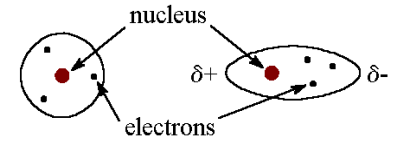
# INTERMOLECULAR FORCES

The attractions that hold atoms together in a compound or within some non-metallic elements (like $H_2$, $P_4$, $S_8$, $Cl_2$ etc.) Are called intramolecular forces, inside one molecule, ionic, covalent, and metallic are examples. There are also forces of attraction between molecules that affect things like an element or compound's state of matter at room temperature. These are intermolecular forces, forces between molecules.

There are 3 types of intermolecular forces that can determine the phase of a substance at a certain temperature:

1. LONDON DISPERSION FORCES (LDF)

Since electrons move, there will be some times when more electrons would be in one part of the energy levels of the atom. This sets up a temporary dipole, where parts of the atom are slightly negative and the other parts are slightly positive. Since like charges repel and opposites attract, this temporary dipole will cause a chain reaction in neighbouring molecules.




symmetrical distribution | unsymmetrical distribution

This general rule of LDF which exists between all molecules, but at differing strengths is:

** the greater the number of electrons in a molecule, the greater the LDF between them

** when the number of electrons between molecules is the same, the molecules with the greater complexity will have a greater LDF

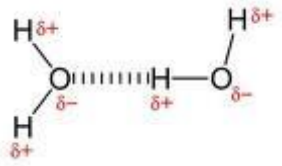
2. Dipole-Dipole (DD)

In molecules that are polar (their electronegativities are different), some parts of the molecule may be permanently more negative and more positive.

There are forces, called dipole-dipole that set up between all polar molecules. (Of course, they also have LDF) This would cause a stronger attraction than LDF alone, causing a higher boiling point in the compound.

3. Hydrogen Bonding (HB)

If the molecule contains hydrogen bonded to highly electronegative atoms like fluorine, oxygen, or nitrogen; this produces a strong attraction between molecules. This causes these compounds to have higher boiling points. (Of course, all of these would also have dipole-dipole and LDF)




To remember that hydrogen-bonding occurs when hydrogen bonds with either **fluorine** or **oxygen** or **nitrogen**, remember H-bonding is lots of **FON**!

**STRENGTHS OF FORCES AND MAKING PREDICTIONS:**

Based on the relative strengths of intermolecular and intramolecular forces we can make predictions about the properties of substances. Keep in mind there are many exceptions, but we can draw some generalizations.

Generalizations from strongest to weakest:

1. Substances with network covalent bonding (network solids) have the highest melting and boiling points and are the hardest common substances (diamond, silicon carbide, silicon dioxide)

2. Both ionic compounds and metals can tie for second, unless it is a weaker metal, like group IA or IIA.

3. Regular molecular compounds ( not network covalent) are the weakest, but there are differences according to what intermolecular forces are present in the compounds:

    a) strongest of these is hydrogen bonding (with the dipole-dipole and LDF)

    b) next would be the molecules that are polar, but have no hydrogen bonding (but of course they have LDF)

    c) last would be the molecules that are not polar, and have only LDF. Remember, the more electrons, the stronger the LDF strength. If the molecules are **isoelectronic** (same number of electrons) compare how complex they are, the larger the molecule, the more LDF strength.

Typical question on exam:

List in order of increasing boiling point, with reasons: NaBr, $C_2H_5OH$, SiC, $C_3H_8$, $C_2H_5F$

Answer, put them in general order:

weakest, all the molecular compounds: $C_2H_5OH$, $C_3H_8$, $C_2H_5F$
next ionic compounds and metals: NaBr, no metals listed
strongest (network covalent) SiC

Now closely examine the molecular compounds, pick out the ones that are non-polar, these have only LDF and are the weakest. $C_3H_8$ is non-polar

The two polar molecules are $C_2H_5F$ and $C_2H_5OH$, but only the ethanol has hydrogen bonding (see how the molecule is written, the O is attached to a separate H)

So in order from weakest to strongest: $C_3H_8$, $C_2H_5F$, $C_2H_5OH$, NaBr, SiC