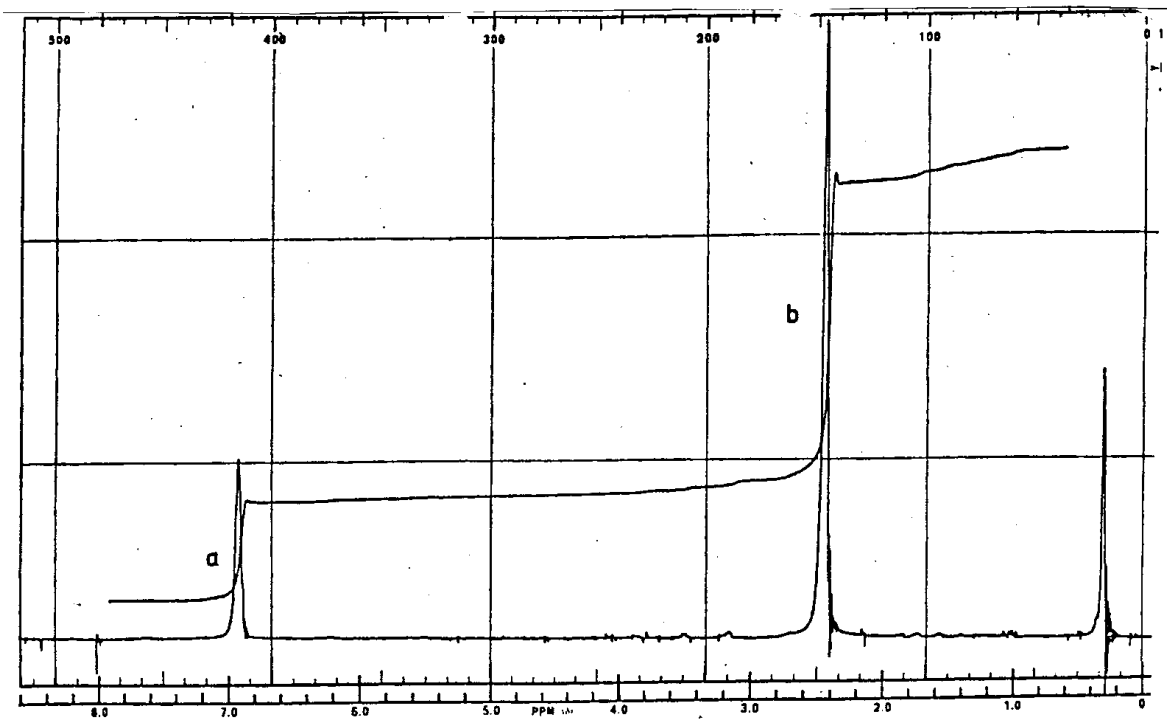


1. The following  $^1\text{H}$  NMR spectrum was recorded on a 60 MHz spectrometer. It shows three signals. The molar mass of the hydrocarbon is 120 g/mol.

- a) (1 point) What causes the unidentified, unintegrated signal?
- b) (1 point) What are the chemical shifts of signals a and b in ppm?
- c) (4 points) Which compound is it?

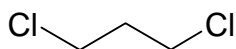
d) (3 points) Calculate the chemical shift for all non-equivalent protons.

e) (2 points) Give a closely related isomeric compound and reason why it is not a proper solution.

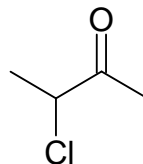


2. Predict the  $^1\text{H}$  NMR spectra for the following compounds. Include chemical shift (with evaluation), integration and multiplicity. Give proper drawings that consider the intensity of the lines within a multiplet.

a) (4 points)



b) (5 points)

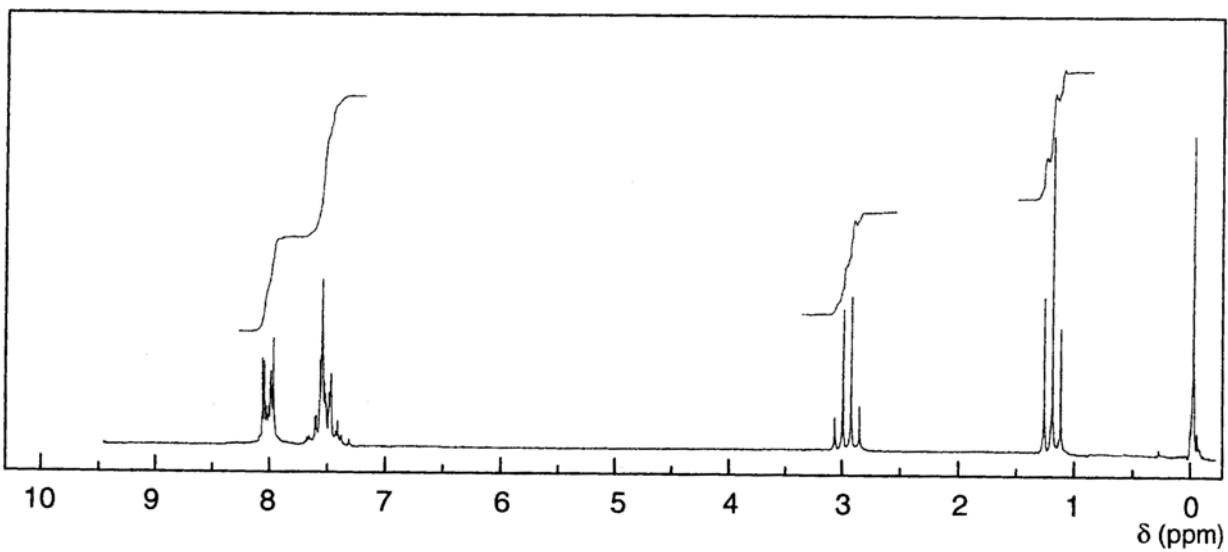
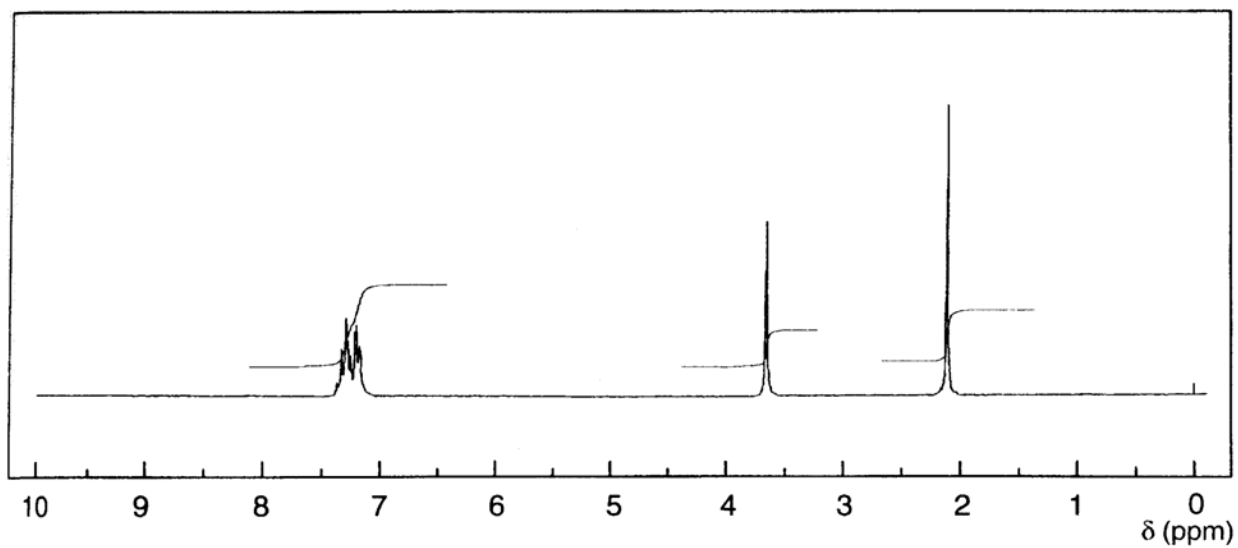


3. For each set of  $^1\text{H}$  NMR data, suggest a structure that is consistent with the data.

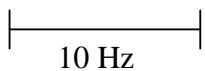
a) (2 points)  $\text{C}_3\text{H}_5\text{Cl}_3$ : 2.20 ppm, 3H; 4.02 ppm, 2H

b) (2 points)  $\text{C}_7\text{H}_8\text{O}$ : 2.43 ppm, 1H; 4.58 ppm, 2H; 7.28 ppm, 5H

4. (11 points) Two isomeric ketones show the following  $^1\text{H}$  NMR spectra. Identify the compounds.  
Provide full labels for all signals.



5. (8 points) The following multiplets are due to protons A, M and X. Determine the signal multiplicity, the coupling constants  $J_{AM}$ ,  $J_{AX}$  and  $J_{MX}$  as well as the number of protons in each group (take the sum of the height of the lines as an integral). Classify the systems as AMX or  $AM_2X$ .



a)



b)



6. (10 points) Identify the compound that shows the following  $^1\text{H}$  NMR spectrum. Provide full labels for all signals.

