10+2 PCM NOTES

BY

JOYOSHISH SAHA

(PDF version handwritten notes of Maths, Physics and Chemistry for 10+2 competitive exams like JEE Main, WBJEE, NEST, IISER Entrance Exam, CUCET, AIPMT, JIPMER, EAMCET etc.)

With best wishes from Joyoshish Saha

Hydrogen

* Hydrogen: $H_1^{1.008}$ $1s^1$. Hydrogen is the first element in the periodic table and its position is anomalous. It resembles alkali metals wrt electronic configuration, electro-positive character, valency and oxidation state, oxidation with electronegative elements & liberation at cathode. It also resembles halogens wrt electronic configuration (one electron less than the nearest noble gas configuration), ionisation energy, electronegative character, oxidation state, diatomic nature & liberation at anode.

* Isotopes of Hydrogen:

Protium	$_1H^1$ or H	99.98%.
Deuterium	$_1H^2$ or D	0.016%
Tritium	$_1H^3$ or T	10-15% (radioactive)

* Preparation of H_2:

i) $Zn + H_2SO_4$ (dil.) $\longrightarrow$ $ZnSO_4 + H_2$ (Lab method)

ii) Hydrolith process: $\underbrace{CaH_2}_{\text{Hydrolith.}} + 2H_2O \rightarrow Ca(OH)_2 + 2H_2\uparrow$

iii) Lane's process: $3Fe(s) + 4H_2O(g) \xrightarrow{750-800^\circ C} Fe_3O_4(s) + 4H_2(g) + \text{Heat}$

Fe $\xleftarrow{\text{reduction}}$ $H_2 + CO$ (Water gas)

iv) Bosch process: $C(s) + H_2O(g) \xrightarrow[1000^\circ C]{} \underbrace{CO(g) + H_2(g)}_{\text{Water gas}}$ (coal gasification)

$CO + H_2 + H_2O \xrightarrow[400^\circ C]{FeCrO_4 \text{ or } Fe_2O_3/Cr_2O_3} \underbrace{CO_2 + 2H_2}$ (Water gas shift reaction).

CO_2 solvated in H_2O, CO-free $\xleftarrow{\text{high pressurised in water \& ammonia-ised } Cu_2Cl_2 \text{ solution}}$

* Chemical properties of Hydrogen: H–H bond dissociation energy 436 kJ/mole. (Highest among the one-one bonding).

i) $H_2 + 2Li \xrightleftharpoons{700°C} 2Li^+H^-$

ii) $H_2 + CuO \xrightarrow[\text{reduction}]{} Cu + H_2O$.

iii) $H_2 + Br_2 \xrightarrow[350°C]{\text{Catalyst}} 2HBr$

iv) $3H_2 + N_2 \xrightarrow[\text{Haber's process}]{\text{Fe catalyst}} 2NH_3 + \Delta$
673K / 200 atm

v) $H_2 + CO \xrightarrow[\text{Fischer–Tropsch Synthesis}]{Fe, Co, Ni}$ Mixture of hydrocarbons

vi) $H_2 + CO \xrightarrow[Cu, ZnO/Cr_2O_3 \text{ (catalyst)}]{700K} CH_3OH$

vii) $H_2 + O_2 \xrightarrow[\text{Electric discharge}]{970\,K} 2H_2O$.

viii) $H_2 + CH_2=CH_2 \xrightarrow[473K]{Ni/Pt} CH_3-CH_3$ (Hydrogenation).

- Pure zinc is not used in the preparation of H_2 because its reaction with H_2SO_4 is slow. The presence of some impurities increases the rate of reaction due to the formation of electrochemical couples.

Concentrated H_2SO_4 is not used because Zn reacts with concentrated acids to form SO_2 instead of H_2. $Zn + 2H_2SO_4 \text{ (conc.)} \rightarrow ZnSO_4 + SO_2 + 2H_2O$.

- Ortho-para Hydrogen: H_2 has two nuclear spin isomers. When spins of both protons are in same direction it is called ortho-hydrogen, otherwise para. Due to difference of internal energy, there are differences in melting & boiling pt., heat conductance etc.

C

Hydrogen

* Nascent Hydrogen: Newly born atomic hydrogen — more reactive & more powerful reducing agent.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + \boxed{2H}$$

$$\overset{+3}{FeCl_3}\ (\text{yellow}) \xrightarrow{H} \overset{+2}{FeCl_2}\ (\text{colourless})$$

$$\overset{+7}{2KMnO_4}\ (\text{violet}) + 3H_2SO_4 + 10H \longrightarrow K_2SO_4 + 2\overset{+2}{MnSO_4} + 8H_2O$$

colourless

* Hydrides:

i) With group 1,2 elements: Saline hydrides.
- Solids with ionic lattices
- High m.pt. & b.pt.
- Thermal stability decreases with increasing size of cations. —

  $LiH > NaH > KH > RbH > CsH$

  $CaH_2 > SrH_2 > BaH_2$.

ii) With group 3–6 elements: Metallic hydrides
- Hydrogen atoms occupy the holes in metal lattices.
- Non-stoichiometric compounds.
- High conductivity.
- Strong reducing agents.

iii) With group 7–9: Hydride gap (unknown).

iv) With group 10–12: Metallic hydrides.
- Hydrides formed on heating with H_2 at high pressure.

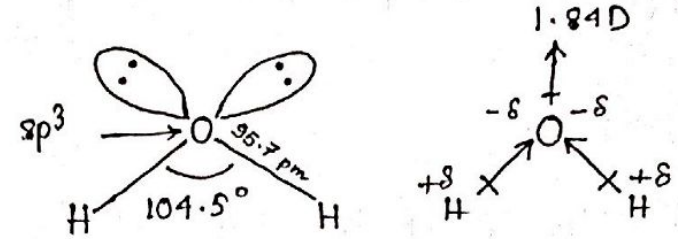
v) With group 13–17: Molecular hydrides
- Molecules are held by van der Waals' forces.

- Low m.pt. & b.pt.
- Low electrical conductivity.
- Volatile in nature.
- Thermal stability decreases with increase in size of the central atom.

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$.

* Water:

1. Structure:



2. Physical properties: i) The freezing pt., b.pt, heat of fusion & heat of vaporisation are higher as compared to the hydrides of other members of the same group, such as H_2S, H_2Se etc. due to the presence of H-bonding in H_2O molecules.
ii) Water has capacity to dissolve most of the inorganic substances & a few organic substances such as urea, alcohol, sugar etc. and is regarded as a universal solvent.

3. Chemical Properties:

i) $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
self-ionisation of water

amphoteric character of H_2O

ii) $H_2O(l) + HCl(aq) \rightleftharpoons H_3O^+(aq) + Cl^-(aq)$
Base acid acid base.

iii) $H_2O(l) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
acid base acid base.

iv) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$ (Oxidising agent)

v) $nCO_2 + nH_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} (CH_2O)_n + O_2$
Carbohydrate
(reducing agent).

4. Heavy Water (Discovered by Urey):

• Obtained by prolonged electrolysis from ordinary water.

• Physical properties: i) colourless, odourless, tasteless liquid formed by deuterium (D). ii) nearly all physical constants of heavy water are higher than the corresponding values of ordinary water.

• Chemical properties:

i) $2D_2O + 2Na \longrightarrow 2NaOD + D_2$.

ii) $Na_2O + D_2O \longrightarrow 2NaOD$ Dentero sodium hydroxide

iii) $SO_3 + D_2O \longrightarrow D_2SO_4$ Dentero sulphuric acid

iv) $Al_4C_3 + 12D_2O \longrightarrow 3CD_4 + 4Al(OD)_3$
Dentero methane

v) $CaC_2 + 2D_2O \longrightarrow DC \equiv CD + Ca(OD)_2$
Dentero ethyn.

5. Hard & Soft Water: Water is soft if it produces sufficient lather with soap it is hard if it forms an insoluble scum before it forms lather with soap.

$$\underset{\text{(present in hard water)}}{CaCl_2} + 2\underset{\text{soap soluble}}{C_{17}H_{35}COONa} \longrightarrow \underset{\text{Insoluble precipitate}}{(C_{17}H_{35}COO)_2Ca} + 2NaCl.$$

• Hardness of Water: i) Temporary: When hardness of water is due to the presence of bicarbonates of Mg & Ca. It can be removed by boiling.

ii) Permanent: When hardness of water is due to the presence of sulphates or chlorides of Ca & Mg. It can't be removed by boiling.

Both temporary & permanent hardness can be removed by adding caustic soda (NaOH).

$Ca(HCO_3)_2 + 2NaOH \longrightarrow CaCO_3 \downarrow + Na_2CO_3 + 2H_2O$

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaCl$

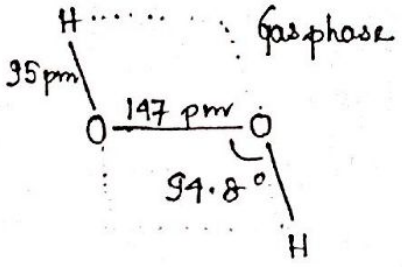
Degree of hardness is the number of parts of $CaCO_3$ present in a million (10^6) parts of water by weight i.e. 1 ppm = 1 part of $CaCO_3$ in 10^6 parts of water.

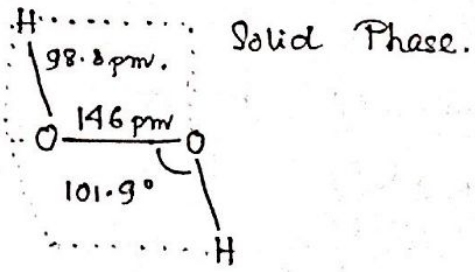
1 $MgCl_2$ ≡ 1 $MgSO_4$ ≡ 1 $CaSO_4$ ≡ 1 $CaCl_2$ ≡ 1 $CaCO_3$

95 ppm 120 ppm 136 ppm 111 ppm 100 ppm.

* Hydrogen Peroxide (Oxygenated Water):

1. Structure: Open-book like structure.





2. Preparation: i) from Na_2O_2: $Na_2O_2 + 2H_2O \xrightarrow[\text{Ice-cold}]{} 2NaOH + H_2O_2$

$Na_2O_2 + H_2SO_4$ (dilute) $\longrightarrow Na_2SO_4 + H_2O_2$

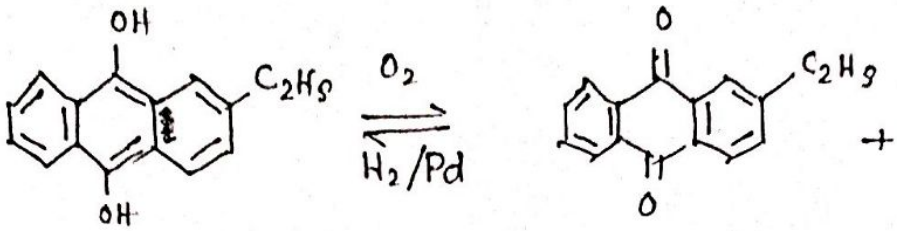
ii) from barium peroxide:

$BaO_2 \cdot 8H_2O + H_2SO_4 \xrightarrow[\text{Ice-cold}]{} BaSO_4 + H_2O_2 + 8H_2O$

$3BaO_2 + 2H_3PO_4 \longrightarrow Ba_3(PO_4)_2 \downarrow + 3H_2O_2$

Merck's process: $BaO_2 + CO_2 + H_2O \longrightarrow BaCO_3 \downarrow + H_2O_2$

iii) From 2-ethylanthraquinol:



iv) From electrolysis of $(NH_4)_2SO_4$ & H_2SO_4:

$$(NH_4)_2SO_4 + H_2SO_4 \longrightarrow 2NH_4HSO_4 \xrightarrow{\text{Electrolysis}} (NH_4)_2S_2O_8$$

$$(NH_4)_2S_2O_8 \xrightarrow{2H_2O} 2NH_4HSO_4 + H_2O_2.$$

3. Reactions: