1. Nomenclature & Fundamentals

(a) **Draw structures** corresponding to the following names – skip any one.

Phenyl benzoate

![Phenyl benzoate structure](image)

Isopropyl 2-methylpropanoate

![Isopropyl 2-methylpropanoate structure](image)

Phenylacetaldehyde  
(2-Phenylethanal)

![Phenylacetaldehyde structure](image)

2,4-Dimethylpentanenitrile

![2,4-Dimethylpentanenitrile structure](image)

(b) **Nucleophile vs. Electrophile.** Indicate whether the following functional group, type of compound, or reagent is more likely to act as a nucleophile (N) or electrophile (E) based on the reactions covered in this class.

<table>
<thead>
<tr>
<th>Methoxide ion</th>
<th>Acids</th>
<th>Bases</th>
<th>Carbocations</th>
<th>Cyanide ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>E</td>
<td>N</td>
<td>E</td>
<td>N</td>
</tr>
</tbody>
</table>

![Nucleophile vs. Electrophile structure](image)

(a) (25 points) **Indicate the approximate pKa** of each in the box provided below the compound using the closest pKa standard. The compounds are not given any particular order.

<table>
<thead>
<tr>
<th>Compound</th>
<th>pKa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol</td>
<td>19</td>
</tr>
<tr>
<td>Phenol</td>
<td>10</td>
</tr>
<tr>
<td>Methylamino benzoate</td>
<td>5</td>
</tr>
<tr>
<td>Methylamino benzoate</td>
<td>10</td>
</tr>
<tr>
<td>Methylamino benzoate</td>
<td>35</td>
</tr>
<tr>
<td>Hydroxide</td>
<td>16</td>
</tr>
<tr>
<td>Hydroxide</td>
<td>Ø</td>
</tr>
<tr>
<td>Hydroxide</td>
<td>50</td>
</tr>
</tbody>
</table>
2. (50 points) **Reaction Puzzle** – Add the missing reagents for each step on the lines provided.

(a) \( \text{CH}_3\text{MgBr} \), \( \text{H}_3\text{O}^+ \)  
   \(-2\) missing steps (fireballs)

(b) \( \text{H}_2\text{SO}_4\text{(aq)}, \Delta \) or \( 2\text{py} \)  
   \( 3 \) \( 2 \)

(c) \( \text{mCPBA} \) or \( \text{RCO}_2\text{H} \)

(d) \( \text{HCN} \) \( \text{NaCN} \)  
   \( 2\) pts

(e) \( \text{NaH} \), \( \text{CH}_3\text{Br} \)  
   \(-2\) missing steps (fireballs)  
   \( 1. \text{MgBr} \) \( 3 \)

(f) \( \text{NaBH}_4 \)  
   \( 2 \)

(g) \( \text{H}_3\text{O}^+ \)  
   \( 2 \)

(h) \( \text{HBr} \) or \( \text{PBr}_3 \)

(i) \( \text{HBr} \), \( \Delta \)  
   \( 3 \) \( 2 \)

(j) \( \text{POCl}_3 \), \( \text{py} \)  
   (better response) \( \Delta \)  
   \( \text{H}_2\text{O}\) accepted, but would give major product  
   \( 2 \)
3. (50 points) **Mini Reaction Puzzles** - Fill in the box with the missing reactant, reagent(s), or product. Pay attention to the direction of the reaction arrow. Complete each part (no opportunity to skip on this page).

(a)
\[
\text{Ph}_3\text{P} = \text{CH}_2 \quad \text{Ph}_3\text{P} = \text{CH}_2 \quad \text{Ph}_3\text{P} = \text{CH}_2
\]

(b)
\[
\text{Ph} = \text{CN} \quad \text{Ph} = \text{CN}
\]

(c)
\[
\text{Ph} = \text{CN} \quad \text{Ph} = \text{CN}
\]

(d)
\[
\text{Ph} = \text{CN} \quad \text{Ph} = \text{CN}
\]
4. Mechanisms

Include all intermediates with appropriate charges circled for each step.

(a) (25 points) One of the products is provided for the reaction below. Draw the other product in the box provided and show this mechanism.

(b) (25 points) The following acetal is made through an acid-catalyzed intramolecular cyclization reaction. The mechanism proceeds by nucleophilic addition and dehydration followed by second nucleophilic addition. Show this mechanism.
5. Mechanisms

Include all intermediates with appropriate charges circled for each step.

(a) (25 points) Imines are formed from the reaction of aldehydes and amines. If the water is not promptly removed, or if water is accidentally added, the imine will revert back to the aldehyde. Provide the mechanism for the imine hydrolysis reaction shown below.

(b) (25 points) Fischer esterification is used to synthesize fruity fragrances. Acetic acid reacts with a variety of alcohols, producing such fragrances as banana, strawberry, and sour apple. Show the mechanism for Fischer esterification between acetic acid and a generic alcohol under acidic conditions.
6. (40 points) Multi-Step Synthesis - Carry out any two of the synthesis problems below using the starting material provided and any other reagents or carbon sources needed. Put a large X over the 2 problems you’re skipping, otherwise (a) and (b) will be graded. Draw the product after each synthetic step. No mechanisms.

(a) 

(b) 

(c) 

(d) 

Put a large X over the 2 problems you’re skipping, otherwise (a) and (b) will be graded.