Reading- The Different Types of Bonds

Atoms form bonds with other atoms in order to have a full outer shell of electrons like the noble gases. If an atom has too few or too many valence electrons it will have to gain, lose, or share those outer electrons with another atom in order to become "happy" or in chemistry terms, more stable. There are many types of chemical bonds that can form, however the 3 main types are: ionic, covalent, and metallic bonds. You must become familiar with how they work and the differences between the 3 types.

I. Ionic bonding: Model 1 is a description of what chemists call ionic bonding. Ionic bonding occurs strictly between metal and nonmetal atoms. In ionic bonding some of the valence electrons of a metal atom are *transferred* to a nonmetal atom so that each atom ends up with a noble gas configuration. Usually one, two, or three electrons are transferred from one atom to another. This transfer of an electron causes the metal atom to have a net positive charge (+) and the nonmetal atom to have a net negative charge (-). The individual atoms in ionic solids are



Model 1

referred to as ions because of their charges. These opposite charges are attracted to one another. On the right is a drawing of a chunk of salt, NaCl, a very common ionic substance. Notice how the sodium and chloride ions alternate throughout the structure. The positive and negative ions alternating in three dimensions make the solid quite strong because of their strong attractions to one another. The sodium ion is written Na+ and the chloride ion is written Cl-.

When ionic solids are placed in contact with water, they dissolve. They remain ions, with charges, but now the individual ions are surrounded by water molecules and distributed throughout the water. Once dissolved, ionic compounds will conduct electricity.



(a) Formation of covalent bond



II. Covalent Bonding: Model 2a represents bonding that is referred to by chemists as covalent bonding. The valence electrons are shared between atoms, such that the electrons are attracted to two nuclei. Non-metal atoms will form covalent bonds with each other. In Model 2a, two fluorine atoms form a stable F_2 molecule in which each atom has an octet of valence

electrons by sharing a pair of electrons.

Notice in <u>Model 2b</u> that the molecules themselves are not connected by covalent bonds to one another, but that the atoms are connected into small units, called molecules, by covalent bonds. Thus, molecular covalent substances consist of a large group of individual molecules. Note that whenever we are talking about *molecules* in chemistry, we are referring to covalently bonded groups of atoms. Molecular covalent substances tend to be liquids, gases or soft solids. This is because the individual molecules have more freedom to move within the substance.



Covalently bonded atoms can share two pairs of electrons (double bond) or three pairs of electrons (triple bond). For instance, oxygen in air does not exist as a single atom. <u>Model</u> <u>3</u> shows two oxygen atoms sharing 2 valence electrons each to form O_2 .

All the macromolecules that comprise the human body (DNA, carbohydrates, lipids, and proteins) are covalently bonded. <u>Model 3b</u> shows a typical saturated and unsaturated

fat molecule. Covalently bonded molecules can form very large and complex molecular structures because of all the combinations and bonds that can be made to a few central atoms such as carbon. In fact, organic chemistry is an entire branch of chemistry that focuses solely on these large, carbon based molecules (and is a dreaded class taken by most science majors).



III. Metallic Bonding: Model 4 is referred to as metallic bonding. In the metallic bond, metal atoms achieve a more stable configuration by sharing the electrons in its outer shell with many other metal atoms. The valence electrons in metals are not tightly bound in the nucleus and each atom in a metal contributes all the electrons in its valence shell to all other atoms in the structure. The electrons then form a sort of "sea of electrons" around the atoms. Thus, each atom becomes essentially positive in charge, having lost some electrons. The atoms in turn are attracted to the negatively charged "sea". Therefore, the individual atoms can "slip" over one another yet remain firmly held together by the electrostatic forces exerted by the electrons. This is why most metals can be hammered into thin sheets (malleable) or drawn into thin wires (ductile). When electricity is applied, the electrons move freely between atoms, and a current flows.

In <u>Model 4b</u> is an artist's rendering of a block of iron, Fe, atoms. The "sea of electrons" is not visible.



(a) Valence electrons in metallic bonds

(b) Overall structure of metallic bonds

Model 4