1. (3 points) Rank the following carboxylic acid derivatives in order of decreasing reactivity toward hydrolysis (most reactive on left):

\[
\begin{array}{cccc}
A & B & C & D \\
\hline
H_C-C-OCH_3 & H_C-C-O-C-CH_2 & H_C-C-NH_2 & H_C-C-Cl \\
\end{array}
\]

A) \( D > B > A > C \)  
B) \( C > A > B > D \)  
C) \( B > D > A > C \)  
D) \( A > B > D > C \)  
E) \( D > B > C > A \)
2. (21 points) Match each of the following molecules with the name of the functional group that it contains:

- **a**
  - ![Structure a](image)
  - a) thioacetal

- **f**
  - ![Structure f](image)
  - (actually, a hemiketal)
  - b) semicarbazone

- **c**
  - ![Structure c](image)
  - c) oxime

- **d**
  - ![Structure d](image)
  - d) imine

- **g**
  - ![Structure g](image)
  - e) hydrazone

- **e**
  - ![Structure e](image)
  - f) hemiacetal - ketone

- **b**
  - ![Structure b](image)
  - g) enamine
3. (16 points) Choose any four of the molecules in Problem 2 and show the reaction(s) to prepare it from an aldehyde (or ketone) and any other reagents you need.

1) 

2) 

3) 

4) 

(or others ...)

4. (36 points) Predict the products of the following reactions.

a. 

b. 

CH₂CH₂OH (excess) 

H⁺

C₆H₁₃CH₂OH 

H⁺

C₆H₁₃CH₂OH 

H⁺

c. 

d. 

Li(O-Bu)₃AlH
5. (6 points) Show the mechanism for the following reaction:
6. (8 points) Show the series of reagents and reactions needed to produce the following transformation. (Hint: This requires more than one step!)

\[
\begin{array}{c}
\text{H} & \text{C} & \text{H} \\
\text{O} & \text{C} & \text{H} \\
\downarrow \text{OH, H}^+ & \text{H}_2\text{O} & \downarrow \text{NaBH}_4 \\
\end{array}
\]

7. (2 points) What reagent(s) would be required to achieve the following conversion?

\[
\begin{array}{c}
\text{C} & \text{H} \\
\text{O} & \text{OH} \\
\end{array}
\rightarrow
\begin{array}{c}
\text{C} & \text{H} \\
\text{O} & \text{H} \\
\end{array}
\]

A) 1. SOCl\textsubscript{2}, 2. LiAl(O-tBu)\textsubscript{3}H  \\
B) 1. NaBH\textsubscript{4}, 2. H\textsubscript{2}CrO\textsubscript{4}  \\
C) 1. LiAlH\textsubscript{4}, 2. H\textsubscript{2}O, PCC  \\
D) 1. Br\textsubscript{2}, cat. P, 2. H\textsubscript{2}O  \\
E) both A and C

8. (4 points) An important step in the reactions of the enzymes known as aldolases is the formation of an imine. Draw the product of the reaction between acetaldehyde and the amino acid lysine (that is part of the enzyme active site).

\[
\begin{array}{c}
\text{H} & \text{C} & \text{H} \\
\text{CH}_3 & \text{H} & \text{O} \\
\end{array}
\rightarrow
\begin{array}{c}
\text{H} & \text{C} & \text{H} \\
\text{C} & \text{H} & \text{N} \\
\end{array}
\]

9. (4 points) In nucleophilic acyl substitution,

a. protonation of the carbonyl is followed immediately by loss of the leaving group.  \\
b. loss of the leaving group is followed by rearrangement of the carbocation.  \\
c. addition to the carbonyl by a nucleophile is followed by loss of the leaving group.  \\
d. ester hydrolysis is followed by deprotonation.  \\
e. an S_N2 reaction occurs.
Extra Credit: (8 points) In acidic methanol, 3-oxobutanal is transformed into a compound with molecular formula C₆H₁₂O₃.

\[ \text{CH₃OH, H}^+ \quad \begin{array}{c} \text{CH₃} \text{O} \\ \text{CH₃} \text{O} \end{array} \quad \rightarrow \quad \text{C₆H₁₂O₃} \]

The IR spectrum contains a single strong absorption at 1715 cm⁻¹. The NMR spectrum contains the following signals: s, δ 2.19, 3H; d, δ 2.75, 2H; s, δ 3.38, 6H; t, δ 4.89, 1H. Draw the product and name the new functional group that it contains.