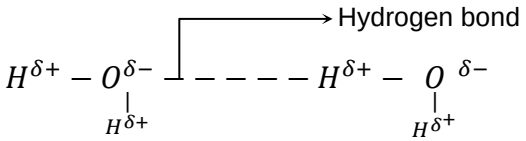
HYDROGEN BOND:

Weak electrostatic attraction between hydrogen & more electronegative atom (F, O, N) is called hydrogen bond.

- Due to difference in electronegativity more electronegative atom develops partial negative charge and less electronegative atom develops partial positive charge.
- (H - bond forms) thus, H - bond is formed between partial positively charged H_2 & partial negatively charge electronegative atom.



H - bond is denoted by a broken line (.....).

- It was proposed by Moore & Winmill
- H - bond is the imprisonment of H_2 between two electronegative atoms.
- In H - bond, H is sandwiched between two electronegative atoms.
- In H - bond, H exhibits a valency of 2.
- H - bond is formed by molecules or ions where H is covalently bonded to more electronegative & smaller atoms like F, O, N.
- Identify the molecules which exhibit H - bond in following :

  HF, H_2O, NH_3, HCl, HI, C_2H_5OH,

  $C_2H_5–O–C_2H_5$, $C_2H_5 – NH_2$, $(CH_3)_2$ NH, $(CH_3)_3N$

  Strength of H-bond depends on size & electronegativity of bonding atom.
- Among HF, H_2O, HI; the strongest H - bonds are formed by HF molecules.
- Which of the following is strongest H - bond

  1) H – F …….. H – F
  2) H – OH …… H – OH
  3) H – NH – H ….. NH - H
     |
     H

  Order of strength of hydrogen bond is

  H ..... F > H .....O > H ..... N
- When compared to covalent bond hydrogen bond is weaker, but longer i.e., higher bond length. The bond energy of covalent bond is 400 KJ/ mole & that of H ⍰ bond is 40KJ/mole

  H $\underline{IA^0}$ O (covalent bond)

  H $\underline{1.76A^0}$ O (Hydrogen bond).
- Even though N, Cl have same electronegativities; NH_3 forms H-bonds, HCl does not form H - bond because Nitrogen is smaller & chlorine is larger in size.

Types of H bonds :

Intermolecular H – bonds :

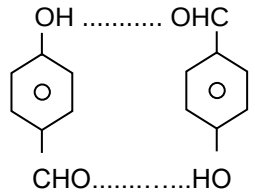
H - bond is formed between two same molecules or different molecules i.e., H-bond between H of one molecule & more electronegative atom of another molecules

Eg :

$H–F^{\delta-}……H^{\delta+}–F$ NH_3, RNH_2, R_2NH, ROH

$H^{\delta+}$ - $O^{\delta-}$ H … $O^{\delta-}$ H Carboxylic acids, Glucose, fructose,

Para-nitrophenol, para chlorophenol Parahydroxy benzal dehyde

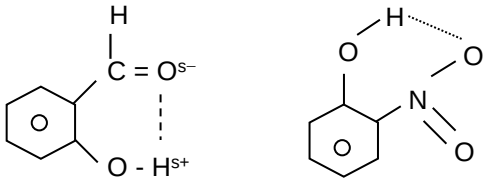


Intramolecular H - bond :

H- bond is formed with in the same molecule i.e., H-bond between δ^+ Hydrogen and δ^- atom both belonging to same molecule

Eg.: Orthohydroxy benzaldehyde (salicylaldehyde) orthohydroxy benzoic acid (salicylic acid) orthonitrophenol, orthoflurophenol, etc.

Salicyaldehyde Orthonitrophenol



Effect of H - bonding: (Intermolecular)

Due to H - bonding,

1) Molecular association increases
2) Melting & boiling points increase
3) Voltaile nature decreases
4) Solubility in water increase
5) Physical state may change

The above effects are observed in case of intermolecular H-bonding but not in the case of intramolecular H-bonding.

Examples :

IV A group hydrides.	V A group Hydrides
CH_4	NH_3
SiH_4	PH_3
GeH_4	AsH_3
SnH_4	SbH_3
PbH_4	BiH_3

Though, molecular weight of NH_3 is less, its BP is much higher than those of PH_3, ASH_3 because of
H - bonding.

VI A group hydrides	VII A group hydrides
H_2O (High BP)	HF (High BP)
H_2S	HCl
H_2Se	HBr
H_2Te	HI
H_2Po	

Though molecular weight of H_2O is least its BP is highest than other hydrides of group due to H-bonding Though molecular weight of HF is least, its BP is highest than all others due to H-bonding

- Two ice cubes can be pressed over each other due to formation of H- bond.
- H_2O is liquid while H_2S is gas due to H- bonding in H_2O. Each water molecule can form four H - bonds on an average
- Certain covalent substances like glucose, fructose, sugar, urea, alcohol, amines, carboxylic acids are soluble in water due to H - bonding
- Orthonitrophenol is more volatile because it forms Intra □ molecular H - bonds.
- Paranitrophenol is less volatile because it forms Inter □ molecular H- bonds.
- Orthohydroxy benzaldehyde (salicylaldehyde) is more volatile & forms Intra-molecular H-bonds while parahydroxy Benzaldehyde is less volatile because of Inter □ molecular H □ bonding
- Certain subatances like acetic acid, benzoic acid will exist as dimers Hydroflouric acid will exist in dimerform due to H-bonding (H_2F_2)
- Generally, H□ bonds are formed in solid & liquid state. But, HF can form H-bonds even in vapour state.

Though HF forms strongest H bonds & has high molecular weight than that of H_2O, the B.P of HF is very less when compared to B.P of H_2O. It is due to

1) H_2O forms double the number of H - bonds than HF.
2) HF can form H - bonds even in vapour state & exists as clusters $[(HF)_6]$ in vapour state.

Thus, it is not necessary to break all H - bonds in HF to vapourise it.