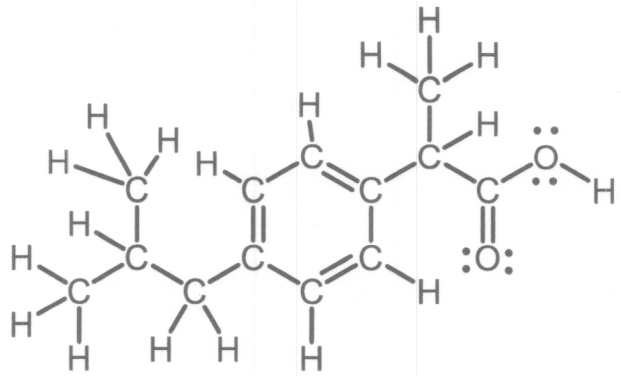
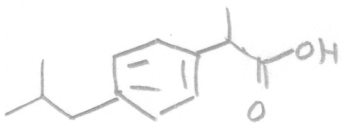
1. For the compound ibuprofen, shown below, draw a *bond-line* structure. (10 points)

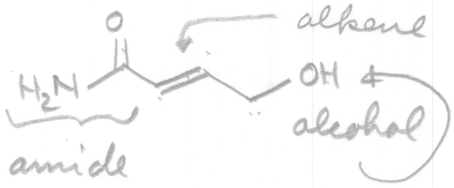


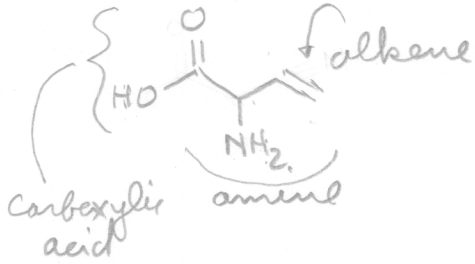


EXTRA CREDIT Write a *condensed* formula for the structure (5 EC points)

$(CH_3)_2CHCH_2(C_6H_4)CH(CH_3)CO_2H$

2. Draw two (2) different *bond-line* structures for molecules with the formula $C_4H_7NO_2$. 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^-) (20 points)

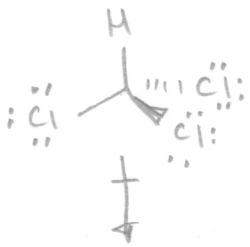




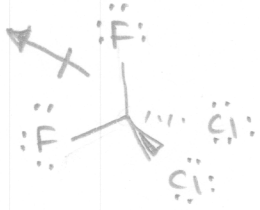
3. For the following molecules,

   a. Draw *bond-line* drawings that show the expected *geometry* (use dashes and wedges where necessary).
   b. Show all of the lone pairs of electrons.
   c. 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)

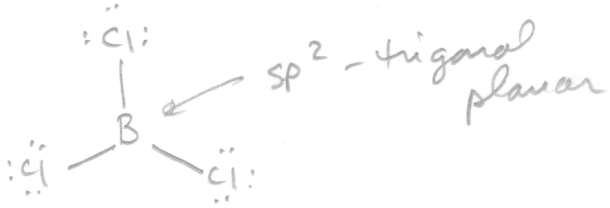
$CHCl_3$ CF_2Cl_2 BCl_3



$\mu \neq 0$

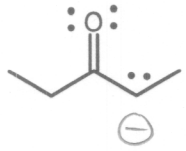


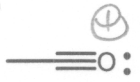
$\mu \neq 0$



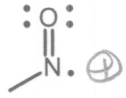
$\mu = 0$

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

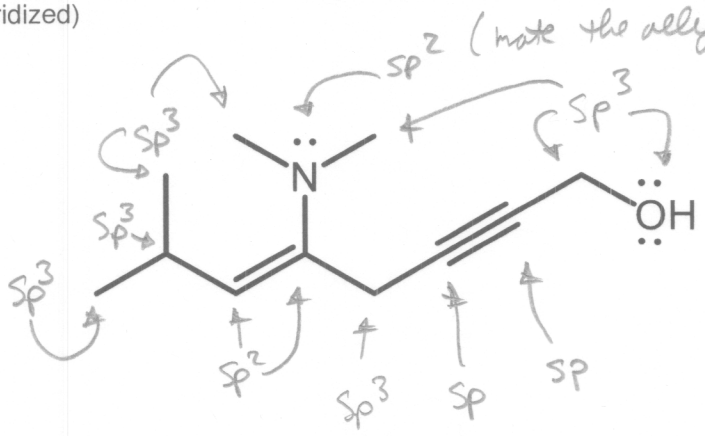
a. 

b. 

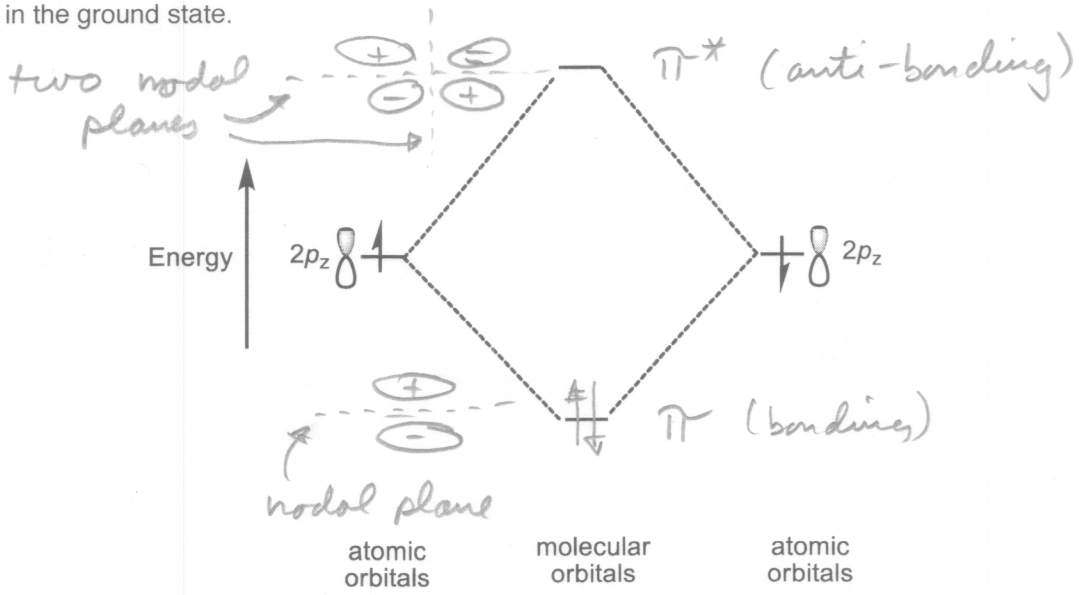
c. 

d. 

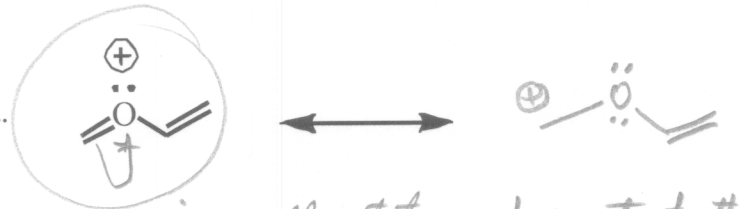
5. Consider the molecule below. Identify the hybridization of each atom of the following molecule (note there are 13 atoms that are hybridized) (26 points)



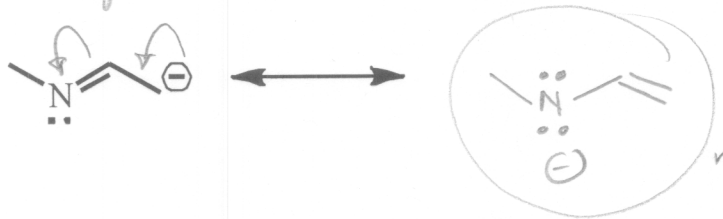
6. Complete the following energy diagram: Provide the name and sketch the shape of the molecular orbitals that are formed (in the center of the diagram) from the indicated atomic orbitals and show how they are filled with electrons in the ground state. (10 points)



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)

a. 

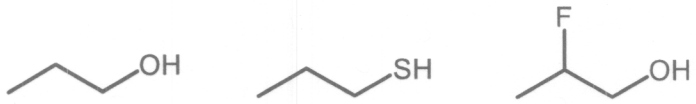
major - all octets and greatest # of bonds

b. 

major - nitrogen is more electronegative

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

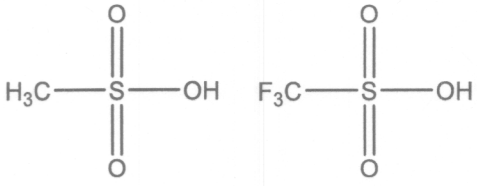
a. Assign these values to the corresponding compounds.
b. Which compound is the most acidic? (8 points)



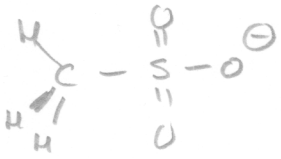
16.0 10.5 14.4

↑ most acidic (atom effect)

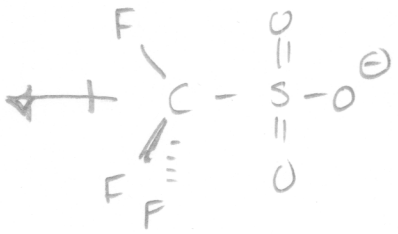
9. Use ARIO to explain the difference in acidity between methanesulfonic acid and trifluoromethane sulfonic acid (don't forget about the conjugate base). (10 points)



pK_a -2.6 -12

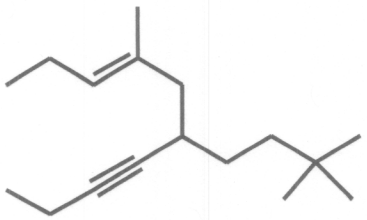


conjugate base

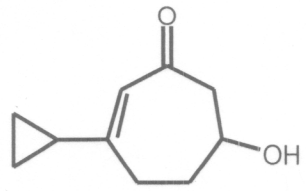


The CF_3 group stabilizes the conjugate base through induction, therefore the acid is more acidic

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

a. 

$C_{17}H_{30}$

b. 

$C_{10}H_{14}O_2$

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

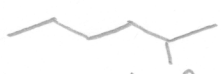
pentane
bp 36°C

2,2-dimethylpropane
bp 10°C

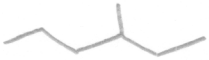
pentane is unbranched and has greater surface area, which provide for more London dispersion attractive forces – so it boiling point is higher the 2,2-dimethyl propane

12. Draw and name all of the *constitutional isomers* of the alkanes with molecular formula C_7H_{16}. (25 points)

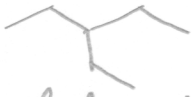
heptane



2-methyl hexane

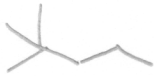


3-methyl hexane

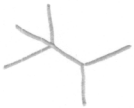


3-ethyl pentane

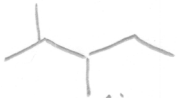
2,4-dimethyl pentane



2,2-dimethyl pentane



2,2,3-trimethyl butane



2,3-dimethyl pentane

3,3-dimethyl pentane

13. 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. Calculate the equilibrium constant (K_{eq}) – show your calculation. (15 points)

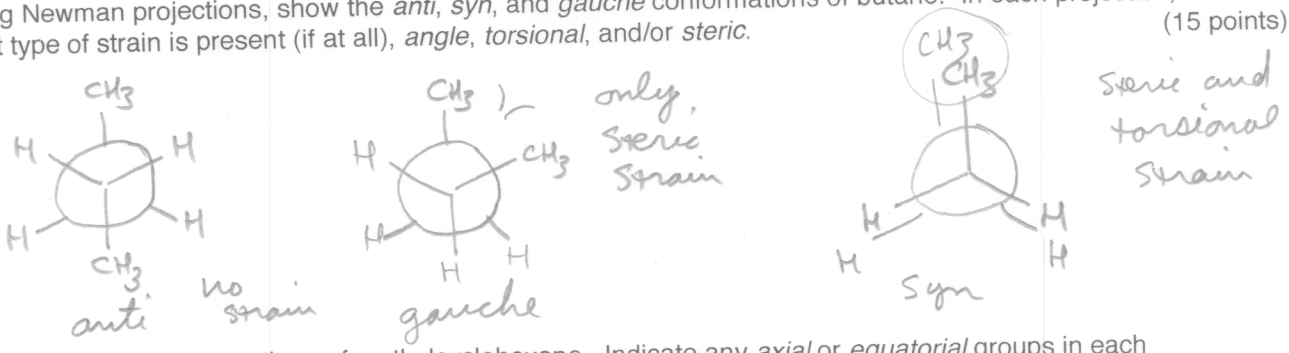
"Nature favors the weakest acid."

thiophenol
pK_a = 6.6

ammonium ion
pK_a = 9.9
weaker acid

$K_{eq} = 10^{9.9-6.6} = 10^{3.3} = 2.0 \times 10^3$
$\simeq 2000$

14. Using Newman projections, show the *anti*, *syn*, and *gauche* conformations of butane. In each projection, indicate what type of strain is present (if at all), *angle*, *torsional*, and/or *steric*. (15 points)



15. Show both chair conformations of methylcyclohexane. Indicate any *axial* or *equatorial* groups in each conformation. (20 points)

16. *Extra Credit* Circle and correctly name all of the functional groups present in the molecule below. (2 EC points each)