2.4: Naming Covalent Compounds

Learning Objectives

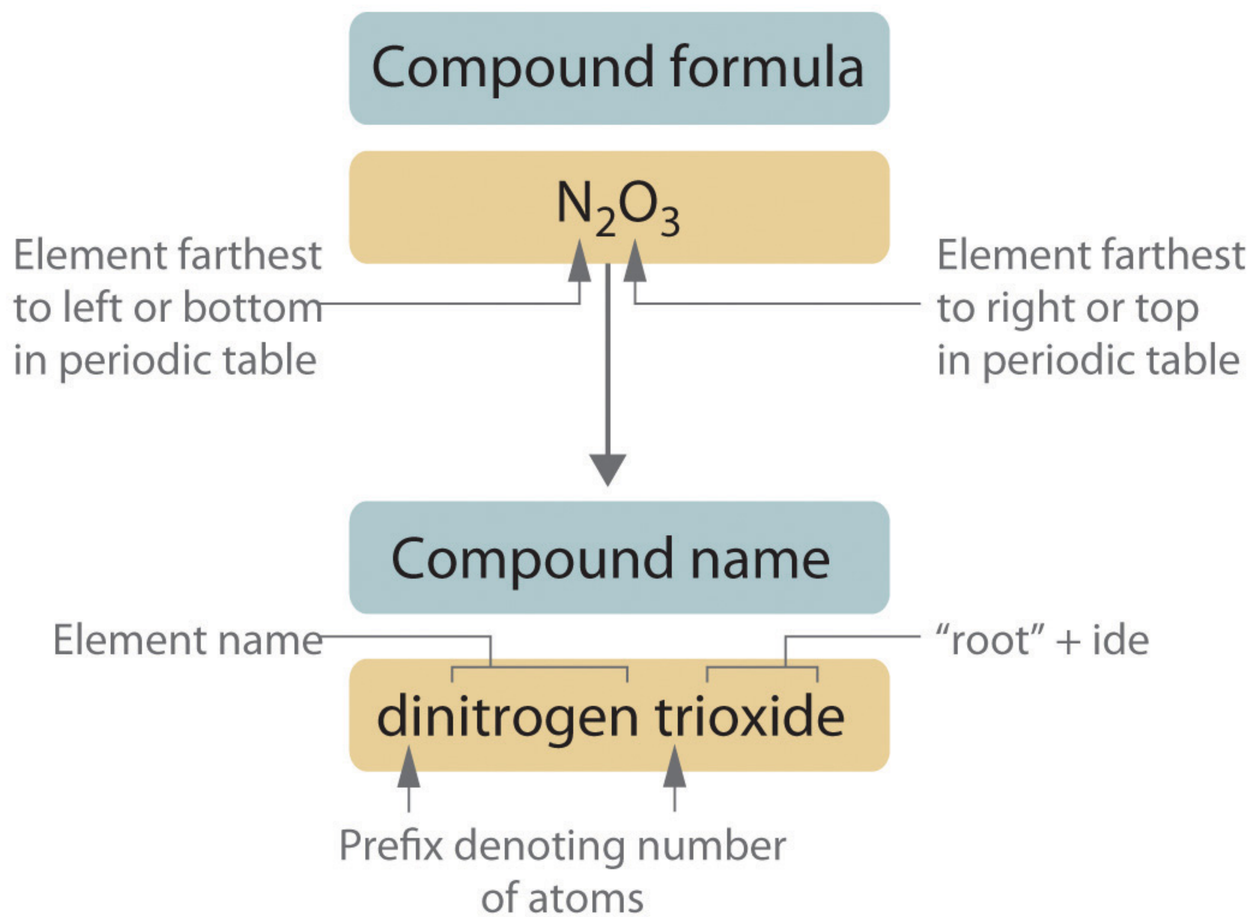
- To name covalent compounds that contain up to three elements.

As with ionic compounds, the system that chemists have devised for naming covalent compounds enables us to write the molecular formula from the name and vice versa. In this and the following section, we describe the rules for naming simple covalent compounds. We begin with inorganic compounds and then turn to simple organic compounds that contain only carbon and hydrogen.

Binary Inorganic Compounds

Binary covalent compounds—that is, covalent compounds that contain only two elements—are named using a procedure similar to that used to name simple ionic compounds, but prefixes are added as needed to indicate the number of atoms of each kind. The procedure, diagrammed in Figure $2.4.1$, uses the following steps:

Figure $2.4.1$*Naming a Covalent Inorganic Compound*



1. Place the elements in their proper order.
    1. The element farthest to the left in the periodic table is usually named first. If both elements are in the same group, the element closer to the bottom of the column is named first.
    2. The second element is named as if it were a monatomic anion in an ionic compound (even though it is not), with the suffix -*ide* attached to the root of the element name.
2. Identify the number of each type of atom present.

1. Prefixes derived from Greek stems are used to indicate the number of each type of atom in the formula unit (Table 2.4.1). The prefix *mono-* (“one”) is used only when absolutely necessary to avoid confusion, just as we omit the subscript 1 when writing molecular formulas.

   To demonstrate steps 1 and 2a, we name HCl as hydrogen chloride (because hydrogen is to the left of chlorine in the periodic table) and PCl_5 as phosphorus pentachloride. The order of the elements in the name of BrF_3, bromine trifluoride, is determined by the fact that bromine lies below fluorine in group 17.

   Table 2.4.1 Prefixes for Indicating the Number of Atoms in Chemical Names

Prefix	Number
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8
nona-	9
deca-	10
undeca-	11
dodeca-	12

2. If a molecule contains more than one atom of both elements, then prefixes are used for both. Thus N_2O_3 is *di*nitrogen *tri*oxide, as shown in Figure 2.4.1.
3. In some names, the final *a* or *o* of the prefix is dropped to avoid awkward pronunciation. Thus OsO_4 is osmium tetroxide rather than osmium tetraoxide.

3. Write the name of the compound.
   1. Binary compounds of the elements with oxygen are generally named as “element oxide,” with prefixes that indicate the number of atoms of each element per formula unit. For example, CO is carbon monoxide. The only exception is binary compounds of oxygen with fluorine, which are named as oxygen fluorides. (The reasons for this convention will become clear in Chapter 7 and Chapter 8.)
   2. Certain compounds are *always* called by the common names that were assigned long ago when names rather than formulas were used. For example, H_2O is water (not dihydrogen oxide); NH_3 is ammonia; PH_3 is phosphine; SiH_4 is silane; and B_2H_6, a *dimer* of BH_3, is diborane. For many compounds, the systematic name and the common name are both used frequently, so you must be familiar with them. For example, the systematic name for NO is nitrogen monoxide, but it is much more commonly called nitric oxide. Similarly, N_2O is usually called nitrous oxide rather than dinitrogen monoxide. Notice that the suffixes *-ic* and *-ous* are the same ones used for ionic compounds.

Note the Pattern

Start with the element at the far left in the periodic table and work to the right. If two or more elements are in the same group, start with the bottom element and work up.

Example 2.4.1

Write the name of each binary covalent compound.

1. SF_6
2. N_2O_4
3. ClO_2

Given: molecular formula

Asked for: name of compound

Strategy:

A List the elements in order according to their positions in the periodic table. Identify the number of each type of atom in the chemical formula and then use Table $2.4.1$ to determine the prefixes needed.

B If the compound contains oxygen, follow step 3a. If not, decide whether to use the common name or the systematic name.

Solution

1. **A** Because sulfur is to the left of fluorine in the periodic table, sulfur is named first. Because there is only one sulfur atom in the formula, no prefix is needed. **B** There are, however, six fluorine atoms, so we use the prefix for six: *hexa-* (Table $2.4.1$). The compound is sulfur hexafluoride.
2. **A** Because nitrogen is to the left of oxygen in the periodic table, nitrogen is named first. Because more than one atom of each element is present, prefixes are needed to indicate the number of atoms of each. According to Table $2.4.1$, the prefix for two is *di-*, and the prefix for four is *tetra-*. **B** The compound is dinitrogen tetroxide (omitting the *a* in *tetra-* according to step 2c) and is used as a component of some rocket fuels.
3. **A** Although oxygen lies to the left of chlorine in the periodic table, it is not named first because ClO_2 is an oxide of an element other than fluorine (step 3a). Consequently, chlorine is named first, but a prefix is not necessary because each molecule has only one atom of chlorine. **B** Because there are two oxygen atoms, the compound is a dioxide. Thus the compound is chlorine dioxide. It is widely used as a substitute for chlorine in municipal water treatment plants because, unlike chlorine, it does not react with organic compounds in water to produce potentially toxic chlorinated compounds.

Exercise 2.4.1

Write the name of each binary covalent compound.

1. IF_7
2. N_2O_5
3. OF_2

Answer

1. iodine heptafluoride
2. dinitrogen pentoxide
3. oxygen difluoride

Example 2.4.2

Write the formula for each binary covalent compound.

1. sulfur trioxide
2. diiodine pentoxide

Given: name of compound

Asked for: formula

Strategy:

List the elements in the same order as in the formula, use Table 2.4.1 to identify the number of each type of atom present, and then indicate this quantity as a subscript to the right of that element when writing the formula.

Solution

1. Sulfur has no prefix, which means that each molecule has only one sulfur atom. The prefix *tri*- indicates that there are three oxygen atoms. The formula is therefore SO_3. Sulfur trioxide is produced industrially in huge amounts as an intermediate in the synthesis of sulfuric acid.
2. The prefix *di*- tells you that each molecule has two iodine atoms, and the prefix *penta*- indicates that there are five oxygen atoms. The formula is thus I_2O_5, a compound used to remove carbon monoxide from air in respirators.

? Exercise 2.4.2

Write the formula for each binary covalent compound.

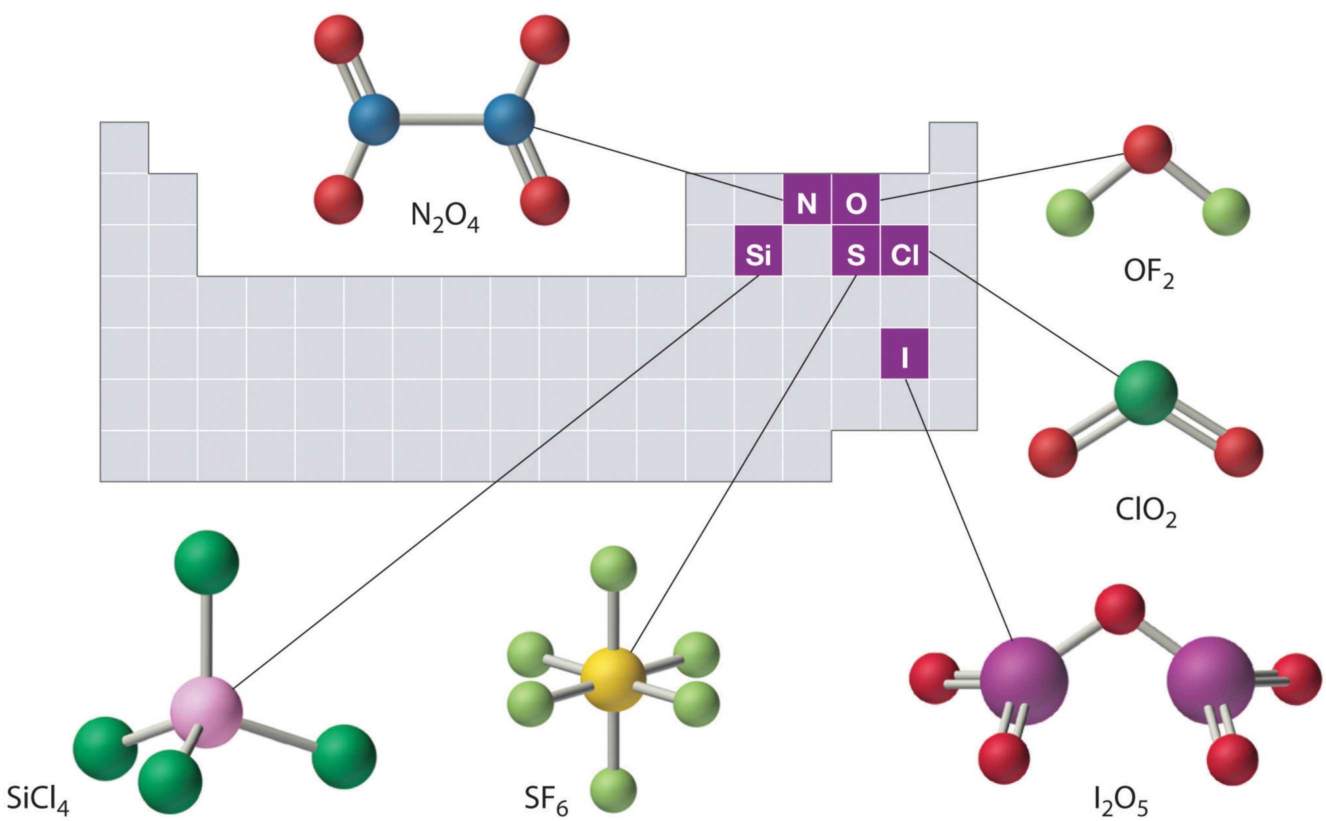
1. silicon tetrachloride
2. disulfur decafluoride

Answer

1. $SiCl_4$
2. S_2F_{10}

The structures of some of the compounds in Example 8 and Example 9 are shown in Figure 2.4.2 along with the location of the "central atom" of each compound in the periodic table. It may seem that the compositions and structures of such compounds are entirely random, but this is not true. After you have mastered the material in Chapter 7 and Chapter 8, you will be able to predict the compositions and structures of compounds of this type with a high degree of accuracy.

Figure 2.4.2 *The Structures of Some Covalent Inorganic Compounds and the Locations of the "Central Atoms" in the Periodic Table*



The compositions and structures of covalent inorganic compounds are not random. As you will learn in Chapter 7 and Chapter 8, they can be predicted from the locations of the component atoms in the periodic table.

Hydrocarbons

Approximately one-third of the compounds produced industrially are organic compounds. All living organisms are composed of organic compounds, as is most of the food you consume, the medicines you take, the fibers in the clothes you wear, and the plastics in the materials you use. Section 2.1 introduced two organic compounds: methane (CH_4) and methanol (CH_3OH). These and other organic compounds appear frequently in discussions and examples throughout this text.

The detection of organic compounds is useful in many fields. In one recently developed application, scientists have devised a new method called "material degradomics" to make it possible to monitor the degradation of old books and historical documents. As paper ages, it produces a familiar "old book smell" from the release of organic compounds in gaseous form. The composition of the gas depends on the original type of paper used, a book's binding, and the applied media. By analyzing these organic gases and isolating the individual components, preservationists are better able to determine the condition of an object and those books and documents most in need of immediate protection.

The simplest class of organic compounds is the **hydrocarbons**, which consist entirely of carbon and hydrogen. Petroleum and natural gas are complex, naturally occurring mixtures of many different hydrocarbons that furnish raw materials for the chemical industry. The four major classes of hydrocarbons are the **alkanes**, which contain only carbon–hydrogen and carbon–carbon single bonds; the **alkenes**, which contain at least one carbon–carbon double bond; the **alkynes**, which contain at least one carbon–carbon triple bond; and the **aromatic hydrocarbons**, which usually contain rings of six carbon atoms that can be drawn with alternating single and double bonds. Alkanes are also called *saturated* hydrocarbons, whereas hydrocarbons that contain multiple bonds (alkenes, alkynes, and aromatics) are *unsaturated*.

Alkanes

The simplest alkane is methane (CH_4), a colorless, odorless gas that is the major component of natural gas. In larger alkanes whose carbon atoms are joined in an unbranched chain (*straight-chain alkanes*), each carbon atom is bonded to at most two other carbon atoms. The structures of two simple alkanes are shown in *Figure* 2.4.3, and the names and condensed structural formulas for the first 10 straight-chain alkanes are in Table 2.4.2. The names of all alkanes end in *-ane*, and their boiling points increase as the number of carbon atoms increases.

Figure 2.4.3 *Straight-Chain Alkanes with Two and Three Carbon Atoms*

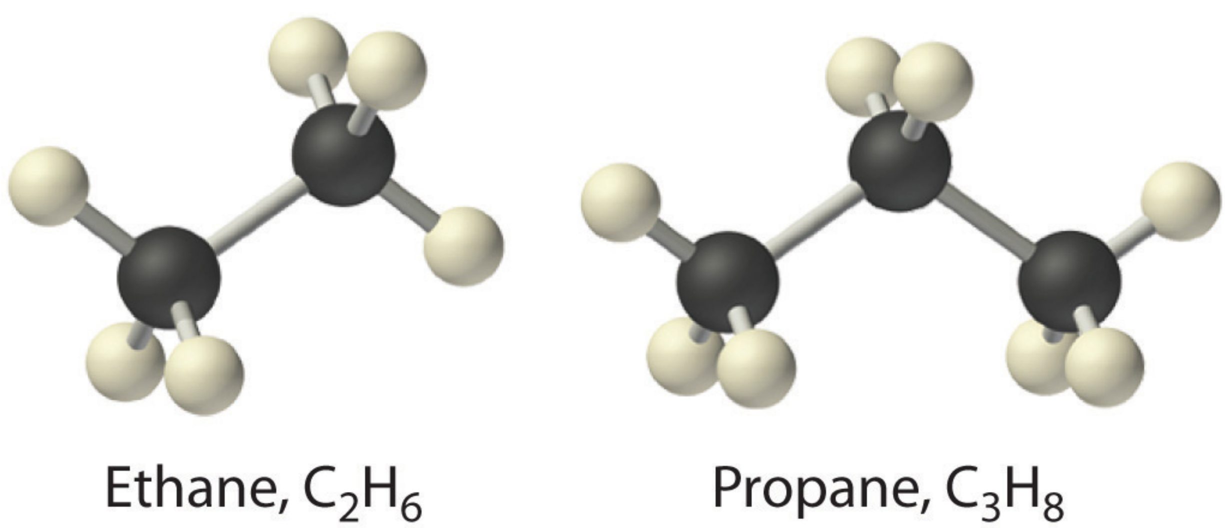
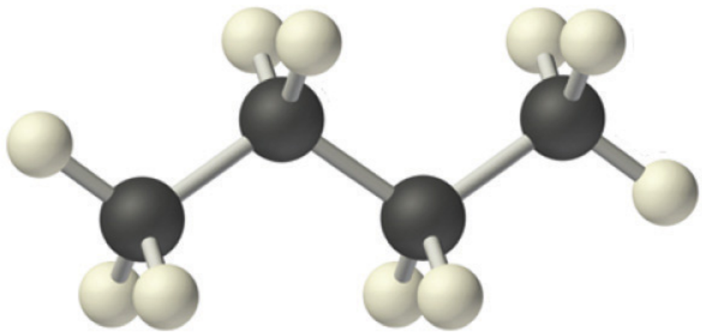


Table 2.4.2The First 10 Straight-Chain Alkanes

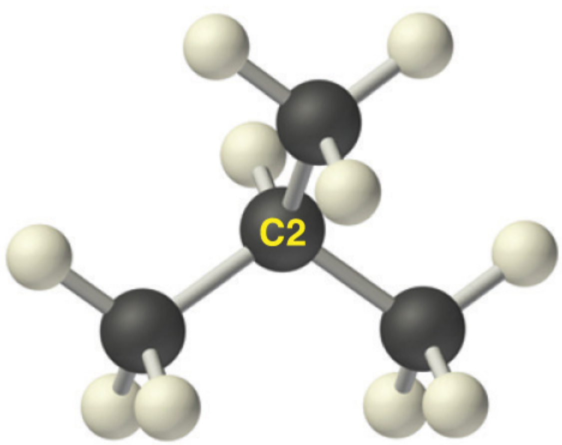
Name	Number of Carbon Atoms	Molecular Formula	Condensed Structural Formula	Boiling Point (°C)	Uses

Name	Number of Carbon Atoms	Molecular Formula	Condensed Structural Formula	Boiling Point (°C)	Uses
methane	1	CH_4	CH_4	−162	natural gas constituent
ethane	2	C_2H_6	CH_3CH_3	−89	natural gas constituent
propane	3	C_3H_8	$CH_3CH_2CH_3$	−42	bottled gas
butane	4	C_4H_{10}	$CH_3CH_2CH_2CH_3$ or $CH_3(CH_2)_2CH_3$	0	lighters, bottled gas
pentane	5	C_5H_{12}	$CH_3(CH_2)_3CH_3$	36	solvent, gasoline
hexane	6	C_6H_{14}	$CH_3(CH_2)_4CH_3$	69	solvent, gasoline
heptane	7	C_7H_{16}	$CH_3(CH_2)_5CH_3$	98	solvent, gasoline
octane	8	C_8H_{18}	$CH_3(CH_2)_6CH_3$	126	gasoline
nonane	9	C_9H_{20}	$CH_3(CH_2)_7CH_3$	151	gasoline
decane	10	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	174	kerosene

Alkanes with four or more carbon atoms can have more than one arrangement of atoms. The carbon atoms can form a single unbranched chain, or the primary chain of carbon atoms can have one or more shorter chains that form branches. For example, butane (C_4H_{10}) has two possible structures. *Normal* butane (usually called *n*-butane) is $CH_3CH_2CH_2CH_3$, in which the carbon atoms form a single unbranched chain. In contrast, the condensed structural formula for *isobutane* is $(CH_3)_2CHCH_3$, in which the primary chain of three carbon atoms has a one-carbon chain branching at the central carbon. Three-dimensional representations of both structures are as follows:

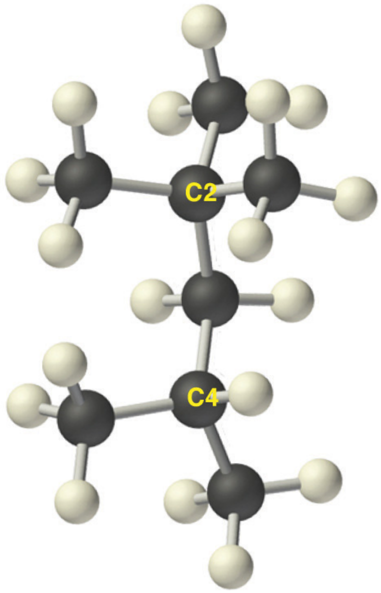


n-Butane, C_4H_{10}



Isobutane (2-methylpropane), C_4H_{10}

The systematic names for branched hydrocarbons use the lowest possible number to indicate the position of the branch along the longest straight carbon chain in the structure. Thus the systematic name for isobutane is 2-methylpropane, which indicates that a methyl group (a branch consisting of $–CH_3$) is attached to the second carbon of a propane molecule. Similarly, you will learn in Section 2.6 that one of the major components of gasoline is commonly called isooctane; its structure is as follows:



Isooctane (2,2,4-trimethylpentane)

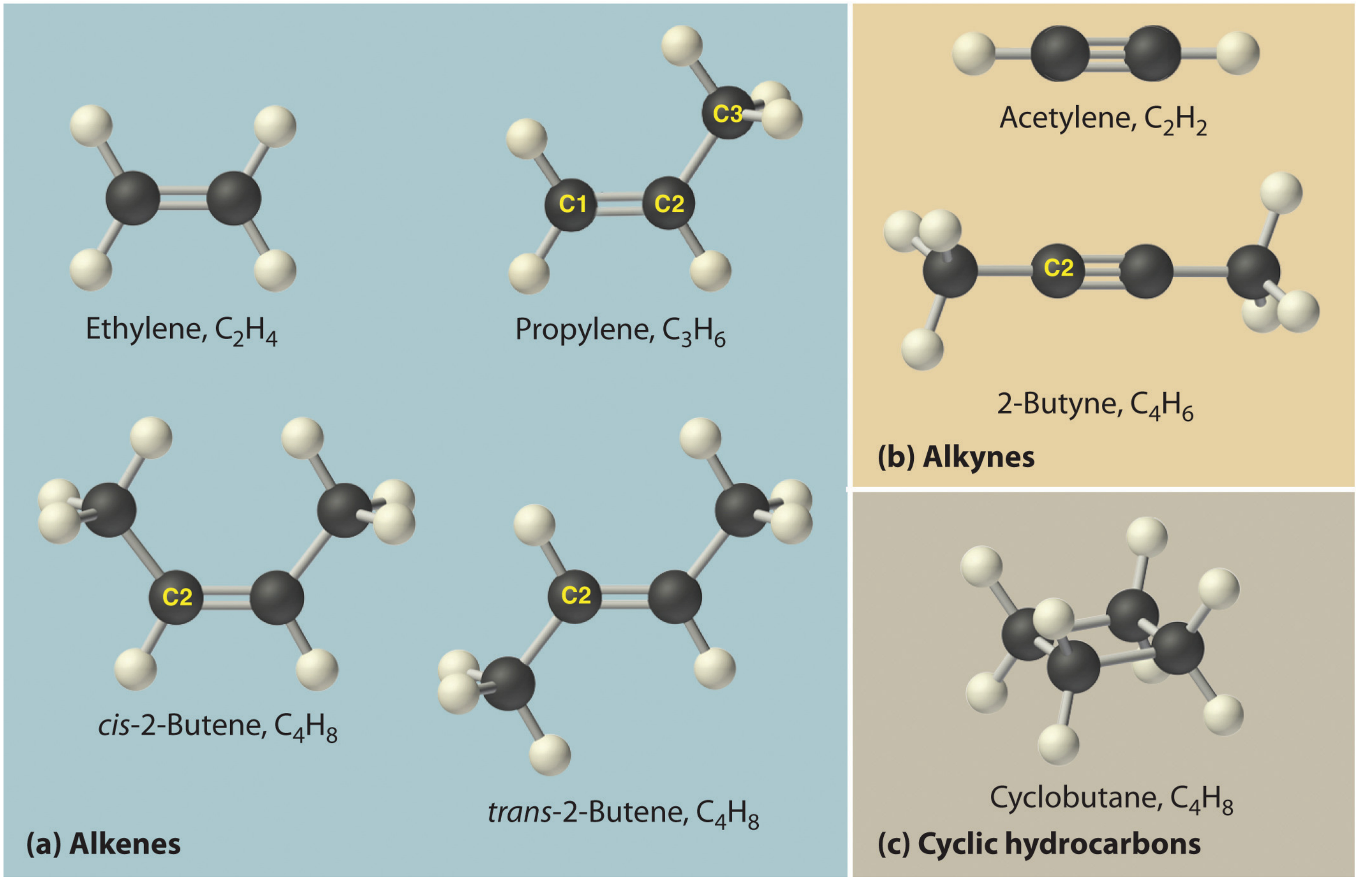
As you can see, the compound has a chain of five carbon atoms, so it is a derivative of pentane. There are two methyl group branches at one carbon atom and one methyl group at another. Using the lowest possible numbers for the branches gives 2,2,4-trimethylpentane for the systematic name of this compound.

Alkenes

The simplest alkenes are *ethylene*, C_2H_4 or $CH_2{=}CH_2$, and *propylene*, C_3H_6 or $CH_3CH{=}CH_2$ (part (a) in Figure 2.16). The names of alkenes that have more than three carbon atoms use the same stems as the names of the alkanes (Table 2.7) but end in -*ene* instead of -*ane*.

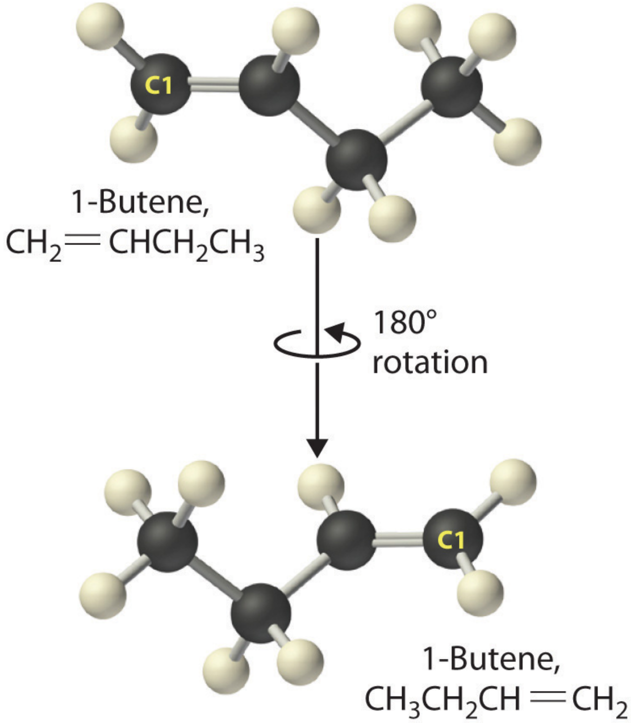
Once again, more than one structure is possible for alkenes with four or more carbon atoms. For example, an alkene with four carbon atoms has three possible structures. One is $CH_2{=}CHCH_2CH_3$ (1-butene), which has the double bond between the first and second carbon atoms in the chain. The other two structures have the double bond between the second and third carbon atoms and are forms of $CH_3CH{=}CHCH_3$ (2-butene). All four carbon atoms in 2-butene lie in the same plane, so there are two possible structures (part (a) in Figure $2.4.4$). If the two methyl groups are on the same side of the double bond, the compound is *cis*-2-butene (from the Latin *cis*, meaning "on the same side"). If the two methyl groups are on opposite sides of the double bond, the compound is *trans*-2-butene (from the Latin *trans*, meaning "across"). These are distinctly different molecules: *cis*-2-butene melts at −138.9°C, whereas *trans*-2-butene melts at −105.5°C.

Figure $2.4.4$ *Some Simple (a) Alkenes, (b) Alkynes, and (c) Cyclic Hydrocarbons*



The positions of the carbon atoms in the chain are indicated by C1 or C2.

Just as a number indicates the positions of branches in an alkane, the number in the name of an alkene specifies the position of the *first* carbon atom of the double bond. The name is based on the lowest possible number starting from *either end* of the carbon chain, so $CH_3CH_2CH{=}CH_2$ is called 1-butene, *not* 3-butene. Note that $CH_2{=}CHCH_2CH_3$ and $CH_3CH_2CH{=}CH_2$ are different ways of writing the *same molecule* (1-butene) in two different orientations.



The name of a compound does not depend on its orientation. *As illustrated for 1-butene, both condensed structural formulas and molecular models show different orientations of the same molecule. Don't let orientation fool you; you must be able to recognize the same structure no matter what its orientation.*

Note the Pattern

The positions of groups or multiple bonds are always indicated by the lowest number possible.

Alkynes

The simplest alkyne is *acetylene*, C_2H_2 or HC≡CH (part (b) in Figure 2.4.4). Because a mixture of acetylene and oxygen burns with a flame that is hot enough (>3000°C) to cut metals such as hardened steel, acetylene is widely used in cutting and welding torches. The names of other alkynes are similar to those of the corresponding alkanes but end in *-yne*. For example, $HC{\equiv}CCH_3$ is *propyne*, and $CH_3C{\equiv}CCH_3$ is *2-butyne* because the multiple bond begins on the second carbon atom.

Note the Pattern

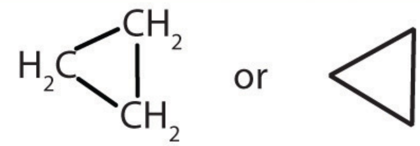
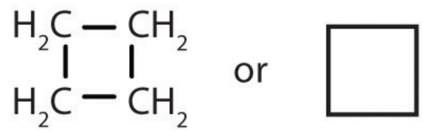
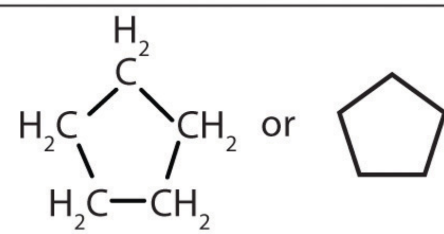
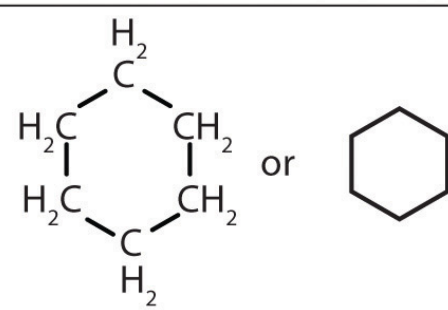
The number of bonds between carbon atoms in a hydrocarbon is indicated in the suffix:

- alk*ane*: only carbon–carbon single bonds
- alk*ene*: at least one carbon–carbon double bond
- alk*yne*: at least one carbon–carbon triple bond

Cyclic Hydrocarbons

In a **cyclic hydrocarbon**, the ends of a hydrocarbon chain are connected to form a ring of covalently bonded carbon atoms. Cyclic hydrocarbons are named by attaching the prefix *cyclo-* to the name of the alkane, the alkene, or the alkyne. The simplest cyclic alkanes are *cyclopropane* (C_3H_6) a flammable gas that is also a powerful anesthetic, and *cyclobutane* (C_4H_8) (part (c) in Figure 2.4.4). The most common way to draw the structures of cyclic alkanes is to sketch a polygon with the same number of vertices as there are carbon atoms in the ring; each vertex represents a CH_2 unit. The structures of the cycloalkanes that contain three to six carbon atoms are shown schematically in Figure 2.4.5.

Figure 2.4.5 *The Simple Cycloalkanes*

Name	Molecular Formula	Structural Formula
cyclopropane	C_3H_6	
cyclobutane	C_4H_8	
cyclopentane	C_5H_{10}	
cyclohexane	C_6H_{12}	

Aromatic Hydrocarbons

Alkanes, alkenes, alkynes, and cyclic hydrocarbons are generally called **aliphatic hydrocarbons**. The name comes from the Greek *aleiphar*, meaning "oil," because the first examples were extracted from animal fats. In contrast, the first examples of **aromatic hydrocarbons**, also called *arenes*, were obtained by the distillation and degradation of highly scented (thus *aromatic*) resins from tropical trees.

The simplest aromatic hydrocarbon is *benzene* (C_6H_6), which was first obtained from a coal distillate. The word *aromatic* now refers to benzene and structurally similar compounds. As shown in part (a) in Figure 2.4.6, it is possible to draw the structure of benzene in two different but equivalent ways, depending on which carbon atoms are connected by double bonds or single bonds. *Toluene* is similar to benzene, except that one hydrogen atom is replaced by a $–CH_3$ group; it has the formula C_7H_8 (part (b) in Figure 2.4.6). As you will soon learn, the chemical behavior of aromatic compounds differs from the behavior of aliphatic compounds. Benzene and toluene are found in gasoline, and benzene is the starting material for preparing substances as diverse as aspirin and nylon.

Figure 2.4.6 *Two Aromatic Hydrocarbons: (a) Benzene and (b) Toluene*

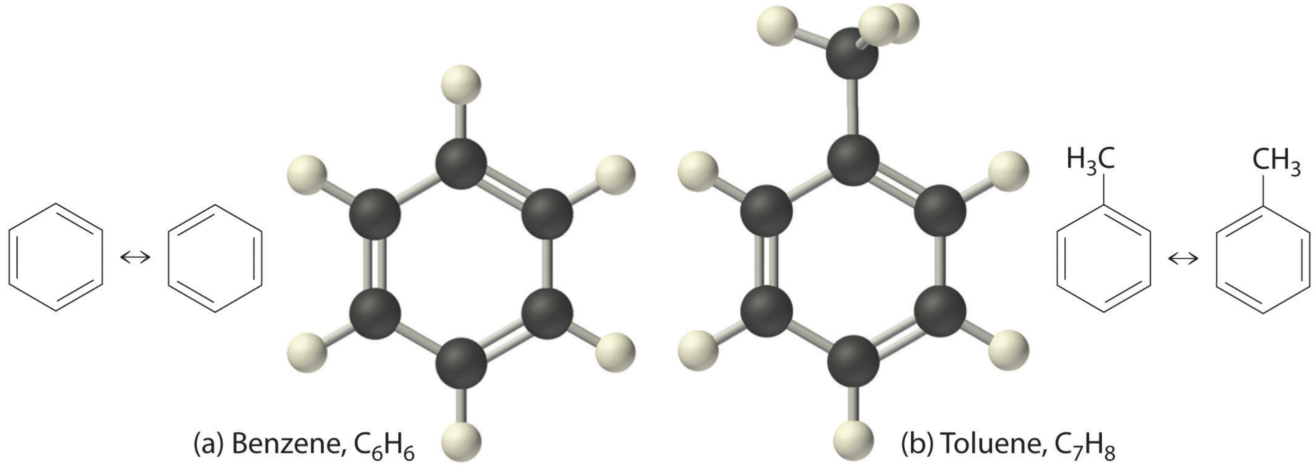
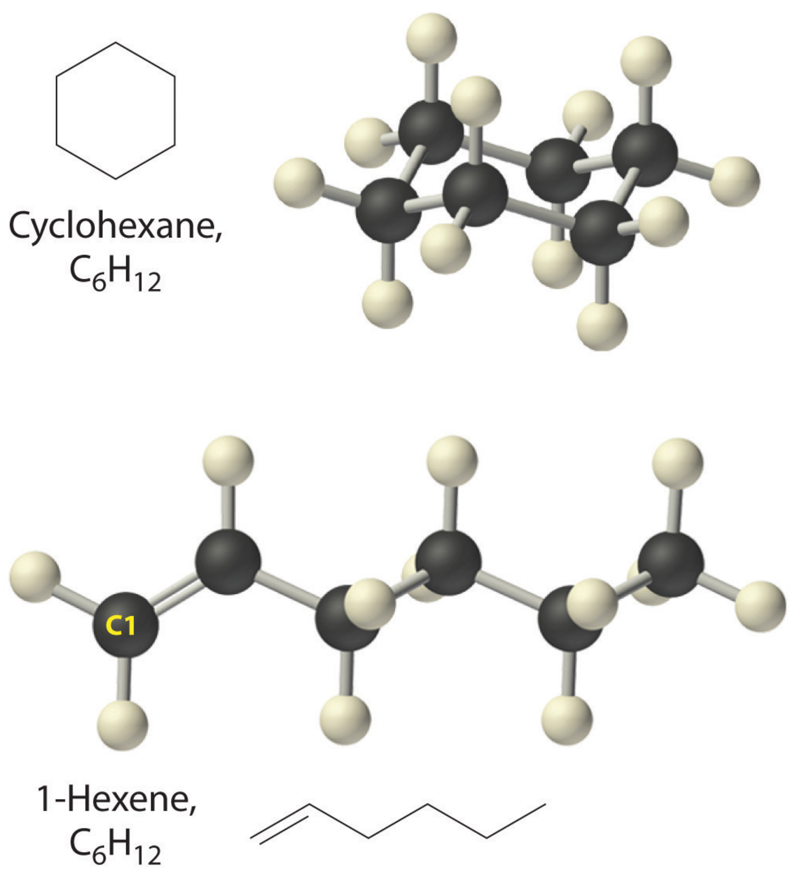


Figure 2.4.7 illustrates two of the molecular structures possible for hydrocarbons that have six carbon atoms. As you can see, compounds with the same molecular formula can have very different structures.

Figure 2.4.7 *Two Hydrocarbons with the Molecular Formula C_6H_{12}*



Example 2.4.3

Write the condensed structural formula for each hydrocarbon.

1. *n*-heptane
2. 2-pentene
3. 2-butyne
4. cyclooctene

Given: name of hydrocarbon

Asked for: condensed structural formula

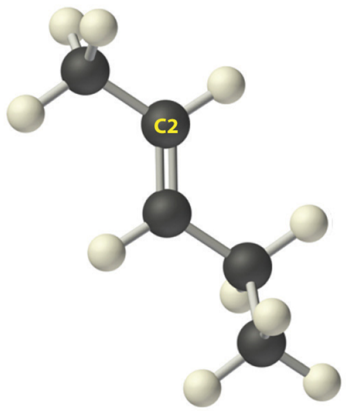
Strategy:

A Use the prefix to determine the number of carbon atoms in the molecule and whether it is cyclic. From the suffix, determine whether multiple bonds are present.

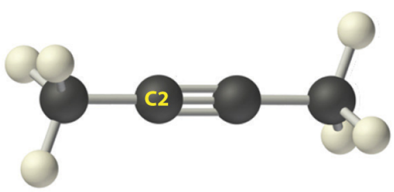
B Identify the position of any multiple bonds from the number(s) in the name and then write the condensed structural formula.

Solution

1. **A** The prefix *hept-* tells us that this hydrocarbon has seven carbon atoms, and *n-* indicates that the carbon atoms form a straight chain. The suffix *-ane* tells that it is an alkane, with no carbon–carbon double or triple bonds. **B** The condensed structural formula is $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$, which can also be written as $CH_3(CH_2)_5CH_3$.
2. **A** The prefix *pent-* tells us that this hydrocarbon has five carbon atoms, and the suffix *-ene* indicates that it is an alkene, with a carbon–carbon double bond. **B** The 2- tells us that the double bond begins on the second carbon of the five-carbon atom chain. The condensed structural formula of the compound is therefore $CH_3CH{=}CHCH_2CH_3$.

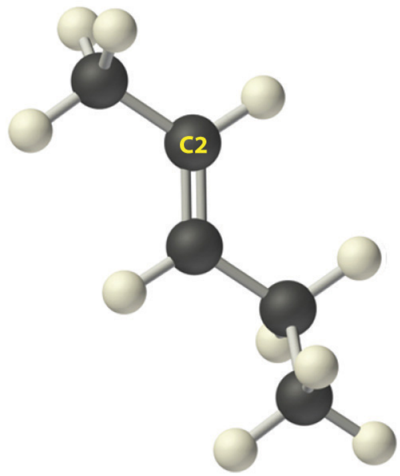


2-Pentene

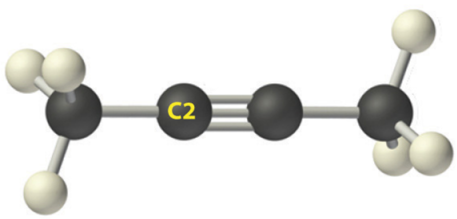


2-Butyne

3. **A** The prefix *but-* tells us that the compound has a chain of four carbon atoms, and the suffix *-yne* indicates that it has a carbon–carbon triple bond. **B** The 2- tells us that the triple bond begins on the second carbon of the four-carbon atom chain. So the condensed structural formula for the compound is $CH_3C{\equiv}CCH_3$.

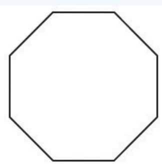


2-Pentene

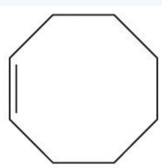


2-Butyne

4. **A** The prefix *cyclo-* tells us that this hydrocarbon has a ring structure, and *oct-* indicates that it contains eight carbon atoms, which we can draw as



The suffix *-ene* tells us that the compound contains a carbon–carbon double bond, but where in the ring do we place the double bond? **B** Because all eight carbon atoms are identical, it doesn't matter. We can draw the structure of cyclooctene as

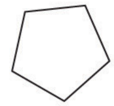


? Exercise 2.4.3

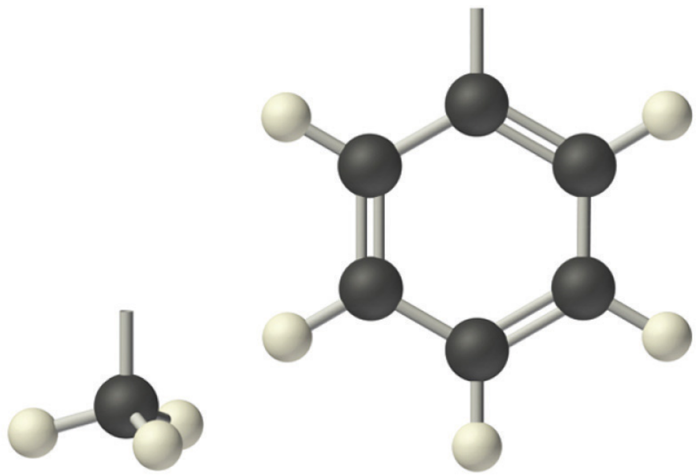
Write the condensed structural formula for each hydrocarbon.

1. *n*-octane
2. 2-hexene
3. 1-heptyne
4. cyclopentane

Answer

1. $CH_3(CH_2)_6CH_3$
2. $CH_3CH{=}CHCH_2CH_2CH_3$
3. $HC{\equiv}C(CH_2)_4CH_3$
4. 

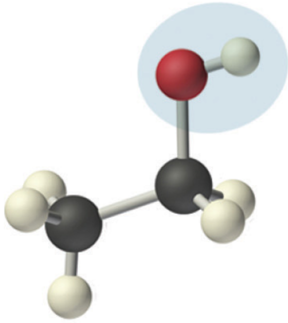
The general name for a group of atoms derived from an alkane is an *alkyl group*. The name of an alkyl group is derived from the name of the alkane by adding the suffix *-yl*. Thus the $–CH_3$ fragment is a *methyl* group, the $–CH_2CH_3$ fragment is an *ethyl* group, and so forth, where the dash represents a single bond to some other atom or group. Similarly, groups of atoms derived from aromatic hydrocarbons are *aryl groups*, which sometimes have unexpected names. For example, the $–C_6H_5$ fragment is derived from benzene, but it is called a *phenyl* group. In general formulas and structures, alkyl and aryl groups are often abbreviated as **R**.



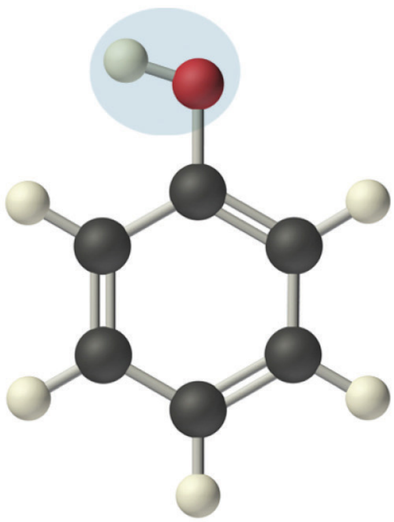
Structures of alkyl and aryl groups. *The methyl group is an example of an alkyl group, and the phenyl group is an example of an aryl group.*

Alcohols

Replacing one or more hydrogen atoms of a hydrocarbon with an –OH group gives an **alcohol**, represented as ROH. The simplest alcohol (CH_3OH) is called either *methanol* (its systematic name) or *methyl alcohol* (its common name) (see "Different Ways of Representing the Structure of a Molecule"). Methanol is the antifreeze in automobile windshield washer fluids, and it is also used as an efficient fuel for racing cars, most notably in the Indianapolis 500. Ethanol (or ethyl alcohol, CH_3CH_2OH) is familiar as the alcohol in fermented or distilled beverages, such as beer, wine, and whiskey; it is also used as a gasoline additive (Section 2.6). The simplest alcohol derived from an aromatic hydrocarbon is C_6H_5OH, *phenol* (shortened from *phenyl* alcohol), a potent disinfectant used in some sore throat medications and mouthwashes.



Ethanol, CH_3CH_2OH



Phenol, C_6H_5OH

Ethanol, which is easy to obtain from fermentation processes, has successfully been used as an alternative fuel for several decades. Although it is a “green” fuel when derived from plants, it is an imperfect substitute for fossil fuels because it is less efficient than gasoline. Moreover, because ethanol absorbs water from the atmosphere, it can corrode an engine’s seals. Thus other types of processes are being developed that use bacteria to create more complex alcohols, such as octanol, that are more energy efficient and that have a lower tendency to absorb water. As scientists attempt to reduce mankind’s dependence on fossil fuels, the development of these so-called *biofuels* is a particularly active area of research.

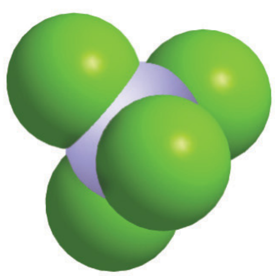
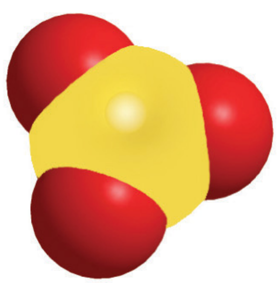
Summary

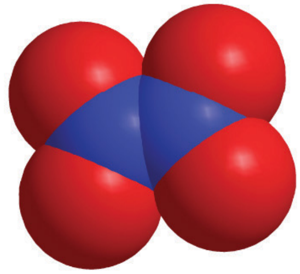
Covalent inorganic compounds are named by a procedure similar to that used for ionic compounds, using prefixes to indicate the numbers of atoms in the molecular formula. The simplest organic compounds are the **hydrocarbons**, which contain *only* carbon and hydrogen. **Alkanes** contain only carbon–hydrogen and carbon–carbon single bonds, **alkenes** contain at least one carbon–carbon double bond, and **alkynes** contain one or more carbon–carbon triple bonds. Hydrocarbons can also be **cyclic**, with the ends of the chain connected to form a ring. Collectively, alkanes, alkenes, and alkynes are called **aliphatic hydrocarbons**. **Aromatic hydrocarbons**, or *arenes*, are another important class of hydrocarbons that contain rings of carbon atoms related to the structure of benzene (C_6H_6). A derivative of an alkane or an arene from which one hydrogen atom has been removed is called an *alkyl group* or an *aryl group*, respectively. **Alcohols** are another common class of organic compound, which contain an –OH group covalently bonded to either an alkyl group or an aryl group (often abbreviated **R**).

KEY TAKEAWAY

- Covalent inorganic compounds are named using a procedure similar to that used for ionic compounds, whereas hydrocarbons use a system based on the number of bonds between carbon atoms.

CONCEPTUAL PROBLEMS

1. Benzene (C_6H_6) is an organic compound, and KCl is an ionic compound. The sum of the masses of the atoms in each empirical formula is approximately the same. How would you expect the two to compare with regard to each of the following? What species are present in benzene vapor?
    1. melting point
    2. type of bonding
    3. rate of evaporation
    4. structure
2. Can an inorganic compound be classified as a hydrocarbon? Why or why not?
3. Is the compound $NaHCO_3$ a hydrocarbon? Why or why not?
4. Name each compound.
    1. NiO
    2. TiO_2
    3. N_2O
    4. CS_2
    5. SO_3
    6. NF_3
    7. SF_6
5. Name each compound.
    1. $HgCl_2$
    2. IF_5
    3. N_2O_5
    4. Cl_2O
    5. HgS
    6. PCl_5
6. For each structural formula, write the condensed formula and the name of the compound.
    1. 
    2. 



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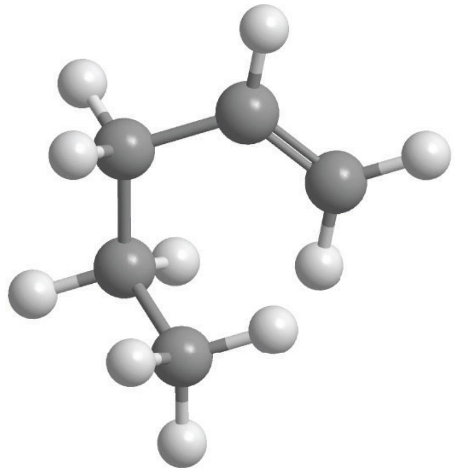

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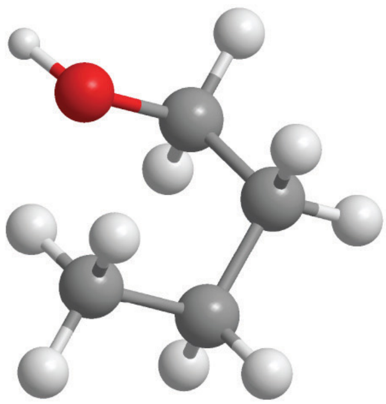
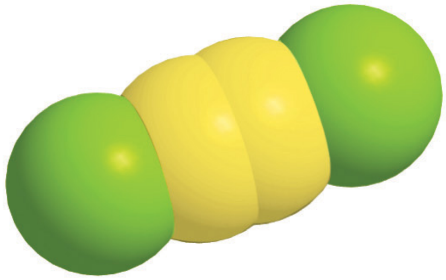
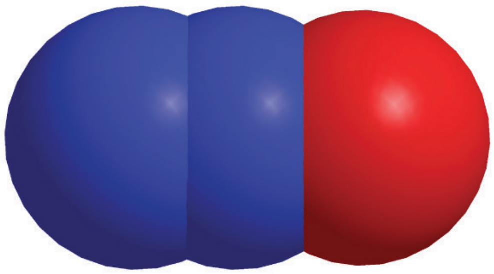


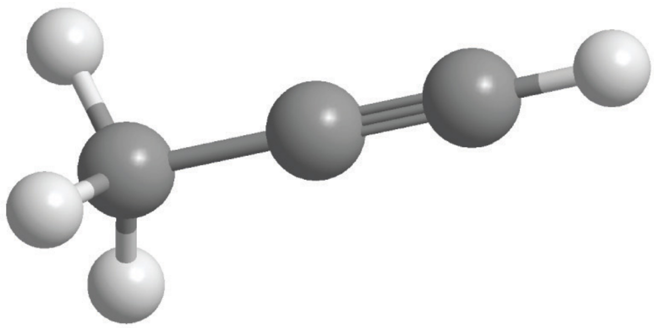
5.

7. For each structural formula, write the condensed formula and the name of the compound.

1.



2. 

3. 

4.

8. Would you expect PCl_3 to be an ionic compound or a covalent compound? Explain your reasoning.
9. What distinguishes an aromatic hydrocarbon from an aliphatic hydrocarbon?
10. The following general formulas represent specific classes of hydrocarbons. Refer to *Table* 2.4.2 and Figure 2.4.4 and identify the classes.
    1. C_nH_{2n+2}
    2. C_nH_{2n}
    3. C_nH_{2n-2}
11. Using R to represent an alkyl or aryl group, show the general structure of an
    1. alcohol.
    2. phenol.

Answer

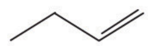
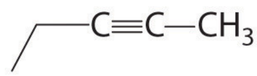
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11. 1. ROH (where R is an alkyl group)
    2. ROH (where R is an aryl group)

NUMERICAL PROBLEMS

1. Write the formula for each compound.
    1. dinitrogen monoxide
    2. silicon tetrafluoride
    3. boron trichloride
    4. nitrogen trifluoride
    5. phosphorus tribromide
2. Write the formula for each compound.
    1. dinitrogen trioxide
    2. iodine pentafluoride
    3. boron tribromide
    4. oxygen difluoride
    5. arsenic trichloride
3. Write the formula for each compound.
    1. thallium(I) selenide
    2. neptunium(IV) oxide
    3. iron(II) sulfide
    4. copper(I) cyanide
    5. nitrogen trichloride
4. Name each compound.
    1. RuO_4
    2. PbO_2
    3. MoF_6
    4. $Hg_2(NO_3)_2 \cdot 2H_2O$
    5. WCl_4
5. Name each compound.
    1. NbO_2
    2. MoS_2
    3. P_4S_{10}
    4. Cu_2O
    5. ReF_5
6. Draw the structure of each compound.
    1. propyne
    2. ethanol
    3. *n*-hexane
    4. cyclopropane
    5. benzene
7. Draw the structure of each compound.
    1. 1-butene
    2. 2-pentyne
    3. cycloheptane
    4. toluene
    5. phenol

AnswerS

1.
    1. N_2O
    2. SiF_4
    3. BCl_3
    4. NF_3
    5. PBr_3

2.
3. 1. Tl_2Se
   2. NpO_2
   3. FeS
   4. CuCN
   5. NCl_3
4.
5. 1. niobium (IV) oxide
   2. molybdenum (IV) sulfide
   3. tetraphosphorus decasulfide
   4. copper(I) oxide
   5. rhenium(V) fluoride
6.
7. 1. 
   2. 

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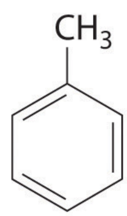
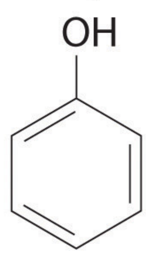
   4. 

   5. 

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