1. Determine the R or S configuration of each of the chiral centers in the molecule shown below. Clearly number the priority of each group. (8 points, 6 minutes)

2. Give the IUPAC name of the following molecule. (8 points, 6 minutes)

3. Label all the acids and bases in the following reaction. (8 points, 6 minutes)

Does the reaction go to the right or to the left?

4. What is the relationship between these two molecules (identical, enantiomers, diastereomers, unrelated)? You are not required to determine R and S. (8 points, 6 minutes)
5a. Draw both chair conformations of the following molecule. (15 points, 12 minutes)

5b. Using the data below, calculate the energy difference between the two chair conformers. **Show your work.**

**Benefit of Equatorial over Axial in kJ/mol**

<table>
<thead>
<tr>
<th>Group</th>
<th>$-\Delta G^\circ$ (kJ/mol)</th>
<th>Group</th>
<th>$-\Delta G^\circ$ (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C≡N</td>
<td>0.8</td>
<td>NH$_2$</td>
<td>5.9</td>
</tr>
<tr>
<td>F</td>
<td>1.0</td>
<td>COOH</td>
<td>5.9</td>
</tr>
<tr>
<td>C≡CH</td>
<td>1.7</td>
<td>CH=CH$_2$</td>
<td>7.1</td>
</tr>
<tr>
<td>I</td>
<td>1.9</td>
<td>CH$_3$</td>
<td>7.28</td>
</tr>
<tr>
<td>Cl</td>
<td>2.2</td>
<td>CH$_2$CH$_3$</td>
<td>7.3</td>
</tr>
<tr>
<td>Br</td>
<td>2.4</td>
<td>CH(CH$_3$)$_2$</td>
<td>9.0</td>
</tr>
<tr>
<td>OH</td>
<td>3.9</td>
<td>C(CH$_3$)$_2$</td>
<td>21.0</td>
</tr>
</tbody>
</table>

$7.3 - 4.9 = 2.4$

5c. Circle the lower energy chair conformer.
6. Draw one reasonable resonance structure for the following molecule. The resonance structure you draw should be a major contributor, a stable resonance structure. (6 points, 4 minutes)

arrows are not required

7. Give a step by step mechanism for each of the following reaction. (12 points, 9 minutes)
8. Give the product or products of each of the following reactions. Be sure to include stereochemistry and to show all products that form. (7 pts each, 5 min each)

a. \[
\begin{align*}
\text{1. BH}_3 \\
\text{2. H}_2\text{O}_2, \text{OH}^- \\
\end{align*}
\]

b. \[
\begin{align*}
\text{Cl}_2/\text{H}_2\text{O} \\
\end{align*}
\]

c. \[
\begin{align*}
\text{1. Hg(OAc)}_2/\text{H}_2\text{O} \\
\text{2. NaBH}_4 \\
\end{align*}
\]

d. \[
\begin{align*}
\text{1. O}_3 \\
\text{2. Me}_2\text{S} \\
\end{align*}
\]

e. \[
\begin{align*}
\text{H}_2/\text{Pd} \\
\end{align*}
\]