1. Predict the major product in the following reactions, showing stereochemistry where necessary:

   a. [Chemical structure diagram]

   b. [Chemical structure diagram]

2. An aldopentose A gave two sugars, B & C when it was subjected to the Kiliani-Fischer synthesis. Treatment of A & B with HNO₃ gave optically inactive dicarboxylic acids. Analogous treatment of C gave an optically active product. Give the structures of A, B & C.

3. Provide a structure for an aldohexose other than D-glucose that is oxidized to D-glucaric acid by nitric acid.

4. Like glucose, galactose shows mutarotation when dissolved in water. α-D-galactopyranose has a specific rotation of +150.7°, while that of the β-anomer is +52.8°. When either of the pure anomers dissolves in water, the specific rotation gradually changes to +80.2°. Determine the percentages of the two anomers present at equilibrium.

5. Provide a synthesis of acetaminophen starting from benzene:
6. Nucleophilic aromatic substitution is very effective when there is a powerful electron withdrawing group (typically a nitro group) ortho or para to a leaving group. Additional powerful electron withdrawing groups make the reaction even more favorable. Compare the following rates of reaction and explain the differences:

*Effect of Substitution:*

<table>
<thead>
<tr>
<th>Compound</th>
<th>Relative Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Compound 1]</td>
<td>1</td>
</tr>
<tr>
<td>![Compound 2]</td>
<td>1</td>
</tr>
<tr>
<td>![Compound 3]</td>
<td>$7 \times 10^{10}$</td>
</tr>
<tr>
<td>![Compound 4]</td>
<td>$2.4 \times 10^{15}$</td>
</tr>
<tr>
<td>![Compound 5]</td>
<td>too fast to measure</td>
</tr>
</tbody>
</table>

*Effect of Leaving Group:*

F is 312 times faster than Cl

Now, using nucleophilic aromatic substitution in one of the steps, synthesize the following compound starting from benzene:

```
[ benzene ]   ?   [ Cl
              NO2 ]
```

7. Provide a synthesis of benphetamine starting from benzene and any other necessary reagents, and using NH₃ as your only source of nitrogen.

```
[ Benzphetamine (Didrex) ]
(antiobesity drug)
```

8. Provide a synthesis of ecstasy starting from phenol:

```
[ phenol ]   ?   [ N
            O ]
```

```
```

```
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9. The process shown below is an example of a Mannich reaction. Nature uses this reaction to synthesize alkaloids (natural products that contain a basic nitrogen). Provide a mechanism for this reaction.

\[
\text{Ph Me} + \text{Ph H} + \text{Me}_2\text{NH} \xrightarrow{\text{H}_3\text{O}^+ \ (\text{cat.})} \text{O NMe}_2
\]

10. Propose a mechanism for the following reaction:

\[
\text{O} \xrightarrow{\text{NaOH} \ \Delta} \text{O}
\]