Hydrides

The binary compounds of hydrogen with other elements are called hydrides. Hydrides are classified into three types.

(i) Saline Hydrides

Compounds of hydrogen with active metals such as *Na, K, Ca* etc. are called saline hydrides or ionic hydrides. In these compounds hydrogen shows an oxidation state of –1. For example, KH, NaH, CaH_2.

Ionic hydrides are crystalline, nonvolatile solids with high melting and boiling points. In the molten state, they conduct electricity liberating dihydrogen at *anode.* Most of the 's' block elements form salt like hydrides (However LiH, $Be\ H_2$ and MgH_2 have considerable covalent character). They react vigourously with water to produce H_2 gas.

$$NaH + H_2O \longrightarrow NaOH + H_2$$

(ii) Covalent Hydrides

Hydrogen forms binary compounds with nonmetals of *p* - block elements and they are called covalent or molecular hydrides. HCl, H_2O, CH_4, PH_3 etc are examples of this type of hydrides.

The hydrides of group 13 (e.g., B_2H_6) do not have sufficient number of electrons to form normal covalent bonds and hence they are called **electron deficient hydrides.** They act as Lewis acids. Hydrides of group 14 (*e.g.*, CH_4, SiH_4, GeH_4 *etc*) contain exact number of electrons to form normal covalent bonds, and are called **electron percise hydrides.**

Hydrides of groups 15,16, and 17 have more electrons than required for normal covalent bonds and are called **electron rich hydrides.** NH_3, PH_3, H_2S, HF, HCl etc belong to this type. Most of them behave as Lewis bases.

(iii) Interstitial hydrides (metallic hydrides):

They are the binary compounds of hydrogen with d–block and f– block elements. In group 6, only chromium forms CrH. Metals of groups 7, 8, 9 do not form hydrides at all. The region of the periodic table from group 7 to 9 is thus called the ***hydride gap.***

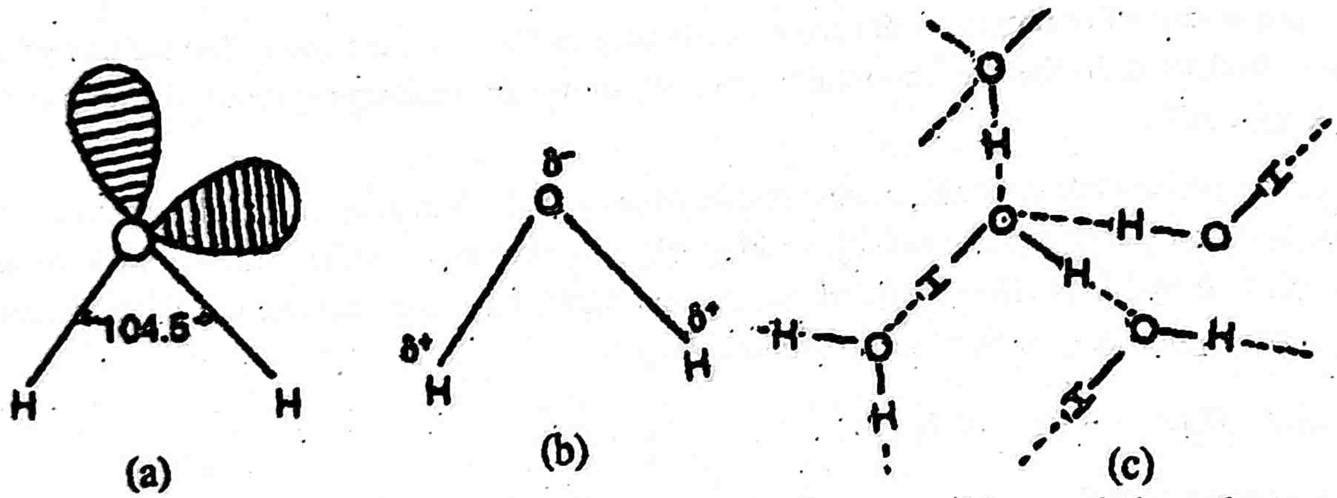
Most of the metallic hydrides are non– stochiometric compounds. Their compositions do not correspond to simple whole number ratio. For example, $LaH_{2.87}$, $ZrH_{1.3}$, $PdH_{0.6}$, $VH_{0.56}$ etc., are non– stoichiometric hydrides. Metals like *Pd, Pt* etc. can take up large volumes of H_2 and this property is used in **hydrogen storage** and transport.

WATER

Water is essential to all forms of life and it is the most abundant compound in the biosphere. Human body has about 65% of water.

Structure of water and ice

In gas phase H_2O is a bent molecule with bond angle 104.5° and O–H bond length 95.7 pm. Because of the high electronegativity of oxygen, water molecule is highly polar.



(a) Water molecule (b) Polarity of water molecule (c) association of water molecules by hydrogen bonds

In the liquid state, molecules of water are associated by intermolecular hydrogen bonding. Due to such molecular association through hydrogen bonds, liquid water has high boiling point (373K).

Ice has an ordered three dimensional hydrogen bonded structure in which each oxygen atom is tetrahedrally surrounded by four other oxygen atoms at a distance 276 pm. The resulting structure contains vacant spaces or holes. Therefore the density of ice is less than that of water. So ice floats in water.

Physical properties

The freezing point, boiling point, heat of vapourisation and heat of fusion of water are higher than that of the hydrides of other members of the same group (group 16) such as H_2S, H_2Se, H_2Te etc. This is due to the presence of hydrogen bonding in water which is not seen in other hydrides of the group. Water is regarded as a *universal solvent*. Inorganic substances are mostly ionic and they readily dissolve in water. Even covalent organic substances such as alcohol, sugar etc dissolve in water due to their ability to form hydrogen bonds with water molecule.

Chemical Properties

Water acts as an acid, a base, an oxidant, a reductant and also as ligand in metal complexes.

(i) Amphoteric nature

Water is said to be *amphoteric* because it acts as a base towards acids stronger than itself and as an acid towards bases stronger than itself.

$$\underset{\text{base}}{H_2O(l)} + \underset{\text{acid}}{HCl(aq)} \rightleftharpoons \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{Cl^-} \quad ; \quad \underset{\text{acid}}{H_2O(l)} + \underset{\text{base}}{NH_3(aq)} \rightleftharpoons \underset{\text{acid}}{NH_4^+} + \underset{\text{base}}{OH^-}$$

Water undergoes very small self ionisation or autoprotolysis as follows:

$$H_2O(l) + H_2O(l) \rightleftharpoons \underset{\text{hydronium ion}}{H_3O^+(aq)} + OH^-(aq)$$

(ii) Oxidation – reduction reactions

With reactive metals such as Na, K, etc., water acts as oxidising agent while with highly electronegative elements it behaves as a reducing agent.

$2Na + H_2O \rightarrow 2NaOH + H_2$ (water is reduced)

$2F_2 + 2H_2O \rightarrow 4HF + O_2$ (water is oxidised)

Water is also oxidised to O_2 during photosynthesis.

(iii) Hydrolysis

Water can participate in many hydrolysis reactions with oxides and halides of non metals. Carbides, nitrides, phosphides etc. of metals are also hydrolysed by water.

$$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$$

$$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl \quad ; \quad \underset{\text{Calcium nitride}}{Ca_3N_2} + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$$

(iv) Hydrate formation

Water also has the ability to combine with some metal salts to form compounds known as *hydrates*. Three types of hydrates are generally observed.

(i) Hydrates in which water molecules are co–ordinated to a metal ion in complexes. e.g., $[Ni(H_2O)_6](NO_3)_2$; $[Cr(H_2O)_6]Cl_3$.

(ii) Hydrates containing hydrogen bonded water. For example, $CuSO_4.5H_2O$ contains four H_2O molecules co–ordinated to cupric ion and the fifth H_2O molecule is hydrogen bonded.

(iii) hydrates containing water molecules occupying voids or interstitial sites in the crystal lattice. eg: $BaCl_2.2H_2O$.