“Twentieth-century medicine, which has worked so many miracles, has been chemically not structurally oriented. Hence, the lay mind thinks of chemistry as the only outstanding healing medium – a drug for this, a shot for that. But any mirror photography would reveal that a great many problems are matters of structure, of physics…” - Ida P. Rolf, biochemist

1. Given the following IR spectra, determine if you have one of the following: aldehyde; alcohol; amide; acid; or amine (you will have one left over). Give specific stretches that allowed you to make your determinations (on the spectra is just fine).
2. Given the following spectra, a compound which is 70.1 %C; 7.1 %H, and 22.7
%X, answer the questions about this molecule.

MS
a. What is the molecular formula of this compound? How did you use the mass spectrum to help you with this determination? What are the units of unsaturation? (4 pts)

b. What information have you gathered from the IR spectrum? Give specific peaks and what they told you. (3 pts)

c. What information have you gathered from the $^{13}$C NMR spectrum? Give information about chemical shift and coupling patterns for full credit. (4 pts)
d. What information have you gathered from the $^1$H NMR spectrum? Give information about chemical shift, coupling patterns, and integrations for full credit. (4 pts)

e. What is the structure of your compound? (3 pts)

(8) 3. In the reaction of an aldehyde with a Grignard reagent, upon protonation, the following product is formed. Given the $^1$H NMR of one of the starting materials, tell me what the reactants were for this reaction (give me the structures of the Grignard reagent and the aldehyde).

![Product structure]

$^1$H NMR
(20) 4. Give the product(s) of four the following five reactions. (5 pts each)

a. \[ \text{Br} \quad 1) \text{PPh}_3, \text{THF} \]
2) n-BuLi, hexane
3) 3-pentanone
4) H_3O^+

b. 1-phenyl-3-butanol \quad 1) \text{PCC, CH}_2\text{Cl}_2
2) \text{HCN}
5. Given the following two reactions, give the products for both of them. (5 pts each) Choose one and give a complete arrow pushing mechanism accounting for the formation of all new bonds, all intermediates, and the sequence of steps to give rise to your product(s). (16 pts)

a. 

b. 

Mechanism:
(10)6. Synthesize **one** of the following two molecules starting from legal starting materials. Legal starting materials: bromobenzene; toluene; **mono**-alcohols of four carbons or less; inorganic reagents (sodium cyanide; triphenylphosphine; n-BuLi as a base; KOTBu as a base; etc.); and any solvent you need. Remember, if carbons are incorporated into the molecule, you must **make** that starting material.

\[
\begin{aligned}
&\text{苯甲酸} \\
&\text{乙醇}
\end{aligned}
\]
(6) 7. In the reaction below, give the product(s) and outline a procedure for their purification. Flow chart format is preferable (and easier to grade).

\[ \text{ester} + \text{alcohol} \xrightarrow{\text{H}_2\text{SO}_4} ? \]

(banana oil)

(3) BONUS: Victor Grignard won what prize for his little reaction?