

CHEMISTRY

CLASS NOTES FOR CBSE

Chapter 09. Hydrogen and Its Compounds

01. Introduction

Hydrogen has electronic configuration $1s^1$. On one hand, its electronic configuration is similar to the outer electronic configuration (ns^1) of alkali metals, which belong to the first group of the periodic table. On the other hand, like halogens (with ns^2np^5 configuration belonging to the seventeenth group of the periodic table), It is short by one electron to the corresponding noble gas configuration, helium ($1s^2$). Hydrogen, therefore, has resemblance to alkali metals, which lose one electron to form unipositive ions, as well as with halogens, which gain one electron to form uninegative ion.

Atomic process of isotopes of hydrogen.

S.No.	Property	H	D	T
(i)	Relative atomic mass	1.007825	2.014102	3.016049
(ii)	Nuclear spin quantum number	1/2	1	1/2
(iii)	Radioactive stability	Stable	Stable	Unstable

02. Methods of Preparation of Hydrogen (H_2)

(i) **By action of water with metals.**

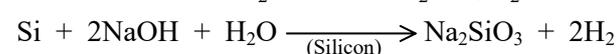
(a) Active metals like Na, K react at room temperature.



(b) Less active metals like Ca, Zn, Mg, Al liberate hydrogen only on heating.



(ii) **By reaction of metals like Zn, Sn, Al with alkalies.**



(iii) **By action of metals with acids.** All active metals which lie above hydrogen in electrochemical series, can displace hydrogen gas from dilute mineral acids.

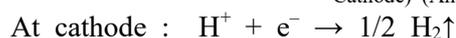
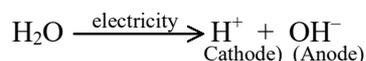


It must be noted that

(a) Pure zinc is not used for preparation.

(b) Conc. H_2SO_4 is not used as it oxidizes the liberated H_2 and produce SO_2

(iv) **By electrolysis of water**



MISOSTUDY.COM

The Best Online Coaching for IIT-JEE | NEET Medical | CBSE INQUIRY +91 8929 803 804

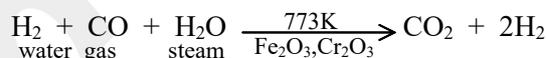
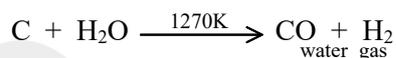
- (v) Preparation of pure hydrogen. It can be obtained by
- The action of pure dil. $\text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$
 - The electrolysis of a solution of barium hydroxide using nickel electrodes.
 - By the action of water on NaH.

$$\text{NaH} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{H}_2$$
 - Very pure form of hydrogen is obtained by the action of KOH on scrap aluminium.

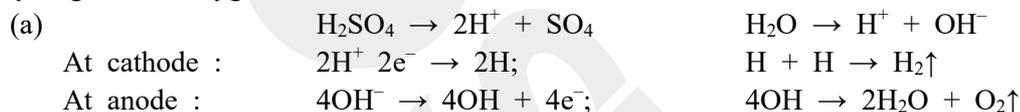
$$2\text{Al} + 2\text{KOH} + 2\text{H}_2\text{O} \rightarrow 2\text{KAlO}_2 + 3\text{H}_2\uparrow$$

(vi) Industrial preparation

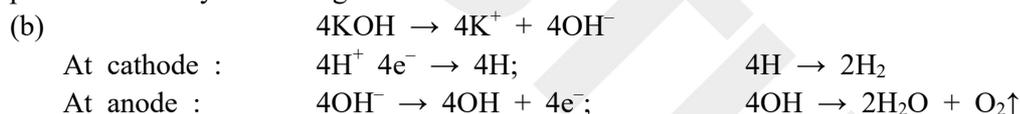
- Bosch process – In this method water gas is mixed with steam and passed over heated catalytic mixture of Fe_2O_3 and Cr_2O_3 at 773 K when CO_2 and H_2 are obtained. The mixture is compressed to 25 atmospheric pressure and passed into water, CO_2 , dissolves while H_2 is set free.



- By the electrolysis of water containing a small amount (15 – 20%) of an acid or alkali. Hydrogen is liberated at the cathode (usually iron) while oxygen (a by product) is liberated at anode (usually nickel plated iron rod.) The anode and cathode are separated by an asbestos diaphragm which serves to prevent mixing of hydrogen and oxygen evolved.



It is important to note that sulphate ions are not discharged as their discharge potential is very much higher than that of OH^- ions.



Note that K^+ ions are not discharged at cathode because their discharge potential is high than that of H^+ ions.

03. Chemical properties :

- Reactions of hydrogen are slow at room temperature but rapid at high temperatures. It is neutral towards litmus. It is combustible and burns in air or oxygen with nearly invisible pale blue flame.

$$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$$
- Reducing property. When hydrogen is passed over heated metal oxides, the latter are reduced to the respective metal.

$$\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}$$
- Reaction with metals and non-metals. It combines with strongly electropositive metals (active metals) like Li, Na and Ca to form corresponding hydrides.

$$2\text{Na} + \text{H}_2 \rightarrow 2\text{NaH}$$

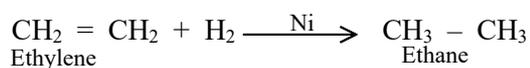
It combines with N, C, O, halogens, S, etc. under suitable conditions to form NH_3 , CH_4 , H_2O , HX and H_2S respectively.



MISOSTUDY.COM

The Best Online Coaching for IIT-JEE | NEET Medical | CBSE INQUIRY +91 8929 803 804

- (iv) Reaction with unsaturated compounds. Hydrogen adds on the double or triple bond in the presence of finely divided Ni to form saturated compounds.



04. Hydrides

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

These are stoichiometric compounds of dihydrogen formed with most of the s-block elements which are highly electropositive in character e.g. LiH, BeH₂ and MgH₂.

Covalent or Molecular Hydride

Dihydrogen forms molecular compounds with most of the *p*-block elements. Most familiar examples are CH₄, NH₃, H₂O and HF.

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, and
- (iii) electron-rich hydrides.

An electron-deficient hydride, as the name suggest has too few electrons for writing its conventional Lewis structure. Diborane (B₂H₆) is an example.

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., CH₄) which are tetrahedral in geometry.

Electron-rich hydrides have excess electrons which are present as lone pairs. Elements of group 15-17 form such compounds. (NH₃ has 1- lone pair, H₂O – 2 and HF-3 lone pairs)

Metallic or Non-stoichiometric or Interstitial (or Interstitial) Hydrides

These are formed by many *d*-block and *f*-block elements. However. The metals of group 7, 8 and 9 do not form hydride.

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.

05. Water

Water is known as universal solvent because

- (i) It can dissolve maximum number of compounds
- (ii) It has high liquid range
- (iii) It has high dielectric constant (82)



MISOSTUDY.COM
The Best Online Coaching for IIT-JEE | NEET Medical | CBSE INQUIRY +91 8929 803 804