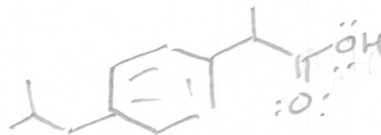
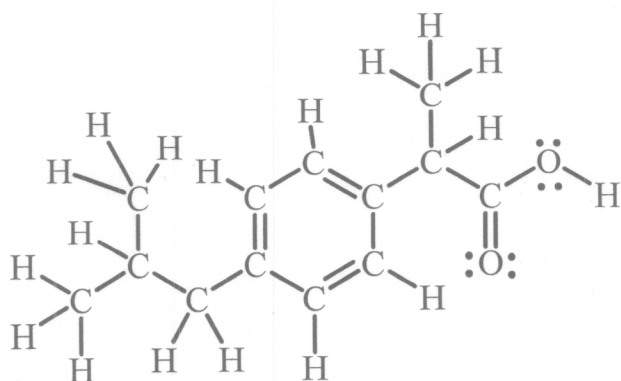
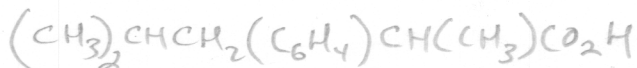


1. For the compound ibuprofen, shown below, draw a bond-line structure. (10 points)

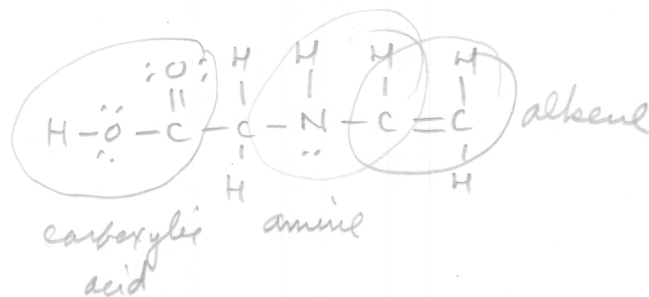
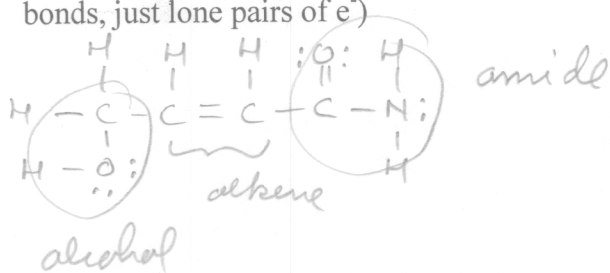


EXTRA CREDIT Write a condensed formula for the structure

(5 EC points)

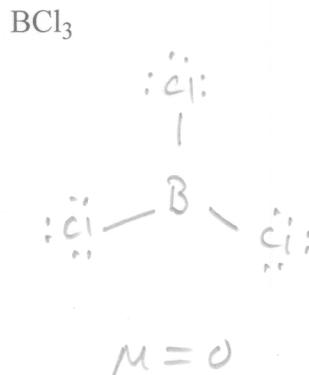
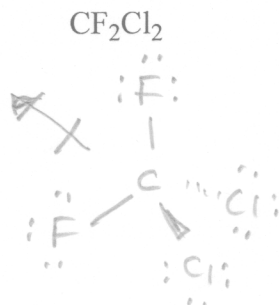
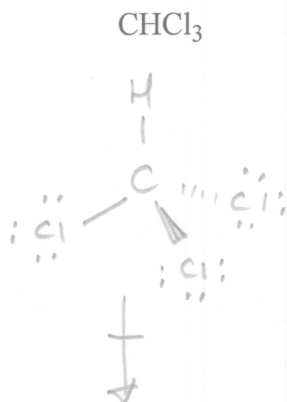


2. Draw two (2) different Lewis structures for molecules with the formula  $\text{C}_4\text{H}_7\text{NO}_2$ . There are very many possibilities, but limit your molecules to ones in which you can name the functional groups and of course show these names on your structures! (Show any lone pairs of  $e^-$ , and remember, no dots for bonds, just lone pairs of  $e^-$ )

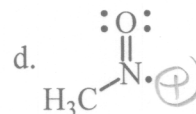
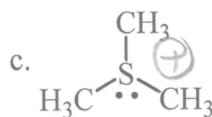
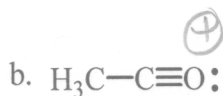
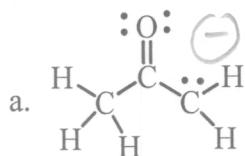


3. For the following molecules,

- Draw bond-line drawings that show the expected geometry (use dashes and wedges where necessary)
- Show all of the lone pairs of electrons, where necessary
- If the molecule has a permanent dipole moment ( $\mu \neq 0$ ), then show the direction of the overall dipole, otherwise write  $\mu = 0$  below the structure. (15 points)

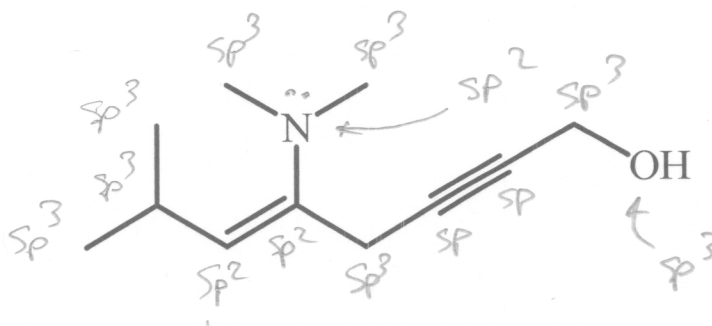


4. Assign formal charges (if non-zero) to the appropriate atoms in the following molecules (or ions).  
 (Note that *all* non-bonded electrons are shown in each structure) (12 points)

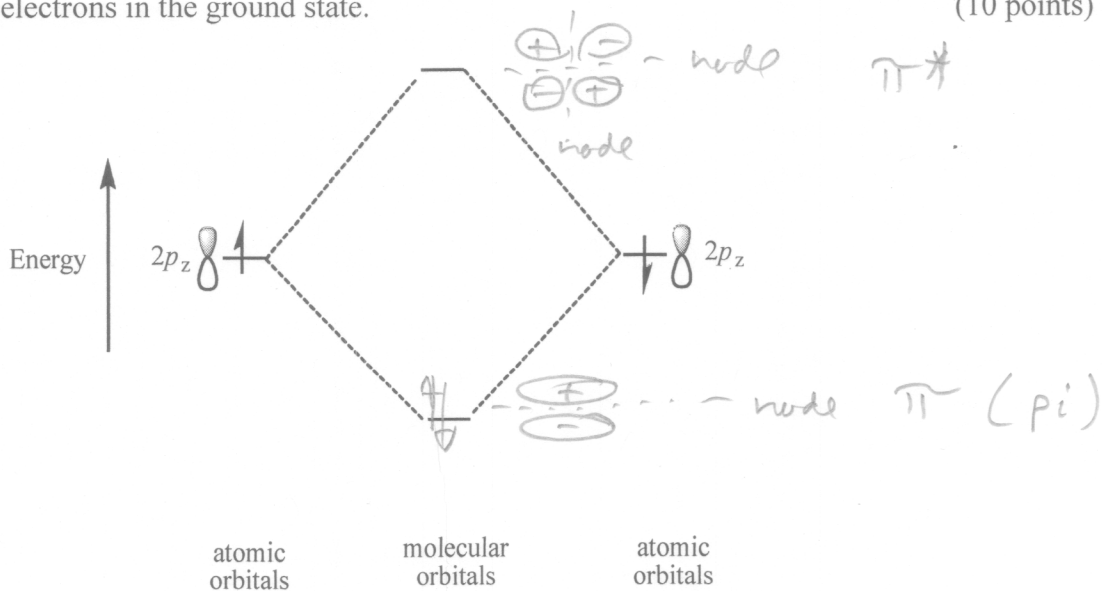


5. Consider the molecule below:

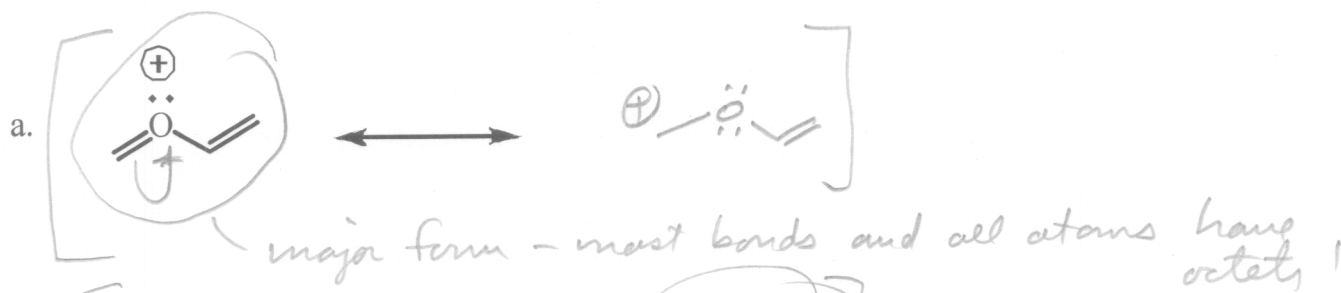
- a. Identify the hybridization of each atom of the following molecule (note there are 13 atoms that are hybridized and *none* of the lone pairs of  $e^-$  are shown) (26 points)



6. Complete the following energy diagram: Provide the name and sketch the shape of the molecular orbitals that are formed (in the center of the diagram) from the indicated atomic orbitals and show how they are filled with electrons in the ground state. (10 points)

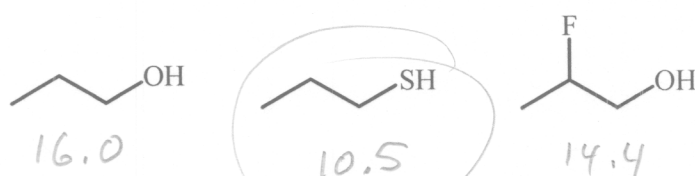


7. By "pushing" electrons, show the other resonance form for each ion shown below. In each case, circle the *major* resonance form and provide the reason for your choice. (10 points)



8. The  $pK_a$  values for the following compounds are 10.5, 14.4, and 16.0, *irrespectively*.

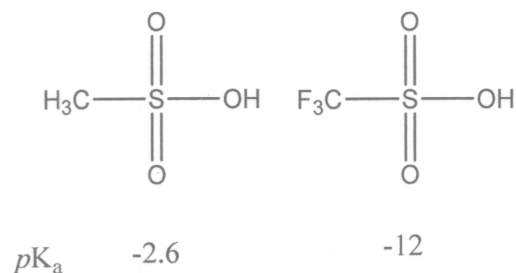
- a. Assign these values to the corresponding compounds.  
 b. Which compound is the most acidic? (8 points)



BTW - the two alcohols differ in acidity due to inductive effect of AR10

most acidic - atom effect of AR10

9. Use ARIO to explain the difference in acidity between methanesulfonic acid and trifluoromethane sulfonic acid (don't forget about the conjugate base). (10 points)

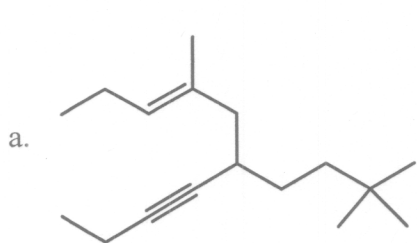


Atom effect - same for both  
 Resonance effect - same for both

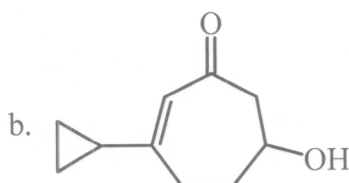
Inductive effect -  $CF_3$  group inductively stabilizes the conjugate base relative to  $CH_3$

Orbital effect - none

10. Provide the *molecular* and *empirical* formulas for the following compounds. (12 points)



$C_{17}H_{30}$  both molecular & empirical



$C_{10}H_{14}O_2$  molecular  
 $C_5H_7O$  empirical

11. Ammonia ( $NH_3$ ) has a dipole moment ( $\mu$ ) of 1.42 D, whereas nitrogen trifluoride ( $NF_3$ ) has a value of 0.234 D. Suggest a reason for the dramatic difference between these two otherwise similar molecules. (Hint: the dipole of a lone-pair of electrons is "toward" the lone pair) (10 points)



the net effect of the 3 N-H bond dipoles adds to the dipole of the lone pair



the net effect of the 3 N-F bonds partially cancels the dipole of lone pair

actual direction of dipole is unknown

12. Pentane and 2,2-dimethylpropane have boiling points of  $36^\circ C$  and  $10^\circ C$ , even though they have the same formula and molecular weight (g/mol). Provide an explanation for the difference in boiling point. (10 points)



pentane  
bp  $36^\circ C$



2,2-dimethylpropane  
bp  $10^\circ C$

less surface area - fewer London dispersion attractive intermolecular forces

more surface area for long alkyl chains means more chances for attractive London dispersion forces

13. The following two compounds below also have the same formula and molecular weight (g/mol). One of them boils at  $-25^\circ C$  and the other at  $78^\circ C$ . Which one is which? Provide an explanation for the difference in boiling point. (10 points)



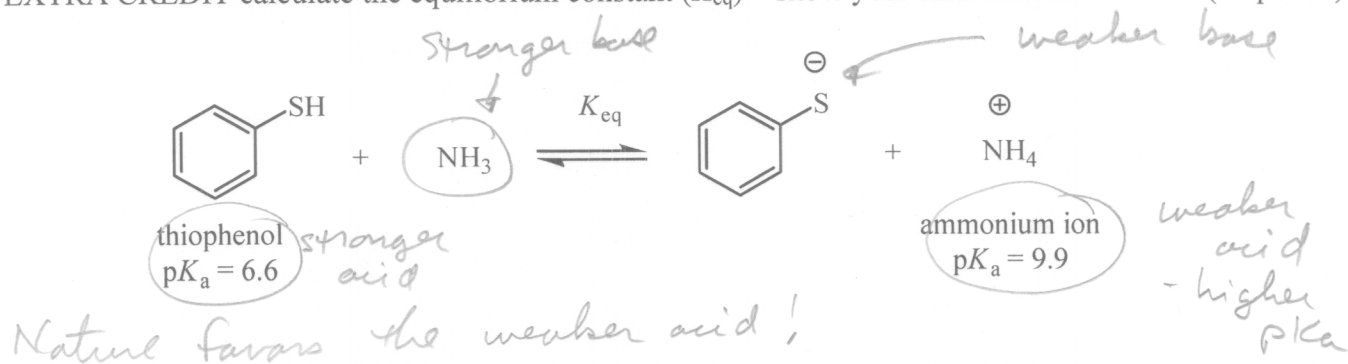
only has moderate to weak permanent dipole



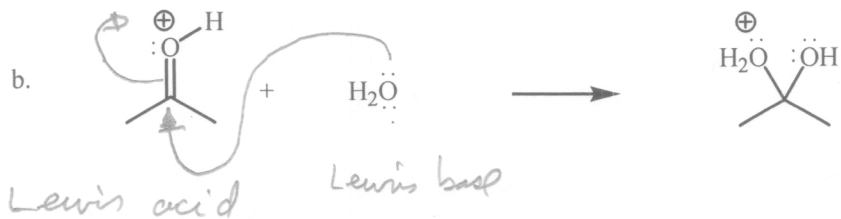
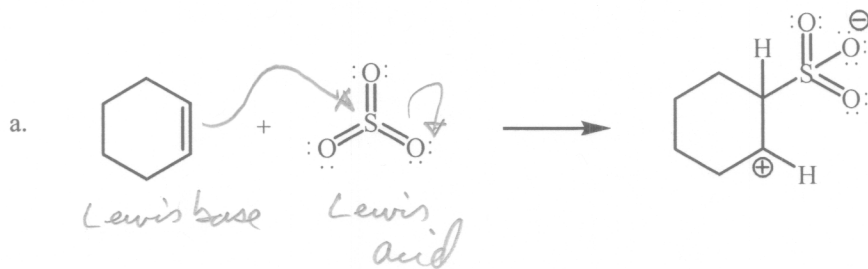
has very strong hydrogen bonding attractive forces (special case of permanent dipole), so has a much higher b.p.

14. Given the  $pK_a$  data below, indicate which side of the equilibrium is favored (i.e., right or left). Also, explain why the data indicate this – be clear about this. (10 points)

EXTRA CREDIT calculate the equilibrium constant ( $K_{eq}$ ) – show your calculation. (10 points)



15. For the following chemical reactions, identify the Lewis base and the Lewis acid. Use electron-pushing to show how the reactions take place. (20 points)



16. Circle and name all of the functional groups present in the molecule below. (7 points)

