Chapter 10 Review Problems

INSTRUCTIONS:

You do not need to write the question, ONLY WRITE THE PROBLEM NUMBER and ANSWERS/SOLUTIONS.

- For problems that involve calculations, you must show your work to get full credit.
- For multiple choice questions, you can simply write the letter (a, b, c, or d) of the correct response.
- Use the navigation buttons at the bottom of the pages to get hints, check your answers, move to the next problem, or go back to previous pages.

Chapter Review Problems are due at the end of class period on the dates shown in the CHEM 108 Schedule.

- Late submissions will not be accepted unless the student can prove to the instructor that something outside of their control prevented them from turning in the problem set on the due date (see the course syllabus for more details).

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10.1)

i) **Alcohols** contain one or more ______________ functional groups attached to a hydrocarbon (alkyl group) part.

   a) carboxyl
   b) amino
   c) carbonyl
   d) hydroxyl

ii) Alcohols are classified as primary \( (1^o) \), secondary \( (2^o) \), or tertiary \( (3^o) \) based on the number of ______________ attached to the carbon that is carrying (bonded to) the hydroxyl group.

   a) R groups
   b) OH groups
   c) methyl groups
   d) lone pairs

iii) Molecules with more than one hydroxyl group are called ________________ **alcohols** .

   a) strong
   b) polyhydroxy
   c) adult beverage
   d) fermentation
10.1)

i) *Alcohols* contain one or more ______________ functional groups attached to a hydrocarbon (alkyl group) part.

**HINT:**
- a) carboxyl
- b) amino
- c) carbonyl
- d) hydroxyl

The general form of an alcohol is: \( R-\overset{\text{o}}{\text{O}}-\text{H} \)

ii) Alcohols are classified as primary \( (1^o) \), secondary \( (2^o) \), or tertiary \( (3^o) \) based on the number of ____________ attached to the carbon that is carrying (bonded to) the hydroxyl group.

**HINT:**
- a) R groups
- b) OH groups
- c) methyl groups
- d) lone pairs

iii) Molecules with more than one hydroxyl group are called ________________ alcohols.

**HINT:**
- a) strong
- b) polyhydroxy
- c) adult beverage
- d) fermentation

*For more help: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.*
i) **Alcohols** contain one or more ______________ functional groups attached to a hydrocarbon (alkyl group) part.
   a) carboxyl
   b) amino
   c) carbonyl
   d) hydroxyl  
   The general form of an alcohol is: \[ \text{R} - \text{O} - \text{H} \]

ii) Alcohols are classified as primary (1\(^{\circ}\)), secondary (2\(^{\circ}\)), or tertiary (3\(^{\circ}\)) based on the number of ______________ attached to the carbon that is carrying (bonded to) the hydroxyl group.
   a) R groups
   b) OH groups
   c) methyl groups
   d) lone pairs

iii) Molecules with more than one hydroxyl group are called ________________ alcohols.
   a) strong
   b) polyhydroxy
   c) adult beverage
   d) fermentation

   An example of a polyhydroxy alcohol is **glycerol** (also known as glycerin). Glycerol is an important biomolecule because it is one of the precursors to triglycerides (fats and vegetable oils) and some of the compounds found in cell membranes.
   - The condensed structure of glycerol is shown on the right.

   \[ \text{OH} \quad \text{OH} \quad \text{OH} \]
   \[ \text{CH}_2 \quad \text{CH} \quad \text{CH}_2 \]

   **glycerol (a polyhydroxy alcohol)**

   For more details: See [chapter 10 part 1 video](#) or chapter 10 section 2 in the textbook.
10.2) Identify each of the alcohols shown below as either primary (1°), secondary (2°), or tertiary (3°).

a) \[
\begin{array}{c}
\text{CH}_3 \text{CHCH}_2 \text{CH}_3 \\
\text{OH}
\end{array}
\]

b) \[
\begin{array}{c}
\text{CH}_3 \text{CH}_2 \text{CH}_2 \text{OH}
\end{array}
\]

c) \[
\begin{array}{c}
\text{CH}_3 \text{CHCHCH}_2 \text{CHCH}_3 \\
\text{OH} \quad \text{CH}_3
\end{array}
\]

d) \[
\begin{array}{c}
\text{CH}_3 \text{CHCH}_2 \text{CHCH}_3 \\
\text{CH}_3 \quad \text{OH}
\end{array}
\]

e) \[
\begin{array}{c}
\text{CH}_3 \text{CCH}_2 \text{CH}_2 \text{CH}_3 \\
\text{OH} \quad \text{CH}_3
\end{array}
\]

f) \[
\begin{array}{c}
\text{CH}_3 \quad \text{OH}
\end{array}
\]
10.2) Identify each of the alcohols shown below as either primary (1°), secondary (2°), or tertiary (3°).

HINT:
- In primary (1°) alcohols, the carbon that is “carrying” the hydroxyl group is bonded to one R group.
- In secondary (2°) alcohols, the carbon “carrying” the hydroxyl group is bonded to two R groups.
- In tertiary (3°) alcohols, the carbon “carrying” the hydroxyl group is bonded to three R groups.

For more help: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.2) Identify each of the alcohols shown below as either primary (1\textsuperscript{o}), secondary (2\textsuperscript{o}), or tertiary (3\textsuperscript{o}).

For more details: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.3) Write the systematic name for each of alcohol molecules below.

a) \[\text{CH}_3\text{CHCH}_3\text{OH}\] \\

b) \[\text{CH}_3\text{CHCHCH}_2\text{CHCH}_3\text{OH}\] \\

c) \[\text{CH}_3\text{CHCH}_2\text{CHCH}_3\text{OH}\] \\

d) \[\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}\] \\

e) \[\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3\text{OH}\] \\

f) [diagram of a branched alcohol]
10.3) Write the **systematic name** for each of alcohol molecules below.

a) \[
\text{CH}_3\text{CHCH}_3 \quad \text{OH}
\]

b) \[
\text{CH}_3\text{CHCHCH}_2\text{CHCH}_3 \quad \text{OH} \quad \text{CH}_3
\]

c) \[
\text{CH}_3\text{CHCH}_2\text{CHCH}_3 \quad \text{OH}
\]

d) \[
\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}
\]

e) \[
\text{CH}_3\text{CCH}_2\text{CHCH}_3 \quad \text{OH}
\]

f) \[
\text{CH}_3
\]

For more help: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.

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**HINT: Naming Alcohols**

**Step 1:** Find and name the parent chain.
- **The parent chain is the longest, continuous chain of carbon atoms that contains the point of attachment to the hydroxyl group (OH).**

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “ol.”

Assign **position numbers** to the carbons in the parent chain. Position number 1 is assigned to the carbon at the **end of the parent chain** that is nearest to the hydroxyl group.

- For alcohols with **more than two carbons**, the position of the point of attachment to the hydroxyl group must be indicated by adding a number before the parent chain.

**Steps 2, 3, and 4** are done the **same way** as you did when naming other organic molecules.

**Step 2:** Name any alkyl group substituents.

**Step 3:** Determine the **point of attachments** of alkyl groups to the parent chain.

**Step 4:** Construct the name of the alcohol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

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Go back to previous question | Click here to check your answer | Go to next question
10.3) Write the **systematic name** for each of alcohol molecules below.

### EXPLANATION: Naming Alcohols

**Step 1:** Find and name the parent chain.
- The **parent chain** is the longest, continuous chain of carbon atoms that contains the point of attachment to the hydroxyl group (OH).

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “ol.”

Assign **position numbers** to the carbons in the parent chain. Position number **1** is assigned to the carbon at the end of the parent chain that is nearest to the hydroxyl group.

- For alcohols with **more than two carbons**, the position of the point of attachment to the hydroxyl group must be indicated by adding a number before the parent chain.

**Steps 2, 3, and 4** are done the same way as you did when naming other organic molecules.

**Step 2:** Name any alkyl group substituents.

**Step 3:** Determine the **point of attachments** of alkyl groups to the parent chain.

**Step 4:** Construct the name of the alcohol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

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For more details: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.4) Draw the condensed and skeletal structure for each of the molecules listed below.

   a) 1-pentanol

   b) 3-pentanol

   c) 4-methyl-2-hexanol

   d) 2,2-dimethyl-1-heptanol
10.4) Draw the condensed and skeletal structure for each of the molecules listed below.

a) 1-pentanol  
HINT:  
CH₃CH₂CH₂CH₂CH₂OH  
or  
CH₂CH₂CH₂CH₂CH₂OH

b) 3-pentanol

c) 4-methyl-2-hexanol

For more help: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.4) Draw the condensed and skeletal structure for each of the molecules listed below.

a) 1-pentanol
   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \]
   or
   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \]

b) 3-pentanol
   \[ \text{OH} \]
   \[ \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \]


c) 4-methyl-2-hexanol
   \[ \text{OH} \]
   \[ \text{CH}_3 \]
   \[ \text{CH}_3\text{CHCH}_2\text{CHCH}_2\text{CH}_3 \]

d) 2,2-dimethyl-1-heptanol
   \[ \text{CH}_3 \]
   \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CCH}_2\text{OH} \]
   \[ \text{CH}_3 \]

For more details: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.5) Write the name of each compound shown below.

a) 

b) 

c)
10.5) Write the names of the compounds shown below.

a) [Chemical structure image]

b) [Chemical structure image]

c) [Chemical structure image]

HINT:

When the hydroxyl group of an alcohol is bound to a ring structure it is called a cyclic alcohol.

Cyclic alcohols are named in a manner similar to that for cycloalkanes.

- Starting with the cycloalkane name that corresponds to the number of carbon atoms in the ring structure, cyclic alcohols are named by replacing the “e” at the end of the cycloalkane name with “ol.”
- The ring-carbon that is carrying the OH is always designated as position number 1.

For more help: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.5) Write the names of the compounds shown below.

a) cyclohexanol

b) cyclopentanol

c) 2-methylcyclopentanol

EXPLANATION:
When the hydroxyl group of an alcohol is bound to a ring structure it is called a cyclic alcohol.

Cyclic alcohols are named in a manner similar to that for cycloalkanes.

• Starting with the cycloalkane name that corresponds to the number of carbon atoms in the ring structure, cyclic alcohols are named by replacing the “e” at the end of the cycloalkane name with “ol.”
• The ring-carbon that is carrying the OH is always designated as position number 1.

For more details: See chapter 10 part 1 video or chapter 10 section 2 in the textbook.
10.6) List the following alcohols in order of increasing solubility in water (least soluble to most soluble).

- CH₃CH₂CH₂CH₂CH₂CH₂—OH  hexanol
- CH₃CH₂—OH  ethanol
- CH₃CH₂CH₂CH₂—OH  butanol

least soluble

most soluble
10.6) List the following alcohols in order of increasing solubility in water (least soluble to most soluble).

- \( \text{C}_6\text{H}_{14}\text{OH} \) (hexanol)
- \( \text{C}_2\text{H}_5\text{OH} \) (ethanol)
- \( \text{C}_4\text{H}_{10}\text{OH} \) (butanol)

**HINT:**

Water molecules are attracted to alcohols and many other families of organic molecules through hydrogen bonding and/or dipole-dipole interactions.

- As the hydrocarbon part of various alcohol molecules gets larger, the water solubility **decreases**.
- As the hydrocarbon part of a molecule gets larger, London forces become more important (stronger), the molecule becomes **less** polar, and the organic molecules are more attracted to each other than they are to water molecules. When this occurs, it is lower in energy for the organic molecules to be surrounded by other organic molecules and therefore the water solubility drastically decreases.

**For more help:** See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.6) List the following alcohols in order of increasing solubility in water (least soluble to most soluble).

<table>
<thead>
<tr>
<th>CH₃CH₂CH₂CH₂CH₂CH₂—OH</th>
<th>CH₃CH₂—OH</th>
<th>CH₃CH₂CH₂CH₂—OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>hexanol</td>
<td>ethanol</td>
<td>butanol</td>
</tr>
</tbody>
</table>

**EXPLANATION:**

Water molecules are attracted to alcohols and many other families of organic molecules through hydrogen bonding and/or dipole-dipole interactions.

- As the hydrocarbon part of various alcohol molecules gets larger, the water solubility **decreases**.

- As the hydrocarbon part of a molecule gets larger, London forces become more important (stronger), the molecule becomes **less** polar, and the organic molecules are more attracted to each other than they are to water molecules. When this occurs, it is lower in energy for the organic molecules to be surrounded by other organic molecules and therefore the water solubility drastically decreases.

**For more details:** See [chapter 10 part 2 video](#) or chapter 10 section 2 in the textbook.
10.7) Predict the order of increasing *boiling points* for the following compounds.

- CH$_3$CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$—OH (hexanol)
- CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$CH$_3$CH$_2$—OH (octanol)
- CH$_3$CH$_2$CH$_2$CH$_2$—OH (butanol)

**lowest boiling point**

_________________
_________________
_________________

**highest boiling point**
10.7) Predict the order of increasing **boiling points** for the following compounds.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>hexanol</td>
<td>CH$_3$CH$_2$CH$_2$CH$_2$CH$_2$OH</td>
</tr>
<tr>
<td>octanol</td>
<td>CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$OH</td>
</tr>
<tr>
<td>butanol</td>
<td>CH$_3$CH$_2$CH$_2$CH$_2$OH</td>
</tr>
</tbody>
</table>

**HINT:**
Stronger/more noncovalent interactions = higher boiling and melting points

**For more help:** See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.7) Predict the order of increasing **boiling points** for the following compounds.

- CH$_3$CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$OH \hspace{1cm} \text{hexanol}
- CH$_2$CH$_2$CH$_2$CH$_2$CH$_2$CH$_3$CH$_2$OH \hspace{1cm} \text{octanol}
- CH$_3$CH$_2$CH$_2$CH$_2$OH \hspace{1cm} \text{butanol}

**EXPLANATION:**

Stronger/more noncovalent interactions = higher boiling and melting points
- As the hydrocarbon part of a molecule gets larger, London forces become stronger, so the molecules are more strongly attracted to each other.

**For more details:** See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.8) Ethanol is produced in nature in a process called alcohol ________________.

a) fermentation
b) hydroxylation
c) India pale ale
d) distillation
10.8) Ethanol is produced in nature in a process called alcohol ________________.

**HINT:**
- a) fermentation
- b) hydroxylation
- c) India pale ale
- d) distillation

**For more help:** See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.8) Ethanol is produced in nature in a process called alcohol _________________.

EXPLANATION:
In the 1850s and 1860s, Louis Pasteur discovered that fermentation involved living organisms. It was not until 1897 that Eduard Buchner found that ground fragments of dead yeast could produce ethanol and CO₂. As a result of Buchner’s work, the term “enzyme” was applied to materials that enabled fermentation, and the understanding that fermentation was a result of enzymatic processes gained acceptance. Buchner’s results are often regarded as the birth of biochemistry, and he was awarded the Nobel Prize in chemistry for this work in 1907.

Alcohol fermentation is a series of chemical reactions that convert sugar molecules, such as glucose, into ethanol and CO₂. The final step in this reaction series involves an enzyme which is only present in yeast and some bacteria. The overall reaction of ethanol formation from a sugar molecule (glucose) is shown below:

\[
\text{C}_6\text{H}_{12}\text{O}_6 \quad \rightarrow \quad 2\text{CH}_3\text{CH}_2\text{OH} \quad + \quad 2\text{CO}_2
\]

For more details: See [chapter 10 part 2 video](#) or chapter 10 section 2 in the textbook.

Options:
- a) fermentation
- b) hydroxylation
- c) India pale ale
- d) distillation
10.9) Match each of the following terms with the appropriate **numbered box** in the energy level diagram.

a)  energy of transition state
b)  energy of products
c)  energy of reactants
d)  activation energy ($E_a$)
e)  $\Delta G = G_{products} - G_{reactants}$
10.9) Match each of the following terms with the appropriate numbered box in the energy level diagram.

**HINT:**

- a) energy of transition state **box 3**
- b) energy of products
- c) energy of reactants
- d) activation energy ($E_a$)
- e) $\Delta G = G_{products} - G_{reactants}$

For more help: See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.9) Match each of the following terms with the appropriate numbered box in the energy level diagram.

a) energy of transition state **box 3**

b) energy of products **box 5**

c) energy of reactants **box 1**

d) activation energy \((E_a)\) **box 4**

e) \(\Delta G = G_{products} - G_{reactants} \) **box 2**

For more details: See [chapter 10 part 2 video](#) or chapter 10 section 2 in the textbook.
10.10) In the nucleophilic substitution ($S_N2$) reaction for the formation of an alcohol, a hydroxide ion reacts with an alkyl halide molecule.

- An **alkyl halide** is a hydrocarbon that had one of its hydrogens replaced with a halogen (F, Cl, Br, or I).

The general form for the ($S_N2$) reaction for the formation of an alcohol is shown below.

\[
\text{R} - \text{X} + \text{OH}^- \rightleftharpoons \text{R} - \text{OH} + \text{X}^-
\]

$X$ represents F, Cl, Br, or I

Predict the products of the following nucleophilic substitutions reaction.

\[
\text{CH}_3\text{F} + \text{OH}^- \rightleftharpoons \]

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{OH}^- \rightleftharpoons \]

[Click here to check your answer]  [Click here for a hint]
10.10) In the nucleophilic substitution (S$\text{N}_2$) reaction for the formation of an alcohol, a hydroxide ion reacts with an alkyl halide molecule.

- An alkyl halide is a hydrocarbon that had one of its hydrogens replaced with a halogen (F, Cl, Br, or I).

The general form for the (S$\text{N}_2$) reaction for the formation of an alcohol is shown below.

\[
\begin{align*}
\text{R} - \text{X} & + \text{OH}^- & \rightleftharpoons & \text{R} - \text{OH} & + & \text{X}^- \\
\text{alkyl halide} & & & \text{hydroxide ion} & & \text{alcohol} & & \text{halogen ion}
\end{align*}
\]

\(\text{X}\) represents F, Cl, Br, or I

Predict the products of the following nucleophilic substitutions reaction.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{F} & + \text{OH}^- & \rightleftharpoons & \text{CH}_3\text{OH} & + & ? \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} & + \text{OH}^- & \rightleftharpoons \\
\end{align*}
\]

For more help: See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.10) In the nucleophilic substitution (SN2) reaction for the formation of an alcohol, a hydroxide ion reacts with an alkyl halide molecule.

- An alkyl halide is a hydrocarbon that had one of its hydrogens replaced with a halogen (F, Cl, Br, or I).

The general form for the (SN2) reaction for the formation of an alcohol is shown below.

\[
\text{alkyl halide} + \text{OH}^- \rightleftharpoons \text{alcohol} + \text{halogen ion}
\]

\(X\) represents F, Cl, Br, or I

Predict the products of the following nucleophilic substitutions reaction.

\[
\text{CH}_3\text{F} + \text{OH}^- \rightleftharpoons \text{CH}_3\text{OH} + \text{F}^-
\]

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{OH}^- \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{Br}^-
\]

For more details: See chapter 10 part 2 video or chapter 10 section 2 in the textbook.
10.11) In chapter 6, you learned that an alkene can react with water to produce an alcohol. In this reaction, a hydrogen from \( H_2O \) is added to one of the double-bonded carbon atoms and \( OH \) from the \( H_2O \) is added to the other double-bonded carbon atom in the alkene, to produce the corresponding alcohol. In chapter 6, we always began with symmetric alkenes when doing hydration reactions. In symmetric alkenes, a line drawn perpendicular to, and through, the middle of the double bond of its structural formula results in _______________ parts on each side of the line.

a) hydroxyl  
b) different  
c) identical  
d) carbonyl

When a symmetric alkene undergoes a hydration reaction, there is only one possible product. When an asymmetric alkene undergoes a hydration reaction, there are _______ different alcohol molecules produced.

a) two  
b) three  
c) four

The hydration of an asymmetric alkene produces an __________ amount of each alcohol product.

a) equal  
b) unequal  
c) large  
d) small
10.11) In chapter 6, you learned that an **alkene** can react with **water** to produce an **alcohol**. In this reaction, a hydrogen from \textbf{H}_2\textbf{O} is added to one of the double-bonded carbon atoms and \textbf{OH} from the \textbf{H}_2\textbf{O} is added to the **other** double-bonded carbon atom in the **alkene**, to produce the corresponding **alcohol**. In chapter 6, we always began with **symmetric** alkenes when doing hydration reactions. In symmetric alkenes, a line drawn perpendicular to, and through, the middle of the double bond of its structural formula results in ________________ parts on each side of the line.

**HINT:**

- a) hydroxyl
- b) different
- c) identical
- d) carbonyl

When a **symmetric alkene** undergoes a hydration reaction, there is only **one** possible product. When an **asymmetric alkene** undergoes a hydration reaction, there are ________ different alcohol molecules produced.

**HINT:**

- a) two
- b) three
- c) four

The hydration of an asymmetric alkene produces an __________ amount of each alcohol product.

**HINT:**

- a) equal
- b) unequal
- c) large
- d) small

**For more help:** See [chapter 10 part 3 video](#) or chapter 10 section 2 in the textbook.
In chapter 6, you learned that an alkene can react with water to produce an alcohol. In this reaction, a hydrogen from H₂O is added to one of the double-bonded carbon atoms and OH from the H₂O is added to the other double-bonded carbon atom in the alkene, to produce the corresponding alcohol. In chapter 6, we always began with symmetric alkenes when doing hydration reactions. In symmetric alkenes, a line drawn perpendicular to, and through, the middle of the double bond of its structural formula results in identical parts on each side of the line.

When a symmetric alkene undergoes a hydration reaction, there is only one possible product. When an asymmetric alkene undergoes a hydration reaction, there are four different alcohol molecules produced.

The hydration of an asymmetric alkene produces an unequal amount of each alcohol product. The product made in greater quantity is called the “major product,” and the product made in lesser quantity is called the “minor product.”

For more details: See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.12) The hydration of an asymmetric alkene does not produce an equal amount of each alcohol product. The product made in greater quantity is called the “major product,” and the product made in lesser quantity is called the “minor product.” Using compete sentence(s), explain how Markovinkov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.
10.12) The hydration of an asymmetric alkene does not produce an equal amount of each alcohol product. The product made in greater quantity is called the “major product,” and the product made in lesser quantity is called the “minor product.”

Using complete sentence(s), explain how Markovnikov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

HINT: Fill in the blanks to get the answer

This rule says that, the major product is formed by adding the ________ - from water - to the alkene’s double-bonded carbon that originally carried the most ____________, and adding the ________ - from water - to the other double-bonded carbon.

For more help: See your lecture notes or see chapter 10 part 3 video or chapter 10 section 2 in the textbook.
The hydration of an asymmetric alkene does not produce an equal amount of each alcohol product. The product made in greater quantity is called the “major product,” and the product made in lesser quantity is called the “minor product.”

Using complete sentence(s), explain how Markovinkov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

This rule says that, the major product is formed by adding the H - from water - to the alkene’s double-bonded carbon that originally carried the most hydrogens, and adding the OH to the other double-bonded carbon.

• The minor product is formed by adding the H and OH in a manner opposite to that described for the major product.

An easy way to remember Markovinkov’s Rule is by using the old saying, “the rich get richer,” where the H’s represent money.

An example of the use of Markovinkov’s Rule to predict the major and minor products for the hydration of propene (a asymmetric alkene) is shown below.

For more details: See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.13) Draw (condensed structures) and name the major and minor products for the hydration of 1-pentene.

\[
\begin{align*}
\text{CH}_2 & \quad \text{CHCH}_2\text{CH}_2\text{CH}_3 & + & \text{H}_2\text{O} & \quad \rightleftharpoons \\
\text{1-pentene} & & & & \\
\end{align*}
\]
10.13) Draw (condensed structures) and name the major and minor products for the hydration of 1-pentene.

\[
\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \rightleftharpoons \\
\text{1-pentene}
\]

**HINT:**

Markovnikov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

The major product is formed by adding the H - from water - to the alkene’s double-bonded carbon that originally carried the most hydrogens, and adding the OH to the other double-bonded carbon.

- The minor product is formed by adding the H and OH in a manner opposite to that described for the major product.

An easy way to remember Markovnikov’s Rule is by using the old saying, “the rich get richer,” where the H’s represent money.

**For more help:** See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.13) Draw (condensed structures) and name the major and minor products for the hydration of 1-pentene.

\[
\text{CH}_2\overset{\text{C}}{\text{C}}\text{HCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \\
\text{1-pentene} \rightleftharpoons \text{2-pentanol}
\]

EXPLANATION:

Markovinkov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

The major product is formed by adding the H - from water - to the alkene’s double-bonded carbon that originally carried the most hydrogens, and adding the OH to the other double-bonded carbon.

• The minor product is formed by adding the H and OH in a manner opposite to that described for the major product.

An easy way to remember Markovinkov’s Rule is by using the old saying, “the rich get richer,” where the H’s represent money.

For more details: See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.14) Draw (condensed structures) and name the major and minor products for the hydration of 4-methyl-3-heptene.

\[
\text{CH}_3\text{CH}_2\text{CH} = \text{CCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \quad \rightleftharpoons \quad \text{CH}_3\\text{CHCH} = \text{CCH}_2\text{CH}_2\text{CH}_3
\]

4-methyl-3-heptene
10.14) Draw (condensed structures) and name the major and minor products for the hydration of 4-methyl-3-heptene.

\[
\text{CH}_3\text{CH}_2\text{CH} = \text{CCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \quad \text{↔}
\]

\[
\text{CH}_3
\]

4-methyl-3-heptene

**HINT:**

Markovnikov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

The major product is formed by adding the H - from water - to the alkene’s double-bonded carbon that originally carried the most hydrogens, and adding the OH to the other double-bonded carbon.

• The minor product is formed by adding the H and OH in a manner opposite to that described for the major product.

An easy way to remember Markovnikov’s Rule is by using the old saying, “the rich get richer,” where the H’s represent money.

For more help: See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.14) Draw (condensed structures) and name the major and minor products for the hydration of 4-methyl-3-heptene.

\[
\text{CH}_3\text{CH}_2\text{CH} = \text{CCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{CHCCH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{CH}_2\text{CHCHCH}_2\text{CH}_2\text{CH}_3
\]

EXPLANATION:

Markovnikov’s Rule is used to predict the major and minor products for the hydration of an asymmetric alkene.

The major product is formed by adding the H - from water - to the alkene’s double-bonded carbon that originally carried the most hydrogens, and adding the OH to the other double-bonded carbon.

- The minor product is formed by adding the H and OH in a manner opposite to that described for the major product.

An easy way to remember Markovnikov’s Rule is by using the old saying, “the rich get richer,” where the H’s represent money.

For more details: See chapter 10 part 3 video or chapter 10 section 2 in the textbook.
10.15)

i) If one of the hydrogens from water is replaced by an alkyl group \((R)\), then a(n) ________________ is obtained.

   a) ester
   b) ether
   c) peroxide
   d) alcohol

ii) If the hydrogen from an alcohol is replaced by an alkyl group \((R')\), then a(n) ____________ is obtained.

   a) ester
   b) ether
   c) peroxide
   d) disulfide

iii) ________________ contain two oxygen atoms that are single-bonded to each other and situated between hydrogens, alkyl groups, or any other organic groups.

   a) esters
   b) carboxylic acids
   c) peroxides
   d) disulfides
10.15)

i) If one of the hydrogens from water is replaced by an alkyl group (R), then a(n) ______________ is obtained.

- a) ester
- b) ether
- c) peroxide
- d) alcohol

HINT:

ii) If the hydrogen from an alcohol is replaced by an alkyl group (R’), then a(n) __________ is obtained.

- a) ester
- b) ether
- c) peroxide
- d) disulfide

HINT:

iii) ______________ contain two oxygen atoms that are single-bonded to each other and situated between hydrogens, alkyl groups, or any other organic groups.

- a) esters
- b) carboxylic acids
- c) peroxides
- d) disulfides

HINT:

For more help: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.15)

i) If one of the hydrogens from water is replaced by an alkyl group (R), then a(n) ________________ is obtained.
   a) ester
   b) ether
   c) peroxide
   d) alcohol

ii) If the hydrogen from an alcohol is replaced by an alkyl group (R’), then a(n) ____________ is obtained.
   a) ester
   b) ether
   c) peroxide
   d) disulfide

iii) ________________ contain two oxygen atoms that are single-bonded to each other and situated between hydrogens, alkyl groups, or any other organic groups.
   a) esters
   b) carboxylic acids
   c) peroxides
   d) disulfides

Peroxides are quite reactive because of the two oxygen atoms that are single-bonded to each other. When the oxygen-oxygen single bond breaks, the oxygen atoms acquire more electrons by oxidizing another molecule. It is for this reason that peroxides are very effective oxidizing agents, and are frequently used as disinfectants and bleaching agents.

For more details: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.16) Predict the order of increasing **boiling points** for the following compounds.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>Order of Boiling Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexane</td>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 )</td>
<td>1</td>
</tr>
<tr>
<td>1-Hexanol</td>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>2</td>
</tr>
<tr>
<td>Dipropyl Ether</td>
<td>( \text{CH}_3\text{CH}_2\text{—O—CH}_2\text{CH}_2\text{CH}_3 )</td>
<td>3</td>
</tr>
</tbody>
</table>

**lowest boiling point:** hexane

**highest boiling point:** dipropyl ether
10.16) Predict the order of increasing *boiling points* for the following compounds.

- **hexane**
- **1-hexanol**
- **dipropyl ether**

**HINT:**

Stronger/more noncovalent interactions = higher boiling and melting points

Because all of these molecules are about the same size, the strength of their London forces would be about equal.

For more help: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.

**lowest boiling point**

_______________

_______________

_______________

**highest boiling point**

_______________

_______________

_______________
10.16) Predict the order of increasing **boiling points** for the following compounds.

- **CH₃CH₂CH₂CH₂CH₂CH₃**  **hexane**
- **CH₃CH₂CH₂CH₂CH₂CH₂—OH**  **1-hexanol**
- **CH₃CH₂—O—CH₂CH₂CH₃**  **dipropyl ether**

**EXPLANATION:** Stronger/more noncovalent interactions = higher boiling and melting points

- Because all of these molecules are about the same size, the strength of their London forces would be about equal.
- Hexane molecules are *not capable* of interacting with each other through hydrogen bonding. Furthermore, because hexane molecules are nonpolar, they *cannot* interact with each other through dipole-dipole forces. It is for this reason that hexane is predicted to have the *lowest boiling point*.
- Because dipropyl ether molecules are polar, they can interact with each other through dipole-dipole forces. It is for this reason that dipropyl ether is ranked in the middle of the boiling point order. Dipropyl ether molecules are not capable of interacting with each other through hydrogen bonding; although they have lone pairs on an oxygen, they do not have a hydrogen that is covalently bonded to an O, N, or F.
- 1-Hexanol molecules are polar, so they can interact with each other through dipole-dipole forces and are also capable of interacting with each other through hydrogen bonding. It is for this reason that 1-hexanol is predicted to have the *highest boiling point*.

The boiling points of 1-hexanol, dipropyl ether, and hexane are 157 °C, 90 °C, and 69 °C, respectively.

**For more details:** See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.17) When the oxygen atom(s) of water, alcohol, ether, or peroxide is replaced by sulfur, the resulting compound is called a sulfur analog.

Match each of the sulfur analog family names (on the left), with the general form of its structure (on the right):

- **sulfide**
  - $R - S - R'$

- **thiol**
  - $R$ or H$\cdot\cdot\cdot S - S - R'$ or H

- **disulfide**
  - $R - S - H$
10.17) When the oxygen atom(s) of water, alcohol, ether, or peroxide is replaced by sulfur, the resulting compound is called a sulfur analog.

Match each of the sulfur analog family names (on the left), with the general form of its structure (on the right):

- **sulfide**: \( R - S - R' \)
- **thiol**: \( R \text{ or } H - S - S - R' \text{ or } H \)
- **disulfide**: \( R - S - H \)

**HINT:**
- A thiol, the sulfur analog of an alcohol, is obtained if the oxygen atom in an alcohol is replaced by sulfur.
- A sulfide, the sulfur analog of an ether, is obtained if the oxygen atom in an ether is replaced by sulfur.
- A disulfide, the sulfur analog of a peroxide, is obtained if the oxygen atoms in a peroxide are replaced by sulfur atoms.

For more help: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.17) When the oxygen atom(s) of water, alcohol, ether, or peroxide is replaced by sulfur, the resulting compound is called a sulfur analog.

Match each of the sulfur analog family names (on the left), with the general form of its structure (on the right):

- **sulfide**
  - [Structure](#)
  - **A sulfide**, the sulfur analog of an ether, is obtained if the oxygen atom in an ether is replaced by sulfur.

- **thiol**
  - [Structure](#)
  - **A disulfide**, the sulfur analog of a peroxide, is obtained if the oxygen atoms in a peroxide are replaced by sulfur atoms.

- **disulfide**
  - [Structure](#)
  - **A thiol**, the sulfur analog of an alcohol, is obtained if the oxygen atom in an alcohol is replaced by sulfur.

For more details: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.18) IUPAC naming is rarely used for small ether or sulfide molecules. Instead, “common names” are used for small ethers and sulfides, as described below:

**Step 1. Identify the alkyl group names for the two alkyl (R) groups.**
- If the two R groups are identical use the “di” prefix before alkyl group name.

**Step 2. Construct the name of the ether by placing the alkyl groups in alphabetical order followed by the word “ether” or “sulfide.”**
- Use a space between the alkyl group names and before the word “ether” or “sulfide.”

Name each of the molecules that are shown here.

\[
\text{CH}_3\text{CH}_2\text{O} \rightleftharpoons \text{CH}_2\text{CH}_3, \quad \text{CH}_3\text{O} \rightleftharpoons \text{CH}_2\text{CH}_2\text{CH}_3, \quad \text{CH}_3\text{CH}_2\text{S} \rightleftharpoons \text{CH}_3
\]
IUPAC naming is rarely used for small ether or sulfide molecules. Instead, “common names” are used for small ethers and sulfides, as described below:

**Step 1. Identify the alkyl group names for the two alkyl (R) groups.**
- If the two R groups are identical use the “di” prefix before alkyl group name.

**Step 2. Construct the name of the ether by placing the alkyl groups in alphabetical order followed by the word “ether” or “sulfide.”**
- Use a space between the alkyl group names and before the word “ether” or “sulfide.”

Name each of the molecules that are shown here.

- \( \text{CH}_3\text{CH}_2\text{O} \text{CH}_2\text{CH}_3 \)
  - HINT: _________ ether

- \( \text{CH}_3 \text{O} \text{CH}_2\text{CH}_2\text{CH}_3 \)
  - HINT: _______ _______ ether

- \( \text{CH}_3\text{CH}_2\text{S} \text{CH}_3 \)
  - HINT: _______ _______ sulfide

**For more help:** See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
IUPAC naming is rarely used for *small ether* or *sulfide* molecules. Instead, “common names” are used for small ethers and sulfides, as described below:

**Step 1. Identify the alkyl group names for the two alkyl (R) groups.**
- If the two R groups are *identical* use the “di” prefix before alkyl group name.

**Step 2. Construct the name of the ether by placing the alkyl groups in alphabetical order followed by the word “ether” or “sulfide.”**
- Use a space between the alkyl group names and before the word “ether” or “sulfide.”

Name each of the molecules that are shown here.

- **diethyl ether**
  \[\text{CH}_3\text{CH}_2\text{O} \rightarrow \text{CH}_2\text{CH}_3\]
- **methyl propyl ether**
  \[\text{CH}_3 \rightarrow \text{O} \rightarrow \text{CH}_2\text{CH}_2\text{CH}_3\]
- **ethyl methyl sulfide**
  \[\text{CH}_3\text{CH}_2 \rightarrow \text{S} \rightarrow \text{CH}_3\]
10.19) **Thiols** are systematically named in the same way as alcohols *with only one exception*:

The term "**thiol**" is added to the *end the alkane name* that indicates the number of carbons in the parent chain (instead of replacing the “e” from the alkane name with “ol,” as we did for alcohols).

Name each of the molecules that are shown here.

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{SH} \quad \text{CH}_3\text{CHCH}_2\text{SH} \\
\text{CH}_3
\]

**Click here for a hint**

**Click here to check your answer**

**Go to next question**
Thiols are systematically named in the same way as alcohols with only one exception:

The term “thiol” is added to the end the alkane name that indicates the number of carbons in the parent chain (instead of replacing the “e” from the alkane name with “ol,” as we did for alcohols).

HINT: Naming Thiols

Name each of the molecules that are shown here.

- 
  \[
  \text{CH}_3\text{CH}_2\text{CH}_2 - \text{SH} \quad \text{CH}_3\text{CHCH}_2 - \text{SH} \quad \text{CH}_3
  \]

  \[
  \text{CH}_3
  \]

  \[
  \text{HINT: } \text{Name Thiols}
  \]

  \[
  \text{Step 1: Find and name the parent chain.}
  \]

  - The parent chain is the longest, continuous chain of carbon atoms that contains the point of attachment to the thiol group (SH).

  The term “thiol” is added to the end the alkane name that indicates the number of carbons in the parent chain.

  Assign position numbers to the carbons in the parent chain. Position number 1 is assigned to the carbon at the end of the parent chain that is nearest to the thiol group (SH).

  - For thiols with more than two carbons, the position of the point of attachment to the thiol group must be indicated by adding a number before the parent chain.

  Steps 2, 3, and 4 are done the same way as you did when using systematic names for other organic molecules.

  - 
  - Step 2: Name any alkyl group substituents.
  - Step 3: Determine the point of attachments of alkyl groups to the parent chain.
  - Step 4: Construct the name of the thiol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

  Go back

  For more help: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.

  Click here to check your answer

  Go to next question
Thiols are systematically named in the same way as alcohols with only one exception:

The term “thiol” is added to the end the alkane name that indicates the number of carbons in the parent chain (instead of replacing the “e” from the alkane name with “ol,” as we did for alcohols).

EXPLANATION: Naming Thiols

**Step 1:** Find and name the parent chain.
- The parent chain is the longest, continuous chain of carbon atoms that contains the point of attachment to the thiol group (SH).

The term “thiol” is added to the end the alkane name that indicates the number of carbons in the parent chain.

Assign position numbers to the carbons in the parent chain. Position number 1 is assigned to the carbon at the end of the parent chain that is nearest to the thiol group (SH).
- For thiols with more than two carbons, the position of the point of attachment to the thiol group must be indicated by adding a number before the parent chain.

Steps 2, 3, and 4 are done the same way as you did when using systematic names for other organic molecules.

**Step 2:** Name any alkyl group substituents.
**Step 3:** Determine the point of attachments of alkyl groups to the parent chain.
**Step 4:** Construct the name of the thiol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

For more details: See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.20) The general form of a **disulfide** is shown below.

The S-S bond is called a **disulfide bond**. Disulfides can be made from the reaction of two thiols. In this reaction, the thiols are oxidized to form a disulfide. The general form of the reaction is shown below.

Draw the condensed structure of the disulfide that is formed by the reaction of two *ethanethiol* molecules.
The S-S bond is called a disulfide bond. Disulfides can be made from the reaction of two thiols. In this reaction, the thiols are oxidized to form a disulfide. The general form of the reaction is shown below.

\[
\text{R or H} \quad \text{S} \quad \text{S} \quad \text{R’ or H}
\]

\[
\begin{array}{c}
\text{R} \quad \text{S} \quad \text{H} + \text{H} \quad \text{S} \quad \text{R} \\
\text{a thiol} & \text{a thiol} & \text{a disulfide}
\end{array}
\]

Draw the condensed structure of the disulfide that is formed by the reaction of two ethanethiol molecules.

**HINT:**

\[
\begin{array}{c}
\text{CH}_3\text{CH}_2\quad \text{S} \quad \text{H} + \text{H} \quad \text{S} \quad \text{CH}_2\text{CH}_3 \\
\text{ethanethiol} & \text{ethanethiol}
\end{array}
\]

**For more help:** See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.20) The general form of a **disulfide** is shown below.

![Diagram of disulfide](image)

The S-S bond is called a **disulfide bond**. Disulfides can be made from the reaction of two thiols. In this reaction, the thiols are oxidized to form a disulfide. The general form of the reaction is shown below.

![Reaction diagram](image)

Draw the condensed structure of the disulfide that is formed by the reaction of two ethanethiol molecules.

**ANSWER:** \[ \text{CH}_3\text{CH}_2\text{S-S-CH}_2\text{CH}_3 \]

**ILLUSTRATIVE EXPLANATION:**

You can recognize that the **thiol reactants** were **oxidized** because they lose hydrogen in the reaction.

**For more details:** See chapter 10 part 4 video or chapter 10 section 2 in the textbook.
10.21) Place an asterisk (*) below the *carbonyl carbon* AND draw a box around the *carbonyl group* in each of these molecules.

a) ![Aromatic Carbonyl](image)

b) ![Aliphatic Carbonyl](image)

c) ![Aliphatic Carbonyl](image)
10.21) Place an asterisk (*) below the *carbonyl carbon* AND draw a box around the *carbonyl group* in each of these molecules.

EXPLANATION:

A *carbonyl group* is a carbon AND oxygen that are *double bonded to each other* (C=O).

The *carbon* in a *carbonyl group* is referred to as the “*carbonyl carbon.*”

For more help: See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.21) Place an asterisk (*) below the *carbonyl carbon* **AND** draw a box around the *carbonyl group* in each of these molecules.

![Molecules with carbonyl groups marked]

**EXPLANATION:**

A *carbonyl group* is a carbon **AND** oxygen that are *double bonded to each other* (C=O).

The *carbon* in a *carbonyl group* is referred to as the “*carbonyl carbon*.”

**For more details:** See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.22) Classify each of the following molecules as either an aldehyde or a ketone.

a) \[ \text{O} \quad \text{C} \quad \text{CH}_3 \]

b) \[ \text{CH}_3\text{CH}_2\text{C} \quad \text{H} \]

c) \[ \text{CH}_3 \quad \text{C} \quad \text{CH}_2\text{CH}_3 \]
10.22) Classify each of the following molecules as either an **aldehyde** or a **ketone**.

![Chemical structures](image)

**HINT:**

In **aldehydes**, the carbonyl carbon is bonded to **one R group and one hydrogen (H)**, except for the simplest aldehyde, formaldehyde, which has the carbonyl carbon bonded to two hydrogens.

In **ketones**, the carbonyl carbon is bonded to **two R groups**.

**For more help:** See **chapter 10 part 5 video** or chapter 10 section 4 in the textbook.
10.22) Classify each of the following molecules as either an aldehyde or a ketone.

a) ![](image)

A ketone - the carbonyl carbon is bonded to **two R groups**.

b) ![](image)

An aldehyde - the carbonyl carbon is bonded to **one R group and one** hydrogen.

c) ![](image)

A ketone - the carbonyl carbon is bonded to **two R groups**.

**EXPLANATION:**

In **aldehydes**, the carbonyl carbon is bonded to **one R group and one** hydrogen (H), except for the simplest aldehyde, formaldehyde, which has the carbonyl carbon bonded to two hydrogens.

In **ketones**, the carbonyl carbon is bonded to **two R groups**.

**For more details:** See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.23) Write the **systematic names** for each of the molecules shown here.

a) \( \text{CH}_3\text{CH}_2\text{C} = \text{H} \)

b) \( \text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \)

c) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{C} = \text{CH}_3 \)

d) \( \text{CH}_3\text{CHCHCH}_2\text{C} = \text{CH}_3 \)

e) \( \text{CH}_3\text{CCH}_2\text{CH}_2\text{C} = \text{H} \)

f) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CCHCH}_2\text{CH}_2\text{CH}_3 \)

Click here for a hint  

Click here to check your answer  

Go to next question
10.23) Write the **systematic names** for each of the molecules shown here.

**HINT:** Naming Aldehydes and Ketones

**Step 1:** Find and name the *parent chain.*

The *parent chain* is the longest, continuous chain of carbon atoms that contains the *carbonyl carbon.*

- **For aldehydes,** starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “al.”

- **For ketones,** starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “one.” **For ketones with more than four carbons,** the position of the *carbonyl carbon* must be indicated by adding a number as a prefix to the parent chain name.
  - Position number **1** is assigned to the carbon at the end of the parent chain that is nearest to the carbonyl carbon.

- **Steps 2, 3, and 4** are done the same way as you did when using systematic names for other organic molecules.

**Step 2:** Name any alkyl group substituents.

**Step 3:** Determine the point of attachments of alkyl groups to the parent chain.

**Step 4:** Construct the name of the thiol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

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**For more help:**
See chapter 10 part 5 video or chapter 10 section 4 in the textbook. 

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Go back | Click here to check your answer | Go to next question
10.23) Write the **systematic names** for each of the molecules shown here.

**EXPLANATION: Naming Aldehydes and Ketones**

**Step 1:** Find and name the **parent chain**.

The **parent chain** is the longest, continuous chain of carbon atoms that contains the carbonyl carbon.

- **For aldehydes**, starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “al.”

- **For ketones**, starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the “e” at the end of the alkane name with “one.” **For ketones with more than four carbons**, the position of the carbonyl carbon must be indicated by adding a number as a prefix to the parent chain name.

  - Position number 1 is assigned to the carbon at the end of the parent chain that is nearest to the carbonyl carbon.

  - Steps 2, 3, and 4 are done the same way as you did when using systematic names for other organic molecules.

**Step 2:** Name any alkyl group substituents.

**Step 3:** Determine the **point of attachments** of alkyl groups to the parent chain.

**Step 4:** Construct the name of the thiol by placing the alkyl groups in alphabetical order and specifying their position number, followed by the name of the parent chain.

For more details:
See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.24) Draw the condensed and skeletal structure for each of these molecules.

   a) 5-methyl-2-hexanone   b) 4,5-dimethylheptanal   c) 3-methyl-2-octanone
10.24) Draw the **condensed and skeletal** structure for each of these molecules.

a) 5-methyl-2-hexanone  
b) 4,5-dimethylheptanal  
c) 3-methyl-2-octanone

**HINT:**
For this molecule, there are six carbons in the parent chain. The **carbonyl carbon** is the carbon at position number 2 of the parent chain.

**For more help:** See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.24) Draw the condensed and skeletal structure for each of these molecules.

a) 5-methyl-2-hexanone

b) 4,5-dimethylheptanal

\[
\begin{align*}
\text{CH}_3 \text{CHCH}_2 \text{CHCH}_2 \text{CH}_2 \text{C} - \text{H} \\
\text{CH}_3 \\
\text{CH}_3
\end{align*}
\]

or

\[
\begin{align*}
\text{CH}_3 \text{CHCH}_2 \text{CHCH}_2 \text{CH}_2 \text{CHO} \\
\text{CH}_3 \\
\text{CH}_3
\end{align*}
\]

For more details: See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.25) Determine whether each of the following statements are **true** or **false**.

a) A cyclic ketone is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.

b) A cyclic aldehyde is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.

c) For ketones with more than four carbons, the position of the carbonyl carbon must be indicated by adding a number as a prefix to the parent chain name.

d) Smaller aldehyde and ketone molecules have significant water solubility because of their ability to interact with water through hydrogen bonding and dipole-dipole interactions.

e) Aldehyde molecules are attracted to each other through hydrogen bonding.

f) Ketone molecules are attracted to each other through dipole-dipole forces.
10.25) Determine whether each of the following statements are true or false.

a) A cyclic ketone is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.

b) A cyclic aldehyde is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.

   HINT: Consider the location of an aldehyde’s carbonyl group in the parent chain.

c) For ketones with more than four carbons, the position of the carbonyl carbon must be indicated by adding a number as a prefix to the parent chain name.

   HINT: What is the maximum number of carbons in a ketone’s parent chain before there is no longer only one, unique, possible parent chain?

d) Smaller aldehyde and ketone molecules have significant water solubility because of their ability to interact with water through hydrogen bonding and dipole-dipole interactions.

   HINT: Consider the structural features that are required for hydrogen bonding and dipole-dipole interactions.

e) Aldehyde molecules are attracted to each other through hydrogen bonding.

f) Ketone molecules are attracted to each other through dipole-dipole forces.

For more help:
See chapter 10 part 5 video or chapter 10 section 4 in the textbook.

Click here to check your answer

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10.25) Determine whether each of the following statements are true or false.

a) A cyclic ketone is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.
   true - Examples of cyclic ketones are cyclopentanone and cyclohexanone.

b) A cyclic aldehyde is a molecule in which a carbonyl carbon occupies a position between two other carbons in a ring structure.
   false - Because an aldehyde’s carbonyl group is at the end of the parent chain, it is impossible for it to be in a ring structure.

c) For ketones with more than four carbons, the position of the carbonyl carbon must be indicated by adding a number as a prefix to the parent chain name.
   true - When a ketone has three or fewer carbons in the parent chain, there is only one, unique, possible parent chain.

d) Smaller aldehyde and ketone molecules have significant water solubility because of their ability to interact with water through hydrogen bonding and dipole-dipole interactions.
   true - Aldehyde and ketone molecules have oxygen atoms with lone pairs that can hydrogen bond with a water molecule’s hydrogen which is covalently bonded to oxygen.

e) Aldehyde molecules are attracted to each other through hydrogen bonding.
   false - Although aldehydes molecules have oxygen atoms with lone pairs, they cannot interact with each other through hydrogen bonding because they do not have a hydrogen which is covalently bonded to oxygen, nitrogen, or fluorine.

f) Ketone molecules are attracted to each other through dipole-dipole forces.
   true - Ketones (and aldehydes) have one or more “highly polar” bonds and are therefore polar. Polar molecules can interact with each other through dipole-dipole forces.

For more details: See chapter 10 part 5 video or chapter 10 section 4 in the textbook.
10.26) The dehydration of any primary (1°), symmetric secondary (2°), or symmetric tertiary (3°) alcohol only produces a single alkene product. When an asymmetric alcohol undergoes a dehydration reaction, there are two different alkene molecules produced. Asymmetric alcohols are 2° or 3° alcohols in which the alkyl groups bonded to the carbon carbon carrying the OH are not identical. The dehydration of an asymmetric alcohol does not produce equal amounts of both alkene products.

- It is possible to predict the major and minor products for the dehydration of an alcohol; in the major product, the double bond is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried fewer hydrogens. The minor product is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried more hydrogens.

**QUESTION:** Draw the condensed structure of the major and minor products for the dehydration of the alcohol shown below.

\[
\begin{align*}
\text{OH} & \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHCH}_3 & \\
\end{align*}
\]
The dehydration of any primary (1°), symmetric secondary (2°), or symmetric tertiary (3°) alcohol only produces a single alkene product. When an asymmetric alcohol undergoes a dehydration reaction, there are two different alkene molecules produced. Asymmetric alcohols are 2° or 3° alcohols in which the alkyl groups bonded to the carbon carbon carrying the OH are not identical. The dehydration of an asymmetric alcohol does not produce equal amounts of both alkene products.

• It is possible to predict the major and minor products for the dehydration of an alcohol; in the major product, the double bond is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried fewer hydrogens. The minor product is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried more hydrogens.

QUESTION: Draw the condensed structure of the major and minor products for the dehydration of the alcohol shown below.

HINT:
In the formation of the major alkene product, the adjacent carbon that originally contained fewer hydrogens will lose another hydrogen when the double bond is formed. The adjacent carbons are shown in blue or green font in the structure shown here.

• An easy way to remember this alcohol dehydration rule is with the old saying, “the poor get poorer,” where hydrogen atoms (H) represent money.

The minor product is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried more hydrogens.

For more help: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
10.26) The dehydration of any primary (1\textsuperscript{o}), symmetric secondary (2\textsuperscript{o}), or symmetric tertiary (3\textsuperscript{o}) alcohol only produces a single alkene product. When an asymmetric alcohol undergoes a dehydration reaction, there are two different alkene molecules produced. Asymmetric alcohols are 2\textsuperscript{o} or 3\textsuperscript{o} alcohols in which the alkyl groups bonded to the carbon carbon carrying the OH are not identical. The dehydration of an asymmetric alcohol does not produce equal amounts of both alkene products.

- It is possible to predict the major and minor products for the dehydration of an alcohol; in the major product, the double bond is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried fewer hydrogens. The minor product is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried more hydrogens.

**QUESTION:** Draw the condensed structure of the major and minor products for the dehydration of the alcohol shown below.

For more details: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
10.27) Draw the condensed structure of the *major and minor products* for the dehydration of the alcohol shown below.

```
OH
CH₃CHCHCH₂CH₃
  CH₃
```

Click here for a hint  
Click here to check your answer  
Go to next question
10.27) Draw the condensed structure of the major and minor products for the dehydration of the alcohol shown below.

\[
\begin{align*}
\text{OH} & \quad \text{CH}_3\text{CHCHCH}_2\text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

HINT:

In the formation of the major alkene product, the adjacent carbon that originally contained fewer hydrogens will lose another hydrogen when the double bond is formed. The adjacent carbons are shown in blue or green font in the structure shown here.

- An easy way to remember this alcohol dehydration rule is with the old saying, “the poor get poorer,” where hydrogen atoms (H) represent money.

The minor product is formed between the carbon that was carrying the OH and the adjacent carbon that originally carried more hydrogens.

For more help: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
10.27) Draw the condensed structure of the **major and minor products** for the dehydration of the alcohol shown below.

\[
\begin{align*}
\text{CH}_3\text{CHCHCH}_2\text{CH}_3 & \rightleftharpoons \text{CH}_3\text{C}=\text{CHCH}_2\text{CH}_3 + \text{CH}_3\text{CHCH}=\text{CHCH}_3 + \text{H}_2\text{O} \\
\end{align*}
\]

**EXPLANATION:**

In the formation of the **major** alkene product, the **adjacent carbon** that originally contained fewer hydrogens will lose another hydrogen when the double bond is formed.

- An easy way to remember this alcohol dehydration rule is with the old saying, “the poor get poorer,” where hydrogen atoms (H) represent money.

The **minor product** is formed between the **carbon that was carrying the OH** and the adjacent carbon that **originally carried more hydrogens**.

**For more details:** See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
i) The **oxidation** of an organic compound in a reaction can be identified by the addition of oxygen and/or loss of _____________.
   a) hydroxide  
   b) an R group  
   c) chirality  
   d) hydrogen

ii) Oxidation of a primary (1°) alcohol produces a(n) ______________.
   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane

iii) Oxidation of a secondary (2°) alcohol produces a(n) ______________.
   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane

iv) Using a strong oxidizing agent, the initial oxidation product of a primary (1°) alcohol can be further oxidized to a(n) _____________.
   a) ether  
   b) ketone  
   c) carboxylic acid  
   d) ester
10.28)  

i) The **oxidation** of an organic compound in a reaction can be identified by the addition of oxygen and/or loss of ____________.

   a) hydroxide  
   b) an R group  
   c) chirality  
   d) hydrogen  

HINT:  

ii) Oxidation of a primary (1°) alcohol produces a(n) ______________.

   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane  

HINT:  

iii) Oxidation of a secondary (2°) alcohol produces a(n) ______________.

   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane  

HINT:  

iv) Using a strong oxidizing agent, the initial oxidation product of a primary (1°) alcohol can be further oxidized to a(n) ____________.

   a) ether  
   b) ketone  
   c) carboxylic acid  
   d) ester  

HINT:  

For more help: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
i) The oxidation of an organic compound in a reaction can be identified by the addition of oxygen and/or loss of ______________.
   a) hydroxide  
   b) an R group  
   c) chirality  
   d) hydrogen

ii) Oxidation of a primary (1°) alcohol produces a(n) ______________.
   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane

   The oxidation of a primary alcohol produces an aldehyde because the hydroxyl group is attached to a carbon at an end of the parent chain, and therefore the carbonyl group in the product is at the end of the chain.

iii) Oxidation of a secondary (2°) alcohol produces a(n) ______________.
   a) aldehyde  
   b) ketone  
   c) alkene  
   d) alkane

   The oxidation of a secondary alcohol produces a ketone because the hydroxyl group is attached to a carbon that is not at the end of the parent chain, and therefore the carbonyl group in the product is not at the end of the parent chain.

iv) Using a strong oxidizing agent, the initial oxidation product of a primary (1°) alcohol can be further oxidized to a(n) ______________.
   a) ether  
   b) ketone  
   c) carboxylic acid  
   d) ester

For more details: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
A strong oxidizing agent, such as the permanganate ion ($\text{MnO}_4^-$), will first oxidize a primary alcohol to an aldehyde, and then it will oxidize the aldehyde to produce a carboxylic acid.

Draw the condensed structure of the **aldehyde** that is initially formed, and then draw the condensed structure of the **carboxylic acid** that is subsequently formed in the oxidation of ethanol when $\text{MnO}_4^-$ is used as the oxidizing agent.

\[ \text{CH}_3\text{CH}_2\text{OH} \xrightarrow{[O]} \text{an aldehyde} \xrightarrow{[O]} \text{a carboxylic acid} \]
10.29) A strong oxidizing agent, such as the permanganate ion (MnO₄⁻), will first oxidize a primary alcohol to an aldehyde, and then it will oxidize the aldehyde to produce a carboxylic acid.

Draw the condensed structure of the **aldehyde** that is initially formed, and then draw the condensed structure of the **carboxylic acid** that is subsequently formed in the oxidation of ethanol when MnO₄⁻ is used as the oxidizing agent.

**HINT:**
The general form for the sequence of oxidation reactions for primary alcohols is shown below.

Consider the general form of the reactions to predict the products. What is represented by the letter “R” in this problem? Be careful; **IT IS NOT** “CH₃CH₂.”

**For more help:** See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
10.29) A strong oxidizing agent, such as the permanganate ion (MnO_4^-), will first oxidize a primary alcohol to an aldehyde, and then it will oxidize the aldehyde to produce a carboxylic acid.

Draw the condensed structure of the **aldehyde** that is initially formed, and then draw the condensed structure of the **carboxylic acid** that is subsequently formed in the oxidation of ethanol when MnO_4^- is used as the oxidizing agent.

\[
\text{CH}_3\text{CH}_2\text{OH} \xrightarrow{[O]} \text{CH}_3\text{C}=\text{H} \xrightarrow{[O]} \text{CH}_3\text{C}=\text{OH}
\]

**ethanol**  
**ethanal**  
**ethanoic acid**

**EXPLANATION:**
The general form for the sequence of oxidation reactions for primary alcohols is shown below.

\[
\text{R} \underset{\text{primary (1°) alcohol}}{\xrightarrow{[O]}} \text{O} \underset{\text{aldehyde}}{\xrightarrow{[O]}} \text{R} \underset{\text{carboxylic acid}}{\xrightarrow{[O]}} \text{OH}
\]

The general form for the reactions is used to predict the products. In the equation here, R represents “CH₃,” not “CH₃CH₂.”

**For more details:** See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
10.30) Draw the condensed structure and name the organic molecule that is produced in the oxidation of the alcohol shown here.

\[
\text{CH}_3\text{CHCH}_2\text{CHCH}_3 \xrightarrow{[\text{O}]} \text{CH}_3\text{CHCH}_2\text{CHCH}_2\text{OH}
\]

**IMPORTANT NOTE:**

The “[O],” drawn above (or below) the arrows in a chemical equation, is often used to indicate that the reactant is being oxidized, and should not be confused with the presence of a catalyst.

When oxidation is indicated by using “[O],” then the identity of the oxidizing agent - which is actually a reactant - and the destination of the hydrogens are often omitted from the chemical equation.

- When doing so, it is acceptable - and expected - that the equation is not balanced.
10.30) Draw the condensed structure **and** name the organic molecule that is produced in the oxidation of the alcohol shown here.

\[
\begin{align*}
\text{CH}_3\text{CHCH}_2\text{CHCH}_3 & \quad \text{OH} \\
\quad & \quad \text{[O]} \\
\text{CH}_3 &
\end{align*}
\]

**HINT:**
This reaction involves the oxidation of a *secondary* alcohol. Find the general form for the oxidation of a secondary alcohols in your lecture notes. Consider the general form for the reaction to predict the products.

**For more help:** See [chapter 10 part 6 video](#) or chapter 10 section 5 in the textbook.
EXPLANATION:

The general form of the reaction for the oxidation of a secondary alcohol is shown below.

\[
\begin{align*}
\text{OH} & \quad \text{[O]} \\
\text{CH}_3\text{CHCH}_2\text{CHCH}_3 & \quad \text{O} \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

A ketone is produced because the hydroxyl group of a secondary alcohol is attached to a carbon that is not at the end of the parent chain, and therefore the carbonyl group in the product is not at the end of the parent chain.

For more details: See chapter 10 part 6 video or chapter 10 section 5 in the textbook.
i) The oxidation of an aldehyde produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) ketone
   d) carboxylic acid

ii) Reduction of aldehydes and ketones is the reverse of the oxidation of ___________ reactions.
   a) alcohols
   b) carboxylic acids
   c) esters
   d) alkenes

iii) The reduction of an aldehyde produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) ketone
   d) carboxylic acid

iv) The reduction of an ketone produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) aldehyde
   d) carboxylic acid
i) The oxidation of an aldehyde produces a(n) ________________.

   a) primary alcohol  
   b) secondary alcohol  
   c) ketone  
   d) carboxylic acid

HINT:

ii) Reduction of aldehydes and ketones is the reverse of the oxidation of ____________ reactions.

   a) alcohols  
   b) carboxylic acids  
   c) esters  
   d) alkenes

HINT:

iii) The reduction of an aldehyde produces a(n) ________________.

   a) primary alcohol  
   b) secondary alcohol  
   c) ketone  
   d) carboxylic acid

HINT:

iv) The reduction of a ketone produces a(n) ________________.

   a) primary alcohol  
   b) secondary alcohol  
   c) aldehyde  
   d) carboxylic acid

HINT:

For more help: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
i) The oxidation of an aldehyde produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) ketone
   d) carboxylic acid

ii) Reduction of aldehydes and ketones is the reverse of the oxidation of _____________ reactions.
   a) alcohols
   b) carboxylic acids
   c) esters
   d) alkenes

iii) The reduction of an aldehyde produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) ketone
   d) carboxylic acid

iv) The reduction of an ketone produces a(n) ________________.
   a) primary alcohol
   b) secondary alcohol
   c) aldehyde
   d) carboxylic acid

For more details: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.32) Draw the condensed structure and name the organic molecule that is produced in the oxidation of the molecule shown here.
10.32) Draw the condensed structure and name the organic molecule that is produced in the oxidation of the molecule shown here.

\[
\begin{align*}
\text{CH}_3 & \quad \text{O} & \quad [\text{O}] \\
\text{CH}_3\text{CHCH}_2\text{CH}_2\text{C} & \quad \text{H} & \quad \text{CH}_3
\end{align*}
\]

**HINT:**

This reaction involves the *oxidation* of an *aldehyde*. Find the general form for the oxidation of an aldehyde in your lecture notes. Consider the general form of the reaction to predict the products.

**For more help:** See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
The general form of the reaction for the oxidation of an aldehyde is shown below.

The oxidation of an aldehyde produces a \textit{carboxylic acid}. The general form for the reaction is used to predict the products.

For more details: See \textit{chapter 10 part 7 video} or chapter 10 section 5 in the textbook.
Reduction of aldehydes or ketones involves the formation of a bond to the *carbonyl carbon* by a *hydride ion* (H⁻), accompanied by the bonding of an H⁺ ion to the carbonyl-oxygen atom, and the conversion of the carbon-oxygen *double* bond into a *single* bond.

**QUESTION:** Draw the condensed structure *and* name the organic molecule that is produced in the reduction of propanal.

\[
\begin{align*}
\text{propanal} & : \quad \text{CH}_3\text{CH}_2\text{C} - \text{H} \\
\text{alcohol} & : \quad [\text{R}] \quad \text{CH}_3\text{CH}_2\text{C} - \text{OH}
\end{align*}
\]
Reduction of aldehydes or ketones involves the formation of a bond to the carbonyl carbon by a hydride ion ($H^-$), accompanied by the bonding of an $H^+$ ion to the carbonyl-oxygen atom, and the conversion of the carbon-oxygen double bond into a single bond.

QUESTION: Draw the condensed structure and name the organic molecule that is produced in the reduction of propanal.

HINT:
This reaction involves the reduction of an aldehyde. To predict the product of this reaction, either use the illustration above or find the general form for the reduction of an aldehyde in your lecture notes.

For more help: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
Reduction of aldehydes or ketones involves the formation of a bond to the carbonyl carbon by a hydride ion (H\textsuperscript{−}), accompanied by the bonding of an \( \text{H}^+ \) ion to the carbonyl-oxygen atom, and the conversion of the carbon-oxygen double bond into a single bond.

QUESTION: Draw the condensed structure \textit{and} name the organic molecule that is produced in the reduction of propanal.

Aldehydes are reduced to primary alcohols.

For more details: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.34) Draw the condensed structure and name the organic molecule that is produced in the reduction of each of these molecules.

a) \[
\begin{align*}
&\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \\
&\text{O} \\
\end{align*}
\]

\[ [\text{R}] \]

\[
\begin{align*}
&\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \\
&\text{O} \\
\end{align*}
\]

b) \[
\begin{align*}
&\text{CH}_3\text{CHCH}_2\text{CH}_2\text{C} - \text{H} \\
&\text{CH}_3 \\
\end{align*}
\]

\[ [\text{R}] \]

\[
\begin{align*}
&\text{CH}_3\text{CHCH}_2\text{CH}_2\text{C} - \text{H} \\
&\text{CH}_3 \\
\end{align*}
\]

c) \[
\begin{align*}
&\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \\
&\text{O} \\
\end{align*}
\]

\[ [\text{R}] \]

\[
\begin{align*}
&\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \\
&\text{O} \\
\end{align*}
\]

NOTE: As was the case for “[O],” an “[R]” is often written above the arrows in a chemical equation to indicate that the reactant is being reduced.

- When reduction is indicated by using “[R],” then the identity of the reducing agent reactant and the source of the hydrogens (or destination of oxygens) are often omitted from the chemical equation. In this case, the equation need not be balanced.
10.34) Draw the condensed structure and name the organic molecule that is produced in the reduction of each of these molecules.

a) \[
\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \rightleftharpoons \text{[R]} \]

b) \[
\text{CH}_3\text{CCH}_2\text{CH}_2\text{C}(-\text{H})\text{CH}_3 \rightleftharpoons \text{[R]} \]

HINT:
These reactions involve the reduction of aldehydes and ketones. Find the general forms of these reductions in your lecture notes. Consider the general form of the reaction to predict the products.

For more help: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.

c) \[
\text{CH}_3\text{CHCH}_2\text{CCH}_3 \rightleftharpoons \text{[R]} \]
10.34) Draw the condensed structure and name the organic molecule that is produced in the reduction of each of these molecules.

a) \( \text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \) or \( \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \)

EXPLANATION:
Aldehydes are reduced to primary alcohols.

b) \( \text{CH}_3\text{O} \)
\( \text{CH}_3\text{CCH}_2\text{CH}_2\text{C} \) \( \text{H} \)

EXPLANATION:
Ketones are reduced to secondary alcohols.

c) \( \text{CH}_3\text{O} \)
\( \text{CH}_3\text{CHCH}_2\text{CCH}_3 \)

EXPLANATION:

For more details: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.35) Draw the general form for a **hemiacetal** and an **acetal**.

**general form of a hemiacetal**

**general form of an acetal**
10.35) Draw the general form for a **hemiacetal** and an **acetal**.

**HINT:**

A **hemiacetal** is a molecule that contains *both* an OR group *and* OH group that are bonded to the *same* carbon.

An **acetal** is a molecule that contains *two OR* groups, where *both* OR groups are bonded to the *same* carbon.

**For more help:** See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.35) Draw the general form for a **hemiacetal** and an **acetal**.

**EXPLANATION:**

A **hemiacetal** is a molecule that contains both an OR group and OH group that are bonded to the same carbon.

An **acetal** is a molecule that contains two OR groups, where both OR groups are bonded to the same carbon.

**For more details:** See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
Identify each of the molecules below as a **hemiacetal**, an **acetal**, or **neither**.

a) ![Chemical structure](image1.png)  
b) ![Chemical structure](image2.png)  
c) ![Chemical structure](image3.png)  
d) ![Chemical structure](image4.png)  
e) ![Chemical structure](image5.png)  
f) ![Chemical structure](image6.png)  
g) ![Chemical structure](image7.png)  
h) ![Chemical structure](image8.png)
10.36) Identify each of the molecules below as a hemiacetal, an acetal, or neither.

a) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{C} \cdots \text{OCH}_3 \\
\text{CH}_3
\end{align*}
\]

b) \[
\begin{align*}
\text{CH}_3\text{CH} \cdots \text{O} \cdots \text{CH}_2\text{CH}_3
\end{align*}
\]

c) \[
\begin{align*}
\text{CH}_3\text{CCHCH}_3 \\
\text{OCH}_3
\end{align*}
\]

d) \[
\begin{align*}
\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \\
\text{OCH}_3
\end{align*}
\]

e) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{C} \cdots \text{O} \cdots \text{CH}_3
\end{align*}
\]

f) \[
\begin{align*}
\text{CH}_3\text{CHCH}_2\text{CCH}_2\text{CH}_3 \\
\text{OCH}_2\text{CH}_3
\end{align*}
\]

g) \[
\begin{align*}
\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \\
\text{OCH}_3 \\
\text{CH}_3
\end{align*}
\]

h) \[
\begin{align*}
\text{O} \\
\text{OH}
\end{align*}
\]

HINT:
A hemiacetal is a molecule that contains both an OR group and OH group that are bonded to the same carbon.
An acetal is a molecule that contains two OR groups, where both OR groups are bonded to the same carbon.

For more help: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.36) Identify each of the molecules below as a **hemiacetal**, an **acetal**, or **neither**.

a) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{C} & \text{OCH}_3 \\
\text{CH}_3 & \\
\text{acetal}
\end{align*}
\]

b) \[
\begin{align*}
\text{CH}_3\text{CH} & \text{O} \text{CH}_2\text{CH}_3 \\
\text{hemiacetal}
\end{align*}
\]

c) \[
\begin{align*}
\text{CH}_3\text{CH} & \text{CHCH}_3 \\
\text{OCH}_3 & \\
\text{neither}
\end{align*}
\]

Although this molecule contains both an OR group and OH group, they are NOT bonded to the same carbon.

d) \[
\begin{align*}
\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 & \\
\text{OCH}_3 & \\
\text{hemiacetal}
\end{align*}
\]

e) \[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{C} & \text{O} \text{CH}_3 \\
\text{neither}
\end{align*}
\]

f) \[
\begin{align*}
\text{CH}_3\text{CHCH}_2\text{C} & \text{CH}_2\text{CH}_3 \\
\text{acetal}
\end{align*}
\]

g) \[
\begin{align*}
\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 & \\
\text{OCH}_2\text{CH}_3 & \\
\text{neither}
\end{align*}
\]

h) \[
\begin{align*}
\text{O} & \text{OH} \\
\text{hemiacetal}
\end{align*}
\]

**EXPLANATION:**

A **hemiacetal** is a molecule that contains **both** an OR group and OH group that are bonded to the **same** carbon.

An **acetal** is a molecule that contains **two** OR groups, where **both** OR groups are bonded to the **same** carbon.

For more details: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.37) Draw the **hemiacetal** and **acetal** that is formed when each of the molecules below reacts with ethanol (CH\(_3\)CH\(_2\)OH).

a) 
```
    O
   \ H
CH_3CH_2CH_2CH=CH_3
```

b) 
```
    O
   \ H
CH_3CH_2CH_2C--H
```
10.37) Draw the **hemiacetal** and **acetal** that is formed when each of the molecules below reacts with ethanol (CH₃CH₂OH).

a) $$\begin{array}{c}
\text{O} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CCH}_3
\end{array}$$

b) $$\begin{array}{c}
\text{O} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{C} \equiv \text{H}
\end{array}$$

**HINT:**

An **aldehyde or a ketone** will react with an **alcohol** to form a **hemiacetal** as shown in the illustration below:

$$\text{aldehyde or ketone} + \text{alcohol} \rightarrow \text{hemiacetal}$$

The **OR”** from the **alcohol** forms a bond to the **carbonyl-carbon** of the aldehyde or ketone, the **H** from the **alcohol** bonds to the **carbonyl-oxygen**, and the carbonyl group’s double bond is changed to a single bond. One way to predict the structure of the hemiacetal is to consider the general form described above. An alternative method to predict the structure of the hemiacetal that is formed would be for you to “add the alcohol across the carbonyl group,” as described in the video and textbook.

The **hemiacetal** that is formed can react with a second **alcohol molecule** to form an **acetal** and an **H₂O** molecule. The structure of the **acetal** that is produced is drawn by **exchanging** the **R”** group of the **alcohol** and the **H** from the hemiacetal’s hydroxyl group (OH), as shown on the right.

**For more help:** See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.37) Draw the hemiacetal and acetal that is formed when each of the molecules below reacts with ethanol (CH$_3$CH$_2$OH).

a)  
\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CCH}_3 + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{C} - \text{OCH}_2\text{CH}_3 + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \begin{array}{c} \text{hemiacetal} \\ \text{H} \end{array}
\]

b)  
\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{C} - \text{H} + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{C} - \text{OCH}_2\text{CH}_3 + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \begin{array}{c} \text{hemiacetal} \\ \text{H} \end{array}
\]

An aldehyde or a ketone will react with an alcohol to form a hemiacetal. The OR$''$ from the alcohol forms a bond to the carbonyl-carbon of the aldehyde or ketone, the H from the alcohol bonds to the carbonyl-oxygen, and the carbonyl group’s double bond is changed to a single bond.

The hemiacetal that is formed can react with a second alcohol molecule to form an acetal and an H$_2$O molecule. The structure of the acetal that is produced is drawn by exchanging the R$''$ group of the alcohol and the H from the hemiacetal’s hydroxyl group.

For more details: See chapter 10 part 7 video or chapter 10 section 5 in the textbook.
10.38) Synthetic organic chemistry involves using starting compounds and one or more chemical reactions to make a new molecule. Pharmaceutical drugs can be either synthesized or extracted from natural sources. If you started with 4-heptanone and wanted to synthesize 3-heptene, **write the series of chemical reactions you would use**. You can use whatever other chemicals you need, but you must start with 4-heptanone.

```
                 O
               ||
CH₃CH₂CH₂CCH₂CH₂CH₃  →  CH₃CH₂CH═CHCH₂CH₂CH₃
  4-heptanone           3-heptene
```
10.38) Synthetic organic chemistry involves using starting compounds and one or more chemical reactions to make a new molecule. Pharmaceutical drugs can be either synthesized or extracted from natural sources. If you started with 4-heptanone and wanted to synthesize 3-heptene, write the series of chemical reactions you would use. You can use whatever other chemicals you need, but you must start with 4-heptanone.

HINT: 3-heptene can be synthesized from 4-heptanone in a series of two reactions. You may wish to try working backwards; do you know of a reaction that produces an alkene?
Synthetic organic chemistry involves using starting compounds and one or more chemical reactions to make a new molecule. Pharmaceutical drugs can be either synthesized or extracted from natural sources. If you started with 4-heptanone and wanted to synthesize 3-heptene, write the series of chemical reactions you would use. You can use whatever other chemicals you need, but you must start with 4-heptanone.

First reaction: (reduction of a ketone)

Second reaction: (dehydration of an alcohol)

ANSWER: