Attractive Forces: Bonds and Intermolecular Forces

Forces binding atoms in a molecule are due to **chemical bonding**. The energy required to break a bond is called the **bond-energy**. For example the average bond-energy for O-H bonds in water is 463 kJ/mol. On average, 463 kJ is required to break 6.023×10^{23} O-H bonds, or 926 kJ to convert 1.0 mole of water into 1.0 mol of O and 2.0 mol of H atoms.

The forces holding molecules together are generally called **intermolecular forces**. The energy required to break molecules apart is much smaller than a typical bond-energy, but intermolecular forces play important roles in determining the properties of a substances. Intermolecular forces are particularly important in terms how molecules interact and form biological organisms or even life.

Classifying Attractive Forces – bonds and IMF's

In general, attractive forces can be divided into several categories. The division into types is for convenience in their discussion. Of course all types can be present simultaneously for many substances. The prominent types are:

Strong: ionic bond
Recall lattice energy and its relations to properties of solid. The more ionic, the higher the lattice energy. Examine the following list and see if you can explain the observed values by way of ionic attraction:
LiF, 1036; LiI, 737; KF, 821; MgF_2, 2957 kJ/mol.

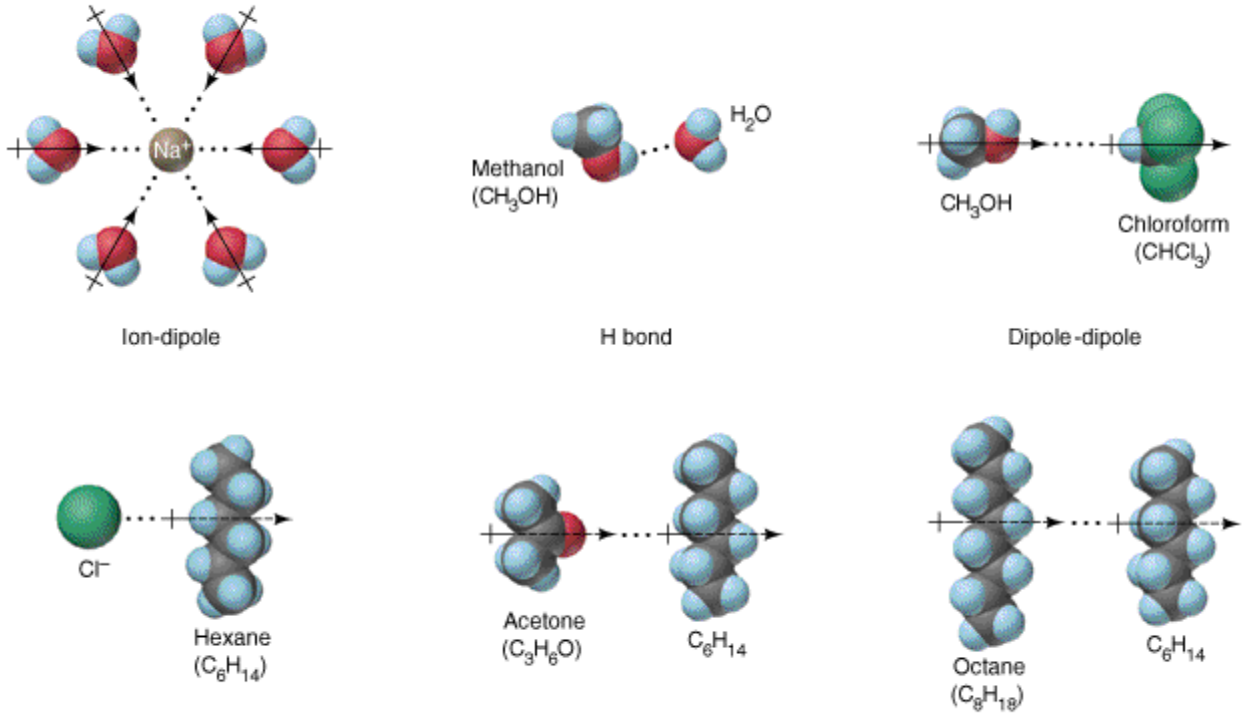
Strong: Covalent bonding
Covalent is really intramolecular force rather than intermolecular force. It is mentioned here, because some solids are formed due to covalent bonding. For example, in diamond, silicon, quartz etc., the all atoms in the entire crystal are linked together by covalent bonding. These solids are typically hard and have high melting points. Covalent bonding holds atoms tighter than ionic attraction.

Strong: Metallic bonding
Forces between atoms in metallic solids belong to another category. Valence electrons in metals are rampant. They are not restricted to certain atoms or bonds. Rather they run freely in the entire solid, providing good conductivity for heat and electric energy. The behavior of these electrons give special properties such as ductility and mechanical strength to metals.

Hydrogen bond
Certain substances such as H_2O, HF, NH_3 form hydrogen bonds, and the formation of which affects properties (mp, bp, solubility) of substance. Other compounds containing OH and NH groups also form hydrogen bonds. Molecules of many organic compounds such as alcohols, acids, amines, and amino acids contain these groups, and thus hydrogen bonding plays an important role in biological science.

Intermediate: dipole-dipole and ion-dipole forces
Substances whose molecules have dipole moment have higher melting point or boiling point than those of similar molecular mass, but their molecules have no dipole moment.

Weak: London dispersion forces
These forces always operate in any substance. The force arises from induced dipoles and the interaction is weaker than the dipole-dipole interaction. In general, the more electrons present in the molecule, the more "polarizable" the substance's electron cloud it, the stronger the London forces of interaction. For example, the boiling points of inert gases increase as their atomic number increases due to an increase in their polarizability, a direct function of their having more electrons, making for stronger London dispersion interactions.



See if you can answer the following questions.

What are dipoles?

How do dipoles interact?

Why do molecules attract one another?

How do London dispersion forces come about?

What parameters cause an increase of the London dispersion forces?

What is a hydrogen bond?

What chemical groups are hydrogen acceptors for hydrogen bonds?

Which of the following molecules have a permanent dipole moment?

a. H_2O b. CO_2 c. CH_4 d. N_2 e. CO f. NH_3

Which has the higher boiling point, Br_2 or ICl?

Which has a higher boiling point, CH_4 or C_3H_6?

Which has a higher boiling point, I_2 or Br_2?

If only London dispersion forces are present, which should have a lower boiling point, H_2O or H_2S?

Ethanol C_2H_5OH and methyl ether CH_3OCH_3 have the same molar mass. Which has a higher boiling point?