1. **Nomenclature** (*) 10 pts (5 each).
   1a. Write the IUPAC name or draw the formula for the following compound (R and S designation not necessary):

   \[ \text{4-methyl-3-cyclohexenol} \]

   ![Chemical Structure Image]

   1b. Draw the following molecule in line-angle notation:

   (E)-3-ethyl-5methylhepta-1,4-diene

   ![Chemical Structure Image]

2. **Conformational analysis** 1 (**) 8 pts. Of the four possible molecules, which would have the energy diagram shown? Show the Newman projection of the molecule you have chosen at its highest (180°) and lowest (0° and 360°) energy levels.

   ![Energy Diagram and Newman Projections]

   a) ![Newman Projection Image]

   b) ![Newman Projection Image]

   c) ![Newman Projection Image]

   d) ![Newman Projection Image]
3. Stereochemistry (** 15 pts (3 points each):

a) Which of the structures below represent (2R, 3R) butane-2,3-diol? Answer by letter.

b) Which represent enantiomers of (2R, 3R) butane-2,3-diol?

c) Which represent diastereomers of (2R, 3R) butane-2,3-diol?

d) Is any of the structures a meso compound?

e) Explain which structures will have the same boiling points

- **A**
- **B**
- **C**
- **D**

**e)** Racemic pair A, B (same boiling point)

* C and D are the same meso compound and ≠ boiling point from A-B
4. Reactions of alkynes (**) 8 pts. Provide the missing reagents and intermediate product.

Et==Me \xrightarrow{Na, NH_3} Et==Me \xrightarrow{\Delta, \text{OsO}_4} \text{EtW==Me} \xrightarrow{\text{NaHSO}_3, \text{H}_2\text{O}_2} \text{Dia} \\
\text{stereochemistry alkene must be trans}

5. Conformational analysis 2 (*) 10 pts. Draw in the substituents on the two chair conformers of each molecule (A and B) to predict which molecule is lower in energy. Explain why.

A

B

\begin{align*}
\text{Lower energy} & \quad 3 \text{CH}_3 \text{ eq} \\
\text{A fewer 3, 3 diaxial interactions in its lowest energy. B 7.78 kJ/mol less stable} \\
\end{align*}
6. Acid/Base (***) 10 pts (3.3 each). a) Provide structures in the boxes to complete the following acid-base (proton-transfer) reactions. b) For each set of reactants, draw in all lone pairs of electrons and show the electron movement by using curved arrows. c) Indicate whether the reactants or products will be favored at equilibrium by circling the appropriate set of equilibrium arrows.

7. Physical properties of alkanes/alkenes (*) 7 pts (3.5 each).

7a. Which of the following undergoes the most exothermic combustion?. Circle your answer.

a. octane; b) 2-methylheptane; c) 2,2-dimethylhexane; d) 2,2,3,3-tetramethylbutane

less stable $\rightarrow$ larger heat of combustion

7b. Rank the following alkenes according to energy (1 = lowest energy)

1

More substituted

4

Less substituted

3

2
8. Reactions of alkenes (** or ***).

8a. (10 pts) Complete template or templates (as needed).

1. OsO₄
2. NaHSO₃, H₂O

1. cis-hex-3-ene →
   syn addition of OsO₄

1. Et
2. H
3. (5) OH
4. H
5. (R) OH
6. Et
7. H
8. Et

Partial credit
- No stereochemistry 5 pts
- Both templates filled correctly not indicating Meso 8 pts

8b. (10 pts, 5 each) Provide products of each reaction. Include all stereoisomers. Indicate if the product is: achiral (by the letter A), chiral (C), a meso compound (M). Indicate if an enantiomeric pair is formed.

i)

<table>
<thead>
<tr>
<th>i)</th>
<th>BH₃, THF</th>
<th>ii) H₂O₂, NaOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syn addition</td>
<td>(both on same face one ax, one eq.)</td>
<td></td>
</tr>
<tr>
<td>Bulky tBu and Me prefer eq. positions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C (chiral) major
(+)

ii)

| i) Hg(OAc)₂, H₂O |
| ii) NaBH₄ |

C (chiral)
Racemic pair

2.5 pts for correct product (no stereochemistry)
9. Reaction mechanism (electrophilic addition) (**). 10 pts. Write the mechanism and products for the following reaction. Use clear, carefully drawn structures and precise curved arrow notation for all steps. Provide distinct structures for all intermediates. Show all lone pairs and resonance structures.

HBr

10. Hybridization (**): 5 pts. What is the hybridization of carbon atoms labeled i-iii in the following structure? b) Draw a three-dimensional representation of the molecule.

H₂C≡C≡CH₂

a. i = sp; ii = sp; iii = sp
b. i = sp²; ii = sp; iii = sp²

10 a)

a) 2.5 points
b) 2.5 points