Molecules: Ionic Bonding: Student Review Notes

$$M + X \longrightarrow M^+X^- \text{ or } MX$$

Metal
Low Ionization Energy
(wants to lose electrons to obtain a noble gas configuration)

Non-Metal
High Electron Affinity
(wants to gain electrons to obtain a noble gas configuration)

electron has been transferred forming the **cation**, M^+, and the **anion** X^-. The molecule is held together by the **electrostatic attraction** of the oppositely charged ions.

$$F = \frac{kq_1q_2}{r^2}$$

How do you tell if a bond between two atoms is ionic?

One way is to use the table of electronegativity values and calculate an electronegativity difference between the bonding species.

Electronegativity Values

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na .9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K .8	Ca 1.0	Sc 1.3	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb .8	Sr 1.0	Y 1.2	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs .7	Ba .9	La 1.0	Pb 1.9	Bi 1.9	Po 2.0	At 2.2

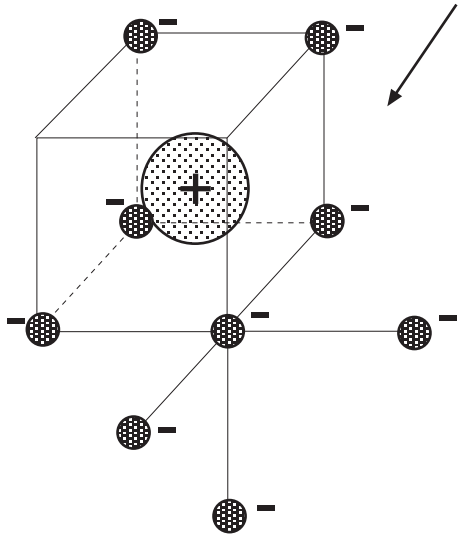
Electronegativity is an idea developed by the chemist Linus Pauling. What he did was assign a number between 0.8 and 4.0 to each element, take a look at the table to the left. The greater an elements ability to attract the electrons in a bond the higher the value. It is generally accepted that an electronegativity difference greater than 2.0 is indicative of an ionic bond.

For example, take a look at NaCl → Sodium = .9 and Chlorine = 3.0. The electronegativity difference is 2.1 and this indicates an ionic bond.

However, the electronegativity difference does not tell you how stable the "molecule" will be. The word molecule is in quotes because it's not correct to think of a single inionically bonded molecule, like a single NaCl molecule. **Ionically bonded compounds exist in a three-dimensional lattice framework.** The formula for the ionic compund just gives you the relative number of ions necessary to have electrical neutrality.

The stability of ionic compounds is due to the fact that the electrostatic attractions between cations and anions are shared within the lattice. Take a look:

This is what's known as a body-centered cubic structure



The cations are at them center of the cube and are surrounded by anions that are at the corners of the cube. The structure goes on in three dimensions and therefore, each ion is attraction to a number of other oppositely charged ions.

Again, this is electrostatic attraction and we know that the force of the attraction is proportional to the product of the charges and inversely proportional to the square of the distance separating them. You can use this relationship as a rule of thumb about the strength of the lattice. The larger the charges and smaller the ions (the closer they can pack together) the stronger the lattice.

The strength of a lattice is measured by the **lattice energy**. Lattice energy is defined as the energy required to completely separate one mole of a solid ionic compound into gaseous ions. The actual calculation can be done from tabulated data using whats called the Born-Haber Cycle but this calculation is a bit much for introductory chemistry. What you really need to be able to do is use the idea of electrostatic attraction and a lattice to explain lattice energies in a relative way for different compounds.