

9. Hydrogen

Hydrogen:

- First element in the periodic table
- Electronic configuration is $1s^1$.
- It resembles with both alkali metals and halogens to a certain extent.
- It is present in the atmosphere as dihydrogen, which is the most abundant element in the universe and the principal element in the solar atmosphere.

Isotopes of hydrogen:

Protium; ${}^1_1\text{H}$

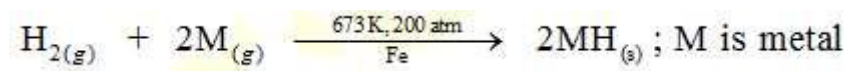
Deuterium (Heavy hydrogen); ${}^2_1\text{H}$ or D

Tritium; ${}^3_1\text{H}$ or T

Tritium is radioactive. ($t_{1/2} = 12.33$ years)

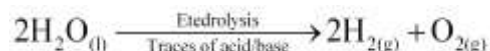
Dihydrogen

Laboratory preparation:

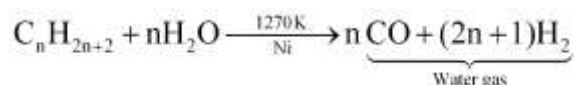


Commercial preparation:

- Electrolysis of acidified water



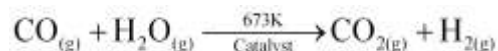
- High purity H_2 is obtained by electrolysis of warm aqueous $\text{Ba}(\text{OH})_2$ between nickel electrodes.
- It is also obtained as a by-product in the manufacture of NaOH and Cl_2 by electrolysis of brine solution.
- Obtained by the reaction of steam on hydrocarbons at high temperatures



The mixture of CO and H_2 is also called water gas. It is also called *synthetic gas* or *syngas*.

[The process of producing *syngas* from coal is called *coal gasification*.]

If carbon monoxide of *syngas* mixtures is treated with steam in the presence of iron chromate as catalyst, then the production of dihydrogen increases. This reaction is called *water-gas shift reaction*.

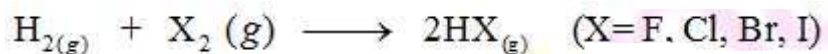


Physical properties: Colourless, odourless, tasteless, combustible gas

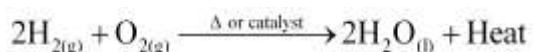
It is lighter than air and insoluble in water.

Chemical properties:

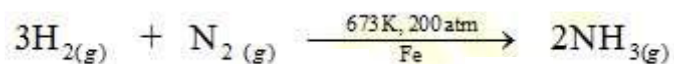
- **Reaction with halogen:**



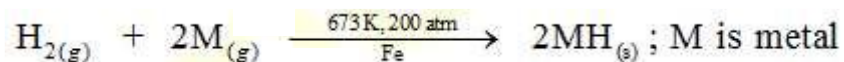
- **Reaction with O₂:**



- **Reaction with N₂:**



- **Reaction with metals:**



- **Reaction with metal ions and metal oxides**

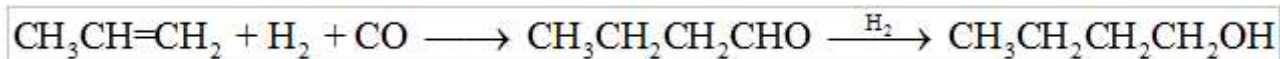
It reduces less reactive metals in aqueous solution and oxides.



- **Reaction with organic compounds**

(i) Hydrogenation of vegetable oils

(ii) Hydroformylation of alkenes to produce aldehydes, which further gives alcohols



Uses:

- Used in the synthesis of ammonia, methanol, metal hydrides, hydrogen chloride, and vanaspati fat.
- Used as rocket fuel in space research
- Used in fuel cells for generating electricity.
- Used in atomic hydrogen and oxy-hydrogen torches, which are used for cutting and welding purposes.

Hydrides (Binary compounds with other elements):

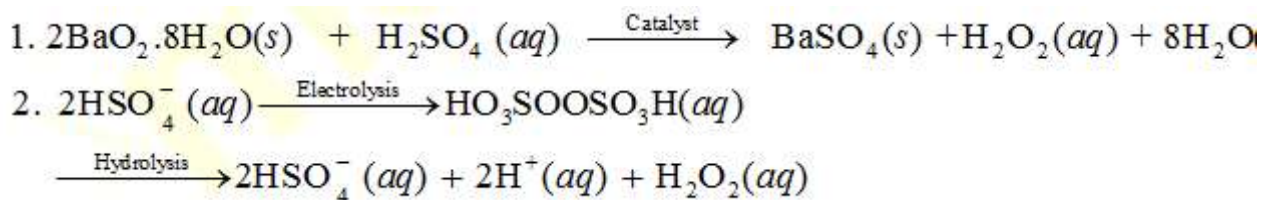
- Ionic or saline hydrides: Stoichiometric compounds with highly electropositive *s*-block elements.
Example: NaH, CaH₂, AlH₃, etc.
- Covalent or molecular hydrides: Compounds with *p*-block elements such as CH₄, NH₃, H₂O

Molecular hydrides are further classified into:

- Electron-deficient hydrides
 - Electron-precise hydrides
 - Electron-rich hydrides
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- Metallic or non-stoichiometric hydrides LaH_{2.87}, TiH_{1.5-1.8}, VH_{0.56}, etc.

Hydrogen peroxide:

Preparation:



Structure: Non-planar

Physical properties:

- Almost colourless (very pale blue) liquid
- Miscible with water and forms a hydrate (H₂O.H₂O)

Chemical properties:

- Acts as an oxidising as well as reducing agent in both acidic and alkaline medium

Storage:

- Stored in wax-lined glass or plastic vessel in dark as it decomposes on exposure to light

Uses:

- As hair bleach, disinfectant, antiseptic
- In manufacture of chemicals used in high quality detergent
- Widely used as an industrial bleach
- In synthesis of food products and pharmaceuticals

- In pollution control treatment

Heavy water (D_2O):

Preparation:

- By the electrolytic enrichment of normal water
- As by-product in some fertiliser industries

Uses:

- As moderator in nuclear reactors
- In exchange reactions to study mechanism of reactions
- To prepare other deuterium compounds