Exercise 2: Conductivity, solubility and oxidation/reduction

Review: Polarity (section 4.7), polar and non-polar molecules (4.10), cis-trans isomers (13.3), enantiomers (15.5), oxidation reduction reactions (6.5)

More rules:
- Oxygen and nitrogen have a slight negative charge (even when the atoms are neutral)
- Carbon and hydrogen have a slight positive charge (even when the atoms are neutral)
- A molecule is called polar if the distribution of positive and negative charges is asymmetric (not symmetrical).
- A molecule is called non-polar if the distribution of positive and negative charges is symmetric.

Note that the first two rules are basically the concept of electronegativity, a measure of the ability of atoms to attract electrons (see Figure 4.5, p. 137)

1. a. Build a model of the amino acid glycine (chemical formula: H₂NCH₂COOH) from the chemical formula. Is there only one way to hook up the ten atoms? If you're getting frustrated, look at page 651 in Chapter 20 (you'll have to modify the structure a little bit). Notice how all of these amino acids are arrayed around a "central" carbon atom. What shape does glycine have (base the shape determination off of the “central” carbon)? Is glycine polar?

b. Is glycine chiral (in other words, does glycine contain one or more chiral carbons)? So does a molecule have to be chiral in order to be polar?

2. a. Build alanine (chemical formula: H₂NCH(CH₃)COOH). Again, look at page 651 if you’re getting frustrated. Is alanine polar? Is its shape around the “central” carbon significantly different from glycine?

b. Is alanine chiral? If you believe “yes”, draw the two stereoisomers of alanine below, using the “dash-wedge” notation as shown on page 500 to indicate parts of the molecule that “go into” the page and “come out of” the page.
c. Is alanine a **diastereomer** or an **enantiomer**? How can you tell?

Construct two **stereoisomers** (not constitutional isomers) of CH(OH)=CH(OH).

3. Write the condensed structural formulas of each, and identify each as either **cis-** or **trans-** isomers.

4. The cis-isomer is **reduced** by adding hydrogen across the double bond. Draw the product’s condensed structural formula. Is the product still a stereoisomer?

Now build two stereoisomers of CH₃CH(Br)C(O)H.

5. Using the conventions used in Timberlake section 15.5, draw the **Fischer projection** representations of the two enantiomers you made. **Oxidation numbers** are assigned to each atom of a molecule in order to determine whether a particular reaction involves an **oxidation** (loss of electrons) or a **reduction** (gain of electrons) or neither.
General rules:
- Atoms in elemental form, like C or O, are assigned an oxidation number of 0.
- In compounds, the more electronegative element (p. 137) is assigned the negative oxidation number.
- Hydrogen in an organic compound is assigned an oxidation number of +1.
- Oxygen in an organic compound generally is assigned an oxidation number of –2.
- The sum of all of the oxidation numbers of atoms in a neutral compound should be zero. The sum of all of the oxidation numbers of atoms in an ion should equal the ionic charge.
- Carbon’s oxidation number is calculated by applying the rules above.

6. Calculate the oxidation number of carbon in each of the following molecules:
   a. C₂H₄ (ethene)  
   b. CH₃O (formaldehyde)  
   c. CO₂

More rules:
- When carbon is oxidized in a reaction, it loses electrons; in other words, it ends up with a more positive or less negative oxidation number.
- When carbon is reduced, it gains reaction and ends up with a more negative or less positive oxidation number.

7. As you know, the combustion of an organic molecule is considered an oxidation. Determine the oxidation numbers of the carbons in all carbon-containing molecules below, and show that this reaction is indeed an oxidation.

   \[ \text{C}_2\text{H}_4 (g) + 3 \text{O}_2 (g) \rightarrow 2 \text{H}_2\text{O} (g) + 2 \text{CO}_2 (g) \]

8. Determine whether the following reaction involves carbon oxidation or reduction. Please show the oxidation numbers of each carbon.

   \[ \text{C}_2\text{H}_4 (g) + \text{H}_2 (g) \rightarrow \text{C}_2\text{H}_6 (g) \]

9. Determine whether the following reaction involves carbon oxidation or reduction. Please show the oxidation numbers of each carbon.

   \[ 2 \text{CH}_2\text{O} (g) + \text{O}_2 (g) \rightarrow 2 \text{CH}_2\text{O}_2 (g) \]

10. Develop a simpler, general rule for recognizing carbon oxidation and reduction. Hint: What reactant seems to be involved when carbon is oxidized? When carbon is reduced?