1) Name the general class of organic compounds that each of these molecules belong to, and circle the molecule with the most ring strain. (17pts)

2) Put a cross through the molecule that has the highest reactivity with nucleophiles. (2pts)
3) Circle the stronger acid in the following pairs, and in a sentence explain your choice. (12pts)

(a) \( \text{H}_3\text{C} \text{--CO}_2\text{H} \) \( \text{F}_3\text{C} \text{--CO}_2\text{H} \)

(b) \( \text{NC} \text{--CO}_2\text{H} \) \( \text{--CO}_2\text{H} \)

(c) \( \text{CBrH}_2\text{H} \text{--CO}_2\text{H} \) \( \text{CH}_3\text{CBrH} \text{--CO}_2\text{H} \)

(d) \( \text{H}_3\text{C} \text{--CO}_2\text{H} \) \( \text{--CO}_2\text{H} \)

4) Circle the more reactive molecule with respect to undergoing nucleophilic acyl substitution. (6pts)

(a) \( \text{CH}_3\text{CH}_2 \text{--OH} \) \( \text{CH}_3\text{--O--C--CH}_3 \)

(b) \( \text{\text{O}} \) \( \text{H}_3\text{C} \text{--O--CH}_3 \)

(c) \( \text{CH}_3\text{NH--C--CH}_3 \) \( \text{CH}_3\text{CH}_2 \text{--CO}_2\text{CH}_3 \)
5) Name the following compounds in IUPAC acceptable terms. (20pts)
6) Benzoic acid can be made from a wide variety of benzene derivatives. Fill in the missing reagents. (12pts)

- CH$_2$CH$_3$
- Br
- CN
- O=CH
7) When trifluoroethanoic acid and ethanoic acid are heated together in the presence of a dehydration agent, three products are formed, all of which are anhydrides. Draw the **three** products and name the *unsymmetrical* (or 'mixed') anhydride. (7pts)

Draw the mechanism for the formation of **one** of the anhydrides (7pts).
8) Draw two resonance structures for diazomethane, CH₂N₂ (3pts)

Give the products for the following transformation. (6pts)

\[
\text{C}_6\text{H}_4\text{CO}_2\text{H} \xrightarrow{\text{CH}_2\text{N}_2, \text{ether}} \text{C}_6\text{H}_4\text{CO}_2\text{H}
\]

\[
\text{C}_6\text{H}_4\text{CO}_2\text{H} \xrightarrow{\text{excess CH}_3\text{CH}_2\text{OH}} \text{acid catalyst}
\]

What is the name of the acid catalyzed reaction above (1pts).

9) Give the products for the following transformations. (8pts)

\[
\text{C}_6\text{H}_9\text{N}_2 \xrightarrow{\text{NaOH, H}_2\text{O, Heat}} \text{C}_6\text{H}_9\text{NaO}_2\text{H}
\]

\[
\text{C}_6\text{H}_9\text{O}_2\text{C}_2\xrightarrow{\text{NaOH, H}_2\text{O, Heat}} \text{C}_6\text{H}_9\text{O}_2\text{C}_2\text{Na}
\]
*Bonus question* (up to 2pts)
Explain why nucleophilic acyl substitution reactions proceed so readily despite the fact that the leaving groups (e.g. HO−, CH₃O−, etc) are typically poor leaving groups?
1) Name the general class of organic compounds that each of these molecules belong to, and circle the molecule with the most ring strain. (17pts)

2) Put a cross through the molecule that has the highest reactivity with nucleophiles. (2pts)

See above
3) Circle the stronger acid in the following pairs, and in a sentence explain your choice. (12pts)

(a) \( \text{H}_3\text{C}-\text{CO}_2\text{H} \)  
(b) \( \text{F}_3\text{C}-\text{CO}_2\text{H} \)

(c) \( \text{CBrH}_2\text{CH}_2-\text{CO}_2\text{H} \)  
(d) \( \text{CH}_3\text{CBrH}-\text{CO}_2\text{H} \)

4) Circle the more reactive molecule with respect to undergoing nucleophilic acyl substitution. (6pts)

(a) \( \text{CH}_3\text{CH}_2-\text{OH} \)  
(b) \( \text{CH}_3-\text{O} \)

(b) \( \text{H}_3\text{C}-\text{C}-\text{O}\text{CH}_3 \)  
(c) \( \text{CH}_3\text{NH}-\text{C}-\text{CH}_3 \)

\( \text{CH}_3\text{CH}_2-\text{CO}_2\text{CH}_3 \)
5) Name the following compounds in IUPAC acceptable terms. (20pts)

\[ \text{methylmethanoate} \]
\[ \text{chloroacetone} \]
\[ \text{butanoic propanoic acid} \]
\[ \text{5-amino-4-fluoropentanoic acid} \]
\[ \text{L-alanine} \]
\[ \text{L-hydroxybutanoic acid lactam} \]
\[ \text{L-hydroxypentanoic acid lactam} \]
6) Benzoic acid can be made from a wide variety of benzene derivatives. Fill in the missing reagents. (12pts)

\[
\begin{align*}
\text{CH}_2\text{CH}_3 & \quad \text{CO}_2\text{H} \\
\text{Br} & \quad \text{CO}_2\text{H} \\
\text{CN} & \quad \text{CO}_2\text{H} \\
\text{O=CH} & \quad \text{CO}_2\text{H}
\end{align*}
\]

1) \( \text{KMnO}_4, \text{OH}^- \) \\
2) \( \text{H}_3\text{O}^+ \)

1) \( \text{Hg} \) \\
2) \( \text{CO}_2 \) \\
3) \( \text{H}_3\text{O}^+ \)

1) \( \text{NaOH, } \text{H}_2\text{O} \) \\
2) \( \text{H}_3\text{O}^+ \)

1) \( \text{KMnO}_4, \text{H} \) \\
or \( \text{As}_2\text{O} \)

or \( \text{Chromic Acid} \)
7) When trifluoroethanoic acid and ethanoic acid are heated together in the presence of a dehydration agent, three products are formed, all of which are anhydrides. Draw the three products and name the unsymmetrical (or 'mixed') anhydride. (7pts)

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

"Trifluoroethanoic ethanoic anhydride"

Draw the mechanism for the formation of one of the anhydrides (7pts).
8) Draw two resonance structures for diazomethane, CH$_2$N$_2$ (3pts)

\[
\begin{align*}
\text{H} & \quad \text{C} = \text{N} = \text{N}^+ & \quad \text{H}^{-} \\
\end{align*}
\]

Give the products for the following transformation. (6pts)

\[
\begin{align*}
\text{CO}_2\text{H} & \quad \xrightarrow{\text{CH}_2\text{N}_2, \text{ether}} & \quad \text{C-O-CH}_3 \\
\text{CO}_2\text{H} & \quad \xrightarrow{\text{excess CH}_3\text{CH}_2\text{OH}, \text{acid catalyst}} & \quad \text{C-O-CH}_3\text{CH}_2 \\
\end{align*}
\]

What is the name of the acid catalyzed reaction above (1pts).

\textbf{FISHER ESTERIFICATION}

9) Give the products for the following transformations. (8pts)

\[
\begin{align*}
\text{N} & \quad \text{C}=\text{O} & \quad \xrightarrow{\text{NaOH, H}_2\text{O, Heat}} & \quad \text{C}=\text{O} \\
\text{O} & \quad \text{C}=\text{O} & \quad \xrightarrow{\text{NaOH, H}_2\text{O, Heat}} & \quad \text{C}=\text{O} \\
\end{align*}
\]
*Bonus question* (up to 2pts)

Explain why nucleophilic acyl substitution reactions proceed so readily despite the fact that the leaving groups (e.g. HO⁻, CH₃O⁻, etc) are typically poor leaving groups?

The leaving group is expelled in an anionic step of the reaction, and therefore, the TS is "reactant-like" placing the leaving group bond is not significantly broken at the TS, and is not a factor energetically.

This TS resembles the tetrahedral intermediate.