Subject: Chemistry
Class: XI
Chapter: Hydrogen
Top concepts

1. Hydrogen is the lightest element known since it has an atomic mass of 1.0079
2. Hydrogen resembles Group 1 elements because it has electronic configuration ($1s^1$) similar to alkali metals and can loose one electron to form unipositive ions
3. Hydrogen also resembles elements of group 17 (Halogens) because hydrogen just like halogens needs just one electron to acquire the configuration of the nearest noble gas i.e. Helium
4. Hydrogen has three isotopes - Protium, deuterium and tritium

Isotopes	No. of protons(p)	No. of neutrons(n)	No. of electrons(e)	Mass number (M)
Protium ($_1^1H$)	1	0	1	1
Deuterium($_1^2H$ or D)	1	1	1	2
Tritium $_1^3H$ or D	1	2	1	3

5. In elemental form Hydrogen exists as a diatomic molecule H_2 and is called dihydrogen

6. Water gas is name given to the mixture of carbon monoxide and hydrogen. Water gas is also called synthesis gas or syngas

7. The production of dihydrogen can be increased by reacting carbon monoxide of syngas mixtures with steam in the presence of iron chromate as catalyst. This reaction is called as water gas shift reaction

$$CO(g) + H_2O(g) \xrightarrow[\text{Catalyste}]{673\ K} CO_2(g) + H_2(g)$$

8. The process of producing 'syngas' from coal is called 'coal gasification'

$$C(s) + H_2O(g) \xrightarrow{1270\ K} CO(g) + H_2(g)$$

9. Physical properties of dihydrogen
   - Hydrogen is a colorless, odorless and a tasteless gas
   - Hydrogen is highly combustible

- Hydrogen is lighter than air
- Hydrogen is insoluble in water

10. The binary compounds of hydrogen with other elements are called hydrides

11. Ionic hydrides or Saline hydrides are binary compounds of hydrogen with s- block elements which are highly electropositive

12. Covalent or molecular hydrides are binary compounds of hydrogen with elements of comparatively high electronegativity such as p-block elements

13. Covalent hydrides are classified as electron rich, electron deficient or electron precise hydrides

- Electron rich hydrides have excess electrons than required to form normal covalent bonds. Excess electrons are present as lone pairs .Examples of this are hydrides of group 15, 16 and 17 such as ammonia, water etc.
- Electron deficient hydrides do not have sufficient number of electrons to form normal covalent bonds. Examples of this are hydrides of group 13
- Electron precise hydrides have required number of electrons to write the conventional Lewis structure. Elements of group 14 like carbon, silicon etc. form these types of hydrides

14. Metallic hydrides or Interstitial hydrides are the compounds of hydrogen with transition metals of group 3,4,5 of d-block, Cr metal of group 6, f-block element

15. Since the composition of metallic hydrides does not correspond to simple whole number ratio they are also called non-stoichiometric hydrides

16. Due to high polarity, water dissolves most of the polar substances

17. Due to hydrogen bonding water has high boiling point and high heat of vaporization

18. Density of water is more than that of ice

19. Water has maximum density ($1 g/cm^3$) at 4 ^oC

20. Water is amphoteric in nature because it has the ability to act as an acid as well as base

21. Autoprotolysis or self ionization of water: One water molecule acts as an acid by donating a proton to another water molecule which acts as a base. This is also called autoprotolyis of water

$$\underset{\text{(acid)}}{H_2O(l)} + \underset{\text{(base)}}{H_2O(l)} \rightleftharpoons \underset{\text{(conjugate acid)}}{H_3O^+(aq)} + \underset{\text{(conjugate base)}}{OH^-(aq)}$$

22. Water free from soluble salts of calcium and magnesium is called soft water

23. Water containing soluble salts of calcium and magnesium in form of hydrogen carbonate, chlorides and sulphates is called hard water

24. Temporary hardness in water is due to soluble salts of hydrogen carbonates of magnesium and calcium

25. Permanent hardness in water is due to soluble salts of chlorides and sulphates of calcium and magnesium

26. Methods to remove temporary hardness

- Boiling: During boiling soluble magnesium hydrogen carbonate is changed to magnesium hydroxide and calcium hydrogen carbonate on heating gets converted into calcium carbonate. Magnesium hydroxide and calcium carbonate being insoluble is filtered off

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

$$Ca(HCO_3)_2 \xrightarrow{\text{Heating}} CaCO_3 \downarrow + H_2O + 2CO_2 \uparrow$$

- Clark's method: Calculated amount of calcium hydroxide is added to a given amount of water. It precipitates out calcium as calcium carbonate and magnesium as magnesium hydroxide which can be filtered off

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

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

27. Methods to remove permanent hardness

- Treatment with washing soda (sodium carbonate) : Washing soda reacts with hard water forming insoluble metal carbonate which can be filtered and removed

$$MCl_2 + Na_2CO_3 \rightarrow MCO_3 \downarrow 2NaCl$$

(M =Mg, Ca)

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

- Calgon's method: Calcium and magnesium ions are rendered ineffective by addition of sodium hexa metaphosphate which is commercially known as Calgon

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

$$M^{2+} + Na_4P_6O_{18}^{2-} \xrightarrow{(M = Mg, Ca)} [Na_2MP_6O_{18}]^{2-} + 2Na^+$$

The complex anion keeps the Mg^{2+} and Ca^{2+} ions in solution

- Ion-exchange method: In this method ions responsible for hardness of water are exchanged by certain less damaging ions present in some chemical compound like sodium aluminium silicate ($NaAlSiO_4$) which can also be written as NaZ (also called as zeolites). When this is added in hard water, exchange reactions take place. Zeolite is said to be exhausted when all the sodium in it is used up. It is regenerated for further use by treating with an aqueous sodium chloride solution

$$2NaZ\ (s) + M^{2+}(aq) \rightarrow MZ_2(s) + 2Na^+(aq)$$

(M =Mg, Ca)

$$MZ_2(s) + 2NaCl(aq) \rightarrow 2NaZ(s) + MCl_2(aq)$$

- Synthetic resins method: These are insoluble polymeric solids having giant hydrocarbon network containing reactive acidic or basic groups. They perform function similar to zeolites but they are superior to zeolites because they can remove all types of ion in water.

28. Hydrogen peroxide can act as oxidizing agent as well as reducing agent in both acidic and alkaline medium

29. Commercially, hydrogen peroxide is generally sold as its percentage solution. For example 10 volume of hydrogen peroxide means that 1 liter of this hydrogen peroxide solution will give 10 liter of oxygen at STP

30. Hydrogen peroxide decomposes to form water and oxygen, on exposure to sunlight. Hence it is stored in wax-lined glass or plastic vessel

31. D_2O is called heavy water. It is manufactured by electrolytic enrichment of normal water. It is used as moderator in nuclear reactor.