Lab 3B • 01/17/12

I want to talk a little bit about oxidation state and formal charge. We had talked about the oxidation states for carbon. You need to know that the difference between oxidation state and formal charge is. They are both just counting systems in which the number of electrons actually around the atom is compared to how many that atom would have in its unreacted state. The difficulty comes from what to do with bonds. We talked a little bit about polarity and what to do about the fact that bonds have some polarity to them. There are two extreme ways that we look at bonding: one is ionic bonding, where we imagine that electrons are completely transfered from one atom to another; then we have covalent bonding, in which, in theory, they're supposed to be equally shared between each other. In most organic compounds, the reality is somewhere in between, where we do have this sharing of electrons that occurs, which is why we characterize those bonds with things like sigma and pi bonds, but at the same time there's an imbalance in charge there, so they're not completely 100% shared covalent bonds. So if we're trying to count how many electrons there are there, that's why we have these two different systems that view these bonds as two extremes. One case is to view the bond as ionic, which means that whichever of the two atoms is more electronegative "owns" the electrons associated with that bond – just for the purposes of counting.

These bond-breaking exercises are not trying to imply at all that that's how it reacts, necessarily; that is just our way of figuring out where electrons went. That's how we did it for oxidation state, giving the electrons to the more electronegative element. For formal charge, which is what we use when we write structures because when we write structures we write them as if they are covalent bonds, we consider all of the bonds covalent, which means that, every case where you have a bond, one atom gets one electron and the other atom gets the other. The one wrinkle is that if you have a bond between two equivalent atoms, even for oxidation state, we would divide the electrons up that way: each atom would get one electron, because neither would be more electronegative than the other. These are both counting systems. Oxidation state treats bonds as if they were ionic, meaning that the atom that is more electronegative receives the electrons from the bond, except when the bond has two of the same element, in which case the electrons are evenly divided. Formal charge is where all bonds are treated as fully covalent, so electrons in the bonds are always given half to each atom.

We can do [oxidation state] the way we did it last time, wherein each case, we look at an atom, we see what is connected to it, we break the bonds appropriately and count electrons. Except, after some time, we do notice some patterns that develop. For example, any time that you have an oxygen connected to carbon, oxygen's going to automatically end up both electrons of however many bonds are present. So for each bond with oxygen, essentially oxygen is taking one electron away from carbon, so each oxygen there would, in turn, cause the carbon to have a +1 oxidation. Similarly, in every case where hydrogen is attached to carbon, the opposite would occur, because carbon's more electronegative than hydrogen, so each time by having a hydrogen there, that effectively makes carbon have a -1 oxidation state. So if you had methane, with four hydrogens, carbon would be -4, one due to each hydrogen. If you had somehow four oxygens connecte to carbon, then you'd have a +4 oxidation state, because you'd lose all four electrons to the surrounding oxygens. So if you're trying to figure out an oxidation state for carbon, you can do it by this shortcut of still evaluating all of the bonds that are around, but instead of going through the process of actually drawing the electrons in, just recognize that every time you have a more electronegative element attached, that causes a +1 on carbon, every time you have a less electronegative element attached that causes a -1 on carbon. If you have a carbon attached, that counts as zero, because that would come under the case where each carbon would receive exactly half of the electrons from the bond. So the shortcut is: each atom more electronegative than carbon causes carbon to have a +1 oxidation state per bond; if you have a double bond with oxygen, that would count as +2. Reverse is true for things that are less electronegative. If we have carbon, it's as if it doesn't count; it doesn't cause + or -. We'll use this simplified way of viewing things to more rapidly come up with oxidation state.

[lab procedure][reminder of how to use drying reagents][reminder of how to perform recrystallization]
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Oxidation state and formal charge are both counting systems in which the number of electrons around an atom in a compound is compared to the number of electrons that atom would have in its unreacted elemental state. Oxidation state treats bonds as if they were ionic, meaning the atom that is more electronegative receives the electrons for the bond (unless the bond is make up of two of the same element, in which case each atom receives half of the bonding electrons). Formal charge treats bonds as if they were covalent, meaning half of the bonding electrons are give to each atom in a bond.

Short cut for oxidation state of carbon
– Each atom more electronegative than carbon (ex: O, N, F, Cl, Br) causes carbon to have +1 O.S. (per bond)
– Each atom less electronegative than carbon (ex: B, H) causes carbon to have -1 O.S. (per bond)
– Each carbon attached has no effect on O.S.
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Structures

No structure for this lab lecture.