Part I. Multiple choice.

1. What is the degree of unsaturation in \( \text{C}_{12}\text{H}_{16}\text{N}_{2}\text{O}_{2} \)?
   a) 3
   b) 4
   c) 5
   d) 6
   e) 7

2. What is the correct IUPAC name of the following compound?
   \( \text{CH}_3\text{C}=-\text{CH}_2\text{CH}_2\text{-CH}_3 \)
   a) 3-methylene hexane
   b) 2-ethyl-2-propylethene
   c) 2-ethyl-1-pentene
   d) 2-ethyl-2-propylethylene
   e) 3-ethenehexane

3. What is the correct IUPAC name of the compound below?
   \( \text{Cl} \)
   a) \( \text{trans} \)-2-chloro-2-butene
   b) \( \text{Z} \)-2-chloro-2-butene
   c) \( \text{E} \)-2-chloro-2-butene
   d) \( \text{Z} \)-1-chloro-2-methyl-2-butene
   e) \( \text{E} \)-1-chloro-2-methyl-2-butene

4. What is the correct IUPAC name of the compound below?
   \( \text{H}_3\text{C}-\text{C}=-\text{C}-\text{CH}_3\text{CH}_2\text{C}=\text{CH}_2\text{-CH}_3\text{C}=-\text{CH}_2\text{H}_3\)
   a) \( \text{Z} \)-3-(1,1-dimethylethyl)-2,4-dimethyl-1,3-hexadiene
   b) \( \text{E} \)-3-(1,1-dimethylethyl)-2,4-dimethyl-1,3-hexadiene
   c) \( \text{E} \)-2,3,3,4-pentamethyl-1,3-hexadiene
   d) \( \text{Z} \)-2,4-dimethyl-3-(1,1-dimethylethyl)-1,3-hexadiene
   e) \( \text{E} \)-2,4-dimethyl-3-(1,1-dimethylethyl)-1,3-hexadiene

5. Which alkyl group below is commonly called an allyl group?
   a) \( \text{H}_2\text{C}=-\text{CH}-\text{CH}_2- \)
   b) \( \text{H}_2\text{C}-\text{=CH}- \)
   c) \( \text{H}_2\text{C}=-\text{CH}- \)
   d) \( \text{CH}_2\text{C}=-\text{CH}=\text{CH}-\text{CH}_2- \)
   e) \( \text{H}_2\text{C}=-\text{CH}-\text{CH}_2\text{-CH}_2- \)

6. Rank the following sets of substituents in order of priority according to the Cahn-Ingold-Prelog sequence rules. Place the highest priority substituent first and the lowest priority substituent last.
   \( \text{I} \text{CH}(-\text{CH}_3)_2 \text{II} \text{CH}_2\text{CH}_2\text{CH}_3 \text{III} \text{CH}_2\text{CHO} \text{IV} \text{CH}_2\text{CH}_2\text{OH} \)
   a) IV > III > I > II
   b) III > IV > II > I
   c) I > II > IV > III
   d) I > III > IV > II
   e) IV > III > II > I

7. Compound A has the formula \( \text{C}_{10}\text{H}_{14} \). On catalytic hydrogenation over palladium, it reacts with 2 molar equivalents of \( \text{H}_2 \). How many rings does compound A have?
   a) 0
   b) 1
   c) 2
   d) 3
   e) not enough information to determine

8. Which of the following alcohols could be selectively prepared by hydroboration/oxidation of an alkene?
   \( \text{I} \text{CH}_3\text{OH} \text{II} \text{CH}_3\text{CH}_2\text{OH} \text{III} \text{CH}_3\text{OH} \text{IV} \text{CH}_3\text{CH}_2\text{OH} \)
   a) II only
   b) III and IV
   c) II and IV
   d) II, III, and IV
   e) I and II
9. Starting with 1-bromo-2-methylbutane, which of the reaction sequences below would yield 2-chloro-2-methylbutane?

a) BH₃ in THF; then H₂O₂, OH⁻; then Cl₂ in CH₂Cl₂
b) Cl₂ in CH₂Cl₂
 c) CHCl₃ in KOH; then KMnO₄
d) Hg(OAc)₂ in H₂O/THF; then NaBH₄; then HCl in ether
e) KOH in ethanol; then HCl in ether

10. Rank the carbocations below in order of decreasing stability. (That is, list the most stable carbocation first, and the least stable carbocation last.)

\[
\begin{align*}
I & \quad \text{CH₃CHCH₂CH₃} \\
II & \quad (\text{CH₃})₂\text{C⁺} \\
III & \quad \text{CH₃CH₂CH₂CH₂⁺}
\end{align*}
\]

\[
\begin{align*}
a) & \quad \text{II} > \text{I} > \text{III} \\
b) & \quad \text{II} > \text{III} > \text{I} \\
c) & \quad \text{III} > \text{I} > \text{II} \\
d) & \quad \text{III} > \text{II} > \text{I} \\
e) & \quad \text{I} > \text{III} > \text{II}
\end{align*}
\]

11. Which compound below is expected to have the largest (i.e., most negative) heat of hydrogenation?

a) 4-methyl-1-pentene
b) 2-methyl-1-pentene
c) 2-methyl-2-pentene
d) (E)-4-methyl-2-pentene
e) (Z)-4-methyl-2-pentene

Answers to Multiple Choice Questions

1. D  6. D  11. A
2. C  7. C
5. A  10. A

Part II. Reactions. Complete the reactions below by drawing any missing reactants, products, and/or reagents. Clearly indicate the regiochemistry and stereochemistry when appropriate.

1. \[
\begin{align*}
\text{CH₃} & \quad 1. \text{BH₃}, \text{THF} \\
\text{H₂O₂}, \text{OH⁻} & \quad 2. 
\end{align*}
\]

2. \[
\begin{align*}
\text{CH₃} & \quad \text{D₂} \\
Pd/C & \quad 
\end{align*}
\]

3. \[
\begin{align*}
\text{CH₂Br} & \quad \text{KOH} \\
\text{CH₃CH₂OH} & \quad A \quad \text{K₃MnO₄} \\
\text{H₃O⁺} & \quad B + C 
\end{align*}
\]

4. \[
\begin{align*}
\text{CH₃} & \quad 1. \text{O₃} \\
\quad & \quad 2. \text{Zn/H₂O⁺} 
\end{align*}
\]

5. \[
\begin{align*}
\text{CH₃CH₂CH=CH₂} & \quad \text{CH₃I₂} \\
\text{Zn(Cu), ether} & \quad 
\end{align*}
\]
6. What starting alkene would you use (A) and what reagents would be used (B) to synthesize the alcohol below, using oxymercuration?

```
<table>
<thead>
<tr>
<th>OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₂CH₃</td>
</tr>
</tbody>
</table>
```

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7. \[
\text{CH}_2\text{CH}_3
\] \[
\text{Br}_2 \\
\text{H}_2\text{O}
\]
```

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8. \[
\text{CHCl}_3 \\
\text{KOH}
\]
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\[\text{OH} \quad \text{O} \quad \text{O} \]

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9. \[
\text{OH} \quad \text{OH}
\]
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\text{O} \\
\text{O}
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**Part III. Mechanisms.**

1. Draw the structure of the transition state that is formed when 1-methylcyclopentene reacts with BH₃ in THF solution. (Only draw the transition state; do not draw the complete mechanism.)

2. Draw the structure of intermediate that is formed when cyclopentene reacts with OsO₄ in pyridine. (Draw only the intermediate; do not draw the complete mechanism.)

3. Draw the complete mechanism for the reaction of cyclopentene with Br₂ in CH₂Cl₂. Use the curved arrow formalism to indicate every bond broken and every bond formed.

4. When 3,3-dimethylcyclohexene reacts with HCl in ether, one product is 1-chloro-1,2-dimethylcyclohexane. Show the complete mechanism for the formation of this product using the curved arrow formalism.

5. Write the complete mechanism for the monobromination of propane.