I. Nomenclature

1. Draw structures for the following compounds: (5 points)

   - **β-butyrolactam**
   - **phthalic acid**

2. Provide common names for each structure below. (5 points)

   ![Structure 1](image1)
   ![Structure 2](image2)

3. Give IUPAC names for each of the following structures. (6 points)

   ![Structure 3](image3)
   ![Structure 4](image4)

II. Theory

1. Which of the following substances would function best as soap? (2 points)
   a) a triester  
   b) decanoic acid  
   c) sodium decanoate  
   d) sodium benzoate

2. Predict the pKa of each indicated H within 2 pKa units. (6 points)

   ![Structure 5](image5)
   ![Structure 6](image6)
   ![Structure 7](image7)
3. Circle all structures that are derivatives of a carboxylic acid. (4 points)

   a) $\text{H}_3\text{C} \equiv \text{N}$  
   b) $\text{H}_2\text{C} \sim \text{N} \sim \text{CH}_3$  
   c) $\text{H}_3\text{C} \sim \text{O} \sim \text{O} \sim \text{CH}_3$  
   d) $\text{H}_3\text{C} \sim \text{N} \sim \text{O} \sim \text{O} \sim \text{CH}_3$

4. The Fischer esterification reaction can be best categorized by which of the following mechanism types? (3 points)

   a) $\text{S}_\text{N}2$  
   b) addition-elimination  
   c) elimination-addition  
   d) $\text{S}_\text{N}1$

5. In each series, circle the structure that is most reactive toward nucleophilic attack. (4 points)

   $\text{H}_3\text{C} \sim \text{S} \sim \text{CH}_3$  
   or  
   $\text{H}_3\text{C} \sim \text{O} \sim \text{CH}_3$  
   or  
   $\text{H}_3\text{C} \sim \text{O} \sim \text{CH}_3$  
   or  
   $\text{H}_3\text{C} \sim \text{O} \sim \text{CH}_3$

6. Indicate the sequence that correctly lists the compounds below in order of increasing boiling points. (3 points)

   1  
   2  
   3  

   a) 1-2-3  
   b) 2-3-1  
   c) 3-1-2  
   d) 3-2-1  
   e) 2-1-3  
   f) 1-3-2

7. Show three different methods for synthesizing benzoic acid from three different starting materials that are not derivatives of a carboxylic acid. (6 points)
8. Carboxylic acids are components of many different useful substances. Match each material with its key functional group. Some functional groups may be used more than once or not used at all. (5 points)

<table>
<thead>
<tr>
<th>Material</th>
<th>Functional Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon</td>
<td>a) ester or lactone</td>
</tr>
<tr>
<td>Sevin insecticide</td>
<td>b) amide or lactam</td>
</tr>
<tr>
<td>Coenzyme A (active portion)</td>
<td>c) carboxylic acid</td>
</tr>
<tr>
<td>penicillin</td>
<td>d) carbamate</td>
</tr>
<tr>
<td>Lexan</td>
<td>e) carbonate</td>
</tr>
<tr>
<td></td>
<td>f) urea</td>
</tr>
<tr>
<td></td>
<td>g) thioester</td>
</tr>
</tbody>
</table>

9. Correlate the indicated IR absorption peaks with the structure of acetylsalicylic acid. (3 points)

![Acetylsalicylic Acid Structure]
III. **Reactions**

1. Predict the reagents or products of the reactions shown below. (14 points)

   1)
   
   \[ \text{CH}_3\text{CH}_{2}\text{CH}_{2}\text{CH}_3 \]  
   \[ \overset{2)}{\longrightarrow} \]  
   \[ \text{CH}_3\text{CH}_{2}\text{CH}_{2}\text{CH}_3 \]  
   \[ \overset{3)}{\longrightarrow} \]  
   \[ \text{CH}_3\text{CH}_{2}\text{CH}_{2}\text{CH}_3 \]  

   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \]  
   \[ \overset{\text{NaOH}}{\longrightarrow} \]  

   \[ \text{C}_5\text{H}_9\text{O} \]  
   \[ \overset{1)}{\underset{\text{NaOEt, EtO}_2\text{COEt}}{\longrightarrow}} \]  
   \[ \overset{2)}{\underset{\text{H}_3\text{O}^+ \text{work up}}{\longrightarrow}} \]  

   \[ \text{H}_3\text{C}\text{NHCH}_2\text{OH} \]  
   \[ \overset{\text{phosgene}}{\longrightarrow} \]  

2. Fill in the missing reagent and intermediate product in the reaction below. (5 points)

   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH} \]  
   \[ \overset{\text{LiAl(Ot-Bu)}_3\text{H}}{\longrightarrow} \]  
   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO} \]
IV. **Mechanism**

1. Show a detailed arrow pushing mechanism for the reaction below. Include all intermediate structures and formal charges. (12 points)

\[
\begin{align*}
\text{RCHO} \quad & + \quad \text{ROH} & \xrightarrow{\text{cat. H}^+} & \text{RCOOH} \quad & + \quad \text{CH}_3\text{OH} \\
\text{heat} & & & & \\
\end{align*}
\]

2. Since the stability of the products are equivalent to the stability of the starting materials, how could this reaction be driven toward the products. (3 points)
V. Synthesis

1. Show all steps that are necessary to complete the synthesis below. (5 points)

\[\text{CH}_3\text{C(O)CH}_3 \rightarrow \text{CH}_3\text{C(O)OCH}_3\]

2. Fill in the missing starting materials and reagents. (9 points)

\[\text{H}_3\text{C} \quad \text{NaOH} \quad \text{H}_3\text{C} \quad \text{Ph}\]

1) \[\text{H}_3\text{C} \quad \text{Ph}\]

2) Acid work up
VI. **Extra Credit** (5 points possible)

Complete the following transformation by filling in the necessary reagents. (Hint: Step 1: a boys name; Step 2: “To make smaller” or a color of an apple is abbr. for this step; Step 3: “Ring around the Rosies”)

On exam 4 you received _________ points out of 100 points possible. To check your overall lecture grade go to http://courses.weber.edu.