**YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM**

- PRINT YOUR NAME ON EACH PAGE!
- READ THE DIRECTIONS CAREFULLY!
- USE BLANK PAGES AS SCRATCH PAPER
- work on blank pages will not be graded...
- WRITE CLEARLY!
- MOLECULAR MODELS ARE ALLOWED
- DO NOT USE RED INK
- DON'T CHEAT, USE COMMON SENSE!

### Interaction Energies, kcal/mol

<table>
<thead>
<tr>
<th>Eclipsing</th>
<th>Gauche</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/H</td>
<td>~1.0</td>
</tr>
<tr>
<td>H/Me</td>
<td>~1.4</td>
</tr>
<tr>
<td>Me/Me</td>
<td>~2.6</td>
</tr>
<tr>
<td>Et/Me</td>
<td>~3.1</td>
</tr>
<tr>
<td>i-Pr/Me</td>
<td>~0.95</td>
</tr>
<tr>
<td>t-Bu/Me</td>
<td>~2.7</td>
</tr>
<tr>
<td>Et/Et</td>
<td>~3.1</td>
</tr>
</tbody>
</table>

### Infrared Correlation Chart

- C-H usually strong
- C=O broad - 3000
- O-H broad with spikes ~3300
- N-H broad - 3300
- O=C

### NMR Correlation Charts

- R-NH₂ variable and condition dependent, ca. 2 - 6 δ
- R-OH

<table>
<thead>
<tr>
<th>δ, ppm</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>220</td>
<td>200</td>
<td>180</td>
<td>160</td>
<td>140</td>
<td>120</td>
<td>100</td>
<td>80</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Aromatic Ar-H
- R₂C=CR₂
- RC=CR
- R-C-OH
- O
- C

The room where most students will take the test for your class, i.e. LS A-191 for onground and PS H-152 for hybrid)

COMPLETE THIS SECTION: Up to TWO POINTS will be removed for incorrect/missing information!
YOU MUST COMPLETE THIS PAGE WITH YOUR NAME
(EVEN THOUGH YOU ALREADY DID THIS ON THE COVER PAGE)
AND ALSO GIVE YOUR ASU OR POSTING ID NUMBER
WE NEED THIS NUMBER BECAUSE YOU WOULDN'T BELIEVE THE NUMBER OF
STUDENTS WHOSE NAMES WE CAN'T READ!

Points by question
1__________/13
2__________/22
3__________/40
4__________/40
5__________/40
5__________/20

Points Removed for cover errors ____/2

Extra Credit______/5

Total (incl Extra)______/175+5

**YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM**
Question 1 (13 pts). Give the IUPAC name for the following compound. Be sure to use cis/trans, E/Z or R/S where appropriate.

5-chloro-7-methyl-(3R)-propyloct-(4Z)-en-2-one

Question 2 (22 pts.) Give an arrow-pushing mechanism for the following reaction, indicate the Lewis and Bronsted acids/bases for each intermoecular step (LB, LB, BB, BA)
- Show all resonance contributors for the intermediates
- Show where all protons come from and go to (no +H^-/-H^+)
- Give the number of steps in your mechanism

Steps: 7
Question 3 (40 pts.) Provide the missing major organic products or reagents/conditions as appropriate, you can IGNORE stereochemistry in these problems

(a) \[
\begin{align*}
\text{H} & \quad \text{1. 1 Equiv. PhMgBr} \\
\text{CO} & \quad \text{2. } \text{H}_3\text{O}^+ \\
\text{Ph} & \quad \text{HO} \\
\text{C} & \quad \text{O} \\
\end{align*}
\]

(b) \[
\begin{align*}
\text{HO} & \quad \text{CO/} \text{HCl} \\
\text{CHO} & \quad \text{AlCl}_3 \\
\end{align*}
\]

(c) \[
\begin{align*}
\text{CH}_3 & \quad \text{TsOH (cat.)} \\
\end{align*}
\]

(d) \[
\begin{align*}
\text{Br} & \quad \text{N}_2\text{H}_4 \\
\text{KOH/heat} & \\
\end{align*}
\]

(e) \[
\begin{align*}
\text{OH} & \quad \text{CH}_3\text{OH} \\
\text{OCH}_3 & \quad \text{Na}^+ \cdot \text{OCH}_3 \\
\end{align*}
\]

Extra credit question (5 pts). \(\beta\)-carotene is synthesized using which reaction?

Clemmenson  Grignard  Wittig  Aldol
Question 4 (40 pts.) Synthesize the (target) molecules on the right from the starting molecules on the left. This cannot be done in one reaction. Give reagents and conditions and the intermediate molecules at each step. Do not show any mechanisms or transient intermediates. If other isomers are formed at any step then you need to indicate this but you do not need to draw their structures.

a)

\[
\begin{align*}
&\text{Cl} \quad \text{AlCl}_3 \quad \text{O} \\
&\text{Br}_2/\text{FeBr}_3 \\
&\text{Br} \quad \text{Zn(Hg)} \\
&\text{Br} \quad \text{HCl/H}_2\text{O} \\
&\text{Br} \quad \text{HNO}_3 \\
&\text{Br} \quad \text{H}_2\text{SO}_4 \\
&\text{Br} \quad \text{separate isomers}
\end{align*}
\]

1. \text{KMnO}_4/\text{OH}/\text{boil}
2. \text{H}_3\text{O}^+

or any other alkyl group that has a benzylic hydrogen

b)

\[
\begin{align*}
&\text{MgBr} \\
&\text{HBr} / \text{ROOR} \\
&\text{Mg}.\text{THF}
\end{align*}
\]

1. \text{H}_3\text{O}^+
2. \text{H}_3\text{O}^+

or any other alkyl group that has a benzylic hydrogen
Question 5 (40 pts.) Give a complete arrow-pushing mechanism for the following reactions, indicate the Lewis and Bronsted acids/bases for each intermolecular step (LB, LB, BB, BA)

- Show all resonance contributors for the intermediates
- Show where all protons come from and go to (no +H/-H)
- Give the number of steps in your mechanism

![Mechanism A](image1)

**# of steps**: 3

![Mechanism B](image2)

**# of steps**: 3

Question 6 (20 pts). Rank the following reactions in order of increasing rate. Give a BRIEF explanation that includes the terms Lewis acidity/basicity OR nucleophilicity/electrophilicity (almost all points for the explanation, not getting the order correct)

A \( \text{O}_2\text{N-} \text{Cl}_2 \text{AlCl}_3 \rightarrow \text{O}_2\text{N-} \text{Cl} \)

B \( \text{NH}_2 \text{Cl}_2 \text{AlCl}_3 \rightarrow \text{NH}_2 \text{Cl} \)

C \( \text{NH}_2 \text{Cl}_2 \text{AlCl}_3 \rightarrow \text{NH}_2 \text{Cl} \)

A \( \text{slowest} \) < B < C \( \text{fastest} \)

These are all electrophilic aromatic substitution, reaction at any position on a ring with a withdrawing group is slow because the W-group is deactivating, so reaction A is slower than both reactions B and C. Reaction B, meta with respect to the strong donating group is slower than C (ortho-) because the positive charge in the intermediate in C is directly stabilized by the strong donating group whereas it is not in B.