Chapter 14 Organic Compounds That Contain Oxygen, Halogen, or Sulfur

Solutions to In-Chapter Problems

14.1 Label the –OH groups, –SH groups, halogens, and ether oxygens in each compound.

b. The OH on the benzene ring of salmeterol is part of a phenol, so it is not an alcohol.

14.2 To determine whether an alcohol is 1°, 2°, or 3°, locate the C with the OH group and count the number of C’s bonded to it. A 1° alcohol has the OH group on a C bonded to one C, and so forth, as in Example 14.1.

14.3 Use the definition in Example 14.1 and Answer 14.2 to label the hydroxyl groups.

All other hydroxyl groups are on C’s bonded to 2 C’s.

2° alcohols

14.4 Alcohols have stronger intermolecular forces and therefore higher boiling points than hydrocarbons of comparable size and shape.

a. \( \text{alcohol} \) or \( \text{alcohol} \) higher boiling point

b. \( (\text{CH}_3)_2\text{C} - \text{OH} \) or \( (\text{CH}_3)_2\text{C} \) higher boiling point
14.5 Hydrocarbons are insoluble in water. Low molecular weight alcohols (< 6 C’s) are water soluble, but higher molecular weight alcohols (≥ 6 C’s) are insoluble in water.

\[
\text{a. Hydrocarbon} \quad \text{b. (CH}_3\text{)}_3\text{C} – \text{OH} \quad \text{c. CH}_2\text{=CHCH}_2\text{CH}_3
\]

14.6 To name alcohols using the IUPAC system, follow the steps in Example 14.2:

1. Find the longest carbon chain that contains the carbon bonded to the OH group.
2. Number the carbon chain to give the OH group the lower number, and apply all other rules of nomenclature.

\[
\begin{align*}
\text{a. CH}_3\text{CH(CH}_3\text{)}_3\text{CH}_3 & \quad \text{OH group at C2} \quad 2\text{-heptanol} \\
\text{7 C’s in the longest chain} & \quad \text{heptanol} \\
\text{b. (CH}_3\text{CH}_2\text{)}_2\text{CHCHCH}_2\text{CH}_3 & \quad \text{OH group at C3} \quad 4\text{-ethyl-3-hexanol} \\
\text{6 C’s in the longest chain} & \quad \text{hexanol} \\
\text{c. Cyclohexanol} & \quad \text{2-methylcyclohexanol}
\end{align*}
\]

14.7 Work backwards to draw the structure corresponding to each name.

\[
\begin{align*}
\text{a. 7,7-dimethyl-4-octanol} & \quad \text{two methyl groups at C7} \\
\text{8 carbon chain} & \quad \text{OH at C4}
\end{align*}
\]
14.8 To draw the products of the dehydration of each alcohol, follow the steps in Example 14.3.
- First find the carbon bonded to the OH group, and then identify all carbons with H’s bonded to this carbon.
- Remove the elements of H and OH from two adjacent C’s, and draw a double bond between these C’s in the product.
- When two different alkenes are formed, the major product has more C’s bonded to the C=C.

\[ \text{a. } \text{CH}_3 - \text{C} - \text{CH}_3 \xrightarrow{\text{H}_2\text{SO}_4} \text{CH}_3 - \text{C} = \text{CH}_2 \]

These 2 C’s are identical. When either one loses a H, the same product is formed.

\[ \text{b. } \text{C}_{6}\text{H}_5 - \text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{H}_2\text{SO}_4} \text{C}_{6}\text{H}_5 - \text{CH} = \text{CH}_2 \]

This C loses a H to form the product.

14.9 The Zaitsev rule states that when two different alkenes are formed, the major product has more C’s bonded to the C=C.

\[ \text{a. } \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{H}_2\text{SO}_4} \text{CH}_2 = \text{CHCH}_2\text{CH}_3 + \text{CH}_3\text{CH} = \text{CHCH}_2\text{CH}_3 \]

1 C bonded to the double bond 2 C’s bonded to the double bond major product

\[ \text{b. } \text{CH}_3 - \text{C} - \text{CH}_2\text{OH} \xrightarrow{\text{H}_2\text{SO}_4} \text{CH}_2 = \text{C} - \text{CH}_2\text{CH}_3 + \text{CH}_3\text{CH} = \text{CHCH}_3 \]

2 C’s bonded to the double bond 3 C’s bonded to the double bond major product
14.10 B has no H on the carbon adjacent to the carbon with the OH group, so \( \text{H}_2\text{O} \) cannot be lost.

14.11 Draw the products when each alcohol is oxidized, as in Example 14.4.
- \( \text{RCH}_2\text{OH} \) (1° alcohols) are oxidized to \( \text{RCHO} \), which are then oxidized to \( \text{RCOOH} \).
- \( \text{R}_2\text{CHOH} \) (2° alcohols) are oxidized to \( \text{R}_2\text{CO} \).
- \( \text{R}_3\text{COH} \) (3° alcohols) are not oxidized because they have no H atom on the C with the OH.

14.12 Ethylene glycol is oxidized to a dicarboxylic acid.

14.13 Draw the three constitutional isomers.

\[
\begin{align*}
\text{CH}_3\text{O} & \text{-CH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CH}_2\text{O} & \text{-CH}_2\text{CH}_3 \\
(\text{CH}_3)_2\text{CHOCH}_3
\end{align*}
\]
14.14 Look at the functional groups to determine the strength of the intermolecular forces, as in Example 14.5. The stronger the forces, the higher the boiling point.

- a. \( \text{CH}_3(\text{CH}_2)_2\text{CH}_3 \) or \( \text{CH}_3(\text{CH}_2)_2\text{OCH}_3 \)
  - hydrocarbon or polar
  - higher boiling point

- b. \( \text{CH}_3(\text{CH}_2)_2\text{OH} \) or \( \text{CH}_3(\text{CH}_2)_2\text{OCH}_3 \)
  - polar, can hydrogen bond or polar
  - higher boiling point or no hydrogen bonding

14.15 Low molecular weight ethers are water soluble. If the ether has more than five carbons, the ether is insoluble in water.

- a. \( \text{CH}_3\text{CH}_2\text{OCH}_3 \)
  - 3 C ether
  - water soluble

- b. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_3 \)
  - 12 C ether
  - water insoluble

- c. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OCH}_3 \)
  - 11 C ether
  - water insoluble

14.16 Name each ether as in Example 14.6.

- a. \( \text{CH}_3\text{OCH}_3 \)
  - 4 C's in the longer chain butane
  - methoxy group
  - 1-methoxybutane (or butyl methyl ether)

- b. \( \text{CH}_3\text{OCH}_3 \)
  - 6 C's in the ring cyclohexane
  - methoxy group
  - methoxycyclohexane

- c. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_3 \)
  - two propyl groups
  - diisopropyl ether

14.17 Work backwards from the IUPAC name to the structure.

- a. \( \text{dibutyl ether} \)
  - two butyl groups on the ether
  - \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_3 \)

- b. \( \text{ethyl propyl ether} \)
  - one ethyl, one propyl group on the ether
  - \( \text{CH}_3\text{CH}_2\text{OCH}_3 \)
14.18

b. Desflurane is organic, and by “like dissolves like,” organic compounds are soluble in organic solvents.

14.19 Draw the three-dimensional structure of halothane. Recall that solid lines represent bonds in the plane of the page, wedges represent bonds in front, and dashed lines represent bonds behind.

14.20 Classify each alkyl halide as 1°, 2°, or 3°.
- A primary (1°) alkyl halide has a halogen on a carbon bonded to one carbon.
- A secondary (2°) alkyl halide has a halogen on a carbon bonded to two carbons.
- A tertiary (3°) alkyl halide has a halogen on a carbon bonded to three carbons.

14.21 Label the alkyl halide and each alcohol as 1°, 2°, or 3°.
### Chapter 14

#### 14.22
The boiling point of alkyl halides increases with the size of the alkyl group as well as the size of the halogen.

- a. $\text{CH}_3\text{CH}_2\text{CH}_2\text{F}$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$
  - Increasing boiling point
  - Increasing size of the halogen

- b. $\text{CH}_3\text{(CH}_2\text{)}_2\text{CH}_3$, $\text{CH}_3\text{(CH}_2\text{)}_2\text{Cl}$, $\text{CH}_3\text{(CH}_2\text{)}_2\text{Br}$
  - Increasing boiling point

#### 14.23
Give the IUPAC name for each compound. Always start by finding the longest chain.

- a. $\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{CH}_3\text{Br}$
  - Longest chain: $\text{hexane}$
  - $\text{Br}$
    - $\text{2-bromohexane}$
  - $\text{Br}$
  - bromo at C2

- b. $\text{(CH}_3\text{)}_2\text{CHCHCH}_2\text{CH}_3\text{Cl}$
  - Longest chain: $\text{pentane}$
  - $\text{Cl}$
    - $\text{3-chloro-2-methylpentane}$
  - $\text{Cl}$

- c. $\text{Br}$
  - Longest chain: $\text{cyclohexene}$
  - $\text{Br}$
  - bromo at C1
  - $\text{1-bromo-2-methylcyclohexene}$

#### 14.24
Work backwards from the name to the structure.

- a. $\text{3-chloro-2-methylhexane}$
  - 6 carbon chain
  - $\text{Cl}$
    - chloro at C3
  - $\text{CH}_3$
    - methyl at C2

- b. $\text{4-ethyl-5-iodo-2,2-dimethyloctane}$
  - 8 carbon chain
  - $\text{CH}_3$
    - ethyl at C4
  - $\text{I}$
    - iodo at C5
  - $\text{CH}_3$
    - two methyl groups at C2

- c. $\text{1,1,3-tribromocyclohexane}$
  - 6 carbon ring
  - $\text{Br}$
    - two bromo groups at C1
  - $\text{Br}$
    - one bromo group at C3

- d. propyl chloride
  - 3 carbon chain
  - $\text{H}$
    - one chloro group
  - $\text{H}$
14.25 Chlorofluorocarbons (CFCs) have the general molecular structure \( \text{CF}_x\text{Cl}_{4-x} \). Hydrochlorofluorocarbons (HCFCs) contain the elements of H, Cl, and F bonded to carbon, whereas hydrofluorocarbons (HFCs) contain the elements of H and F bonded to carbon.

a. \( \text{CF}_3\text{Cl} \) is a CFC.  

b. \( \text{CHFCl}_2 \) is an HCFC.  

c. \( \text{CH}_2\text{F}_2 \) is an HFC.

14.26 Name the thiols using the steps in Example 14.7.

a. \[ \begin{align*} &\text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \quad \text{SH} \quad \text{pentane} \\ &\text{3-pentanethiol} \end{align*} \]

b. \[ \begin{align*} &\text{cyclohexane} \\ &\text{c.} \quad \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_2\text{CH}_2\text{SH} \quad \text{SH at C1} \quad \text{cyclohexanethiol} \end{align*} \]

14.27 When thiols are oxidized, they form disulfides. Disulfides are converted back to thiols with a reducing agent.

a. \( \text{2 CH}_3\text{CH}_2\text{CH}_2\text{SH} \xrightarrow{[O]} \text{CH}_3\text{CH}_2\text{CH}_2\text{SSCH}_2\text{CH}_3 \)

b. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{SSCH}_2\text{CH}_3 \xrightarrow{[\text{H}]} \text{CH}_3\text{CH}_2\text{CH}_2\text{SH} + \text{CH}_3\text{CH}_2\text{SH} \)

14.28

\( \text{CH}_2=\text{CHCH}_2\text{SSCH}_2\text{CH}=\text{CH}_2 \xrightarrow{[\text{H}]} \text{2 CH}_2=\text{CHCH}_2\text{SH} \)

### Solutions to End-of-Chapter Problems

14.29 To determine whether an alcohol is 1°, 2°, or 3°, locate the C with the OH group and count the number of C’s bonded to it. A 1° alcohol has the OH group on a C bonded to one C, and so forth, as in Example 14.1.

a. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \)  

b. \( \text{(CH}_3\text{CH}_2)_3\text{COH} \)  

c. \( \text{CH}_3\text{CH}_2\text{CHCHCH}_3 \)  

d. \( \text{CH}_3\text{CH}_2\text{CHCHCH}_3 \)  

\[ \begin{align*} &\text{C bonded to 1 C} \\ &\text{1° alcohol} \\ &\text{C bonded to 3 C’s} \\ &\text{3° alcohol} \\ &\text{C bonded to 2 C’s} \\ &\text{2° alcohol} \\ &\text{C bonded to 2 C’s} \\ &\text{2° alcohol} \end{align*} \]
14.30 To determine whether an alcohol is 1°, 2°, or 3°, locate the C with the OH group and count the number of C’s bonded to it. A 1° alcohol has the OH group on a C bonded to one other C, and so forth, as in Example 14.1.

![Chemical structures](image)

14.31 Classify each alkyl halide as 1°, 2°, or 3°.
- A primary (1°) alkyl halide has a halogen on a carbon bonded to one carbon.
- A secondary (2°) alkyl halide has a halogen on a carbon bonded to two carbons.
- A tertiary (3°) alkyl halide has a halogen on a carbon bonded to three carbons.

![Chemical structures](image)

14.32 Classify each alkyl halide as 1°, 2°, or 3°.
- A primary (1°) alkyl halide has a halogen on a carbon bonded to one carbon.
- A secondary (2°) alkyl halide has a halogen on a carbon bonded to two carbons.
- A tertiary (3°) alkyl halide has a halogen on a carbon bonded to three carbons.

![Chemical structure](image)

14.33 Draw a structure that fits each description.

- a. CH₃CH₂CH₂CH₂CH₃  
  2° alcohol
- b. CH₃CH₂OCH₂CH₂CH₂CH₃  
  ether with a methoxy group
- c. CH₃CH₂CH₂CH₂Br  
  2° alkyl halide

14.34 Draw a structure that fits each description.

- a. CH₃CH₂CH₂CH₂CH=CH₂  
  2° alcohol
- b. CH₃CH₂CH₂CH₂CH₂OCH₂CH₂CH₃  
  cyclic ether
- c. CH₃CH₂CH₂CH₂CH₂CH₃  
  1° alkyl halide
14.35 Draw the structure of the six constitutional isomers of molecular formula C₅H₁₂O that contain an ether functional group.

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

14.36 Draw the structure of the four constitutional isomers of molecular formula C₃H₆Br₂.

\[
\begin{align*}
\text{Br} & \quad \text{Br} \quad \text{Br} \quad \text{Br} \quad \text{Br} \\
\text{CH}_3\text{CH}_3 & \quad \text{CH}_3\text{CH}_2\text{Br} \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{H} \quad \text{BrCH}_2\text{CH}_2\text{CH}_2\text{Br}
\end{align*}
\]

14.37

\[\text{a.} \quad \text{5 C's in the longest chain} \quad \text{pentanol} \quad \text{methyl group at C2} \quad \text{2-methyl-3-pentanol}
\]

\[\text{b.} \quad \text{chloro group at C1} \quad \text{1-chloro-2-methylcyclopentane} \quad \text{5 C's in a ring} \quad \text{cyclopentane} \quad \text{methyl group at C2}\]
14.38

2 C's: ethyl group  ether  5 C's: pentyl group

a. \( \text{CH}_3\text{CH}_3\text{O} \text{-CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \)  ethyl pentyl ether

b. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \)  2\(^\text{e}\)C's: hexanethiol  2-hexanethiol

14.39

a. skeletal structure  condensed structure

b. The alcohol contains a 2\(^e\) hydroxyl group because C is bonded to 2 C's.

c. 3,3-dimethyl-2-pentanol

14.40

a. C bonded to 2 C's  b. 2\(^e\) alcohol  c. 3-ethylcyclohexanol

14.41  To name alcohols using the IUPAC system, follow the steps in Example 14.2:

[1] Find the longest carbon chain that contains the carbon bonded to the OH group.

[2] Number the carbon chain to give the OH group the lower number, and apply all other rules of nomenclature.

a. \( \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 \)  \( \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 \)  2-pentanol
To name alcohols using the IUPAC system, follow the steps in Example 14.2:

1. Find the longest carbon chain that contains the carbon bonded to the OH group.
2. Number the carbon chain to give the OH group the lower number, and apply all other rules of nomenclature.

a. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{CH}_3 \) \( \rightarrow \) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{C}_3 \) \( \rightarrow \) \( \text{6-methyl-3-heptanol} \)

b. \( \text{C}_4\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{methyl at C3} \) \( \rightarrow \) \( \text{C}_4\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{C}_3 \) \( \rightarrow \) \( \text{3,3-dimethyl-2-hexanol} \)

c. \( \text{C}_7\text{H}_4\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{C}_2 \) \( \rightarrow \) \( \text{C}_7\text{H}_4\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{OH} \) \( \text{C}_3 \) \( \rightarrow \) \( \text{4-ethyl-6-methyl-1-heptanol} \)

d. \( \text{C}_6\text{H}_5\text{CH}_3 \) \( \text{OH} \) \( \text{C}_4 \) \( \rightarrow \) \( \text{C}_6\text{H}_5\text{CH}_3 \) \( \text{OH} \) \( \text{C}_4 \) \( \rightarrow \) \( \text{4-butylcyclohexanol} \)

e. \( \text{C}_4\text{H}_5\text{CH}_3 \) \( \text{OH} \) \( \text{C}_2 \) \( \rightarrow \) \( \text{C}_4\text{H}_5\text{CH}_3 \) \( \text{OH} \) \( \text{C}_2 \) \( \rightarrow \) \( \text{2,2-dimethylcyclobutanol} \)

f. \( \text{C}_5\text{H}_6\text{CH}_3 \) \( \text{OH} \) \( \text{C}_2 \) \( \rightarrow \) \( \text{C}_5\text{H}_6\text{CH}_3 \) \( \text{OH} \) \( \text{C}_2 \) \( \rightarrow \) \( \text{2,5-diethylcyclopentanol} \)
14.43 Work backwards to draw the structure corresponding to each name.

a. 3-hexanol

b. propyl alcohol

c. 2-methylcyclopropanol
Work backwards to draw the structure corresponding to each name.

**d. 1,2-butanediol**
\[ \text{OH OH} \rightarrow \text{CH}_2\text{CH}_2\text{CH}_3 \]
4 C chain with OH groups at C1 and C2

**e. 4,4,5-trimethyl-3-heptanol**
\[ \text{CH}_3\text{CH}_2-\text{C}-\text{C}-\text{CH}_2\text{CH}_3 \]
7 C chain with OH at C3

three methyl groups at C4 and C5

**f. 3,5-dimethyl-1-heptanol**
\[ \text{HOCH}_2\text{CH}_2\text{CCH}_2\text{CH}_2\text{CH}_3 \]
7 C chain with OH at C1

two methyl groups at C3 and C5

**14.44**

Work backwards to draw the structure corresponding to each name.

**a. 3-methyl-3-pentanol**
\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \]
5 C chain with OH at C3
and methyl at C3

**b. 4-methyl-2-pentanol**
\[ \text{CH}_2\text{CHCH}_2\text{CHCH}_3 \]
5 C chain with OH at C2
and methyl at C4

**c. 2,4-dimethyl-2-hexanol**
\[ \text{CH}_2\text{CCH}_2\text{CHCH}_2\text{CH}_3 \]
6 C chain with OH at C2
and methyls at C2 and C4

**d. 1,3-propanediol**
\[ \text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH} \]
3 C chain with OH at C1
and C3

**e. 3,5-dimethylcyclohexanol**
\[ \text{CH}_3\text{C}_5 \]
6 C in a ring with OH at C1
and methyls at C3 and C5

**f. 6,6-diethyl-4-nonanol**
\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CHCH}_2\text{CHCH}_2\text{CH}_3 \]
9 C chain with OH at C4
and 2 ethyls at C6
14.45 Name each ether as in Example 14.6.

a. \( \text{CH}_3\text{CH}_2\text{O}\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{CH}_3\text{CH}_2\text{O}\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{1-ethoxybutane} \) (or butyl ethyl ether)

b. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{1-ethoxybutane} \)

c. \( \text{OCH}_2\text{CH}_3 \) \( \text{OCH}_2\text{CH}_3 \) \( \text{ethoxycyclopentane} \)

14.46 Name each ether as in Example 14.6.

a. \( \text{CH}_3\text{O}\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{CH}_3\text{O}\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{1-methoxypropane} \) (or methyl propyl ether)

b. \( \text{CH}_3\text{O}\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{CH}_3\text{O}\text{CH}_2\text{CH}_2\text{CH}_3 \) \( \text{2-methoxybutane} \)

c. \( \text{OCH}_3 \) \( \text{OCH}_3 \) \( \text{methoxycyclopropane} \)

14.47 Draw the structures and then name the isomers.

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)

\( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) \( \text{1-heptanol} \)
14.48 Draw the structures and then name the isomers.

\[
\begin{align*}
\text{1-butanol} & \quad \text{2-methyl-1-propanol} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} & \quad \text{CH}_3\text{CH}_2\text{OH} \\
\text{OH at C1} & \quad \text{OH at C2} \\
\text{CH}_3\text{CH}_2\text{CHCH}_3 & \quad \text{methyl at C2} \\
\text{OH} & \quad \text{OH} \\
\end{align*}
\]

\[
\begin{align*}
\text{2-butanol} & \quad \text{2-methyl-2-propanol} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} & \quad \text{CH}_3\text{CH}_3 \\
\text{methyl at C2} & \quad \text{OH at C2} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_3 \\
\end{align*}
\]

14.49 Name each compound using the IUPAC system.

a. \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}\) 7 C's in the longest chain
   Br at C4
   4-bromoheptane

b. \(\text{CH}_3\text{Cl}\) 4 C's in the ring
   Cl at C1
   methyl at C3
   1-chloro-3-methylcyclobutane

c. \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{SH}\) 5 C's in the longest chain
   SH at C1
   1-pentanethiol

14.50 Name each compound using the IUPAC system.

a. \(\text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{F}\) 10 C's in the longest chain
   F at C3
   ethyl at C5
   5-ethyl-3-fluorodecane

b. \(\text{CH}_3\text{CH}_2\text{CHC}_l\) 5 C's in the ring
   Cl at C1
   ethyl at C3
   1-chloro-3-ethylcyclopentane

c. \(\text{CH}_3\text{CHCH}_3\) 3 C's in the longest chain
   SH at C2
   2-propanethiol

14.51 Work backwards from the name to draw each structure.

a. 2-methoxypropane
   \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \quad \text{OCH}_3\)
   3 C chain
   methoxy at C2

b. cyclobutyl ethyl ether
   \(\text{CH}_2\text{C} \quad \text{OCH}_2\text{CH}_3\)
   4 C ring
   ethoxy at C1

c. 1-ethoxy-2-ethylcyclohexane
   \(\text{CH}_2\text{C} \quad \text{OCH}_3\)
   6 C ring
   ethyl

d. butyl chloride
   \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \quad \text{OCH}_2\text{CH}_3\)
   4 C chain
   chlorine at C1

e. 2-methylcyclohexanethiol
   \(\text{CH}_2\text{C} \quad \text{OCH}_2\text{CH}_3\)
   6 C ring with SH group
   ethoxy at C1

f. 1-ethyl-2-fluorocyclobutane
   \(\text{CH}_2\text{C} \quad \text{OCH}_2\text{CH}_3\)
   4 C ring
   ethyl
   fluoro at C2
14.52 Work backwards from the name to draw each structure.

a. dicyclohexyl ether

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3
\]

two 6 C rings

d. 3-methyl-1-pentanethiol

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

5 C chain

b. 2-ethoxy-2-methylpropane

\[
\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3
\]

3 C chain

e. 1-chloro-2-methylpropane

\[
\text{ClCH}_2\text{CHCH}_3
\]

chlorine at C1

f. 2-bromo-3-methylheptane

\[
\text{BrCH}_3\text{CHCH}_2\text{CHCH}_3\text{CH}_2\text{CH}_3
\]

7 C chain

iodine at C1

14.53 Alcohols have higher boiling points than hydrocarbons of comparable size and shape. The boiling points of alkyl halides increase with the size of the alkyl group and the size of the halogen.

a. CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}I (larger halogen)

c. CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}OH (can hydrogen bond)
b. HOCH\textsubscript{2}CH\textsubscript{2}OH (two hydroxyl groups)

14.54 CH\textsubscript{3}CH\textsubscript{2}OH < CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}OH < CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}OH

14.55 C has the highest boiling point because it has an OH group that can intermolecularly hydrogen bond. B is a hydrocarbon with the weakest intermolecular forces, so it has the lowest boiling point. In order of increasing boiling point:

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}
\]

14.56 The boiling point of D is higher than the boiling point of F, even though F has a higher molecular weight, because D is capable of hydrogen bonding to itself, whereas F is not. E is an alkane, so it will have the lowest boiling point.

butane (E) < 1-chlorobutane (F) < 1-butanol (D)

14.57 Ethanol is a polar molecule capable of hydrogen bonding with itself and water. Dimethyl ether is polar, but cannot hydrogen bond with itself. The stronger intermolecular forces make the boiling point of ethanol higher. Both ethanol and dimethyl ether have only two carbons and can hydrogen bond to H\textsubscript{2}O, so both are water soluble.

14.58 1,6-hexanediol is much more water soluble than 1-hexanol because 1,6-hexanediol has two OH groups that can hydrogen bond to water, whereas 1-hexanol has only one OH group.

14.59 B (CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}OH) has an OH group capable of intermolecular hydrogen bonding, so its boiling point is higher than the boiling point of A (CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}SH), which has weaker intermolecular forces. Thus, the boiling point of A is 98 °C and the boiling point of B is 118 °C.
14.60 X [CH₃CH₂CHOHCH₂CH₃] is 3-pentanol whereas Y [CH₃CH₂CH₂CHSHCH₃] is 2-pentanethiol. X is water soluble because it has an OH group capable of hydrogen bonding to water. Y is unable to hydrogen bond to water and is therefore insoluble in water.

14.61 To draw the products of dehydration of each alcohol, follow the steps in Example 14.3.

a. \[
\begin{array}{c}
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{H} \\
\text{H}
\end{array}
\text{This C loses a H to form the product.}
\]

b. \[
\begin{array}{c}
\text{CH₃} \\
\text{CH₃}
\end{array}
\rightarrow \begin{array}{c}
\text{CH} = \text{CHCH₃}
\end{array}
\text{This C loses a H to form the product.}
\]

c. \[
\begin{array}{c}
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{CH₃CH} = \text{CHCH₂CH₂CH₃} + \text{CH₂} = \text{CH(CH₂)₃CH₃}
\end{array}
\text{2 C's bonded to the double bond major product 1 C bonded to the double bond}
\]

d. \[
\begin{array}{c}
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{CH₃} \\
\text{CH₃}
\end{array}
\text{3 C's bonded to the double bond major product}
\]

14.62 To draw the products of dehydration of each alcohol, follow the steps in Example 14.3.

a. \[
\begin{array}{c}
\text{(CH₃)₂CHCH₂CH₂CH₂OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{(CH₃)₂CHCH₂CH=CH₂}
\end{array}
\text{This C loses a H to form the product.}
\]

b. \[
\begin{array}{c}
\text{CH₂CH₃} \\
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{CH₃} \\
\text{CH₃}
\end{array}
\text{3 C's bonded to the double bond major product}
\]

c. \[
\begin{array}{c}
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{CH₃CH} = \text{CHCH₂CH₂CH₂CH₃} + \text{CH₂} = \text{CH(CH₂)₃CH₃}
\end{array}
\text{2 C's bonded to the double bond major product 1 C bonded to the double bond}
\]

d. \[
\begin{array}{c}
\text{OH} \\
\text{H}_2\text{SO}_4
\end{array}
\rightarrow \begin{array}{c}
\text{CH₃} \\
\text{CH₃}
\end{array}
\text{3 C's bonded to the double bond major product 2 C's bonded to the double bond}
\]
14.63 Draw the products of dehydration, as in Example 14.3.

a. \( \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CH} = \text{CHCH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{CH}_2\text{CH} = \text{CHCH}_2\text{CH}_3 \)

b. The carbons of both double bonds are bonded to an equal number of C’s; as a result, roughly equal amounts of both isomers are formed.

14.64 The Zaitsev rule states that the major product in elimination is the alkene that has more alkyl groups bonded to the double bond.

a. 

\[ \begin{align*}
\text{OH} \\
\text{CH}_3
\end{align*} \]
\[ \begin{align*}
\text{OH} \\
\text{CH}_3
\end{align*} \]

b. Both products are formed in equal amounts because the carbons of both double bonds are bonded to an equal number of C’s.

14.65 Work backwards to determine what alcohol can be used to form each product.

a. 

b. 

14.66 Work backwards to determine what alcohol can be used to form each product.

a. 

b. 

14.67 Work backwards to determine what alcohols can be used to form propene. The OH group can be bonded to either the middle or the end carbon.

\[ \text{CH}_3\text{CH} = \text{CH}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \]  

or 

\[ \text{CH}_3\text{CH} = \text{CH}_2 \rightarrow \text{CH}_3\text{CH} \]

14.68 Work backwards to determine what alcohols can be used to form 2-methylpropene. The OH group can be bonded to either the middle or the end carbon.

\[ \text{CH}_3\text{CH} = \text{CH}_2 \rightarrow \text{CH}_3\text{CH} = \text{CH}_2\text{OH} \]  

or 

\[ \text{CH}_3\text{CH} = \text{CH}_2 \rightarrow \text{CH}_3\text{CH}_2\text{OH} \]
14.69 Draw the products when each alcohol is oxidized, as in Example 14.4.
- $RCH_2OH$ ($1^\circ$ alcohols) are oxidized to $RCHO$, which are then oxidized to $RCOOH$.
- $R_2CHOH$ ($2^\circ$ alcohols) are oxidized to $R_2CO$.
- $R_3COH$ ($3^\circ$ alcohols) are not oxidized because they have no H atom on the C with the OH.

\[
\begin{align*}
\text{a. } & \text{CH}_3(\text{CH}_2)_6\text{CH}_2\text{OH} & \text{c. } & \text{CH}_3\text{CH}_2\text{CHCH}_2\text{OH} \\
1^\circ\text{ alcohol} & \xrightarrow{[O]} & \text{carboxylic acid} & \xrightarrow{[O]} \\
& & \text{CH}_3(\text{CH}_2)_6\text{COH} & \text{CH}_3(\text{CH}_2)_6\text{COH} \\
\text{b. } & (\text{CH}_3\text{CH}_2)_2\text{CHOH} & \text{d. } & \text{CH}_3\text{CH}_2\text{COH} \\
2^\circ\text{ alcohol} & \xrightarrow{[O]} & \text{ketone} & \text{[O]} \quad \text{No reaction} \\
& & (\text{CH}_3\text{CH}_2)_2\text{CCH}_2\text{CH}_3 & \text{CH}_3(\text{CH}_2)_6\text{COH} \\
& & \text{3}\text{° alcohol} & \text{3}\text{° alcohol} \\
\end{align*}
\]

14.70 Draw the products when each alcohol is oxidized, as in Example 14.4.
- $RCH_2OH$ ($1^\circ$ alcohols) are oxidized to $RCHO$, which are then oxidized to $RCOOH$.
- $R_2CHOH$ ($2^\circ$ alcohols) are oxidized to $R_2CO$.
- $R_3COH$ ($3^\circ$ alcohols) are not oxidized because they have no H atom on the C with the OH.

\[
\begin{align*}
\text{a. } & \text{2}\text{° alcohol} & \xrightarrow{[O]} & \text{ketone} \\
& & \text{CH}_3\text{CCH}_3 & \text{CH}_3\text{OH} \\
\text{b. } & \text{CH}_3(\text{CH}_2)_6\text{CH}_2\text{OH} & \xrightarrow{[O]} & \text{carboxylic acid} \\
1^\circ\text{ alcohol} & & \text{CH}_3(\text{CH}_2)_6\text{COH} & \text{CH}_3(\text{CH}_2)_6\text{COH} \\
\text{b. } & (\text{CH}_3\text{CH}_2)_2\text{CHOH} & \xrightarrow{[O]} & \text{No reaction} \\
& & \text{3}\text{° alcohol} & \text{3}\text{° alcohol} \\
\end{align*}
\]

14.71 Draw the product of oxidation.
14.72 Classify the OH groups and draw the products of oxidation.

\[ \text{CH}_2\text{OH} \quad \text{H-C-OH} \quad \text{CH}_2\text{OH} \]

\[ \text{H-C-OH} \quad \text{H-C-OH} \quad \text{H-C-OH} \]

\[ \text{H-C-OH} \quad \text{H-C-OH} \quad \text{H-C-OH} \]

a. \(2^\circ\)  

b. \(\text{[O]}\)

c. \(\text{[O]}\)

14.73 Work backwards to determine what alcohol can be used to prepare each carbonyl compound.

\[ \text{a. ketone} \quad \text{2}^\circ \text{ alcohol} \quad \text{b. carboxylic acid} \quad \text{1}^\circ \text{ alcohol} \]

14.74 Work backwards to determine what alcohol can be used to prepare each carbonyl compound.

\[ \text{a. ketone} \quad \text{2}^\circ \text{ alcohol} \]

b. \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H} \quad \text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \)

\[ \text{carboxylic acid} \quad \text{1}^\circ \text{ alcohol} \]

14.75 Draw the products of each reaction.

\[ \text{a. CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{H}_2\text{SO}_4 \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}==\text{CHCH}_2\text{CH}_3 \]

\[ \text{b. CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{K}_2\text{Cr}_2\text{O}_7 \quad \text{CH}_3\text{CH}_2\text{CH}==\text{CHCH}_2\text{CH}_3 \]

14.76 Draw the products of each reaction.

\[ \text{a. CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{H}_2\text{SO}_4 \quad \text{CH}_3\text{CHCH}==\text{CHCH}_2\text{CH}_3 \quad \text{CH}_3\text{CH}_2\text{CH}==\text{CHCH}_2\text{CH}_3 \]

\[ \text{b. CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{K}_2\text{Cr}_2\text{O}_7 \quad \text{CH}_3\text{CHCH}==\text{CHCH}_2\text{CH}_3 \]
14.77
\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}=&\text{H} & \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \\
\text{alcohol} & \overset{-\text{H}_2\text{O}}{\longrightarrow} & \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \\
& \downarrow\text{K}_2\text{Cr}_2\text{O}_7 & \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}
\end{align*}
\]

14.78
\[
\begin{align*}
\text{CH}_3\text{H} & \quad \text{CH}_3\text{O} \\
\text{CH}_3\text{CH}_3 & \quad \text{CH}_3\text{CH}_3 \\
\text{2° alcohol} & \quad \text{ketone}
\end{align*}
\]

14.79 Draw the structure of the alcohol that fits the description. Since no reaction occurs with an oxidizing agent, the compound must be a 3° alcohol. Since only one alkene is formed when treated with sulfuric acid, all carbons adjacent to the C–OH must be identical.

\[
\begin{align*}
\text{(CH}_3\text{)_3COH} & \\
\text{3° alcohol} & \\
\text{All 3 C's adjacent to the C–OH are identical.}
\end{align*}
\]

14.80 \((\text{CH}_3\text{CH}_2)_3\text{COH}\) is a tertiary alcohol and will not react with an oxidizing agent such as \(\text{K}_2\text{Cr}_2\text{O}_7\), whereas \(\text{CH}_3(\text{CH}_2)_6\text{OH}\) is a primary alcohol and will undergo oxidation. The test tube that shows a color change from red-orange to green is the one that contains the \(\text{CH}_3(\text{CH}_2)_6\text{OH}\).

14.81 Draw the disulfides formed by thiol oxidation.

a. \[
\begin{align*}
\text{SH} & \overset{[O]}{\longrightarrow} \text{S-S} \\
\text{H}_2\text{N-C-H} & \quad \text{H}_2\text{N-C-S-S-C-NH}_2 \\
\text{CH}_2\text{SH} & \quad \text{H}_2\text{N-C-S-C-NH}_2
\end{align*}
\]

b. \[
\begin{align*}
\text{CH}_3(\text{CH}_2)_4\text{SH} & \overset{[O]}{\longrightarrow} \text{CH}_3(\text{CH}_2)_4\text{S-S(CH}_2)_4\text{CH}_3
\end{align*}
\]

14.82 Draw the disulfide formed by thiol oxidation.

\[
\begin{align*}
\text{H}_2\text{N-C-H} & \overset{[O]}{\longrightarrow} \text{H}_2\text{N-C-S-S-C-NH}_2 \\
\text{CH}_2\text{SH} & \quad \text{H}_2\text{N-C-S-C-NH}_2
\end{align*}
\]

14.83 Draw the thiols formed by disulfide reduction.

a. \[
\begin{align*}
\text{CH}_3\text{S-SCH}_2\text{CH}_2\text{CH}_3 & \overset{[\text{H}]}{\longrightarrow} \text{CH}_3\text{SH} + \text{HSCH}_2\text{CH}_2\text{CH}_3
\end{align*}
\]

b. \[
\begin{align*}
\text{CH}_2=\text{CHCH}_2\text{S-SCH}_2\text{CH}_2\text{CH}_3 & \overset{[\text{H}]}{\longrightarrow} \text{CH}_2=\text{CHCH}_2\text{SH} + \text{HSCH}_2\text{CH}_2\text{CH}_3
\end{align*}
\]

14.84 Draw the thiol formed by disulfide reduction.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{S-S-SCH}_2\text{CH}_2\text{CH}_3 & \overset{[\text{H}]}{\longrightarrow} \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_2\text{CHCH}_2\text{CH}_3 \\
\text{S-S} & \quad \hat{\text{S}}\text{H} \quad \hat{\text{S}}\text{H}
\end{align*}
\]
14.85 Write a balanced equation for the combustion of diethyl ether.

\[
\text{C}_4\text{H}_9\text{O} + 6\text{O}_2 \rightarrow 4\text{CO}_2 + 5\text{H}_2\text{O}
\]

diethyl ether

14.86 Write a balanced equation for the combustion of methanol.

\[
2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}
\]

methanol

14.87 a. CFCs are chlorofluorocarbons with a general formula of CF\(_2\)Cl\(_{x}\); HCFCs have fluorine, chlorine, and hydrogen bonded to carbon; and HFCs have only hydrogen and fluorine bonded to carbon.
b. CFCs destroy the ozone layer whereas HCFCs and HFCs decompose more readily before ascending to the ozone layer.

14.88 An example of a CFC is CF\(_3\)Cl. The widespread use of CFCs has been detrimental to the environment because they destroy the ozone layer that protects earth’s surface from ultraviolet radiation.

14.89 PEG is capable of hydrogen bonding with water, so PEG is water soluble. PVC cannot hydrogen bond to water, so PVC is water insoluble, even though it has many polar bonds.

14.90

\[
\begin{align*}
\text{Halogenated ethers} \\
\text{are now used in place of diethyl ether as anesthetics because they are less flammable than diethyl ether and do not cause nausea in patients.}
\end{align*}
\]

14.91 The greater the blood alcohol level, the greater the color change from red-orange to green with the breathalyzer.

\[
\text{CH}_3\text{CH}_2\text{OH} + \text{K}_2\text{Cr}_2\text{O}_7 \rightarrow \text{CH}_3\text{COH} + \text{Cr}^{3+}
\]

14.92 2,3-Butanediol is needed to prepare 2,3-butanedione by an oxidation reaction.

\[
\begin{align*}
\text{CH}_3\text{C} = \text{C} = \text{CH}_3 + \text{[O]} & \rightarrow \text{CH}_3\text{C} = \text{C} = \text{CH}_3 \\
2,3\text{-butanediol} & \rightarrow 2,3\text{-butanedione}
\end{align*}
\]
14.93 Draw the product of the oxidation of propylene glycol.

\[
\text{propylene glycol} \xrightarrow{[O]} \text{pyruvic acid}
\]

14.94 Draw the product of the oxidation of lactic acid.

\[
\text{lactic acid} \xrightarrow{[O]} \text{pyruvic acid}
\]

14.95 Draw the oxidation products formed from ethanol. Antabuse blocks the conversion of acetaldehyde to acetic acid, and the accumulation of acetaldehyde makes people ill.

\[
\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{acetaldehyde} \xrightarrow{\text{Antabuse}} \text{acetic acid}
\]

14.96 In order to make straight hair curly, the disulfide bonds in the protein chains are reduced to free SH groups. The hair is turned around curlers and then oxidized to reform new disulfide bonds that help the hair to maintain its new curls.

14.97 Ether molecules have no H’s on O’s capable of hydrogen bonding to other ether molecules, but the hydrogens in water can hydrogen bond to the oxygen of the ether.

14.98 Figure a shows the oxygen atom of the alcohol hydrogen bonding with a hydrogen atom from water. Figure b shows the hydrogen atom of the alcohol hydrogen bonding to the oxygen atom of the water.
14.99 Answer each question about the alcohol.

a. and b. 2° alcohol

5 C's in the ring = cyclopentanol
ethyl group at C3
3-ethylcyclopentanol

c. HO-CH₂CH₃

\[ \text{H₂SO₄} \rightarrow \text{HO-CH₂CH₃} + \text{CH₂CH₃} \]

d. HO-CH₂CH₃ \[ \rightarrow \text{[O]} \] O-CH₂CH₃

e. \text{constitutional isomer}

f. HO-CH₂CH₃ \[ \text{constitutional isomer} \]

14.100 Answer each question about the alcohol.

a. 2-methyl-1-heptanol

b. 1° alcohol

c. \[ \text{CH₃CH₂CH₂CH₂CH₂CH₂CH₂CH₂OH} \rightarrow \text{CH₃CH₂CH₂CH₂CH₂CH₂C=CH₂} \]

d. \[ \text{CH₃CH₂CH₂CH₂CH₂CH₂CH₂OH} \rightarrow \text{CH₃CH₂CH₂CH₂CH₂CH₂CHCOOH} \]

e. \text{constitutional isomer}

f. \text{constitutional isomer}

14.101

a. and b. A \[ \text{CH₃CH₂CCH₂OH} \rightarrow \text{CH₃CH₂C=CH₂} \]

2-methyl-1-butene

B \[ \text{CH₃CH₂CCH₂OH} \rightarrow \text{CH₃CH₂C=CH₂} \]

2-methyl-1-butene

\[ \text{major product} \]

14.102

\[ \text{HO-CH₃} \rightarrow \text{CH₃C=CH} \]

\[ \text{CH₃} \]