Intermolecular forces.

In an ionic compound, the structural units are ions. These ions are held together by very powerful electrostatic forces are known as inter ionic forces. On the other hand, in non-ionic (covalent) compounds, the structural units are molecules. These molecules are held together by very weak forces are known as **intermolecular forces or secondary forces**. Secondary forces are of the following types,

(1) Dipole – dipole forces.

(2) Van der Waal's forces.

(3) Hydrogen bond.

(1) **Dipole – Dipole Forces:** These forces exist between polar molecules which have permanent dipoles. The interactions of the **permanent dipole** in different molecules are called **dipole-dipole forces (DF).** Magnitude of DF depends on the dipole moment (μ) of the bond of the compound and intermolecular distance (d), $DF \propto \mu \propto \frac{1}{d^4}$ (i.e. these forces are effective only over short distance)

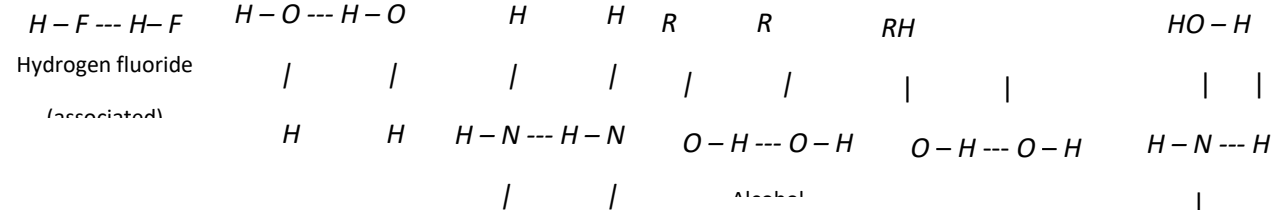
Example $\xrightarrow[d \text{ in increasing order, } \mu \text{ in decreasing order and DF also in decreasing order}]{CH_3-Cl,\ \ CH_3-Br,\ \ CH_3-I}$

(2) **Vander Waal's forces:**These forces exist between non-polar molecules. The intermolecular electrostatic attractions between nuclei of one molecule and electrons of the other molecule are called **Vander Waal's forces (VF)**. Magnitude of VF depends on the number of electrons (e^-) and protons (p) in the molecule as well as on the intermolecular distance (d),

VF $\propto$ number of e^- and p; $\propto 1/d^7$; $\propto$ MW; $\propto$ Surface area of the molecule and $\propto$ Symmetry of the molecule (symmetry of molecule decreases intermolecular distance (d)).

(3) **Hydrogen bonding:** An electrostatic attractive force between the covalently bonded hydrogen atom of one molecule and an electronegative atom (such as F, O, N) of the other molecule is known as **hydrogen bonding**.

Examples of H-bonding in between the two molecules of same or different compounds are



Nature and Importance of Hydrogen bonding

(i) Hydrogen bond is merely an electrostatic force rather than a chemical bond.

(ii) Hydrogen bond never involves more than two atoms.

(iii) Bond energy of hydrogen bond is in the range of 3 to 10 kcal/mol or 10 to 40 kJ/mol, i.e., about $1/10^{th}$ the energy of a covalent bond.

(iv) With the increase of electronegativity of the atom to which hydrogen is covalently linked, the strength of the hydrogen bond increases.

(v) All the three atoms in X – H- - - X lie in a straight line.

(vi) The bond length of hydrogen bond is of the order of 250 to 275 pm.

The relative order of these intermolecular forces is,

Hydrogen bonding > dipole-dipole forces > Vander Waal's forces.