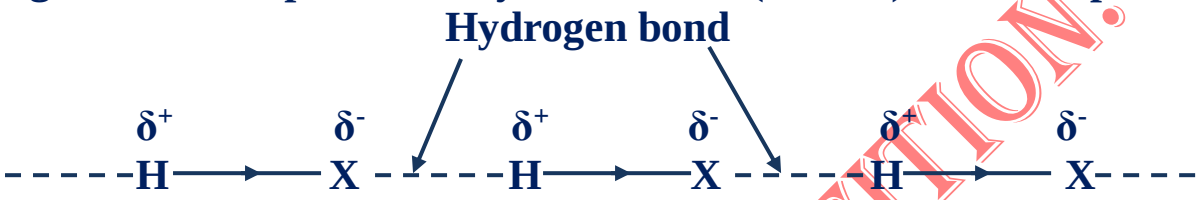
By-Shailendra Shukla Sir

Hydrogen Bonding

When hydrogen atom is covalently bonded with highly electronegative atoms, such as F, O or N, then shared election pair gets shifted towards more electronegative bonded atom. Thus, electronegative atom acquire partial negative charge while hydrogen atom acquire partial positive change. This positively charged hydrogen attracts electronegative atom of same or different molecule and forms a weak bond called hydrogen bond and this phenomenon is called hydrogen bonding.

Hydrogen bond is represented by dotted lines (---------).For example,



Here, X = F, O or N

In hydrogen bonding, hydrogen atom acts like bridge between two highly electronegative atoms, hence, it is also called hydrogen bridging. Here, hydrogen atom doesn't lie just middle of the two highly electronegative atoms, but it is close to the atom to which it is bonded with covalent bond and is farther from the atom to which it is bonded with hydrogen bond.

Conditions of hydrogen bonding

Following are two important conditions of hydrogen bonding-

(1) Hydrogen atom should be covalently bonded with highly electronegative atoms such as F, O or N.

(2) The atomic size of the electronegative atom should be smaller.

The larger the electronegativity of electronegative atom, the more stronger is the hydrogen bond formed. Similarly, if atomic size of the electronegative atom is smaller, the hydrogen bond formed is stronger.

Types of hydrogen bonding

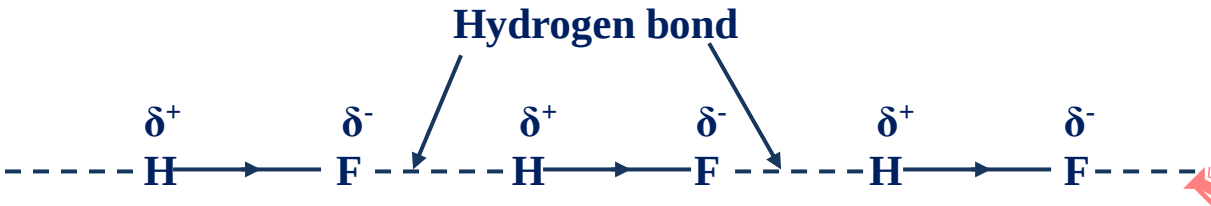
Hydrogen bonding may be of following two types-

(1) Inter-molecular Hydrogen bonding- If hydrogen bond is formed between hydrogen atom of one molecule and electronegative atom of another molecule of same or different substance, then it is called inter-

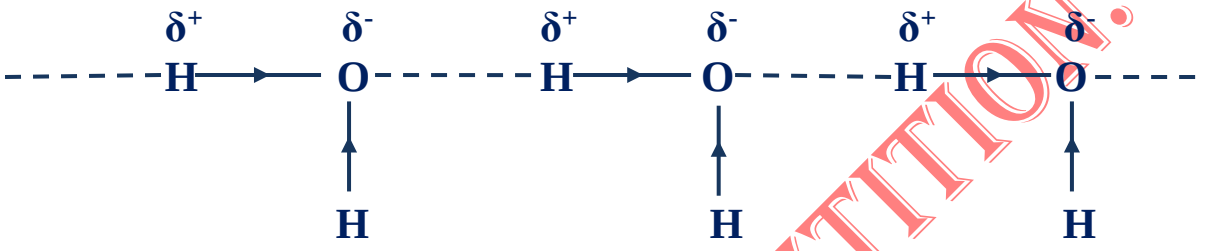
CHEMISTRYFORCOMPETITION.COM

molecular hydrogen bond and this phenomenon is called inter-molecular hydrogen bonding. For example,

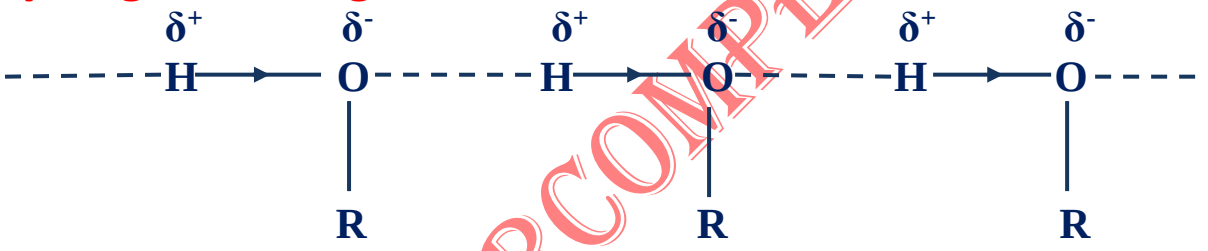
(1) Hydrogen bonding in HF



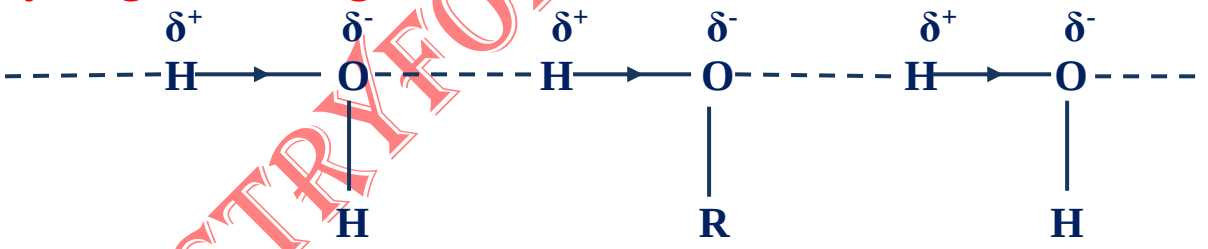
(2) Hydrogen bonding in water



(3) Hydrogen bonding in alcohols



(4) Hydrogen bonding in water and alcohols

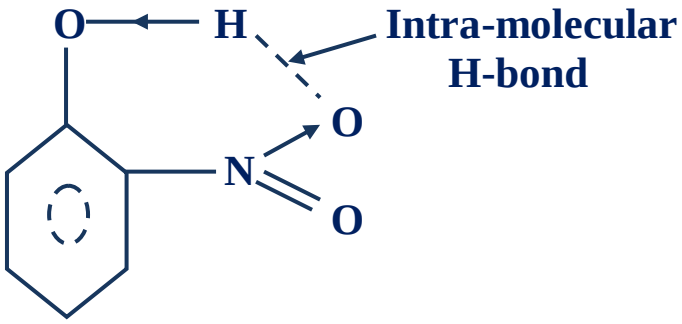


Intermolecular hydrogen bonding causes association of molecules and therefore, it affects the physical properties of the substances to the large extent. However, it has negligible effect on the chemical properties of the substances.

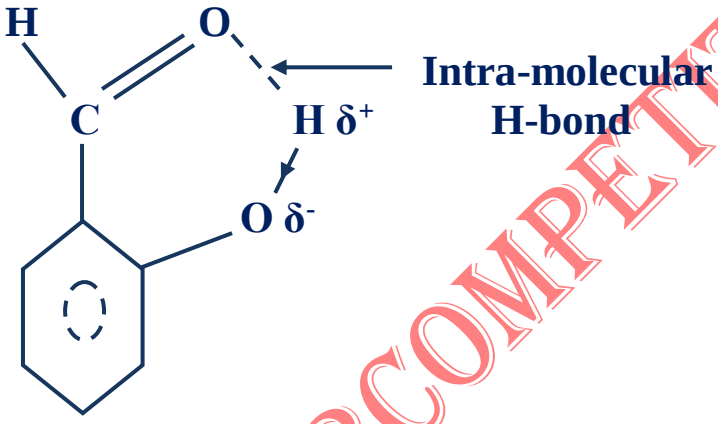
(2)Intra-molecular Hydrogen bonding- If hydrogen bond is formed within the molecule, then it is termed as intra-molecular hydrogen bond and this phenomenon is called intra-molecular hydrogen bonding. Here, hydrogen atom of one group forms hydrogen bond with electronegative atom of another group of same molecule. For example,

CHEMISTRYFORCOMPETITION.COM

(1) Hydrogen bonding in ortho nitro phenol



(2)Hydrogen bonding in ortho hydroxy benzaldehyde (Salicylaldehyde)



Intra-molecular hydrogen bonding causes cyclization of molecules called chelation and therefore, it has negligible effect on the physical properties of the substances. However, it affects the chemical properties of the substances to some extent.

Consequences of hydrogen bonding

(1) Effect on physical state of substances-Inter molecular hydrogen bonding causes association of molecules and therefore, affects the physical state of substances to a large extent. For example, HF is liquid at room temperature while, HCl is gas. In fact, HF involves inter-molecular hydrogen bonding and therefore, exist as associated liquid at room temperature.

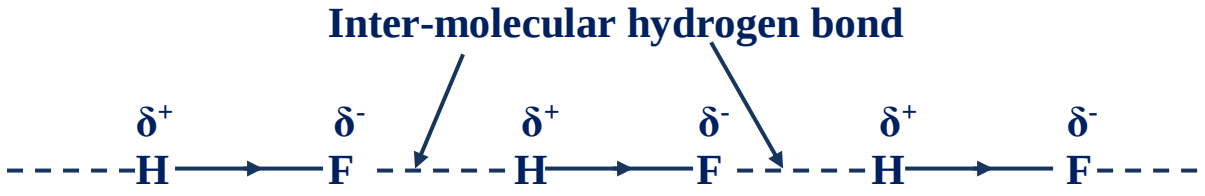


Fig.- Inter-molecular H-bonding in HF

CHEMISTRYFORCOMPETITION.COM

On the other hand, due to relatively bigger atomic size and lesser electronegativity of chlorine atom, HCl does not involve inter-molecular hydrogen bonding and therefore, exist as gas at room temperature.
Similarly, H_2O is liquid at room temperature while, H_2S is gas. In fact, H_2O involves inter-molecular hydrogen bonding and therefore, exist as associated liquid at room temperature.

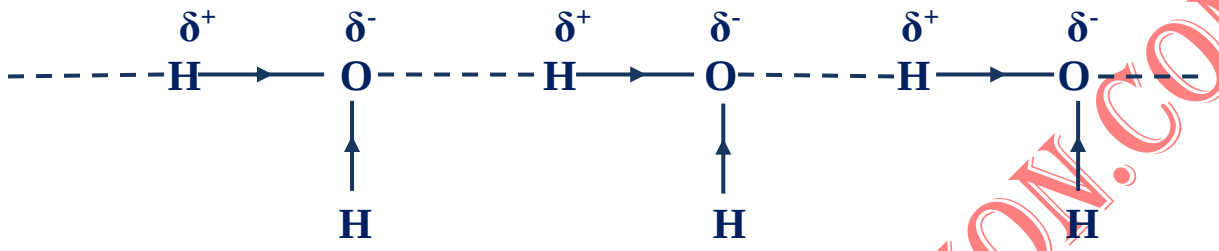


Fig.- Inter-molecular H-bonding in water

On the other hand, due to relatively bigger atomic size and lesser electronegativity of sulphur atom, H_2S does not involve inter-molecular hydrogen bonding and therefore, exist as gas at room temperature.

(2) Increase of melting and boiling points

Due to inter-molecular hydrogen bonding, additional inter-molecular attraction operates amongst the molecules. Hence, melting and boiling points of substances gets increased. For example, boiling point of alcohols is higher than haloalkanes of comparable molecular mass.
In fact, alcohols involve inter-moleculer hydrogen bonding and therefore, have relatively higher boiling points.

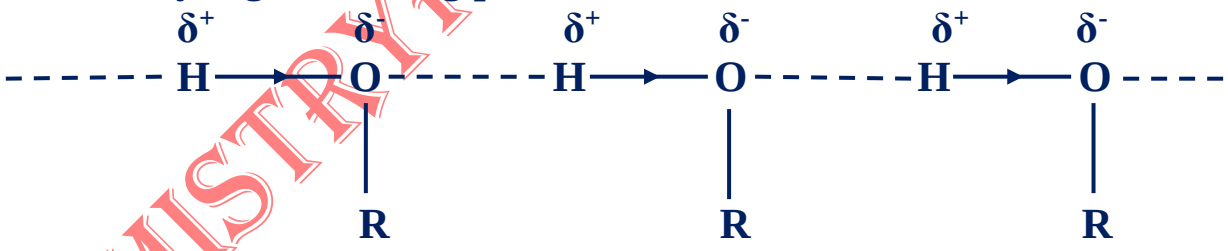


Fig.- Inter-molecular Hydrogen bonding in alcohols

On the other hand, haloalkanes do not involve inter-molecular hydrogen bonding and therefore, they have relatively lesser boiling points.

(3) Effect on water Solubility

In general, organic substances are insoluble in water. However, those organic substances which from inter-molecular hydrogen bond with water are soluble in water. For example, alcohols from inter-molecular hydrogen bond with water and therefore, they are soluble in water.

CHEMISTRYFORCOMPETITION.COM

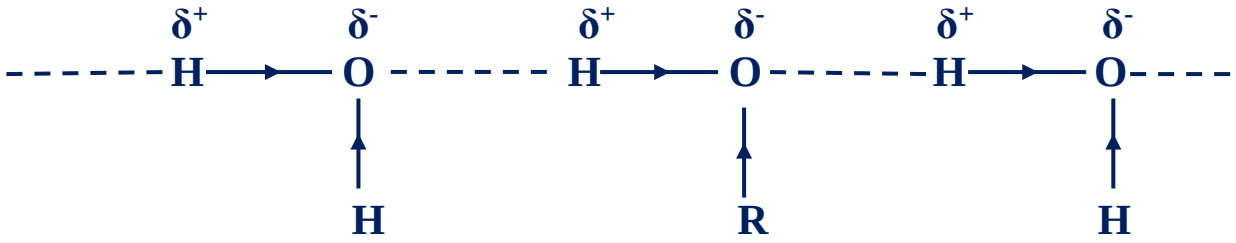


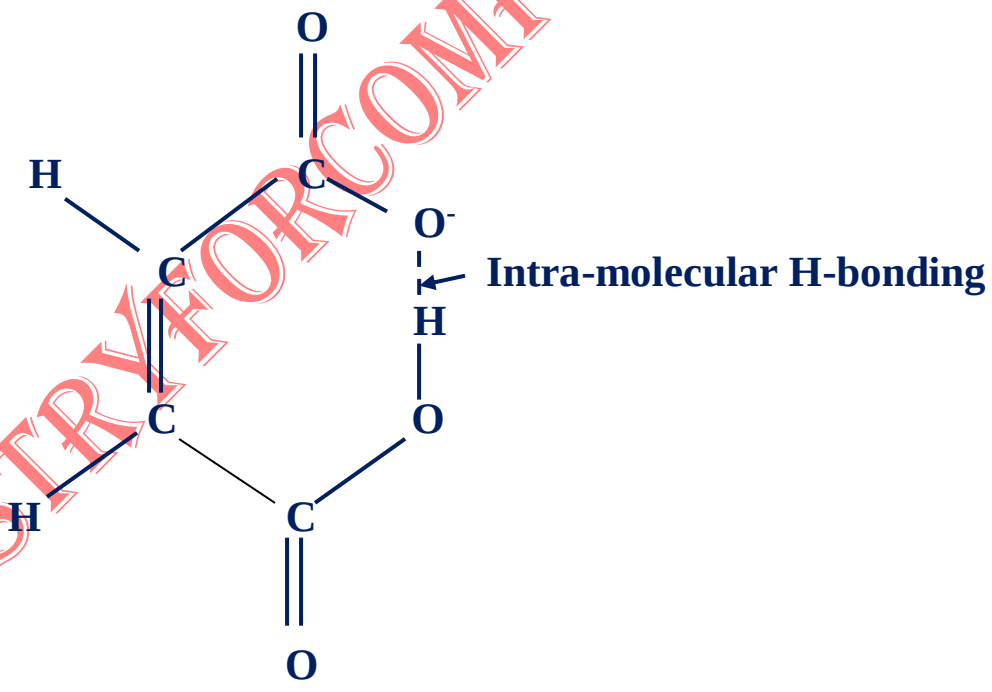
Fig.- Inter-molecular hydrogen bonding in water and alcohols

On the other hand, haloalkanes do not form inter-molecular hydrogen bond with water and therefore, are insoluble in water.

Consequences of Intra-molecular H-bonding

(1) Effect on acidic strength of maleic and fumeric acids

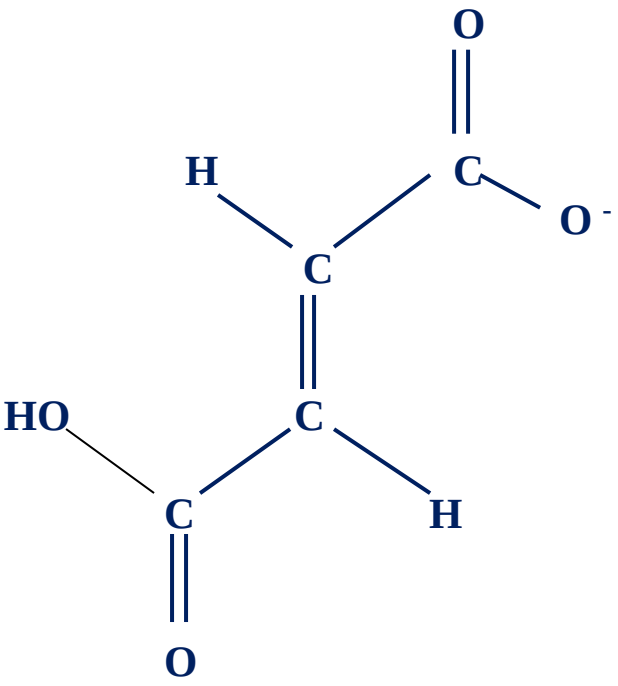
The acidic strength of maleic acid is found to be more than that of the fumeric acid. It is because, after removal of a proton, the anion formed in case of maleic acid gains stability by intra-molecular hydrogen bonding.



Intra-molecular H-bonding in maleate ion

No such intra-molecular hydrogen bonding is possible in case of anion obtained from fumeric acid.

CHEMISTRY FOR COMPETITION.COM



Fumerate ion (intra-molecular hydrogen bonding is not possible)

Hence, maleic acid has more tendency to remove proton to form maleate ion and its acidic strength is relatively high.

Download Mobile App -"Exacademy" from App Store
Download pdf at- https://chemistryforcompetition.com/
or
https://exacademy.in/
For Video Lectures Visit- "Exacademy" YouTube Channel

CHEMISTRY FOR COMPETITION.COM