

First name: _____ Last name: _____ i.d.: _____

Midterm 1

Version 1

Organic Chemistry 2

CHEM222 and CHEM234

9 February 2011, 6-9 pm

INSTRUCTIONS:

Please write your **Name and ID number** in the space provided above.

This is a Closed Book Examination. Multiple choice questions **1-15** are worth **3 points** each. Multiple choice questions **16-20** are worth **5 points** each. Choose 4 questions within questions 21-25, worth **7.5 points** each.

Answer multiple choice questions on the answer sheet provided and questions 21-25 directly on the exam paper.

Molecular models and pen/pencils are allowed.

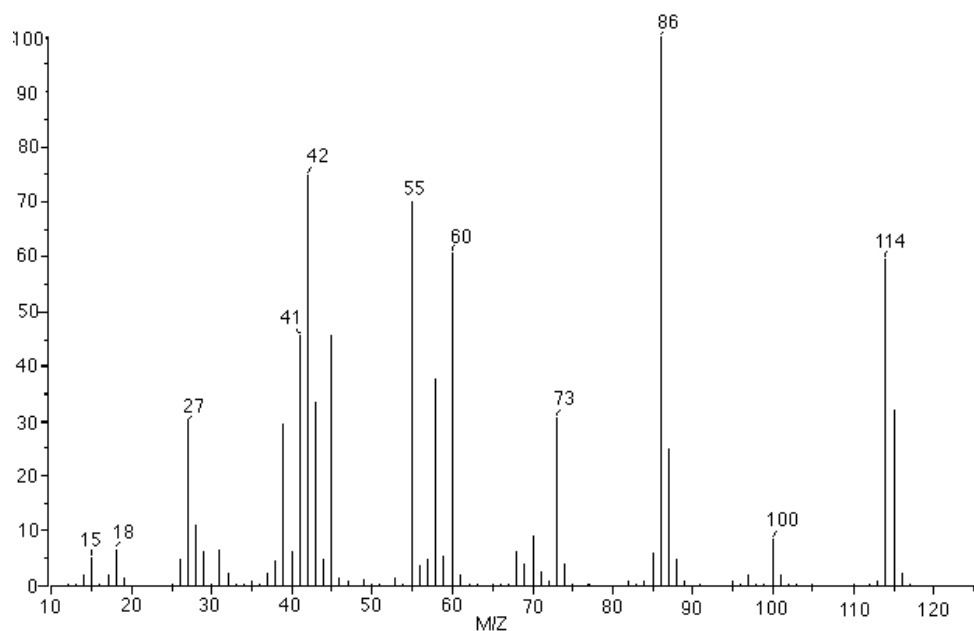
Calculators, dictionaries or electronic devices are NOT allowed.

At the end you must **hand in ALL pages** of your exam.

McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism, and other academic offenses under the code of students conduct and disciplinary procedures.

Good Luck!

Questions 1-3 refer to the MS spectrum below



1-Which of the peaks of the above MS spectrum corresponds to the base peak?

- a) 15
- b) 86
- c) 114
- d) 116

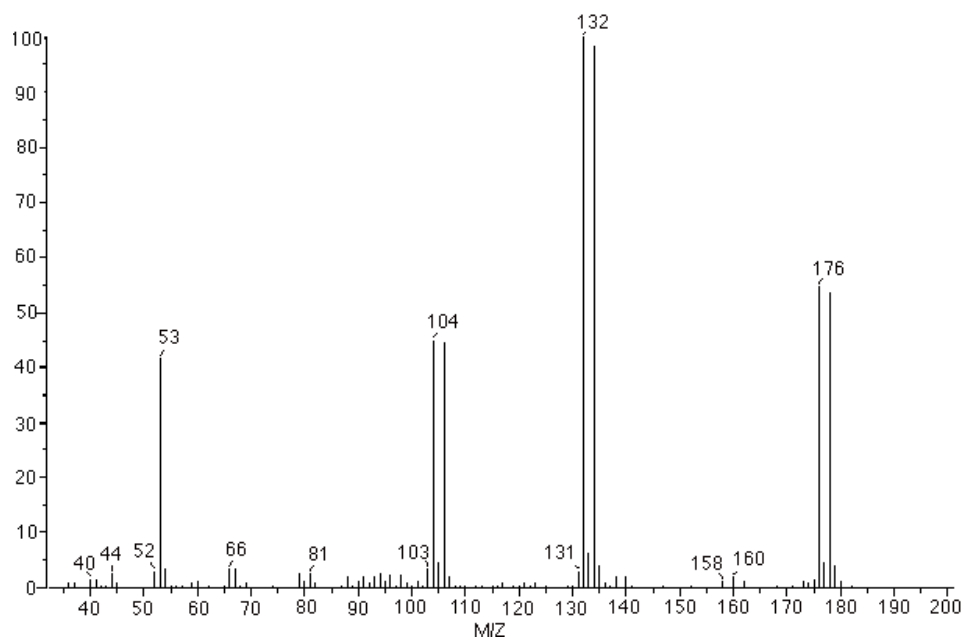
2- Which of the peaks of the above MS spectrum corresponds to the molecular ion?

- a) 15
- b) 86
- c) 114
- d) 116

3-What can you conclude from this MS spectrum?

- a) this molecule contains 3 atoms of Cl
- b) this molecule contains 1 atom of Br
- c) this molecule contains an even number of N
- d) the molecule must be radioactive

4-What can you say about the molecule that gives the MS spectrum below?



- a) it contains Br
- b) it contains Cl
- c) it contains 7 carbon atoms
- d) it contains an odd number of N

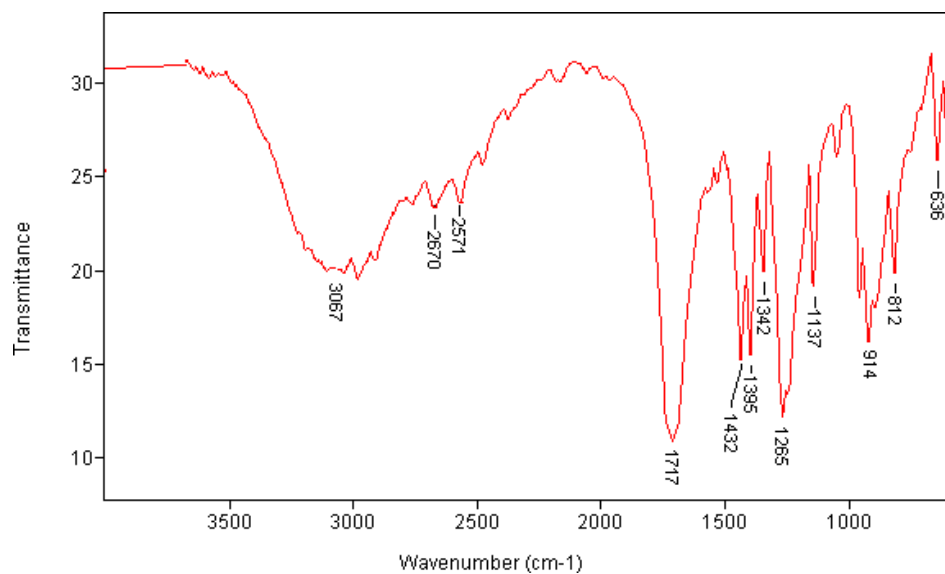
5-How many unsaturations do you expect from a molecule of formula C_6H_7N ?

- a) 0
- b) 2
- c) 3
- d) 4

6-What does the M+1 peak in MS typically represent?

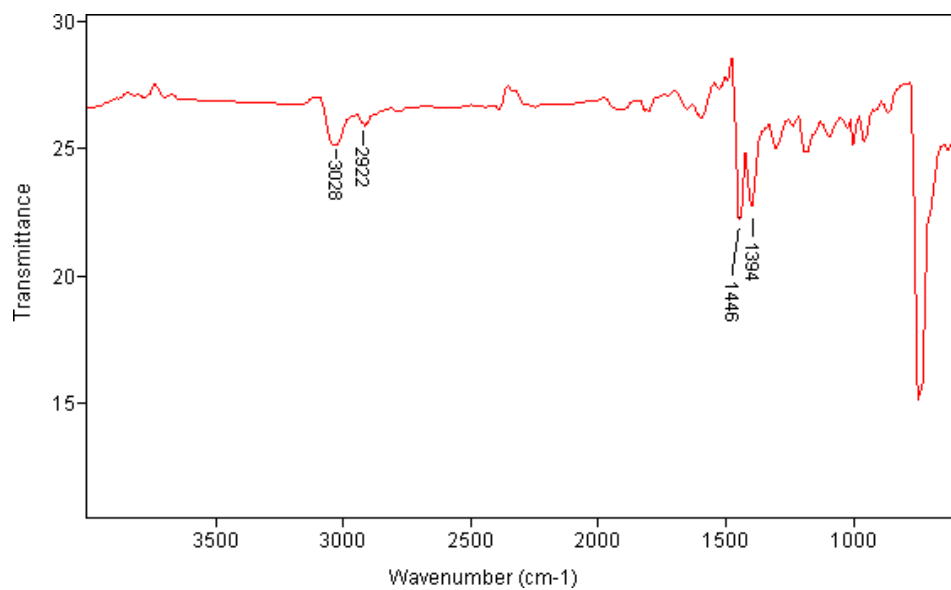
- a) This is the molecular ion
- b) Presence of ^{37}Cl in the molecule
- c) The ^{13}C isotope of carbon found in the molecule sample
- d) The ratio of Cl/Br

7- From the IR spectrum below, what can you conclude?



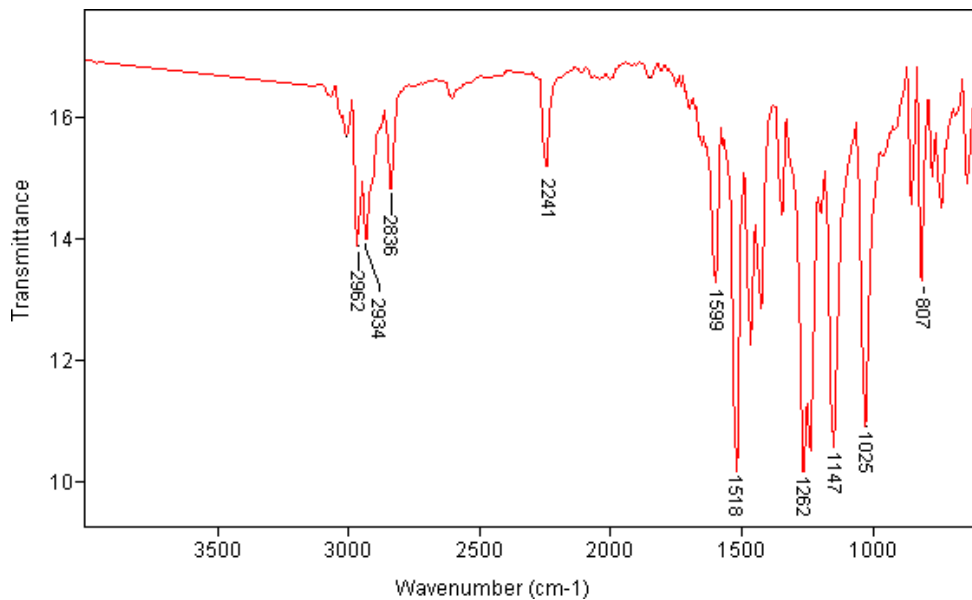
- a) presence of OH in the molecule
- b) presence of CO₂H in the molecule
- c) presence of NH₂ in the molecule
- d) presence of NH in the molecule

8- From the IR spectrum below, what can you conclude?



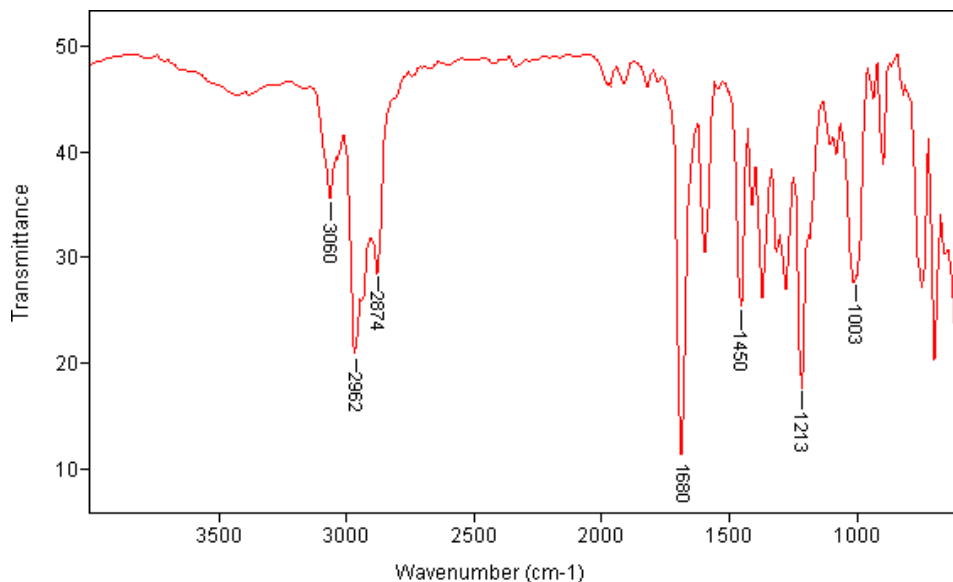
- a) presence of a carbonyl in the molecule
- b) presence of a triple bond in the molecule
- c) presence of an ether
- d) Likely an aromatic compound

9- From the IR spectrum below, what can you conclude?



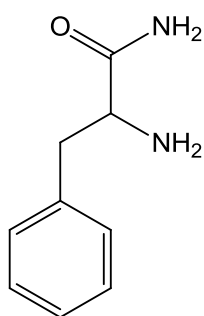
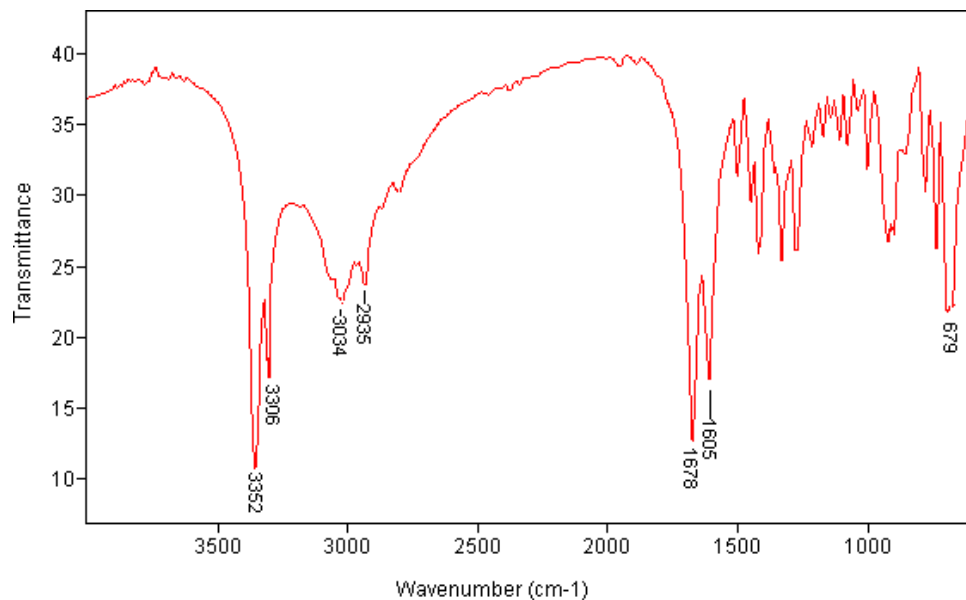
- a) molecule contains an alcohol
- b) molecule contains a triple bond
- c) molecule contains an aldehyde group
- d) molecule contains 2 ester bonds

10- From the IR spectrum below, what can you conclude?

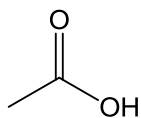


- a) molecule must contain an acid
- b) molecule must contain a ketone
- c) molecule must contain a triple bond
- d) molecule must contain an alcohol

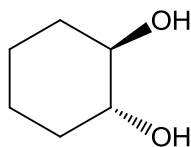
11-Which of the molecules below is more likely to give the IR spectrum below?



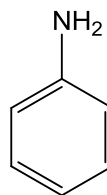
a



b

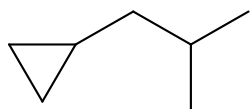


c



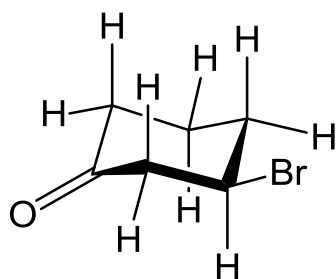
d

12- How many ¹H NMR signals would you expect for the molecule below?



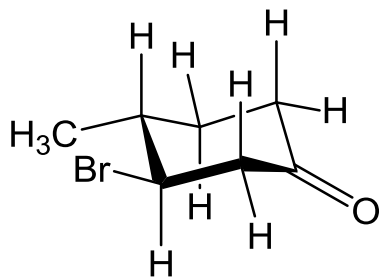
- a) 8
- b) 7
- c) 6
- d) 5

13- How many ^1H NMR signals would you expect for the molecule below?



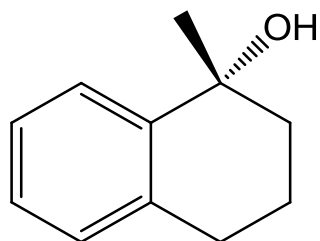
- a) 11
- b) 9
- c) 6
- d) 5

14- How many ^{13}C NMR signals would you expect for the molecule below?



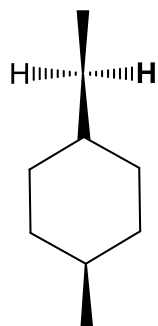
- a) 9
- b) 7
- c) 6
- d) 5

15- How many ^1H NMR signals would you expect for the molecule below?



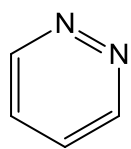
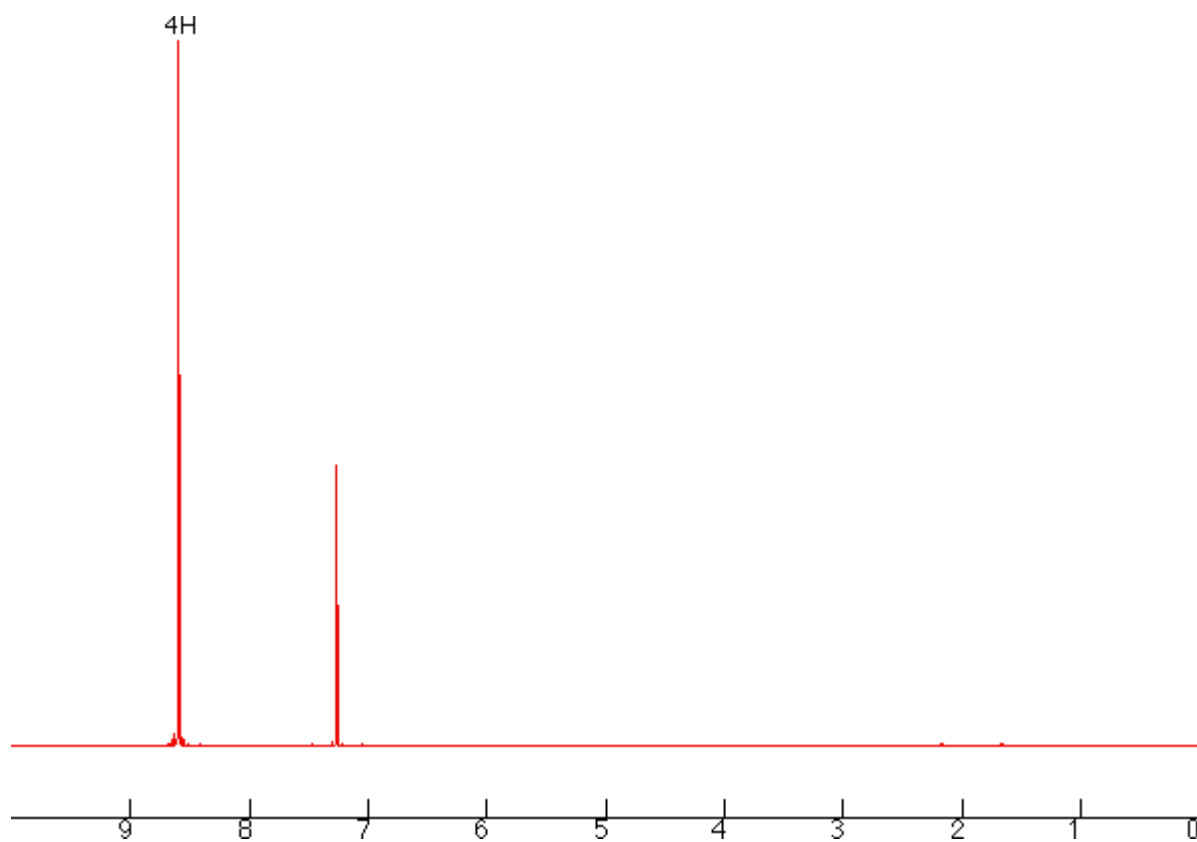
- a) 12
- b) 9
- c) 7
- d) 6

16-How can you qualify the two protons drawn out in the molecule below?

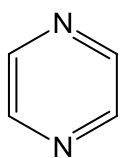


- a) homotopic
- b) enantiotopic
- c) diastereotopic

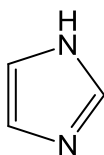
17- Which molecules below is more likely to have resulted in the ^1H NMR spectrum shown ?
(signal at ~ 7.3 ppm is due to NMR solvent)



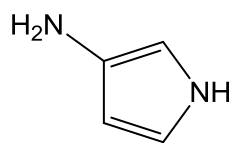
a



b

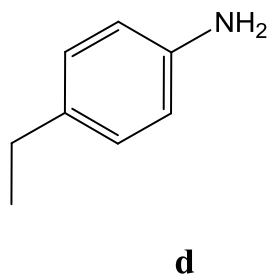
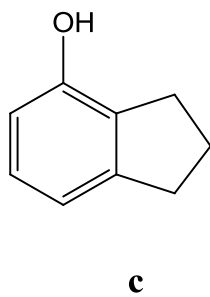
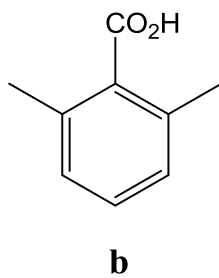
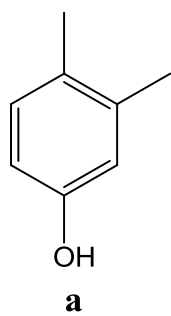
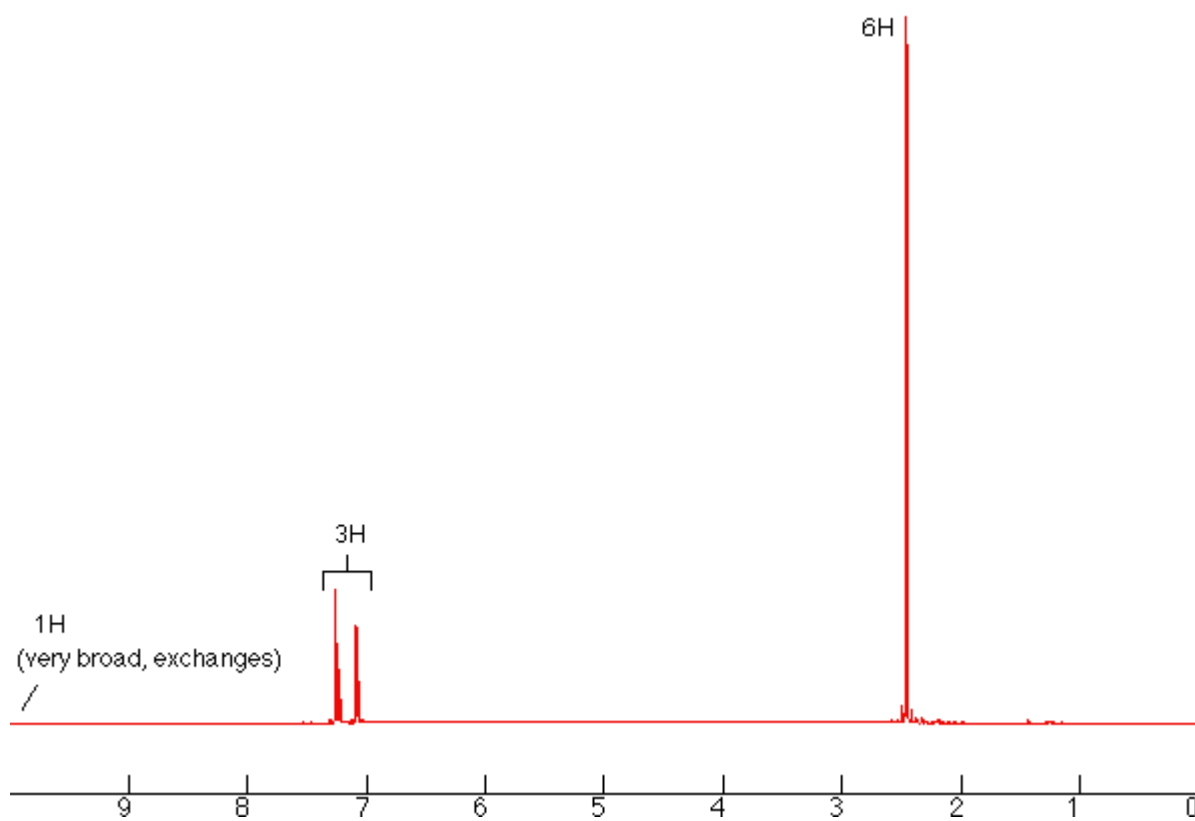
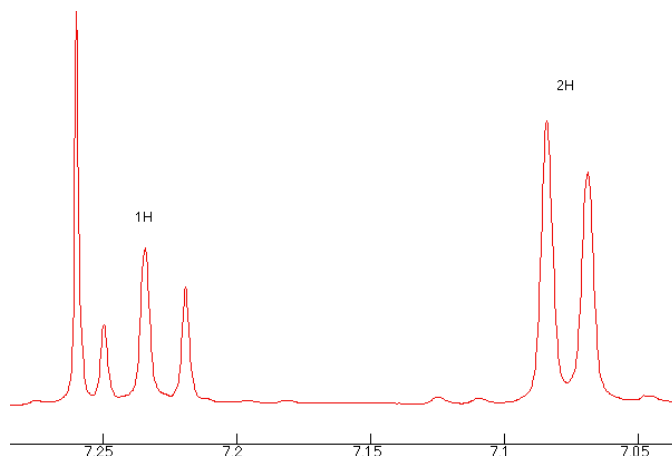


c

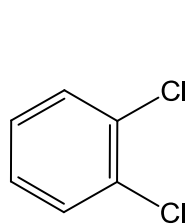
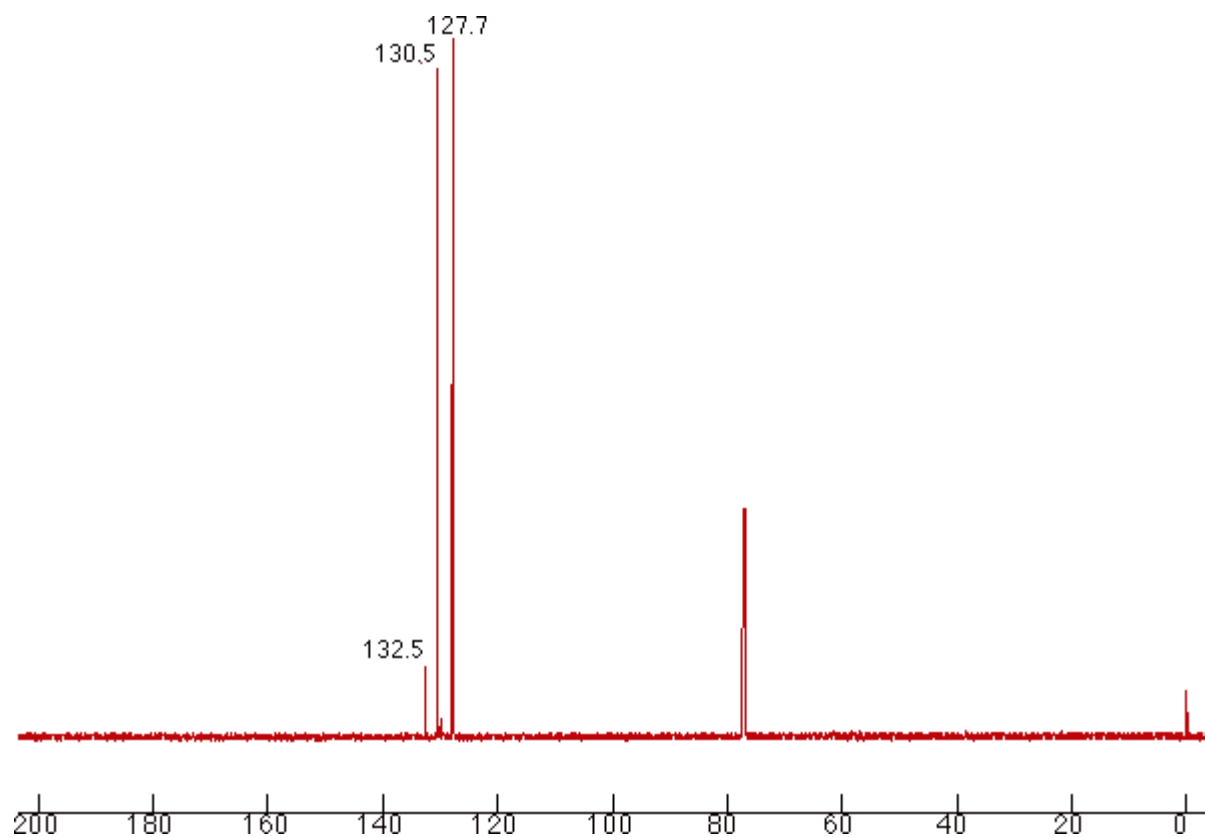


d

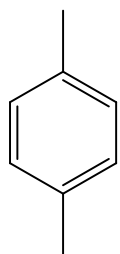
18- Which of the molecules below is more likely to have resulted in the ^1H NMR spectrum shown (expansions are shown and peak at ~ 7.3 is due to NMR solvent)?



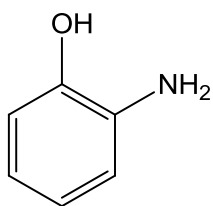
19- Which of the molecules below could best account for the ^{13}C NMR spectrum shown?
(the signal at 77 ppm is due to NMR solvent)



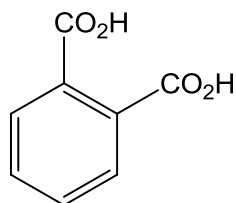
a



b

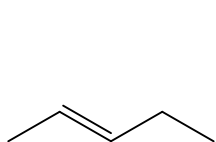
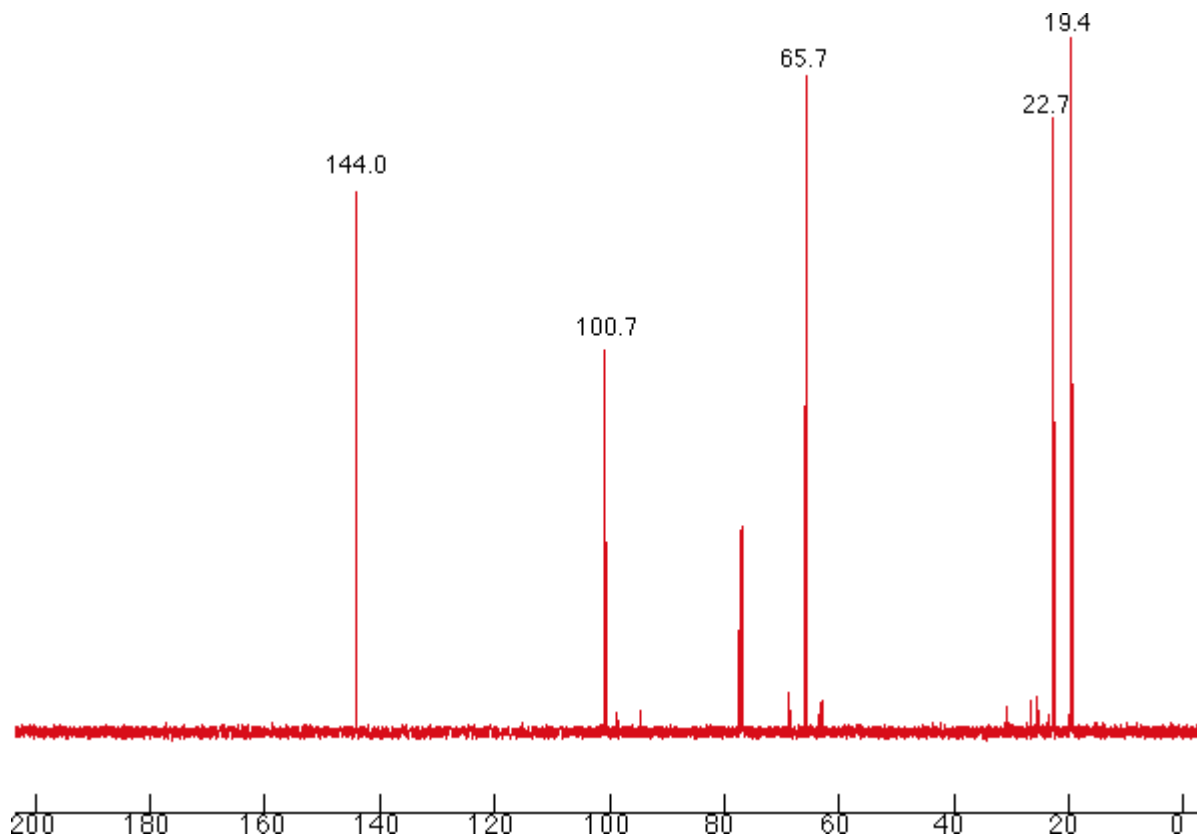


c

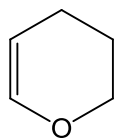


d

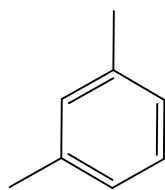
20- Which of the molecules below could best account for the ^{13}C NMR spectrum shown?
(the signal at 77 ppm is due to the NMR solvent)



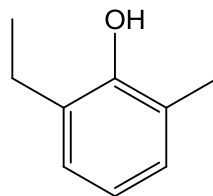
a



b



c



d

FOR QUESTIONS 21-25: CHOOSE 4/5, EACH IS WORTH 7.5 POINTS.

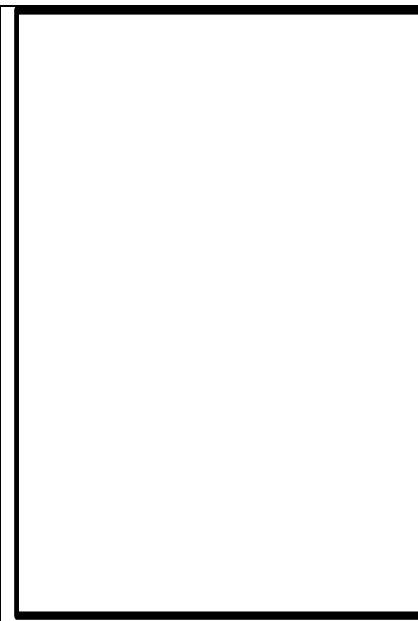
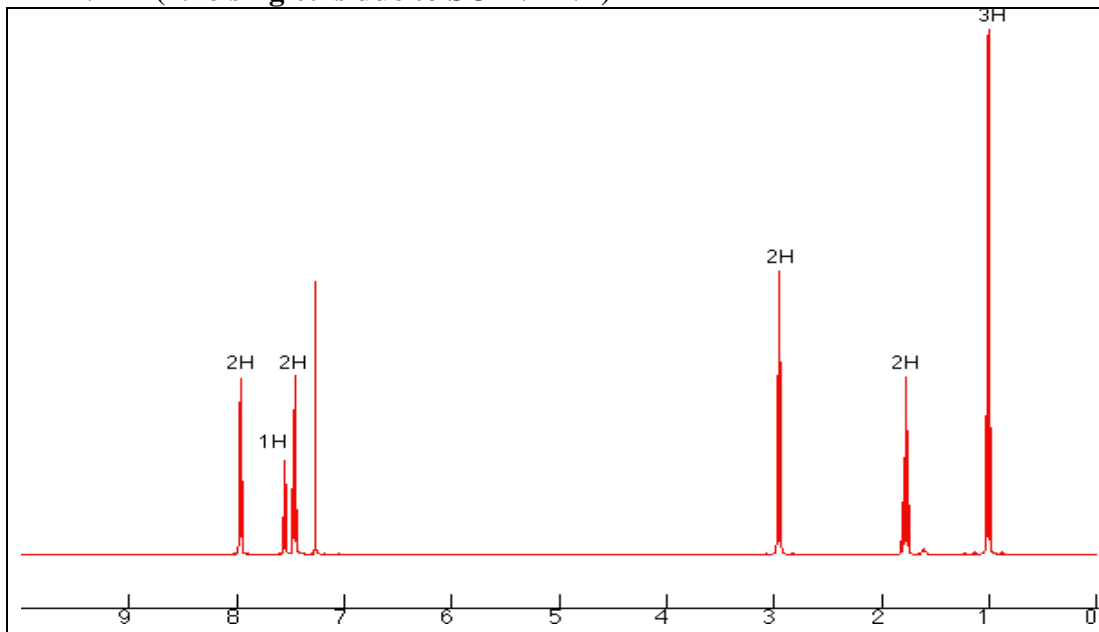
THE FIRST 4 QUESTIONS WITH AN ANSWER IN THE BOX WILL BE GRADED.

ANY STRUCTURES OUTSIDE THE BOX WILL NOT BE CONSIDERED BY THE GRADERS.

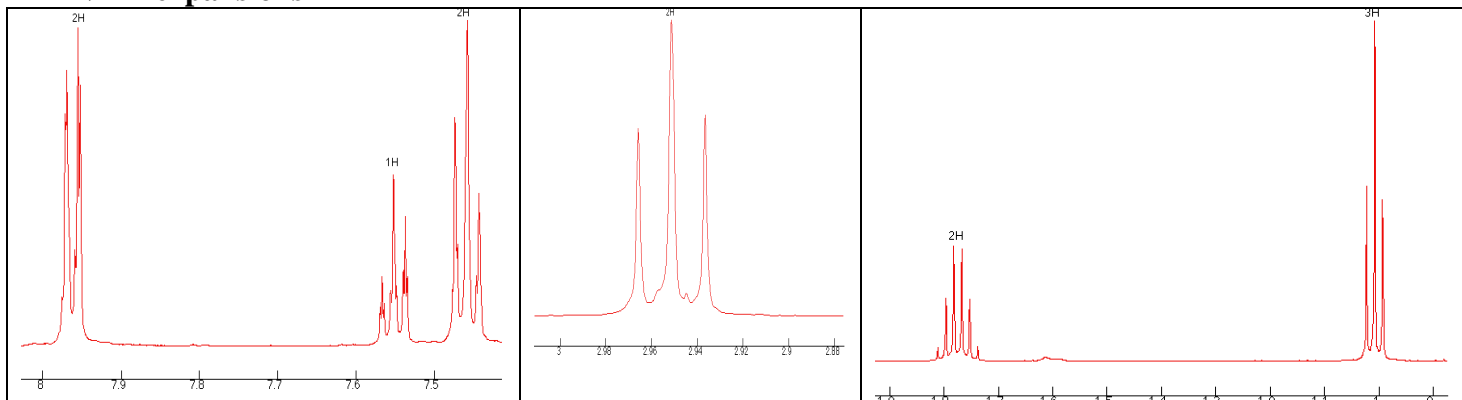
21- Spectra are shown for a molecule of formula $C_{10}H_{12}O$. Peaks with no labels are solvent peaks and not part of the unknown molecules. Propose a structure (write final answer in the box).

1H NMR (7.26 singlet is due to SOLVENT)

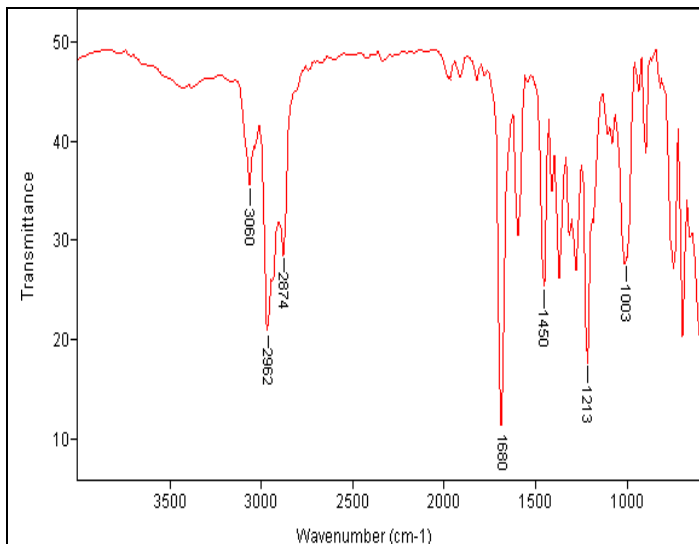
ANSWER



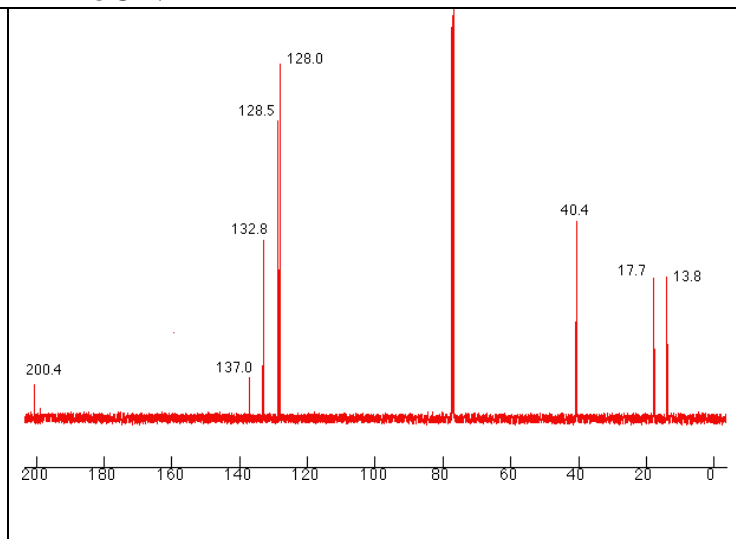
1H NMR expansions



IR



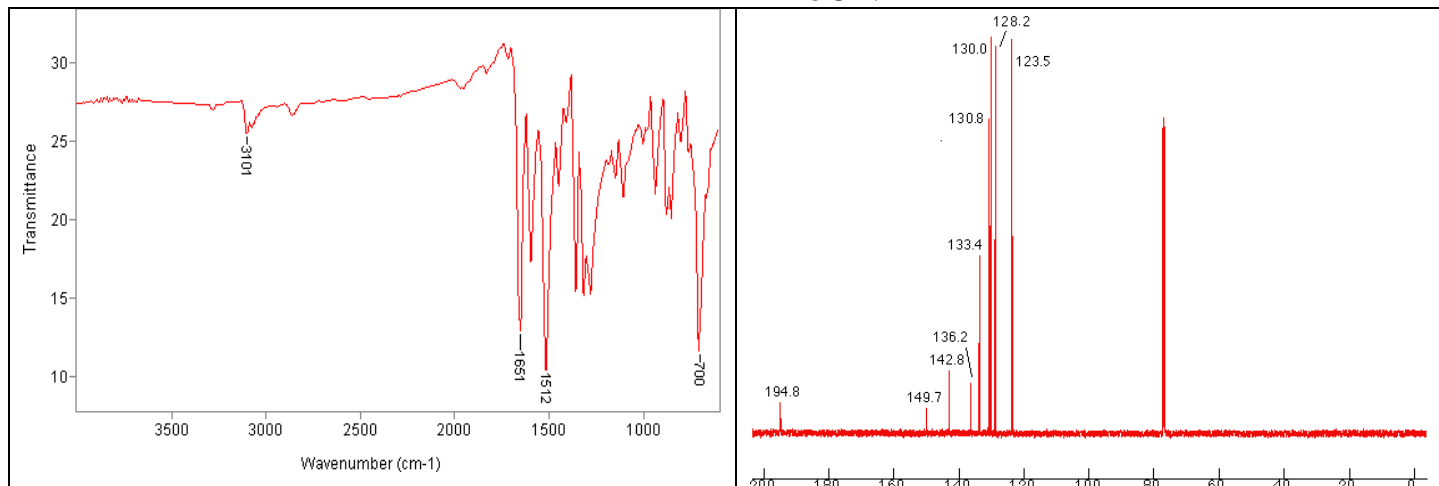
^{13}C NMR



22- Spectra are shown for a molecule of formula $C_{13}H_9NO_3$. Peaks with no labels are solvent peaks and not part of the unknown molecules. Propose a structure (write final answer in the box). No partial points given.

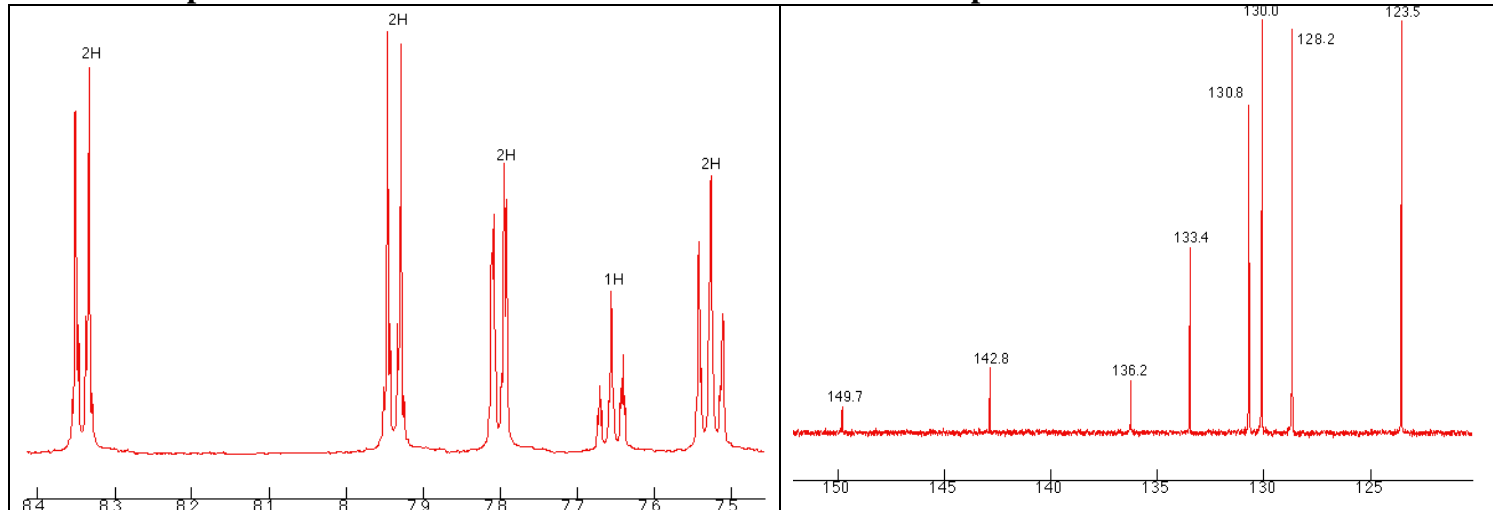
IR

^{13}C NMR



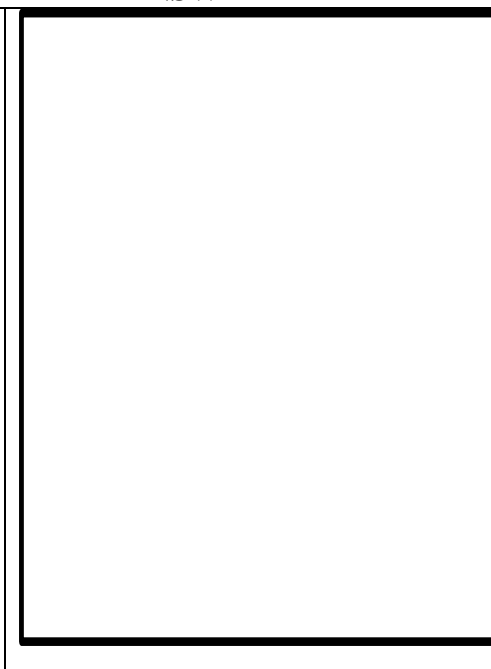
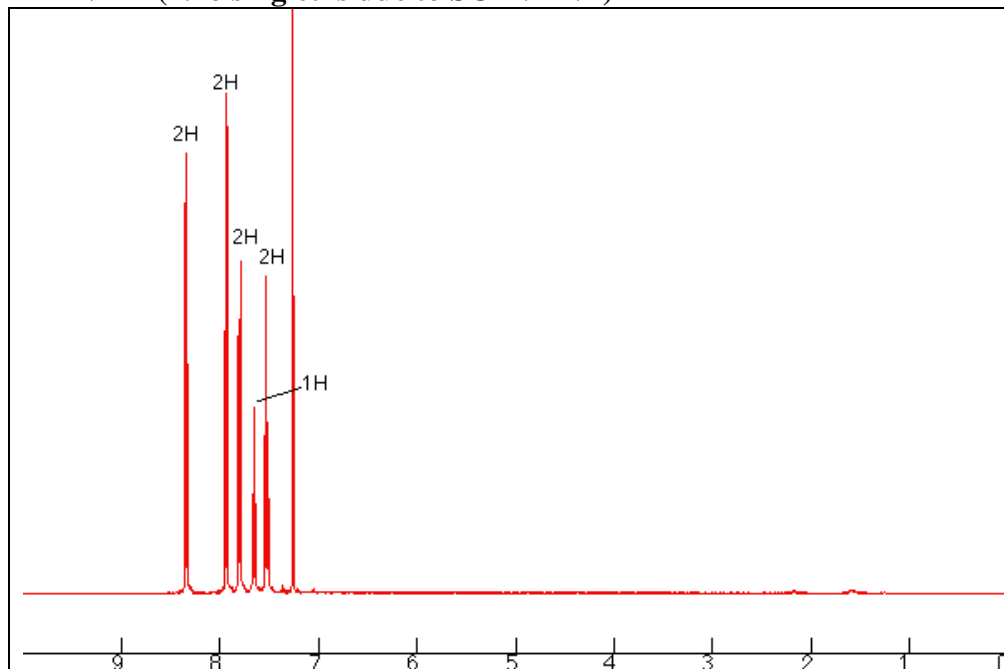
1H NMR expansion

^{13}C NMR expansion



1H NMR (7.26 singlet is due to SOLVENT)

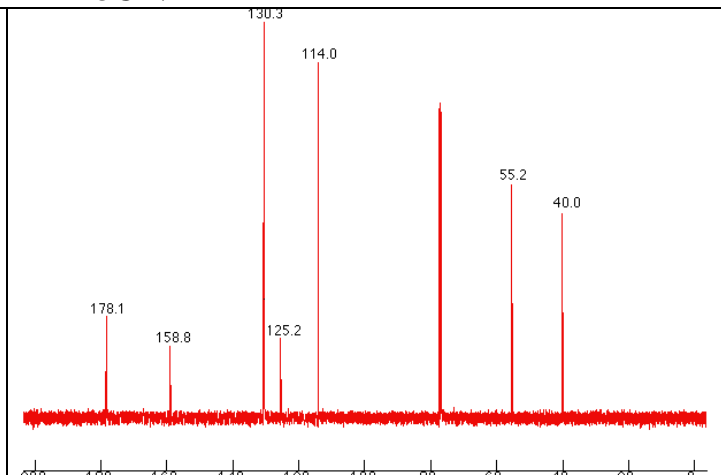
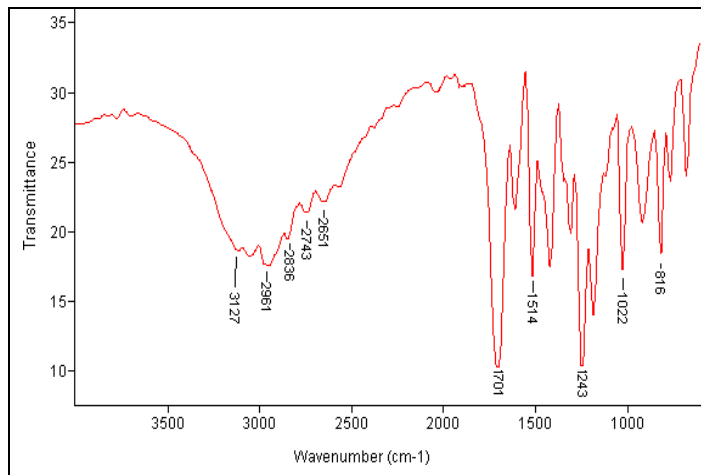
ANSWER



23- Spectra are shown for a molecule of formula $C_9H_{10}O_3$. Peaks with no labels are solvent peaks and not part of the unknown molecules. Propose a structure (write final answer in the box). No partial points given.

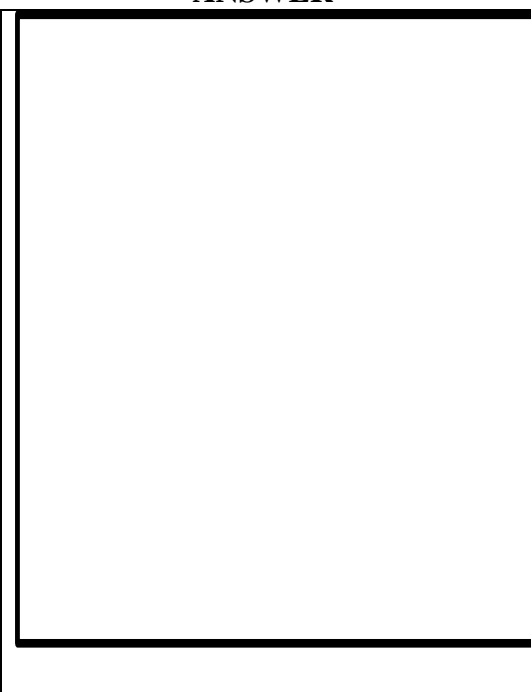
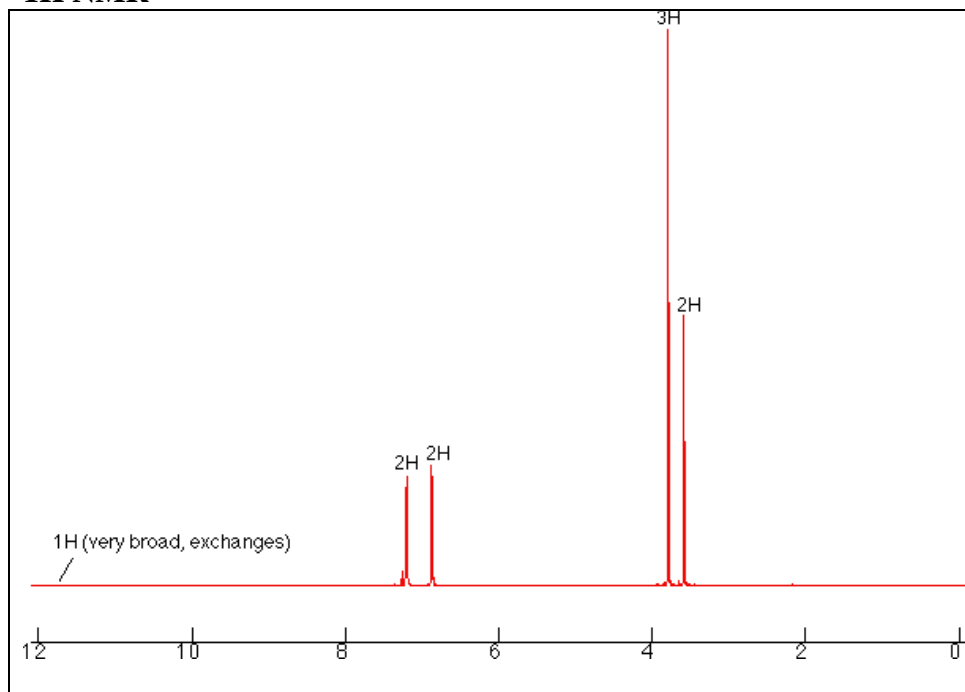
IR

^{13}C NMR



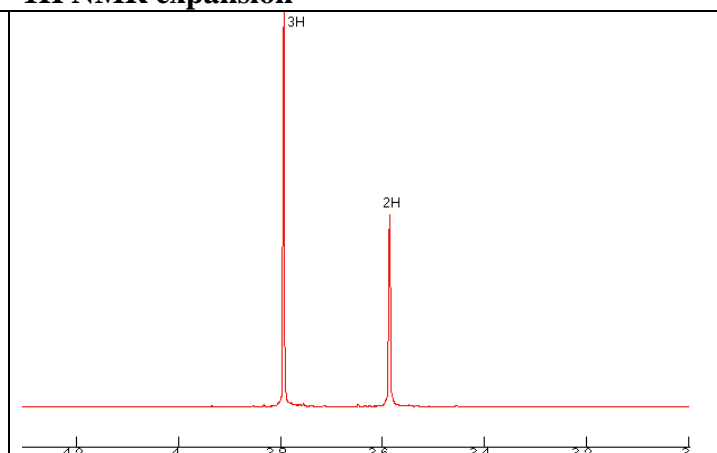
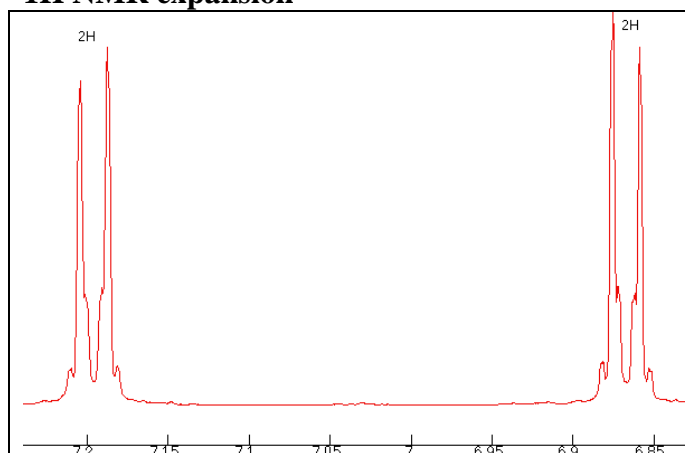
1H NMR

ANSWER



1H NMR expansion

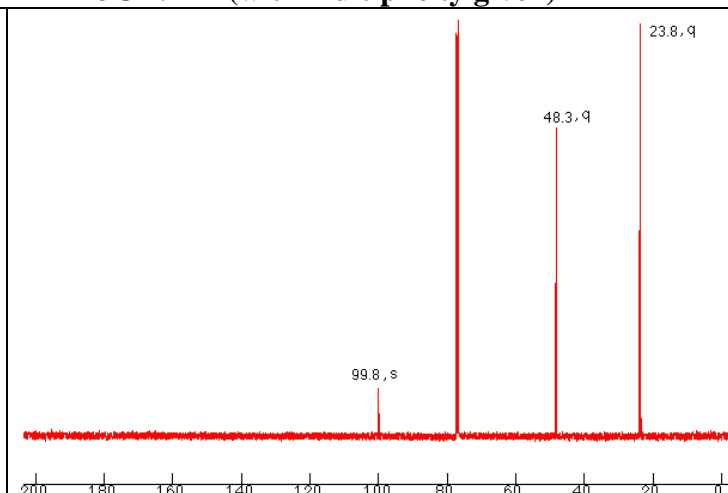
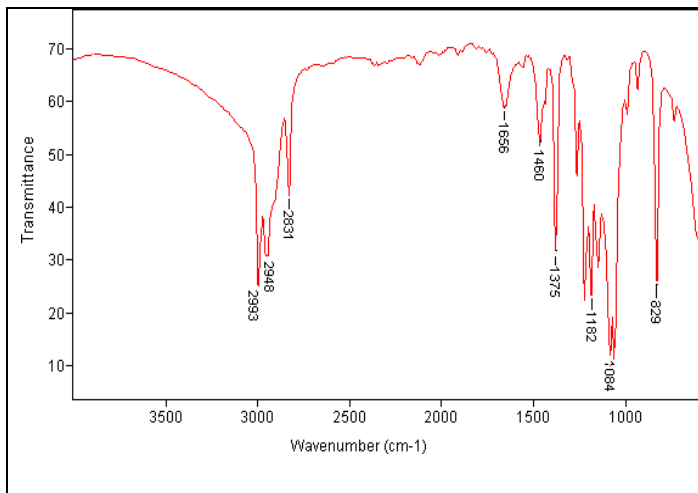
1H NMR expansion



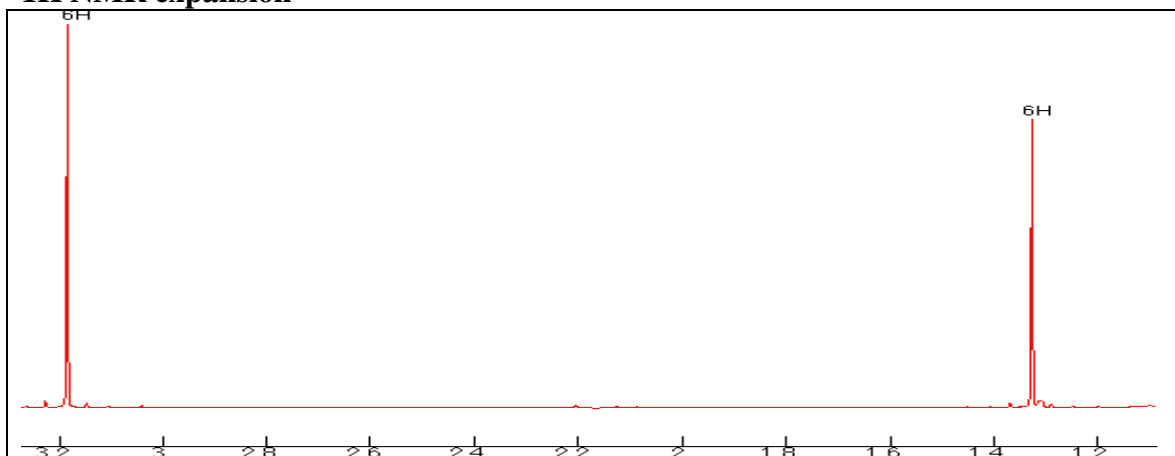
24- Spectra are shown for a molecule of formula $C_5H_{12}O_2$. Peaks with no labels are solvent peaks and not part of the unknown molecules. Propose a structure (write final answer in the box). No partial points given.

IR

^{13}C NMR (with multiplicity given)

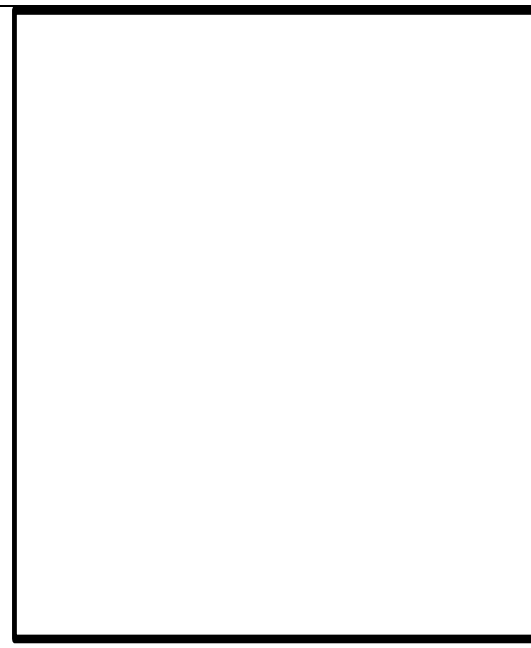
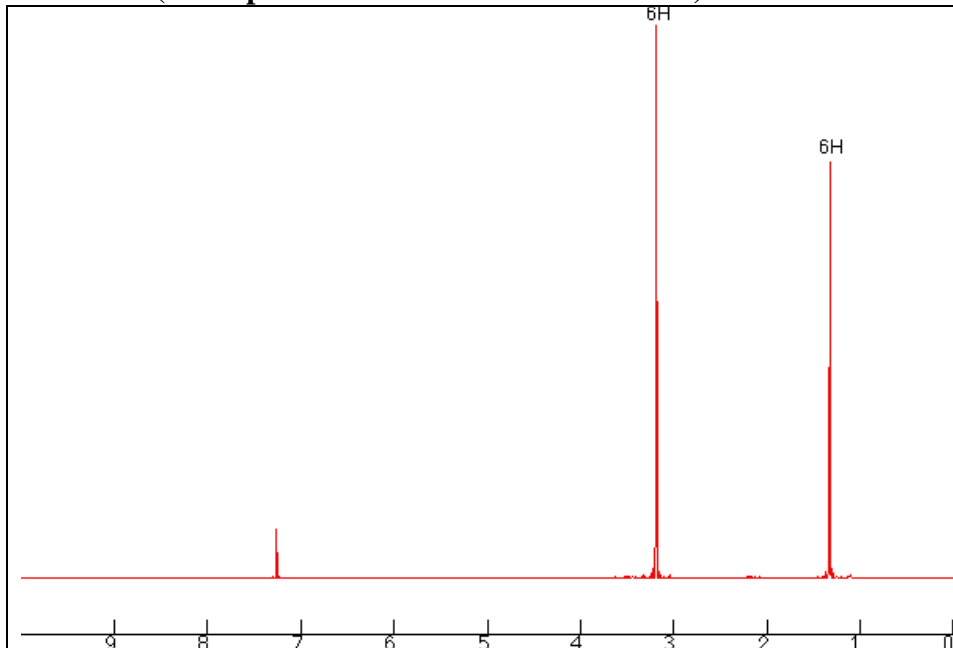


1H NMR expansion



1H NMR (small peak at 7.26 is due to SOLVENT)

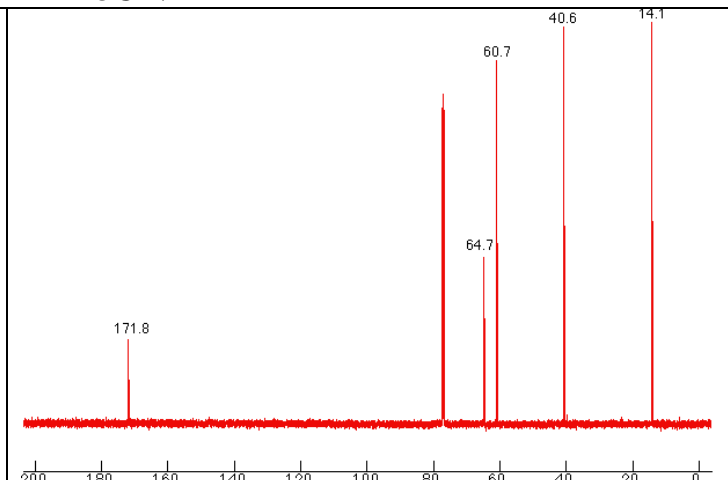
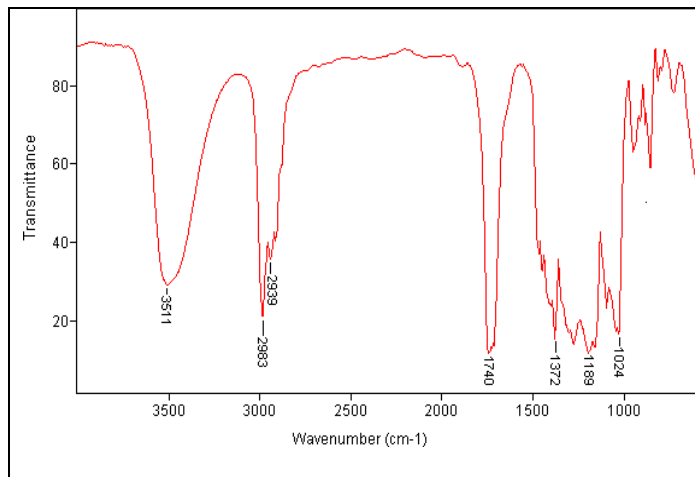
ANSWER



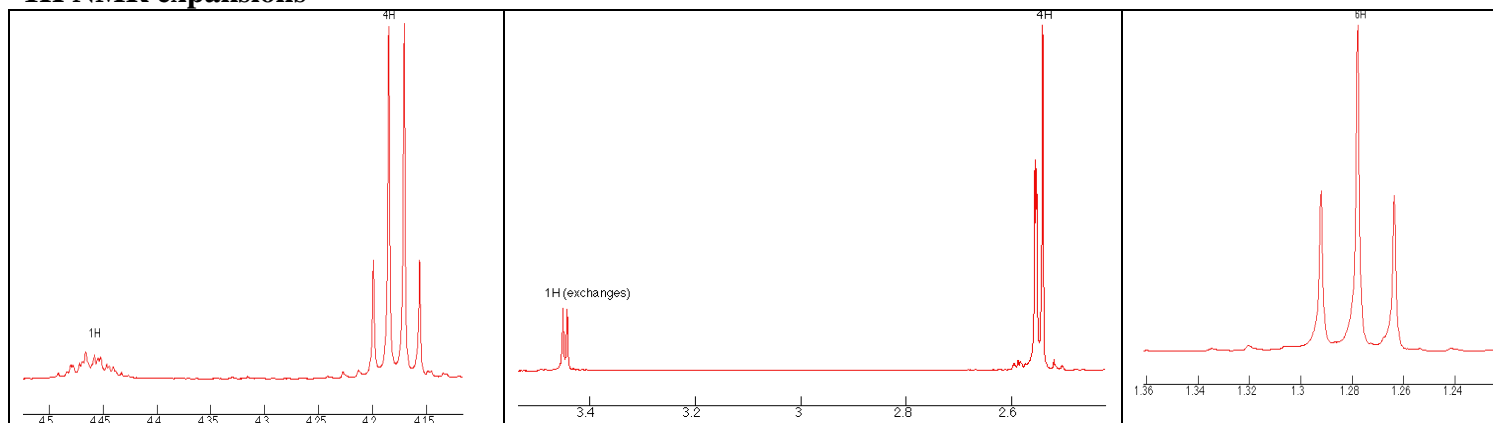
25- Spectra are shown for a molecule of formula $C_9H_{16}O_5$. Peaks with no labels are solvent peaks and not part of the unknown molecules. Propose a structure (write final answer in the box). No partial points given.

IR

^{13}C NMR

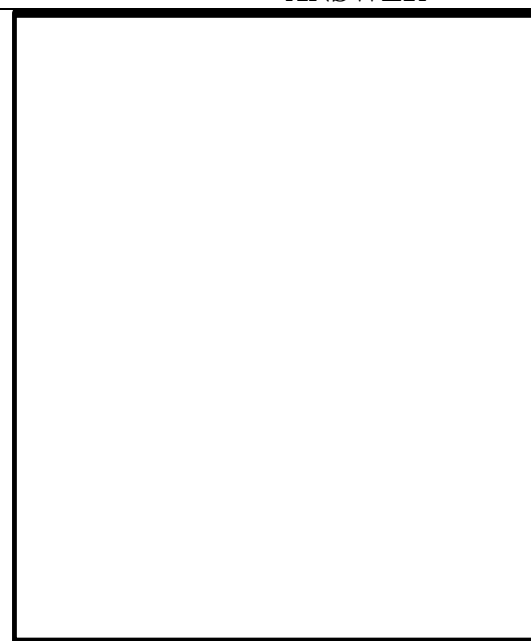
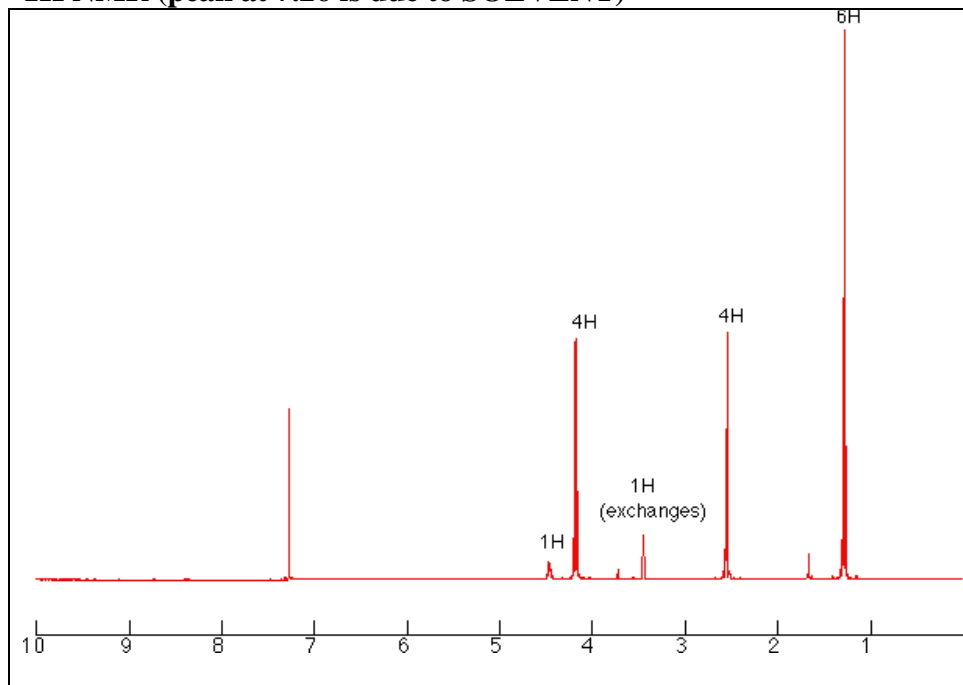


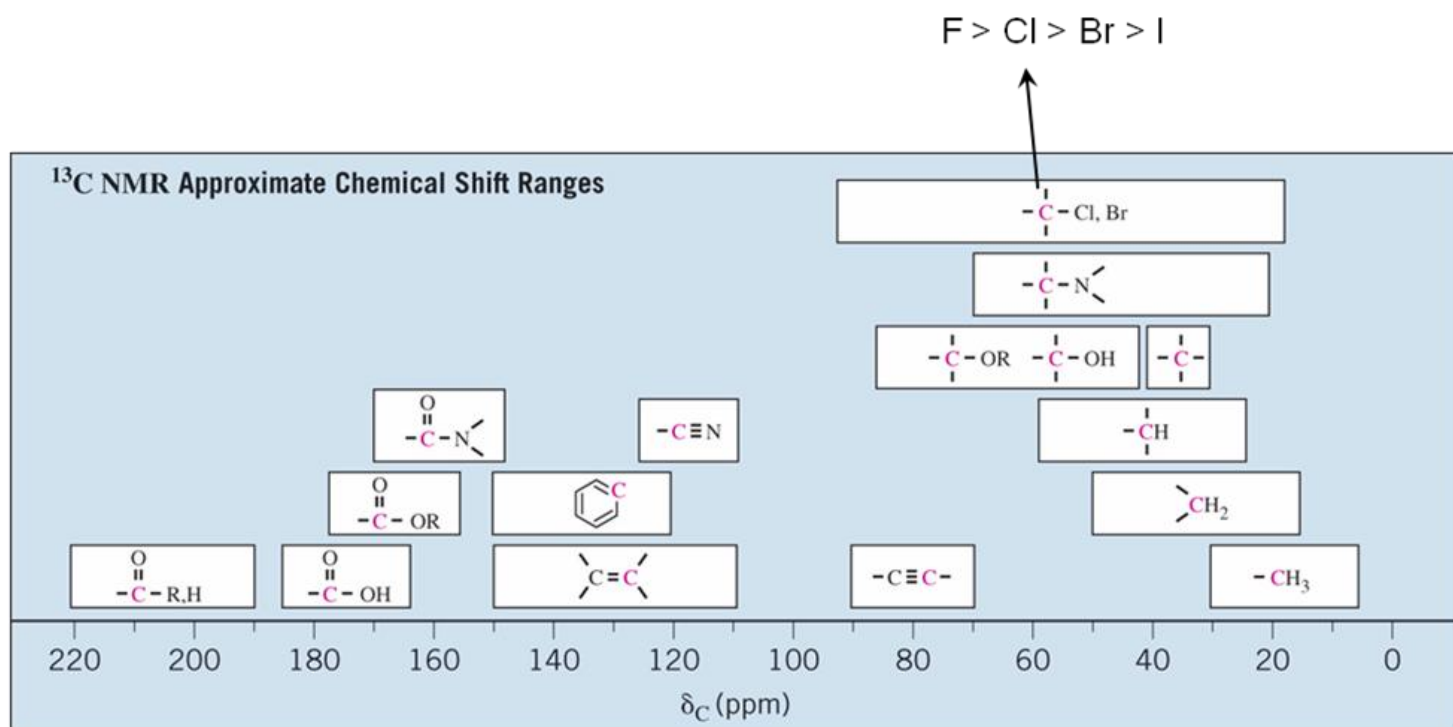
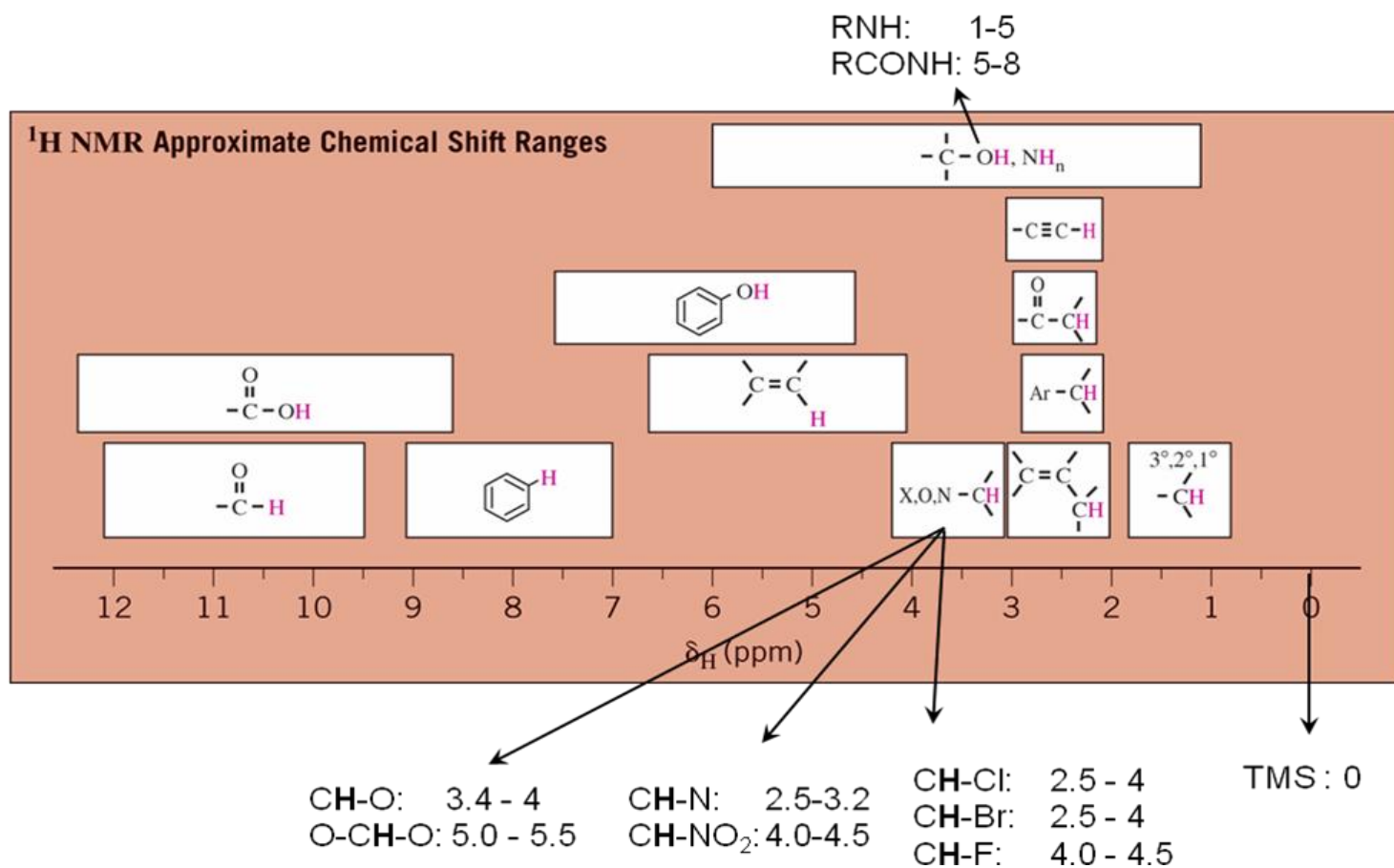
1H NMR expansions



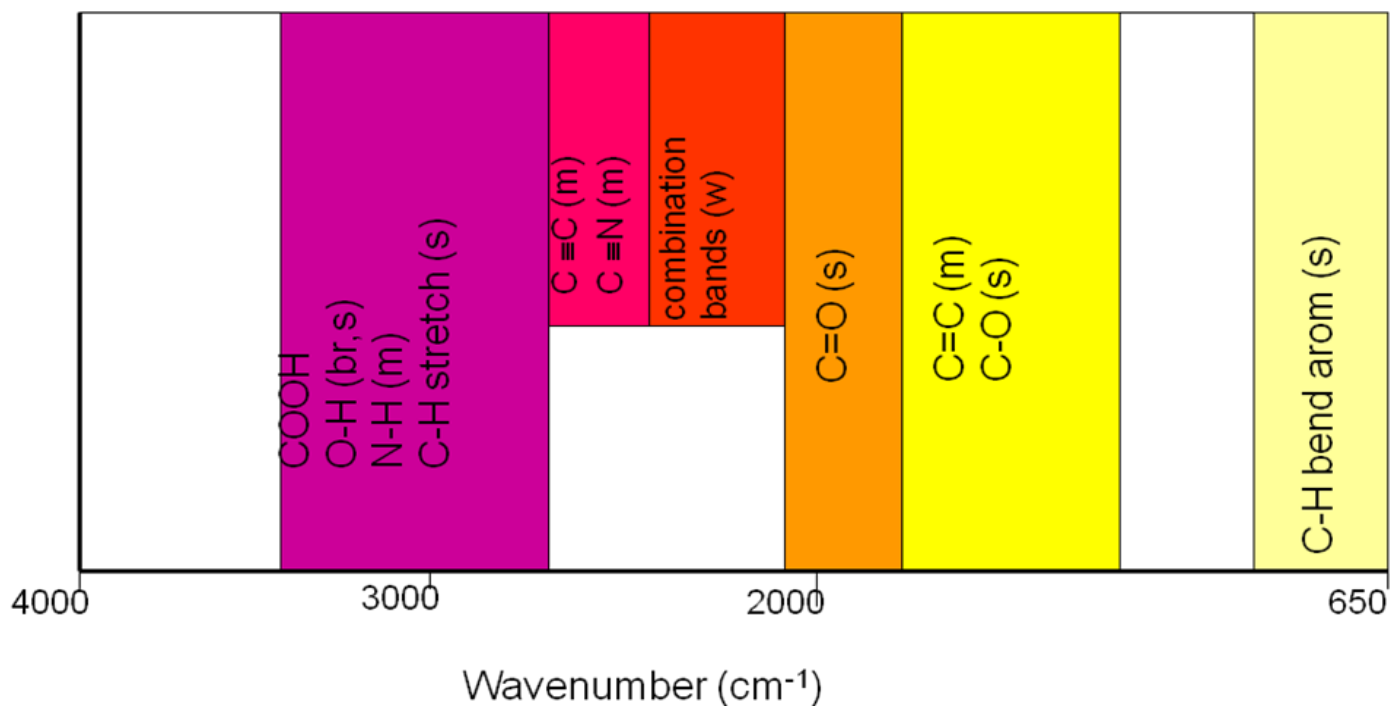
1H NMR (peak at 7.26 is due to SOLVENT)

ANSWER





IR Absorption Ranges



Group	Frequency Range (cm ⁻¹)	Intensity ^a
A. Alkyl		
C—H (stretching)	2853–2962	(m–s)
Isopropyl, —CH(CH ₃) ₂	1380–1385	(s)
	and 1365–1370	(s)
<i>tert</i> -Butyl, —C(CH ₃) ₃	1385–1395	(m)
	and ~ 1365	(s)
B. Alkenyl		
C—H (stretching)	3010–3095	(m)
C=C (stretching)	1620–1680	(v)
R—CH=CH ₂	985–1000	(s)
	and 905–920	(s)
R ₂ C=CH ₂	880–900	(s)
		(s)
<i>cis</i> -RCH=CHR	675–730	(s)
<i>trans</i> -RCH=CHR	960–975	(s)
C. Alkynyl		
≡C—H (stretching)	~ 3300	(s)
C≡C (stretching)	2100–2260	(v)
D. Aromatic		
Ar—H (stretching)	~ 3030	(v)
Aromatic substitution type (C—H out-of-plane bendings)		
Monosubstituted	690–710	(very s)
<i>o</i> -Disubstituted	and 730–770	(very s)
<i>m</i> -Disubstituted	735–770	(s)
	680–725	(s)
	and 750–810	(very s)
<i>p</i> -Disubstituted	800–860	(very s)
E. Alcohols, Phenols, and Carboxylic Acids		
O—H (stretching)		
Alcohols, phenols (dilute solutions)	3590–3650	(sharp, v)
Alcohols, phenols (hydrogen bonded)	3200–3550	(broad, s)
Carboxylic acids (hydrogen bonded)	2500–3000	(broad, v)
F. Aldehydes, Ketones, Esters, and Carboxylic Acids		
C=O (stretching)	1630–1780	(s)
Aldehydes	1690–1740	(s)
Ketones	1680–1750	(s)
Esters	1735–1750	(s)
Carboxylic acids	1710–1780	(s)
Amides	1630–1690	(s)
G. Amines		
N—H	3300–3500	(m)
H. Nitriles		
C≡N	2220–2260	(m)

^aAbbreviations: s = strong, m = medium, w = weak, v = variable, ~ = approximately.

