23.2

1 FOCUS

Objectives

23.2.1 Identify how alcohols are classified and named.

23.2.2 Predict how the solubility of an alcohol varies with the length of its carbon chain.

23.2.3 Name the reactions of alkenes that may be used to introduce functional groups.

23.2.4 Construct the general structure of an ether and **describe** how ethers are named.

Guide for Reading

Build Vocabulary L2

Word Forms To help students relate vocabulary to concepts discussed in this section, have them distinguish between hydration and hydrogenation. Although both terms come from the same root word, hydration is the addition of water, whereas hydrogenation is the addition of hydrogen.

Reading Strategy L2

Compare and Contrast Have students write a short paragraph comparing structural formulas and space-filling models. Students should explain what information each representation best shows about a compound and what each representation does not show.

2 INSTRUCT

Connecting to Your World

Have students read the opening paragraph of the section. Ask, **Why do you think ethyl ether is no longer used as an anesthetic?** *(It causes nausea, is highly flammable, and it is difficult to control the dosage of an inhaled vapor.)*

23.2 Alcohols and Ethers

Guide for Reading

Key Concepts

- How are alcohols classified and named?
- How does the solubility of an alcohol vary with the length of its carbon chain?
- What reactions of alkenes may be used to introduce functional groups into organic molecules?
- What is the general structure of an ether and how are their alkyl groups named?

Vocabulary

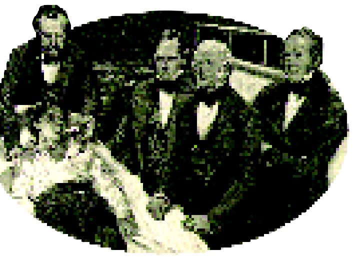
alcohol
hydroxyl group
fermentation
denatured alcohol
addition reaction
hydration reaction
hydrogenation reaction
ether

Reading Strategy

Relating Text and Visuals As you read, look carefully at the structural formulas and the space-filling models in the section. In your notebook, explain how each type of representation of a compound helps you to understand organic compounds and their functional groups.

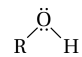
Connecting to Your World

Prior to the 1840s, patients had to endure surgery while they were fully conscious. Today, when having major surgery, a patient often receives a general anesthetic. In addition to causing the patient to lose consciousness, a general anesthetic also causes the patient's muscles to relax. The major benefit of a general anesthetic is that the patient does not experience pain during surgery. The earliest anesthetics, used during the Civil War, belonged to a class of chemical compounds called ethers. In this section, you will read about the chemical characteristics of ethers that make them good anesthetics.



Alcohols

What do mouthwash, perfume, and hairspray have in common? They all contain an alcohol of some type. An **alcohol** is an organic compound with an —OH group.



Alcohol molecule

The —OH functional group in alcohols is called a **hydroxyl group** or hydroxy function. **Aliphatic alcohols can be classified into structural categories according to the number of R groups attached to the carbon with the hydroxyl group.** If one R group is attached, the alcohol is a primary alcohol; if two R groups, a secondary alcohol; if three R groups, a tertiary alcohol. This nomenclature is summarized below.

Primary alcohol	$R-CH_2-OH$	Only one R group is attached to C—OH of a primary (abbreviated 1°) alcohol.
Secondary alcohol	$R-CH(R)-OH$	Two R groups are attached to C—OH of a secondary (2°) alcohol.
Tertiary alcohol	$R-C(R)(R)-OH$	Three R groups are attached to C—OH of a tertiary (3°) alcohol.

Checkpoint *What is an alcohol?*

Section Resources

Print

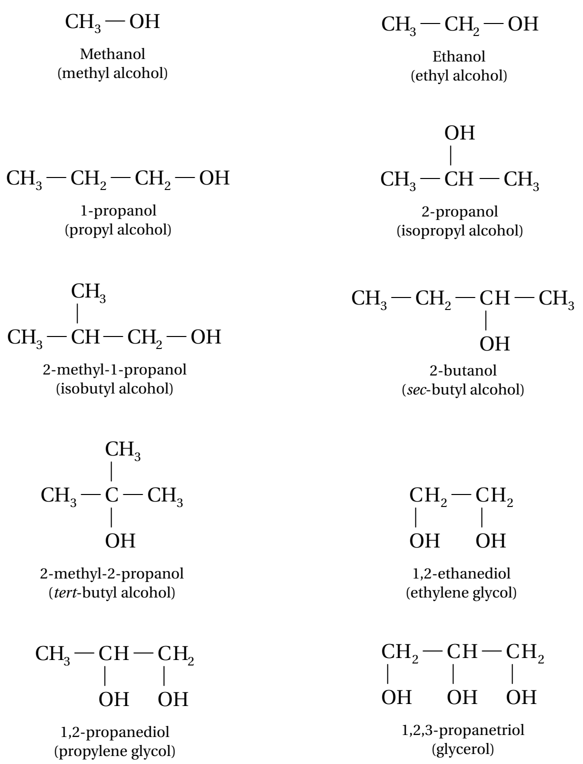
- **Guided Reading and Study Workbook,** Section 23.2
- **Core Teaching Resources,** Section 23.2 Review
- **Transparencies,** T265–T267

Technology

- **Interactive Textbook with ChemASAP,** Assessment 23.2
- **Go Online,** Section 23.2

Both IUPAC and common names are used for alcohols. **When using the IUPAC system to name continuous-chain and substituted alcohols, drop the -*e* ending of the parent alkane name and add the ending -*ol*.** The parent alkane is the longest continuous chain of carbons that includes the carbon attached to the hydroxyl group. In numbering the longest continuous chain, the position of the hydroxyl group is given the lowest possible number. Alcohols containing two, three, and four —OH substituents are named diols, triols, and tetrols, respectively.

Common names of aliphatic alcohols are written in the same way as those of the halocarbons. The alkyl group ethyl, for example, is named and followed by the word alcohol, as in ethyl alcohol. Figure 23.4 shows several products that contain ethyl alcohol. Compounds with more than one —OH substituent are called glycols. The structural formulas for some simple aliphatic alcohols along with their IUPAC and common names are shown below.



Phenols are compounds in which a hydroxyl group is attached directly to an aromatic ring. Phenol is the parent compound. Cresol is the common name for the *o*, *m*, and *p* structural isomers of methylphenol. Phenols are commonly used to make plastics, fibers, and drugs.

Go Online NSTA SciLinks
For: Links on Alcohols
Visit: www.SciLinks.org
Web Code: cdn-1232

Figure 23.4 Ethanol (ethyl alcohol) is a common component of many household products.

Alcohols

Discuss L2

Explain that many biochemically active molecules contain carbon atoms bonded to oxygen atoms. Point out that the presence of a single oxygen atom significantly alters the chemical and physical properties of a hydrocarbon. Explain that alcohols and ethers are two important classes of organic compounds that contain oxygen.

Go Online NSTA SciLinks
Download a worksheet on **Alcohols** for students to complete, and find additional teacher support from NSTA SciLinks.

Discuss L2

Discuss the IUPAC conventions for naming aliphatic alcohols. Write the condensed structural formulas of several primary, secondary, and tertiary alcohols on the board, and help students to name them. Remind students how to distinguish primary, secondary, and tertiary carbons. Write the structures of methanol, ethanol, and isopropyl alcohol on the board and point out that students already know a lot about the uses and properties of these alcohols. Help students name the structures shown and challenge them to cite everyday examples where these alcohols are used. *(Methanol is a good fuel for internal combustion engines; it is sometimes used for race cars. Methanol is also an excellent solvent, and is used for paints, shellacs, and varnishes. Ethanol is found in alcoholic beverages and is sometimes used as a gasoline additive to produce cleaner burning fuels. Isopropyl alcohol is used as an antiseptic—rubbing alcohol.)* Ask, **How does a hydroxyl group differ from a hydroxide ion?** *(The bonding between carbon and the hydroxyl group in alcohols is covalent. The bonding between a metal and the hydroxide ion in bases is ionic.)*

Properties of Alcohols

Discuss L2

Write the structure of water and the general structures of alcohols and ethers on the board. Point out that alcohols and ethers can be viewed as derivatives of water. Allow students to handle ball-and-stick and space-filling models of water, ethanol, and diethyl ether. Write the condensed structural formula for each on the board. Ask students to describe the structural similarities between all three compounds. (Students should identify the bent geometry around the oxygen atom.) Ask, **What significance does this bent shape have for the overall polarity of the molecules?** *(Each O—H and O—C bond is polar. Because the molecules are bent, the bond polarities do not cancel, and the molecules as a whole are polar. The region around the oxygen atom has a slight negative charge.)* Point out that the polar character of alcohols and ethers is tempered by the alkyl groups, which are nonpolar. Challenge students to name the important intermolecular forces holding like molecules together in each case. Ask, **How are water, ethanol, and diethyl ether ranked in order of increasing boiling point?** *(Ether, ethanol, water; ether molecules are attracted to one another by intermolecular dipolar attractions, while ethanol and water molecules have strong intermolecular hydrogen bonding.)*

TEACHER Demo

Are Alcohols Basic? L1

Purpose Students will observe that, although alcohols contain —OH groups, they are not hydroxides.

Materials Several alcohols, litmus paper

Procedure Test several alcohols with litmus paper to show that they have no basic properties.

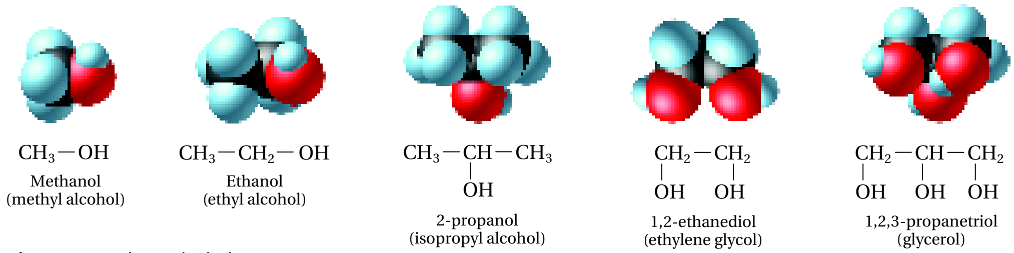


Figure 23.5 These alcohols contain one, two, or three hydroxyl groups. **Classifying** ***Which space-filling model depicts a diol? A triol?***

Properties of Alcohols

Alcohols are capable of intermolecular hydrogen bonding. Therefore, they boil at higher temperatures than alkanes and halocarbons containing comparable numbers of atoms.

Because alcohols are derivatives of water (the hydroxyl group is part of a water molecule), they are somewhat soluble. **Alcohols of up to four carbons are soluble in water in all proportions. The solubility of alcohols with four or more carbons in the chain is usually much lower.** This is because alcohols consist of two parts: the carbon chain and the hydroxyl group. The carbon chain is nonpolar and is not attracted to water. The hydroxyl group is polar and strongly interacts with water through hydrogen bonding. For alcohols of up to four carbons, the polarity of the hydroxyl group is more significant than the nonpolarity of the carbon chain. Thus, these alcohols are soluble in water. As the number of carbon atoms increases above four, however, the nonpolarity of the chain becomes more significant, and the solubility decreases.

Many aliphatic alcohols are used in laboratories, clinics, and industry as shown in Figure 23.6. Isopropyl alcohol (IUPAC: 2-propanol), which is more familiarly known as rubbing alcohol, is a colorless, somewhat odorless liquid (bp 82°C) often used as an antiseptic. It is also used as a base for perfumes, creams, lotions, and other cosmetics. Ethylene glycol (IUPAC: 1,2-ethanediol) is the principal ingredient of certain antifreezes. Its boiling point is 197°C. Its advantages over other liquids with high boiling points are its solubility in water and its freezing point of −17.4°C. If water is added to ethylene glycol, the mixture freezes at an even lower temperature. For example, a 50% (v/v) aqueous solution of ethylene glycol freezes at −36°C. Another aliphatic alcohol, glycerol (IUPAC: 1,2,3-propanetriol), is a viscous, sweet-tasting, water-soluble liquid used as a moistening agent in cosmetics, foods, and drugs. Glycerol is also an important component of fats and oils, which you will learn about in Chapter 24.

Figure 23.6 Aliphatic alcohols are used in many common household products. (a) Isopropyl alcohol is an effective antiseptic. (b) Ethylene glycol is the main ingredient in antifreeze. (c) Many cosmetic products contain glycerol. **Applying Concepts** ***How does antifreeze prevent the water in a car's radiator from freezing at 0°C and boiling at 100°C?***

Facts and Figures

Antifreeze Poisoning

Every year, about 10,000 dogs and cats are victims of accidental poisoning by automobile antifreeze. A pet does not have to drink a lot of antifreeze to be poisoned. Most brands of commercial antifreeze consist of 95 percent ethylene glycol, an extremely toxic chemical. Even a few licks of this sweet-tasting liquid can be fatal to a cat or dog. For a medium-sized dog, ingestion of about 3 to 4 tablespoons of antifreeze is toxic. For cats, as little as 1 to 2 teaspoons can be lethal. Antifreeze poisoning commonly occurs in spring and fall when car owners replace the old antifreeze in their car radiators with fresh antifreeze. However, poisoning can happen anytime, particularly when a car boils over or when a hose leaks, releasing the antifreeze.

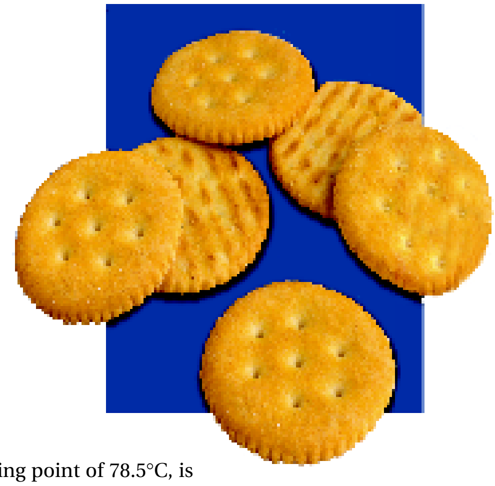


Figure 23.7 Cracker and bread dough are both made primarily of flour and water, but bread dough also contains yeast. Carbon dioxide, a product of sugar fermentation by yeast, causes bread to rise. **Inferring** ***What happens to the ethanol that is also produced?***

Ethyl alcohol (IUPAC: ethanol), which has a boiling point of 78.5°C, is also called grain alcohol. It is an important industrial chemical. Most ethanol is still produced by yeast fermentation of sugar. **Fermentation** is the production of ethanol from sugars by the action of yeast or bacteria. The bread shown in Figure 23.7 is different from the crackers because of fermentation. The enzymes of the yeast or bacteria serve as catalysts for the transformation. The breakdown of the sugar glucose ($C_6H_{12}O_6$) is an important fermentation reaction.

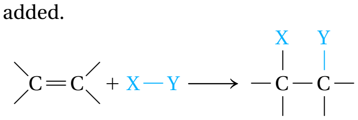
$$\underset{\text{Glucose}}{C_6H_{12}O_6(aq)} \longrightarrow \underset{\text{Ethanol}}{2CH_3CH_2OH(aq)} + \underset{\text{Carbon dioxide}}{2CO_2(g)}$$

Ethanol is the intoxicating substance in alcoholic beverages. It is a depressant that can be fatal if taken in large doses at once. Over time, continuous abuse of alcoholic beverages can damage the liver, which can lead to death.

The ethanol used in industrial applications is denatured. **Denatured alcohol** is ethanol with an added substance to make it toxic (poisonous). That added substance, or denaturant, is often methyl alcohol (IUPAC: methanol). Methyl alcohol is sometimes called wood alcohol because, prior to 1925, it was prepared by the distillation of wood. Wood alcohol is extremely toxic. As little as 10 mL has been reported to cause permanent blindness, and as little as 30 mL has been known to cause death.

Addition Reactions

The carbon–carbon single bonds in alkanes are not easy to break. In an alkene, however, one of the bonds in the double bond is somewhat weaker and thus is easier to break than a carbon–carbon single bond. So it is sometimes possible for a compound of general structure X—Y to add to a double bond. In an **addition reaction,** a substance is added at the double or triple bond of an alkene or alkyne. **Addition reactions of alkenes are an important method of introducing new functional groups into organic molecules.** In the general reaction shown below, X and Y represent the two parts of the compound that are added.



CLASS Activity

Household Products with Alcohols L2

Bring household products that contain alcohols to class. Read the name of the alcohol given on each label, and help students to write the structure for each alcohol. Explain why alcohols are used in so many commercial products. *(Because alcohols have both polar and nonpolar characteristics, and are capable of forming hydrogen bonds, they make excellent solvents for a wide variety of polar and nonpolar compounds.)*

TEACHER Demo

Aqueous Solubility of Alcohols L2

Purpose Students will observe the aqueous solubilities of alcohols and glycols.

Materials 10 or 15 test tubes with stoppers, distilled water, ethanol, 1-butanol, 1-hexanol, 1-octanol, a hexanediol

Procedure Prepare two or three sets of 5 test tubes, labeled 1 to 5, each containing a small volume of distilled water and an equal volume of ethanol, 1-butanol, 1-hexanol, 1-octanol, and a hexanediol. Stopper the tubes securely. Instruct students to mix the contents of each tube and allow the mixture to settle. Have students record their observations and describe any trends. Students should generalize about the aqueous solubility of straight–chain alcohols and about the role that —OH groups play in this solubility.

Expected Outcome Students should observe that the solubilities of the alcohols decrease as the alkyl chains increase in length.

Differentiated Instruction

Gifted and Talented L3

Have students research the role of microorganisms in fermentation processes and fermentation as a cellular process that extracts energy from glucose in the absence of oxygen. Have students design a simple experiment to show that fermentation can take place when the starting ingredient is table sugar (sucrose) rather than glucose.

Less Proficient Readers L1

Students may not understand why breaking one of the bonds in a double bond opens up two bonding sites. Have them count the number of bonds each carbon atom can form after the double bond has been broken. Remind them that each carbon atom can form single bonds with four other atoms. Therefore, one atom may be added to each carbon involved.

Answers to...

Figure 23.5 Ethylene glycol is a diol; glycerol is a triol.
Figure 23.6 A nonvolatile solute depresses water's freezing point and elevates its boiling point.
Figure 23.7 It evaporates.

Section 23.2 (continued)

Addition Reactions

Use Visuals L1

Figure 23.8 Direct students to study the figure. Ask, **If the orange color remains, what would you conclude about the sample?** *(The sample is saturated.)* Remind students that a double or triple bond is more reactive than a single covalent bond. Write the equation for the addition of Br_2 to 2-butene on the board. Explain that when a molecule containing a double bond reacts, one of the bonds in the double bond is broken. This reaction opens up two bonding sites, one on each of the carbon atoms that previously shared the double bond. Explain that the addition of molecules to alkenes makes it possible for chemists to synthesize a large variety of compounds, including polymers.

TEACHER Demo

Test for Unsaturation L2

Purpose Students will observe the reactions of alkenes and alkynes with oxidizing agents such as potassium permanganate. This reaction can be used to test for unsaturated compounds.

Materials $KMnO_4$, NaOH, distilled water, cyclohexane, cyclohexene, 2 test tubes with stoppers

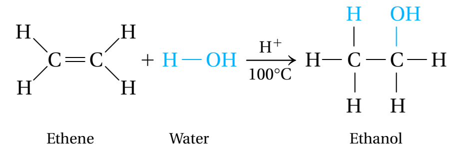
Procedure Prepare an alkaline solution of potassium permanganate by dissolving 0.1 g $KMnO_4$ and 15 g NaOH in 100 mL distilled water. Put 12 mL cyclohexane in one test tube and 12 mL cyclohexene in a second test tube. Add 1 mL of the alkaline permanganate solution to each. Stopper and shake. The general equation for the reaction of permanganate with an unsaturated hydrocarbon is

$$R{-}RCH{=}CH{-}R + MnO_4^- \rightarrow$$
$$R{-}CHOH{-}CHOH{-}R + MnO_2$$

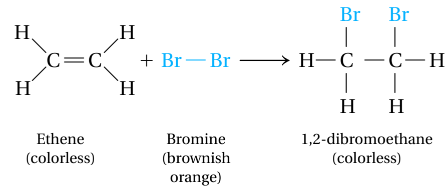
Expected Outcomes The decolorization of cyclohexene indicates the presence of a double or triple bond. Cyclohexane does not decolorize.

Figure 23.8 Bromine can be used to identify unsaturated compounds. **a** Bromine has a brownish-orange color. **b** A few drops of bromine solution are added to an unsaturated organic compound. **c** The bromine reacts to form a colorless halocarbon.

The addition of water to an alkene is a **hydration reaction.** Hydration reactions usually occur when the alkene and water are heated to about 100°C in the presence of a trace of strong acid. The acid, usually hydrochloric acid or sulfuric acid, serves as a catalyst for the reaction. The addition of water to ethene, the equation for which is shown below, is a typical hydration reaction. The parts of ethanol that come from the addition of water are shown in blue.

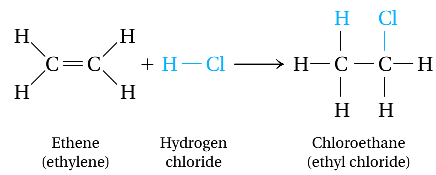


When the reagent X—Y is a halogen molecule such as chlorine or bromine, the product of the reaction is a disubstituted halocarbon. The addition of bromine to ethene to form the disubstituted halocarbon 1,2-dibromoethane is an example.



The addition of bromine to carbon–carbon multiple bonds is often used as a chemical test for unsaturation in an organic molecule. Bromine has a brownish-orange color, but most organic compounds of bromine are colorless. The test for unsaturation is performed by adding a few drops of a 1% solution of bromine in carbon tetrachloride (CCl_4) to the suspected alkene. As Figure 23.8 shows, the loss of the orange color is a positive test for unsaturation. If the orange color remains, the sample is completely saturated.

Hydrogen halides, such as HBr or HCl, also can add to a double bond. Because the product contains only one substituent, it is called a monosubstituted halocarbon. The addition of hydrogen chloride to ethene is an example.



The addition of hydrogen to a carbon–carbon double bond to produce an alkane is called a **hydrogenation reaction.** Hydrogenation reactions usually require a catalyst. Finely divided platinum (Pt) or palladium (Pd) is often used. The manufacture of margarine from unsaturated vegetable oils is a common application of a hydrogenation reaction. Adding hydrogen to unsaturated oils results in the formation of saturated fats that have higher melting points than the unsaturated oils and remain solid at room temperature.

Facts and Figures

Trans Fats

Trans fats are produced through hydrogenation, the chemical process by which hydrogen is added to unsaturated fatty acids in vegetable oil. Hydrogenation converts the unsaturated bonds in the oil to saturated bonds, creating margarine—a solid, spreadable fat with increased shelf life. Although hydrogenation eliminates some double bonds, it transforms others from the natural *cis* configuration to the *trans* configuration. Research indicates that eating trans fats is associated with an increased risk for heart disease.

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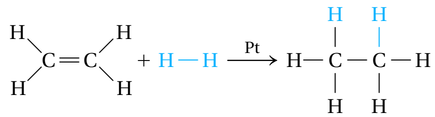
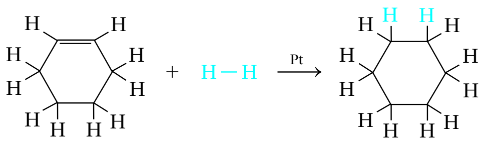
The hydrogenation of a double bond is a reduction reaction. In the examples below, ethene is reduced to ethane, and cyclohexene is reduced to cyclohexane.

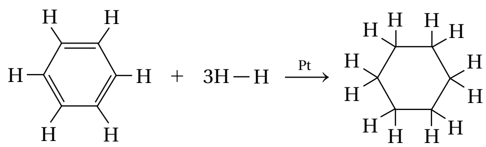


Ethene (ethylene) | Hydrogen | Ethane



Cyclohexene | Hydrogen | Cyclohexane

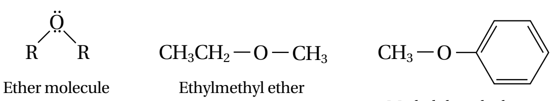
Under normal conditions, benzene resists hydrogenation. It also resists the addition of a halogen or a hydrogen halide. Under conditions of high temperatures and high pressures of hydrogen, and with certain catalysts however, three molecules of hydrogen gas can reduce one molecule of benzene to form one molecule of cyclohexane.



Benzene | Hydrogen | Cyclohexane

Ethers

Another class of organic compounds may sound familiar to you—ethers. An **ether** is a compound in which oxygen is bonded to two carbon groups. **The general structure of an ether is R—O—R. The alkyl groups attached to the ether linkage are named in alphabetical order and are followed by the word *ether*.**



Ether molecule | Ethylmethyl ether | Methylphenyl ether (anisole)

Some ethers, such as ethylmethyl ether and methylphenyl ether, are nonsymmetric. This is because the R groups attached to the ether oxygen are different. When both R groups are the same, the ether is symmetric. Symmetric ethers are named by using the prefix *di-*. Sometimes, however, the prefix *di-* is dropped and a compound such as diethyl ether is simply called ethyl ether. Figure 23.9 shows examples of a nonsymmetric ether and a symmetric ether.

Checkpoint ***What is an ether?***

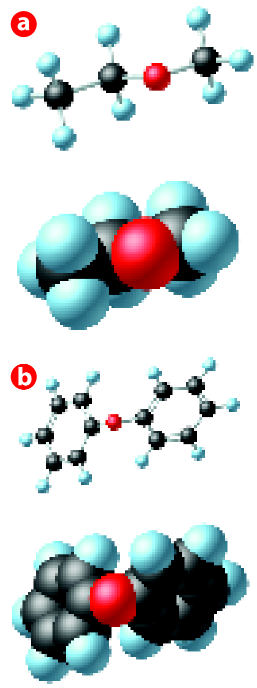


Figure 23.9 Ethers are either nonsymmetric or symmetric. **a** Ethylmethyl ether is an example of a nonsymmetric ether. **b** Diphenyl ether is a symmetric ether. Both space-filling and ball-and-stick models of each ether are shown. **Interpreting Visuals** ***Describe the differences between a nonsymmetric ether and a symmetric ether.***

Discuss — L2

Write several examples of addition reactions on the board and help students predict the structure of the expected product in each case.

Ethers

Use Visuals — L1

Figure 23.9 Have students study the models in the figure. Write the structures for these molecules on the board and describe the molecular structure of ethers. Point out that ethers are slightly polar due to the bent geometry around the oxygen atom. Ask, **Are ethers more or less soluble in water than alkanes of similar size?** *(Ethers are generally more soluble due to their ability to participate in hydrogen bonding with water.)* **Would you expect an ether named butyl ether to be symmetric or nonsymmetric? How do you know?** *(Symmetric, the prefix* di- *is often dropped when naming symmetric ethers.)* Discuss the naming of ethers using a number of specific examples. Explain that because ethers contain nonpolar and polar regions and because they are very inert to most chemical reagents, they make excellent solvents for reactions involving nonpolar and polar organic compounds.

Facts and Figures

Ethers as Solvents

Ethers are used as nonpolar solvents to extract natural products such as lipids. Low molar-mass ethers are partially soluble in water due to the ability of the oxygen atoms in the ether functional groups to form hydrogen bonds with water molecules. Solubility in water decreases as the mass of the carbon groups increases.

Answers to...

Figure 23.9 A nonsymmetric ether contains two different alkyl groups; a symmetric ether contains two identical alkyl groups.

Checkpoint a compound in which oxygen is bonded to two carbon groups.

Discuss L2

Ask students whether it is possible to have a compound that contains both ether and alcohol functional groups. *(Yes, 4-methoxy-2-butanol is an example.)*

3 ASSESS

Evaluate Understanding L2

Have students draw the structural formulas for 3-pentanol, 2-methyl-2-butanol, 1-heptanol, ethylpropyl ether, and diphenyl ether. Have them classify each alcohol as primary, secondary, or tertiary. Have students name and describe a chemical test for unsaturation in an organic molecule. Have them write the chemical equation for the reaction. Write the structure for 2-butanol on the board and ask, **What reactants could a chemist use to prepare this compound?** *(2-butene and aqueous acid)*

Reteach L1

Using the reactions given in this section, point out that the two atoms being added to double-bonded carbons in an alkene can be identical or they can be different. In hydrogenation, the atoms added are the same. When HCl reacts with an alkene to produce an alkyl chloride or when water and an alkene react to produce an alcohol, the atoms added are different.

Writing Activity

Engines knock when gasoline burns too soon or too quickly. MTBE replaced tetraethyl lead as an anti-knocking additive. MTBE from leaking storage tanks and fuel spills contaminates groundwater.

Interactive Textbook

If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 23.2.

with ChemASAP

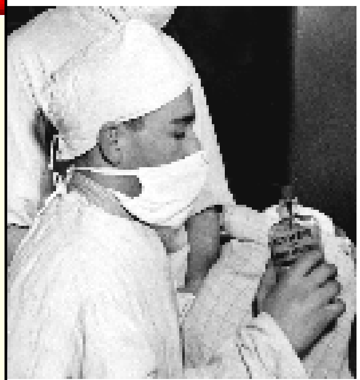
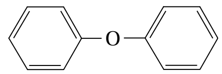


Figure 23.10 Diethyl ether is a dangerous, highly flammable liquid. It is usually stored in metal cans to keep it away from direct sunlight.

Diethyl ether, a volatile liquid (bp 35°C) shown in Figure 23.10, was the first reliable general anesthetic. Originally reported in 1849 by Crawford W. Long, an American physician, diethyl ether was used by doctors for more than a century.

$$CH_3CH_2—O—CH_2CH_3$$

Diethyl ether
(ethyl ether)



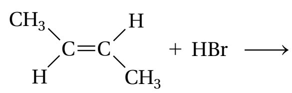
Diphenyl ether
(phenyl ether)

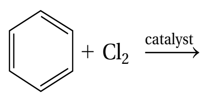
Diethyl ether has been replaced by other anesthetics such as halothane because it is highly flammable and often causes nausea.

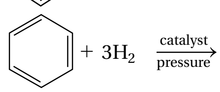
Ethers usually have lower boiling points than alcohols of comparable molar mass. They have higher boiling points than comparable hydrocarbons and halocarbons. Ethers are more soluble in water than hydrocarbons and halocarbons, but less soluble than alcohols. This is because the oxygen atom in an ether is a hydrogen acceptor. Ethers have no hydroxyl hydrogen atoms to donate in hydrogen bonding. Ethers, therefore, form more hydrogen bonds than hydrocarbons and halocarbons but fewer hydrogen bonds than alcohols.

23.2 Section Assessment

7. **Key Concept** How are alcohols classified and named?
8. **Key Concept** How does the solubility of alcohols vary with the length of the carbon chains?
9. **Key Concept** How can functional groups be introduced into organic molecules?
10. **Key Concept** Write the general structure for an ether and explain how ethers are named.
11. Give the structure for the expected organic product from each of the following reactions.

a. 

b. 

c. 

12. Write the common names for the following compounds.

a. $CH_3CH_2CHCH_3$ (with OH on C-2)   **b.** CH_3CHCH_2OH (with CH_3 on C-2)

c. $CH_3CH_2OCH_2CH_3$

d. $CH_3CH_2CH_2OCH_2CH_2CH_2CH_3$

Writing Activity

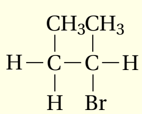
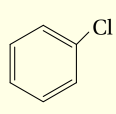
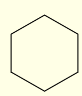
Portfolio Project Research and write a report on methyl-*tert*-butyl ether (MTBE), which is a gasoline additive. Find out why MTBE was introduced and why there are now efforts to limit its use.

Interactive Textbook

Assessment 23.2 Check your understanding of the important ideas and concepts in Section 23.2.

with ChemASAP

Section 23.2 Assessment

7. Alcohols are classified as primary (1°), secondary (2°), or tertiary (3°). They are named by dropping the *-e* ending of the parent alkane name and adding the ending *-ol*.
8. Alcohols are soluble in water when the carbon chain of the alcohol contains four or fewer carbons. The solubility of longer chain alcohols is much lower.
9. by addition or substitution reactions
10. R—O—R; list the alkyl groups attached to the ether linkage in alphabetical order and add *ether*.
11. **a.**  **b.**  **c.** 
12. **a.** *sec*-butyl alcohol **b.** isobutyl alcohol
c. diethyl ether (ethyl ether)
d. butylpropyl ether