

## HYDROGEN

<b>Isotopes</b> ${}^1_1\text{H}$ , ${}^2_1\text{D}$ , and ${}^3_1\text{T}$	<b>1<sup>st</sup> Ionization energy</b> 1312 kJ/mol
<b>Earth's crust abundance</b> 0.15%	<b>Common oxidation num.</b> -1, +1
<b>Electron configuration</b> $1s^1$	<b>Physical state</b> gas
<b>Melting point</b> $-259.1\text{ }^\circ\text{C}$	<b>Discovery date</b> 1766
<b>Boiling point</b> $-252.9\text{ }^\circ\text{C}$	<b>Discoverer</b> Henry Cavendish
<b>Density</b> 0.0899 g/L	<b>Place Discovered</b> London

### Introduction

- Hydrogen has three natural isotopes,  ${}^1\text{H}$ ,  ${}^2\text{D}$ , and  ${}^3\text{T}$ .
- Deuterium forms  $\text{D}_2\text{O}$ , heavy water.
- Tritium is radioactive, exist in trace amounts.
- Hydrogen is colorless, odorless, tasteless, and the lightest gas in diatomic form in nature.
- It is slightly soluble in water and some metals like Pd, Au, Pt, Ni, and Fe.
- It is the most abundant element in the universe by 75% by mass.

### 1. Occurrence

- It is found in atmosphere less than 0.03% by volume.
- It is also found in metal hydrates, water and most of the organic substances such as hydrocarbons, natural gas, and petroleum.
- The energy sources of sun, and stars are hydrogen.
- In each second, 550 million tons of  $\text{H}_2$  is consumed to give us heat and light.

#### Preparation in Laboratory

- Active metals with water.  
 $\text{Li(s)} + \text{H}_2\text{O(l)} \rightarrow \text{LiOH(aq)} + 1/2\text{H}_2\text{(g)}$
- Electrolysis of water.  
 $2\text{H}_2\text{O(l)} \rightarrow \text{O}_2\text{(g)} + 2\text{H}_2\text{(g)}$
- Electrolysis of some solutions.  
 $2\text{NaCl(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Cl}_2\text{(g)} + 2\text{NaOH(aq)} + \text{H}_2\text{(g)}$
- Metal hydrides with water.  
 $\text{CaH}_2\text{(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)} + 2\text{H}_2\text{(g)}$
- Amphoteric metals with bases.  
 $\text{Zn(s)} + 2\text{NaOH(aq)} \rightarrow \text{Na}_2\text{ZnO}_2\text{(aq)} + 1/2\text{H}_2\text{(g)}$

#### Preparation in Industry

- Charcoal with water steam.  
 $\text{C(s)} + 2\text{H}_2\text{O(g)} \rightarrow \text{CO}_2\text{(g)} + 2\text{H}_2\text{(g)}$
- Hydrocarbons with water steam.  
 $\text{C}_2\text{H}_6\text{(g)} + 4\text{H}_2\text{O(g)} \rightarrow 2\text{CO}_2\text{(g)} + 7\text{H}_2\text{(g)}$
- Heating hydrocarbons without  $\text{O}_2$ .  
 $\text{C}_2\text{H}_6\text{(g)} + \text{heat} \rightarrow 2\text{C} + 3\text{H}_2\text{(g)}$

### 2. Chemical Properties

- Forms ammonia with  $\text{N}_2$ .  
 $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightarrow 2\text{NH}_3\text{(g)}$
- Good reducing agent.  
 $\text{FeO} + \text{H}_2\text{(g)} \rightarrow \text{Fe} + \text{H}_2\text{O}$
- Forms hydrides with active metals.  
 $2\text{K} + \text{H}_2 \rightarrow 2\text{KH}$
- Forms water with  $\text{O}_2$ .  
 $\text{O}_2 + 2\text{H}_2 \rightarrow 2\text{H}_2\text{O}$

### Uses

Hydrogen gas is directly used in the synthesis of HCl,  $\text{NH}_3$ , methanol, fuel, in the saturation of oil to obtain margarines and fats, in metallurgy to reduce metals.