Before you begin this exam: First: You are allowed to have 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. If you do not have ID, tell the proctor and 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. You have until 12:50 to complete this exam. There will be no extensions, so budget your time carefully.

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<th>Problem</th>
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1. (8 points) You know that nucleophiles attack carbonyl groups at carbon. This occurs even when the oxygen is positively charged, as it is when acid is present. Explain why, in this situation, the nucleophile attacks at carbon instead of at the positively charged oxygen. Do not exceed the space provided.

![Diagram showing nucleophilic attack at carbon vs. oxygen]

2. (35 points) Predict the product of the following reactions. If you believe that no reaction will occur, write ‘no reaction.’

a)

![Diagram of reaction with catalytic TsOH]

b)

![Diagram of reaction with Ph₃P, BuLi, and aldehyde]

c)

![Diagram of reaction with excess K₂Cr₂O₇ and H₂SO₄]
3. (10 points) Draw a viable mechanism for the formation of the imine shown below. Be sure to pay attention to the proper use of arrows, and be sure that all “H+ ions come from an acid (not just H+ floating in solution).

\[
\begin{align*}
\text{CH}_3\text{CH=CH}_2 & \quad \text{CH}_3\text{NH}_2 \\
\text{cat. TsOH} & \\
\quad & \text{NCH}_3
\end{align*}
\]
4. (15 points) Below are shown the IR and $^1$H NMR spectra of a compound with the molecular formula C$_9$H$_{12}$O.

a) What functional group(s) are evident from the IR spectrum below?

(below is the IR spectrum)

b) Below is the $^1$H NMR spectrum of the compound. Use this spectrum and the IR spectrum above to deduce the structure. Note: exchangeable H’s (NH’s, OH’s, SH’s) usually do NOT produce coupling.

(below is the NMR spectrum with integrals indicated)

SDBSWeb: http://www.aist.go.jp/RIDDB/SDBS/ (National Institute of Advanced Industrial Science and Technology, 2/28/06)
5. (12 points) Provide the reagents needed to perform each of the steps in the sequence below. More than one step may be required for a given transformation, and in such cases be sure to clearly state each step (i.e. “1. Reagent A; 2. Reagent B.”)

![Diagram of chemical reactions involving ketones, hydroxyl groups, and aromatic rings.]

6. (10 points) Provide a viable mechanism for the reaction below. Be sure to pay close attention to the use of mechanism arrows!

![Diagram of a ketone reaction with hydrochloric acid, leading to a product with hydroxyl and methyl groups.]
7. (10 points) Design a viable synthesis of one of the following compounds, utilizing the starting material shown. You do not need to show a retro synthesis, but doing one may help you plan your synthesis. You may also use triphenylphosphine, benzene, other organic compounds of 3 carbons or less, and any inorganic reagents that you need. Do any one of the problems given below. If you do more than one, only the first one will be graded.

a)

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

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

b)

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

END OF EXAM