

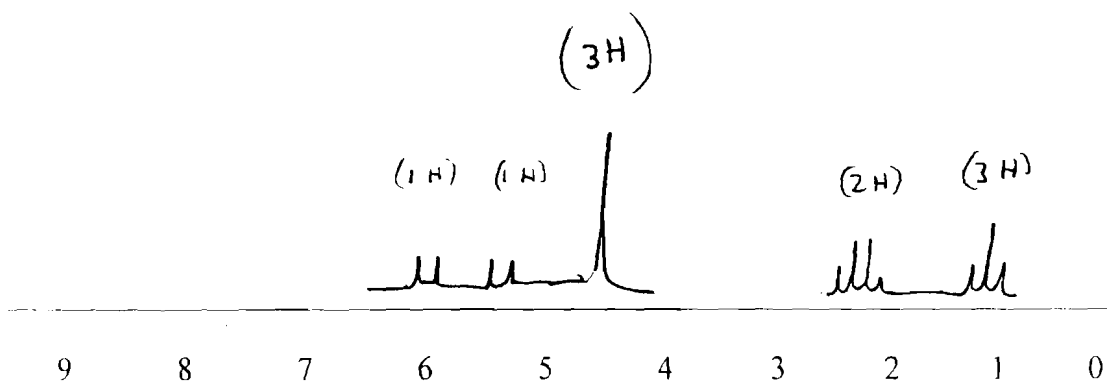
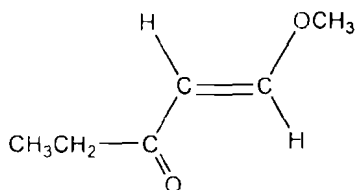
1. (10 pts) Circle what is true about NMR.

- a) NMR stands for 'Nuclear Magnetic Resonance.
- b) The 'Coupling constant' measures the electron density about a hydrogen
- c) Protons that are 'upfield' are in electron rich environments
- d) 'I had my spin flipped' is what chemists say when they fall in Love
- e) Upfield protons are closer to 0 ppm than downfield protons.

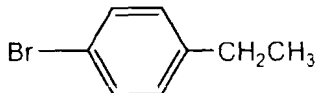
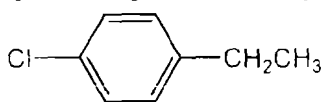
2. (10 pts) Circle what is true about IR

- a) IR stands for "Insight Radical" spectroscopy
- b) The intensity of an IR absorption band depends on the polarity of the bond.
- c) IR spectroscopy gave rise to MRI (magnetic resonance imaging) technology.
- d) A single bond will absorb IR radiation at a lower frequency than a double bond.
- e) Alcohol (OH) absorptions are broad due to hydrogen bonding.

3. (8 pts) Draw the NMR spectrum for the compound below. Be sure to include splitting and integration values (See the tables on the last page of the exam)



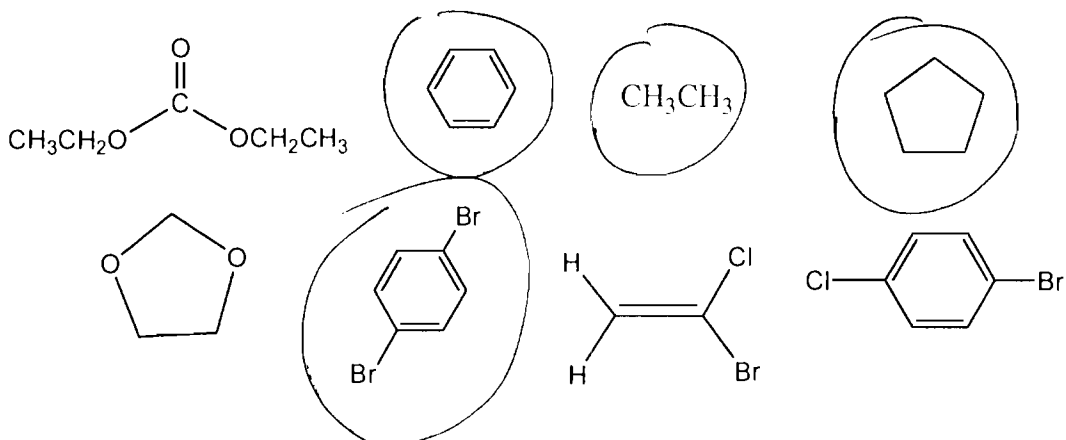
4. (4 pts) Which method (NMR, IR or Mass spec) would be best to distinguish between the two compounds below? **Briefly explain** how you could easily tell them apart using the method you chose.



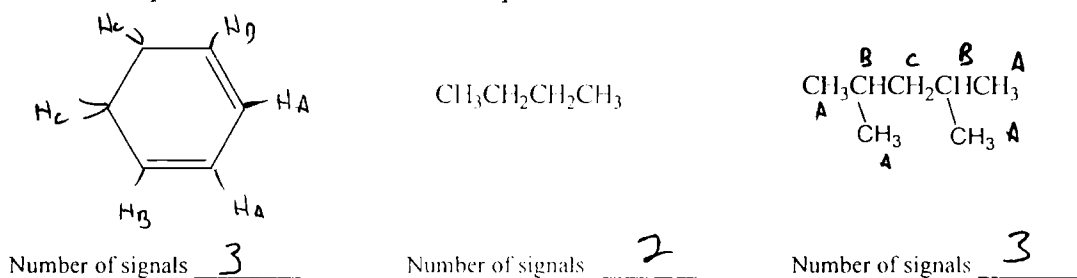
Both Give M+2 peaks
 Br → m/z
 Cl → m/z

Mass spec can distinguish Br from Cl by isotope patterns.
 Br 50% ^{79}Br
 50% ^{81}Br
 Cl ~75% ^{35}Cl
 25% ^{37}Cl

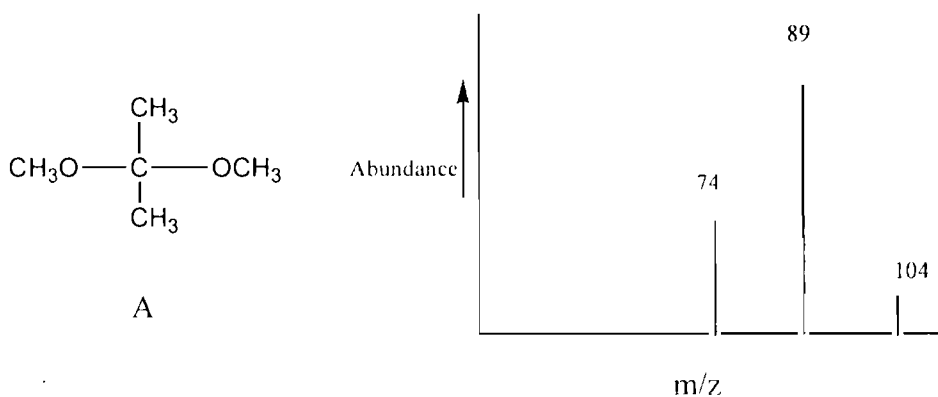
5. (10 pts) Circle the molecules below that would only give one signal (one peak) on the NMR



6. (9 pts) How many signals (how many different protons) would you expect to see in the NMR spectrum of each of the compounds.

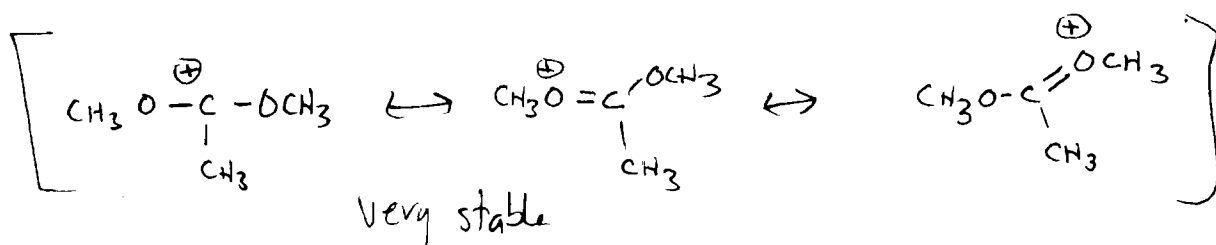


7. A Mass Spec is taken of the compound shown below.

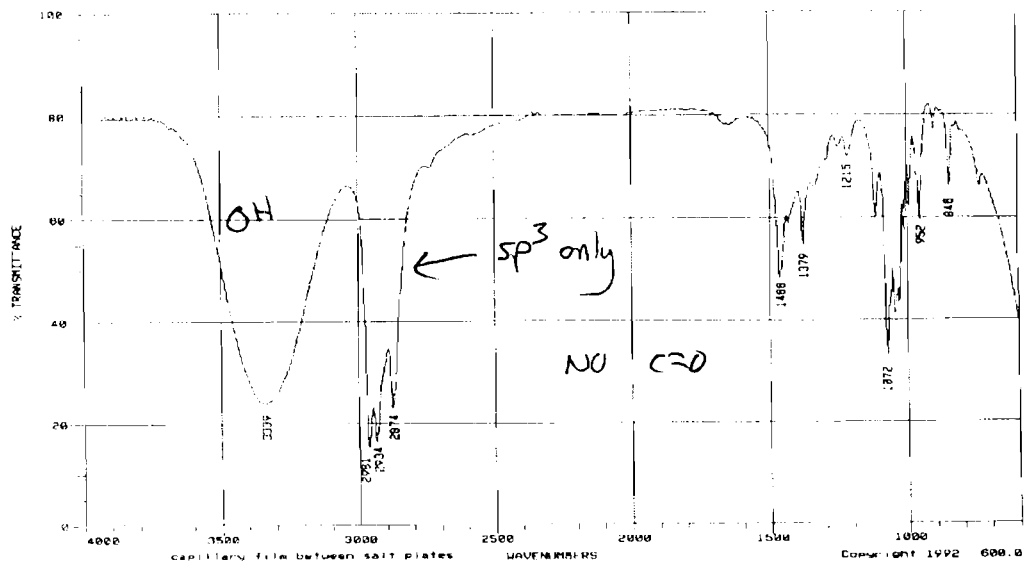
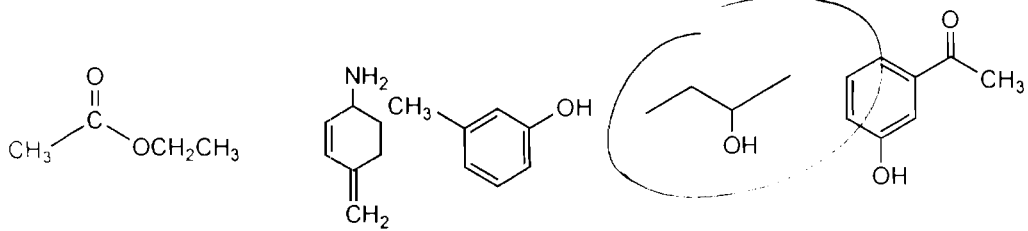
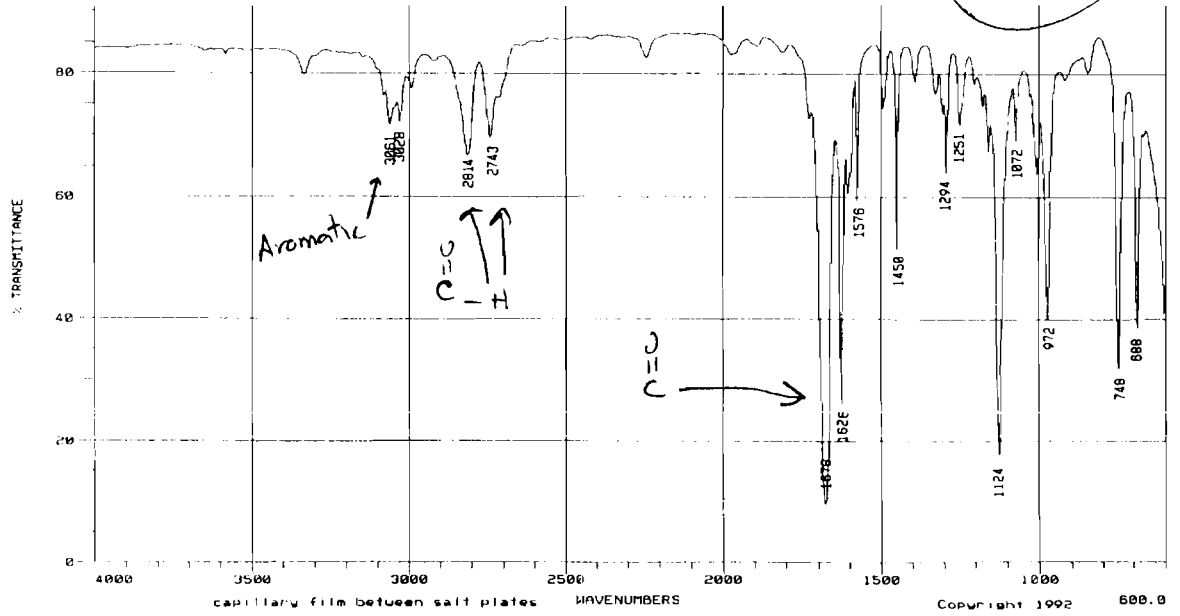
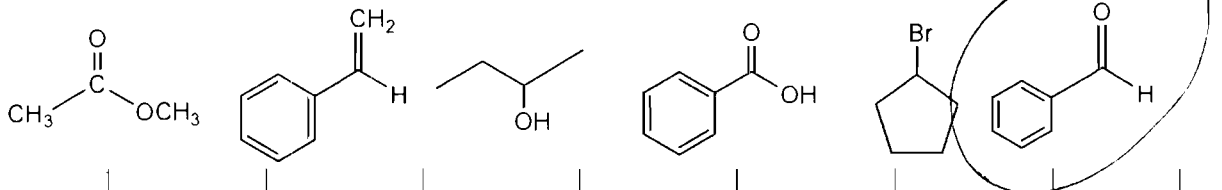


- a) (3 pts) Which peak is the **molecular ion peak**? → 104
 b) (2 pts) Which peak is the **base peak**? — 89 (Tallest)

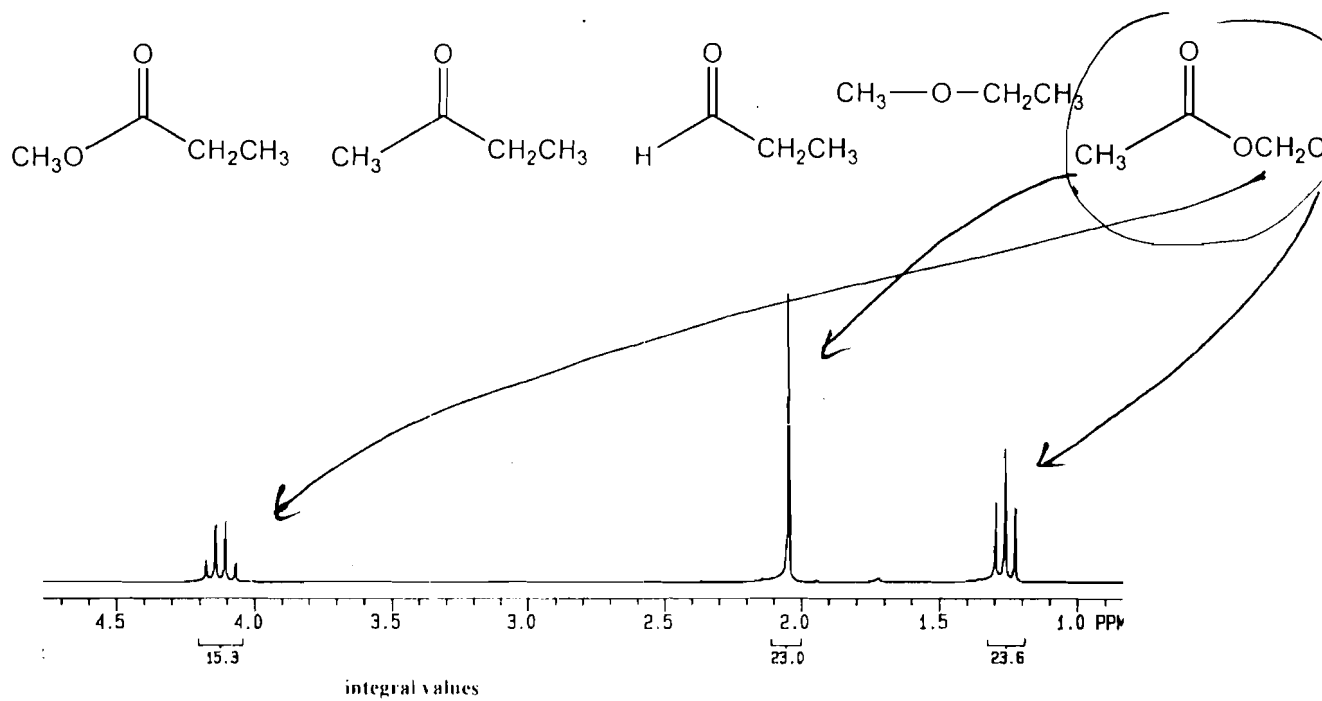
c) (6 pts) Draw the structure of the ion that represents the **base peak** (show all pertinent resonance structures.)



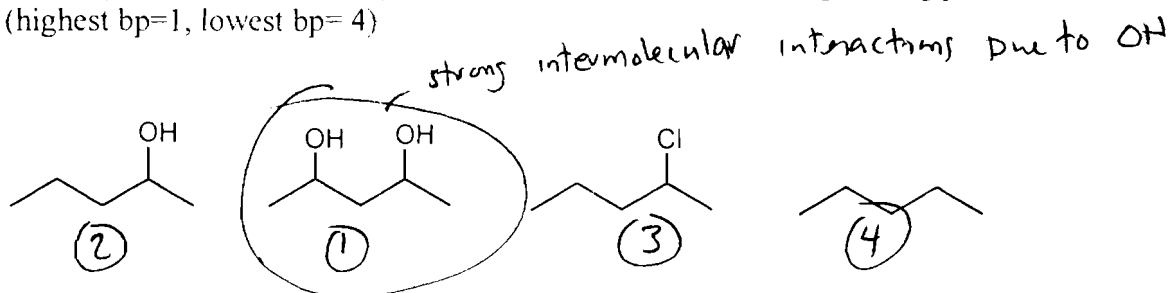
8. (12 pts-6 pts ea) Above each of the 2 IR spectra below there are 5 compounds that it could be. Circle the compound which would best match the IR spectra.



9 (8 pts) Above the NMR spectra below there are 5 compounds that it could be. Circle the compound which would best match the NMR spectra. Integration values are shown below the peaks.

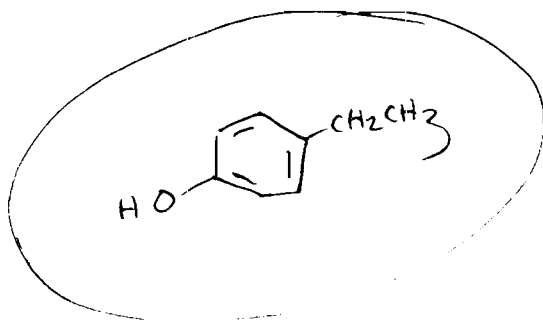
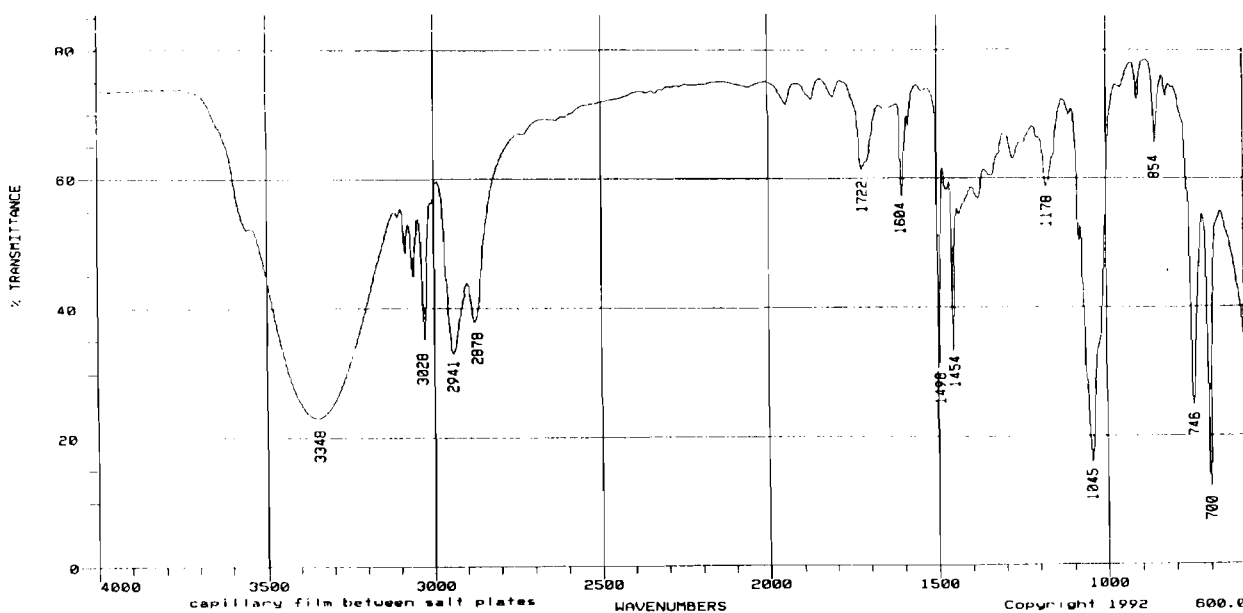
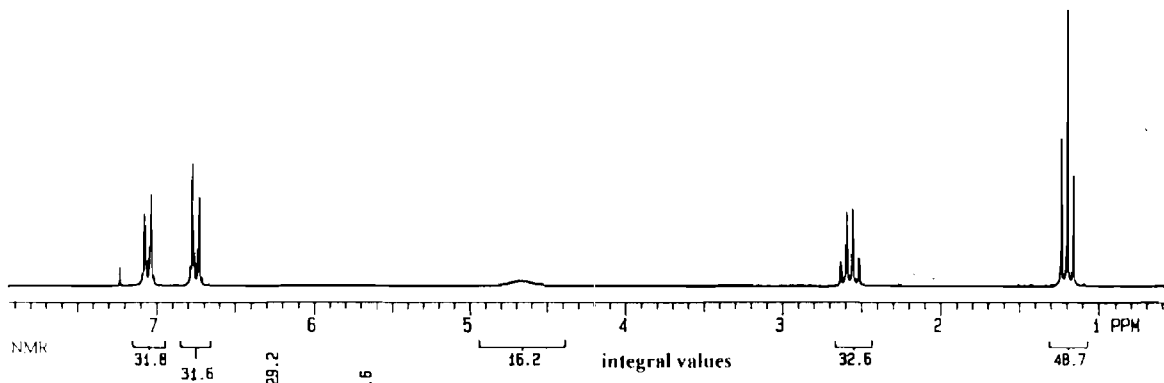


10 a. (5 pts) List the following compounds in order of decreasing boiling point (highest bp=1, lowest bp=4)

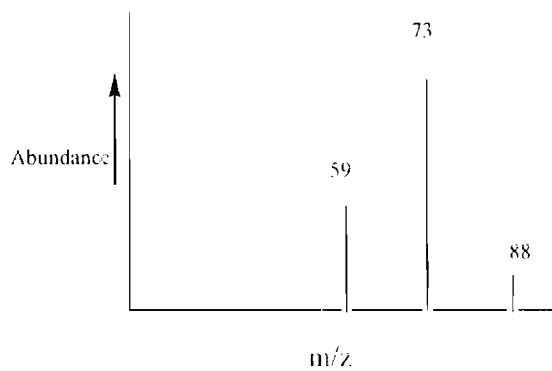
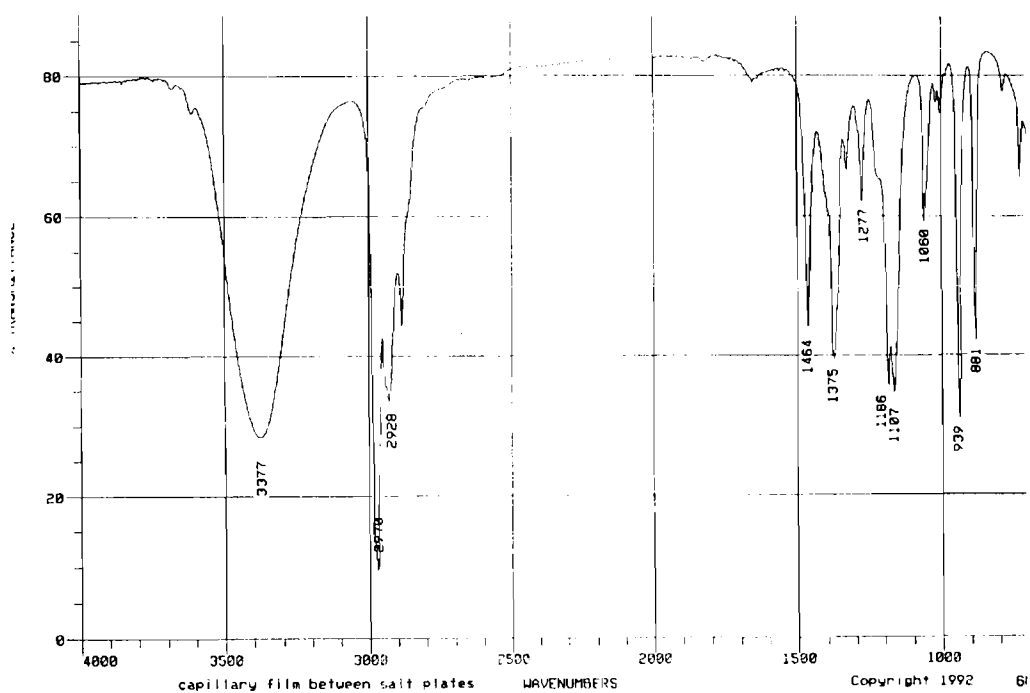
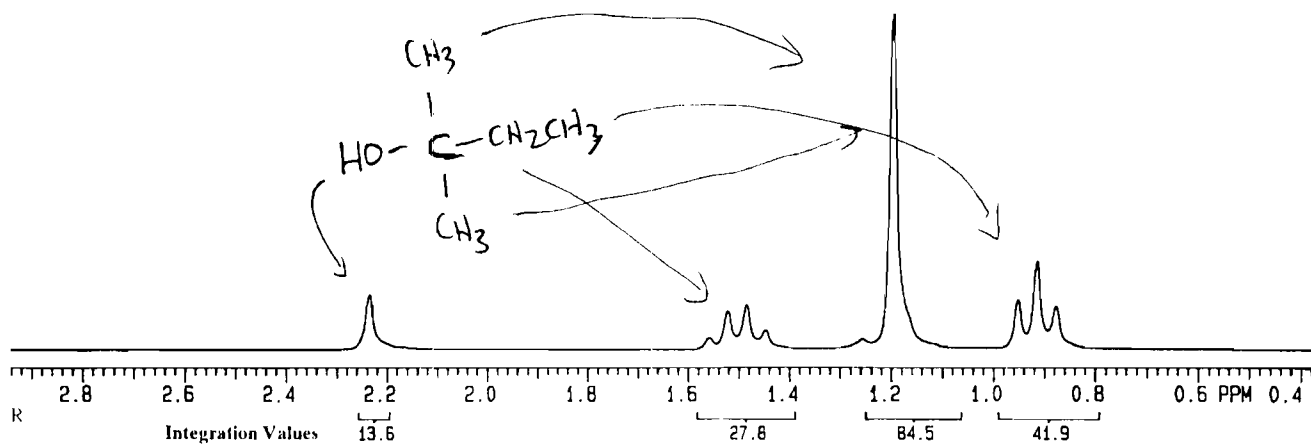


b (3 pts) Circle the compound above that would be the most water soluble.

11. (10 pts) Give the structure for the following unknown using the NMR and IR data below. The molecular weight is 122. On the NMR there is a broad peak at 4.7 ppm



Extra credit (4 pts) Give the structure for the following unknown using the NMR, IR and Mass spec data below:



b. (1 pts) Why do you think they call it the 'Fingerprint region' in IR.

All humans have unique finger prints ; All compounds have unique fingerprint regions

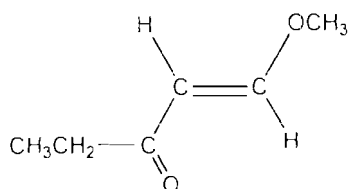
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- a) NMR stands for 'Nuclear Magnetic Resonance.'
 b) The 'Chemical Shift is related to the electron density about a hydrogen
 c) Protons that are 'downfield' are in electron rich environments
 d) Multiplicity (Splitting patterns) measure the number of hydrogen *neighbors*
 e) 'I had my spin flipped' is what chemists say when they fall in Love

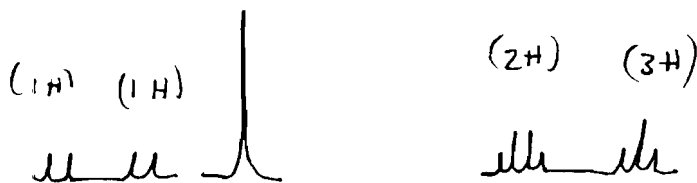
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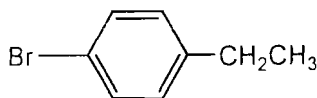
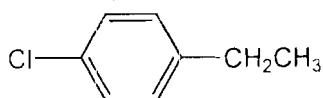
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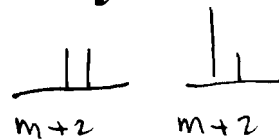
(3H)



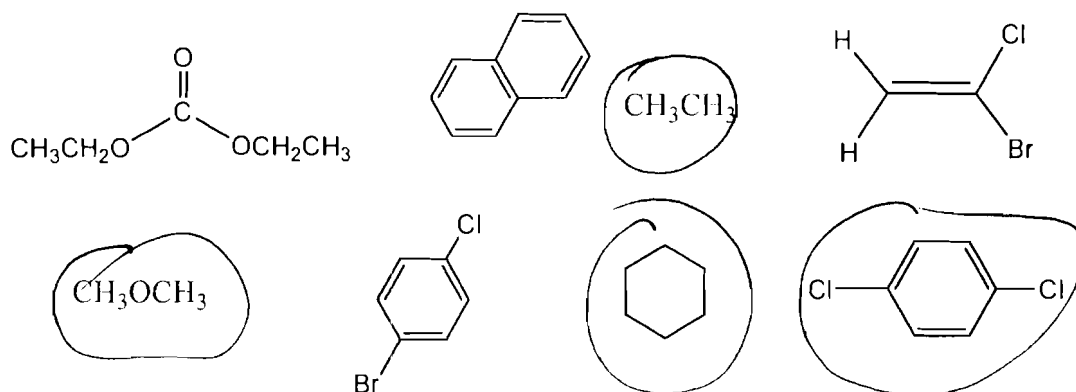
9 8 7 6 5 4 3 2 1 0

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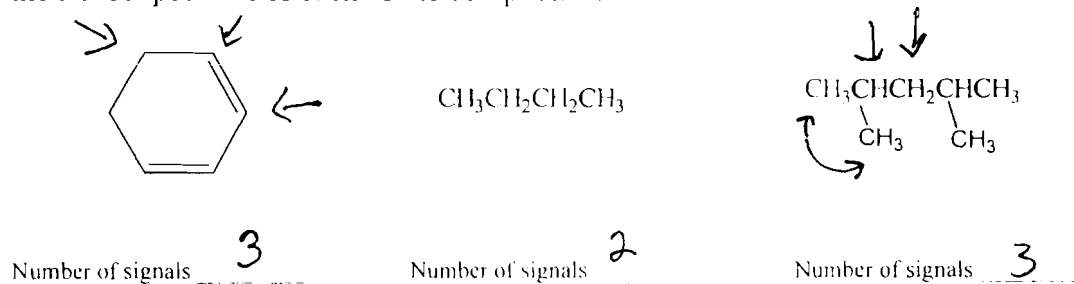
Mass spec → Br/Cl Have different Isotope patterns



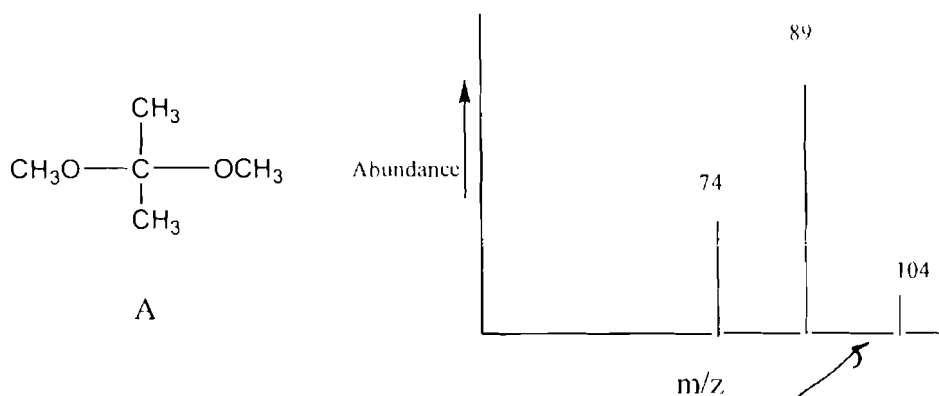
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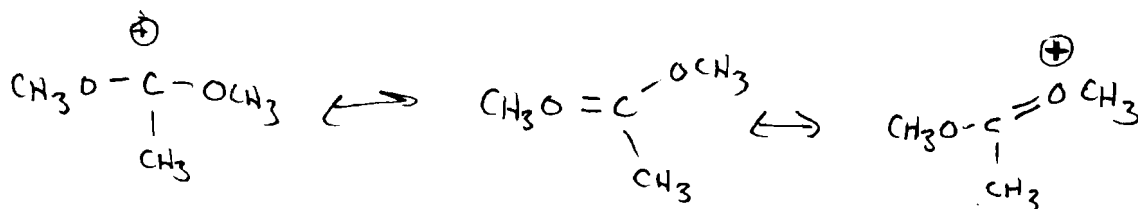


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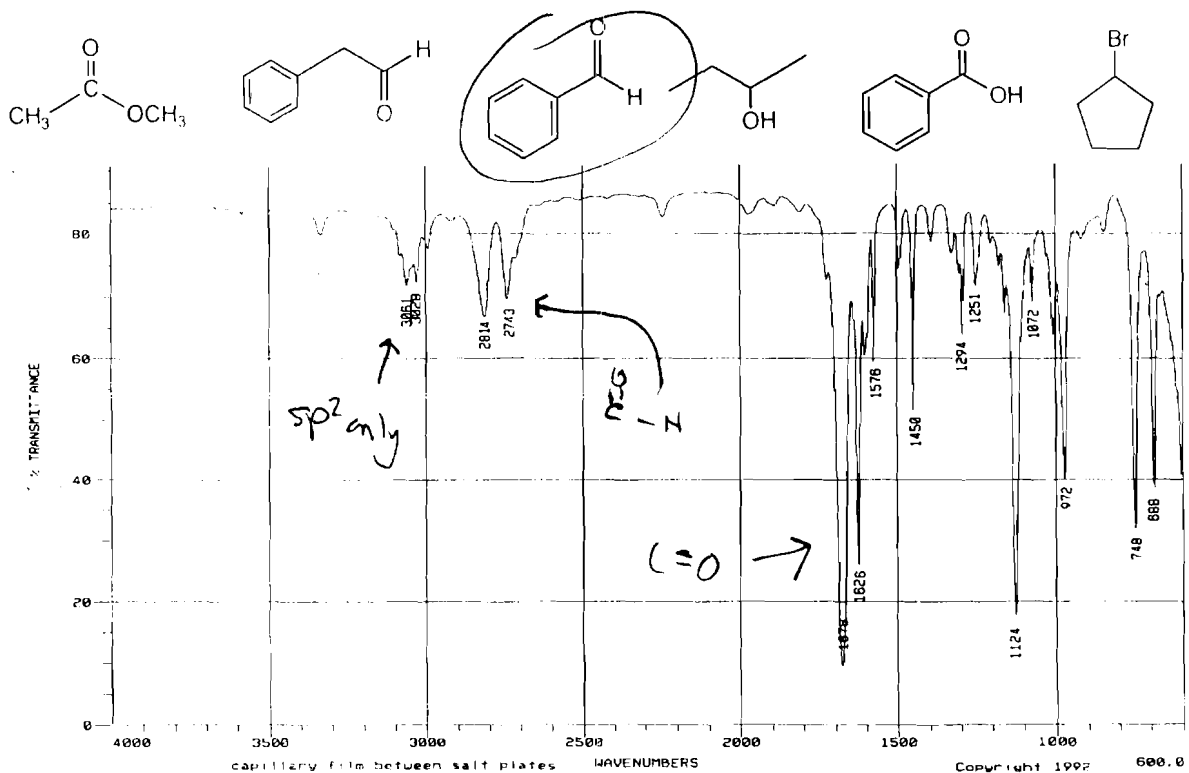
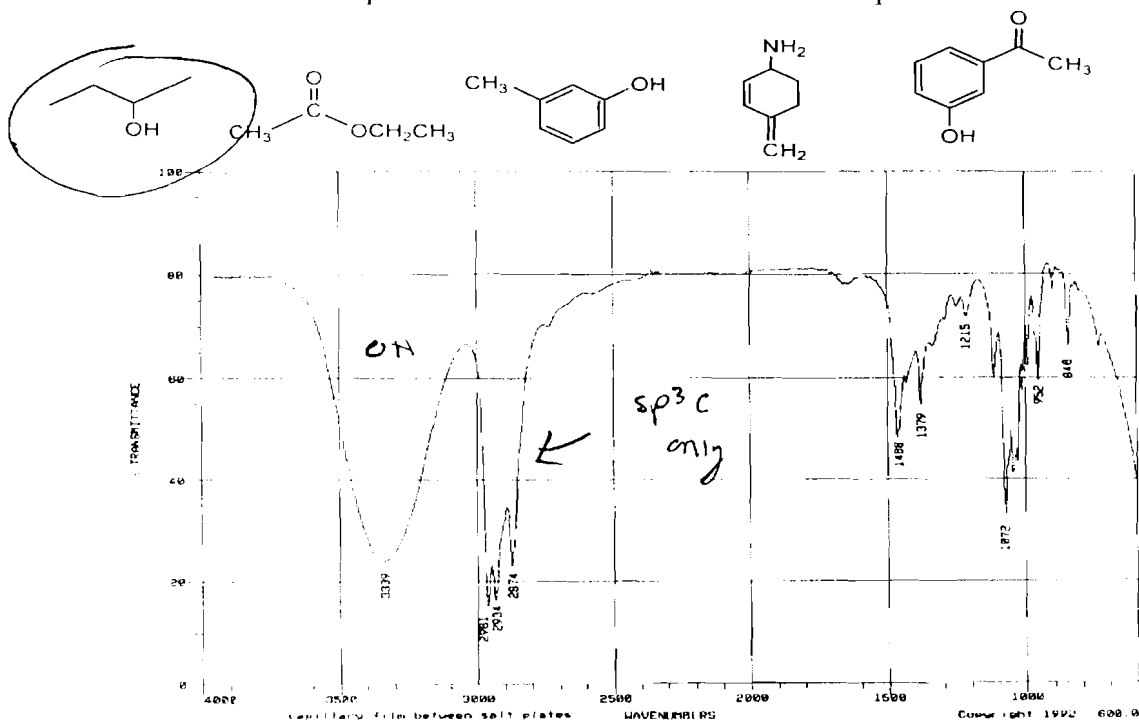


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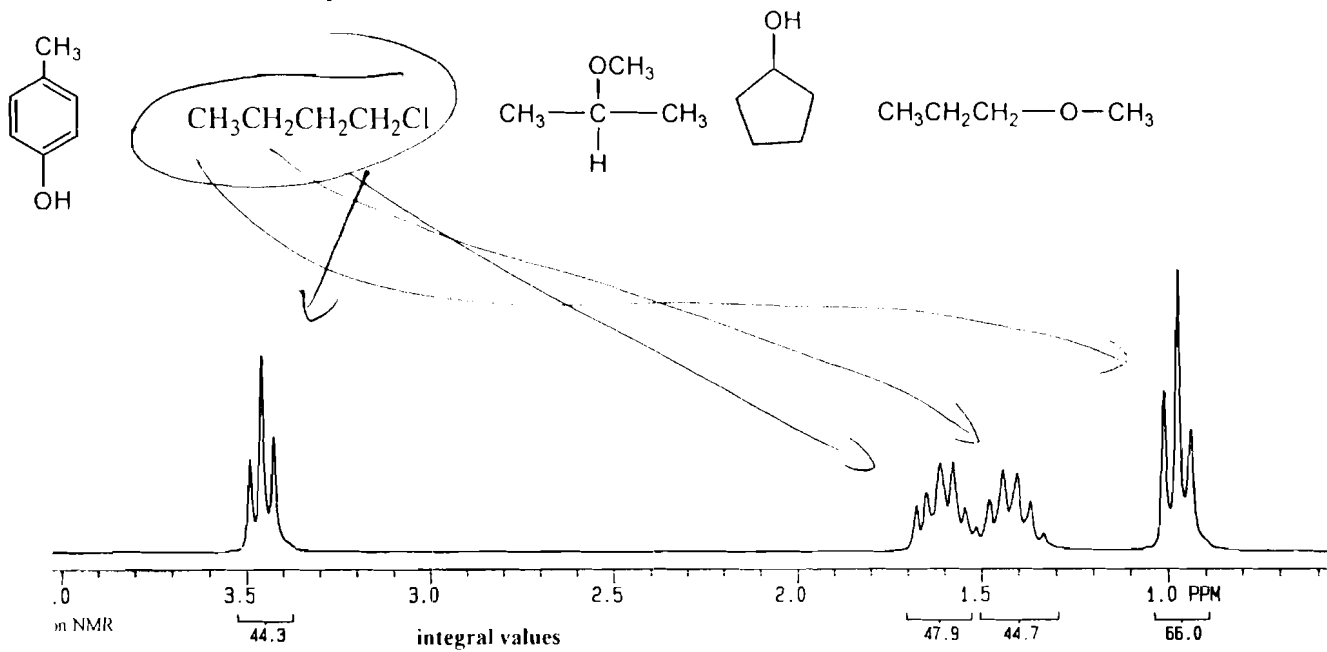
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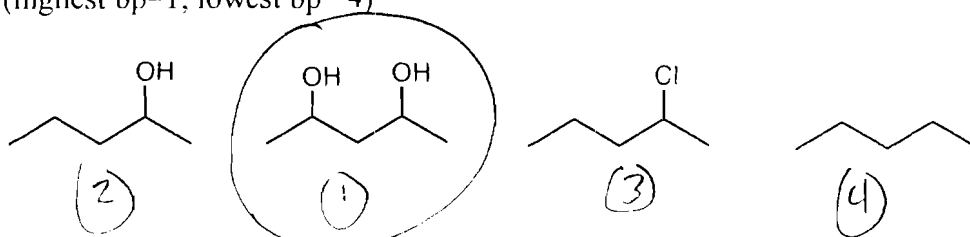
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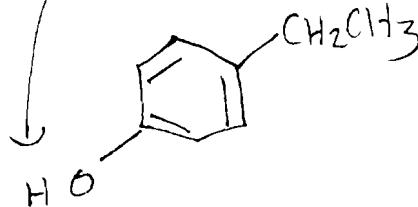
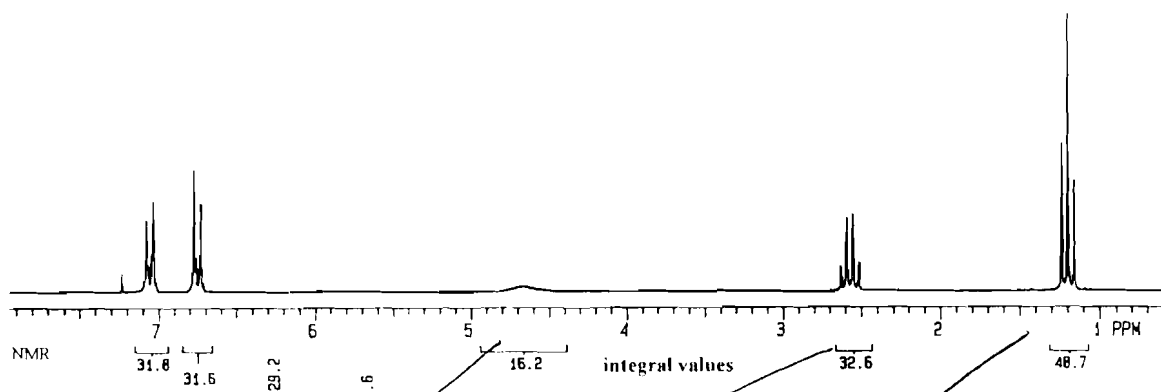
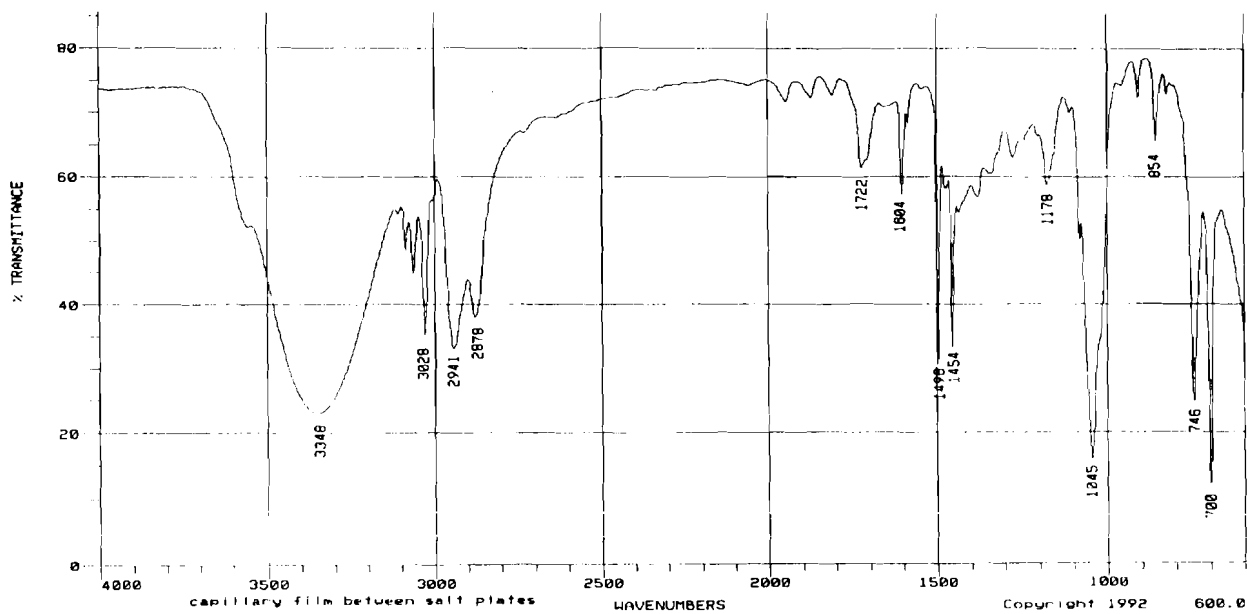


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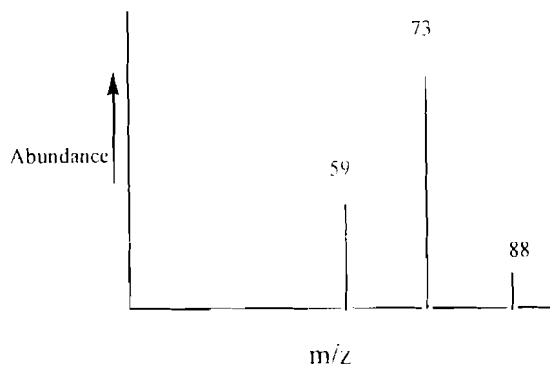
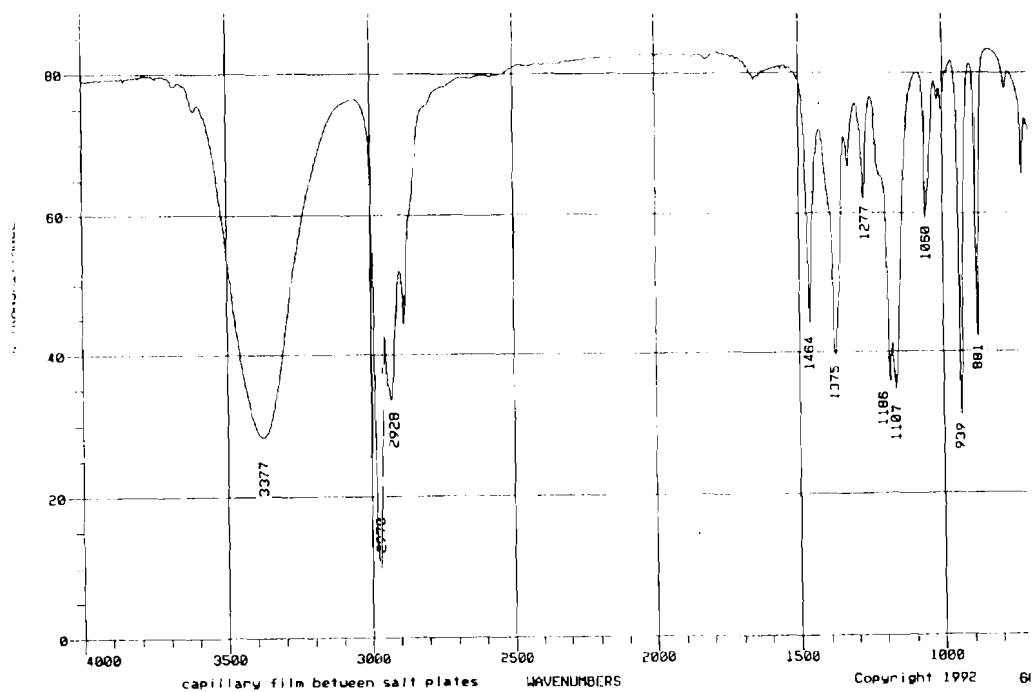
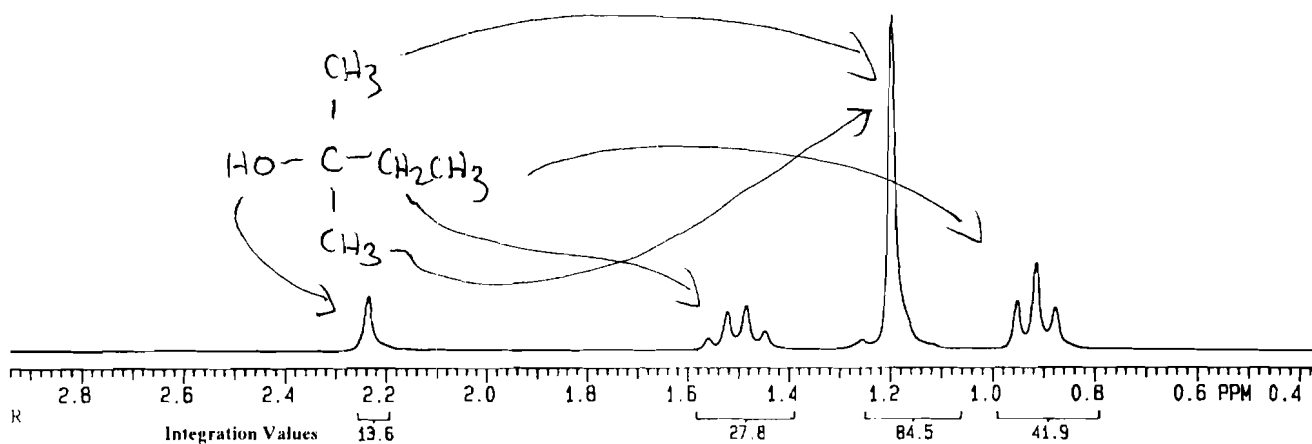


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As all humans have unique finger prints All molecules have unique absorptions in the fingerprint region