MODELS OF CHEMICAL BONDING

When we are faced the need to find a scientific explanation for a complex phenomenon such as bonding, experience has shown that it is often best to begin by developing a model. A scientific model is something like a theory in that it should be able to explain observations and to make useful predictions. But whereas a theory can be discredited by a single contradictory case, a model can be useful even if it does not encompass all instances of the effects it attempts to explain. We do not even require that a model be a credible representation of reality; all we ask is that it be able to explain the behavior of those cases to which it is applicable in terms that are consistent with the model itself.

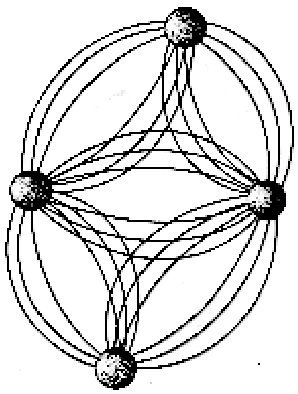
> *An example of a model that you may already know about is the kinetic molecular theory of gases. Despite its name, this is really a model (at least at the level that beginning students use it) because it does not even try to explain the observed behavior of real gases. Nevertheless, it serves as a tool for developing our understanding of gases, and as an essential starting point for more elaborate treatments.*

One thing is clear: chemical bonding is basically electrical in nature, the result of attraction between bodies of opposite charge; bonding occurs when outer-shell electrons are simultaneously attracted to the positively-charged nuclei of two or more nearby atoms. The need for models arises when we try to understand why

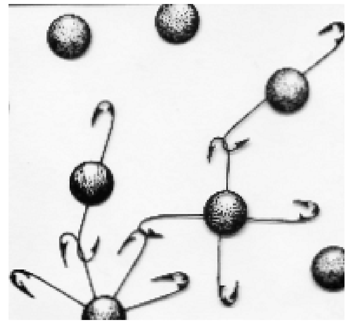
- Not all pairs of atoms can form stable bonds
- Different elements can form different numbers of bonds (this is expressed as "combining power" or "valence".)
- The geometric arrangement of the bonds ("bonding geometry") around a given kind of atom is a property of the element.

Given the extraordinary variety of ways in which atoms combine into aggregates, it should come as no surprise that a number of useful bonding models have been developed. Most of them apply only to certain classes of compounds or attempt to explain only a restricted range of phenomena. In this section we will provide brief descriptions of some of the bonding models; the more important of these will be treated in much more detail in later lessons in this unit.

Some early views of chemical bonding



Intense speculation about “chemical affinity” began in the 18th century. Some likened the tendency of one atom to “close” with another as an expression of a human-like kind of affection. Others attributed bonding to magnetic-like forces (left) or to varying numbers of “hooks” on different kinds of atoms (right). The latter constituted a primitive (and extremely limited) way of explaining the different combining powers(valances) of the different elements.



"There are no such things..."

Napoleon's definition of history as a set of lies agreed on by historians seems to have a parallel with chemical bonding and chemists. At least in Chemistry, we can call the various explanations "models" and get away with it even if they are demonstrably wrong, as long as we find them useful. In a provocative article (J Chem Educ 1990 67(4) 280-298), J. F. Ogilvie tells us that there are no such things as orbitals, or, for that matter, non-bonding electrons, bonds, or even uniquely identifiable atoms within molecules.

This idea disturbed a lot of people (teachers and textbook authors preferred to ignore it) and prompted a spirited rejoinder (J Chem Ed 1992 69(6) 519-521) from Linus Pauling, father of the modern quantum-mechanical view of the chemical bond.

But the idea has never quite gone away. Richard Bader of McMaster University has developed a quantitative "atoms in molecules" model that depicts molecules as a collection of point-like nuclei embedded in a diffuse cloud of electrons. There are no "bonds" in this model, but only "bond paths" that correspond to higher values of electron density along certain directions that are governed by the manner in which the positive nuclei generate localized distortions of the electron cloud.

Source: http://www.chem1.com/acad/webtext/chembond/cb02.html