I. Nomenclature
   1. Name the following functional groups.

   \[
   \text{isocyanate} \quad \text{urea} \quad \text{carbonate} \quad \text{enamine}
   \]

   2. Provide an IUPAC and/or common name for each of the following:
      (I = IUPAC / C = Common)

   \[
   \text{I: N-methyl butanamide} \quad \text{I: propane nitrile} \quad \text{I: Phenyl ethanoate}
   \]

   \[
   \text{C: N-methyl butyramide} \quad \text{C: propio nitrile} \quad \text{C: Phenyl acetate}
   \]

   \[
   \text{I: 4-aminobutyric acid lactam} \quad \text{C: oxalic acid} \quad \text{I: ethanedioic acid}
   \]

   \[
   \text{C: \(\gamma\)-butyrolactam} \quad \text{I: acetic acid} \quad \text{C: acetic acrylic anhydride}
   \]

II. Theory
   1. Give the pKa values of each of the following.

   \[
   \begin{align*}
   &\text{I: } 20 \\
   &\text{C: } 24 \\
   &\text{I: } 20 \\
   &\text{C: } 50
   \end{align*}
   \]
2. Explain why the C=O bond of conjugated esters have lower vibrational frequencies and lactones have higher frequencies than unconjugated acyclic esters.

\[ \text{The greater the C-O single bond contrib., the weaker the C=O bond and lower the } \nu. \]

3. Which would you expect to have a higher C=O bond frequency, an ester or a thioester? Explain.

\[ \text{Thioester } \xrightarrow{\text{less contribution}} \text{ S does not form strong } \pi \text{ bonds.} \]

4. In considering the rate of hydrolysis of an ester and a thioester to carboxylic acids, which would proceed most rapidly?

\[ \text{Thioester - lacks resonance stabilization compared to ester.} \]

III. Reactions
1. What might be a side reaction associated with the direct alkylation of an ester?

\[ \text{Claisen ester condensation} \]

\[ \text{OE}^{-} + R\text{X} \xrightarrow{\text{OE}^{-}} R\text{XOE}^{-} \]

\[ \text{(2nd equivalent lost)} \]

\[ \text{OE}^{-} + R\text{XOE}^{-} \xrightarrow{\text{OE}^{-}} R\text{X} \text{OE}^{-} + \text{CH}_3 \text{OE}^{-} \]
2. In the Claisen ester condensation reaction, why do only two molecules condense and not several to form a polymer?

$$\text{H}_2\text{C}^{\text{OEt}} + \text{H}_2\text{C}^{\text{OEt}} \rightarrow \text{H}_2\text{C}^{\text{OEt}}$$

1. NaOEt
2. H$_2$O$^{\text{O}}$

$$\text{H}_2\text{C}^{\text{OEt}} + \text{H}_2\text{C}^{\text{OEt}} \rightarrow \text{H}_2\text{C}^{\text{OEt}}$$

Resonance and $\oplus$ greatly decrease electrophilicity of ketone & ester.

3. In nucleophilic addition to a conjugated ketone, explain the factors favoring 1,2 addition versus 1,4 addition. Draw out intermediates.

$$\text{R} = \text{Nu}$$

1,2 addition

$$\text{R} = \text{Nu}$$

1,4 addition

most stable intermediate (favored by Nu which add)

reversibly 1,2

Kinetic based

isolated charge

-No resonance

(favored by Nu which add irreversibly 1,2)

4. Provide the starting material, reagent, or product of the reactions on last page.
IV. Mechnisms
1. Provide the mechanisms of the following reactions:

\[ \text{weak electrophile} \quad \text{strong nucleophile} \]

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{OCH}_3 \\
\text{O} & \quad \text{OH} \\
\text{H} & \quad \text{OH} \\
\text{H}_2\text{O} & \quad \text{heat} \\
\text{H}_3\text{C} & \quad \text{COH} \\
\end{align*}
\]

\[
\begin{align*}
\text{weak electrophile} \quad \text{EtOH, } \text{H}^+, \text{ heat} \\
\text{activated} \\
\end{align*}
\]
1) NaOEt
2) allyl bromide
3) H$_3$O$^+$, heat

 aldol product

(Not require showing saponification mech.)

(Decarboxylation)