Please read through each question carefully and answer in the spaces provided.

A good strategy is to go through the test and answer all the questions you can do easily. Then go back and tackle the more difficult problems.

Please make sure your structures are drawn clearly and indicate any necessary stereochemistry with bold or dashed bonds.

Finally, think about what you know. Reason and common sense can often help you out. You may use the back of the pages for scratch paper.

Problem 1  12 pts
Problem 2  18 pts
Problem 3  10 pts
Problem 4  10 pts
Problem 5  6 pts
Problem 6  9 pts
Problem 7  6 pts
Problem 8  20 pts
Problem 9  9 pts
TOTAL  100 pts
1. For each pair of molecules below, circle the one that is most stable (lower energy). (12 pts)

   a) ![Molecule A](image1) or ![Molecule B](image2)

   b) ![Molecule C](image3) or ![Molecule D](image4)

2. Draw the structure or provide a name for the following. (18 pts)

   a) ![Structure A](image5) \[ \text{Z-3-ethyl-2,2,4-trimethyl-3-octene} \]

   b) 3-chlorocyclohexene

   c) \[ \text{E-2-chloro-3-ethyl-3-heptene} \]

   d) ![Structure B](image6) \[ \text{3-isopropyl-1-methylcyclobutene or 3-(1-methylethyl)-1-methylcyclobutene} \]

   e) \[ \text{cis,trans-2,4-hexadiene} \]
3. Classify each of the following reactions as either an addition, elimination, substitution or rearrangement (check the appropriate box). (10 pts)

<table>
<thead>
<tr>
<th></th>
<th>Reaction</th>
<th>Addition</th>
<th>Elimination</th>
<th>Substitution</th>
<th>Rearrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>[Diagram of reaction]</td>
<td>□</td>
<td>□</td>
<td>[X]</td>
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<tr>
<td>b)</td>
<td>[Diagram of reaction]</td>
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<tr>
<td>c)</td>
<td>[Diagram of reaction]</td>
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<td>[X]</td>
</tr>
</tbody>
</table>

4. A reaction coordinate diagram for a two-step reaction is shown below. Please read the instructions carefully and indicate on the graph the following: Draw an arrow showing the activation energy for the rate determining step and label it; Draw an arrow showing the change in Gibbs Free Energy and label it; Place a circle around all transition states; Place a box around any intermediates. (10 pts)
5. Answer the following questions about the reaction coordinate diagram shown in Problem 4. (6 pts)

a) Is the first step Endothermic or Exothermic? ___________ Endothermic ___________

b) Is the second step Endothermic or Exothermic? ___________ Exothermic ___________

c) Is the overall reaction Endothermic or Exothermic? ___________ Exothermic ___________

6. Provide the reagents necessary to carry out the following reactions. (9 pts)

\[
\begin{align*}
\text{a)} & & \begin{array}{c}
\text{Hg(OAc)}_2 \\
\text{H}_2\text{O}
\end{array} & & \rightarrow & & \begin{array}{c}
\text{OH} \\
\bigcup
\end{array} \\
\text{b)} & & \text{NaBH}_4 & & & & & & & & \text{H}_2\text{O} \\
\end{align*}
\]

\[
\begin{align*}
\text{b)} & & \begin{array}{c}
\text{BH}_3 \\
\bigcup
\end{array} & & \rightarrow & & \begin{array}{c}
\text{OH} \\
\bigcup
\end{array} \\
\text{b)} & & \begin{array}{c}
\text{H}_2\text{O}_2 \\
\text{NaOH}
\end{array} & & & & & & & & \text{H}_2\text{O} \\
\end{align*}
\]

\[
\begin{align*}
\text{c)} & & \begin{array}{c}
\text{Br}_2 \text{ or NBS} \\
\text{H}_2\text{O}
\end{array} & & \rightarrow & & \begin{array}{c}
\text{OH} \\
\bigcup
\end{array} \\
\bigcup
\end{align*}
\]

7. Draw the products for the following two step sequence. (6 pts)

\[
\begin{align*}
\text{Cl}_2 \text{ light} & & \rightarrow & & \begin{array}{c}
\text{Cl} \\
\bigcup
\end{array} \\
\text{KOH} & & \rightarrow & & \bigcup
\end{align*}
\]
8. Provide the major organic products for the following reactions of methylcyclohexene. (20 pts)

- H₂ / Pd/C
- HCl
- Cl₂
- CHCl₃ / KOH
- KMnO₄
- a) OsO₄
- b) NaHSO₃
- Carboxylic acid
- Hydroxylic acid
9. For each polymerization reaction shown below, the monomer unit is provided on the left. The polymer repeating units on the right are only partially completed. Complete the polymer structure by adding any substituents that are on the polymer. (9 pts)

a) \( \text{F}_2\text{C} = \text{CF}_2 \) polymerize

b) \( \text{CH}_2=\text{C} = \text{C} = \text{C} \) polymerize

c) \( \text{CH}_2=\text{CH} \) polymerize