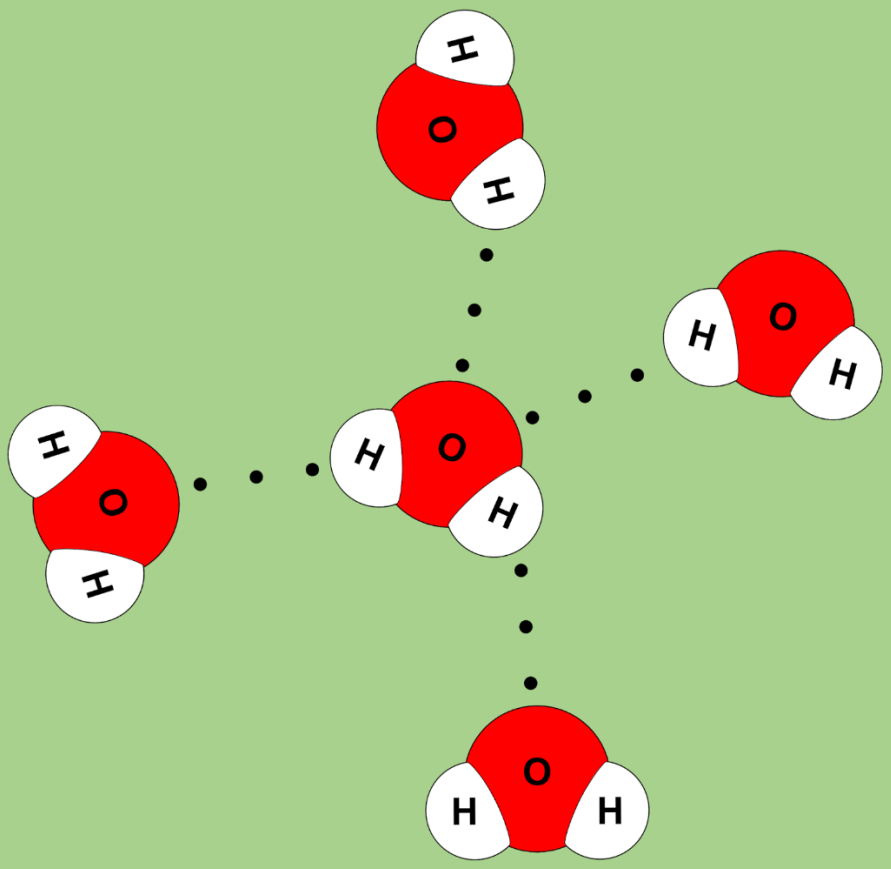
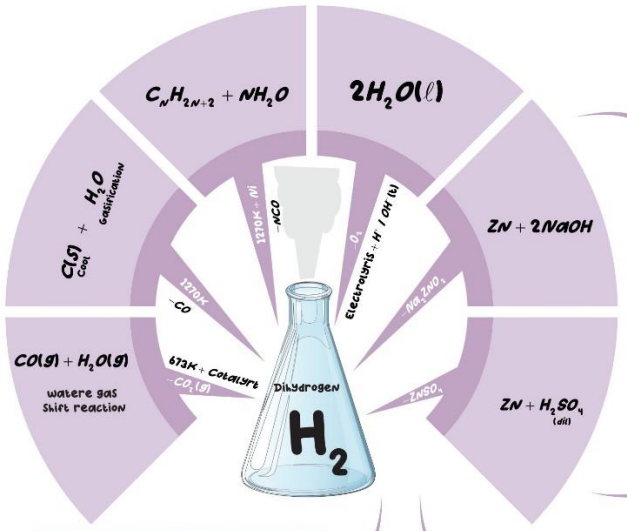
9.HYDROGEN



Chemistry Smart Booklet

Theory + NCERT MCQs + Topic Wise Practice MCQs + NEET PYQs

HYDROGEN



USES

- Synthesis of ammonia
- Manfacture of vanaspati fat
- Preparation of HCl
- If fuel cells
- As a rocket fuel

PHYSICAL PROPERTIES

- Colourless
- tasteless
- odorless
- Combustible
- Lighter than air
- Insoluble in water

CHEMICAL PROPERTIES

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

$2H_{2(g)} + O_{2(g)} \xrightarrow{\text{Catalyst } \Delta} 2H_2O(\ell)$

$3H_2 + N_{2(g)} \xrightarrow[Fe]{673\,k,\ 200\ atom} 2NH_{3(g)}$

$H_2 + 2M_{(s)} \rightarrow 2NH_{3(s)}M = \text{alkali metal}$

$H_2 + Pd^{2+}_{(aq)} \rightarrow Pd + 2H^+_{(aq)}$

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

$H_2 + RCH_2CH_2CHO \rightarrow RCH_2CH_2CH_2OH$

OCCURENCE

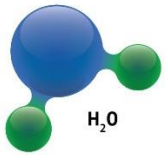
Lightest Element in the periodic table

If exists as diatomic gas (H_2) at STP.

Most abundant Element

TYPES OF HYDRIDES

IONIC



- Stoichiometric compounds of dihydrogen formed with S block element
- Also known as Saline Hydrides

COVALENT

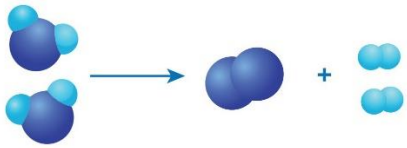
- Formation of molecular compounds from dihydrogen & block elements
- Also known as molecular hydrides

METALLIC

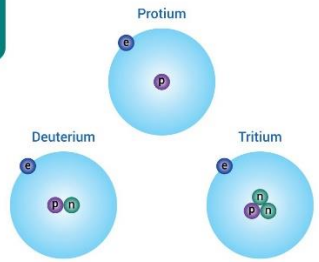
- Formed by D & F block Elements
- Also known as NON - Stoithiometric or interstitial hydrides

HYDROGEN ECONOMY

- Use of Hydrogen as alternate source of energy
- Non Polluting



ISOTOPES OF HYDROGEN



HEAVY WATER H_2O

- Preparation: By enchanting electrolysis of water.
- Uses: As a moderator in nuclear reactors in exchange reactions for the study of reaction mechanisms.

PHYSICAL PROPERTIES

- Colourless and tasteless
- Hight freeging point, B.P. high heat of vaporization, high heat of funon

CHEMICAL PROPERTIES

$H_2O_{(\ell)} + NH_{3(aq)} \rightleftharpoons OH^-_{(aq)} + NH^+_4$

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

$6CO_{2(g)} + 12H_2O \rightarrow C_6H_{12}O_{6(aq)} + 6H_2O_{(\ell)} + 6O_{2(g)}$

$P_4O_{10(s)} + 6H_2O_{(\ell)} \rightarrow 4H_3PO_{4(aq)}$

WATER H_2O

COMPOUNDS

SOFT WATER: water that produces sufficient later with soap

HARD WATER: It forms an involuble sum before it form lather with soap

- Temporary hardness Bicarbonates of mg/ca
- Permanent Hardness Sulfates or Cl of mg/ca

HYDROGEN PEROXIDE H_2O_2

PREPARATION

$BaO_2 \cdot \delta H_2O_{(s)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + H_2O_{2(aq)} + 8H_2O$

$2HSO^-_4 \xrightarrow{\text{Electrolysis}} HO_2SOOSO_3H_{(aq)}$

$\downarrow$

$2HSO^-_4 + 2M^+ + H_2O_{2(s)}$

2 ethylarthrquinol $\xrightarrow[H_2/Pd]{O_2\,(air)}$ H_2O_2 + oxidising product

PHYSICAL PROPERTIES

- Colourless (very pale blue)
- Miscible with water

USES

- As hair bleach, disinfectant
- Manufacture chemicals used in detergents
- In environmental Chemistry

CHEMICAL PROPERTIES

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

$HOCl + H_2O_2 \rightarrow H_3O^+ + Cl + O_2$

$Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2OH$

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

HYDROGEN

Introduction

In this chapter we will study the preparation, properties of dihydrogen and of some important compounds formed by hydrogen like H_2O and H_2O_2.

Hydrogen is the first element of the periodic table. The atomic structure of hydrogen is the most simplest one with only one proton and one electron. Hydrogen occurs in its atomic form only at very high temperatures. Water is one of the most important compounds formed by hydrogen. Even its name hydrogen was given by Lavoisier because of its ability to form water as in Greek, hydro means water and gene means forming.

Position of Hydrogen in the Periodic Table

Hydrogen is the first element in the periodic table. The electronic configuration of hydrogen is $1s^1$, yet its position in the periodic table is not certain and unsatisfactory. Hydrogen exhibits properties similar to both alkali metals (Group 1) and halogens (Group 17).

Resemblance with Alkali Metals

Like alkali metals, hydrogen has only one electron in its outer shell.

Alkali metals have a strong tendency to lose one electron from their outermost shell. Similarly, hydrogen also loses electron to form H^+ ion.

Alkali metals form stable oxides, halides and sulphides. Similarly, hydrogen also forms stable oxide (H_2O), halides (HF) and sulphide (H_2S).

Resemblance with Halogens

Halogens have a tendency to gain one electron. Similarly, hydrogen ($1s^1$) gains one electron to form H^- ion.

Hydrogen molecule is diatomic (H_2) and so are the molecules of halogens (say F_2).

Hydrogen forms hydrides with carbon (e.g., CH_4), just like halogens form halides with carbon (CCl_4).

Isotopes of Hydrogen

Isotopes are the different forms of the same element having same atomic number but different mass numbers. There are three isotopes of hydrogen namely protium, deuterium and tritium.

1. **Protium or ordinary hydrogen ($_1H^1$):** It has one proton and no neutron in the nucleus and one electron revolves around the nucleus.

2. **Deuterium ($_1H^2$ or D):** It is also known as heavy hydrogen. It has one proton and one neutron in the nucleus around which one electron revolves.

3. **Tritium ($_1H^3$ or T):** This isotope of hydrogen is radioactive and emits low energy β– particles having half-life period of 12.33 years. It has one proton and two neutrons in the nucleus. The concentration of tritium is very low.

Dihydrogen

Occurrence

Dihydrogen is the most abundant element in the universe. It constitutes about 70% of the total mass of the universe. But its abundance in earth's atmosphere is very less. It is just 0.15% by mass in the earth's atmosphere. In free state hydrogen is present in volcanic gases and in the combined form it constitutes 15.4% of the earth's crust and the oceans. However, it is also present in the plant and animal tissues, carbohydrates, proteins etc. Even hydrogen is present in mineral resources like coal and petroleum.

Hydrogen is the principal element in the solar atmosphere. It is present in the outer atmosphere of Sun and other stars of the universe+ like Jupiter and Saturn.

Preparation of Dihydrogen

1. **Laboratory Preparation of Dihydrogen**

   i. In laboratory dihydrogen is prepared by the reaction of granulated zinc with dilute hydrochloric acid or dilute sulphuric acid.

   $Zn + 2H^+(dil) \longrightarrow Zn^{2+} + H_2$

   ii. Zinc reacts with aqueous alkali to give dihydrogen

   $Zn + 2NaOH \longrightarrow Na_2ZnO + H_2$

2. **Commercial Production of Dihydrogen**

   i. **By the electrolysis of water:** Electrolysis of acidified water using platinum electrodes is used for the bulk preparation of hydrogen.

   $2H_2O \longrightarrow 2H_2 + O_2$

   ii. **By the action of steam on coke:** Dihydrogen is prepared by passing steam over coke or hydrocarbons at high temperature (1270 K) in the presence of Nickel catalyst.

   $C + H_2O \longrightarrow CO + H_2$

   The mixture of CO(g) and H_2(g) is called water gas. It is also known as synthesis gas or simply 'syn gas' because it is used in the synthesis of methanol and many other hydrocarbons.

Properties of Dihydrogen

i. Physical Properties

- Dihydrogen is a colourless, odourless, tasteless, combustible gas.

- It is lighter than air.
- It is insoluble in water.

ii. Chemical Properties

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

$H_2 + X_2 \longrightarrow 2HX$ (X F,Cl, Br,I)

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

$2H_2 + O_2 \longrightarrow 2H_2O$

Reaction with dinitrogen: With dinitrogen it forms ammonia.

$3H_2 + N_2 \longrightarrow NH_3$

Reactions with metals: Dihydrogen reacts with metals to yield hydrides at high temperature.

$H_2 + 2M(g) \longrightarrow 2MH(s)$

where M is an alkali metal.

Hydrogenation of vegetable oils: Edible oils (unsaturated) like cotton seed oil, groundnut oil are converted into solid fat (saturated) also called vegetable ghee by passing hydrogen through it in the presence of Ni at 473 K.

Vegetable oil + $H_2 \longrightarrow$ Fat

Uses of Dihydrogen

1. **Synthesis of ammonia:** Dihydrogen is used in Haber's process in the synthesis of ammonia.
2. **Hydrogenation of oils:** Dihydrogen is added to oils like soyabean oil, cotton seed oil for manufacturing vanaspati fat.
3. **Manufacture of methyl alcohol:** Water gas enriched with hydrogen gas in the presence of cobalt catalyst gives methanol.
4. **Manufacture of hydrogen chloride:** It is used in the manufacturing of hydrogen chloride which is a very important chemical.
5. **Manufacture of metal hydrides:** It is used in the manufacture of many metal hydrides.
6. **Metallurgical processes:** Since, dihydrogen is used to reduce heavy metal oxides to metals, as it is a reducing agent. Therefore, it finds its use in metallurgical processes.
7. **Rocket fuel:** It is used as a rocket fuel for space research in the form of liquid

hydrogen and liquid oxygen.

8. **Fuel Cells:** Dihydrogen is used in fuel cells for the generation of electrical energy.
9. It is used in the atomic hydrogen torch and oxyhydrogen torches for cutting and welding purposes.

Hydrides

Hydrogen combines with a large number of other elements including metals and non-metals, except noble gases to form binary compounds called hydrides. If 'E' is the symbol of the element then hydrides are represented as EH_x (e.g., BeH_2)

Based on their physical and chemical properties, the hydrides have been classified into three main categories:

- Ionic or saline or salt like hydrides.
- Covalent or molecular hydrides.
- Metallic or non-stoichiometric hydrides.

Ionic or Saline Hydrides

The ionic hydrides are stoichiometric which are formed when hydrogen combines with elements of s-block elements except Be. Ionic hydrides are formed by transfer of electrons from metals to hydrogen atoms and contain hydrogen as H– ion e.g., sodium hydride (Na^+H^-)

Covalent or Molecular Hydrides

Covalent or molecular hydrides are the compounds of hydrogen with p-block elements. The most common hydrides are CH_4, H_2O, NH_3 etc. Covalent hydrides are volatile compounds.

Metallic or Non-Stoichiometric Hydrides

The elements of group 3, 4, 5 (d-block) and f-block elements form metallic hydrides. In group 6, only chromium forms hydride (CrH). Metals of group 7, 8, 9 do not form hydrides. These hydrides are known as metallic hydrides because they conduct electricity.

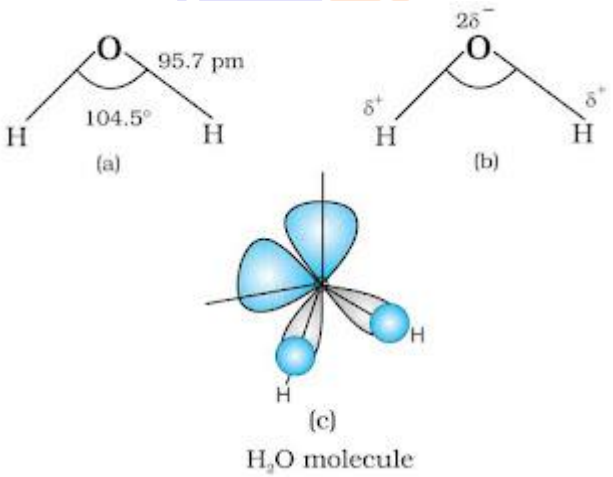
Water

Water is an oxide of hydrogen. It is an important component of all living organisms. Water constitutes about 65% of human body and 95% of plants. It is therefore essential for life. The ability of water to dissolve so many other substances makes it a compound of great importance. Almost three-fourth of the earth's surface is covered with water.

Physical Properties of Water

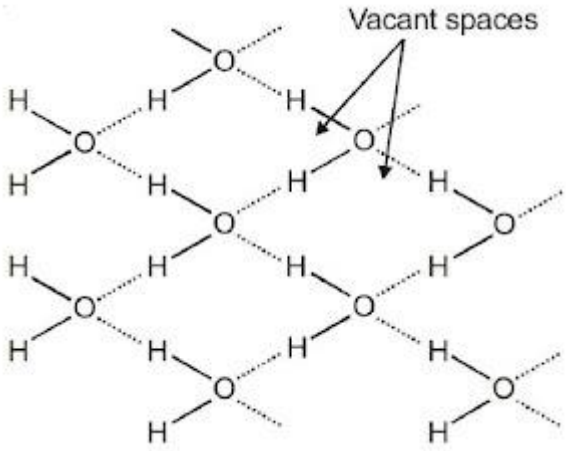
1. Pure water is colourless, odourless and tasteless.
2. Water is present in the liquid state at room temperature.
3. Water boils at 100°C and changes into the gaseous state whereas it freezes at 0°C to form ice.
4. Water molecules undergo extensive hydrogen bonding.
5. It is an excellent solvent for many thing like alcohols and carbohydrates dissolve in water.

Structure of Water



H_2O molecule

Structure of Ice



Chemical Properties

1. **Amphoteric nature:** Water can act both as an acid as well as a base and is thus said to be an amphoteric substance.

   Water as base: Water acts as a base towards acids stronger than it as shown below,

$H_2O + HCl \longrightarrow H_3O^+ + Cl^-$

Water as an acid: Water acts as an acid towards bases stronger than it.

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

2. **Redox reactions involving water:** Water can act both as oxidising as well as reducing agent.

   Oxidising agent: Water acts as an oxidising agent when it gets reduced.

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

   Reducing agent: Water acts as a reducing agent when it gets oxidised.

   $2H_2O + 2F_2 \longrightarrow 4H^+ + 4F^- + O_2$

3. **Hydrolysis reaction:** Water is an excellent solvent due to its high dielectric constant (78.39). In addition, water can easily hydrolyses many ionic and covalent compounds.

   Water hydrolyses oxides and halides of non-metals forming their respective acids

   $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

4. **Hydrates Formation:** From aqueous solutions many salts can be crystallised as hydrated salts. Hydrates are of three types:

   i. Coordinated water

   For example: $[Ni(H_2O)_6]_{2+}$ $(NO_{3-})_2$ and $[Fe(H_2O)_6]Cl_3$

   ii. Interstitial water

   For example: $BaCl_2.2H_2O$

   iii. Hydrogen bonded water

   For example: $[Cu(H_2O)_4]^{2+}$ SO_4^{2-} H_20 in $CuS0_4.5H_2O$

Hard and Soft Water

Hard water is the one which does not produce lather with soap easily due to the presence of calcium and magnesium salts in the form of their bicarbonates, chlorides and sulphates. For example, sea water etc.

Soft water is the one which is free from the soluble salts of calcium and magnesium. It gives lather with soap easily. For example, distilled water, rain water etc.

Types of Hardness

1. **Temporary hardness:** It is due to the presence of bicarbonates of calcium and magnesium. Temporary hardness is called so because it can be easily removed by

boiling.

2. **Permanent hardness:** This type of hardness is due to the presence of chlorides and sulphates of calcium and magnesium dissolved in water. As this type of hardness cannot be removed by simple boiling, therefore it is known as permanent hardness.

Softening of Water

The process of removal of hardness from water is called softening of water.

i. **Removal of temporary hardness:** Temporary hardness can be removed by the following methods:

   a) **Boiling:** The temporary hardness of water can easily be removed by boiling the water in large boilers. During boiling the soluble $Mg(HCO_3)_2$ is converted into $Mg(OH)_2$ instead of $MgCO_3$ because $Mg(OH)_2$ is precipitated easily, whereas $Ca(HCO_3)_2$ is changed to insoluble $CaCO_3$ and gets precipitated. These precipitates can be removed by filtration process. So, the filtrate obtained will be soft water.

   $Mg(HCO_3)_2 \longrightarrow Mg(OH)_2 + 2CO_2$

   $Ca(HCO_3)_2 \longrightarrow Ca(OH)_2 + H_2O + 2CO_2$

   b) **Clark's method:** In this process the calculated amount of lime is added to hard water containing bicarbonates of calcium and magnesium. It precipitates out calcium carbonate and magnesium hydroxide which are then filtered to obtain soft water.

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

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

ii. **Permanent hardness:** Permanent hardness of water is due to the presence of chlorides and sulphates of calcium and magnesium. It cannot be removed by simple boiling. So, the following methods are employed for removing permanent hardness:

   a) **Treatment with washing soda:** When calculated amount of Na2CO3 (washing soda) is added to hard water containing soluble sulphates and chlorides of calcium and magnesium, then these soluble salts get converted into insoluble carbonates which get precipitated.

   $CaCl_2 + Na_2CO_3 \longrightarrow 3CaCO_3\downarrow + 2NaCl$

   $MgSO_4 + Na_2CO_3 \longrightarrow 3MgCO_3\downarrow + Na_2SO_4$

   d) **Ion-exchange method:** This process employs the use of zeolite or permutit which is hydrated sodium aluminium silicate ($NaAlSiO_4$), therefore, it is also known as zeolite/permutit process. For the sake of simplicity sodium aluminium silicate is written as NaZ. When zeolite is added to hard water, the cations present in hard water are exchanged for sodium ions.

   $2NaZ(s) + M^{2+}(aq) \longrightarrow MZ_2(s) + 2Na^+(aq)$ (M = Mg, Ca)

Hydrogen Peroxide

Hydrogen peroxide was discovered by a French chemist J. L. Thenard. It is an important chemical used in pollution control treatment of domestic and industrial effluents.

Preparation

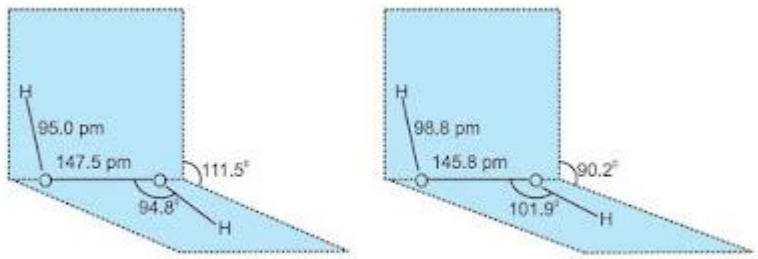
By the action of sulphuric acid on hydrated barium peroxide

$BaO.8H_2O + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2 + H_2O$

Physical Properties

1. Pure hydrogen peroxide is a syrupy liquid. It is colourless but gives a bluish tinge in thick layers.
2. It is soluble in water, alcohol and ether in all proportions.
3. It is more viscous than water. This is due to the fact that molecules of H_2O_2 are more associated through H-bonding.

Structure



(a) Gas phase (b) Solid phase

Chemical Properties

a) **Oxidising property:** Hydrogen peroxide acts as an oxidising agent both in acidic as well as in alkaline medium.

$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

b) **Reducing Property:** In presence of strong oxidising agents, hydrogen peroxide behaves as a reducing agent in both the medium.

$H_2O_2 + O_3 \longrightarrow H_2O + 2O_2$

c) **Decomposition:** H2O2 is an unstable liquid

$2H_2O_2 \longrightarrow 2H_2O + O_2$

Uses

1. In daily life it is used as a material to bleach delicate materials like hair, cotton, wool, silk etc.
2. It is used as a mild disinfectant. It is also a valuable antiseptic which is sold under the name of perhydrol.
3. In the manufacture of sodium perborate, sodium percarbonate. These are used in

high quality detergents.

4. In the synthesis of hydroquinone, tartaric acid and certain food products and pharmaceuticals (cephalosporin) etc.
5. It is used in industries as a bleaching agent for paper pulp, leather, oils, fats and textiles etc.

Heavy Water (D_2O)

Method Heavy water is chemically deuterium oxide (D_2O). It was discovered by Urey in 1932.

Preparation

It is prepared by the exhaustive electrolysis of water. When prolonged electrolysis of water is done, then H_2 is liberated much faster than D_2 and the remaining water becomes enriched in heavy water.

$H_2O + D_2 \longrightarrow D_2O + H_2$

Uses

1. Heavy water is used as a moderator in nuclear reactors.
2. It is used as a tracer compound, in studying the reaction mechanisms.
3. It is used as a starting material for the preparation of a number of deuterium compounds.

Summary-

1. Hydrogen has the simplest atomic structure with only one proton and one electron. It is the only element which has no neutron.
2. Hydrogen has properties similar to both alkali metals as well as halogens. Therefore, its position in the periodic table was not certain and it is best placed separately.
3. There are three isotopes of hydrogen namely protium ($_1H^1$), deuterium ($_1H^2$, D) and tritium ($_1H^3$, T) . The predominant form of hydrogen is protium which has no neutron, deuterium has one neutron, tritium which is radioactive has two neutrons.
4. Hydrogen in its elemental form exists as dihydrogen. Dihydrogen is the most abundant element in the universe.
5. 'Syn gas' or 'water gas' is a mixture of CO and H_2.
6. Dihydrogen is colourless, odourless and combustible gas. The H–H bond dissociation enthalpy is the highest for a single bond between two atoms of any element.
7. The main use of dihydrogen is in the formation of vegetable ghee by hydrogenation of vegetable oils and also the formation of ammonia by Haber's process.
8. Atomic hydrogen and oxyhydrogen torches are used for cutting and welding purpose.

9. It acts as a rocket fuel and even has a promising potential for use as a non-polluting fuel of the near future (hydrogen economy).
10. Hydrogen forms three category of hydrides namely ionic hydrides, covalent hydrides and metallic hydrides.
11. Covalent hydrides are further classified into electron-deficient, electron-precise and electronrich hydrides based on the relative number of electrons and bonds in their Lewis structures.
12. Water is a substance which is of great chemical and biological significance. It is a solvent of great importance.
13. Water has highest density at 4°C.
14. Water reacts with large number of substances. It exhibits amphoteric nature.
15. Water dissolves many salts in it making it hard. Hard water is the one which contains calcium and magnesium salts in the form of hydrogencarbonate, chlorides and sulphates.
16. The temporary hardness of water is due to the presence of magnesium and calcium hydrogencarbonates which can be removed simply by boiling.
17. The permanent hardness of water is due to the presence of soluble salts of magnesium and calcium in the form of chlorides and sulphates. It is mainly removed by the ion-exchange methods.
18. Hydrogen peroxide has a non-planar open-book like structure. It is a good bleaching agent and is used in pollution control treatment

NCERT LINE BY LINE QUESTIONS

(1.) does not react with cold water.

(a.) Na (b.) Mg

(c.) Au (d.) Fe

(2.) How many protons and neutrons are present in an isotope of hydrogen ? **[Page: 285]**

(a.) 0 protons and 1 neutron (b.) 1 proton and 0 neutrons

(c.) 1 proton and 1 neutron (d.) 1 proton and 2 neutrons

(3.) Which of the following ions is responsible for causing hardness in water ? **[Page: 291]**

(a.) Ca^{2+} (b.) Na^{+}

(c.) Cl (d.) K^{+}

(4.) What is the result of the formation of sodium peroxide with dilute sulphuric acid? **[Page: 293]**

(a.) Sodium sulphate and water (b.) Sodium sulphate and oxygen

(c.) Sodium sulphate, hydrogen and oxygen (d.) Sodium sulphate and hydrogen peroxide

(5.) $CuSO_4.5H_2O$ has — hydrogen bonded water molecules.

(a.) 7 (b.) 5

(c.) 3 (d.) 1

(6.) An electron precise hydride is **[Page: 288]**

(a.) B_2H_6 (b.) NH_3

(c.) H_2O (d.) CH_4

(7.) Which of the following statements about water is correct **[Page: 290]**

(a.) H-O-H bond angle is 109o28'. (b.) O-H bond length is 95.7 pm.

(c.) In liquids, intramolecular H-bonding is there. (d.) All of the above

(8.) Which of the following equations depicts the oxidising nature of H_2O_2? **[NCERT Exemplar, Page8: 293-294]**

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

(9.) What is the maximum number of hydrogen bonds formed by a molecule of water in ice?

(a.) 4 (b.) 1

(c.) 2 (d.) 3

(10.) The only metal ion group 6 forming hydride is

(a.) Mo (b.) W

(c.) Cr (d.) Sg

(11.) The freezing point of heavy water is

(a.) −3.8oC (b.) 3.8oC

(c.) 0oC (d.) -38oC

(12.) **Assertion:** Molecular hydrogen consists of ortho and para hydrogen. **[Page: 285]**
Reason: Ortho and para hydrogen differ by the spins of electrons and nuclei Which of the following alternatives is true for the given information

(a.) Both A and R are true and 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.) Both A and R are false.

(13.) — process is used for the removal of hardness of water.

(a.) Calgon (b.) Baeyer

(c.) Bosch (d.) Lane

(14.) Which of the following reactions increases production of dihydrogen from synthesis gas **[Page: 286]**

(a.) $CH_4(g)+H_2O(g)\xrightarrow[Ni]{1270K}CO(g)+3H_2(g)$ (b.) $C(s)+H_2O(g)\xrightarrow{1270K}CO(g)+H_2(g)$

(c.) $CO(g)+H_2O(g)\xrightarrow[Catalyst]{673K}CO_2(g)+H_2(g)$ (d.) $C_2H_6+2H_2O\xrightarrow[Ni]{1270K}2CO+5H_2$

(15.) A blue colour is formed when hydrogen peroxide is treated with cold acidified $K_2Cr_2O_7$ solution containing ether. This is because of the formation of **[Page: 294]**

(a.) Chromium sulphate (b.) Perchromic acid

(c.) Potassium chromate (d.) Chromium trioxide

(16.) On treatment with water, metal hydrides give **[Page: 288]**

(a.) acid. (b.) water.

(c.) hydrogen. (d.) hydrogen peroxide.

(17.) 0.710 g of I_2 is liberated when $7.1cm^3$ solution of H_2O_2 is titrated against KI solution acidified with H_2SO_4. What is the volume strength of H_2O_2 solution? **[Page: 293]**

(a.) 4.11 (b.) 4.25

(c.) 4.41 (d.) 4.55

(18.) How is heavy water manufactured? **[Page: 294]**

(a.) By combination of hydrogen and heavier isotope of oxygen (b.) By electrolysis of water containing heavy hydrogen dissolved in it

(c.) By repeated electrolysis of 3% aqueous solution of NaOH (d.) None of the above

(19.) Most of the s-block elements form dihydrogen compounds that are **[QR code, Page: 286]**

(a.) highly electropositive. (b.) highly electronegative.

(c.) Neutral. (d.) Covalent.

(20.) A 30% solution of H_2O_2 is marked as X volume hydrogen peroxide. It indicates 1 millilitreof 30% H_2O_2 solution will yield Y volumes of oxygen at STP. X and yare **[Page: 293]**

(a.) 10 V and 100 mL respectively
(b.) 100 ml- and 10 V respectively
(c.) 100 V and 100 mL respectively
(d.) 10 V and 50 mL respectively

(21.) Which of the following statements regarding water is not correct **[Page: 289]**

(a.) Water can act both as an acid and as a base
(b.) Ice formed by heavy water sinks in normal water
(c.) Water is oxidised to oxygen during photosynthesis
(d.) There is an extensive intramolecular hydrogen bonding in the condensed phase

(22.) Pollutants in the combustion of H_2 will be — than petrol.

(a.) more
(b.) less
(c.) equal
(d.) moderate

(23.) Metal hydrides are ionic, covalent or molecular in nature. Among LiH, NaH, KH, RbH, CsH, the correct order of increasing ionic character is **[NCERT Exemplar, Page: 285]**

(a.) LiH > NaH > CSH > KH > RbH
(b.) LiH < NaH < KH < RbH < CsH
(c.) RbH > CsH > NaH > KH > LiH
(d.) NaH > CSH > RbH > LiH > KH

(24.) Why is it not possible to dry moist hydrogen peroxide over conc. H_2SO_4?

(a.) It can catch fire
(b.) It is reduced by sulphuric acid
(c.) It is oxidised by sulphuric acid
(d.) It is decomposed by sulphuric acid

(25.) Elements of which of the following group(s) of periodic table do not form hydrides **[Page: 288]**

(a.) Groups 7, 8, 9
(b.) Group 13
(c.) Groups 15, 16, 17
(d.) Group 14

(26.) Find the oxidation state of the most electronegative element formed as a result of reaction of BaO_2 with dilute H_2SO_4. **[Page: 293]**

(a.) -2
(b.) -1
(c.) +1
(d.) +2

(27.) The reaction of dihydrogen with dioxygen to form water **[Page: 287]**

(a.) is slightly endothermic.
(b.) is highly endothermic.
(c.) is highly exothermic.
(d.) None of these.

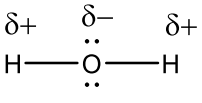
(28.) H_2O is not used in a nuclear reactor as

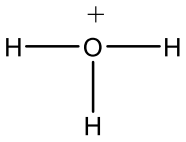
(a.) It is not able to slow down the fast moving neutrons
(b.) It cannot remove the heat from the reactor core
(c.) It exhibits corrosive action on metallic part of nuclear reactor
(d.) None of these

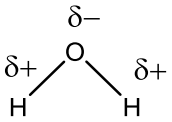
(29.) Which of the following hydrides is electron precise hydride ? **[Page: 288]**

(a.) B_2H_6
(b.) NH_3
(c.) H_2O
(d.) CH_4

(30.) Which of the following structures indicates water in gaseous phase

(a.) 

(b.) 

(c.) 

(d.) None of these

(31.) $5cm^3$ of H_2O_2 release 0.58 g of I_2 from acidified solution of KI. The strength of H_2O_2 is

(a.) 6.48 Volumes (b.) 4.48 Volumes

(c.) 3.68 Volumes (d.) 1.48 Volumes

(32.) An excess of acidified potassium iodide solution was added to 250 mL of hydrogen peroxide solution. 0.5 N sodium thiosulphate was consumed by the liberated iodine. **[Page: 293]** The volume strength of the given solution is

(a.) 1.12 (b.) 2.24

(c.) 11.2 (d.) 22.4

(33.) is formed when calcium carbide reacts with heavy water.

(a.) C_2D_2 (b.) CaD_2

(c.) CD_2 (d.) Ca_2D_2

(34.) Which of the following compounds is used for water softening) **[NCERT Exemplar, Page: 294]**

(a.) $Ca_3(PO_4)_2$ (b.) Na_3PO_4

(c.) $Na_6P_6O_{18}$ (d.) Na_2HPO_4

(35.) Consider the following reactions: **[Page: 294]**

I. $2KI + H_2SO_4 + H_2O_2 \rightarrow K_2SO_4 + I_2 + 2H_2O$

II. $MnO_2 + H_2SO_4 + H_2O_2 \rightarrow MnSO_4 + O_2 + 2H_2O$

Which of the following alternatives is correct for the given reactions

(a.) H_2O_2 acts as an oxidising agent in both reactions I and II.

(b.) H_2O_2 acts as a reducing agent in both reactions I and II.

(c.) H_2O_2 acts as an oxidising agent in reaction I and as a reducing agent in reaction II.

(d.) H_2O_2 acts as a reducing agent in reaction I and as a oxidising agent in reaction II.

(36.) Saline hydrides can remove water traces from organic compounds since

(a.) In saline hydrides H is a strong Bronsted base

(b.) In saline hydrides H is a weak Bronsted base

(c.) In saline hydrides M^+ is a strong Bronsted acid

(d.) In saline hydrides M^+ is a weak Bronsted acid

(37.) Despite having the same electronic configurations and chemical properties, the isotopes of hydrogen differ in the rates of reaction. This happens due to the difference in

(a.) Enthalpy of fusion

(b.) Enthalpy of vaporisation

(c.) Bond dissociation enthalpy (d.) Atomic mass

(38.) **Assertion:** Pt and Pd can be used to store hydrogen **[Page: 288]**
Reason: Pt and Pd can absorb large volumes of hydrogen Which of the following alternatives is true for the given information .

(a.) Both A and R are true and 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.) Both A and R are false.

(39.) Which reaction is not used to prepare deuterium compounds using heavy water?

(a.) $CaC_2 + 2D_2O \rightarrow C_2D_2 + Ca(OD)_2$
(b.) $SO_3 + D_2O \rightarrow D_2SO_4$
(c.) $2AlN + 3D_2O \rightarrow A1_2O_3 + 2ND_3$
(d.) $A1_4C_3 + 12D_2O \rightarrow 3CD_4 + 4A1(OD)_3$

(40.) Which option is not correct for the commercial production of dihydrogen) **[Page: 286]**

(a.) Electrolysis of acidified water using platinum electrodes
(b.) Electrolysis of warm aqueous barium hydroxide solution between nickel electrodes
(c.) Electrolysis of brine solution
(d.) Reaction of cold water with hydrocarbon or coke in the presence of catalyst

(41.) Reducing nature of H_2O_2 in basic medium is being shown in

(a.) $2[Fe(CN)_6]^{4} + 2H^{+} + H_2O_2 \rightarrow 2[Fe(CN)_6]^{3-} + 2H_2O$
(b.) $I_2 + H_2O_2 + 2\bar{O}H \rightarrow 2I^{-} + 2H_2O + O_2$
(c.) $Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2\bar{O}H$
(d.) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

(42.) Which of the following statements about hydrogen is incorrect) **[NEET-2016, Page: 285]**

(a.) Hydrogen never acts as a cation in ionic salts.
(b.) Hydronium ion H_3O^{+} exists freely in solution.
(c.) Dihydrogen acts as a reducing agent.
(d.) Hydrogen has three isotopes of which one is titanium.

(43.) What is the advantage of hydrogen economy?. **[Page: 295]**

(a.) Transmission of mechanical energy
(b.) Transmission of energy in the form of electric power
(c.) Transmission of energy in the form of chemical energy
(d.) Transmission of energy in the form of dihydrogen and not electric power

(44.) **Assertion:** H_2O_2 gets mixed with water in all proportions. **[Page: 294]**
Reason: H_2O_2 forms a hydrate having formula $H_2O_2.H_2O$.
Which of the following alternatives is true for the given information?

(a.) Both A and R are true and 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.) Both A and R are false.

(45.) (i) $H_2O_2 + O_3 \rightarrow H_2O + 2O_2$ **[Page: 294]**
(ii) $H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$

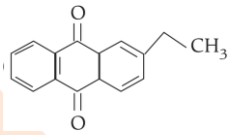
The role of hydrogen peroxide in the above reactions is

(a.) Oxidising in (i) and reducing in (ii)
(b.) Reducing in (i) and oxidising in (ii)
(c.) Reducing in (i) and (ii)
(d.) Oxidising in (i) and (ii)

(46.) Hydrogen resembles halogens in many respects for which several factors are responsible. of the following factors which one is most important in this respect? . **[QR code, NCERT Exemplar, Page: 285]**

(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 gain enthalpy value.
(d.) Its small size.

(47.) — cannot be used to prepare H_2O_2.

(a.) Na_2O_2
(b.) 
(c.) $Na_2S_2O_3.xH_2O$
(d.) BaO_2

(48.) Which of the following statement is correct. **[Page: 291]**

(a.) Hydrolysis yields the original acid and base whereas hydration forms hydrated salts or ions
(b.) Hydrolysis forms hydrated salts or ions whereas hydration yields the original acid and base
(c.) Hydrolysis yields only the original acid whereas hydration yields the original base
(d.) Hydrolysis yields only the original base while hydration yields the original acid

(49.) How much oxygen at NTP will be obtained if 100 mL H_2O_2 marked 30 volume gets completely decomposed **[Page: 293]**

(a.) 1 L
(b.) 2 L
(c.) 3 L
(d.) 4 L

(50.) The name hydrogen; means **[Page: 284]**

(a.) water forming
(b.) water fearing
(c.) fire forming
(d.) fire fearing

TOPIC WISE PRACTICE QUESTIONS

TOPIC 1: Preparation, Properties of Hydrogen and Hydrides

1. Which one of the following is not an isotope of hydrogen ?
(1) Deuterium (2) Tritium (3) Ortho hydrogen (4) None of these

2. The ionization of hydrogen atom would give rise to
(1) hydride ion (2) hydronium ion (3) proton (4) hydroxyl ion.

3. Number of neutrons in three isotopes of hydrogen, protium, deuterium and tritium respectively is
(1) 0, 1, 2 (2) 1, 1,1 (3) 2, 1, 0 (4) 2, 0, 1

4. Which of the following metal evolves hydrogen on reacting with cold dilute HNO_3?
(1) Mg (2) Al (3) Fe (4) Cu

5. Hydrogen can behave as a metal
(1) at very high temperature (2) at very low temperature
(3) at very high pressure (4) at very low pressure

6. Out of the two allotropic forms of dihydrogen, the form with lesser molecular energy is
(1) ortho (2) meta (3) para (4) all have same energy

7. Which of the following reaction(s) represents commercial method for production of dihydrogen?
(i) $CO(g) + H_2O(g) \xrightarrow[\text{catalyst}]{673K} CO_2(g) + H_2(g)$
(ii) $2H2O(l) \xrightarrow[\text{traces of acid/base}]{\text{electrolysis}} 2H_2(g) + O_2(g)$
(iii) $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$
(iv) $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + 3H_2(g)$
(1) (i), (ii) and (iii) (2) (iii) only (3) (i), (ii) and (iv) (4) (ii), (iii) and (iv)

8. Hydrogen accepts an electron to form inert gas configuration. In this it resembles
(1) halogen (2) alkali metals (3) chalcogens (4) alkaline earth metals

9. Hydrogen bond energy is equal to :
(1) 3-7 cals (2) 30-70 cals (3) 3-10 kcals (4) 30-70 kcals

10. Which of the following ions can be replaced by H^+ ions when H_2 gas is bubbled through the solutions containing these ions ?
(1) Li^+ (2) Ba^{2+} (3) Cu^{2+} (4) Be^{2+}

11. Saline hydrides react explosively with water, such fires can be extinguished by
(1) water (2) carbon dioxide (3) sand (4) none of these

12. Which one of the following pairs of substances will not produce hydrogen when reacted together?
(1) Copper and conc. nitric acid (2) Ethanol and metallic sodium
(3) Magnesium and steam (4) Phenol and metallic sodium

13. Ortho and para hydrogen differ.
(1) in the number of protons (2) in the molecular mass
(3) in the nature of spins of protons (4) in the nature of spins of electrons

14. Which of the following will not displace hydrogen ?
(1) Ba (2) Pb (3) Hg (4) Sn

15. Which hydride is an ionic hydride?
(1) H_2S (2) TiH_4 (3) NH_3 (4) NaH

TOPIC 2: Preparation and Properties of Water

16. Match the columns

Column-I	**Column-II**
(1) Coordinated water	(p) $[Cu(H_2O)_4]^{4+}SO_4^{2-} . H_2O$
(2) Interstitial water	(q) $C_{17}H_{35}COONa$
(3) Hydrogen-bonded water	(r) $BaCl_2.2H_2O$
	(s) $[Cr(H_2O)_6]^{3+} 3Cl^-$

(1) A – (r), B – (s), C – (q) (2) A – (q), B – (r), C – (s)
(3) A – (r), B – (q), C – (p) (4) A – (s), B – (r), C – (p)

17. Which of the following groups of ions makes the water hard?
(1) Sodium and bicarbonate (2) Magnesium and chloride
(3) Potassium and sulphate (4) Ammonium and chloride

18. The H–O–H angle in water molecule is about
(1) 90° (2) 180° (3) 102.5° (4) 104.5°

19. Match the Column-I with Column-II and mark the appropriate choice.

Column-I	**Column-II**
(1) Syn gas	(p) $Na_6P_6O_{18}$
(2) Calgon	(q) $NaAlSiO_4$
(3) Permutit	(r) $CO + H_2$
(4) Producer gas	(s) $CO + N_2$

(1) (1) – (p), (2) – (q), (3) – (r), (4) – (s) (2) (1) – (r), (2) – (p), (3) – (q), (4) – (s)

(3) (1) – (r), (2) – (q), (3) – (s), (4) – (p) (4) (1) – (r), (2) – (q), (3) – (p), (4) – (s)

20. Water is :
(1) more polar than H_2S (2) more or less identical in polarity with H_2S
(3) less polar than H_2S (4) None of these

21. The boiling point of water is exceptionally high because
(1) there is covalent bond between H and O.
(2) water molecule is linear.
(3) water molecules associate due to hydrogen bonding.
(4) water molecule is not linear.

22. Water possesses a high dielectric constant, therefore
(1) it always contains ions. (2) it is a universal solvent.
(3) can dissolve covalent compounds. (4) can conduct electricity.

23. Which of the following groups of ions makes the water hard?
(1) Sodium and bicarbonate (2) Magnesium and chloride
(3) Potassium and sulphate (4) Ammonium and chloride.

24. When hydrolith is treated with water it yields
(1) H_2 (2) H_2O_2 (3) N_2 (4) NaH

25. The low density of ice compared to water is due to
(1) hydrogen-bonding interactions. (2) dipole-dipole interactions.
(3) dipole-induced dipole interactions. (4) induced dipole-induced dipole interactions.

26. Which is not present in clear hard water:
(1) $Mg(HCO_3)_2$ (2) $CaCl_2$ (3) $MgSO_4$ (4) $MgCO_3$

27. D_2O is preferred to H_2O, as a moderator, in nuclear reactors because
(1) D_2O slows down fast neutrons better
(2) D_2O has high specific heat
(3) D_2O is cheaper
(4) none of these

28. The boiling point of heavy water is:
(1) 100 °C (2) 101.4 °C (3) 104 °C (4) 102.5 °C

29. The shape of water molecule is same as that of
(1) C_2H_2 (2) CO_2 (3) NH_3 (4) Cl_2O

30. Match list I with list II and select the correct answer using the codes given below the lists :

List I	**List II**
1. Heavy water	A. Bicarbonates of Mg and Ca in water
2. Temporary	B. No foreign ions hard water in water
3. Soft water	C. D_2O
4. Permanent hard	D. Sulphates and chlorides of water Mg and Ca in water

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

31. The maximum density of water is reached at a temperature
(1) 273 K (2) 277 K (3) 373 K (4) none of above

32. The critical temperature of water is higher than that of O_2 because H_2O molecule has:
(1) fewer electrons than oxygen (2) two covalent bonds
(3) V-shape (4) dipole moment

33. Water contracts on heating
(1) to 100 °C (2) from 0 °C to 4 °C (3) to 273 K (4) from 10 °C to 20 °C

TOPIC 3: Preparation and Properties of Hydrogen Peroxide

34. When H_2O_2 is oxidised, the product is:
(1) OH^- (2) O_2 (3) O^{2-} (4) HO_2^-

35. The decomposition of H_2O_2 is accelerated by
(1) glycerine (2) alcohol (3) phosphoric acid (4) Pt powder

36. The structure of H_2O_2 is
(1) planar (2) non planar (3) spherical (4) linear

37. The reaction
$H_2S + H_2O_2 \longrightarrow S + 2H_2O$ manifests
(1) acidic nature of H_2O_2 (2) alkaline nature of H_2O_2
(3) oxidising action of H_2O_2 (4) reducing action of H_2O_2.

38. Which one of the following undergoes reduction with hydrogen peroxide in an alkaline medium ?
(1) Mn^{2+} (2) HOCl (3) PbS (4) None of these

39. Which substance does not speed up decomposition of H_2O_2
(1) Glycerol (2) Pt (3) Gold (4) MnO_2

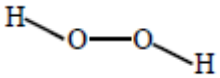
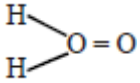
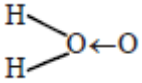
40. H_2O_2 is
(1) poor polar solvent than water. (2) better polar solvent than H_2O.
(3) both have equal polarity.
(4) better polar solvent but its strong auto-oxidising ability limits its use as such.

41. H_2O_2 is always stored in black bottles because
(1) it is highly unstable.
(2) its enthalpy of decomposition is high.
(3) it undergo auto-oxidation on prolonged standing.
(4) none of these.

42. Identify *x* and *y* in following reaction:

$$2HSO_4^-(aq) \xrightarrow{\text{electrolysis}} x \xrightarrow{\text{hydrolysis}} y + 2H^+(aq) + H_2O_2(aq)$$

(1) *x* = H_2SO_4(aq), *y* = $2HSO_4^-(aq)$
(2) *x* = HO_3SOOSO_3H(aq), *y* = $2HSO_4^-(aq)$
(3) *x* = HO_3SOOSO_3H (aq), *y* = $2HSO_4(aq)$
(4) *x* = H_2SO_4(aq) , y = HO_3SOOSO_3H(aq)

43. Which of the following is the true structure of H_2O_2?
(1) H–O–O–H (2)  (3)  (4) 

44. D_2O is used in
(1) motor vehicles (2) nuclear reactor (3) medicine (4) insecticide

45. The oxidizing property of H_2O_2 is best explained by assuming that two oxygen atoms in its molecules are:
(1) bonded differently (2) bonded similarly (3) bonded covalently (4) bonded by hydrogen bonds

46. H_2O_2 is stored in:
(1) iron container after addition of stabilizer (2) glass container after addition of stabilizer
(3) plastic container after addition of stabilizer (4) none of the above

47. H_2O_2 converts potassium ferrocyanide to feericyanide. The change observed in the oxidation state of iron is
(1) $Fe^{2+} \longrightarrow Fe^{3+}$ (2) $Fe \longrightarrow Fe^{2+}$ (3) $Fe^{3+} \longrightarrow Fe^{2+}$ (4) $Fe^{2+} \longrightarrow Fe^{+}$

48. Water can be tested by
(1) smell (2) taste (3) hydrated $CuSO_4$ (4) anhydrous $CoCl_3$ (blue) which changes to pink

49. H_2O_2 turns an acidified solution of.....to orange red.
(1) BaO2 (2) PbO_2 (3) Na_2O_2 (4) TiO_2

50. Hydrogen peroxide does not
(1) liberate iodide from KI (2) turn titanium salt yellow
(3) gives silver peroxide with moist silver oxide
(4) turn mixture of aniline, $KClO_3$ and dil. H_2SO_4 violet

NEET PREVIOUS YEARS QUESTIONS

1. Which of the following statements about hydrogen is incorrect? **[2016]**

(1) Hydrogen has three isotopes of which tritium is the most common.

(2) Hydrogen never acts as cation in ionic salts

(3) Hydronium ion, H_3O^+ exists freely in solution

(4) Dihydrogen does not act as a reducing agent

2. (i) $H_2O_2 + O_3 \rightarrow H_2O + 2O_2$

(ii) $H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$

Role of hydrogen peroxide in the above reactions is respectively - **[2014]**

(1) Oxidizing in (i) and reducing in (ii)

(2) Reducing in (i) and oxidizing in (ii)

(3) Reducing in (i) and (ii)

(4) Oxidizing in (i) and (ii)

3. The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is :- **[NEET-2019]**

(1) 10 (2) 20 (3) 30 (4) 40

4. The method used to remove temporary hardness of water is : **[NEET-2019]**

(1) Calgon's method (2) Clark's method

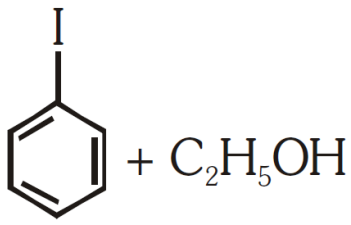
(3) Ion-exchange method (4) Synthetic resins method

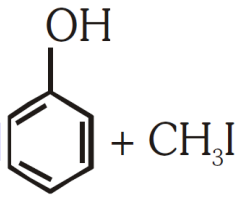
5. Which one of the following reactions does not come under hydrolysis type reaction? **[NEET-2020(COVID-19)]**

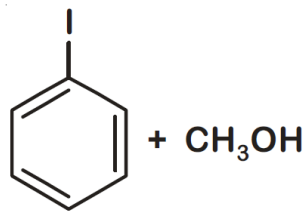
(1) $SiCl_{4(l)} + 2H_2O_{(l)} \rightarrow SiO_{2(s)} + 4HCl_{(aq)}$ (2) $Li_3N_{(s)} + 3H_2O_{(l)} \rightarrow NH_{3(g)} + 3LiOH_{(aq)}$

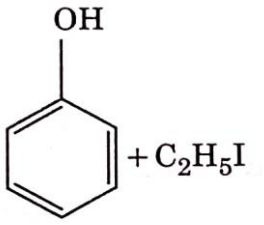
(3) $2F_{2(g)} + 2H_2O_{(l)} \rightarrow 4HF_{(aq)} + O_{2(g)}$ (4) $P_4O_{10(s)} + 6H_2O_{(l)} \rightarrow 4H_3PO_{4(aq)}$

6. Anisole on cleavage with HI gives **[NEET-2020]**

1) 

2) 

3) 

4) 

7. Match the following and identify the correct option. **[NEET-2020]**

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

1) a-i, b-iii, c-ii, d-iv
2) a-iii, b-i, c-ii, d-iv
3) a-iii, b-ii, c-i, d-iv
4) a-iii, b-iv, c-ii, d-i

8. Tritium a radioactive isotope of hydrogen, emits which of the following particles? **[NEET-2021]**

1) Alpha (α) 2) Gamma (γ) 3) Neutron (n) 4) Beta (β^-)

NCERT LINE BY LINE QUESTIONS – ANSWERS

(1.)	d	**(2.)**	b	**(3.)**	a	**(4.)**	d	**(5.)**	d
(6.)	d	**(7.)**	b	**(8.)**	c	**(9.)**	a	**(10.)**	c
(11.)	b	**(12.)**	a	**(13.)**	a	**(14.)**	c	**(15.)**	b
(16.)	c	**(17.)**	c	**(18.)**	c	**(19.)**	a	**(20.)**	a
(21.)	d	**(22.)**	b	**(23.)**	b	**(24.)**	d	**(25.)**	a
(26.)	a	**(27.)**	c	**(28.)**	d	**(29.)**	d	**(30.)**	c
(31.)	b	**(32.)**	d	**(33.)**	a	**(34.)**	c	**(35.)**	c
(36.)	a	**(37.)**	c	**(38.)**	a	**(39.)**	c	**(40.)**	d
(41.)	b	**(42.)**	d	**(43.)**	d	**(44.)**	a	**(45.)**	d
(46.)	b	**(47.)**	c	**(48.)**	a	**(49.)**	c	**(50.)**	a

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1)	3	**2)**	3	**3)**	1	**4)**	1	**5)**	3	**6)**	3	**7)**	3	**8)**	1	**9)**	3	**10)**	3
11)	3	**12)**	1	**13)**	3	**14)**	3	**15)**	4	**16)**	4	**17)**	2	**18)**	4	**19)**	2	**20)**	1
21)	3	**22)**	2	**23)**	2	**24)**	1	**25)**	1	**26)**	4	**27)**	4	**28)**	2	**29)**	4	**30)**	4
31)	2	**32)**	4	**33)**	2	**34)**	2	**35)**	4	**36)**	2	**37)**	3	**38)**	2	**39)**	1	**40)**	4
41)	3	**42)**	2	**43)**	2	**44)**	2	**45)**	1	**46)**	3	**47)**	1	**48)**	4	**49)**	4	**50)**	3

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1)	(1,4)	**2)**	3	**3)**	3	**4)**	2	**5)**	3	**6)**	2	**7)**	2	**8)**	4

NCERT LINE BY LINE QUESTIONS – SOLUTIONS

(1.) (d)

(2.) (b) Protium, an isotope of hydrogen, has 1 proton, 1 electron and 0 neutrons.

(3.) (a) Carbonates, sulphates and bicarbonates of Ca^{2+} are responsible for causing hardness in water.

$$Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$$

(4.) (d)

Sodium peroxide	Sodium sulphate	Hydrogen peroxide

(6.) (d) Of all the given hydrides, CH_4 is electron precise as it has exact number of electrons to form normal covalent bonds.

(7.) (b) The O-H bond length in H_2O is 95.7 pm.

(8.) (c) I is oxidised to I_2. So, H_2O_2 acts as an oxidising agent.

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

Oxidation

(12.) (a) Hydrogen gas contains atoms with different electrons and nuclear spin. If the nuclear spins are in the same direction, then that hydrogen molecule is known as ortho hydrogen. However, if the nuclear spins are in the opposite directions, then that hydrogen molecule is called as para hydrogen. Hydrogen present in room temperature has 75% ortho character and 25% para character.

(14.) (c) When CO of syngas is heaved with steam at 673 K, in the presence of catalyst (iron chromate), then the production of hydrogen increases.

(15.) (b) $K_2Cr_2O_7$ in H_2SO_4 gets oxidised to blue chromic acid by H_2O_2 and dissolve in ether to form blue-coloured solution.

$K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + H_2Cr_2O_7$

$H_2Cr_2O_7 + 4H_2O_2 \rightarrow 2CrO_5 + 5H_2O$

$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \rightarrow K_2SO_4 + 2CrO_5 + 5H_2O$

(Perchromic acid) $[\text{Blue}]$

(16.) (c) On treatment with water, metal hydrides give hydrogen gas.

$KH + H_2O \rightarrow KOH + H_2$

(17.) (c) The balanced reaction between H_2O_2 and acidified KI solution can be written as:

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

1 mole of I_2 is liberated from 1 mole of H_2O_2, i.e. 254 g of I_2 is liberated from 34 g of H_2O_2. So,

0.710 g of I_2 will be liberated from $\left(\frac{34 \times 0.710}{254}\right) = 0.095g$ of H_2O_2 .

Now, volume strength of H_2O_2 solution depends upon the amount of oxygen liberated from decomposition of $1.0cm^3$ of $HO_2.H_2O_2$ decomposes as:

$2H_2O_2 \rightarrow 2H_2O + O_2$

From the above reaction it is evident that 2 moles of H_2O_2 upon decomposition give 1 mole of O_2 gas at NTP.

i.e. 68 g of H_2O_2 upon decomposition gives $22400cm^3$ of O_2 gas at NTP.

0.095 g of H_2O_2 will produce $\left(\frac{22400 + 0.095}{68}\right) = 31.29cm^2$ of O_2 gas at NTP.

From the information provided in the question, $7.1cm^3$ contains 0.095 g of H_2O_2

$7.1cm^3$ of H_2O_2 will liberate $31.29cm^3$ of O_2 gas at NTP.

So $1.0cm^3 H_2O_2$ will liberate $\left(\frac{1 \times 31.29}{7.1}\right) = 4.41cm^3$ of O_2 gas at NTP.

Volume strength of provided H_2O_2 solution = 4.41.

(18.) (c) Heavy water is manufactured by repeated electrolysis of 3% aqueous solution of NaOH.

(19.) (a) Ionic or electrovalent hydrides are formed when hydrogen reacts with most s-block elements. In solid state, the ionic hydrides are crystalline, non-conducting and non-volatile. It conducts electricity in liquid state.

(20.) (a) A 30% solution of H_2O_2 is marked as X volume hydrogen peroxide. It indicates 1 millilitre of 30% H_2O_2 solution will yield 100 mL oxygen at STP.

(21.) (d) In condensed phase, water exhibits an extensive intermolecular and not intramolecular hydrogen bonding.

(23.) (b) With an increase in atomic size, the ionic character increases.

(25.) (a) The elements of group 7, 8 and 9 accept the lone valence electron of hydrogen. By doing so, they behave as Lewis base. Hydrogen donates its lone valence electron and acts as Lewis acid.

(26.) (a) The following chemical equation illustrates the reaction between BeO_2 and dilute H_2SO_4.

$BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

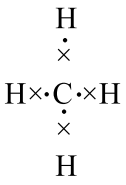
The most electronegative element in the product is oxygen. The oxidation state of oxygen in $BaSO_4$ is -2.

(27.) (c) A tremendous amount of energy is released when dihydrogen reacts with dioxygen. The following chemical reaction takes place:

$2H_2 + O_2 \rightarrow 2H_2O + 285kJ / mol$

This is an example of combustion reaction which involves release of a large amount of heat. It is thus an exorthermic reaction.

(29.) (d) Of the given hydrides, CH_4 is electron precise. This is because the carbon atom has exactly four electrons and forms normal covalent bonds with four hydrogen atoms. The structure is as follows:



(32.) (d) According to normality equation

$N_{H_2O_2} \times V_{H_2O_2} = N_{Na_2S_2O_3} \times V_{Na_2S_2O_3}$

or, $N_{H_2O_2} \times 250 = 0.5 \times 200$

or, $N_{H_2O_2} = \dfrac{0.5 \times 200}{250} = 0.4N$

Strength of $H_2O_2 = 0.4 \times 17 = 6.8g / L$

$2H_2O_2 \rightarrow 2H_2O + O_2$

2×34 22.41 =68g =22400 mL

68g of H_2O_2 produce $22400mLO_2$ at NTP 6.8g of H_2O_2 produce $\dfrac{22400 \times 6.8}{68}$

$= 2240mLO_2$ at NTP

Now, 6.8 g of H_2O_2 is present in 1000 mL of solution.

In other words, 1000 mL of H_2O_2 gives 2240 mL of O_2 at NTP

1 mL of H_2O_2 gives 2240/1000 = 22.4 mL of O_2 at NTP.

So, the volume strength of H_2O_2 is 22.4.

(34.) (c) Calgon or sodium hexametaphosphate is used for softening hard water.

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

(35.) (c) In reaction I, H_2O_2 is liberating iodine from potassium iodide solution. During the course of the reaction, I_2 is oxidised from -1 to 0 oxidation state.

In reaction II, H_2O_2 is liberating oxygen from manganese dioxide.

During the course of the reaction, Mn is reduced from $+4$ to $+2$ oxidation state.

Therefore, the correct answer is (c)

(38.) (a) Since metals such as Pt and Pd absorb large volumes of hydrogen, they are used as the storage media for hydrogen.

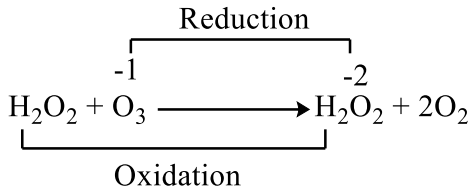
(40.) (d) When steam reacts with hydrocarbons or coke at high temperatures, in the presence of catalyst, it yields dihydrogen.

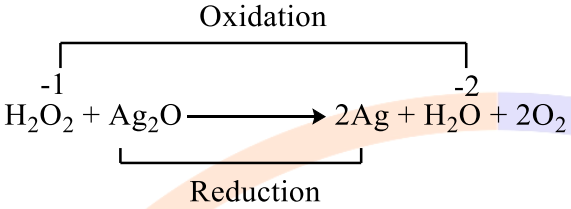
(42.) (d) Hydrogen has three isotopes.

(43.) (d) Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power.

(44.) (a) H_2O_2 gets mixed with water in all proportions. It forms a hydrate, $H_2O_2.H_2O$, having melting point 221 K.

(45.) (d)

(i) 

(ii) 

So, H_2O_2 is acting as an oxidising agent in both the reactions.

(46.) (b) Similar to halogens, hydrogen accepts an electron readily to achieve the nearest noble gas configuration.

(48.) (a) Hydrolysis is the interaction of H^+ and OH ions of H_2O with the anion and the cation of a salt to yield the original acid and the original base respectively.

$Na_2CO_3 + 2H_2O \rightarrow 2NaOH + H_2CO_3$

Salt Base Acid

Addition of H_2O to ions or molecules to form hydrated ions or hydrated salts is called hydration.

$KCl + H_2O(l) \rightarrow K^+(aq) + Cl(aq)$

Salt

$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4 \cdot 5H_2O(s)$

Colourless Blue

(49.) (c) $1mL H_2O_2$ of 30 volume liberates $30mL O_2$ at NTP.

$100mL H_2O_2$ of 30 volume liberates 30×100 mL or $31O_2$ at NTP.

(50.) (a) Hydrogen means water forming This is because hydrogen and oxygen combine with each other to form water, H_2O.

TOPIC WISE PRACTICE QUESTIONS – SOLUTIONS

1. **(3)** (i) Protium, deuterium and tritium are isotopes of hydrogen.
(ii) Ortho and para hydrogens are allotropes of hydrogen. In ortho hydrogen, protons are spinning in same direction (parallel spin), while in para hydrogen, protons spin in opposite direction (antiparallel).

2. **(3)** $H(g) \longrightarrow H^+(g) + e^-$

3. **(1)** Number of neutrons in protium, deuterium and tritium respectively is = 0, 1 and 2

4. **(1)** $Mg + \text{dil. } HNO_3 \rightarrow Mg(NO_3)_2 + H_2$ (Mg and Mn give H_2 with dil HNO_3)

5. **(3)** Hydrogen behaves as a metal at very high pressure.

6. **(3)** The para form of H_2 has lesser energy than the ortho form.

7. **(3)**

8. **(1)** $H + e^- (1s^1) \rightarrow H^- (1s^2 \text{ or } [He])$
$F + e^- ([He]2s^2 2p^5) \rightarrow F^- ([He]\ 2s^2\ 2p^6 \text{ or } [Ne])$

9. **(3)** Hydrogen bond is weak force of attraction existing between molecules. Its energy is equal to 3-10 kcal.

10. **(3)** Among the given ions, only Cu^{2+} lies below H^+ in electrochemical series.

11. **(3)** Fire due to action of water on saline hydrides cannot be extinguished with water or CO_2. These hydrides can reduce CO_2 at high temperature to produce O_2.

12. **(1)** $Cu + 4HNO_3(conc.) \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
$C_2H_5OH + Na \longrightarrow C_2H_5O^- Na^+ + 1/2 H_2 \uparrow$
$Mg + 2H_2O(steam) \longrightarrow Mg(OH)_2 + H_2 \uparrow$
$C_6H_5OH + Na \longrightarrow C_6H_5O^- Na^+ + 1/2 H_2 \uparrow$
$NaH + H_2O \longrightarrow NaOH + H_2 \uparrow$

13. **(3)**

14. **(3)** Hg will not displace hydrogen since it is present below hydrogen in ECS.

15. **(4)** All metal hydrides are ionic in nature.

16. **(4)** Many salts can be crystallised as hydrated salts from an aqueous solutions. Such 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., $[Cu(H_2O)_4]^{4+} SO_4^{2-} . H_2O$ in $CuSO_4.5H_2O$

17. **(2)**

18. **(4)** The hybridisation in water is *sp*3 and bond angle 104.5º

19. **(2)**

20. **(1)** Polarity of bond depends on difference in electronegativity of the two concerned atoms. H_2O is more polar than H_2S because oxygen (in O–H) is more electronegative than sulphur (in S–H).

21. **(3)** The high boiling point of water is due to H-bonding.

22. **(2)**

23. **(2)** Temporary hardness is due to presence of bicarbonates of calcium and magnesium and permanent hardness is due to the sulphates and chlorides of both of calcium and magnesium.

24. **(1)**

25. **(1)**

26. **(4)**

27. **(4)** H_2O absorbs neutrons more than D_2O and this decreases the number of neutrons for the fission process.

28. **(2)**

29. **(4)**

30. **(4)**

31. **(2)**

32. **(4)**

33. **(2)** When water is heated from 0 °C to 4 °C , its density. increases and volume decreases. $\left(d = \frac{m}{V}\right)$

34. **(2)** $H_2O_2 + [O] \xrightarrow{\text{Oxidation}} H_2O + O_2 \uparrow$

35. **(4)** Decomposition of H_2O_2 can be accelerated by finely divided metals such as Ag, Au, Pt, Co, Fe etc.

36. **(2)** Structure of H_2O_2 is nonplanar

37. **(3)** H_2S is oxidised to S by H_2O_2.

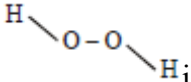
38. **(2)** $HOCl(aq) + H2O2\ (aq) \longrightarrow H_3O^+(aq)\ Cl^-(aq) + O_2\ (g)$

39. **(1)** Glycerol, phosphoric acid or acetanilide is added to H_2O_2 to check its decomposition.

40. **(4)** Although H_2O_2 is a better polar solvent than H_2O.
However it cannot be used as such because of the strong auto-oxidation ability.

41. **(3)** H_2O_2 is unstable liquid and decomposes into water and oxygen either on standing or on heating.

42. **(2)** $2HSO_4^-(aq) \xrightarrow{\text{electrolysis}} HO_3SOOSO_3H(aq)$
$\xrightarrow{\text{Hydrolysis}} 2HSO_4^-(aq) + 2H^+(aq) + H_2O_2(aq)$

43. **(2)**  is the true structure of H_2O_2.

44. **(2)** D_2O is used in nuclear reactors as moderator.

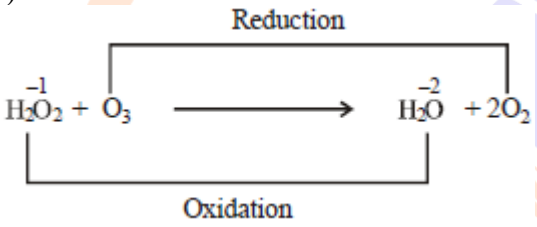
45. **(1)**

46. **(3)**
47. **(1)**
48. **(4)**
49. **(4)**
50. **(3)** No such reaction is known (3).

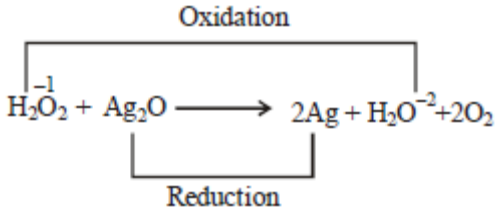
NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. **(a and d)**
Among the three isotopes of hydrogen, Protium ($_1H^1$) is most common. It is an energetic reducing agent. It reduces oxides, chlorides and sulphides of certain metals and produce free metals at ordinary temperature. $CuO + 2H \rightarrow Cu + H_2O$

2. **(3)**
(i)



(ii)



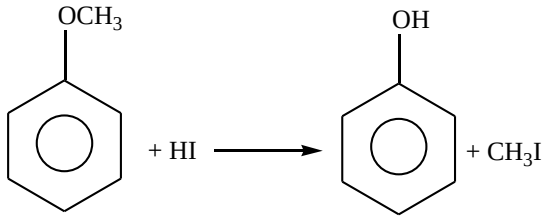
Hence in both the reactions H_2O_2 is acting as an reducing agent.

3. **$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$**
2 mole $NH_3(g)$ requires 3mole $H_2(g)$
20 mole $NH_3(g)$ requires $= \frac{3}{2} \times 20\,\text{mole}H_2(g)$
= 30 mole

4. Clark's method used to remove temporary hardness of water
$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$

5. $2F_{2(g)} + 2H_2O_{(l)} \rightarrow 4HF_{(aq)} + O_{2(g)}$
It's a type of Redox reaction.

6.



Bond between aromatic carbon and oxygen has partial double bond character and hence can not be broken.

7. $CO + H_2 \rightarrow$ gas
Temporary hard news $\rightarrow Mg(HCO_3)_2 + Ca(HCO_3)_2$

$B_2H_6 \rightarrow$ Electron deficient molecule

$H_2O_2 \rightarrow$ Non planer molecule

8. Tritium is radio active and emits low energy β^- particles.