# Thoughts for the Day
# CH301 Fall 2010
# 09/07/10

Bond lengths and Bond strengths are generally correlated

Long bonds are weaker
Shorter bonds are stronger

Remakably similar bonds in totally different molecules have the similar strength and lengths. This allows us to think about molecules are being composed of discrete bonds. And treating different parts of the molecules are separate from one another.

Some bonds look very different from each other even between the same two atoms. As such we group by bond energy (strength) or bond length.

The longest (weakest) we call single bonds
The shorter (stronger) we call double bonds
The shortest (strongest) we call triple bonds

Ionic Bonding

The net effect for forming an ionic bond between two atoms is the sum of all of the "parts" of the potential.

First is the energy to make the ions from the atoms. This the ionization energy (cost to make the cation) minus electron affinity (the energy gained from making the anion). This is a positive number for all compounds. The bond forms (is lower in potential energy than the separated atoms) because of the coulomb attraction of the ions for each other.

The Coulomb potential substantially lowers the energy of the ion pair. However, the ions are not point charges. As such at close range they actually repel each other. We can add in a short range repulsive part to the total potential.

Add it all up and you get a potential minimum at a particular distance (the bond length) with a particular depth (the bond strength).

I have added some other thoughts on this particular topic to the webpage. Along with some questions

Lewis Dot structures

IE trends give us a shell structure for the atoms with nobel gases being very stable. We will try to make molecules which share electrons such that each atom has a nobel gas structure.

The shell structure and periodic trends tell us that only the valence electrons matter. These are the electrons outside the nobel gas core. For example, Si has a core of Ne plus 4 more valence electrons.

If you are having difficulty making basic Lewis Dot structures see the flow chart in the book (page 88).

What do we learn from Lewis Dot structures? How molecules are bonded together (which atoms are bonded to which) and bond order. What don't we get? Shape

Formal charges

To distinguish between structures that all satisfy the octet rule we can use "formal" charges. These are not actual charges found in the molecule, but give us an idea of how the elements have changed in the compound compared to lone atoms.

The formal charge = valence electrons – (lone pair electrons + 1/2(bonded electrons))

The "best" structure will minimize formal charge. Ideally negative formal charges would be found on the most electronegative atom.

Resonance structures

When there are two lewis dot structure that you cannot distinguish based on the formal charges, we say these are resonance structures. They may be identical (exactly the same, but with a double bond in one of three equivalent places) or they may be similar (with a two double bonds or a single and a triple). Either way, IT IS VERY IMPORTANT TO REALIZE THAT THE REAL STRUCTURE IS NOT FLIPPING AROUND BETWEEN THESE. The real structure is simply closer to one that can't be drawn in which we insist on pair of electrons and only single, double, and triple bonds. The real structure is like the average of the resonance structures.

Most importantly is what you might predict based on the structure. For example you might decide that the C-C bond length in benzene is between the C-C bond length in ethane and Ethene. (if you don't know what these molecules are, look them up online. I'm sure you can find them (and maybe even their Lewis Dot structures).

Failings of the Octet Rule

1. Odd electron systems

When the total number of valence electrons is an odd number, it is not possible to give each atom a noble gas structure. Where to put the odd electron? Use formal charges to decide on the best structure

2. Suboctet

Boron and Beryllium will make strange covalent compounds in which they don't obey the octet rule. Boron will make three bonds, and Be will make two. These tend to be the only exceptions to this rules as the other elements in group II and group III tend to make ionic compounds rather than covalent. The correct structures here will always minimize formal charges (rather than follow the octet rule)

3. Expanded octet

Elements in row 3 and down can make more than 4 bonds. For such systems it is again impossible to follow the octet rule (too many electrons). Again go with formal charges.