In contrast to intramolecular forces, such as the covalent bonds that hold atoms together in molecules and polyatomic ions, intermolecular forces hold molecules together in a liquid or solid.

Characteristics of Intermolecular forces:

(1) These are electrostatic in nature means they arise from the interaction between positively and negatively charged species.

(2) These are sum of both attractive and repulsive components.

(3) These forces increase as distance between molecule decreases and decrease as distance between molecule increases.

(4) These are weaker than covalent or ionic bonds

(5) Heat required to break Intermolecular forces range ~~from~~ upto 50 kJ/mol where as covalent bonds need 50 — 250 kJ/mol.

(6) Intermolecular forces control many properties of solids and ~~gas~~ liquids like
(a) Boiling point
(b) Melting point
(c) Vapour pressure
(d) Viscosity.

These forces become important for gases only at very high pressures, where they are responsible for the observed deviations from the ideal gas law at high pressures.

Types of Intermolecular forces:

(1) Dipole – dipole: These types of interactions occur between polar molecules. A polar molecule is a molecule where centre of negative charge density does not coincide with centre of positive charge density, it means certainly this molecule has ~~going~~ two or more than two atoms of different electronegativity e.g H_2O, C_2H_5OH.

Polar molecules are represented as oval structures:

(δ^- δ^+) (δ^- δ^+)

The opposite charges attract and these molecules remain attracted towards each other.

Among $CH_3OCH_2CH_3$, $CH_3-\underset{\displaystyle CH_3}{CH}-CH_3$ (with CH_3 written above CH), $CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$

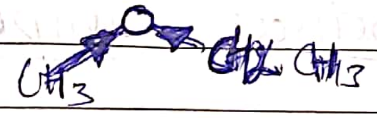
which has more boiling point among each other.

So we have to consider their molar masses and polarities.

Molar masses of all the three are comparable so only polarities will decide the boiling point.

In 2-methyl propane there is no electronegative atom so it is least polar among three as rest two have oxygen.

Ethyl methyl ether has structure similar to H_2O



two C-O bond dipoles reinforce one another and generate significant dipole moment which give high boiling point.

In acetone C=O double bond is oriented at about 120° to two methyl groups (non-polar C-H bonds). Dipole moment of this C=O bond is high so

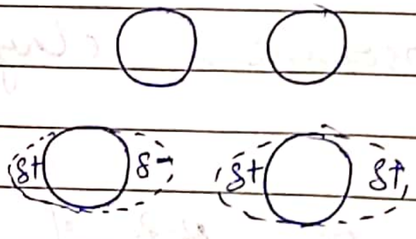
B.P.
2-methylpropane < ethyl methyl ether < acetone.

You can compare B.P. of CF_4, $CH_3SC_2H_5$, $(CH_3)_2S{=}O$ and $CH_3-\underset{\displaystyle CH_3}{\underset{|}{C}}-CH_2CH_3$ on your own.

2. London forces: Many nonpolar molecules are liquids like Br_2, benzene, hexane etc are liquids at room temperature and others such as iodine, naphthalene etc are solids at room temperature. Even noble gases can be liquefied or solidified at low temperatures, high pressures or both. Now Question arises that what kind of forces exist between nonpolar molecules or atoms?

Fritz London answered this question. According to him temporary fluctuations in electron distributions within atoms and nonpolar molecules result in the formation of short-lived instantaneous dipoles which result in attractions between the molecules. These attractive forces are called London forces.

Consider two nonpolar molecules:

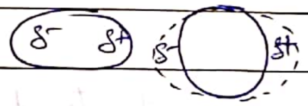


Interactions between these temporary and instantaneous dipoles cause molecules to attract each other. But these attractive forces are weak and fall off rapidly with increasing distance.

These are also called instantaneous dipole - induced dipole interactions.

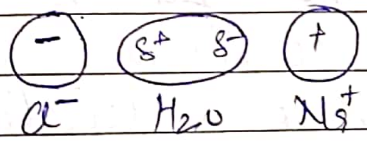
The above two intermolecular forces are also called Vaander Waal forces.

3. Dipole — Induced dipole interactions: These interactions take place between polar and nonpolar molecules.



4. Dipole— ion attractions: These take place between polar molecule and ion.

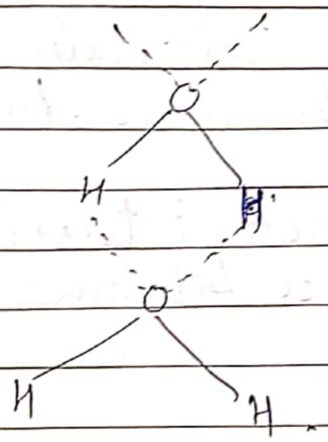
e.g dissolution of NaCl in polar H_2O.



5. Hydrogen bonding: H-bonding is strongest among all of intermolecular forces. Molecules where hydrogen atoms are bonded to electronegative atoms (O, N, F and to lesser extent Cl, S) tend to exhibit unusually strong intermolecular interactions. Large difference between electronegativity of hydrogen and other atom results in a large partial positive charge on hydrogen and a correspondingly large partial negative charge on the other atom (O, N, F). So these bonds have high dipole moment. As hydrogen ~~at~~ atom is small so these dipoles

can approach one another more closely than

H-bond is shown by dotted lines:



Now we will understand the role of intermolecular forces in behaviour of gases.
All gases do not obey ideal gas equation at under all conditions of temperature and pressure. So no gas is ideal gas. So all gases are considered as real gases. These real gases show deviations from ideal gas equation.

Now first we should ~~first~~ understand ideal gas equation briefly.

$$PV = nRT$$

where P is pressure, V is volume, n is number of moles, R is gas constant and T is temperature.
This ideal gas equation has been derived on the basis of kinetic theory of gases. Kinetic theory gases has many postulates but two important postulates are: