HYDROGEN AND IT's COMPOUNDS..

Major Topics → H_2O_2, Heavy Water, H_2O, preparation of H_2.

→ Lightest element and simplest configuration ($1s^1$)
→ 1 proton, 1 electron.
→ Hydrogen is found as dihydrogen (H_2 gas).
→ H_2 Gas - Most abundant in Universe. (Saturn, Jupiter, Sun) → most of mass is due to Hydrogen.
→ $1^{H^1} + 1^{H^1} \xrightarrow{\text{fusion}} {}_1H^2$ + energy release

② Position of Hydrogen in Periodic Table.

Resembles with alkali
- has $1e^-$ in outermost shell.
- M^+ ion formation
- Valency and Oxidation State = 1
- Both Hydrogen and alkali combines with halogen, and form halides.
- Oxygen → Oxide
- Sulphur → Sulphide

Resembles with halogen.
- Both are non-metal.
- Diatomic molecule formation
- Similar Ionisation Energy

→ So hydrogen is given a separate place in periodic table.

③ Isotope of Hydrogen (3 Isotopes)

- ${}_1H^1$ — Hydrogen / protium. → most abundant isotope.
- ${}_1H^2$ — Deuterium (Heavy hydrogen)
- ${}_1H^3$ — Tritium → Radioactive. ($t_{1/2}$ = 12.33 years) → Rarely found in Nature.

④ Di-Hydrogen → (Preparation)

(Lab)

① Zinc + Dilute acid and aqueous base → H_2.

$Zn + dil\ HCl \rightarrow ZnCl_2 + H_2\uparrow$

$Zn + aq\ alkali \rightarrow Na_2ZnO_2 + H_2\uparrow$
NaOH
KOH

$Sn \rightarrow Na_2SnO_2$
$Pb \rightarrow Na_2PbO_2$
$Zn \rightarrow Na_2ZnO_2$
$Al \rightarrow NaAlO_2$
} Soluble in NaOH

(Commercial preparation) →

① Electrolysis of acidified Water →

Platinum Electrode Sey.

$2H_2O(l) \xrightarrow[\text{Pt electrode}]{\text{electrolysis}} 2H_{2(g)} + O_{2(g)}$
(Traces of acid/Base)

→ High purity H_2 → Electrolysis → Warm $Ba(OH)_2$ → Ni electrode.

→ Steam on HydroCarbon →

$CH_4 + H_2O_{(g)} \xrightarrow[Ni]{1270K} \underbrace{CO_{(g)} + H_{2(g)}}_{\text{water gas/syn gas}}$

→ Coal - Gasification →

$C_{(s)} + H_2O_{(g)} \xrightarrow{1270K} \underbrace{CO_{(g)} + H_{2(g)}}_{\text{water gas/syn gas}}$

Water Gas Shift →

$CO_{(g)} + H_2O_{(g)} \xrightarrow{Fe_2Cr_2O_3} CO_{2(g)} + H_{2(g)}$

→ product.^{n} of H_2 is ↑↑sed by water gas shift rx.^{n}.

→ H_2 also obtained as by-product of electrolysis of brine

⑤ Physical properties :→

- Colourless, Odourless, Tasteless.
- Lighter than air.
- Insoluble in Water.
- H-H Bond enthalpy is highest among all single bond

⑥ Chemical properties :→

① Rx.^{n} with halogen.

$H_2 + X_2 \rightarrow HX$ (X = F, Cl, Br, I → catalyst)
↓
Dark

② Rx.^{n} with Oxygen.

$H_{2(g)} + O_{2(g)} \xrightarrow{\Delta} 2H_2O_{(l)}$ (exothermic)

③ Rx.^{n} with Nitrogen. (exothermic)

$H_{2(g)} + N_{2(g)} \xrightarrow[Fe, Mo]{673K, 200atm} 2NH_3$ (Haber's proces

④ Rx.ⁿ with Metal.

$H_2(g) + M \rightarrow MH / MH_2$ – Group 2
Group 1

⑤ Reduced

$H_2(g) + Pd^{+2}_{(aq)} \rightarrow Pd(s) + 2H^+_{(aq)}$

$H_2(g) + MxOy \rightarrow H_2O + M(s)$

⑥ Rx.ⁿ with Organic Compound →

→ Hydrogenation of Vegetable oil (Ni electrode) → edible fats. (Vanaspati Ghee) (Margarine)

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

Olefins — water gas — aldehyde — alcohol.

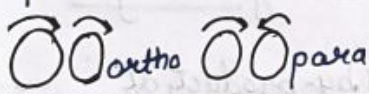
Hydroformylation

⑦ Uses of Di–Hydrogen →

→ Hydrogenation of Vegetable oil
→ atomic-hydrogen torch-Welding purpose
→ Rocket fuel.
→ Watergas preparation, ammonial prep.ⁿ, fertilizer prep., methanol, alcohol, aldehyde

⑧ Ortho and Para Hydrogen →

→ proton spin → Same direction → Orthohydrogen
→ proton spin → Opposite direction → parahydrogen



Hydride

Ionic Hydride
S-Block
crystalline
non-Volatile
Non-Conductor
High MP and BP.
$LiH > NaH > KH > RbH > CsH$.
$CaH_2 > SrH_2 > BaH_2$

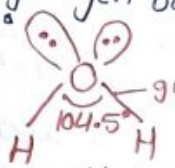
Metallic Hydride
d-f Block
(non-stiochiometric)
$LaH_{2.87}$
$YbH_{2.25}$

Covalent Hydride
p-Block
(covalent)
Volatile.
Non-Conductor
$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$.

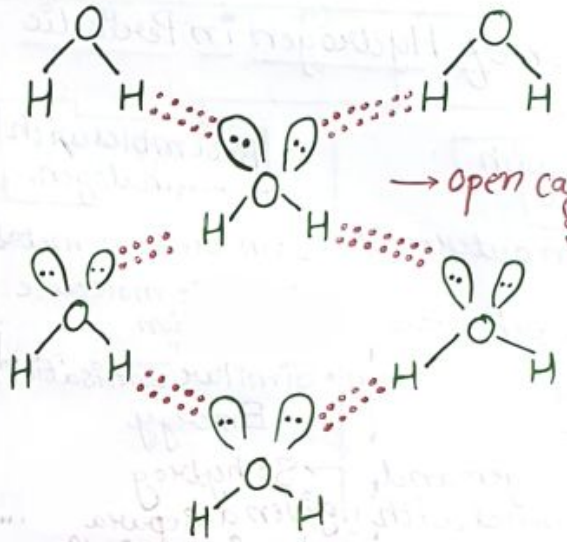
G_7, G_8, G_9 do not form hydride. (Hydride Gap)
G_6 (CrH) → yahi banayega

→ Water ←

→ High freezing point, ↑↑ B.P., ↑↑ Heat of
→ Colourless, Tasteless, Odourless
→ ↑↑ Heat of fusion
→ Due to extensive hydrogen bonding
→ Bond angle → 104.5°
→ Bent Shape / angular shape.



→ Liquid phase → Water → Hydrogen bond, associated hai.
→ Water → Crystalline form → Ice → Open Cage Structure
→ Each water molecule is generally H-Bond with 4 other water molecule



Chemical properties of Water →

① Self Ionization of Water →

$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

② Amphoteric Character →

$\underset{\text{Base}}{H_2O_{(l)}} + \underset{\text{Acid}}{HCl_{(aq)}} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$

$\underset{\text{acid}}{H_2O_{(l)}} + \underset{\text{base}}{NH_{3(aq)}} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

③ Redox Reaction → (metal, non-metal)

$Na + H_2O \rightarrow NaOH + H_2(g)$

$F_2 + H_2O \rightarrow F^- + H^+ + O_2$

④ Hydrolysis Reaction →

$P_4O_{10} + H_2O \rightarrow H_3PO_4$.

$SiCl_4 + H_2O \rightarrow SiO_2$

⑤ Hydrate Formation →

① Coordinated Water → $[Cr(H_2O)_6]^{+3}3Cl^-$

② Interstitial Void → $BaCl_2 \cdot 2H_2O$

③ Hydrogen-Bounded Water → $CuSO_4 \cdot 5H_2O$

Hard Water and Soft Water

→ Water forming lather with soap → Soft Water.

→ Water not forming lather with soap → Hard Water.

Hardness Of Water → presence of bicarbonate, chloride, sulphate of Ca, Mg.

→ Hard water forms scum (precipitate) with soap.

Soap has sodium stearate ($C_{17}H_{35}COONa$) reacts with hard water and forms precipitate with Ca or Mg sterate

$C_{17}H_{35}COONa + Ca^{+2}/Mg^{+2} \rightarrow \underbrace{(C_{17}H_{35}COO)_2Ca}_{ppt.}$

Hardness

Temporary Hardness

Bicarbonate of Ca, Mg.

Removal

① → Boiling

$M(HCO_3)_2 \xrightarrow{\Delta} MCO_3\downarrow$

(soluble) (insoluble) ppt.

② Clarck's Method.

$Ca(HCO_3)_2 + Ca(OH)_2$ (soluble)

$\rightarrow CaCO_3\downarrow$ (insoluble) ppt.

(lime)

Permanent Hardness

Chloride and sulphate of Ca and Mg.

Removal of permanent Hardness →

① Treating with washing soda →

$CaSO_4 + Na_2CO_3 \rightarrow$

$CaCO_3\downarrow + Na_2SO_4$ ppt

$MgCl_2 + Na_2CO_3 \rightarrow$

$MgCO_3\downarrow + NaCl$ ppt

② Calgon's Method →

$Na_6P_6O_{18} \rightarrow 2Na^+ + Na_4P_6O_{18}^{-2}$ (Calgon)

$M^{+2} + Na_4P_6O_{18}^{-2} \rightarrow [Na_2MP_6O_{18}]^{-2} + 2Na^+$

③ Ion-exchange / Zeolite / Permutit process →

Zeolite → $NaAlSiO_4 \rightarrow NaZ$

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

Permutit / Zeolite → Regenerated.

$MZ_2 + NaCl \rightarrow NaZ$

④ Synthetic Resin Method.

Resin with acidic group – SO_3H, $-COOH$,

Cation exchanger

exchanges H^+ ion with Ca^{+2}/Mg^{+2}

$\Rightarrow 2RCOOH + M^{+2} \rightarrow (RCOO)_2M + H^+$

(Cation exchange resin). (Exhausted Resin).

→ Resin with basic group OH^- → Anion exchange Resin.

$RNH_3^+OH^- + Cl^- \rightarrow RNH_3^+Cl^- + OH^-$

Anion exchange resin (Exhausted Resin).

$RNH_3^+OH^- + SO_4^{-2} \rightarrow (RNH_3)_2SO_4^{-2} + OH^-$

exchanged Resin

$H^+ \rightarrow$ Cation exchange
$OH^- \rightarrow$ Anion exchange } H_2O

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ – deionized water or demineralised water

Exhausted Resin is regenerated again.

$(RCOO)_2Ca^{+2} + H_2SO_4 \rightarrow RCOOH$

$RNH_4^+Cl^- + NaOH \rightarrow RNH_4OH$

H_2O_2 (Hydrogen Peroxide)

* Lab preparation →

- $BaO_2 \cdot 8H_2O_{(s)} + H_2SO_{4\,(aq)} \rightarrow BaSO_{4\,(s)} + H_2O_{2\,(aq)} + 8H_2O_{(l)}$
- $2HSO_4^-{}_{(aq)} \xrightarrow{\text{electrolysis}} HO_3SOOSO_3H_{(aq)} \xrightarrow{\text{hydrolysis}} 2HSO_4^-{}_{(aq)} + 2H^+_{(aq)} + H_2O_{2\,(aq)}$.
- $K_2S_2O_{8\,(s)} + 2D_2O_{(l)} \rightarrow 2KDSO_{4\,(aq)} + D_2O_{2\,(l)}$

* Industrial preparation →

- auto-oxidation of 2-alkylanthraquinols.

2-ethylanthraquinol $\xrightarrow[H_2/Pd]{O_2(air)}$ H_2O_2 + (oxidised product).

* physical properties →

- H_2O_2 is miscible with water in all proportions and forms a hydrate $H_2O_2 \cdot H_2O$ (M.P. 221 K).
- 30% solution of H_2O_2 is marked as (100 volume).

hydrogen peroxide → perhydrol.

* Volume strength of H_2O_2 Solution →

x volume of H_2O_2 solution means that x ml O_2 will be released for every 100 ml of H_2O_2 solution, means x L of O_2 is released per 100 L of H_2O_2 sol^n.

- Volume Strength = 11.2 × molarity.
- Volume strength = 5.6 × normality.
- Normality = molarity × n factor. ($n = 2$)

* Structure and Chemical properties →

- H_2O_2 structure in gas phase, dihedral angle is 1115°.
- H_2O_2 structure in solid phase at 110 K, dihedral angle is 90.2°.

- Oxidising action in acidic medium.

$2Fe^{2+}_{(aq)} + 2H^+_{(aq)} + H_2O_{2\,(aq)} \rightarrow 2Fe^{3+}_{(aq)} + 2H_2O_{(l)}$

$PbS_{(s)} + 4H_2O_{2\,(aq)} \rightarrow PbSO_{4\,(s)} + 4H_2O_{(l)}$

- Reducing action in acidic medium.

$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

$HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$.

- Oxidising action in basic medium.

$2Fe^{2+} + H_2O_2 \rightarrow 2Fe^{3+} + 2OH^-$

$Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2OH^-$

- Reducing action in basic medium.

$I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

$2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH$

* Uses →

- Hair bleach, mild disinfectant. perhydrol → antiseptic.
- Synthesis of hydroquinone, tartaric acid and certain food products and pharma-ceuticals (cephalosporin).

Heavy Water

- manufactured in India at Trombay.
- In heavy water, weight % of deuterium is 20.
- By repeated distillation and condensation, heavy water (D_2O) is produced. One part of D_2O is present in 6000 part of H_2O.
- In atomic reactor, heavy water has found application as moderator.
- Deuterium resembles hydrogen in chemical properties but reacts slower than hydrogen

NEET SLAYER.. ♡ & ☽