1. Assign R/S centers.

(1) \[ \text{H}_3\text{C} \quad \text{H} \quad \text{F} \quad \text{CH}_2\text{F} \quad \text{OH} \quad \text{C(CH}_3\text{)}_3 \]

(2) 

(3) 

(4) 

2. Identify whether the acid-base equilibrium lies to the left or to the right in the reactions below. (2 pts each)

\[ \text{H}_3\text{C} \quad \text{C} \quad \text{Pr} \quad \text{H} \quad \text{Br} \quad \text{C(CH}_3\text{)}_3 \quad \text{Br} \quad \text{C(CH}_3\text{)}_3 \]

\[ pK_a = 6.95 \quad pK_a = -6.8 \]
3. What is the index of hydrogen deficiency of a compound with a molecular formula of C₉H₁₁NO?

(a) 3  (b) 4  (c) 5  (d) 6

Complete the following acid-base reaction (write the products).

\[
\text{[Diagram of reaction: benzene carboxylic acid + NaOH → HOH]}
\]

5. Azide anion is a very good nucleophile. Predict the major product from the following reaction?

\[
\text{[Diagram of reaction: 2-bromomethylcyclohexane + NaN₃ (excess)]}
\]

(a) \[\text{Product a: } \text{N}_3\text{-substituted cyclohexane} \]
(b) \[\text{Product b: } \text{N}_3\text{-substituted cyclohexane with bromine} \]
(c) \[\text{Product c: } \text{Cl-substituted cyclohexane with azide} \]
(d) \[\text{Product d: } \text{Cl-substituted cyclohexane with azide} \]

6.
Which of the following would react most quickly in an $S_N1$ reaction with acetic acid?

a. methyl fluoride  
b. ethyl chloride  
c. isopropyl chloride  
d. tert-butyl bromide

7. Which structure(s) contain(s) an oxygen that bears a formal charge of $+1$?

I  
II  
III  
IV  
V

(a) I and II  
(b) III and IV  
(c) V  
(d) III  
(e) I and V

10. Which compounds is not a meso compound?

(a)  
(b)  
(c)  
(d)  
(e)
12. The given reaction should be favorable based on the pKa values shown.

\[
\text{H}_2\text{O} + \text{phenolate} \rightarrow \text{HO}^- + \text{phenol}
\]

\[\text{pKa}=15.7 \quad \text{pKa}=9.9\]

12. For each of the indicated chiral centers below, provide the correct R or S designation. (6 pts)
12. Match each compound to its IR spectrum. (12 pts)
14. For the problem shown below, answer the questions and draw the structure that corresponds to the following spectra.

Empirical Formula: C₄H₅O
Mass Spec: M⁺ m/e = 138
**Determination of the Molecular Formula (3pts)**

a) What is the molecular weight of the unknown compound? 

b) What is the correct molecular formula of the unknown compound? 

c) How many degrees of unsaturation does this compound have? 

**Analysis of the IR spectrum (3 pts)**

d) Which of the following bonds are present?

(circle all that are present) O-H C-O C=O 

e) Based on the analysis of the IR, what type(s) of functional group(s) is/are present? 

**Analysis of the 1H NMR spectrum (5 pts)**

f) How many different protons are there in the molecule? 

g) Which of the following are present? (circle all that apply)

Et iPr tBu H on a heteroatom vinylic H (i.e. an alkene) aromatic H 

h) How many aromatic hydrogens are there? 

i) How many substituents are there on the aromatic ring? 

Analysis of the $^{13}$C NMR (4pts)

j) How many different carbons are there in the molecule? _____

k) How many types of aromatic carbons are there in the molecule? _____

l) Is there a peak arising from a carbonyl in the $^{13}$C NMR spectrum? (circle one) Yes No

m) How many types of sp$^3$ carbons are there? _____

Putting it all together (5 pts)

n) Suggest a single structure for the molecule that is consistent with all of the data presented.

*Note: Most of the credit for this problem comes from answering the questions above in the spaces provided.*
Note this is strictly for helping you on other problems (i.e. IR)! It’s important you’re familiar with some functional groups. :) You will not be tested about nomenclature only.

16. Draw the most stable chair conformation of the following compounds. (pts)
18. Provide **three possible resonance contributors** for the following compound (12 pts total).

![Resonance contributor diagram]

19.

![Reaction diagram]