Before you begin this exam:

First: You are allowed to have a calculator and a simple model set at your seat. Please put away all other materials. Second: Place your student identification on your desk. A proctor will come around to check everyone’s ID. Third: Read through the entire exam. Your goal, as always, is to score as many points as possible. Do not waste time on problems that you can’t do if there are others that look easy. Fourth: It is critically important that your answers be written in a clear, unambiguous manner. Answers in which your intentions are unclear will not receive credit. Fifth: READ THE INSTRUCTIONS FOR EACH PROBLEM.

If you wish to have your exam score posted beside your student ID number in the glass case (1st floor, CP Building, behind CP-139) with the exam key, place an ‘X’ in this space. If you do not mark this space, your exam score will not be posted.

You have until 6:50 to complete this exam. There will be no extensions, so budget your time carefully.

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Total 100
1. (6 points) The two compounds below show carbonyl absorptions in the IR spectrum. Circle the compound that you predict to have the lower frequency carbonyl stretch.

![Compound A](image1)

![Compound B](image2)

2. (15 points) The synthetic methods we have discussed can be used to make a wide range of compounds from simple starting materials. Provide the reagents needed to convert 1-pentene into each of the products shown below. More than one step may be required in some cases.

![Conversion Diagram](image3)

3. (20 points) Predict the products of the following reactions. Be sure to indicate relevant stereochemistry in parts a), b) and d).

   a)

   ![Reaction A](image4)

   b)

   ![Reaction B](image5)
4. (8 points) Write 3 viable molecular formulae for a compound that shows a parent ion (M⁺) of 108. Assume that C, H, and O are the only elements that may be present (i.e. the molecular formulae may contain C&H, or C,H,&O). If you write more than 3 we will only grade the first three we see.

\[ C_8H_{12} \]
\[ C_7H_8O_1 \]
\[ C_6H_4O_2 \]

5. (9 points) Predict the multiplicity (singlet, doublet, triplet, quartet) of the resonances from the protons indicated.
6. (6 points) Imagine you have just developed a new reagent, catalyst X, that facilitates addition of HCN to alkenes. An important question burns in your mind - does the addition proceed in a Markovnikov fashion or in an anti-Markovnikov fashion?

![Chemical structure](image)

You race to the NMR spectrometer and measure the $^1$H NMR spectrum of the product. You find that the spectrum consists of a 6-proton doublet and a 1-proton multiplet. What is the answer? (i.e. circle the compound formed in the reaction above).

7. (10 points) Shown below are the NMR and IR spectra of a compound with molecular formula of $C_4H_9Br$. What is the structure of this compound?

![Spectral images](image)
8. (6 points) A compound has a molecular formula of $\text{C}_5\text{H}_{12}$ and shows only 2 different resonances in the $^{13}\text{C}$ NMR spectrum. What is the structure? (Suggestion: draw out as many isomers of $\text{C}_5\text{H}_{12}$ as you can and choose the one that is consistent with the NMR data)

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

9. (10 points) Two IR spectra are shown below. One of them is heptane and one is 1-hexanol. Which is which? (write the name on the corresponding spectrum)
10. (10 points) Provide a viable mechanism for the following reaction. Be sure that your use of mechanism arrows conforms to the established conventions.

I would accept either path.
END OF EXAM