1. (9 pts) Name 3 out of 4 of the following compounds: Cross one out or graded in order.

- formamide
- DMF
- dimethyl oxalate
- ethanedioate
- methyl benzozate
- acetyl chloride
- ethanoyl chloride

2. (10 pts) Predict the products of the following carboxylic acid derivatives:

- \[
\text{acid catalyst} \quad \text{HNO}_2/\text{H}_2\text{SO}_4 \quad + \quad \text{acetic acid}
\]

3. (8 pts) Succinic Anhydride has the structure shown below. It is formed by the dehydration of succinic acid, a starch modifier and flavoring in soy sauce and sake.

\[
\text{succinic acid} \quad \rightarrow \quad \text{succinic anhydride} + \text{H}_2\text{O}
\]

Draw succinic acid:

What is the product of succinic anhydride when heated to 200°C with dry ammonium chloride (NH₃ + HCl)?

\[
\text{succinic anhydride} + \text{NH}_4^+ \rightarrow \text{succinimide} - \text{H}_2\text{O}
\]

The molecule formed by the reaction above can be reacted with Br₂ and base to make a very important organic reagent for substituting an H in the allyl or benzyl position with Br. Draw the Bromo-organic reagent and give the name and acronym.

Structure:

Name \text{N-Bromo succinimide}  
Abbreviation \text{NBS}
4. (16 pts) Given that enols have pKa about 16, α-C-H has pKa of about 20, and β-keto α-H (double α) has a pKa of 9.
(a) For methyl ethyl ketone (MEK) or 2-butanone: Draw the 2 enol forms. Indicate which is more stable and briefly explain:

#### Form 1
- Not most stable
- Explanation for relative stability: 

#### Form 2
- Most stable
- Explanation for relative stability: 

(b) The following molecule belongs to a class called enediols: each C in the double bond carries an –OH group. Draw structural formulas for the α-hydroxyketone and the α-hydroxylaldehyde. that would be part of the equilibrium below:

(c) 1,3-Cyclohexanedione is a β-keto carbonyl compound. Draw the structures for the equilibrium between the β-diketone and the β-keto-enol form

5. (9 pts) Predict the major organic products of the following reactions: Assume acid work-up for each reaction.

- **First Reaction:**
  - Reaction: 
  - Conditions: 
  - Product:

- **Second Reaction:**
  - Reaction: 
  - Conditions: 
  - Product:

- **Third Reaction:**
  - Reaction: 
  - Conditions: 
  - Product:
6. (15 pts) Synthetic amino acids can be made simply starting with diethyl malonate, adding the proper substituent, using the Hell-Volhard-Zelenskii reaction to make the α-Bromo acid, which is finally converted by S₂N₂ reaction with ammonia. Complete the following steps for the synthesis of phenylalanine. Fill in the empty boxes.

![Chemical diagram]

7. (9 pts) Provide reagents that would carry out the following transformations:

![Chemical diagram]

8. (6 pts) Fill in the proper reagents over the arrows to transform benzonitrile below. Assume acid work-up for each reaction.

![Chemical diagram]
9. (12 pts) Fill in the proper reagents over the arrows to turn cyclohexanone into the following:

\[ \text{Cyclohexanone} \xrightarrow{\text{LDA}} \text{Cyclopentene} \xrightarrow{\text{CH}_3\text{I}} \text{Cyclohexylketone} \xrightarrow{1. \text{LAH}} \xrightarrow{2. \text{HBr, heat}} \text{1-methylcyclohexene} + \text{H}_2\text{O} \]

\[ \text{Cyclohexanone} \xrightarrow{\text{LDA}} \text{Cyclopentene} \xrightarrow{\text{CH}_3\text{I}} \text{Cyclohexylketone} \xrightarrow{1. \text{C}_3\text{H}_7\text{Br}} \xrightarrow{2. \text{HBr, heat}} \text{1-methylcyclohexene} + \text{H}_2\text{O} \]

10. (10 pts) NMR. This compound, whose formula=$\text{C}_8\text{H}_6\text{O}_4$, was synthesized by a single alkylation of diethyl malonate. Draw the compound based on the chemistry and the NMR below. Identify and assign all peaks. Try the $^{13}\text{C}$ too.

The IR indicates C-H at 2988 and 2945 cm$^{-1}$ and C=O at 1734 cm$^{-1}$.

\[ \text{No NMR on test} \]