant to store a particular chemical, i.e. keep it in the dark room, add some urea in it, and keep it away from dust. This chemical acts as an oxidising as well as a reducing agent in both acidic and alkaline media. This chemical is important for use in the pollution control treatment of domestic and industrial effluents.

(i) Write the name of this compound.

(ii) Explain why such precautions are taken for storing this chemical.

➠(i) The name of the compound is hydrogen peroxide, H_2O_2. It acts as an oxidising agent as well as reducing agent in both acidic and basic medium.

➠(ii) H_2O_2 is decomposed by light and dust particies. Ureas is added as a negative catalyst. i.e. to check its decomposition.

$$2H_2O_{2(aq)} \xrightarrow{h\nu} 2H_2O_{(l)} + O_{2(g)}$$

Because of the oxidising properties H_2O_2 used to control pollution by oxidation of harmful cyanides and obnoxious smelling sulphides present in domestic and industrial offluects

➠ It is also helps in sewage disposal by supplying O_2 for oxidation of org. matter present in sewage water.

46) Give reasons why hydrogen resembles alkali metals ?

➠ Hydrogen resembles alkali metals, i.e. Li, Na, K, Rb, Cs and Fr of group 1 of the periodic table in the following respects.

(i) Like alkali metals, hydrogen also contain one electron in its outermost orbit. It like alkali metal it gave + 1 oxidation state.

(ii) Like alkali metals, hydrogen also loses its only electron to form hydrogen ion, i.e., H^+.

(iii) Like alkali metals, hydrogen combines with electronegative elements such as oxygen, halogens and sulphur forming their oxides, halides and sulphide respectively.

(iv) Like alkali metals, hydrogen also acts as a strong reducing agent.

47) Hydrogen generally forms covalent compounds. Give reason.

➠ Hydrogen has one electron which it can either lose or gain or share to acquire noble gas, i.e. helium gas configuration.

So, in principle, it can form either ionic or covalent bonds. But the ionisation enthalpy of hydrogen is very high (1312 kJ mol^{-1}) and its electron gain enthalpy is only slightly negative (–73 kJ mol^{-1}). As a result, it does not have a high tendency to form ionic bonds but rather prefers to form only covalent bonds.

48) Why is the ionisation enthalpy of hydrogen higher than that of sodium ?

➠ Both hydrogen and sodium have one electron in the valence shell. But the size of hydrogen is much smaller than that of sodium and hence, the ionisation enthalpy of hydrogen is much higher (1312 kJ mol^{-1}) than that of sodium (496 kJ mol^{-1}).

49) Basic principle of hydrogen economy is transportation and storage of energy in the form of liquid or gaseous hydrogen. Which property of hydrogen may be useful for this purpose ? Support your answer with the chemical equation if required.

➠ Hydrogen is a gas at room temperature. Because of its bulk, it is difficult to transport it either by rail or by road. So by cooling and applying high pressure, gaseous H_2 can be converted into liquid H_2 which has much smaller volume and hence can be transported easily. Thus, the basic property of hydrogen which is useful for hydrogen economy is that it can be converted into a liquid by cooling under high pressure.

50) What is the importance of heavy water ?

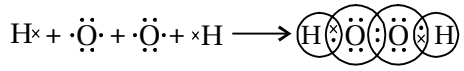
➠ (i) Heavy water is extensively used as a moderator in nuclear reactors.

(ii) It is widely used as a tracer compound for studying the mechanism of many reasons.

(iii) Heavy water is used in preparation of other deuterium compounds like CD_4, D_2SO_4, etc.

51) Write the Lewis structure of hydrogen peroxide.

➠ The Lewis structure of H_2O_2 is



52) An acidic solution of hydrogen peroxide behaves as an oxidising as well as reducing agent. Illustrate it with the help of a chemical equation.

➠ The following chemical equation indicate the oxidising and reducing nature of H_2O_2.

(i) H_2O_2, oxidises acidified KI to iodine.

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

(ii) H_2O_2 reduces $KMnO_4$ to MnO_2 in alkaline medium.

$$2KMnO_4 + 3H_2O_2 \rightarrow 2MnO_2 + 2KOH + 3O_2 + 2H_2O$$

53) With the help of suitable examples, explain the property of H_2O_2 that is responsible for its bleaching action ?

➠ The bleaching action of hydrogen peroxide is due to the nascent oxygen which it liberates on decomposition.

$$H_2O_2 \longrightarrow H_2O + [O]$$

➠ The nascent oxygen combines with colouring matter which in turn, gets oxidised. Thus, the bleaching action of H_2O_2 is due to the oxidation of colouring matter by nascent oxygen. It is used for the bleaching of delicate materials like ivory, feathers, silk, wool etc.

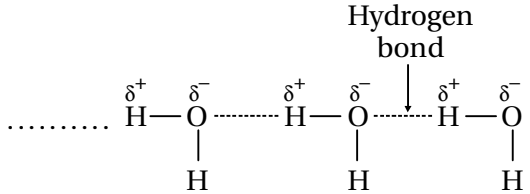
Colouring matter + [O] → Colourless matter

54) Why is water molecule polar ?

➠ Oxygen is more electronegative than hydrogen. Therefore O – H bond is polar. In water molecule, there are two polar O – H bond are present. In water molecule there are two polar O – H which are held together at an angle of 104.5°. Due to the resultant of these two dipoles, water molecule is polar and has an dipole moment of 1.84 Debye.

55) Why does water show high boiling point as compared to hydrogen sulphide ? Give reasons for your answer.

➠ Water show high boiling point as compared to hydrogen sulphide due to high electronegativity of oxygen (EN = 3.5). Water undergoes extensive H – bonding as a result of which water exists as associated molecule.



➠ To breaking these hydrogen bond, a large amount of energy is required so, the boiling point of H_2O is high. In contract, due to the lower electronegativity of S, hydrogen sulphide does not undergo Hydrogen bonding H_2S exists as discreatemolecules and hence its boiling point is much lower than that of H_2O. Thats why H_2S is a gas at room temperature.

56) Why can dilute solutions of hydrogen peroxide not be concentrated by heating ? How can a concentrated solution of hydrogen peroxide be obtained ?

➠ H_2O_2 cannot be concentrated by heating because it decomposes much below its boiling point to give H_2O and O_2.

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

➠ Therefore, concentrated of H_2O_2 is carried out in a number of stage (i) The H_2O_2 formed (about 1%) is extracted with water and the aqucous solution is concentrated by distillation under reduced pressure. to give 30% H_2O_2 solution.

57) Why is hydrogen peroxide stored in wax lined bottles ?

➠ Hydrogen peroxide is decomposed by rough surfaces of glass, alkali oxides present in it and light to form H_2O and O_2.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

➠ To stop this decomposition, H_2O_2 is usually stored in coloured paraffin wax coated plastic or teflon bottles.

58) Why does hard water not form lather with soap ?

➠ Hard water contains bicarbonates chlorides and sulphates of calcium and magnesium ions. These combine with soap molecules to form precipitate of calcium magnesium salts of soaps.

$$2C_{17}H_{35}COONa_{(aq)} + M^{+2}_{(aq)} \rightarrow (C_{17}H_{35}COO)_2\,M\downarrow + 2Na^{+}_{(aq)}$$ (Where M = Ca/Mg)

➠ As a result, soap is wasted and here hard water does not produce lather with soap.

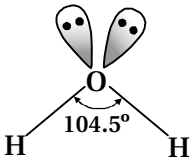
59) Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides. Why ?

➠ H_2SO_4 acts as a catalyst for decomposition of H_2O_2. Therefore, some weaker acids such as H_3PO_4 is preferred over H_2SO_4 for preparing H_2O_2 from peroxides.

$$2BaO_2 + 2H_3PO_4 \rightarrow Ba_3(PO_4)_2 + 3H_2O_2$$

60) How will you account for 104.5° bond angle in water ?

➠ In water oxygen undergoes sp^3 hybridisation so H-O-H bond angle should have been 109°28' but In water, the oxygen atom is surrounded by two shared pairs two lone pairs electrons.



And according to VSEPR theory, lone pair - lone pair repulsions are stronger than bond pair-bond pair repulsions. As a result, the HOH bond angle in water slightly decreases from the regular bond angle of 109°.28' to 104.5°.

61) Write redox reaction between fluorine and water.

➠ F_2 is a strong oxidising agent. It oxidises H_2O to either O_2 or O_3.

$$2F_{2(g)} + 2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4F^-_{(aq)}$$

$$3F_{2(g)} + 3H_2O_{(l)} \rightarrow O_{3(g)} + 6H^+_{(aq)} + 6F^-_{(aq)}$$

62) Write two reactions to explain amphoteric nature of water.

➠ Water is amphoteric in nature. It acts as an acid in presence of strong bases and as a base in presence of strong acids.

➠ $\underset{\text{Base}_1}{H_2O_{(l)}} + \underset{\text{Acid}_2}{H_2S_{(aq)}} \longrightarrow \underset{\text{Acid}_1}{H_3O^+_{(aq)}} + \underset{\text{Base}_2}{HS^-_{(aq)}}$

$\underset{\text{Aacid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{NH_{3(aq)}} \longrightarrow \underset{\text{Aacid}_2}{NH^+_{4(aq)}} + \underset{\text{Base}_1}{OH^-_{(aq)}}$

➠ Due to amphoteric character, water undergoes self ionisation as following

$$\underset{\text{Acid}_1}{H_2O_{(l)}} + \underset{\text{Base}_2}{H_2O_{(aq)}} \rightleftharpoons \underset{\substack{\text{Acid}_2\\(\text{Conjugate acid})}}{H_3O^+_{(aq)}} + \underset{\substack{\text{Base}_1\\(\text{Conjugate acid})}}{OH^-_{(aq)}}$$

Matching The Columns

63) Correlate the items listed in column I with those listed in Column II. Find out as many correlations as you can.

Column-I	Column-II
(A) Synthesis gas	(1) $Na_2[Na_4(PO_3)_6]$
(B) Dihydrogen	(2) Oxidising agent
(C) Heavy water	(3) Softening of water
(D) Calgon	(4) Reducing agent
(E) Hydrogen peroxide	(5) Stoichiometric compounds of *s*-block elements
(F) Salt like hydrides	(6) Prolonged electrolysis of water
	(7) Zn + NaOH
	(8) Zn + dil. H_2SO_4
	(9) Synthesis of methanol
	(10) Mixture of CO and H_2

➠ **(A – 9, 10), (B – 4, 5, 7, 8, 9), (C – 6), (D – 1, 3), (E – 2, 4), (F – 5)**

64) Match Column-I with Column-II for the given properties/applications mentioned therein.

Column-I	Column-II
(A) H	(1) used in the name of perhydrol.
(B) H_2	(2) can be reduced to dihydrogen by NaH.
(C) H_2O	(3) can be used in hydroformylation of olefin.
(D) H_2O_2	(4) can be used in cutting and welding.

➠ **(A – 4), (B – 3), (C – 2), (D – 1)**

65) Match the terms in Column-I with the relevant item in Column-II.

Column-I	Column-II
(A) Electrolysis of water produces	(1) atomic reactor
(B) Lithium aluminium hydride is used as	(2) polar molecule
(C) Hydrogen chloride is a	(3) recombines on metal surface to generate high temperature
(D) Heavy water is used in	(4) reducing agent
(E) Atomic hydrogen	(5) hydrogen and oxygen

➠ (A – 5), (B – 4), (C – 2), (D – 1), (E – 3)

66) Match the items in Column-I with the relevant item in Column-II.

Column-I	Column-II
(A) Hydrogen peroxide is used as a	(1) zeolite
(B) Used in Calgon method	(2) perhydrol
(C) Permanent hardness of hard water is removed by	(3) sodium hexametaphosphate
	(4) propellant

➠ (A – 2, 4), (B – 3), (C – 1, 3)

Assertion and Reason Type Questions

❖ **In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the options given below in each question.**

67) Assertion (A) : Permanent hardness of water is removed by treatment with washing soda.

Reason (R) : Washing soda reacts with soluble magnesium and calcium sulphate to form insoluble carbonates.

➠ (A) Statements (A) and R both are correct and (R) is the correct explanation of (A).

(B) (A) is correct but (R) is not correct.

(C) (A) and R both are correct but (R) is not the correct explanation of (A).

(D) (A) and (R) both are false.

Ans. **(A) Statements (A) and (R) both are correct and (R) is the correct explanation of (A).**

➠ Statements of assertion and reason both are correct and reason is the correct explanation of assertion.

$$Na_2CO_3 + MgSO_4 \rightarrow Na_2SO_4 + MgCO_3$$

or or

$CaSO_4$ $CaCO_3$

(from hard water) (insoluble)

68) Assertion (A) : Some metals like platinum and palladium, can be used as storage media for hydrogen.

Reason (R) : Platinum and palladium can absorb large volumes of hydrogen.

➠ (A) Statements (A) and (R) both are correct and (R) is the correct explanation of (A).

(B) (A) is correct but (R) is not correct.

(C) (A) and (R) both are correct but (R) is not the correct explanation of (A).

(D) (A) and (R) both are false.

Ans. **(A) Statements (A) and (R) both are correct and (R) is the correct explanation of (A).**

➠ Statements of assertion and reason both are correct and reason is the correct explanation of assertion. Since, metals like Pd and Pt adsorbs a large volume of hydrogen hence, these are used as a storage media for it.

Long Answer Type Questions

69) Atomic hydrogen combines with almost all elements but molecular hydrogen does not. Explain.

➠ Atomic hydrogen is highly unstable and hence it is very reactive. Its electronic configuration is $1s^1$. For stability it accept 1 more electron and thus it almost combine with all the elements.

➠ Atomic hydrogen make hydride by three different type.

(i) If remove one electron and form H^+

(ii) It accept one electron and form H^-

(iii) It share one electron and form covalent single bond. In contrast, the bond dissociation energy of H – H bond is very high (435.88 kJ mol^{-1}). As a result molecular hydrogen is almost inert at room temp. and hence reacts only with a few elements.

70) How can D_2O be prepared from water ? Mention the physical properties in which D_2O differs from H_2O. Give at least three reactions of D_2O showing the exchange of hydrogen with deuterium.

➠ D_2O is prepared by prolonged electrolysis of water.

➠ **Physical properties :**

(i) D_2O is colourless, odourless and tasteless liquid. Its maximum density is –1.1073 gmL^{-1}. It 11.6°C maximum density of water is 4°C.

(ii) The solubility of salt in heavy water is less than ordinary water. So, the viscosity is high of heavy water.

(iii) Exchange reactions of hydrogen with deuterium

$NaOH + D_2O \longrightarrow NaOD + HOD$

$HCl + D_2O \longrightarrow DCl + HOD$

$NH_4Cl + D_2O \longrightarrow NH_3DCl + HOD$

71) How will you concentrate H_2O_2 ? Show differences between structures of H_2O_2 and H_2O by drawing their spatial structures. Also mention three important uses of H_2O_2.

➠ **Industrially method :**

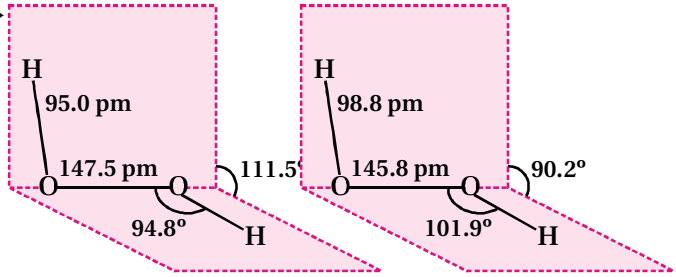
➠ Industrially it is prepared by the auto-oxidation of 2-alklylanthraquinols.

$$\begin{pmatrix}\text{2-ethyl}\\ \text{anthraquinol}\end{pmatrix} \underset{H_2/Pd}{\overset{O_2\,(air)}{\rightleftharpoons}} H_2O_2 + \begin{pmatrix}\text{Oxidised}\\ \text{product.}\end{pmatrix}$$

➠ In this case 1% H_2O_2 is formed. It is extracted with water and concentrated to ~30% (by mass) by distillation under reduced pressure.

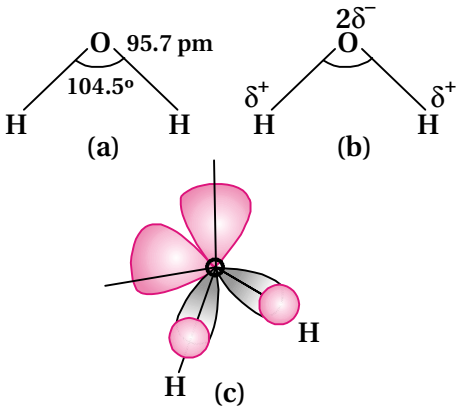
➠ It can be further concentrated to ~85% by careful distillation under low pressure. The remaining water can be frozen out to obtain pure H_2O_2.

➠



(a) Gas phase (b) Solid phase

➠ In gas phase the shape of H_2O is as under.



(a) Bent shape of H_2O.

(b) Dipole moment containing structure of H_2O

(c) Hybridisation containing structure of H_2O

➠ **Importance of H_2O_2 :**

(i) In daily life it is used as a hair bleach and as a mild disinfectant. As an antiseptic it is sold in the market as perhydrol.

(ii) It is used to manufacture chemicals like sodium perborate and per-carbonate, which are used in high quality detergents.

(iii) It is used in the synthesis of hydroquinone, tartaric acid and certain food products and pharmaceuticals etc.

(iv) It is employed in the industries as a bleaching agent for textiles, paper pulp, leather, oils, fats etc.

(v) Nowadays it is also used in Environmental (Green) Chemistry. For example, in pollution control treatment of domestic and industrial effluents, oxidation of cyanides, restoration of aerobic conditions to sewage wastes, etc.

72) (i) Give a method for the manufacture of hydrogen peroxide and explain the reactions involved therein.

(ii) Illustrate oxidising, reducing and acidic properties of hydrogen peroxide with equations.

➠ Industrially it is prepared by the auto-oxidation of 2-alklylanthraquinols.

$$\begin{pmatrix}\text{2-ethyl}\\ \text{anthraquinol}\end{pmatrix} \underset{H_2/Pd}{\overset{O_2\,(air)}{\rightleftharpoons}} H_2O_2 + \begin{pmatrix}\text{Oxidised}\\ \text{product.}\end{pmatrix}$$

➠ In this case 1% H_2O_2 is formed. It is extracted with water and concentrated to ~30% (by mass) by distillation under reduced pressure.

➠ It can be further concentrated to ~85% by careful distillation under low pressure. The remaining water can be frozen out to obtain pure H_2O_2.

➠(i) **Oxidising effect in acidic medium :**

$$2Fe^{2+}_{(aq)} + 2H^+_{(aq)} + H_2O_{2(aq)} \longrightarrow 2Fe^{3+}_{(aq)} + 2H_2O_{(l)}$$

$$PbS_{(s)} + 4H_2O_{2(aq)} \longrightarrow PbSO_{4(s)} + 4H_2O_{(l)}$$

➠(ii) **Reducing effect in acidic medium :**

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

$$HOCl + H_2O_2 \longrightarrow H_3O^+ + Cl^- + O_2$$

➠(iii) **Oxidising effect in basic medium :**

$$2Fe^{2+} + H_2O_2 \longrightarrow 2Fe^{3+} + 2OH^-$$

$$Mn^{2+} + H_2O_2 \longrightarrow Mn^{4+} + 2OH^-$$

➠(iv) **Reducing effect in basic medium :**

$$I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$$

$$2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$$

73) (i) What mass of hydrogen peroxide will be present in 2 L of a 5 molar solution ?

(ii) Calculate the mass of oxygen which will be liberated by the decomposition of 200 ml of this solution.

➠(i) Mol mass of H_2O_2 = 34 g mol^{-1}

∴ 1L of 5 M solution of H_2O_2 will contain

34×5 g H_2O_2

2 L of 5 M solution of H_2O_2 will contain

$34 \times 2 \times 5 = 340$ g H_2O_2

➠(ii) 0.2 L or 200 mL of 5 M solution will contain H_2O_2

$$= \frac{340 \times 0.2}{2} = 34 \text{ g } H_2O_2$$

Now, $2H_2O_2 \rightarrow 2H_2O + O_2$

$2 \times 34 = 68$ gm $2 \times 16 = 32$ gm

Now, 68 g of H_2O_2 on decomposition will give O_2 = 32 g

34 g of H_2O_2 on decomposition will give

$$= \frac{32 \times 34}{68} = 16 \text{ g } O_2.$$

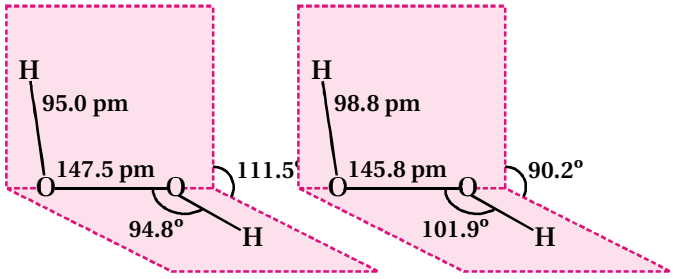
74) A colourless liquid 'A' contains H and O elements only. It decomposes slowly on exposure to light. It is stabilised by mixing urea to store in the presence of light.

(i) Suggest possible structure of A.

(ii) Write chemical equations for its decomposition reaction in light.

➠(i) Since, a colourless liquid 'A' contains only hydrogen and oxygen and decomposes slowly on exposure to light but is stabilised by addition of urea, therefore, liquid A may be H_2O_2.

The structure of H_2O_2 is



(a) Gas phase (b) Solid phase

➠(ii) $2H_2O_2 \xrightarrow[\text{Sunlight}]{h\nu} 2H_2O + O_2$

75) An ionic hydride of an alkali metal has significant covalent character and is almost unreactive towards oxygen and chlorine. This is used in the synthesis of other useful hydrides. Write the formula of this hydride. Write its reaction with Al_2Cl_6.

➠ The comp is LiH. It is a smallest alkali metal. It has a covalent character. Since LiH is very stable therefore it is almost unreactive towards O_2 and Cl_2.

➠ It reacts with Al_2Cl_6 to form lithium aluminium hydride.

$$8LiH + Al_2Cl_6 \rightarrow 2LiAlH_4 + 6LiCl$$

76) Sodium forms a crystalline ionic solid with dihydrogen. The solid is non-volatile and non-conducting in nature. It reacts violently with water to produce dihydrogen gas. Write the formula of this compound and its reaction with water. What will happen on electrolysis of the melt of this solid.

➠ Sodium reacts with dihydrogen to form sodium hydride which is a crystalline ionic solid.

$$2Na + H_2 \rightarrow 2Na^+ H^-$$

➠ It reacts with H_2O to produce H_2 gas.

$$2NaH + 2H_2O \rightarrow 2NaOH + 2H_2$$

➠ Although Na^+H does not conduct electricity in the solid state but the electrolysis of its melt produces H_2 at the anode and Na at the cathode.

$$Na^+H^- \xrightarrow{\text{Electrolysis}} \underset{\text{At cathode}}{2Na_{(l)}} + \underset{\text{At Anode}}{H_{2(g)}}$$

Section-D Multiple Choice Questions (MCQs)

Darpan's Exam Oriented MCQs

1) Electron configuration of hydrogen is ..... .
(A) $1s^2$ (B) $2p^1$ (C) $1s^1$ (D) $2d^1$
Ans. **(C)** $1s^1$

2) The ionic radius of H^+ ions and that of other ions is ..... pm and ..... pm respectively.
(A) 50 – 200, 1.5×10^{-3}
(B) 1.5×10^{-3}, 50 – 200
(C) 10^{-3}, 300 (D) 1.5, 400
Ans. **(B)** 1.5×10^{-3}, 50 – 200

3) Molecular formula of sodium hexameta-phosphate is ..... .
(A) $Na_5P_5O_{10}$ (B) $Na_6P_6O_{18}$
(C) $Na_6P_5O_{17}$ (D) $Na_6P_6O_{17}$
Ans. **(B)** $Na_6P_6O_{18}$

4) Which is the isotope of dihydrogen ?
(A) ^1_1H (B) ^2_1H (C) ^3_1H (D) All
Ans. **(D)** All

5) Which particle does tritium emit ?
(A) α (B) β^- (C) β^+ (D) γ
Ans. **(B)** β^-

6) ..... group elements give saline hydrides.
(A) *s* (B) *p* (C) *d* (D) *f*
Ans. **(A)** *s*

7) ..... hydrides are non-stoichiometric hydride.
(A) $LaH_{2.87}$ (B) $YbH_{2.55}$
(C) $VH_{0.56}$ (D) (A), (B) and (C)
Ans. **(D)** (A), (B) and (C)

8) Cation exchange resins is a ..... group containing organic molecule.
(A) SO_2 (B) SO_3H (C) SO_3 (D) SO_4^{2-}
Ans. **(B)** SO_3H

9) How many % of H_2O_2 is present in commercially marketed H_2O_2 at STP ?
(A) 10% (B) 20% (C) 30% (D) 40%
Ans. **(C)** 30%

10) How many neutrons are there in nucleus of tritium ?
(A) Zero (B) Two (C) Three (D) One
Ans. **(B)** Two

11) Which catalyst is used for preparation of water-gas from methane ?
(A) Co (B) Ni (C) Cu_2O (D) Fe_2O_3
Ans. **(B)** Ni

12) What is shape of H_2O molecule ?
(A) Linear (B) Angular
(C) Triangular (D) planar
Ans. **(B)** Angular

13) Modern period, the water gas is known as which gas ?
(A) Natural gas (B) Artifical gas
(C) Synthesis gas (D) Productive gas
Ans. **(C)** Synthesis gas

14) What is the half-life period of tritium ?
(A) 12.33 minute (B) 12.33 second
(C) 12.33 years (D) 12.33 hour
Ans. **(C)** 12.33 years

15) Crystal structure of ice is detected by ..... .
(A) Microscope (B) X-rays
(C) Infrared rays (D) I. R. Spectrum
Ans. **(B)** X-rays

16) Which of the following salts are responsible for temporary hardness of water ?
(A) $Ca(HCO_3)_2$ (B) Mg $(HCO_3)_2$
(C) (A) and (B) Both (D) $NaHCO_3$
Ans. **(C)** (A) and (B) Both

17) Because of which bond three dimensional structure is formed in ice ?
(A) Covalent bond (B) Hydrogen bond
(C) Ionic- bond (D) Metallic bond
Ans. **(B)** Hydrogen bond

18) What is form when heavy water reacts with CaC_2 ?
(A) CaD_2 (B) C_2D_2 (C) Ca_2D_2O (D) CD_2
Ans. **(B)** C_2D_2

19) ..... % dihydrogen is added in CNG.
(A) 1 (B) 2 (C) 3 (D) 5
Ans. **(D)** 5

20) Sodium hexametaphosphate is known as ..... commerically.
(A) calgon (B) complex
(C) leuco (D) caglon
Ans. **(A)** calgon

21) At ..... distance the four oxygen atoms surrounded to each oxygen atom in ice.
(A) 2.76×10^{-10}m (B) 2.76 Å
(C) 276 pm (D) (A), (B) and (C)
Ans. **(D)** (A), (B) and (C)
➠ 1 m = 10^{12} pm = 10^{10}Å

22) Which element of group six forms metal hydride ?
(A) Na (B) Cr (C) Mn (D) Fe
Ans. **(B)** Cr

23) Which of the following used in CLARK method to remove temporary hardness of water ?
(A) Na_2CO_3
(B) Sodium hexametaphosphate
(C) $Ca(OH)_2$ (D) Zeolite
Ans. **(C)** $Ca(OH)_2$
➠ $Ca(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow 2CaCO_{3(s)}\downarrow + 2H_2O_{(l)}$

24) The electric conductivity of ..... is not equal to that of metals.
(A) CrH (B) NaH
(C) TiH (D) All (A), (B) & (C)
Ans. **(A) CrH**

25) The structure of ice is ..... type.
(A) Linear (B) Two dimensional
(C) Three dimensional (D) Metal like
Ans. **(C)** Three dimensional

26) $N_{2(g)} + 3H_{2(g)} \underset{Fe}{\overset{200\ Atm}{\rightleftharpoons}} 2NH_{3(g)}$, at which temperature this reaction will be possible ?
(A) 327° C (B) 620.6° F (C) 600 K (D) 673 K
Ans. **(D)** 673 K

27) Complete the reaction : $8LiH + Al_2Cl_6 \longrightarrow$?
(A) $LiAlCl_5 + LiCl$ (B) $LiAlH_4 + LiCl$
(C) $2LiAlH_4 + 6LiCl$ (D) $LiAlCl_3 + LiCl_2$
Ans. **(C)** $2LiAlH_4 + 6LiCl$

28) 99.95% dihydrogen is obtained by electrolysing warm aqueous $Ba(OH)_2$ solution by ..... electrodes.
(A) Cu (B) Pt (C) Ni (D) Zn
Ans. **(C)** Ni

29) The industrial dihydrogen is produced ..... from coal.
(A) 77% (B) 18% (C) 4% (D) 50%
Ans. **(B)** 18%

30) ..... undergoes oxidation in the following reaction.
$Zn_{(s)} + 2NaOH_{(aq)} \rightarrow Na_2ZnO_{2(aq)} + H_{2(g)}$
(A) Zn (B) Na+ (C) OH^- (D) H_2
Ans. **(A)** Zn
➠ The oxidation number of Zn changes from 0 to + 2

31) Hydrogen forms hydride (H^- negative ions) by accepting one electron. This property is similar to.....
(A) F (B) Cl
(C) Br (D) All (A), (B) & (C)
Ans. **(D)** All (A), (B) & (C)

32) ..... is used as moderator in nuclear reactor.
(A) H_2O (B) H_2O_2 (C) D_2O (D) NH_3
Ans. **(C)** D_2O

33) How many total fundamental particles are there in tritium (isotope of hydrogen) ?
(A) 4 (B) 3 (C) 5 (D) 2
Ans. **(A)** 4

34) How many types of hidride compounds are these ?
(A) Two (B) Three (C) Four (D) Five
Ans. **(B)** Three

35) How many nutrons are there in hydrogen ?
(A) Zero (B) Three (C) Four (D) Five
Ans. **(A)** Zero

36) Ionic hydride contains ..... property.
(A) Crystal (B) Solid
(C) non-valatile (D) All of these
Ans. **(D)** All of these

37) The half life time of ^3_1H is 12.33 years, what is the decay constant ?
(A) 12.33 years (B) 0.5620 years^{-1}
(C) 0.05620 years^{-1} (D) 0.05620 years^{-1}
Ans. **(C)** 0.05620 years^{-1}
➠ $t_{1/2}$ = 12.33 years

$\therefore$ Decay constant $\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{12.33}$ years
= 0.05620 years^{-1}

38) Calculate the strength of H_2O_2 solution in 10 volume.

(A) 36.30 gm (B) 30 gm
(C) 30.36 gm (D) 36 gm

Ans. **(C)** 30.36 gm

➠ At STP H_2O_2 gives O_2 gas

$2H_2O_2 \longrightarrow O_2 + H_2O$

(2×34) gm 22.4 Ltr.

So, in 22.4 Ltr O_2 gas there must be 68 gm H_2O_2

$\therefore$ In 10 Ltr O_2 gas there must be

$= \frac{10 \times 68}{22.4} = 30.36$ gm

39) The grade of 2.95 M H_2O_2 in volume of percentage is ..... and ..... respectively.

(A) 33, 10 (B) 35, 12 (C) 28, 10 (D) 36, 12

Ans. **(A)** 33, 10

➠ $V = M \times 11.2$

$= 2.95 \times 11.2 = 33.04$ (volume)

$\%w/v = \frac{M \times 34}{10} = \frac{2.95 \times 34}{10} = 10.03$ %w/v

40) The solubility of H_2O_2 is 48 gm in 500 mL calculate volume strength and %w/v.

(A) 34.62, 19.2 (B) 31.62, 19.2
(C) 31.62, 9.6 (D) 30.2, 9.6

Ans. **(C)** 31.62, 9.6

➠ $\text{Molarity} = \frac{\text{Weight of solute gm}}{\text{Molecular mass} \times \text{Volume of solution in litre}}$

$= \frac{48}{34 \times 0.5} = 2.82$ M H_2O_2

$\%w/v = \frac{M \times 34}{10} = \frac{2.82 \times 34}{10} = 9.6$

$V = M \times 11.2 = 2.82 \times 11.2 = 31.58$

41) The volume of O_2 gas evolved from 40 gram per litre H_2O_2 at STP is.....

(A) 22.4 (B) 11.2 (C) 33.6 (D) 13.18

Ans. **(D)** 13.18

➠ $\text{Molarity} = \frac{\text{gram/litre}}{\text{molecular mass}} = \frac{40}{34} = 1.176$ M H_2O_2

$V(O)_2 = 11.2 \times M$

$= 11.2 \times 1.176$

$= 13.18$ litre O_2 release

42) 6L H_2O_2 contains 440 gm solute than how much litre O_2 gas will produce from this solution at STP ?

(A) 24.16 (B) 22.8 (C) 30.16 (D) 25.8

Ans. **(A)** 24.16

➠ $\text{Morlarity} = \frac{\text{Weight of solute gm}}{\text{Molecular mass} \times \text{Volume of solution in litre}}$

$= \frac{440}{34 \times 6} = 2.156$ M H_2O_2

$V(O)_2 = M \times 11.2$

$= 2.156 \times 11.2$

$= 24.16$ L O_2 gas

43) Calculate the strength of H_2O_2 solution in 10 volume.

(A) 36.30 gm (B) 30 gm
(C) 30.36 gm (D) 36 gm

Ans. **(C)** 30.36 gm

➠ At STP H_2O_2 gives O_2 gas

$2H_2O_2 \longrightarrow O_2 + H_2O$

(2×34) gm 22.4 Ltr.

So, in 22.4 Ltr O_2 gas there must be 68 gm H_2O_2

$\therefore$ In 10 Ltr O_2 gas there must be

$= \frac{10 \times 68}{22.4} = 30.36$ gm

44) How many grams of H_2O_2 in 1 litre of 1.5 N H_2O_2.

(A) 25 gram (B) 25.5 gram
(C) 30 gram (D) 8.0 gram

Ans. **(B)** 25.5 gm

➠ Weight of H_2O_2

= Normality of H_2O_2 $\times$ equivalent weitght of H_2O_2

$= (1.5) \times (17) = 25.5$ gm/lit

45) The molarity and % w/v of 40 volume H_2O_2 is ..... and ..... respectively.

(A) 3.57 and 12.14 (B) 3.57 and 12.4
(C) 35.7 and 1.24 (D) 35.7 and 14.1

Ans. **(A)** 3.57 and 12.14

➠ $M = \frac{V}{11.2} = \frac{40}{11.2} = 3.57$ M

$M = \frac{10 \times \%\,w/v}{34}$ $\%w/v = \frac{34 \times 3.57}{10} = 12.14$

46) The lable is 'volume' is stiched on one bottle of H_2O_2 then ..... is its strength.

(A) 10% (B) 40% (C) 8% (D) 4.55%

Ans. **(D)** 4.55%

➠ $M = \frac{V}{11.2} = \frac{15}{11.2} = 1.3392$

$\%\,w/v = \frac{M \times 34}{10} = \frac{1.3392 \times 34}{10}$

$= 4.55$ % w/v

47) 0.01 mole solution of '10 volume' H_2O_2 is required to convert 0.01 mol PbS into $PbSO_4$?

(A) 11.2 (B) 22.4 (C) 33.6 (D) 44.8

Ans. **(D)** 44.8

➠ $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

$4H_2O_2 \rightarrow 4H_2O + 2O_2$

To convert 1 mole PbS

➠ 1 mole $PbSO_4$ required = 4 mole H_2O_2

$\therefore$ to convert 0.01 mol PbS to $PbSO_4$ = (?)

$= \frac{0.01 \times 4}{1}$ = 0.04 mol H_2O_2 required

Strength of volume = 10

$M = \frac{V}{11.2} = \frac{10}{11.2}$ = 0.8928 mol/lit H_2O_2

0.8928 mol $H_2O_2 \rightarrow$ 1 litre H_2O_2

$\therefore$ 0.04 mol $H_2O_2 \rightarrow$ (?)

$= \frac{0.04 \times 1}{0.8928}$

= 0.04480 litre

= 44.80 ml H_2O_2

48) ..... ml (volume) is required of or 10 volume H_2O_2 of 2N $KMnO_4$ in acidic medium?

(A) 200 ml (B) 100 ml (C) 224 ml (D) 150 ml

Ans. **(C)** 224 ml

➠ $N = \frac{V}{5.6} = \frac{10}{5.6}$ = 1.7857 N H_2O_2

N_1V_1 (H_2O_2) = N_2V_2 ($KMnO_4$)

$V_1 = \frac{2 \times 200}{1.7857}$ = 224 ml H_2O_2

REMEMBER

❖ **Dear Students,**

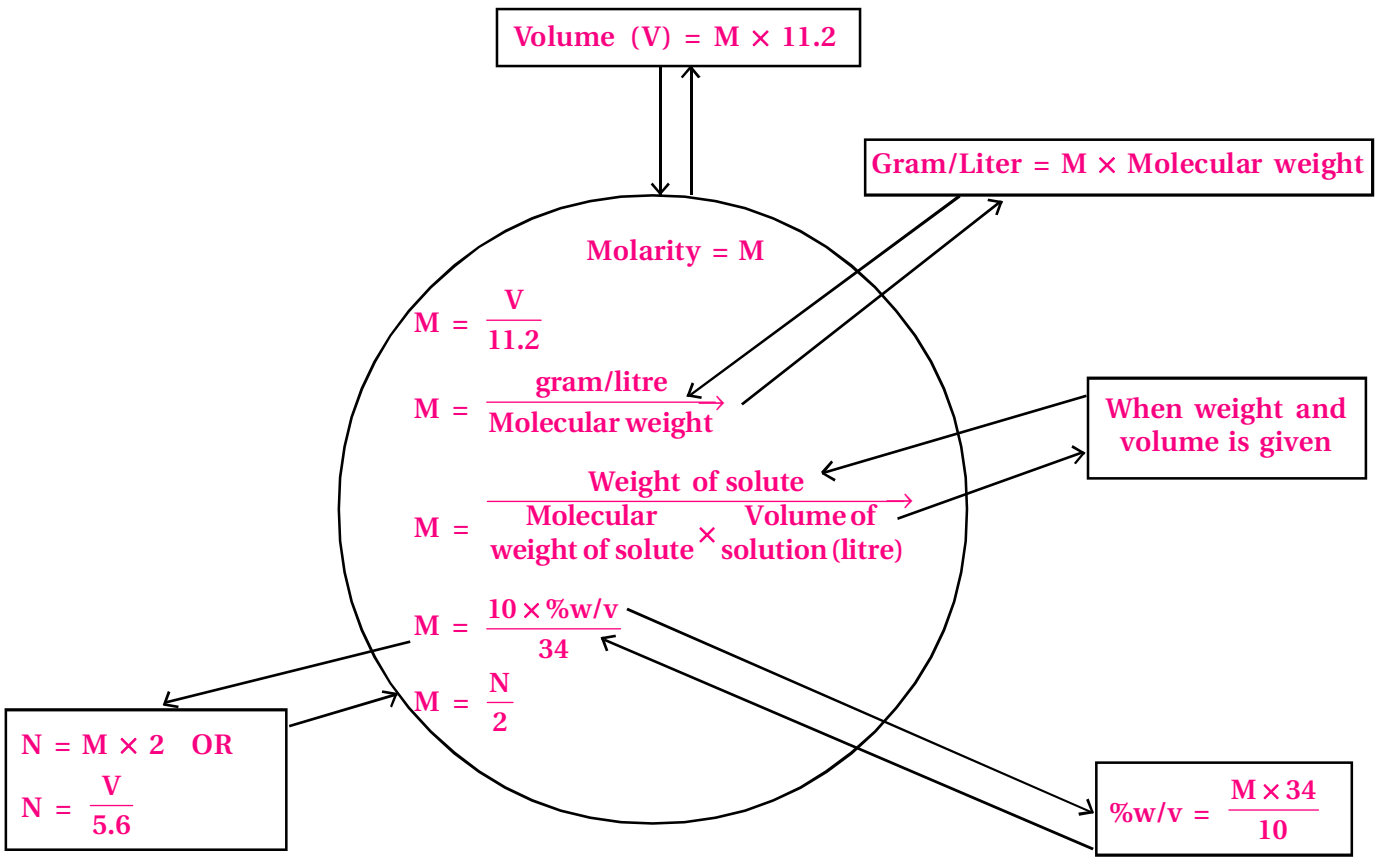
Following points are remember to solve the examples of H_2O_2.

➥ Volume strength = Volume strength = grade = volume of O_2 obtain at STP.

(above from matter are same 50 you find V)

➥ Key points : In numerical first of all calculate the molarity and then after calculate the unit of concentration

C H A R T



MCQs asked in Competitive Exams

1) Hydrogen will not reduce..... [IIT - 1985]

(A) heated cupric oxide.

(B) heated ferric oxide.

(C) heated stannic oxide.

(D) heated aluminium oxide.

Ans. **(D)** heated aluminium oxide.

2) The oxidation states exhibited by hydrogen in its various compounds are..... [Pb, JET - 1988]

(A) – 1 only (B) zero only

(C) +1, –1 and zero (D) +1 only

Ans. **(C)** +1, –1 and zero

3) The oxidation states of the most electro-negative element in the products of the reaction, BaO_2 with dil. H_2SO_4 are..... [IIT - 1991]

(A) 0 and –1 (B) –1 and –2

(C) –2 and 0 (D) –2 and +1

Ans. **(B)** –1 and –2

4) 30 volumes H_2O_2 means.....

(A) 30% H_2O_2 [Haryana, CEET - 1992]

(B) 30 cm^3 of the solution contains 1 g of H_2O_2

(C) 1 cm^3 of the solution liberates 30 cm^3 of O_2 at STP

(D) 30 cm^3 of the solution contains one mole of H_2O_2

Ans. **(C)** 1 cm^3 of the solution liberates 30 cm^3 of O_2 at STP

5) An oxide which gives H_2O_2 on treatment with dilute acid is..... [AFMC - 1994]

(A) PbO_2 (B) Na_2O_2 (C) MnO_2 (D) TiO_2

Ans. **(B)** Na_2O_2

6) Nascent hydrogen consists of..... [AIIMS - 1994]

(A) Hydrogen atoms with excess energy

(B) Hydrogen molecules with excess energy

(C) Hydrogen ions in the excited state

(D) Solvated protons

Ans. **(B)** Hydrogen molecules with excess energy

7) The oxidation number of O in H_2O_2 is..... [MINR Allahabad - 1994]

(A) –2 (B) –1 (C) +1 (D) +2

Ans. **(B)** –1

8) Hydrolysis of one mole of peroxodisulphuric acid produces..... [IIT - 1996]

(A) two moles of sulphuric acid.

(B) two moles of peroxomonosulphuric acid.

(C) one mole of sulphuric acid and one mole of peroxomonosulphuric acid.

(D) one mole of sulphuric acid, one mole of peroxomonosulphuric acid and one mole of hydrogen peroxide.

Ans. **(C)** one mole of sulphuric acid and one mole of peroxomonosulphuric acid.

9) Which contains both polar and non-polar bonds ? [IIT - 1997]

(A) NH_4Cl (B) HCN (C) H_2O_2 (D) CH_4

Ans. **(C)** H_2O_2

10) The critical temperature of water is higher than that of O_2 because the H_2O molecule has..... [IIT - 1997]

(A) fewer electrons than oxygen.

(B) two covalent bonds.

(C) V-shape. (D) dipole moment.

Ans. **(D)** dipole moment.

11) Among KO_2, AlO_2, BaO_2 and NO_2^+, unpaired electron is present in..... [IIT - 1997]

(A) NO_2^+ and BaO_2 (B) KO and AlO_2^-

(C) KO_2 only (D) BaO_2 only

Ans. **(C)** KO_2 only

12) Which of the following statements is correct for hydrogen ? [AFMC - 1997]

(A) Hydrogen has same ionization potential as alkali metals.

(B) H^+ has same electronegativity as halogens.

(C) H^+ has oxidation number of –1 or +1.

(D) H^+ is always collected at cathode.

Ans. **(C)** H^+ has oxidation number of –1 or +1.

13) What is heavy water ?

(A) H_2O^{17} (B) H_2O^{18} (C) H_2O_2 (D) D_2O

Ans. **(D)** D_2O

14) Acidified solution of chromic acid on treatment with H_2O_2 yields. [MFCEE - 1999]

(A) $CrO_3 + H_2O + O_2$ (B) $Cr_2O_3 + H_2O + O_2$

(C) $CrO_5 + H_2O$ (D) $H_2O_7 + H_2O + O_2$

Ans. **(C)** $CrO_5 + H_2O$

15) **Amongst H_2O, H_2S, H_2Se and H_2Te, the one with the highest boiling point is...** [IIT-2000]

(A) H_2O because of hydrogen bonding.

(B) H_2Te because of higher molecular weight.

(C) H_2S because of hydrogen bonding.

(D) H_2Se because of lower molecular weight.

Ans. **(A)** H_2O because of hydrogen bonding.

16) **Fenton's reagent is...** [MP PET-2000; RPET-2000]

(A) $FeSO_4 + H_2O_2$ (B) Zn + HCl

(C) Sn + HCl (D) None of these

Ans. **(A)** $FeSO_4 + H_2O_2$

17) **Ortho and parahydrogen differ in.....** [AFMC - 2001]

(A) atomic number (B) atomic mass

(C) spins of protons (D) number of neutrons

Ans. **(C)** spins of protons

➠ Ortho and para hydrogen differ in proton spin.

18) **Heavy water is obtained by.....** [AFMC - 2001]

(A) boiling water.

(B) fractional distillation of H_2O.

(C) prolonged electrolysis of H_2O.

(D) heating H_2O_2.

Ans. **(C)** prolonged electrolysis of H_2O.

19) **Heavy water is...**

[AFMC-1997, 2006; Pb.CET-2001; UPSEAT-2003; MH CET-2003; Similar CPMT-2007]

(A) Water containing Fe, Cr, Mn

(B) Water at 0°C (C) D_2O (D) H_2O^{18}

Ans. **(C)** D_2O

➠ D_2O in which D = $_1H^2$

20) **Polyphosphates are used as water softening agents because they.....** [IIT - 2002]

(A) form soluble complex with anionic species

(B) precipitate anionic species

(C) form soluble complex with cationic species

(D) precipitate cationic species

Ans. **(C)** form soluble complex with cationic species

21) **Action of water or dilute mineral acids on metals can give.....** [Kerala, MEE - 2002]

(A) Mono hydrogen (B) Tritium

(C) Di hydrogen (D) Trihydrogen

Ans. **(C)** Di hydrogen

22) **Which of the following reaction produces hydrogen ?** [AIIMS - 2002]

(A) $Mg + H_2O$ (B) $BaO_2 + HCl$

(C) $H_2S_4O_8 + H_2O$ (D) $Na_2O_2 + 2HCl$

Ans. **(A)** $Mg + H_2O$

➠ $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2\uparrow$

23) **Which of the following pair of ions makes the water hard ?** [AMU - 2002]

(A) Na^+, SO_4^{2-} (B) K^+, HCO_3^-

(C) Ca^{2+}, NO_3^- (D) NH_4^+, Cl^-

Ans. **(B)** K^+, HCO_3^-

➠ HCO_3^- is main reason of temporary hardness of water.

24) **On reaction with Mg, very dilute nitric acid produces** [CPMT - 2003]

(A) NH_3 (B) Nitrous oxide

(C) Nitric oxide (D) Hydrogen

Ans. **(D)** Hydrogen

➠ $Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$

25) **Which of the following gas is insoluble in water ?** [Pb.CET - 2003]

(A) SO_2 (B) NH_3 (C) H_2 (D) CO_2

Ans. **(C)** H_2

➠ Hydrogen is the lightest gas. It is insoluble in water.

26) **In lab H_2O_2 is prepared by....** [CPMT - 2002; MH CRET - 2003; Pb.PMT - 2004; BCECE - 2005]

(A) Cold $H_2SO_4 + BaO_2$

(B) $HCl + BaO_2$

(C) Conc. $H_2SO_4 + Na_2O_2$

(D) $H_2 + O_2$

Ans. **(A)** Cold $H_2SO_4 + BaO_2$

➠ $H_2SO_4 + BaO_2 \rightarrow BaSO_4 + H_2O_2$

27) **20 volume H_2O_2 Solution has a strength of about....** [MP PMT-2006]

(A) 30% (B) 6% (C) 3% (D) 10%

Ans. **(B)** 6%

➠ 22.4 litre O_2 at N.T.P. obtained by 68 gm of H_2O_2

∴ 1 litre O_2 at N.T.P. obtained by $\frac{68}{22.4}$ gm of H_2O_2

∴ 20 litre O_2 at N.T.P. obtained by $\frac{68}{22.4} \times 20$ gm of H_2O_2 = 60.71 gm of H_2O_2

∴ 1000 ml O_2 at N.T.P. obtained by = 60.71 gm of H_2O_2

∴ 100 ml O_2 at N.T.P. obtained by

$= \frac{60}{1000} \times 100 = 6.71\%$

28) Hydrogen can be prepared by the action of dil. H_2SO_4 on [AIIMS - 2007]

(A) Copper (B) Iron (C) Lead (D) Mercury

Ans. **(B)** Iron

➠ Hydrogen cannot be prepared by the action of dil. H_2SO_4 on copper or mercury as these two metals cannot displace hydrogen from acids. Action of dil. H_2SO_4 on Pb stops after sometime due to the formation of insoluble $PbSO_4$. Only iron reacts rapidly with dil. H_2SO_4 to give H_2.

30) Ozone is used for purifying water because.... [UPCPMT - 2007]

(A) it dissociates and release oxygen.

(B) do not leave any foul smell like chlorine.

(C) kills bacteria 'cyst' fungi and acts as a biocide.

(D) all of the above

Ans. **(D)** all of the above

➠ **Ozone is used to purify water** → Ozone kills bacteria, cysts, fungi, mold, parasites, viruses, contaminates etc. It is one of the effective way of eliminating microorganism in the water. Ozone also oxidizes toxins and odours. O_3 is most effective oxidant (secondary to F_2).

It inactivates and oxidizes organic matter, contaminates, pesticides, viruses and bacteria faster than chlorine.

O_3 do not form TMH which have unpleasent odour and are also carcinogenic. O_3 is very good biocide. Ozone also absorb UV radiation.

MCQs asked in Board Exam

1) Select the correct choice for given statements. T for true and F - for false

(i) The physical properties of hydrogen are like those of metals.

(ii) Some chemical properties of hydrogen are those of metals and of non-metals.

(iii) Metals of groups 7, 8 and 9 form nonstoichiometric hydrides.

(iv) The percentage of water in natural sources like rivers is 2.04. [October - 2011]

(A) (i) – F, (ii) – T, (iii) – F, (iv) – F

(B) (i) – T, (ii) – T, (iii) – T, (iv) – F

(C) (i) – T, (ii) – F, (iii) – F, (iv) – F

(D) (i) – F, (ii) – T, (iii) – F, (iv) – T

Ans. **(A)** (i) – F, (ii) – T, (iii) – F, (iv) – F

2) The relative proportion of the atoms of tritium and protium is : [October - 2011]

(A) $10 : 10^{17}$ (B) $1 : 10^{17}$

(C) $10 : 10^{-7}$ (D) $1 : 10^{7}$

Ans. **(B)** $1 : 10^{17}$

3) Dihydrogen gas is obtained by using, which reactant ? [October - 2011]

(A) $Cl_2 + NaOH_{(aq)}$ (B) $CH_4 + O_2$

(C) $Zn + ZnCl_2$ (D) $Zn + NaOH_{(aq)}$

Ans. **(D)** $Zn + NaOH_{(aq)}$

➠ $Zn(s) + 2NaOH_{(aq)} \longrightarrow Na_2ZnO_{2(aq)} + H_{2(g)}$

Zinc metal; Sodium hydroxide; Sodium Zincate; Dihydrogen

4) Which of the group given below is most appropriate for the hydride compounds ? [October - 2011]

(A) *s*-block – Metallic hydride – TiH_2

(B) *p*-block – Molecular hydride – CH_4

(C) *d*-block – Metallic hydride – BeH_2

(D) *f*-block – Ionic hydride – TiH_2

Ans. **(B)** *p*-block – Molecular hydride – CH_4

5) In the reaction : $2H_2O_2 \longrightarrow 2H_2O + O_2$ [October - 2011]

(A) H_2O_2 undergoes only oxidation.

(B) H_2O_2 undergoes both oxidation and reduction.

(C) H_2O_2 undergoes neither oxidation nor reduction.

(D) H_2O_2 undergoes only oxidation.

Ans. **(B)** H_2O_2 undergoes both oxidation and reduction.

$2H_2O_2 \longrightarrow 2H_2O + O_2$

$2(-1) \xrightarrow{\text{Reduction}} -2$

$0 \xrightarrow{\text{Oxidation}}$

6) $H_3S - O - O - SO_3H_{(aq)} \xrightarrow[H_2O]{\text{hydrolysis}} 2H_2SO_4 + X$

The product X is ..... [October - 2011]

(A) SO_2 (B) H_2O_2 (C) SO_3 (D) O_2

Ans. **(B)** H_2O_2

When acidified sulphate (HSO_4^-) ion containing solution is electrolytically oxidized at high current density, oxodisulphate is obtained which on hydrolysis give hydrogen peroxide.

$2HSO_{4(aq)}^- \xrightarrow{\text{Electrolysis}} HO_3SOOSO_3H_{(aq)} + 2\bar{e}$

$\xrightarrow[H_2O]{\text{Hydrolysis}} \underbrace{2HSO_{4(aq)}^- + 2H_{(aq)}^+}_{2H_2SO_4} + H_2O_{2(aq)}$

7) The empirical formula of Marshal's acid and 'calgon' are respectively : [October - 2011]

(A) H_2SO_6, Na_2PO_4 (B) HSO_4, Na_2PO_3

(C) H_2SO_5 , $NaPO_5$ (D) HSO_4, $NaPO_3$

Ans. **(C)** H_2SO_5 , $NaPO_5$

Note : $NaPO_3$ should be in place of $NaPO_5$ in option (C).

Sodium Hexameta phosphate is known as 'Calgon' on commercial base.

$Na_6P_6O_{18}$	$NaPO_3$
Molecular formula	Empirical formula
H_2SO_5	Marshall's acid

$H - O - \overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}} - O - O - H$ Permono sulphuric acid

8) What does the resulting solution contain when ammonia gas reacts with water ? [Oct. - 2011]

(A) NH_2, H_3O^+ (B) NH_4^+, OH^-

(C) NH_4^+, NO_3^- (D) N_2H_4, NO_3^-

Ans. **(B)** NH_4^+, OH^-

$NH_{3(g)} + H_2O_{(l)} \longrightarrow NH_{4(aq)}^+ + OH_{(aq)}^-$

Base Acid Acid Base

9) Molarity and Normality of 20 volume H_2O_2 solution is [October - 2012]

(A) 0.892 M, 3.57 N (B) 1.787 M, 3.57 N

(C) 0.892 M, 1.785 N (D) 3.57 M, 1.787 N

Ans. **(B)** 1.787 M, 3.57 N

10) Which pair of species are formed when hydrogen peroxide is react with suspension of PbS ? [October - 2012]

(A) $PbO + SO_2 + H_2O$ (B) $PbSO_4 + H_2O$

(C) $PbSO_3 + H_2O$ (D) $Pb + SO_2 + H_2O$

Ans. **(B)** $PbSO_4 + H_2O$

$PbS_{(s)} + 4H_2O_{2(aq)} \longrightarrow PbSO_4 + 4H_2O_{(l)}$

11) What is the strength of H_2O_2 solution whose volume is 12 ? [October - 2012]

(A) 31.20 (B) 36.42 (C) 31.34 (D) 33.44

Ans. **(B)** 36.42

Weight strenght,

$= \frac{\text{Volume strength} \times 68}{22.4} = \frac{12 \times 68}{22.4} = 36.42$ g

12) Which of the following compound is used to increase stability of hydrogen peroxide ? [October - 2012]

(A) Sulphuric acid (B) Phosphorous acid

(C) Sulphurous acid (D) Phosphoric acid

Ans. **(D)** Phosphoric acid

13) Which substance is known as 'Calgon' ? [October - 2012]

(A) $Na_6P_4O_{18}$ (B) $Na_6P_6O_{18}$

(C) $Na_4P_4O_{16}$ (D) $Na_6P_6O_{16}$

Ans. **(B)** $Na_6P_6O_{18}$

14) The maximum production of hydrogen is obtain from [October - 2012]

(A) Metal react with acid

(B) Petrochemicals (C) By coal

(D) By electrolysis

Ans. **(B)** Petrochemicals

15) Match Section-I with II and select correct option : [October - 2012]

Section-I	Section-II
(1) Ionic hydride	(P) BeH_2
(2) Interstitial hydride	(Q) TiH
(3) Electron precise hydride	(R) CH_4
(4) Electron rich hydride	(S) H_2O
	(T) B_2H_6

(A) 1 – P, 2 – Q, 3 – S, 4 – R
(B) 1 – T, 2 – Q, 3 – P, 4 – S
(C) 1 – P, 2 – Q, 3 – R, 4 – S
(D) 1 – Q, 2 – T, 3 – R, 4 – S

Ans. **(C)** 1 – P, 2 – Q, 3 – R, 4 – S

16) Which statement is proper for water ? [October - 2012]

(A) Volume of H_2O is smaller than hydride of 16^{th} group elements.
(B) It's solid state is tetrahedral.
(C) It's concentration is 55.55M having amphoteric nature.
(D) Above all are correct.

Ans. **(D)** Above all are correct.

17) Which of following is Isotopes of Hydrogen ? [October - 2013]

(A) $_1H^0$ (B) $_1D^2$ (C) $_1T^2$ (D) $_3T^1$

Ans. **(B)** $_1D^2$

18) Which elements does not give Hydride ? [October - 2013]

(A) Te (B) Ti (C) Tl (D) Th

Ans. **(C)** Tl

19) Which substance is called as a calgon for business purpose ? [October - 2013]

(A) Sodium pyrometa phosphate
(B) Sodium meta phosphate
(C) Sodium poly meta phosphate
(D) Sodium Hexa meta phosphate

Ans. **(D)** Sodium Hexa meta phosphate

20) Classification of hydride according to Lewis structure is ..... . [October - 2013]

(A) LiH (B) CaH_2 (C) NH_3 (D) NbH_2

Ans. **(C)** NH_3

21) What is the grade of H_2O_2 whose concentration is 3.125m for selling in open market ? [October - 2013]

(A) 30 (B) 35 (C) 40 (D) 25

Ans. **(B)** 35

22) Give molarity and strength % w/v accordingly in 30 volume of H_2O_2 solution. [October - 2013]

(A) 2.678 M, 18.22% (B) 2.678 M, 9.11%
(C) 5.356 M, 9.11% (D) 5.356 M, 18.22%

Ans. **(A)** 2.678 M, 18.22%

23) Which of the following products is obtain when ethene react with hydrogen in presence of raney nikel at 390 K ? [October - 2013]

(A) Ethane (B) Ethanal
(C) Ethane 1, 2-diol (D) Ethanol

Ans. **(A)** Ethane

24) Which of the following is used in Ion Exchange method as a Ion Exchanger ? [October - 2013]

(A) Alum (B) Zeolite
(C) Calgon (D) Flake Lime

Ans. **(B)** Zeolite

25) $CH_3OH_{(l)} \xrightarrow[673\,k]{50\,bar} CO_{(g)} + 2H_{2(g)}$

which catalyst is used in the above reaction. [October - 2014]

(A) Copper oxide (B) Iron chromate
(C) Cuprous oxide (D) Nickel

Ans. **(C)** Cuprous oxide

26) The concentration of OH^- in water at 298 K [October - 2014]

(A) 10^{-14} (B) 55.55 (C) 10^{-7} (D) All of these

Ans. **(C)** 10^{-7}

➠ Because of self ionization of H_2O, $[H_3O^+] = [OH^-] = 1.0 \times 10^{-7}$ mol L^{-1}, is obtained at equilibrium condition.

➠ $H_2O_{(l)} + H_2O_{(l)} = H_3O^+_{(aq)} + OH^-_{(aq)}$

27) When zinc pieces are added to concentrated NaOH solution, $H_{2(g)}$ is formed along with [October - 2014]

(A) Na_3ZnO_2 (B) Na_2ZnO_2
(C) Na_4ZnO_2 (D) Na_2ZnO_3

Ans. **(B)** Na_2ZnO_2

➠ $Zn_{(S)} + 2NaOH_{(aq)} \longrightarrow \underset{\text{Sodium Zincate}}{Na_2ZnO_{2(aq)}} + H_{2(g)}$

28) Which of the following compound is used to understand the reaction mechanism and exchange of ions ? [October - 2014]

(A) H_2O (B) D_2O (C) H_2O_2 (D) H_2

Ans. **(B)** D_2O

29) Assertion : The relative proportion of Tritium and Protium is $1 : 10^{17}$

Reason : The property responsible for the low proportion of Tritium is its non-radioactivity. [October - 2014]

(A) Both assertion and reason are true.

(B) Both assertion and reason are true and reason is the correct explanation of the assertion.

(C) Assertion is false but reason is true.

(D) Assertion is true but reason is false.

Ans. **(D)** Assertion is true but reason is false

30) Column-I represents hydride compounds and column-II represents types of hydride, Match column-I and column-II and select the correct option. [October - 2014]

Column- I	Column- II
(1) VH	(p) Ionic hydride
(2) HF	(q) Metal hydride
(3) Magnesium hydride	(r) Electron rich hydride
	(s) Polymeric hydride
(4) NaH	(t) Molecular hydride

(A) 1 → q; 2 → r, t; 3 → p, s; 4 → p

(B) 1 → t; 2 → p, q; 3 → p; 4 → q

(C) 1 → q; 2 → r; 3 → s; 4 → p

(D) 1 → q; 2 → t; 3 → p, 4 → t

Ans. **(A)** 1 → q; 2 → r, t; 3 → p, s; 4 → p

31) Which of the statement given below are correct ?

(i) Pure dihydrogen 99.5 % is obtained by heating hydrocarbons at 1270 K temperature using Fe catalyst.

(ii) In acidic medium H_2O_2 decolourises potassium permanganate solution.

(iii) Ca^{2+} and Mg^{2+} ions can be precipitated by calgon to soften the hard water

(iv) The strength of 15 volume H_2O_2 at STP is 45.54 gram. [October - 2014]

(A) (i), (ii) (B) (ii), (iv)

(C) (ii), (iii), (iv) (D) (i), (iii), (iv)

Ans. **(C)** (ii), (iii), (iv)

32) Among the elements In, Ti, Tl and Ca which element do not form hydride ? [October - 2015]

(A) In, Tl (B) In, Tl, Ca

(C) In, Ca (D) In, Ti

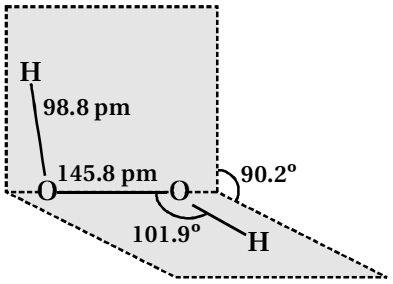
Ans. **(A)** In, Tl

33) What is the –O–O–H bond angle in solid form of H_2O_2 ? [October - 2015]

(A) 94.8° (B) 111.5° (C) 92.2° (D) 101.9°

Ans. **(D)** 101.9°

➠



Solid form

34) Dihydrogen and alkli metals resemble in which of the following properties ? [October - 2015]

(A) Both are powerful oxidising agents

(B) Both have low ionization enthalpy

(C) Both are diatomic

(D) Both are powerful reducing agents

Ans. **(D)** Both are powerful reducing agents

35) Which ion is displaced by Na^+ ions when hard water is passed over Zeolite ? [October - 2015]

(A) OH^- (B) Ca^{2+} (C) K^+ (D) H^+

Ans. **(B)** Ca^{2+}

36) What is added as stabilizer to aqueous solution of H_2O_2 ? [October - 2015]

(A) Phosphoric acid (B) Phosphonic acid

(C) Pyrophosphoric acid (D) Phosphorous acid

Ans. **(A)** Phosphoric acid

37) Choose the correct option. T stands for True and F stands for False. [October - 2015]

(i) Tritium can be obtained from natural sources.

(ii) In ionic hydride, the oxidation state of hydrogen is +1.

(iii) The four atoms of oxygen in H_2O_2 are in the same plane.

(iv) Na_2CO_3 removes temporary and permanent hardness of water.

(A) TFFF (B) TFFT (C) TTTF (D) TFTT

Ans. **(A)** TFFF

38) Which of the following is correct matching of column-A with column-B : [October - 2015]

Column-A	Column-B
(i) Ionic hydride	(p) LaH_2
(ii) Metallic hydride	(q) LiH
(iii) Molecular hydride	(r) TiH
(iv) Interstitial hydride	(s) HF

(A) (i) → q; (ii) → p; (iii) → r; (iv) → s

(B) (i) → q; (ii) → p; (iii) → s; (iv) → s, q

(C) (i) → s; (ii) → r; (iii) → p; (iv) → q

(D) (i) → q; (ii) → p, r; (iii) → s; (iv) → p, r

Ans. **(D)** (i) → q; (ii) → p, r; (iii) → s; (iv) → p, r

➠ (i) Ionic hydride LiH, NaH, BeH_2, MgH_2

(ii) Metallic hydride LaH_2, TiH, NbH, VH...

(iii) Molecular hydride HF, H_2O, B_2H_6 ...

(iv) Interstitial hydride LaH → $LaH_{2.87}$; TiH → $TiH_{1.5-1.8}$

➠ Metallic hydrides are mostly non-stoichiometric compounds.

MCQs asked in JEE / NEET / AIEEE

1) The O–O–H bond angle in H_2O_2 is..... [CBSE PMT - 1994]

(A) 106° (B) 109°28' (C) 120° (D) 98.8°

Ans. **(D)** 98.8°

2) The high density of water as compared to ice is due to..... [CBSE PMT - 1997]

(A) Hydrogen bonding interactions

(B) Dipole-dipole interactions

(C) Dipole-induced dipole interactions

(D) Induced dipole induced dipole interactions

Ans. **(A)** Hydrogen bonding interactions

3) The volume strength of 1.5 N H_2O_2 solution is..... [CBSE PMT - 1997]

(A) 4.8 (B) 5.2 (C) 8.8 (D) 8.4

Ans. **(D)** 8.4

4) The hydride ion H^- is a stronger base than hydroxide ion. Which of the following reactions will occur if sodium hydride (NaH) is dissolved in water ? [CBSE PMT - 1997]

(A) $H^-_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)}$

(B) $H^-_{(aq)} + H_2O_{(l)} \rightarrow OH^-_{(aq)} + H_{2(g)}$

(C) $H + H_2O \rightarrow$ No reaction

(D) None of these

Ans. **(B)** $H^-_{(aq)} + H_2O_{(l)} \rightarrow OH^-_{(aq)} + H_{2(g)}$

5) When a substance reacts with water, it produces a combustible gas B and a solution of substance C in water. When another substance D reacts with this solution of C, it produces the same gas B on warming but D can produces gas B on reaction with dilute sulphuric acid at room temperature. A imparts a deep golden yellow color to a smokeless flame of Bunsen burner. A, B, C and D respectively are..... [CBSE PMT - 1998]

(A) Na, H_2, NaOH, Zn

(B) K, H_2, KOH, Al

(C) Ca, H_2, $Ca(OH)_2$, Sn

(D) CaC_2, C_2H_2, $Ca(OH)_2$, Fe

Ans. **(A)** Na, H_2, NaOH, Zn

6) Which of the following pairs of substances on reaction will not evolve H_2 gas ? [CBSE PMT - 1998]

(A) Fe and H_2SO_4 (aqeous)

(B) copper and HCl (aqueous)

(C) sodium and ethyl alcohol

(D) iron and steam

Ans. **(B)** copper and HCl (aqueous)

7) The structure of H_2O_2 is.... [CBSE PMT-1999]

(A) planar (B) non-planar

(C) spherical (D) linear

Ans. **(B)** non-planar

8) The metallic Na dissolves in liquid ammonia to form a deep blue colour is due to formation of ..... . [AIEEE-2002]

(A) Solvated electron, $e(NH_3)_x^-$

(B) Solvated atomic sodium, $Na\ (NH_3)_y$

(C) $(Na^+ - Na^-)$ (D) $NaNH_2 + H_2$

Ans. **(A)** Solvated electron, $e(NH_3)_x^-$

9) Which one of the following processes will produce permanent hard water ? [AIEEE - 2003]

(A) Saturation of Na_2SO_4 to water

(B) Saturation of water with $CaCO_3$

(C) Saturation of water with $MgCO_3$

(D) Saturation of water with $CaSO_4$

Ans. **(D)** Saturation of water with $CaSO_4$

10) Which one of the following processes will produce hard water ? [AIEEE-2003]

(A) Saturation of water with $CaCO_3$

(B) Saturation of water with $MgCO_3$

(C) Saturation of water with $CaSO_4$

(D) Addition of Na_2SO_4 to water

Ans. **(C)** Saturation of water with $CaSO_4$

11) Commercial 11.2 volume H_2O_2 solution has a molarity of..... [Karala, AIEEE - 2004]

(A) 1.0 (B) 0.5 (C) 11.2 (D) 0.75

Ans. **(A)** 1.0

12) Based on the lattice energy and other consideraction which one of the following alkali metal chloride is expected to have the highest melting point. [AIEEE-2005]

(A) LiCl (B) NaCl (C) KCl (D) RbCl

Ans. **(B)** NaCl

13) In context with the industrial preparation of hydrogen from water gas (CO + H_2), which of the following is the correct statement ? [AIEEE-2008]

(A) CO is removed by absorption in aqueous $CaCl_2$ solution.

(B) H_2 is removed through occlusion with Pd

(C) CO is oxidised 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 differences in their densities.

Ans. **(C)** CO is oxidised to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali.

14) Very pure hydrogen (99.9) can be made by which of the following processes. [AIEEE-2012]

(A) reaction of methane with steam.

(B) mixing natural hydrocarbons of high molecular weight.

(C) electrolysis of water.

(D) reaction of salts like hydrides with water.

Ans. **(D)** reaction of salts like hydrides with water.

15) In which of the following reactions H_2O_2 acts as a reducing agent ? [JEE-2014]

(i) $H_2O_2 + 2H^+ + 2\bar{e} \longrightarrow 2H_2O$

(ii) $H_2O_2 - 2\bar{e} \longrightarrow O_2 + 2H^+$

(iii) $H_2O_2 + 2\bar{e} \longrightarrow 2OH^-$

(iv) $H_2O_2 + 2OH^- - 2\bar{e} \longrightarrow O_2 + 2H_2O$

(A) (iii), (iv) (B) (i), (iii)

(C) (ii), (iv) (D) (i), (ii)

Ans. **(C)** (ii), (iv)

➠ These two reactions are oxidation.

(ii) $H_2O_2 - 2\bar{e} \longrightarrow O_2 + 2H^+$

$(-1) \xrightarrow{\text{Oxidation}} (0)$

(iv) $H_2O_2 + 2OH^- - 2\bar{e} \longrightarrow O_2 + 2H_2O$

$(-1) \xrightarrow{\text{Oxidation}} 0$

➠ H_2O_2 is acting as a reducing agent, it is oxidised.

16) The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic conditions gives : [AIEEE-2014]

(A) Mn^{4+} and O_2 (B) Mn^{2+} and O_2

(C) Mn^{2+} and O_3 (D) Mn^{4+} and MnO_2

Ans. **(B)** Mn^{2+} and O_2

➠ $3H_2SO_4 + 2KMnO_4 + 5H_2O_2 \rightarrow 5O_2 + 2MnSO_4 + 8H_2O + K_2SO_4$

17) Find one wrong statement regarding H_2O_2. [JEE - 2015]

(A) It acts only as an oxidising reagent.

(B) It decomposes in presence of light.

(C) It is stored in dark plastic or wax coated bottle.

(D) It is kept away from dust.

Ans. **(A)** It acts only as an oxidising reagent.

18) Which one of the following statements about water is FALSE ? [JEE - 2016]

(A) Ice formed by heavy water sinks in normal water.

(B) Water is oxidized to oxygen during photo-synthesis.

(C) Water can act both as an acid and as a base.

(D) There is extensive intramolecular hydrogen bonding in the condensed phase.

Ans. **(D)** There is extensive intramolecular hydrogen bonding in the condensed phase.

➠ Water is having sp^3 hybridization of bent structure and in condensed (ice) state it can form only intermolecular hydrogen Bonding.

19) In the following reactions, ZnO is respectively acting as a/an ..... [JEE - 2017]

(a) $ZnO + Na_2O \longrightarrow Na_2ZnO_2$

(b) $ZnO + CO_2 \longrightarrow ZnCO_3$

(A) base and acid (B) base and base

(C) acid and base (D) acid and base

Ans. **(D)** acid and base

➠ (1) $\underset{\text{Acidic Oxide}}{ZnO} + \underset{\text{Basic Oxide}}{Na_2O} \longrightarrow Na_2ZnO_2$

(2) $\underset{\text{Basic Oxide}}{ZnO} + \underset{\text{Acidic Oxide}}{CO_2} \longrightarrow ZnCO_3$

20) Hydrogen peroxide oxidises $[Fe(CN)_6]^{4-}$ to $[Fe(CN)_6]^{3-}$ in acidic medium but reduces $[Fe(CN)_6]^{3-}$ to $[Fe(CN)_6]^{4-}$ in alkaline medium. The other products formed are, respectively.

(A) $(H_2O + O_2)$ and H_2O [JEE - 2018]

(B) $(H_2O + O_2)$ and $(H_2O + OH^-)$

(C) H_2O and $(H_2O + O_2)$

(D) H_2O and $(H_2O + OH^-)$

Ans. **(C)** H_2O and $(H_2O + O_2)$

➠ $[Fe(CN)_6]^{4-} + \frac{1}{2}H_2O_2 + H^+ \rightarrow [Fe(CN)_6]^{3-} + H_2O$

$[Fe(CN_6)]^{3-} + \frac{1}{2}H_2O_2 + OH^- \rightarrow [Fe(CN)_6]^{4-} + H_2O + \frac{1}{2}O_2$

21) The isotopes of hydrogen are.... [JEE January - 2019]

(A) Tritium and protium only.

(B) Deuterium and tritium only.

(C) Protium and deuterium only.

(D) Protium, deuterium and tritium.

Ans. **(D)** Protium, deuterium and tritium

➠ Hydrogen has three isotopes :

Protium : $_1H^1$; Deuterium : $_1H^2$; Tritium : $_1H^3$

➠ Their natural abundance is in order H > D > T.

22) The method used to remove temporaty hardness of water is : [NEET - 2019]

(A) Synthetic resins method

(B) Calgon's method

(C) Clark's method

(D) Ion-exchange method

Ans. **(C)** Clark's method

➠ Clark's method is used to remove temporary hardness of water, in which bicarbonates of calcium and magnesium are reacted with slaked line $Ca(OH)_2$.

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

23) In comparison to the zeolite process for the removal of permanent hardness, the synthetic resins method is : [JEE - 2020]

(A) Less efficient as it exchanges only anions.

(B) More efficient as it can exchanges only cations.

(C) Less efficient as the resins cannot be generated.

(D) More efficient as it can exchange both cations and anions.

Ans. **(D)** More efficient as it can exchange both cations and anions.

24) Match the following and identify the correct option.

(a) $CO_{(g)} + H_{2(g)}$	**(i)** $Mg(HCO_3)_2 + Ca(HCO_3)_2$
(b) Temporary hardness of water	**(ii)** An electron deficient hydride
(c) B_2H_6	**(iii)** Synthesis gas
(d) H_2O_2	**(iv)** Non-planar structure

[NEET - 2020]

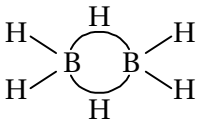
	(a)	(b)	(c)	(d)
(A)	(iii)	(iv)	(ii)	(i)
(B)	(i)	(iii)	(ii)	(iv)
(C)	(iii)	(i)	(ii)	(iv)
(D)	(iii)	(ii)	(i)	(iv)

Ans. **(C)** (iii) (i) (ii) (iv)

➠ (a) The mixture of CO and H_2 is used to synthesis many compounds such as methanol and hence it is known as syn-gas.

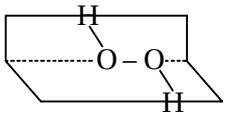
(b) The hardness of water is because of presence of hydrogen carbonates and sulphates of calcium and magnesium.

(c) B_2H_6 =



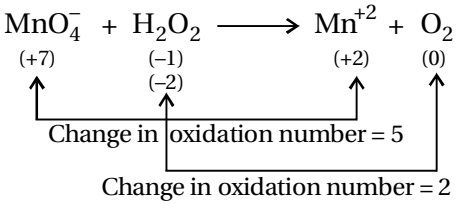
Boron requires 5 e^- to complete the octet. It has 3 e^- in the valance shell. Hence, it is electron deficient. Thus, B_2H_6 is electron deficient.

(d) H_2O_2 has non-planar structure.



25) A 20.0 mL solution containing 0.2 g impure H_2O_2 reacts completely with 0.316 g of $KMnO_4$ in acid solution. The purity of H_2O_2 (in %) is.... (mol. wt. of H_2O_2 = 34 g mol^{-1}, mol. wt. of $KMnO_4$ = 158 g mol^{-1}) [JEE September-2020]

➠ Let mass of pure H_2O_2 is x gram.



➠ Equivalent of H_2O_2 = Equivalent of MnO_4

$$\left(\frac{x}{34}\right) \times 2 = \left(\frac{0.316}{158}\right) \times 5$$

$$\therefore \quad x = 0.17$$

➠ So, % purity of H_2O_2 solution

$$= \frac{0.17}{0.2} \times 100 = 85\%$$

Question for Module

[Time : 1 Hour] [Total Marks : 20]

Section - A [06]

❖ **Answer the following question in very short :**

1) **Which isotopes of hydrogen has least proportion ?**

2) **Why the hydrogen is inert at room temperature.**

3) **Give reaction of Ca_3N_2 with water.**

4) **Arrange in increasing order of conductivity in molten state of CaH_2, BeH_2 TiH_2.**

5) **Draw the molecular structure of H_2O_2.**

6) **Due to which soluble salt water possess permanent hardness ?**

Section - B [04]

❖ **Answer the following question in short :**

7) **Explain ionic hydride**

8) **Give any two reaction for production of pure hydrogen.**

Section - C [06]

❖ **Answer the following question :**

9) **Complete the reaction :**

(i) $HNO_2 + H_2O_2 \rightarrow$

(ii) $PbS + H_2O_2 \rightarrow$

(iii) $MnO_4^- + H_2O_2 \rightarrow$

10) **Explain ion exchange method for removing permanent hardness.**

Section - D [04]

❖ **Do as directed :**

11) **Explain production of heavy water and its reaction with metal carbide with three equations.**

❖ ❖ ❖