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CLASS 11 & 12th



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CLASS 11th

Hydrogen and Its Compounds

misostudy



01. Introduction

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

Hydrogen forms more compounds than even carbon. Use of alkali metals and water to produce H_2 is very dangerous. These reactions are highly exothermic and as such H_2 produced can easily catch fire. To prevent such mishaps, amalgams of alkali metals are used for the preparation of H_2 . It reduces the activity of alkali metals. It also increases the density of the alkali metals as such, these amalgams no longer float over water like pure alkali metals. Thus, the heat liberated is easily absorbed by water, thereby preventing the alkali metal and H_2 from catching fire. Para-hydrogen has lesser molecular energy than *ortho*-hydrogen. Therefore, at lower temperatures *para*-hydrogen is more stable than *ortho*-hydrogen. However at room temperature *ortho*-hydrogen predominates due to its higher molecular energy. Do not use dilute nitric acid for producing hydrogen. Active metals like Zn, Al, Mg, Fe do not produce hydrogen with dilute HNO_3 . It is because dilute HNO_3 is an oxidizing agent and it oxidizes the hydrogen produced to water. Hydrogen is the lightest element known. Metals like Pd, Pt, Au etc. have the property of absorbing large quantity of hydrogen at normal or higher temperature. e.g., colloidal Pd can absorb 2950 times its own volume of hydrogen and Pd metal can absorb 900 times its own volume of hydrogen. Part of this absorbed hydrogen exist as an interstitial hydride and part is physically occluded. This phenomenon is known as occlusion of hydrogen. The occlusion property of these metals is in the order.

Colloidal Palladium > Palladium < Platinum > Gold > Nickel

Properties of natural hydrogen resembles with protium because it is present in largest quantity. The existence of heavy hydrogen (deuterium) was first of all proposed by Urey.

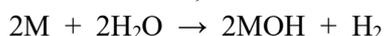
Nascent and Atomic hydrogen :

Nascent hydrogen is the hydrogen at the moment of its generation in a chemical reaction. It consist of atoms of hydrogen and hence has more energy and so it is more reactive and is a stronger reducing agent than ordinary hydrogen. Atomic hydrogen. At high temperature (about $3000^\circ C$) and low pressure molecules of dihydrogen dissociate to form atoms of hydrogen known as atomic hydrogen. Nascent hydrogen can be produced even at room temperature but atomic hydrogen is produced at elevated temperatures. Nascent hydrogen can never be isolated but atomic hydrogen can be isolated. Reducing power of atomic hydrogen is much greater than that of nascent hydrogen.

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.

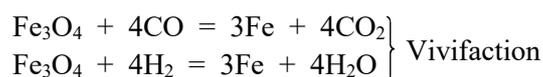


(ii) **Lane's Process :**

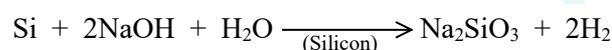
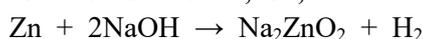
In this process, steam is passed over hot iron. Iron decomposes steam with the formation of magnetic oxide (Fe_3O_4) and hydrogen. The temperature of iron is maintained between 550 to 800°C. This reaction is termed *gassing reaction* and time allotted for this reaction is about 10 minutes.



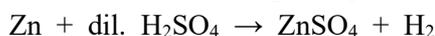
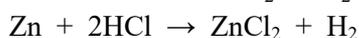
Iron is generated by reducing magnetic oxide with water gas ($\text{CO} + \text{H}_2$). This reaction is called vivification and time allotted for this reaction is about 20 minutes.



(iii) **By reaction of metals like Zn, Sn, Al with alkalis.**



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

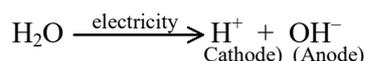


It must be noted that

(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

(v) **By electrolysis of water**

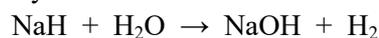


(vi) Preparation of pure hydrogen. It can be obtained by

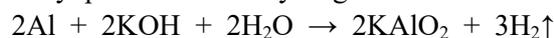
(a) The action of pure dil. $\text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$

(b) The electrolysis of a solution of barium hydroxide using nickel electrodes.

(c) By the action of water on NaH.

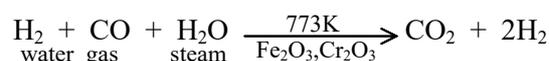
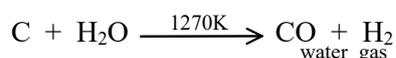


(d) Very pure form of hydrogen is obtained by the action of KOH on scrap aluminium.

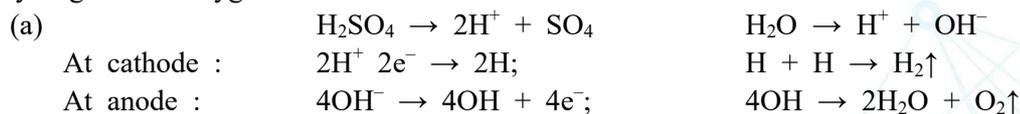


(vii) Industrial preparation

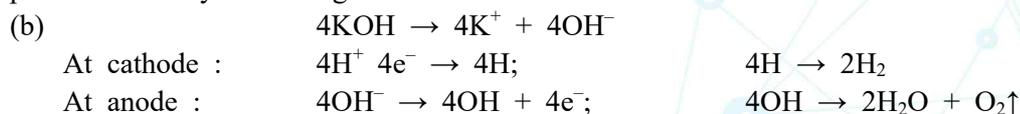
- Bosch process – In this method water gas is mixed with steam and passed over heated catalytic mixture of Fe_2O_3 and Cr_2O_3 at 773 K when CO_2 and H_2 are obtained. The mixture is compressed to 25 atmospheric pressure and passed into water, CO_2 , dissolves while H_2 is set free.



- 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.



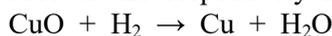
Note that K^+ ions are not discharged at cathode because their discharge potential is high than that of H^+ ions.

03. Chemical properties :

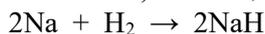
- (i) Reactions of hydrogen are slow at room temperature but rapid at high temperatures. It is neutral towards litmus. It is combustible and burns in air or oxygen with nearly invisible pale blue flame.



- (ii) Reducing property. When hydrogen is passed over heated metal oxides, the latter are reduced to the respective metal.

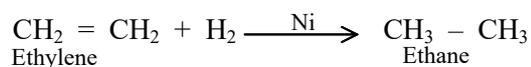


- (iii) Reaction with metals and non-metals. It combines with strongly electropositive metals (active metals) like Li, Na and Ca to form corresponding hydrides.



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.

- (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 thermal stability decreases with increasing size of cations. Thus

- (i) **Interstitial hydrides or Metallic hydrides** : The hydrogen atoms occupy the interstitial spaces of transition elements and hence they are interstitial hydrides. They are nonstoichiometric in nature. CaH_2 is called hydrolith. Since hydrogen is inflammable, a mixture of 85% He and 15% H_2 is used in the filling of air ships and balloons. Hydrogen acts as both as oxidizing and reducing agent since it can form both cations H^+ (by loss of electron) and anion H^- (by gain of electron). In ordinary hydrogen, the ratio of protium to deuterium is 6400 : 1. Rain water is the purest form of natural water.