Self-Study Worksheet #3, Isomerism

This worksheet is due in class on the day that we return from the flood. It will be counted in some as-yet undetermined way toward your course grade.

General Comment on the reading assignment (overall) for this worksheet. Read the section on “Structure and Isomerization” (Section 24.4 in Tro) up through Example 24.6 (pp. 1057-1060). Given the circumstances of the flood and missed class time, I will not hold you responsible for knowing exactly what optical isomers “are” or how to identify or draw them in PS11. You do have to know that they are a type of stereoisomer, however. Be familiar with the name and distinguish it from geometric isomers.

Task 1. Read Slide 1 in the PowerPoint on Isomers (TM IV)

**Exercise 1:** Fill in the blanks for the following:

If two structures or compounds are *isomers*, then they must have the same *chemical formula*, and they must also have at least one different *property* that can be measured experimentally in some way. If two structures or compounds have exactly the same physical and chemical properties (every possible property!) then they are not distinguishable and therefore must be the same compound (i.e., they cannot be isomers).

Task 2. Examine Slides 2-7 and Fig. 24.6 in Tro, as well as the section on structural isomerism on pp 1057-1058 in Tro

**Exercise 2:**

(a) If two structures or compounds are *structural* isomers, then *even though* not only do they have the same chemical formula, they must also have the same ___________, they must also **not** have the same __________ity (see Tro), which means that at least one type of “connection” (bond) is different in the two structures. Another way to put this is that the same exact number and type of atoms is the same between the two, but the way those atoms are connected to one another is not 100% identical.

(b) If all you know about two structures is that they are structural isomers, they could be ______ coordination isomers or they could be ______ linkage isomers.

(c) If two structures are linkage isomers, are all of the ligands of the metal cation the same? **Y** or **N**

If two compounds are coordination isomers, are all of the ligands the same to the metal cation (or to each metal cation if there are two)? **Y** or **N**

(d) What is the key difference between linkage isomers and coordination isomers?

In a pair of linkage isomers, the ligand itself is the same in the two structures, it is just connected via a different atom. In coordination isomers, at least one ligand is different in the two structures—it either became a counterion or it became a ligand on a different metal cation (if both the cation and anion are metal complexes).

(e) In which kind of structural isomer must the pair being considered be *salts*? **coordination**

Why must this be so? (Hint: something must be “swapped out” in this type of isomer.)
In order to swap out a ligand (and put it "someplace else" but yet "still in the compound" (to keep the formula the same)) it must "go" to the counterion position—either it becomes a counterion, or it becomes a ligand in the counterion (if that counterion is a metal complex). Another way to put this is that if there were no counterion, there would be no place to "move" the ligand to. A coordination isomer must have something be different about the ligands coordinating, so it cannot "stay" in the coordination sphere.

(f) Draw the structures of the ligands from Table 24.2 can bind to a metal cation via two different atoms (not at the same time, though!) and therefore can lead to the formation of ___linkage___ isomers?

   CN– and SCN– (I would also accept CO, although I don’t know if it ever bonds via the O atom)

(g) When trying to "create" coordination isomers on paper, one must be careful not to swap a counterion with a ligand that is ___neutral__ because one cannot have a counterion unless it has a charge!

**Task 3.** Examine Slides 8-13 and the section on stereoisomerism *up through Example 24.6* (pp. 1058-1060).

**Exercise 3:**

(a) In a pair of stereoisomers, all of the ___connections (or bonds)___s are the same, but something is different about the spatial ___arrangement___ of the atoms. This may involve a difference in the bond ___angles___s between two ligands, in which case the kind of isomerization is called ___geometric___ isomerism. If all of the connections *and* angles are the same between all atoms / ligands, in order for the structures to still be isomers, they must be ___optical___ isomers, which means they are not superimposable on each other (i.e., not "identical") but they are mirror images of each other.

(b) The most common form of geometric isomerism is called ___cis___ - ___trans___ isomerism, which can occur in either a square planar complex or an octahedral one. In the ___cis___ isomer, two identical ligands are at ___90___° to one another, and in the ___trans___ isomer, these same two ligands are at ___180___° from one another.

(c) When considering whether structures are geometric isomers, one must be careful to consider ___orientation___ since sometimes structures that *look* different are actually the same exact structure (i.e., are superimposable) (See Slide 11 in the PowerPoint)