

## Lab 10B • 11/01/11

Let us start with the answers to quiz #2. The first problem: determining configuration. First problem had what I guess you could call a trick question in it. Just like I had done in class, I problem on here that does have part of the structure where it's written with dashes and wedges, but the left carbon that has that dash on it is actually not a stereocenter, since there are two methyl groups that are attached to that same common point. Whenever you do have two or more substituents that are exactly the same, you could draw a mirror plane through that particular carbon; another way of expressing it is if you swapped those two groups, since they are the same, then there is no stereoconfiguration at that point. So for the first molecule, it's only carbon number three, where it has the wedge and the dash, that is, in fact, a stereocenter. Following the priority rules, we could first look at atomic number. Oxygen is higher atomic number than nitrogen; nitrogen's higher atomic number than carbon, but we have two different carbon chains. One of them, at that first carbon out, you only have one other carbon attached; so the propyl group, there's only one carbon [C-H-H]. But the other direction, the isopropyl group, at that attachment point, there are two carbons that come off of it. So two carbons beats out one carbon, so the isopropyl group is priority number three, and then the propyl group is number four. This would appear to be S, but this structure is not correctly written for direct visualization, because the least-important group, which is not hydrogen in this case – and it's not always hydrogen, but the least important group is not oriented in the back, so it's actually going to give you the misleading answer. What we could do is that we imagine that we rotate around this single bond, make a rotamer of it, and we could put the propyl group in the back where it should be, and if we did that, we could take the amino group, move it to the alcohol and take the alcohol and put it where the propyl group is. If we do that, now we'll get our priorities processing in a clockwise direction, which means that stereocenter is in the R configuration.

Moving on to the second one. There are two stereocenters in this next problem because the ring is not symmetric. Coming from that –OH group, if you went clockwise versus counterclockwise, you'd end up with different priorities. For that top stereocenter, oxygen is the most important versus either of the carbons attached. Going towards the clockwise direction, we could get a portion of the ring that is connected to a carbon and a deuterium, whereas going the other direction we have a carbon and just hydrogen. The second rule, the highest mass number, would apply in this case. So, the direction that has deuterium would be priority number two, and then the one without the deuterium would be number three. Hydrogen is already correctly written in the back, and so we can go ahead and read this configuration directly; it is R. Looking at the second stereocenter, we again have two substitution patterns, depending on which way we go around the ring. Carbon is going to be higher priority than either deuterium or hydrogen, atomic number first, so the direction where we have carbon with an oxygen is going to be more important than the direction without that oxygen. The deuterium itself is priority number 3, and then hydrogen is number 4. Notice that the hydrogen is in front, so whatever we visualize, we have to reverse; it appears S, but it's really R.

The last one only had one stereocenter, because the righthand side, where it's planar – since it's planar, it is its own mirror image. On the other side where you have a wedge, even though you have a wedge you've again got a situation where you have two of the same substituent. So the only stereocenter is in the middle of the molecule. In order to answer this, then, we're going to have to use phantom atoms to figure out how to correctly read the double bond. So, rewriting, you double up the oxygen that's connected to the carbon, and then on each oxygen, you're going to double up the carbon. Now if we look what we've got from the stereocenter, you've got carbons in three directions. We've got a carbon that's got oxygens, a carbon that's only got hydrogens; that third one will be the least important, so we'll go ahead and assign that priority three. The hydrogen which is there would be priority four. Notice that it's in the front again so whatever we're about to come up with for the order, we've got to reverse it. Comparing the two other carbons, we've got a carbon with two oxygens, carbon with two oxygens, that's the same, so we have to go one more position out. In this first case, the oxygen only has hydrogen on it, versus in the other case, oxygen has carbon on it. Since carbon is more important than the hydrogen, that makes the group on the right have higher priority than the group on the left, so even though it appears S, because hydrogen is in front, it's really R.

Let's move on to the next problem, then, which is on nomenclature. First of all, this is a five-carbon molecule, so it's going to be some form of pentanol. Since the –OH group is on the first carbon, it's going to be a pentan-1-ol, or 1-pentanol. We have two different substituents: there's a deuterium that's located at the point where the alcohol is. Deuterium's substituent name is deutero, just like chlorine/chloro-, bromine/bromo-. Now we have the methyl group at the 4 position. Since the 'd' in deutero comes before the 'm' in methyl, we're going to list this as 1-deutero-4-methyl. Then, we do have a stereocenter. The one on the very left is not a stereocenter because you've got two of the same substituent attached; on the righthand side, oxygen is priority 1, carbon is priority 2, deuterium is priority 3, the hydrogen that's there is already in back, so this is S. Because it's only one stereocenter that needs specification in this compound, you do not use numbers in front of that S. If we have multiple stereocenters, then we would put those position numbers.

Moving on to the next problem, that was for the terminology: enantiomers, diastereomers, and epimers. Enantiomers, you could have said that they were non-superimposable mirror images. Another way you could have said that, then, is that all of the stereocenters from one form to the other are inverted. For diastereomers, they're non-superimposable non-mirror images; if you just said that it has stereocenters, that's not enough cause enantiomers have stereocenters as well.

You could say that they're non-superimposable images, which is true, but then you have to say that they're non-mirror images, because enantiomers are also non-superimposable. Another way that you could have said it is that one or more of the stereocenters are changed, but then you had to say not all of them, because if all of them changed, it'd be back to enantiomers again. Epimers are a subset of diastereomers in which only one configuration has been changed.

Where most of you had difficulty is writing the example molecules. For enantiomers, for example, some of you might have done something like this. You had exactly the right idea, but realize that those are not enantiomers because they're both exactly the same molecule, because there is no stereocenter, because if you look at it, you've got three of the same substituent all located on the same carbon. An example of a pair of molecules that are enantiomers would be something like this. For diastereomers, since it's some, but not all of the stereocenters that change, you need to have at least stereocenters on it. It's not that you couldn't use methyl groups to show stereocenters, you just had to make sure that they really were stereocenters. This would be an example of showing diastereomers. Then for epimers, again you need to show at least two stereocenters, and for an epimer, you need to show that only one of those changed.

The last problem. Whether the molecules were chiral or not. In this question, if you wanted to say something was chiral, you couldn't just say that it had stereocenters, because the first molecule is chiral and it does have stereocenters, but the last molecule, it turns out, is not chiral, even though it has stereocenters. What you have to say, if you're going to focus on stereocenters [to explain it] is, yes, it has stereocenters, but it also cannot have an internal mirror. For the first molecule, there is no mirror plane; that means that if you took the mirror image of that molecule, that mirror image is not going to be identical to the original one, so you'd end up with nonsuperimposable mirror images, which means that this does have handedness. Because it does have handedness, it is chiral. For the last one, it does have a mirror plane; since it does have a mirror plane, even though it's got stereocenters, it is achiral, because it's meso. For the middle molecule, it does have a mirror plane as well, but it turns out, there aren't any actual stereocenters there, because from each of those positions with a wedge or a dash, if you went either direction around the ring, you'd end up having exactly the same substitution pattern. So you can't say that it's meso in that case since meso means havin stereocenters. But, you could still, in this case, say that it is achiral, because there are no stereocenters.

I want to over one of the problems from the first exam, the SMOG problem. The problem that we had was this, where we had both a lone pair and a radical. First, let's rewrite this as a full structure, to make sure that we have the right number of atoms, the right number of hydrogens in particular. First, rewriting this, there are five carbons in the compound. On the leftmost carbon, because there are three bonds shown, there's one missing, so that's one hydrogen. The second carbon over, it's already got four bonds shown, so it doesn't need another hydrogen. Third carbon, the lone pair itself would have come from one bond with hydrogen, but that means there's one more left over. Similarly, on the radical, with there being one electron left from what would have been a hydrogen, that means there's again one hydrogen left. On the last carbon, because it only has one bond showing so far, that means there's going to be three hydrogens. For determining hybridization, we look at sigma bonds and lone pairs. We ignore pi bond, and we ignore individual electrons. Individual electrons just don't have the repulsive force of pairs of electrons, so that's why we don't count those, and since we can model pi bonds as coming from just one electron on each atom, again that would mean it doesn't have an effect on hybridization. First two carbons, they're both going to be sp-hybridized; the third and the fifth, because they each have four pairs, either in sigma bonds or lone pairs, they'll both be sp<sup>3</sup>; and then the remaining carbon, because it has that lone electron, it's only going to be sp<sup>2</sup>-hybridized.

When we go to write the SMOG, one common misunderstanding is that somehow the hybridization applies to bonds. But no, the hybridization applies to an atom, so if you double-check your SMOGs, if you pointed to where the bond would be and called that some particular hybridization, that's not how the model works. We take each atom, write out its orbitals, and then if they happen to overlap, then that's where bonds form. But within a bond, it could be made up of orbitals that are, by the system, two different hybridizations. For sp, sp means there are two different orbitals. For sp<sup>3</sup>, it's going to automatically mean there are four orbitals, and for sp<sup>2</sup>, there are only three orbitals. I'll go ahead and put my hydrogens in. The sp<sup>2</sup>-hybridized orbital, since it only used up three of the valence orbitals, we have a p orbital that's left over. The sp<sup>3</sup>, since we've used up the s, p, p, and p, there is nothing left, so there won't be any p orbitals on sp<sup>3</sup> hybridization. On the sp, because we only used two of the orbitals in hybridization, that means there's going to be two sets of p orbitals left over. There's two types of bonds that we have: in the triple bond, there are the two sets of p orbitals that overlap, those are our pi bonds; then, anywhere where you've got head-to-head overlap of orbitals, all of those places would be sigma bonds. So there's the full SMOG for this molecule. Hyperconjugation could occur from this sp<sup>3</sup> center back over to the triple bond, or to the p orbital, and hybridization could also happen between this sp<sup>3</sup>-hybridized system in the back. Either of the sp<sup>3</sup>-hybridized centers would be able to hyperconjugate with the p orbitals that are right next to it.

[lab reports]  
[TLC directions]

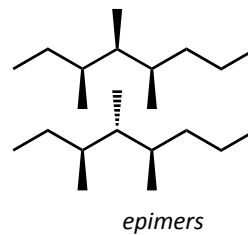
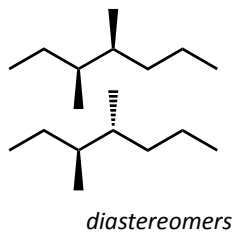
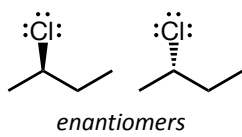
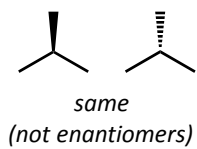
You dip your TLC plate in the [p-anisaldehyde stain], leave it in just for a moment, pull it right back out, and let any excess stain drip off of it. You're then going to use a heat gun, which is nothing more than an industrial hair dryer, really. [using low heat setting to prevent TLC plates to melt][safety of p-anisaldehyde]

You do need to handle the plates using tweezers, at first at least until you heat it up and evaporate off the stain. Some of the dots [will turn] a distinctive yellow, a distinctive purple; some of them seemed to remain white. If it didn't turn colors, that in itself is a piece of information. Whether things do or don't turn colors, that should hopefully be additional information for you to help identify which unknowns are in your mixture.

---

Structures (remaining structures identical to lab 10A)

11/01/11 lab • 1



..

..