Write your name on every page.

- The exam is 5 pages long (not including this one). Please make sure you have all of the pages.
- Write complete but succinct answers. Good Luck!

Question 1 (20 pts): __________

Question 2 (25 pts): __________

Question 3 (15 pts): __________

Question 4 (20 pts): __________

Question 5 (20 pts): __________

Total (100 pts): __________
1. Provide detailed mechanisms for the following transformations:

a. (10 pts)

\[
\begin{align*}
\text{R-NMe_2} & \xrightarrow{1. \text{OH, H}_2\text{O}} \text{R-COOH} \\
& \xrightarrow{2. \text{H}_3\text{O}^+} \text{R-COOH}
\end{align*}
\]

b. (10 pts)

\[
\begin{align*}
\text{Me-CH-CH-H} & \xrightarrow{-\text{OH, H}_2\text{O}} \text{O}
\end{align*}
\]
2. Predict the major product of the following reactions:

a. (10 pts)

\[
\begin{align*}
&\text{\includegraphics[width=0.2\textwidth]{image1.png}} \\
&\text{OH, H}_2\text{O}
\end{align*}
\]

b. (10 pts)

\[
\begin{align*}
&\text{\includegraphics[width=0.4\textwidth]{image2.png}} \\
&\text{H}^+
\end{align*}
\]

c. (5 pts)

\[
\begin{align*}
&\text{\includegraphics[width=0.25\textwidth]{image3.png}} \\
&\text{i-Pr}_2\text{N-Li (LDA)} \\
&\text{-78 °C} \\
&\text{CH}_3\text{I}
\end{align*}
\]
3. a. (5 pts) Using resonance structures, provide a brief explanation for the observation that amides typically display a lower C=O stretching frequency in the IR spectra relative to ketones:

\[
\begin{align*}
\text{Amide} & : \quad \text{R} - \text{NR}_2 - \text{C}=\text{O} \\
\text{Ketone} & : \quad \text{R} - \text{R} - \text{C}=\text{O}
\end{align*}
\]

~1670 cm\(^{-1}\)  
~1720 cm\(^{-1}\)

b. (10 pts) Rank the three compounds shown below from lowest frequency to highest frequency for the C=O stretch in the IR spectra. Please clearly write one letter in each box.

\[
\begin{align*}
\text{A}  & : \quad \text{N-C-CH}_2\text{CF}_3 \\
\text{B}  & : \quad \text{N-C-CH}_2\text{N} \\
\text{C}  & : \quad \text{N-C-CH}_2\text{CH}_3
\end{align*}
\]

\[
\begin{align*}
\text{Lowest Frequency} & \quad \text{A} \quad \text{B} \quad \text{C} \quad \text{Highest Frequency}
\end{align*}
\]
4. (20pts) Provide the missing products of the following sequence of reactions:

\[
\begin{align*}
&\text{MeO} - \text{CO} - \text{CO} - \text{OMe} \\
&\xrightarrow{2 \text{ equiv Na}^+ - \text{OEt, Br}} \text{H}_3\text{O}^+, \Delta \\
&\xrightarrow{\text{SOCl}_2} \\
&\xrightarrow{\text{Et}_3\text{N}} \\
&\xrightarrow{\text{LiAlH}_4}
\end{align*}
\]
5. The illustrated tricyclic compound may be synthesized in only a few steps from the illustrated starting materials. If you understand the Robinson Annulation, then you can understand this modified version of it.

\[
\begin{align*}
\text{H}_2\text{C}-\text{O} & \quad + \quad \text{CH}_3\text{O} \quad \rightarrow \quad \text{H}_3\text{C}-\text{C} \quad \text{O} \\
\end{align*}
\]

a. (10 pts) The last step involves two aldol condensations, one after the other. The starting material for this double aldol condensation is a tetraketone. Thinking "backwards" from the product, provide the structure of this tetraketone:

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

b. (10 pts) Show how you might synthesize the tetraketone you have just identified in two steps from the starting materials provided above.