

# HYDROCARBON COMPOUNDS

## SECTION 22.1 HYDROCARBONS (pages 693–701)

*This section describes the bonding in hydrocarbons and distinguishes straight-chain from branched-chain alkanes. It also provides rules for naming branch-chained alkanes.*

### ► Organic Chemistry and Hydrocarbons (pages 693–694)

1. What is organic chemistry? It is the study of the chemistry of carbon compounds.
2. Organic compounds that contain only carbon and hydrogen are called hydrocarbons.
3. Is the following sentence true or false? Hydrogen atoms are the only atoms that can bond to the carbon atoms in a hydrocarbon. false
4. Circle the letter of each statement that is true about carbon's ability to form bonds.
  - a. Carbon atoms have four valence electrons.
  - b. Carbon atoms always form three covalent bonds.
  - c. Carbon atoms can form stable bonds with other carbon atoms.

### ► Alkanes (pages 694–699)

5. Is the following sentence true or false? Alkanes contain only single covalent bonds. true
6. What is the simplest alkane? methane
7. What are straight-chain alkanes? They contain any number of carbon atoms, one after another, in a chain.
8. The names of all alkanes end with the suffix -ane.

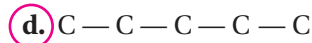
Match the name of the straight-chain alkane with the number of carbon atoms it contains.

- |                      |      |
|----------------------|------|
| <u>d</u> 9. nonane   | a. 3 |
| <u>a</u> 10. propane | b. 4 |
| <u>c</u> 11. heptane | c. 7 |
| <u>b</u> 12. butane  | d. 9 |

13. The straight-chain alkanes form a(n) homologous series because there is an incremental change of a  $\text{CH}_2$  group from one compound in the series to the next.

**CHAPTER 22, Hydrocarbon Compounds** (continued)

14. Circle the letter of each condensed structural formula for pentane.



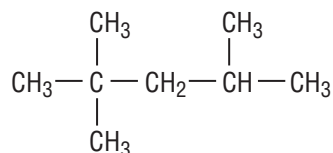
15. The IUPAC system uses prefixes to show the number of carbon atoms in a straight-chain alkane.

16. A(n) substituent is an atom or group of atoms that replaces a hydrogen in a hydrocarbon molecule.

17. Alkyl groups are named by removing the *-ane* ending of the parent hydrocarbon and adding -yl.

18. What is a branched-chain alkane? It is an alkane with one or more alkyl groups.

19. Circle the letter of the correct IUPAC name for the molecule below.

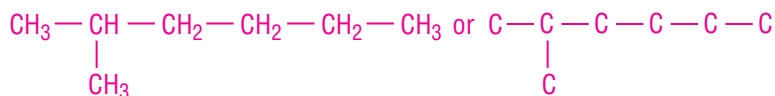


a. 2,2,4-triethylpentane

b. 3-methylpentane

**c.** 2,2,4-trimethylpentane

20. Draw a condensed structural formula for 2-methylhexane.



### ► Properties of Alkanes (page 700)

21. Why are hydrocarbon molecules such as alkanes nonpolar? Hydrocarbon molecules such as alkanes are nonpolar because the electron pair in a carbon-hydrogen or a carbon-carbon bond is shared almost equally by the nuclei of the atoms involved.

22. Hydrocarbons and other nonpolar molecules are not attracted to water or polar molecules.



## Reading Skill Practice

A flowchart can help you to remember the order in which events occur. On a separate sheet of paper, create a flowchart that describes the steps for naming branched-chain alkanes using the IUPAC system. This process is explained on page 698.

Students' flowcharts will vary. A typical flowchart should include a box for each of the numbered steps on page 698.

## SECTION 22.2 UNSATURATED HYDROCARBONS (pages 702–703)

*This section explains the difference between unsaturated and saturated hydrocarbons. It also describes the difference between alkenes and alkynes.*

### ► Alkenes (page 702)

1. What is an alkene?

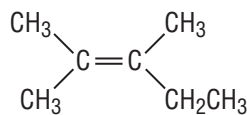
It is a hydrocarbon containing one or more carbon–carbon double covalent bonds.

2. Organic compounds that contain the maximum number of hydrogen atoms per carbon atoms are called saturated compounds.

3. Which family of hydrocarbons are always saturated compounds?

alkanes

4. Circle the letter of the correct name for the alkene shown below.



- a. 2,3-dimethyl-3-pentene      **c.** 2,3-dimethyl-2-pentene  
 b. 2-methyl-3-methyl-2-pentene      d. 3-ethyl-2-methyl-2-butene

5. Is the following sentence true or false? Rotation can occur around a carbon–carbon double bond. false

### ► Alkynes (page 703)

6. Hydrocarbons that contain one or more triple covalent bonds between carbons are called alkynes.

7. Ethyne is the simplest alkyne, and is also known by the common name acetylene.

**CHAPTER 22, Hydrocarbon Compounds** (continued)

8. Circle the letter of each compound that is an aliphatic compound.

- a.** 1-butene  
**b.** acetylene  
**c.** 2-methylpropane

9. What are the major attractive forces between alkane, alkene, or alkyne molecules?

The major forces are weak van der Waals forces.

10. Complete the table below with the names of the indicated alkanes, alkenes, and alkynes. For the alkenes and alkynes, assume that the multiple bond occurs between the first two carbons.

Number of Carbons	Alkane	Alkene	Alkyne
C <sub>6</sub>	hexane	1-hexene	1-hexyne
C <sub>7</sub>	heptane	1-heptene	1-heptyne
C <sub>8</sub>	octane	1-octene	1-octyne

11. Is the following sentence true or false? The angle between the carbon atoms in a carbon-carbon triple bond is 120°. false

**SECTION 22.3 ISOMERS (pages 704–707)**

*This section explains how to distinguish among structural, geometric, and stereoisomers. It also describes how to identify the asymmetric carbon or carbons in stereoisomers.*

**► Structural Isomers (page 704)**

1. What are structural isomers?

They are compounds that have the same molecular formula but the atoms are joined together in a different order.

2. Is the following sentence true or false? Structural isomers have the same physical properties. false

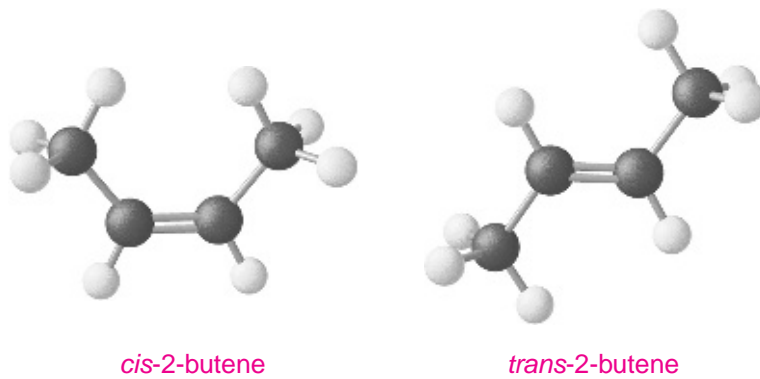
3. How many structural isomers are there for C<sub>4</sub>H<sub>10</sub>? two

4. Name the structural isomers of C<sub>4</sub>H<sub>10</sub>. butane and 2-methylpropane

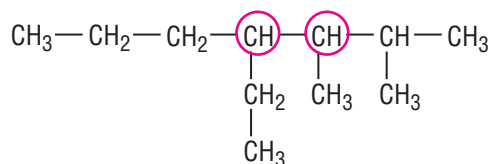
5. In general, what determines which of two structural isomers will have the lower boiling point? In general, the more highly branched structure will have the lower boiling point.

► **Stereoisomers (pages 705–706)**

6. Stereoisomers differ only in the position of their atoms.
7. What two things need to be present for geometric isomers to exist?
- a double bond
  - at least one substituent on each carbon of the double bond
8. What are the names of the molecules represented by the ball-and-stick models below?



9. Objects that are symmetrical will produce a reflection that is indistinguishable from the original object.
10. Mirror images of a right hand and a left hand cannot be superimposed.
11. What is an asymmetric carbon?  
It is a carbon with four different atoms or groups attached.
12. Is the following sentence true or false? The relationship of optical isomers is similar to that between right and left hands. true
13. Look at Figure 22.9 on page 705. Why are these two molecules optical isomers?  
They contain an asymmetric carbon atom.
14. Circle the two asymmetric carbons in the structure shown below.



**CHAPTER 22, Hydrocarbon Compounds** (continued)**SECTION 22.4 HYDROCARBON RINGS** (pages 709–711)

This section describes how to identify and classify cyclic hydrocarbons. It also explains the bonding in benzene.

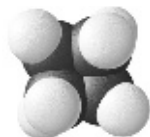
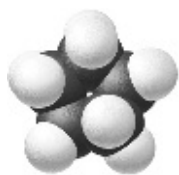
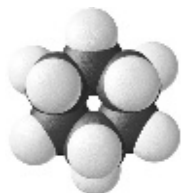
► **Cyclic Hydrocarbons** (page 709)

1. What is a cyclic hydrocarbon?

It is a compound that contains a hydrocarbon ring.

2. The most abundant cyclic hydrocarbons contain five or six carbons.

3. What are the names of the cyclic hydrocarbons represented below?



- a. cyclohexane    b. cyclopentane    c. cyclobutane    d. cyclopropane

4. Is the following sentence true or false? Cyclic hydrocarbons that contain only single carbon–carbon bonds are called cycloalkanes. true

► **Aromatic Hydrocarbons** (pages 710–711)

5. What is the origin of the name *aromatic compounds*?

Many aromatic compounds have pleasant odors.

6. Benzene has the chemical formula  $C_6H_6$ .

7. Is the following sentence true or false? Any substance that has carbon–carbon bonding like that of benzene is called an aromatic compound. true

8. Another name for an aromatic compound is a(an) arene.

9. What does it mean to say that benzene exhibits resonance?

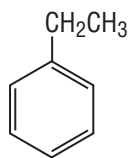
Two equally valid structures can be drawn for benzene.

10. Molecules that exhibit resonance are more stable than similar molecules that do not exhibit resonance.

11. The actual bonds in a benzene ring are identical hybrids of single and double bonds.

12. When benzene is a substituent on an alkane, it is called a phenyl group.

13. Circle the letter of the name of the compound shown below.



- a. ethylhexene  
b. dimethylbenzene  
c. ethylbenzene

14. Derivatives of benzene that have two substituents are called disubstituted benzenes.

15. Why do disubstituted benzenes always have three structural isomers?

There are three possible positions for the two substituents.

Match the terms for naming a disubstituted benzene with the substituent positions they represent.

b 16. *meta*                      a. 1,2

a 17. *ortho*                      b. 1,3

c 18. *para*                      c. 1,4

19. What is another name for the dimethylbenzenes? xylene

## SECTION 22.5 HYDROCARBONS FROM EARTH'S CRUST (pages 712–715)

*This section describes the origin, composition, and uses of natural gas, petroleum, and coal.*

### ► Natural Gas (page 712)

1. What are fossil fuels?

They are carbon-based fuels derived from the decay of organisms.

2. List three factors needed to produce fossil fuels from organic residue.

a. pressure

b. bacterial action

c. heat

3. Petroleum and natural gas contain mostly aliphatic hydrocarbons.

4. What are the four main components of natural gas?

methane, ethane, propane, and butane

5. Which noble gas is found in natural gas? helium

**CHAPTER 22, Hydrocarbon Compounds** (*continued*)

6. Fill in the missing reactants and products in the equation for the combustion of methane.



7. Propane and butane are sold in liquid form to be used as heating fuels.
8. Complete combustion of a hydrocarbon produces a blue flame; incomplete combustion produces a yellow flame.
9. What toxic gas is formed during incomplete combustion of a hydrocarbon?  
carbon monoxide (CO)

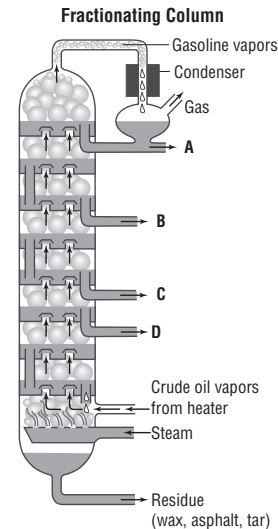
**► Petroleum (page 713)**

10. The first oil well was drilled in Pennsylvania in the late 1850s.
11. Is the following sentence true or false? Petroleum is commercially useful without refining. false
12. How is petroleum refined?  
It is refined by fractional distillation. Compounds are collected according to their boiling points.
13. Circle the letter of the distillation fraction that represents the highest percent of crude oil.
- a. natural gas
  - b.** gasoline
  - c. kerosene
  - d. lubricating oil
14. Using a catalyst and heat to break hydrocarbons down into smaller molecules is called cracking.



15. Complete the table below about four fractions obtained from crude oil. Indicate where each fraction will be collected from the fractionating column shown at the right.

Fraction	Composition of Carbon Chains	Where in Column?
Fuel oil	C <sub>15</sub> to C <sub>18</sub>	C
Gasoline	C <sub>6</sub> to C <sub>12</sub>	A
Kerosene	C <sub>12</sub> to C <sub>15</sub>	B
Lubricating oil	C <sub>16</sub> to C <sub>24</sub>	D

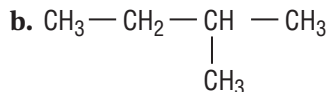
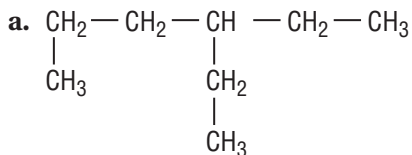


### ► Coal (pages 714–715)

16. Peat is the intermediate material that is the first stage in coal formation.
17. Name the three types of coal and the carbon content of each.
- lignite; about 50%
  - bituminous; 70–80%
  - anthracite; > 80%
18. Is the following sentence true or false? Coal mines in North America are usually at least a kilometer below Earth's surface. false
19. Coal consists primarily of aromatic compounds of extremely high molar mass.
20. Aromatic compounds produce more soot when burned than do aliphatic fuels.
21. What major air pollutants are produced by burning coal that contains sulfur?  
SO<sub>2</sub> and SO<sub>3</sub>
22. List four products that can be obtained by distilling coal.
- gas
  - coal tar
  - coke
  - ammonia
23. Which of these products can be distilled further?  
coal tar

**CHAPTER 22, Hydrocarbon Compounds** *(continued)***GUIDED PRACTICE PROBLEM****GUIDED PRACTICE PROBLEM 3 (page 699)**

3. Name these compounds according to the IUPAC system.



Use the steps on pages 698–699 to name each compound.

**Step 1.** How long is the longest string of carbon atoms? What is the name of the parent hydrocarbon structure?a. 6; hexaneb. 4; butane**Step 2.** From which side will you number the carbon chain? Why?a. It should be numbered from the right, because the substituent is closer to this end.b. It should be numbered from the right, because the substituent is closer to this end.**Step 3.** What are the names and positions of the substituents?a. 3-ethylb. 2-methyl**Step 4.** Explain why neither name will contain a prefix.a. Each compound has only one substituent.**Step 5.** Does the name contain any commas or hyphens?a. The name contains one hyphen, after the number. It contains no commas.b. The name contains one hyphen, after the number. It contains no commas.**Step 6.** What is the complete name of each compound?a. 3-ethylhexaneb. 2-methylbutane**EXTRA PRACTICE PROBLEM (similar to Practice Problem 18, page 706)**

18. Circle the symmetric carbon, if there is one, in each of these structures.

