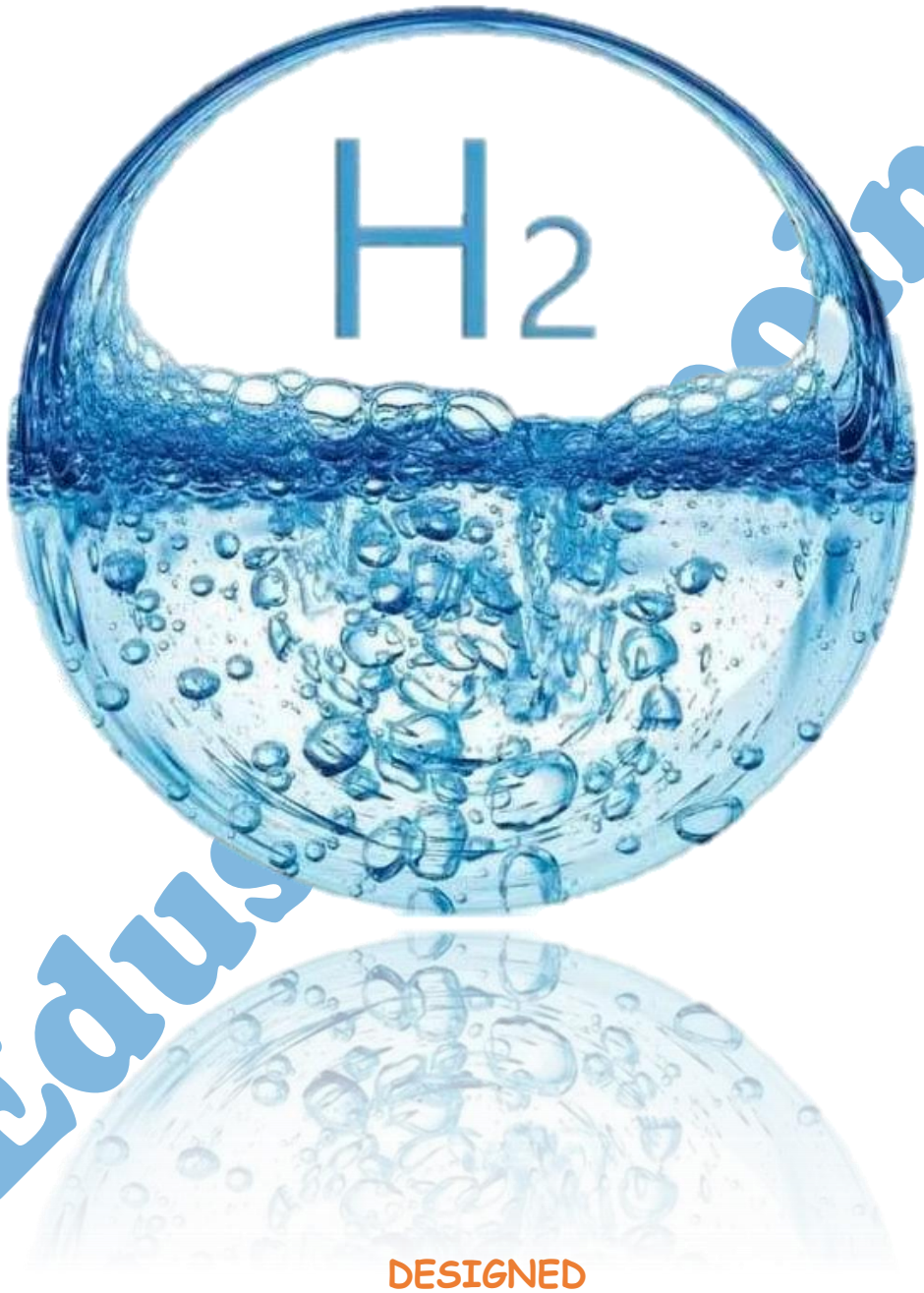
Hydrogen



DESIGNED

By

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Hydrogen: On the earth Hydrogen exists as H_2 molecule (dihydrogen). The symble of hydrogen is 'H'. It's Atomic No. is '1'. It exists in 3 isotopes as-

H_1^1	H_1^2	H_1^3
Protium	Deuterium	Tritium

Dihydrogen: It is the most abundant element in the universe (70% of the total mass of universe).

- **H_2 Preparation (in laboratory)**

  It is formed in labs by reacting granulated Zinc with dilute hydrochloric acid .

  $Zn + HCl \rightarrow ZnCl_2 + H_2$

  Other Methods that can be used :-

  $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

- **Commercialy preparation :-**

  1. **By Electrolysis of water** using platinum electrodes.

     $2H_2O \rightarrow 2H_2 + O_2$

  2. The Steam and coal can be used to produce H_2 as shown below :

     $C + H_2O \rightarrow CO + H_2$

     $CO + H_2O \rightarrow CO_2 + H_2$

Physical properties of H_2: It is colourless, Odourless, Tasteless. Its vapor density = 1 (lighter than air). It is non – poisonous and It's solubility in H_2O is very low.

Chemical Properties –

- **Reaction with metal**: At high tempurature, it react with highly reactive metals like : Potassium ,Sodium.

  $H_2 + 2K \rightarrow 2KH$

- **Burning in presence of O_2** – It reacts with oxygen to form water and the reaction is exothermic.

  $2H_2 + O_2 \rightarrow H_2O$

- **Reaction with halogens** : it react with halogens to form respectives halides as shown below :

  $H_2 + Cl_2 \rightarrow 2HCl$

- **Reaction with N-metal** : It reacts with many non metals to form hydrides. Like with sulphur it forms sulphides ,with Oxygen it forms oxides ,with Flourine it forms flourides etc.

  $H_2 + S \rightarrow H_2S$

$2H_2 + O_2 \rightarrow H_2O$

$H_2 + F_2 \rightarrow HF$

$N_2 + 3H_2 \rightarrow 2NH_3$

Uses of H_2 –

- It is used as rocket fuel because of its high calorific value.
- OxyHydrogenflame is used for welding.
- It helps in synthesis of NH_3, HNO_3, HCl etc.
- It helps in the synthesis of vanspati ghee.
- It is a reducing agent .

Hydrides: The dihydrogen combines with number of elements to form Hydrides . The general formula for hydrides are given below where E is any element.

EH_X or E_MH_N

Example : MgH_2 , B_2H_6

There are 3 type of Hydrides (based on behaviour and type of bond):

i. Ionic - Salt Like Hydrides
ii. Covalent - Molecular Hydrides
iii. Metallic - Non-Stochiometric Hydrides

1) **Ionic Hydrides**: They are formed when metals with high reactivity react with Hydrogen. It basically includes group 1 and group 2 .They are actually binary compounds.

Out of all ,Lithium,Beryllium and Magnessium hydrides have high covalent character.

Characterstics of Ionic hydrides:

- They have crystalline structure with high melting point and boiling point.
- Their density is higher than that of metals.
- In molten state, they conduct electricity and liberate H_2 gas .

Reactivity of hydrides: They have moderate reactivity ,but out of all LiH is unreactive at moderate temperature However, these hydrides react at high temperatures .It undergo reactions such as shown below :

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

$2LiH + B_2H_6 \rightarrow 2LiBH_4$

2) **Covalent or molecular hydrides**: They are mainly formed by p block elements and some s block elements ,which have less electronegativity difference than hydrogen.

Characterstics:

- They are binary compounds .
- They have covalent bond : Example – CH_4(methane) , NH_3(ammonia) , H_2O(water)
- They are of three types :

1. **Electron deficient** : They have less electrons than its octet .

   Example : BH_3 (Boron hydride-only 6electrons present).Therefore, exist as B_2H_6 (dimer).They act as Lewis acids .

2. **Electron precise** :They have have sufficient electrons .

   Example : CH_4(Methane) , SiH_4 (Silicon hydride -have 8 electrons)

3. **Electron rich** : They have extra electrons that is more than the octet.

   Example : Hydrides of group 15,16,17 act as Lewis bases .

3) <u>Metallic hydrides</u>: In this, Hydrogen combines with with d & f elements .Out of all group 6,7,8,9 does not form hydrides, but group 3,4,5,10,11,12 can form hydrides.

the inability of these groups to form hydrides is called Hydride gap.

Characterstics :

1. They are deficient in Hydrogen
2. These are also called non-stochiometric hydrides.
3. Hydrogen occupy interstitial spaces between these atoms.

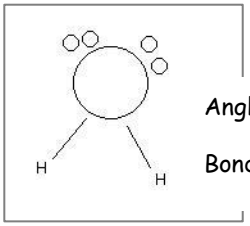
   Ni , Pt , Pd , Ce , Ac , have these structure.
4. The catalytic reduction & Hydrogenation involves trapping of H_2 between these atoms and this factor is responsible for catalytic action.
5. They are good conductor of electricity.
6. They are harder than parent metal.

Water: It covers 71% of earth surface but its distribution is not uniform.

That is:- 97.33% Oceans, 2% Polar ice caps and 1% remaining H_2O

<u>Physical properties</u>

1. It is tasteless and odourless liquid.
2. It freezes to ice at 273K.
3. Its boiling point is 373K.
4. Its density is 1g / cc.
5. It has high thermal conductivity , dipole moment , dilectric constant and high specific heat value.



Angle is 104.5^0

Bond Length = 97.7 pm

6. It is an excellent solvent.
7. Water is polar covalent molecule .
8. Its crystalline form is Ice.

Chemical properties

- Reaction with metal : It reacts with metal to form hydroxides and hydrogen gas is released.

$$Na + H_2O \rightarrow NaOH + H_2$$

- Water is amphoteric in nature ,so reacts with acid as well as with base as shown below :

$$H_2O + HCl \rightarrow H_3O^+ + Cl^- \quad (H_2O \text{ as base})$$

$$H_2O + NH_3 \rightarrow OH^- + NH_4^+ \quad (H_2O \text{ as acid})$$

- Autopyrolysis :it can undergo self decomposition that is :

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

- Role in photosynthesis :It helps plants in preparing food .

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2 \text{ (In the presence of Sunlight)}$$

- **Hydrolysis:** Water dissolves many Ionic compounds and also help in dissociating the compounds .

$$SO_2 + H_2O \rightarrow H_2SO4$$

$$P_4O_{10} + H_2O \rightarrow H_3PO_4$$

$$SiCl_4 + H_2O \rightarrow SiO_2 + HCl$$

- The salts in which H_2O react with salts are called as "**Hydrated salt** "

Hydrated salts are of three types :

- Water combined by coordinate bond
- Water occupying interstitial spaces
- Water bonded by H bond

Types of water: We have two types of water:

- Hard : Forms No lather with soap . Example : River water ,sea water etc .
- Soft : Forms lather with soap. Example : Rain water

Hardness of water : It is due to the presence of Calcium and Magnessium (Ca^{2+} and Mg^{2+})salts in water . The water with these salts is called as hard water.

There are two types of hardness :

- Temporary: It is due to soluble $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ (calcium and magnessium bicarbonates) .

- Permanent: It is due to soluble Mg and Ca chlorides and sulphides .

Methods to remove hardness:

Temporary hardness : It can be removed by following methods :

- **Boiling**

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

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

- **Clark's method**:

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

Permanent hardness : It is removed by following methods :

- With washing soda
- Calgon's process
- Ion exchange method
- Synthetic resin method

1) **With washing soda** : In this washing soda is added .It reacts with calcium and magnessium chlorides and sulphates to form soluble carbonates as shown :

$$MCl_2 + Na_2Co_3 \rightarrow NaCl + MCo_3$$

$$MSO_4 + NaCo_3 \rightarrow Na_2SO_4 + MCo_3$$

2) **2.Calgon process**: In this procss calcium and magnessium ions are rendered ineffective by treatment with sodium polymetaphosphate . $CaCl_2 + Na_2[Na_4(Po_3)_6] \longrightarrow Na_2[Ca_2(Po_3)_6] + NaCl$

3) **Ion – exchange method**: In this a substance called zeolite or permutit is added. This zeolite exchange Sodium with Calcium and Magnessium ions of hard water .

$$Mg^{2+} + Na\ Z \text{ --------} Mg\ Z_2 + 2Na^+$$
$$Ca^{2+} + Na\ Z \text{ --------} Ca\ Z_2 + 2Na^+$$

4) **3.Synthetic Resin Method**: Synthetic resin methods are more superior then the ion exchange method as they remove all types of cations and anions and the resultant water is distilled water .

These resins are generally of two types: Cation exchange resin and Anion exchange resin

Hydrogen peroxide: Its formula is H_2O_2 and is important chemical used in population control treatment of domestic and industrial effulents .

Preparation :

1. **From barium peroxide** :This is laboratory preparation.

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

2. **By electrolysis of 50% sulphuric acid:** In this high current is passed through a cell containg 50% Sulphuric acid.

   The Platinum electrode act as anode and graphite act as cathode .Then the following reactions occur :

$$H_2SO_4 + H_2O \longrightarrow H_2SO_4 + H_2O_2$$

Physical properties :

1. It is pure state.
2. It is colourless liquid.
3. It is miscible with water in all proportions and forms a hydrate $H_2O_2.H_2O$

Chemical properties of hydrogen perioxide: It act as oxididing as well as reducing agent in both acidic and alkaline media .

1. Oxidising action in acidic media:

$$2Fe^{2+}(aq) + 2H^+(aq) + H_2O_2(aq) \longrightarrow 2Fe^{3+}(aq) + 2H_2O(l)$$

$$PbS(s) + 4H_2O_2(aq) \longrightarrow PbSO_4(s) + 4H_2O$$

2. Reducing action in acidic medium:

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

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

3. Oxidising action in basic medium:

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

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

4. Reducing action in basic medium

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

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

Storage of hydrogen peroxide : When it is exposed to light it undergoes decomposition and forms :

$$2H_2O \dashrightarrow 2H_2O + O_2$$

- to prevent decomposition it is stored in dark within wax lined glass or plastic vessel.

Uses of hydrogen perioxide

1. It is used as bleaching hair.

2. It is used in pollution control treatments.
3. It is used as bleaching agent in industries making paper pulp etc

Heavy water: Its formula is D_2O . In this the isotope of hydrogen deutrium is being used .

Preparation : It is prepared by prolonged electrolysis of water.

Physical properties

- It is colorless,odourless,tasteless liquid that is heavier than water.

Chemical properties :

1. On electrolysis:
   $D_2O \longrightarrow D_2 + O_2$
2. Reaction with alkali metal :
   $Na + D_2O \longrightarrow NaOD + H_2$
3. Reaction with metallic oxides
   $Na_2O + D_2O \longrightarrow NaOD + H_2O$
4. Reaction with nonmetallic oxides
   $P_2O_5 + D_2O \longrightarrow D_3PO_4$
5. it helps in the formation of deutrates i.e
   $CaC_2 + D_2O \longrightarrow C_2D_2 + Ca(OD)_2$

KHATAM