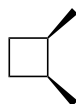
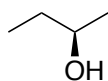
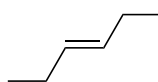
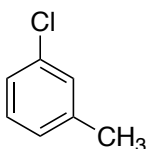
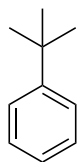
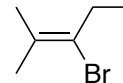
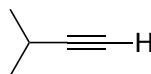
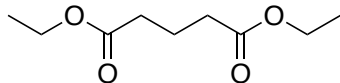
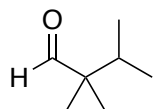


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Chapter 13: NMR Spectroscopy Problem Set

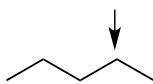
- 1) For each compound below, identify each chemically distinct type of hydrogen. Specify the number of ^1H NMR signals you would expect to see.



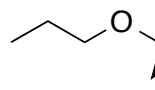
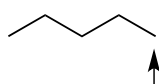
- 2) Which of the indicated protons in each pair shows up farther downfield?

Tips: For H-C-Z, H moves further downfield as Z becomes more electronegative

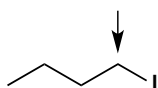
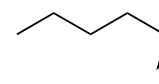
For $\text{C}_{\text{sp}^3}\text{-H}$, H moves further downfield as C becomes more substituted ($3^\circ > 2^\circ > 1^\circ$)



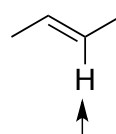
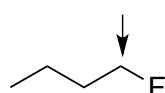
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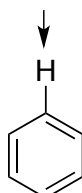
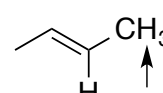
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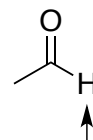
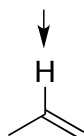
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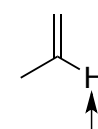
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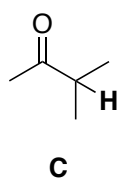
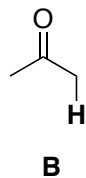
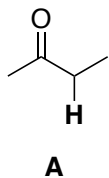
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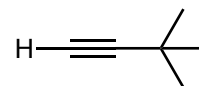
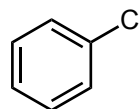
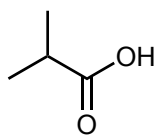
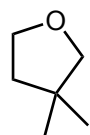
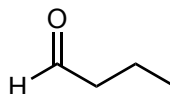
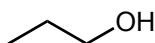
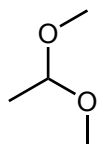
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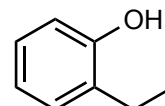
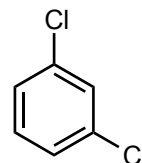
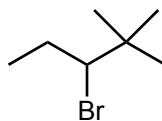
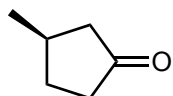
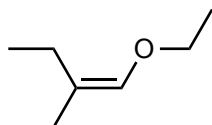
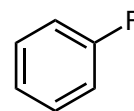
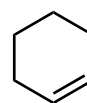
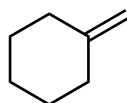
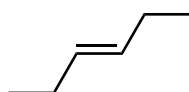
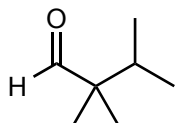
3) Consider the indicated protons in each of the three compounds below. Arrange in order of increasing chemical shift of the indicated proton. *See tips in Q2.*



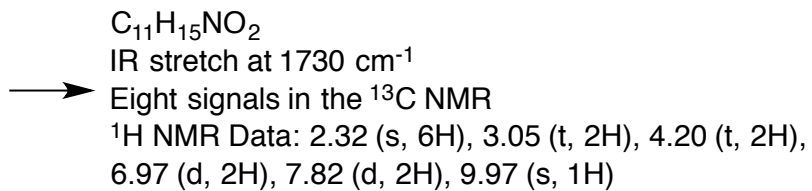
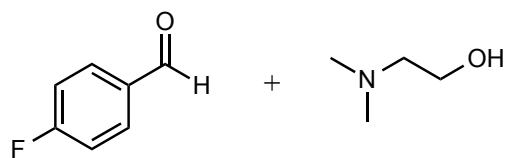
4) For each of the compounds below, determine the expected splitting for all protons.



5) How many ^{13}C signals would you expect each compound below to exhibit? (i.e. How many chemically distinct C atoms are present in each molecule?)

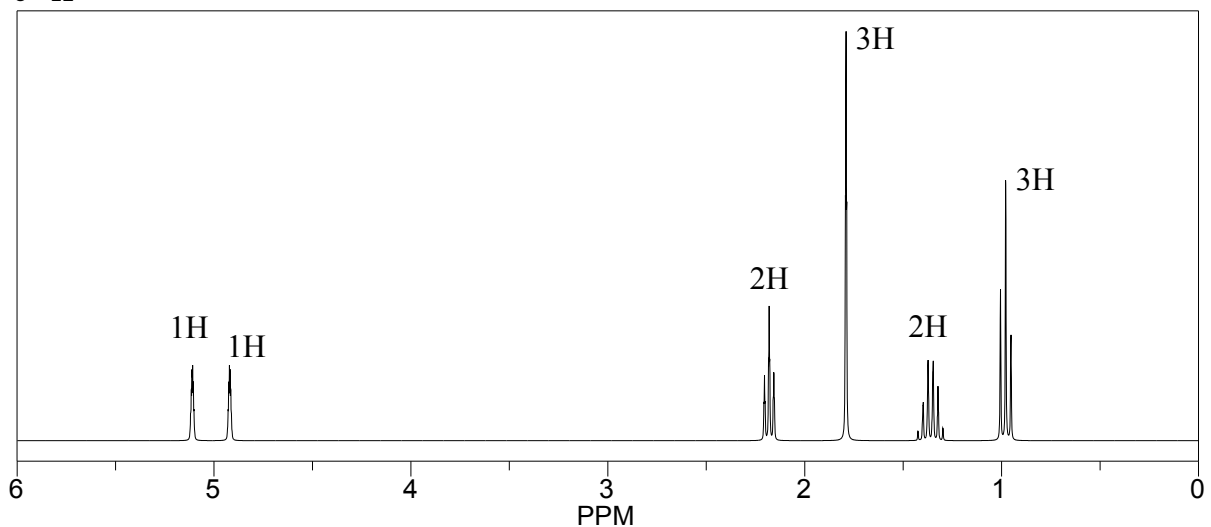


- 6) The reaction shown below was carried out in a laboratory to give a compound with the indicated spectral data. Determine the structure of this compound.

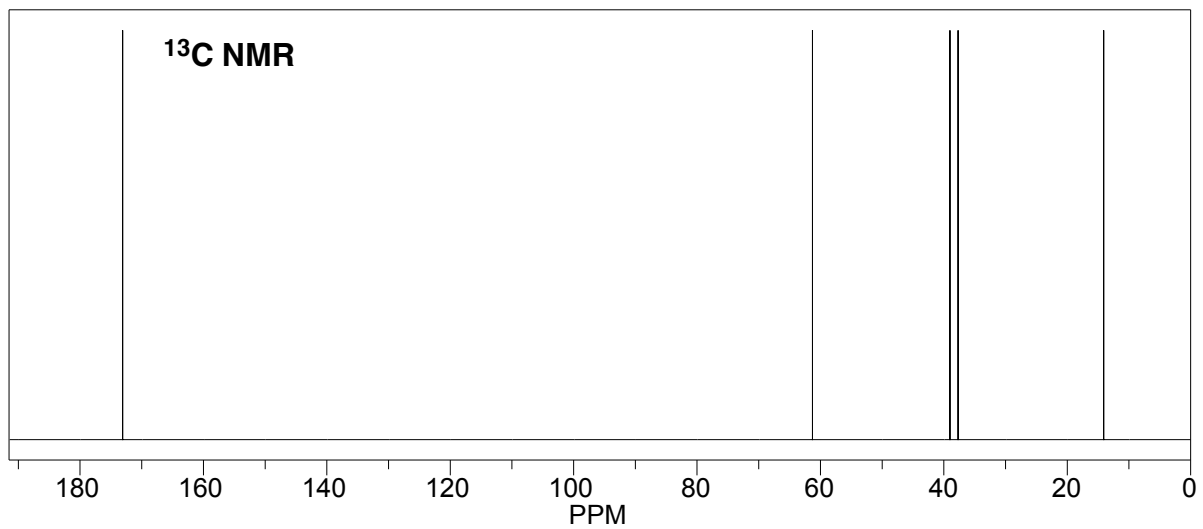
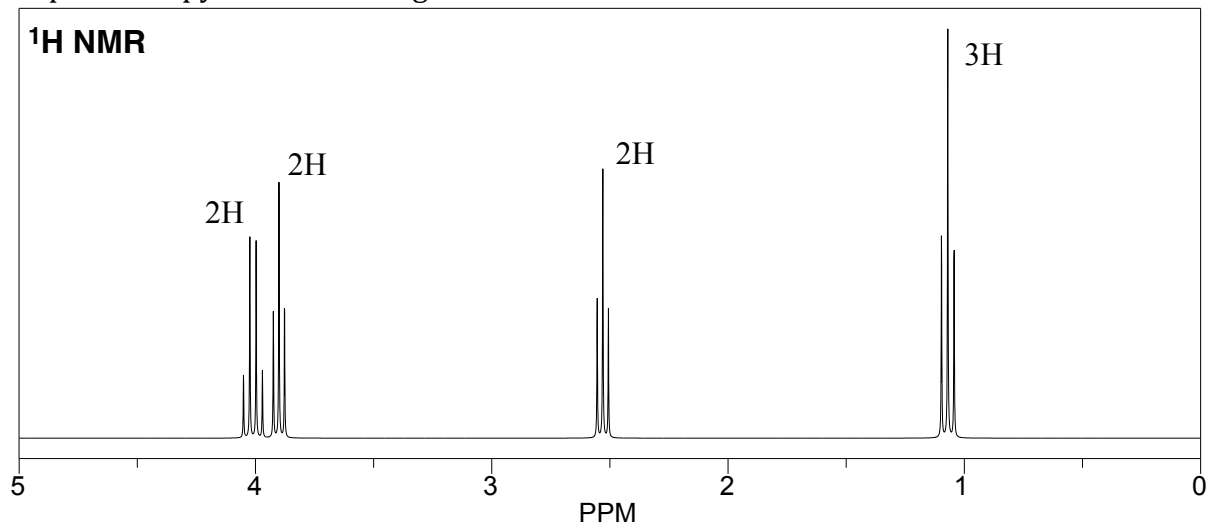


- 7) For each of the following, use the data provided to deduce an appropriate structure.

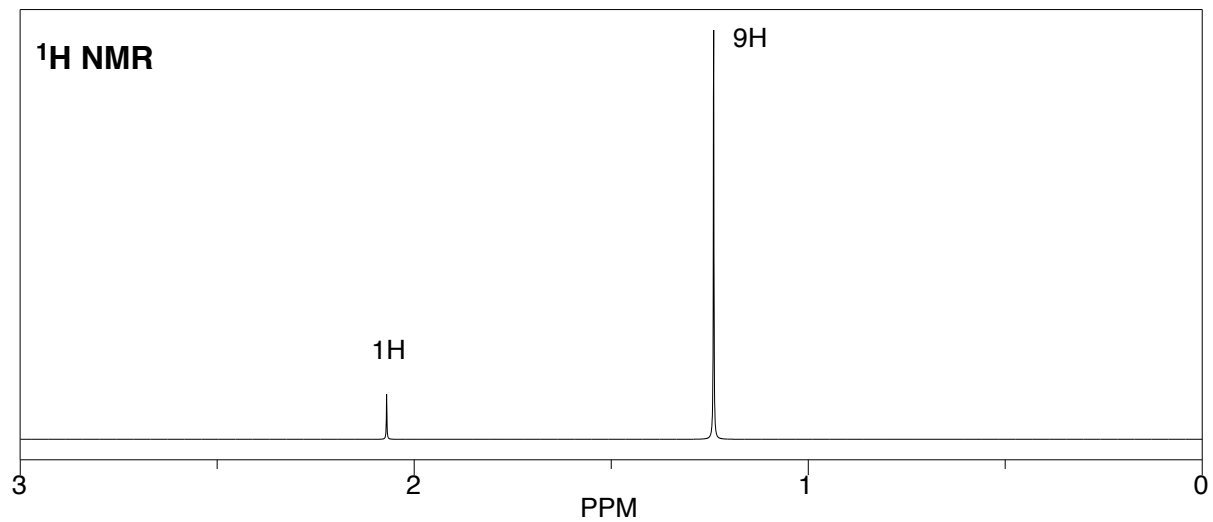
A. C_6H_{12}



B. $C_5H_9ClO_2$ Use the ^{13}C NMR to determine the number of distinct C atoms.
IR spectroscopy shows a strong C=O stretch.

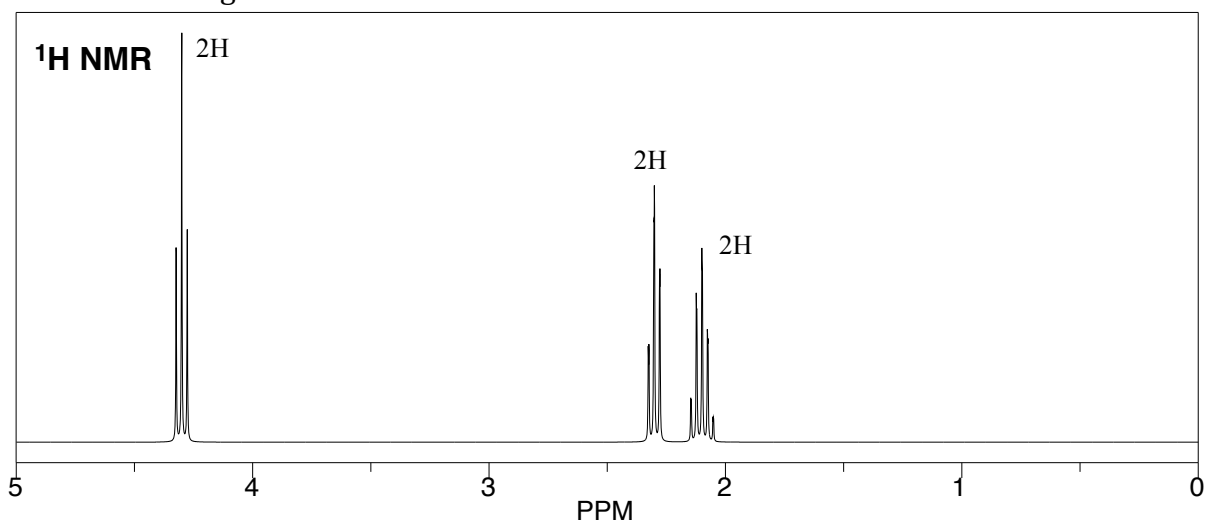


C. C_6H_{10}

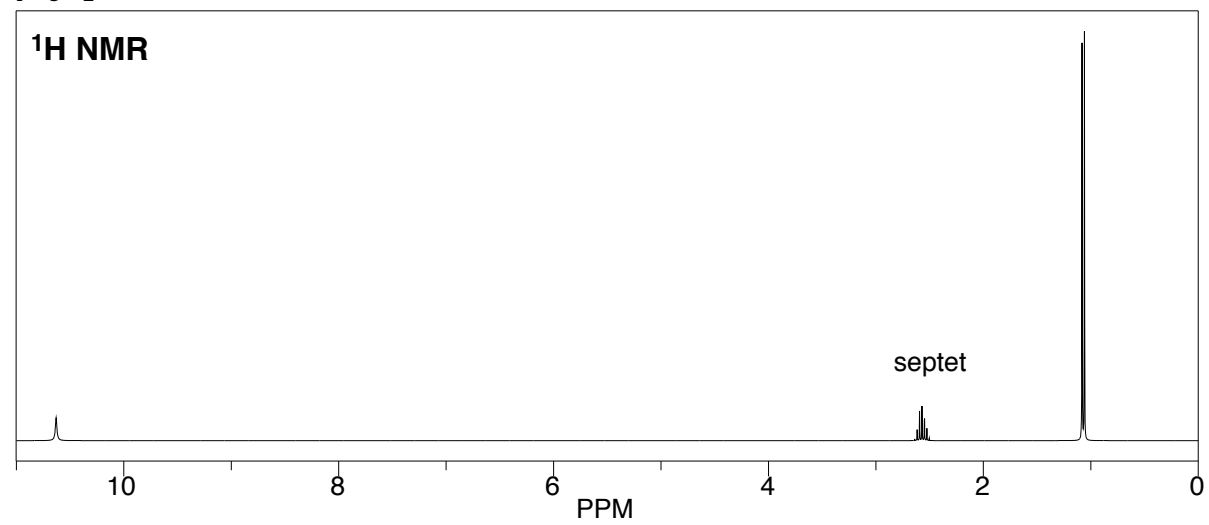


D. C₄H₆O₂

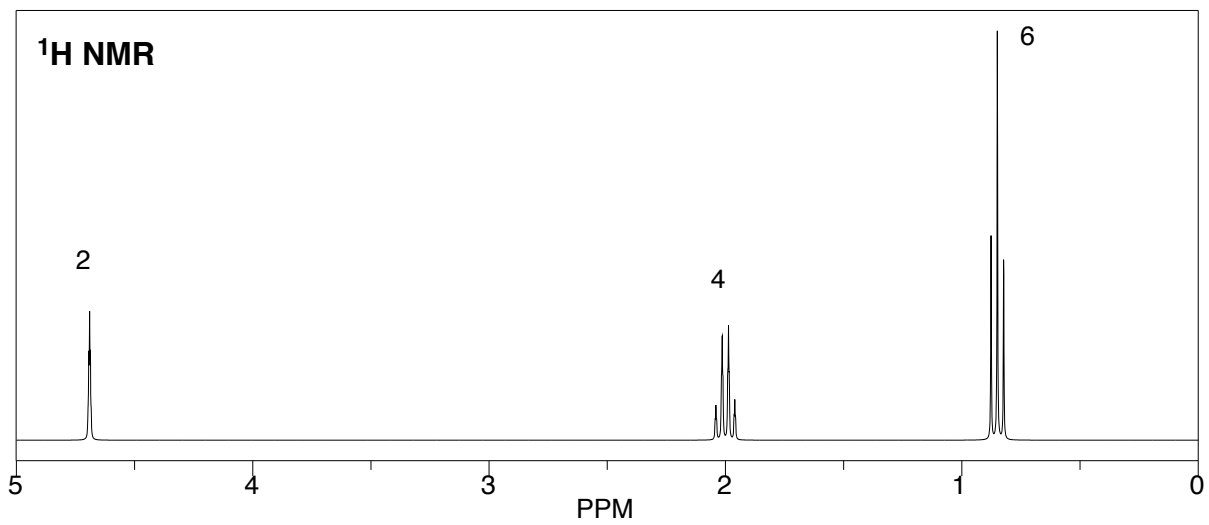
IR shows a strong stretch at 1740 cm⁻¹



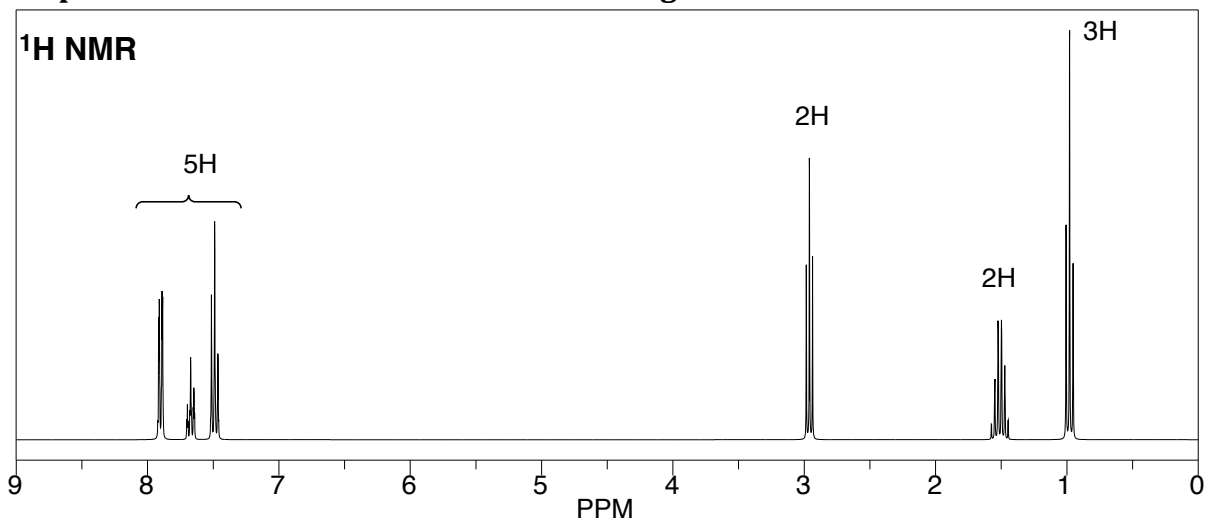
E. C₄H₈O₂



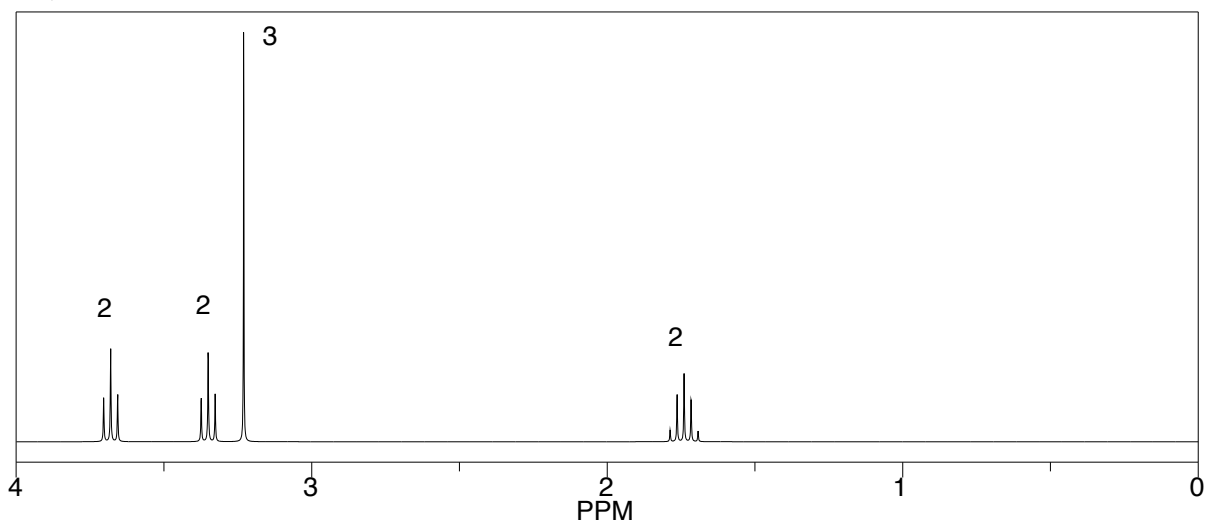
F. C₆H₁₂



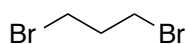
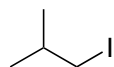
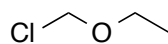
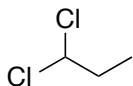
G. Compound contains 10C and IR shows a strong stretch around 1690 cm^{-1}



H. $\text{C}_4\text{H}_9\text{OCl}$



8) For each of the compounds below, draw a rough estimation of its expected ^1H NMR spectrum.



9) The vinyl proton chemical shift in the two compounds shown below is substantially different. Explain why the shift in these two compounds is so different. *Hint: think about resonance.*

