HYDROGEN:

- H_2 is most abundant in universe
- principal element in solar atm.
- ^1_1H → protium
  ^2_1H → Deuterium
  ^3_1H → Tritium → radioactive

PREPARATIONS:

① Laboratory:

$Zn + H^+ \rightarrow Zn^{2+} + H_2$

$Zn + NaOH \rightarrow H_2 + Na_2ZnO_2$
Sodium zincate

② Commercially:

i) Electrolysis of H_2O:

$H_2O \xrightarrow{H^+/OH^-} H_2 + \frac{1}{2}O_2$.

ii) Electrolysis of aq. $Ba(OH)_2$ b/w nickel electrodes. (purity > 99.95%)

iii) Electrolysis of Brine solution

iv) Steam on Hydrocarbons.

$CH_4 + H_2O \xrightarrow[Ni]{\Delta} CO + H_2$
watergas | syngas

– $(CO + H_2)$ → preparation of methanol / hydrocarbons.
syngas

– $C + H_2O \xrightarrow{\Delta} CO + H_2$
coal
coal gasification

– $CO + H_2O \xrightarrow[(Cr)]{\Delta} CO_2 + H_2O$
watergas shift reaction

PHYSICAL PROPERTIES:

- colourless
- odourless
- tasteless
- combustile
- lighter than air
- insoluble in H_2O.

CHEMICAL PROPERTIES:

- High H-H bond enthalpy

① $H_2 + X_2 \rightarrow 2HX$ ($X = F, Cl, Br, I$)

② $H_2 + O_2 \rightarrow H_2O$, $\Delta H = -ve$

③ $H_2 + N_2 \rightarrow NH_3$, $\Delta H = -ve$

④ $H_2 + MO \rightarrow M + H_2O$ (Metal)

⑤ $H_2 + CO + RCH=CH_2$
↓
RCH_2CH_2CHO
+
$H_2 \rightarrow RCH_2CH_2CH_2OH$

USES:

- Ammonia synthesis
- Vanaspati fat ".
- Organic molecules preparation
- Rocket fuel (fuel cells)

HYDRIDES (EH_x)

① Ionic / Saline

- s-block elements
- lighter metal hydrides → covalent
  LiH, BeH_2, MgH_2 ★
  → polymeric ★
- ionic hydrides → crystalline, non-volatile, non conducting in solid state. (melts conduct electricity)
- H_2 on electrolysis on anode.
  ↳ presence of H^- ions.

② Covalent / Molecular:

- p-block

i) e^- deficient: grp-13 B_2H_6 → lewis acid

ii) e^- precise: grp-14 CH_4 → tetrahedral geometry

iii) e^- rich: grp 15-17. → lewis Base

F / O / N → H-bonding

③ ~~e⁻ rich hydrides~~: Grp- 3, 4, 5, (6), 7, 8, 9 ... ⑥ — Only Cr forms Hydride

(3, 4, 5: form Hydride; 6: Cr; 7, 8, 9: No Hydride)

③ Metallic / Non-stoichiometric:

- d & f -block
- H - deficient
- Law of const. composition doesn't hold good.
- Interstitial halides
- Hydrogen storage (Pd | Pt)

$LaH_{2.87}$, $YbH_{2.55}$

NCERT / PYQ

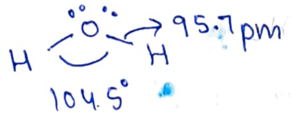
Q→ PH_5 exist?

→ No, because ΔH_a, ΔH_{eg} of Hydrogen don't favour high O.S of P

WATER

Physical Properties:

- colourless, tasteless
- High freezing, BP.
- High heat of vaporisation & heat capacity.
- excellent solvent



- ice crystallises in hexagonal form but at low T, in cubic form.
- Density of ice is less than H_2O.

Chemical Properties:

1) Amphoteric Nature:

$H_2O + NH_3 \rightarrow OH^- + NH_4^+$

$H_2O + H_2S \rightarrow H_3O^+ + HS^-$

2) Redox Reactions:

$H_2O + Na \rightarrow NaOH + H_2$ (reduced to H_2)

- In photosynth. H_2O is oxidised to O_2.

3) Hydrolysis Reaction:

$SiCl_4 + H_2O \rightarrow SiO_2 + HCl$

$P_4O_{10} + H_2O \rightarrow H_3PO_4$

$N^{3-} + H_2O \rightarrow NH_3 + 3OH^-$

4) Hydrates formation:

i) Coordinate water: $[Cr(H_2O)_6]^{3+} 3Cl^-$

ii) Interstitial water: $BaCl_2 \cdot 2H_2O$

iii) Hydrogen-bonded H_2O: $[Cu(H_2O)_4]^{2+} SO_4^{2-} \cdot H_2O$ in $CuSO_4 \cdot 5H_2O$

NCERT / PYQ

Q) How many H-bonded H_2O molecules in $CuSO_4 \cdot 5H_2O$? ⇒ 1 molecule

SOFT Water: water free from calcium and magnesium salts.

HARD Water: salts in the form of hydrogencarbonate, chloride & sulphate, in water.

Temporary Hardness:

- due to Mg & Ca Hydrogencarbonates.

i) Boiling:

$Mg(HCO_3)_2 \xrightarrow{\Delta} Mg(OH)_2 \downarrow + 2CO_2 \uparrow$

$Ca(HCO_3)_2 \xrightarrow{\Delta} Ca(OH)_2 \downarrow + CO_2 + H_2O$

ii) CLARK'S METHOD:

calculate amount of lime is added.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + H_2O$$

Permanent Hardness:

due to Ca & Mg chlorides & sulphates.

i) with washing soda (Na_2CO_3)

$$MCl_2 + Na_2CO_3 \rightarrow MCO_3\downarrow + NaCl$$

$$MSO_4 + Na_2CO_3 \rightarrow MCO_3\downarrow + Na_2SO_4$$

ii) CALGON'S METHOD:

Sodium Hexametaphosphate → $Na_2[Na_4(PO_3)_6]$ → CALGON

$$M^{2+} + Na_4(PO_3)_6^{2-} \rightarrow [Na_2MP_6O_{18}] + 2Na^+$$

(Ca & Mg)

iii) Ion-Exchange method:

Hydrated Sodium Aluminium silicate } Zeolite/permutit

$$NaZ + M^{2+} \rightarrow MZ_2 + Na^+$$

($NaAlSiO_4$) — Z ; M = (Mg/Ca)

iv) Synthetic resins method:

- more effective than zeolite process.

$$RSO_3H + NaCl \rightarrow RNa +$$

$$RNa + M^{2+} \rightarrow R_2M + Na^+$$

M = (Ca/Mg)

Cation exchange - H^+ (Na^+, Ca^{2+}, Mg^{2+})

Anion exchange - OH^- (Cl^-, HCO_3^-, SO_4^{2-})

$$H^+ + OH^- \rightarrow H_2O$$

$$PPM = \frac{\text{wt. of solute}}{\text{wt. of solution}} \times 10^6$$

Permutit Process:

$$MZ_2 + NaCl \rightarrow NaZ + MCl_2$$

(NaZ regenerated)

HYDROGEN PEROXIDE (H_2O_2)

- used in pollution control.

PREPARATIONS:

i) By acidified Barium Peroxide:

$$BaO_2 \cdot 8H_2O + H_2SO_4 \rightarrow BaSO_4 + H_2O_2 + H_2O$$

ii) Acidified aq. HSO_4^-: lab. process

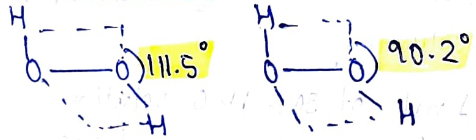
$$HSO_4^- \xrightarrow{\text{electrolysis}} HO_3SOOSO_3H \xrightarrow{\text{Hydrolysis}} H^+ + HSO_4^- + H_2O_2 +$$

iii) Industrial method:

auto oxidation of 2-alkylanthraquinols

Physical Properties:

- Colourless (very pale blue)
- miscible with water
- non-planar



Gas-phase Solid phase

Chemical Properties:

- Oxidising & Reducing agent
- decomposes slowly to light.

$$H_2O_2 \rightarrow H_2O + O_2$$

- Stored in wax-line plastic vessels.
- urea as stabiliser.
- res tore colour of lead paintings by oxidising PbS to $PbSO_4$.

USES:

- Hair bleach, mild disinfectant
- Bleaching agent
- In detergent, making
- pollution control treatment for domestic and industrial effluents.

Heavy Water (D_2O)

- Prepared by exhaustive electrolysis of water.
- used as moderator in nuclear reactor.

H_2 as a Fuel:

- Mass for mass basis H_2 release more energy than petrol.
- Hydrogen Economy: transportation & storage of energy in form of liq. or gaseous dihydrogen.

limitations: – storage &
– transportation,
– expensive insulated tanks.

- x volume of H_2O_2 solution means that x mL of O_2 will be released for every ~~wt~~ 100 mL of H_2O_2 solution.
- 10 V H_2O_2 solution contains 3.035% H_2O (mass/volume).

Molarity of H_2O_2 (M) $= \dfrac{\text{Volume str.}}{11.2}$

% strength $= \dfrac{M \times 34}{10}$

Numericals:

- 30% H_2O_2 solution is marketed as 100 volume.
  - ↳ 1 mL of 30% H_2O_2 solution will give 100 mL O_2 at STP.
- 3% H_2O_2 solution → 10 V
  ~~[illegible]~~
- '10' V solution means that 1 L of this solution gives 10 L O_2 at STP.

  $2H_2O_2 \rightarrow O_2 + H_2O$

- 10 V H_2O_2 means 3.035% H_2O_2
  ⇒ 100 mL solution contains 3.035 gm H_2O_2.