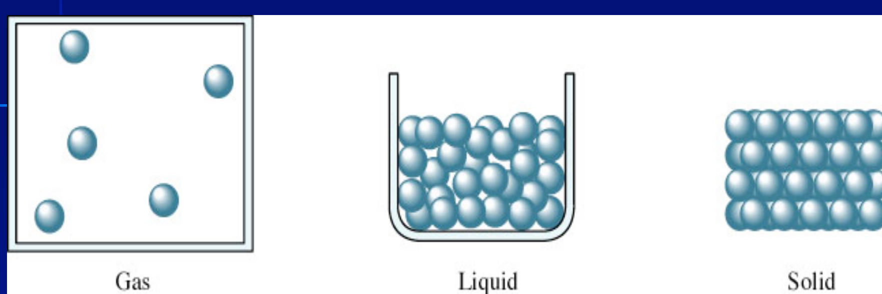
INTERMOLECULAR FORCES

LIQUIDS & SOLIDS



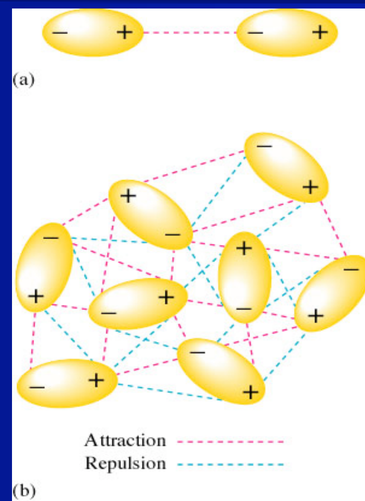
Now it is time to consider the forces that condense matter.

These can be due to ionic or covalent bonding [intramolecular forces — ionic stronger than covalent] or much weaker attractive forces we call intermolecular forces. These are the forces ***between*** (rather than within) molecules.

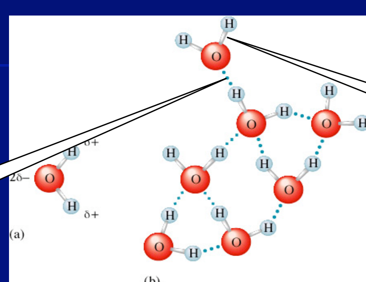
We briefly visited the IMF’s earlier when discussing the nonideal behavior of gases. These forces cause changes of state by causing changes among the molecules, NOT within them.

Dipole-Dipole IMF's

Molecules with dipoles orient themselves so that "+" and "-" ends of the dipole are close together.

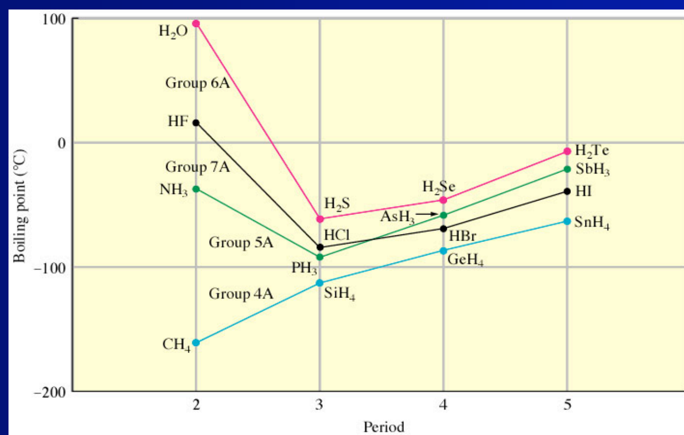


Hydrogen Bonds



Dipole-dipole attraction in which hydrogen on one molecule is attracted to a highly electronegative atom on an adjacent molecule. (F, O, N)

WHY is there such variation among the covalent hydrides of groups IV through VII?



One would expect that BP would increase with increasing molecular mass [since the more electrons in a molecule, the more polarizable the cloud {more about that in the next section}, the stronger the IMF's, the more E needed to overcome these attractions and vaporize].

Hydrogen bonding, That’s why!

TWO Reasons

Both reasons enhance the IMF we refer to as hydrogen bonding.

1. The lighter hydrides have the highest En values which leads to especially polar H-X bonds.

2. The small size of each dipole allows for a closer approach of the dipoles, further strengthening the attractions.

London Dispersion Forces Weakest IMF's

Relatively weak forces that exist among noble gas atoms and nonpolar molecules. (Ar, C_8H_{18})

Caused by instantaneous dipole formation, in which electron distribution becomes asymmetrical.

The newly formed dipoles now find each other FAR more attractive than before!

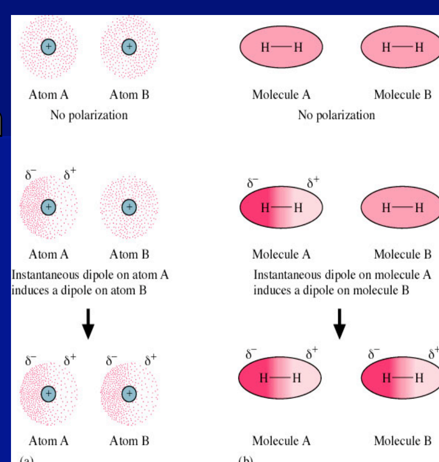
a.k.a.

Dipole-induced dipole if an *ion or polar molecule* causes the distortion.

OR

Induced dipole-induced dipole if a *nonpolar moleule* sets off the chain reaction of induction like in iodine.

The ease with which the electron "cloud" of an atom can be distorted is called **polarizability**. You'll want to write about polarizability when EXPLAINING these concepts.



Without these forces, we could not liquefy covalent gases or solidify covalent liquids.

Consider the halogens…

These forces INCREASE as we go down the family since the electron cloud becomes more polarizable with increasing FW [more principle E levels added, more electrons present, more shielding, valence farther from the nucleus, etc.].

It explains WHY F_2 and Cl_2 are gases, Br_2 is a liquid [moderate dispersion forces a.k.a. London forces, a.k.a. dipole-induced dipole forces] and ultimately I_2 is a solid!

What does that tell us about boiling points??

Which substance has the higher boiling point?

a) NH_3 or CH_4?
b) CH_4 or CCl_4?
c) NaCl or Cl_2 ?

Which substance has the higher boiling point?

a) NH_3 or CH_4?

NH_3 is polar, while CH_4 is nonpolar. Ammonia has hydrogen bonding attractive forces and dispersion forces, while methane has only dispersion forces The attractive forces are stronger in ammonia, so ammonia has a higher boiling point.

Which substance has the higher boiling point?

b) CH_4 or CCl_4?

Both CH_4 or CCl_4 are nonpolar with the only intermolecular attractive force is dispersion forces. Since Cl has more electrons compared to H CCl_4 is more polarizable compared to CH_4. The more polarizable the stronger the dispersion forces the higher the boiling point.

Which substance has the higher boiling point?

c) NaCl or Cl_2 ?

NaCl is an ionic compound with ionic bonding, while chlorine is a covalent molecule with only dispersion intermolecular attractive forces. Ionic bonds are very strong intraparticle forces compared to any intermolecular attractive forces, so NaCl has the higher boiling