"I learned there are troubles
Of more than one kind.
Some come from ahead
And some come from behind.

But I've bought a big bat.
I'm all ready, you see.
Now my troubles are going
To have troubles with me!"

Dr. Seuss  -I Had Trouble in Getting to Solla Sollew
1. Supply the missing reactants, reagents, or products for five out of the following six equations. Indicate only five for grading. If none are indicated, the first five will be graded. Be mindful of details such as solvent, stereochemistry, and temperature.

a. \( \text{1) KMnO}_4, \text{KOH, H}_2\text{O, } \Delta \)
   \( \text{2) H}_3\text{O}^+ \)
   \( \text{3) 2 eq HOEt, H}^+ \)

b. \( \text{1) Na}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{SO}_4 \)
   \( \text{2) CH}_2\text{N}_2 \)

\[
\text{c. } \begin{array}{c}
\text{OH} \text{O} \\
\text{O} \text{O} \\
\text{O} \text{O} \\
\text{O} \text{O} \\
\text{CH}_2\text{CH(CH}_3)_2 \\
\end{array}
\rightarrow
\begin{array}{c}
\text{O} \\
\text{O} \\
\text{O} \text{O} \\
\text{CH}_2\text{CH(CH}_3)_2 \\
\end{array}
\]

d. \( \text{1) Mg, Et}_2\text{O} \)
   \( \text{2) CO}_2 \)
   \( \text{3) H}_3\text{O}^+ \)
   \( \text{4) LAH, EtOH} \)
   \( \text{5) H}_3\text{O}^+ \)

\[
\text{e. } \begin{array}{c}
\text{CO}_2\text{H} \\
\text{CO}_2\text{H} \\
\end{array}
\rightarrow
\begin{array}{c}
\text{O} \\
\text{CH}_2\text{CH}_2\text{CH}_3 \\
\end{array}
\]

\[
\text{f. } \begin{array}{c}
\text{CO}_2\text{H} \\
\text{CO}_2\text{H} \\
\end{array}
\rightarrow
\begin{array}{c}
\text{O} \\
\end{array}
\]

\( \text{1) ClCOCOCl, CH}_2\text{Cl}_2 \)
\( \text{2) Li}^+\text{-AlH(OtBu)}_3 \)
(20)  2. Propose synthesis routes for two out of the following three compounds. Legal starting materials include monofunctional organic compounds of four carbons or less, benzene, toluene, and any inorganic reagent or solvent required to carry out the transformation. Keep in mind there are many correct synthesis routes for each compound.

Any nitrogen containing compound should derive the nitrogen from an inorganic source (i.e.: NH$_3$, NaCN, NaN$_3$, HNO$_3$, etc.)
3. What is the mechanism for two out of the following three transformations? Be sure to include all intermediates, resonance structures where applicable, and arrow pushing to show the flow of electrons. Use back of this page or previous page if needed.

A. 

B. 

C. 

Below are the $^1$H NMR and IR spectra of phenacetin, an analgesic drug that is no longer used because of its toxicity. It has the molecular formula C$_{10}$H$_{13}$NO$_2$. **[HINT: when this compound is shaken with KOH in water a new product with the molecular formula C$_8$H$_{10}$NO is formed. The spectroscopic changes observed are: the peak at 9 ppm moves to 4.7 ppm and the integration doubles; the peak at 2.1 ppm disappears completely in the $^1$H NMR; the peak at 3300 cm$^{-1}$ broadens and shows two sharp points; and the peak at 1665 cm$^{-1}$ also disappears completely in the IR.]**

a. What are the units of unsaturation for this compound? (2 pts)

b. Explain the relevant peaks in the IR spectrum. (5 pts)

c. Explain the relevant peaks in the $^1$H NMR spectrum. (5 pts)

d. What is the structure of phenacetin? (3 pts)
5. For the following problem, consider the three brominated carboxylic acids given below.

a. Rank the following carboxylic acids in order of increasing acidity (from weaker acid to stronger acid). (5 pts)

b. Explain your ranking based on resonance structures, inductive effects, etc. Why is the strongest acid the strongest? (3 pts)

6. The following amino acid (lysine) comes together with a molecule of itself to make a dipeptide. Draw the structure of the dipeptide.
7. Assistant Beaker has found a rusty 50 L drum of some organic compound in a storeroom here on campus. The label for the drum has long since disintegrated, and Bunsen Honeydew (and the rest of us!) wants to know what the 50 L drum contains. Beaker took a small amount of the unknown and found that it is soluble in water and the pH of the aqueous solution is neutral indicating that it could be a monofunctional alcohol, aldehyde, ketone, ester, nitrile, or amide of five carbons or fewer. The unknown also has a negative nitrogen test and negative halogen test after sodium fusion. The only peak of interest in the IR is a strong stretch at 1705 cm\(^{-1}\). What have all these tests told Beaker (analyze all the data given!)? To what general class of compound does the unknown belong? Suggest some possibilities for the unknown.

(5) Bonus: By midnight this evening, taxes are due. Did you file a tax form (yes or no)? (3 pts.) If yes, which form did you fill out? If no, why not? (2 pts)