

# The two electrons in a hydrogen molecule always ?

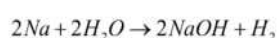
## Hydrogen and its Compounds

### GENERAL INTRODUCTION

Symbol of hydrogen is H. Electronic Configuration  $1s^1$ . Hydrogen is the lightest and most abundant element in the universe. It was first prepared by Sir Henry Cavendish by the action of sulphuric acid on Zinc and named by Antoine Lavoisier since it produced water on burning. (Greek : hydra= water, gennas = maker or producing)

### PREPARATION OF DI HYDROGEN

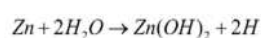
1. **From cold water :** By the action of Na, K, Ca etc.



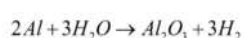
• (highly exothermic and  $H_2$  catches fire)

• Al-Hg and Zn-Cu couple decompose water to give nascent hydrogen Hence Couples constitute better reducing agents

2. **From hot water:** By the action of Mg, Zn, Al etc.



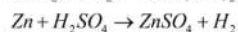
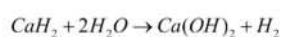
3. **From steam :** By the action of Fe, Sn etc.



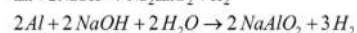
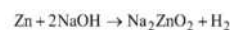
4. **From water:** By the action of metallic hydrides of alkali and alkaline earth metals.



5. **From acids:** By the action of dilute acids on Zn, Mg, Fe, etc. placed above hydrogen in electrochemical series.

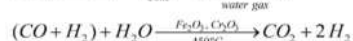


6. **From alkalis :** By the action Zn, Al, Sn etc.



### MANUFACTURE OF HYDROGEN

1. **From water gas (Bosch process) :** By passing water gas mixed with steam over heated catalyst  $Fe_3O_4$  and  $Cr_2O_3$  at  $450^\circ C$ .

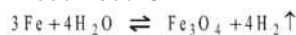


• The  $CO_2$  is removed by dissolving in water under high pressure.

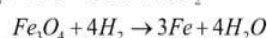
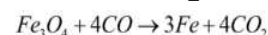
2. **By Lane's process:** The superheated steam is passed



over heated iron at  $600 - 800^\circ C$

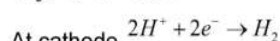
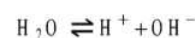


• Iron is regenerated by passing water gas. ( $H_2 + CO$ )



• In actual practice steam is passed over hot iron for 10 - 15 minutes and then water gas is blown over heated oxide for 25 - 30 minutes.

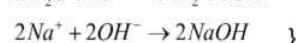
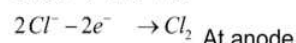
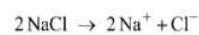
3. **By electrolysis of water :** By the electrolysis of acidified or alkaline water.



At anode

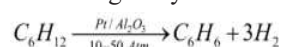


4. **As by product:** When NaOH is manufactured by electrolysis of NaCl in Nelson or Castner Kellner cell hydrogen is obtained as by product.



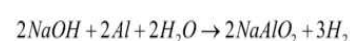
Cathode

5. **From hydrocarbons:** By cracking of hydrocarbons

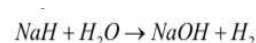


### PURE HYDROGEN METHOD OF PREPARATION

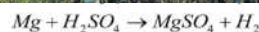
1. By Uyeno's method : By the action of Caustic Soda on aluminium.



2. By the action of NaH on water



3. By treating pure Mg or Al with chemically pure  $H_2SO_4$  (dil) or HCl



### PHYSICAL PROPERTIES

Hydrogen is tasteless, odourless, colourless gas. It is non poisonous but presence of  $AsH_3$  makes it poisonous. Its critical temperature is  $-234.5^\circ C$  which makes its liquefaction difficult. It is slightly soluble in water.

### ISOTOPES OF HYDROGEN

Hydrogen has three isotopes Name  ${}_1H^1$   ${}_1H^2$  or D  ${}_1H^3$  or T Protium Deuterium Tritium Abundance 99.985% 0.016% Traces ( $10^{-15}$  %)

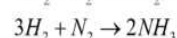
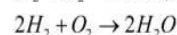
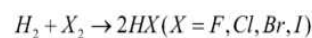
**Deuterium** is known as heavy hydrogen.

**Tritium** is formed in upper atmosphere and is  $\beta$ -radioactive.

### CHEMICAL PROPERTIES

Its chemical properties are

#### 1. Reaction with non metals :

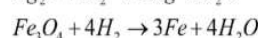
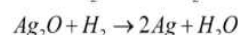
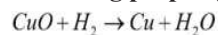


#### 2. Reaction with metals :

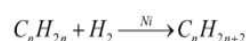


• Metals like Fe, Ni and Pd form interstitial or metallic hydrides.

#### 3. Reducing property :

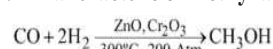


#### 4. Hydrogenation :

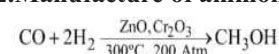


### APPLICATIONS OF HYDROGEN

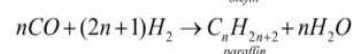
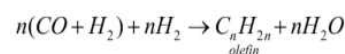
#### 1. Manufacture of methyl alcohol :



#### 2. Manufacture of ammonia :



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3. **Synthetic petrol :** Fisher-Tropsch process

4. **Manufacture of vegetable ghee:** By hydrogenation of oils in presence of Ni.

5. **To produce low-temperature fluid:** It is used as Cryogenic fluid.

6. **Oxy-hydrogen flame :** It produces temperature of  $2850^\circ C$  and oxy-atomic hydrogen flame produces a temperature of  $4000^\circ C$ .

7. Mixed with Helium - It is used for filling balloons.

### FORMS OF HYDROGEN

#### 1. Atomic Hydrogen :

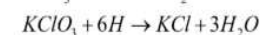
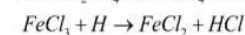
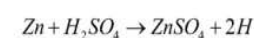


It is very reactive and its half life period is 0.33 seconds.

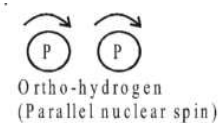
2. **Occluded Hydrogen :** Hydrogen adsorbed by certain metals eg. Pt, Pd, Fe, Ni etc is known as occluded hydrogen. One volume of finely divided metals adsorb the following volumes of hydrogen.

• Palladium black 870, Platinum 49.5, Gold 46.3, Iron 15.7, Copper 4.5, Aluminium 2.7.

3. **Nascent hydrogen:** Freshly prepared hydrogen is known as nascent hydrogen and is more reactive than ordinary hydrogen. It causes the reduction of certain compounds which is not possible with ordinary hydrogen.



4. **Ortho and Para hydrogen:** The nucleus of the hydrogen atom also spins like a top. When in hydrogen molecule, the nuclear spins are in the same direction it is known as ortho hydrogen and when the nuclear spins are in the opposite direction it is known as para hydrogen. The two electrons in a hydrogen molecule always spin in opposite direction. At room temperature hydrogen consists of 75% ortho and 25% para. At low temperature more para is present.



$$\text{Nuclear spin} = \frac{1}{2} + \frac{1}{2} = 1 \quad (\text{For ortho-hydrogen})$$

$$\text{Nuclear spin} = \frac{1}{2} + \left(-\frac{1}{2}\right) = 0 \quad (\text{For para-hydrogen})$$

5. **Transportation of hydrogen :** It is transported in the form of Hydrolith ( $CaH_2$ ) or ammonia ( $NH_3$ ). Ammonia is cracked by passing over heated catalysts yielding a mixture of hydrogen (75%) and  $N_2$  (25%).

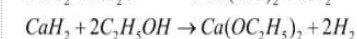
### HYDRIDES

• Binary compounds of hydrogen and other elements are called hydrides. Hydrides are classified into the following four classes.

- Saline or ionic hydrides.
- Molecular or covalent hydrides.
- Metallic or interstitial hydrides.
- Polymeric hydrides.

1. **Saline or ionic hydrides :** These are formed by elements of group 1, 2 (Except Be and Mg) and lanthanides by heating the metal in hydrogen.

- These are white colourless solids (crystalline) having high mpt. and bpt. easily decomposed by water, alcohol,  $CO_2$  or  $SO_2$ .



- They are strong reducing agents. Alkali metal hydrides are used for making  $LiAlH_4$ ,  $NaBH_4$  etc and for removing last traces of water from organic compound.

2. **Molecular or covalent hydrides :** These are formed by 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>, 7<sup>th</sup> group elements and boron by sharing electrons with hydrogen atoms. eg.:  $NH_3$ ,  $HCl$ ,  $B_2H_6$ ,  $AsH_3$ . These are non electrolytes and are usually gases or liquids.

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