General Instructions:
Use scratch paper at the back of the exam to work out answers. Final answers must be recorded at the proper place on the exam itself for credit.
Print your name and ID # on each page.
Please keep your paper covered and your eyes on your own work.
Academic misconduct will lead to failure in the course.

1. (35 pts.) Give the major product(s) of the following reactions. Show stereochemistry in 3-D where necessary and all stereoisomers.

(a) \[ \text{CH}_3\text{O} \quad \text{Br} \]

(b) \[ \text{N} \quad \text{C} \quad \text{O} \quad \text{CH}_3 \]

(c) \[ \text{Ag}_2\text{O} \]

(d) \[ \text{NaOH, H}_2\text{O} \]

\[ \text{heat} \]
(e)  \[
\text{CH}_2\text{CHOCH}_2\text{CH}_2\text{OH} \xrightarrow{1. \text{NaOCH}_3, \text{CH}_3\text{OH}} \text{CH}_3\text{OCH}_2\text{CH}_2\text{OH} \xrightarrow{2. \text{H}_3\text{O}^+, \text{H}_2\text{O}, \text{excess}}
\]

(f)  \[
\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{N} \xrightarrow{1. \text{LiAlH}_4} \text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{N} \xrightarrow{2. \text{H}_2\text{O}}
\]

(g)  \[
\text{CH}_2\text{CH}_2\text{Cl} \xrightarrow{1. \text{Cu}} \text{CH}_2\text{CH}_2\text{Cu} \xrightarrow{2. \text{H}_2\text{O}}
\]
2. (15 pts.) Draw the reagents (over the arrow) needed to accomplish the following transformations. Number the reagents if they cannot be mixed.

(a) 

(b) 

(c) 

(d)
3. (20 pts.) Follow the directions for each question.

(a) **Circle the strongest acid** and put a box around the weakest acid.

\[ \text{H}_2\text{O}^+, \text{Ag}_2\text{O}, \text{LiAlH(Ot-Bu)}_3, \text{LiN(i-Pr)}_2 \]

(b) **Circle the oxidizing agent** and put a box around the reducing agent.

\[ \text{H}_3\text{O}^+, \text{Ag}_2\text{O}, \text{LiAlH(Ot-Bu)}_3, \text{LiN(i-Pr)}_2 \]

(c) **Circle the strongest base** and put a box around the weakest base.

\[ \text{OCH}_3, \text{OCH}_2\text{O}^-, \text{OCH}_2\text{OC}=\text{O}^-, \text{OCH}_2\text{O}^- \]

(d) **Circle the ketone which cannot be made by the acetoacetic ester synthesis.**

\[ \text{CH}_3\text{C}=\text{O}, \text{CH}_3\text{C}=\text{CH}, \text{CH}_3\text{C}=\text{CH}_2, \text{C}_5\text{H}_6\text{O} \]

(e) **Circle the halogen which will react most rapidly with a ketone under basic conditions.**

\[ \text{Cl}_2, \text{Br}_2, \text{I}_2, \text{all the same} \]
4. (9 pts.) Write the complete mechanism for the following reaction including all intermediates and electron-pushing arrows.

\[
\begin{align*}
\text{O} & \quad \text{Ph} \\
\text{O} & \quad \text{O} \\
\text{NaOH} & \quad \text{H}_2\text{O} \\
\text{O} & \quad \text{O} \\
\text{Ph} & \\
\end{align*}
\]

5. (7 pts.) How would you prepare the following compound using a Robinson annulation reaction between a β-diketone and a conjugated enone? Draw the structures of both reactants and the intermediate Michael addition product.

\[
\text{Michael Addition product}
\]

\[
\text{Reactants}
\]
6. (8 pts.) Give a specific example of the following reactions. Show starting materials, reagents over the arrow and products.

   a) hydrolysis of an amide

   b) reduction of a ketone to a hydrocarbon

7. (6 pts.) Draw the structure of each of the following:

   (a) a lactone

   (b) diethyl malonate