Chemistry Study Materials for Class 11
(NCERT Based Notes of Chapter 09)
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Hydrogen

HYDRIDES

The binary compounds of hydrogen with other elements are called Hydrides. They are classified into three:

1. **Ionic or saline or salt-like hydrides**:

These are stoichiometric compounds of H_2 with s-block elements. They are crystalline, non-volatile solids. They are non-conductors in the solid state but conduct electricity in the molten state or in aqueous solution state. LiH, BeH_2 and MgH_2 are significantly covalent in nature. e.g. NaH, KH, CaH_2, BaH_2 etc.

2. **Covalent or Molecular Hydrides**:

These are the hydrides of p-block elements. Examples are CH_4, NH_3, H_2O and HF. Being covalent, they are volatile compounds. Molecular hydrides are further classified into 3 according to the relative numbers of electrons and bonds in their Lewis structure - (i) *electron-deficient*, (ii) *electron-precise* and (iii) *electron-rich hydrides*.

An electron-deficient hydride has very few electrons for writing its Lewis structure. E.g. Diborane (B_2H_6). All elements of group 13 will form electron-deficient compounds. They act as Lewis acids (i.e. they accept electron pairs).

Electron-precise compounds have the required number of electrons to write their Lewis structures. All elements of group 14 form such compounds (e.g., CH_4, SiH_4 etc.)

Electron-rich hydrides have excess electrons which are present as lone pairs. Elements of group 15 to 17 form such compounds. They behave as Lewis bases (i.e., electron donors).

3. **Metallic Hydrides**:

These are formed by many d-block and f-block elements. However, the metals of group 7, 8 and 9 do not form this hydride.

They are almost always nonstoichiometric, being deficient in hydrogen. They conduct heat and electricity. e.g. $LaH_{2.87}$, $YbH_{2.55}$, $TiH_{1.5–1.8}$, $ZrH_{1.3–1.75}$, $VH_{0.56}$, $NiH_{0.6–0.7}$, $PdH_{0.6–0.8}$ etc.

In these hydrides the hydrogen atom is occupied in the metal lattice. So they are also called ***interstitial hydrides***.

Due to the property of absorption of hydrogen on interstitial sites, they are widely used as hydrogenation catalysts.

WATER

Water is a liquid with high boiling point. This is due to extensive hydrogen bonding in water. On comparison to other liquid water has a higher specific heat capacity, thermal conductivity, surface tension, dipole moment, dielectric constant etc.Ice is the crystalline form of water. It has a highly ordered three dimensional hydrogen bonded structure. Hydrogen bonding gives its an open type structure with wide holes. So it has low density and floats on water. In winter season ice formed on the surface of a lake provides thermal insulation which ensures the survival of the aquatic life.

Hard and soft water

Water which does not easily form lather with soap is called hard water. It is due to the presence of calcium and magnesium salts in the form chlorides, sulphates and bicarbonates. Water free from soluble salts of calcium and magnesium is called soft water. It easily forms lather with soap.

Soaps are sodium or potassium salts of fatty acids like palmitic acid, stearic acid oleic acid etc. They react with calcium or magnesium salts presenting in hard water and form precipitates.

Types of hardness of water

There are two types of hardness of water – temporary hardness and permanent hardness.

I. Temporary Hardness

Hardness which can be removed by simple boiling is called temporary hardness. It is due to the presence of bicarbonate of calcium and magnesium. The following methods are used to remove temporary hardness.

1. ***Boiling***: During boiling, the soluble $Mg(HCO_3)_2$ is converted into insoluble $Mg(OH)_2$ and $Ca(HCO_3)_2$ is changed to insoluble $CaCO_3$, which can be removed by filtration.

   $Mg(HCO_3)_2 \longrightarrow Mg(OH)_2\downarrow + 2CO_2\uparrow$

   $Ca(HCO_3)_2 \longrightarrow CaCO_3\downarrow + H_2O + CO_2\uparrow$

2. ***Clark's method***: In this method calculated amount of lime is added to hard water. It precipitates out calcium carbonate and magnesium hydroxide which can be filtered off.

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

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

II. Permanent Hardness

Hardness which cannot be removed by boiling is called Permanent hardness. It is due to the presence of soluble chlorides and sulphates of calcium and magnesium in water. It can be removed by the following methods:

1. **Treatment with washing soda** (Sodium carbonate): Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates.

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

$MgCl_2 + 2Na_2CO_3 \rightarrow MgCO_3\downarrow + 2NaCl$

$CaSO_4 + 2Na_2CO_3 \rightarrow CaCO_3\downarrow + Na_2SO_4$

2. **Calgon's method**: Sodium hexametaphosphate ($Na_6P_6O_{18}$) is commercially called 'calgon'. When it is added to hard water, the Ca and Mg ions in hard water are replaced by Na^+ ions

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

$M^{2+} + Na_4P_6O_{18}^{\ 2-} \rightarrow [Na_2\,MP_6O_{18}]^{2-} + 2Na^+$

3. **Ion-exchange method**: This method is also called zeolite/permutit process. Zeolite /permutit is hydrated sodium aluminium silicate which can be written as NaZ. When this is added to hard water, exchange reactions take place.

$$2NaZ + M^{2+} \rightarrow MZ_2 + 2Na^+ \text{ (where M = Mg or Ca)}$$

Permutit/zeolite is regenerated for further use by treating with an aqueous sodium chloride solution.

$$MZ_2 + 2NaCl \rightarrow 2NaZ + MCl_2$$

4. **Synthetic resins method**: This method is more efficient than zeolite process. Pure demineralized water can be obtained by this method. Here the hard water is first passed through a cation exchange (acidic) resin which contains H^+ ions (H^+ Resin) and then through anion exchange (basic) resin which contains OH^- ions (OH^- Resin). The cations (Ca^{2+} and Mg^{2+} ions) present in hard water is exchanged with H^+ ion and the anions (Cl^- and SO_4^{2-}) are exchanged with OH^- ions.

$$H^+ \text{ Resin} + Ca^{2+} \longrightarrow Ca^{2+} \text{ Resin} + H^+$$

$$OH^- \text{ Resin} + Cl^- \longrightarrow Cl^- \text{ Resin} + OH^-$$

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

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