

CONCEPT MAP

HYDROGEN

Occurrence

- Most abundant element in the universe.
- 3rd most abundant element on the globe's surface.
- 9th on earth.

Isotopes

Differ in number of neutrons

Protium (${}^1_1\text{H}$)

- Most abundant (99.984%)
- 1 proton, 0 neutron

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

- in HD form (0.0156%)
- 1 proton, 1 neutron

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

- unstable, radioactive (traces)
- 1 proton, 2 neutrons

Preparation

- By action of water
 - With cold water: very reactive metals like Na, K, Ca, etc.
 - With boiling water: Zn, Mg, Al, etc.
 - With Steam: Fe, Sn, Ni, etc.
- By electrolysis of water

$$\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$$

At cathode: $2\text{H}^+ + 2e^- \rightarrow \text{H}_2$
- From alkalis

e.g., $\text{Zn} + 2\text{NaOH} \xrightarrow{\Delta} \text{Na}_2\text{ZnO}_2 + \text{H}_2$
- From acids

e.g., $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$
- Bosch process - from water gas

$$\text{H}_2 + \text{CO} + \text{H}_2 \xrightarrow[\text{water gas}]{\text{catalyst}} \xrightarrow[\text{steam}]{\text{CO}_2} 2\text{H}_2$$

Hydrides (MH_x)

$M \rightarrow$ except noble gases, In, Tl

Ionic or saline

M has lesser electronegativity than H (group 1 and 2 elements)

Metallic or interstitial

- $M =$
 - d -block (group 3, 4, 5 and 10, 11, 12)
 - f -block elements,
 - group 6 only Cr
- Groups 7, 8, 9 do not form hydride, so known as hydride gap
- Non-stoichiometric
- Shows occlusion

Covalent or molecular

- $M =$
- p -block (MH_{8-n})
 - some s -block (MH_n) elements (Be & Mg)
 - e.g., phosphine - PH_3 , oxidane - H_2O , azane - NH_3

Compounds

Water (H_2O)

Physical properties

- have intermolecular H-bonding
- high dielectric constant - universal solvent

Chemical properties

- amphoteric
- form hydrates
- undergoes oxidation-reduction reactions

Heavy water (D_2O)

- discovered by H.C. Urey (1932)
- low dielectric constant than water so ionic compounds are less soluble in D_2O
- used as moderator in nuclear reactors and tracer compounds

Hydrogen peroxide (H_2O_2)

discovered by J.L. Thenard (1818)

Preparation

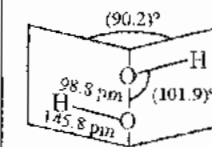
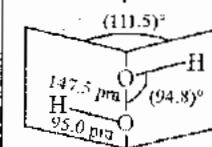
- from Na_2O_2 (Mark's method)
- from $\text{BaO}_2 \cdot 8\text{H}_2\text{O}$
- electrolysis of 50% H_2SO_4

Properties

- acidic
- undergoes auto-oxidation and auto-reduction
- bleaching action
- addition reactions

Structure

- non-polar
- 2 O - H bonds in different planes



Uses of H_2

- Manufacture of NH_3 (Haber's process), HCl, metal hydrides
- Hydrogenation of oils
- In atomic hydrogen & oxy-hydrogen torches
- Liquid hydrogen used as a rocket fuel.