NAME:

There are six questions on this test. You are allowed to use molecular models but nothing else. A periodic table is provided at the end on the exam.

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
<th>Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>250</td>
</tr>
</tbody>
</table>
1. Rank the following compounds in the trend requested. (15 points each)

a. Rank by nucleophilicity. The strongest nucleophile is 1, while the weakest is 5.

<table>
<thead>
<tr>
<th>CH₃ONa</th>
<th>(CH₃)₂COH</th>
<th>CH₃NHNa</th>
<th>CH₃PHNa</th>
<th>(CH₃)₃COna</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

b. Rank by S₅1 reactivity. The compound which would undergo an S₅1 reaction the fastest is 1, while the compound which would react the slowest is 5.

<table>
<thead>
<tr>
<th>BrCH₂Br</th>
<th>BrCH₂Br</th>
<th>C₆H₅C₁Cl</th>
<th>BrCH₂Br</th>
<th>ClC₆H₅</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Rank by reactivity for a bromination reaction. The compound which would react the fastest in a bromination reaction is 1, while the compound which would react the slowest is 5.

<table>
<thead>
<tr>
<th>C₆H₅CH₃</th>
<th>C₆H₅CH₃</th>
<th>C₆H₅CH₃</th>
<th>C₆H₅CH₃</th>
<th>C₆H₅CH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Indicate the preferred product(s) for the following reactions.

a. (6)

\[
\text{[Chemical structure]} \xrightarrow{\text{Br}_2} \text{[Chemical structure]}
\]

b. (6)

\[
\text{[Chemical structure]} \xrightarrow{\text{Br}_2} \text{[Chemical structure]}
\]

c. (6)

\[
\text{[Chemical structure]} \xrightarrow{\text{Br}_2} \text{[Chemical structure]}
\]

d. (8)

\[
\text{[Chemical structure]} \xrightarrow{\text{Cl}_2} \text{[Chemical structure]}
\]

e. (4) Of the reactions listed above (a-d), which will react the fastest?
3. For the following reactions indicate the preferred product. Only write ONE product for each question - multiple answers will not be considered. (8 points each)

a. \[
\begin{array}{c}
\text{O} \quad \text{CH}_2\text{SNa} \\
\text{CH}_3\text{CH}_2\text{Br}
\end{array}
\]

b. \[
\begin{array}{c}
\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{C} \\
\text{H}_3\text{CBr} \\
\text{H}_3\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{CH}_3\text{SNa} \\
\text{CH}_3\text{CH}_2\text{Br}
\end{array}
\]

c. \[
\begin{array}{c}
\text{CH}_3\text{CH}_2\text{Br}
\end{array}
\]

d. \[
\begin{array}{c}
\text{CH}_3 \\
\text{H} \\
\text{H} \\
\text{CH}_3 \\
\text{H} \\
\text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{Nal} \\
\text{CH}_3\text{O}\text{Na}
\end{array}
\]

e. \[
\begin{array}{c}
\text{Br}
\end{array}
\]

\[
\begin{array}{c}
\text{CH}_3\text{O}\text{Na}
\end{array}
\]
f. \[ \text{Br} \quad \xrightarrow{\text{AgNO}_3, \text{CH}_3\text{OH}} \]

g. \[ \text{Cl} \quad \xrightarrow{\text{NaN}_3} \]

h. \[ \text{H} \quad \xrightarrow{\text{CH}_3\text{Br}} \quad \text{NH}_2 \]

i. \[ \text{Cl} \quad \xrightarrow{(\text{CH}_3)_2\text{CONa}} \quad \text{CH}_3 \]

j. \[ \text{I} \quad \xrightarrow{\text{H}_2\text{O}, []} \]
4. Indicate how the following compounds can be prepared from the starting materials indicated. More than one step may be required. Write a reaction sequence to indicate the procedure. (For example, in question 3 you were given the starting materials and reagents and were asked to indicate the product. In this question you are given the starting material and product and asked to indicate the reagents.)

a. (15) Prepare cyclopentylcyanide (product) from cyclopentane (starting material).

b. (15) Prepare (S)-2-iodobutane from (R)-2-butanol (this compound has a hydroxy group at the 2-position).
5. The ratio of elimination to substitution is exactly the same for 2-bromo-2-methylbutane and 2-iodo-2-methylbutane in 80% ethanol/20% water at 25°C. The products are also the same for these reactions.

a.(8) What are the two substitution products obtained from these reactions?

b.(8) What are the two elimination products obtained from these reactions?

c.(9) Why is the ratio of elimination to substitution the same for the two substrates?
6. Consider the energy diagram shown. The energy values for the structures A-E are indicated in the diagram.

![Energy Diagram]

a.(6) What is the Ea for this reaction (in Kcal/mol)?

b.(8) Of the five structures shown (A-E) which are important to predict the rate?

c.(6) Does this diagram correspond to an $S_N^1$ or $S_N^2$ reaction?
d.(8) If this reaction corresponds to a substitution from 2-bromobutane to 2-ethoxybutane in ethanol, what is the structure for C?

![Reaction diagram]

What would happen to the rate of the reaction in part d if the concentration of ethanol was doubled?

f.(6) What would happen to the rate of the reaction in part d if the solvent polarity is decreased?