1. (32 points) Circle the letter on the right which corresponds to the answer to each question. There is only one correct answer for each question.

(i) Which of the following reactions of alkenes is stereospecific?
A. Markovnikov addition of HBr
B. acid-catalyzed hydration (treatment with aqueous H₂SO₄)
C. hydrogenation (treatment with H₂/Pt)
D. anti-Markovnikov addition of HBr to alkenes (treatment with HBr, peroxides)

(ii) What is the mechanism by which the major product is formed upon treatment of 1-bromoethane and sodium tert-butoxide?
E. S₅₁  F. S₅₂  G. E₁  H. E₂

(iii) What is the mechanism by which the major product is formed upon treatment of 1-bromoethane and sodium methoxide?
I. S₅₁  J. S₅₂  K. E₁  L. E₂

(iv) What is the mechanism by which the major product is formed upon treatment of 2-bromopropane and sodium iodide?
M. S₅₁  N. S₅₂  O. E₁  P. E₂

(v) What type of reactive intermediate is formed in the reaction of an alkene with HBr and peroxides to give a bromoalkane?
Q. Carbocation  R. Cyclic bromonium ion  S. Carbanion  T. Radical

(vi) Which of the following alkenes undergoes the least exothermic hydrogenation upon treatment with H₂/Pd?

U. 1  V. 2  W. 3  X. 4

U. 1  V. 2  W. 3  X. 4

(vii) Rank the following alkenes in order of decreasing exothermicity for their combustion (more exothermic > less exothermic)

Y. 1 > 2 > 3  Z. 3 > 1 > 2  AA. 3 > 2 > 1  BB. 2 > 1 > 3

(viii) Which monomer is used to prepare the following polymer?

CC. ethene  DD. propene  EE. 1-butene  FF. styrene
2. (32 points) Provide the structures (first five reactions) and reagents (last three reactions) to complete the following reaction schemes. Indicate the stereochemistry of the products wherever appropriate.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Structure/Reagents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lindlar cat.</td>
</tr>
<tr>
<td>2.</td>
<td>Ag₂O, H₂O</td>
</tr>
<tr>
<td>3.</td>
<td>Heat</td>
</tr>
<tr>
<td>4.</td>
<td>H₂SO₄</td>
</tr>
<tr>
<td>5.</td>
<td>Br₂</td>
</tr>
<tr>
<td>6.</td>
<td>H₂O, H₂SO₄, HgSO₄</td>
</tr>
<tr>
<td>7.</td>
<td>1. (CH₃)₃N</td>
</tr>
<tr>
<td>8.</td>
<td>2. Ag₂O, H₂O</td>
</tr>
<tr>
<td>9.</td>
<td>3. Heat</td>
</tr>
</tbody>
</table>

**Diagram:**

- [Chemical structures and reaction arrows]
3. (20 points) The following transformations cannot be performed in a single step. Provide sequences of
reactions, showing reagents and isolated synthetic intermediates, to achieve each transformation.

**PROBLEM SOLVING HINTS:** Each of these transformations requires 2-3 steps. Approach this type of
problem by asking yourself what the final product can, in fact, be made from. Can this compound be
prepared from the given starting material?

\[
\text{Br} \xrightarrow{\text{reaction}} \text{O} \xrightarrow{\text{Ph}}
\]

\[
\text{HO} \xrightarrow{\text{Br}}
\]

4. (12 points)
(a) Reaction of *cis*-2-butene with Br₂ provides *racemic* 2,3-dibromobutane. However, reaction with OsO₄
followed by NaHSO₃ gives *meso*-2,3-butanediol. Briefly explain the origin of the different
stereochemical outcomes of these reactions.

(b) Treatment of alkene A with H₂SO₄ gives alkene B. (i) Provide the structure of the initially-formed
carbocation, (ii) show the movement of electrons which takes place when this carbocation rearranges,
and (iii) show the structure of the rearranged carbocation.

\[
\text{A} \xrightarrow{\text{H₂SO₄}} \text{B}
\]