Chem 125a Problems

due Friday, September 15, 2006

Again you are encouraged to work with classmates on this problem set. But be sure at the end that you can do similar problems by yourself. The Wiki may be useful for questions, but unless you have some idle time, don't spend your effort trying to draw structures on its pages. (It took me a LONG time to draw up the functional group page.) Many important questions can be formulated and answered in words.

One aim of this exercise is to gain (or revive) facility with drawing Lewis dot structures. The other aim is to make you think about them. There is a relevant passage in Robert Frost's poem *The Witch of Coös*:

> SON: Mother can make a common table rear
> And kick with two legs like an army mule.
>
> MOTHER: And when I've done it, what good have I done?

Facility with drawing includes replacing bonding pairs by lines for speed and clarity - even omitting them altogether in parts of the structure that are not of interest - and omitting the symbols for C and H atoms when everything is clear (*e.g.* an angle between straight lines can denote CH_2, and the end of a straight line can denote CH_3)

Crucial skills include recognizing when octets are complete, where charges should be placed (*e.g.* on tetravalent N, trivalent O or S, tetravalent B), and being sure to account for all valence electrons through single, double, and triple bonds, and lone pairs. Sometimes there are not enough electrons. Other times there is an odd number of electrons, which obviously means that not all electrons are paired. Such molecules are typically very reactive, as we'll see.

Most of you have already had experience with Lewis structures, and at one level it's a simple process of electronic bookkeeping. Some have reduced it, at least for simple compounds, to a set of rules (*e.g.* **"A Sure-Fire Way to Draw Lewis Structures!"** at http://misterguch.brinkster.net/lewisstructures.html, or http://www.stolaf.edu/depts/chemistry/courses/toolkits/121/js/lewis/). Note that such formulaic approaches usually sweep the role of unrecognized "lore" under the rug. That is, in many cases drawing the right structure comes AFTER knowing the experimental facts, not as a predictive exercise. In the second link there is a warning, "Some knowledge of the way the atoms are connected may be required." *Yes, indeed!*

At this stage we are not trying to be perfect (there is a lot of lore to learn), but it is important to be able to draw familiar structures and to recognize how others have drawn them. When we've learned more about how electrons really behave, we'll see that although Lewis structures are very popular, there is a lot of arbitrary lore about them, and they are FAR from the last word on bonding.

The complication for a given set of atoms is not just that they can be arranged differently in space, but also that there are often several possible ways of drawing Lewis structures for a given arrangement, especially when there are both multiple bonds and unshared electron pairs. Then we have to worry which Lewis structure is "right" or preferable, or whether there is (shudder) "resonance". Obviously you can't know this yet. The facts must come first.

(1) Draw Lewis structures for the following molecular types from our course's Functional Group webpage: carbonyl, imine, enol, α,β-unsaturated carbonyl, ester, amide, acyl halide, carboxylic acid (and the anion formed by loss of H^+ from its OH group)

In each case above see if you can draw more than one "reasonable" Lewis structure.

It is important to realize when several alternative "reasonable" structures are possible. It is less important at this juncture to be able to "predict" when such cases involve single minima (resonance) and when they involve double minima (equilibrium). One needs better experimental or theoretical tools to answer this question.

(2) Draw the Lewis structure for a nitrogen atom attached to two methyl groups (CH_3) and one oxygen atom

(3) Draw Lewis Dot Structure(s) for: H N C (arranged in the order shown)

(4) Draw Lewis Dot Structure for H, C, N, O (same 4 atoms in all different orders)

(5) Draw an equilibrium between two cyclic arrangement of 6 CH groups, in which successive C-C distances alternate in length.

(6) Draw a resonance diagram for an hexagonal arrangement of 6 CH groups, in which all C-C distances have the same length. Experiment shows that benzene is indeed "resonant" and unusually stable.

(7) Repeat the last two problems substituting NH and BH for two successive CH groups (the other 4 groups are still CH)**.**

(8) Say something sensible about the following two questions:

a) Are Lewis Structures correct?

b) What do they suggest that one might want to check experimentally?