LESSON 22.2 Unsaturated Hydrocarbons

Key Objectives
- **DESCRIBE** the structural characteristics of alkenes.
- **DESCRIBE** the structural characteristics of alkynes.

Additional Resources
Reading and Study Workbook, Lesson 22.2

Engage

**CHEMISTRY & YOU** Have students study the photo and read the opening text. Ask students to share what they know about the effects of consuming saturated and unsaturated fats on health. (Consumption of saturated fats is associated with heart disease, atherosclerosis, and high blood cholesterol levels. Unsaturated fats lower these risks.)

Activate Prior Knowledge
Assess students’ prior knowledge of multiple covalent bonds. **Ask** What kind of bonding occurs between carbon and oxygen in a molecule of CO₂ and between nitrogen atoms in a molecule of N₂? (a double bond; a triple bond)

Foundations for Reading
**BUILD VOCABULARY** Draw students’ attention to the terms alkene and alkyne. Explain that the root that they share with alkane, alk-, is derived from the word alkyl. Point out that this root word indicates that alkenes and alkynes have many of the structural characteristics exhibited by alkanes.

**READING STRATEGY** Have students make a compare/contrast table for saturated and unsaturated hydrocarbons.

Alkenes

What are the structural characteristics of alkenes?

An organic compound that contains the maximum number of hydrogen atoms per carbon atom is called a saturated compound. Alkanes are saturated compounds because the only bonds in alkanes are single covalent bonds. An organic compound that contains double or triple carbon-carbon bonds is called an unsaturated compound. The ratio of hydrogen atoms to carbon atoms is lower in an unsaturated compound than in a saturated compound. An alkene is a hydrocarbon that contains one or more carbon-carbon double covalent bonds. A carbon-carbon double bond is shown in structural formulas as two parallel lines. At least one carbon-carbon bond in an alkene is a double covalent bond. Other bonds may be single carbon-carbon bonds and carbon-hydrogen bonds.

Ethene (C₂H₄) is the simplest alkene. It is often called by the common name ethylene. Figure 22.5 shows the ball-and-stick model of ethene. To name an alkene by the IUPAC system, find the longest chain in the molecule that contains the double bond. This chain is the parent alkene. It has the root name of the alkane with the same number of carbons plus the ending -ene. The chain is numbered so that the carbon atoms of the double bond have the lowest possible numbers. Substituents on the chain are named and numbered in the same way they are for alkanes. Some examples of the structures and IUPAC names of simple alkenes are shown below.

\[
\begin{align*}
\text{Ethene} & : \text{CH}_2=\text{CH}_2 \\
\text{Propene} & : \text{CH}_3=\text{C}=\text{CH}_2 \\
1-\text{butene} & : \text{CH}_3=\text{CH}=\text{CH}_2 \\
2-\text{butene} & : \text{CH}_3=\text{C}=\text{CH}_3 \\
4-\text{methyl}-2-\text{pentene} & : \text{CH}_3\text{CH}(_2)\text{CH}_2\text{CH}=\text{CH}_3
\end{align*}
\]

Focus on ELL

1 **CONTENT AND LANGUAGE** Remind students that an alkane is a hydrocarbon in which there are only single covalent bonds. Write the words alkane, alkene, and alkyne on the board. Underline the root of each word and circle each suffix. Draw an arrow to the words single bond. Guide student to see that the suffix in the names of these compounds tells you the type of bond.

2 **FRONLOAD THE LESSON** Have students list the first ten straight-chain alkanes on the board, and review the IUPAC naming rules. Then, have students preview the chemical structures discussed throughout the lesson, noting the similarities between the names of the unsaturated hydrocarbons and their related alkanes.

3 **COMPREHENSIBLE INPUT** Have students form human models of the hydrocarbons in this lesson. Divide students into three groups, each representing a different class of hydrocarbon: alkane, alkene, alkyne. Provide short lengths of rope to represent the bonds between the atoms and “C” and “H” signs to indicate which students are carbon and hydrogen atoms.
Unsaturated fats have at least one carbon-carbon bond in an alkene. Other bonds may be single or double C–C bonds. Like alkenes, alkylns are unsaturated compounds.

Alkynes

What are the structural characteristics of alkynes?

A hydrocarbon that contains one or more carbon-carbon triple covalent bonds is called an alkyne. A carbon-carbon triple bond is shown in structural formulas as three parallel lines. At least one carbon-carbon bond in an alkene is a triple covalent bond. Other bonds may be single or double carbon-carbon bonds and carbon-hydrogen bonds. Alkynes are not plentiful in nature. The simplest alkyne is ethyne (C₂H₂), which has the common name acetylene. Acetylene is the fuel burned in oxy-acetylene torches used for welding. Figure 22.7 shows that the single bonds that extend from the carbons in the carbon-carbon triple bond of ethyne are separated by an angle of 180°, which makes ethyne a linear molecule.

Like alkenes, the major attractions between alkenes and alkynes are weak van der Waals forces. As a result, the introduction of a double or triple bond into a hydrocarbon does not have a dramatic effect on physical properties such as boiling point. Compare the boiling points for alkanes, alkenes, and alkynes with two and three carbons in Figure 22.6.

Choiry & YOU Unsaturated fats have double carbon-carbon bonds. All the carbon-carbon bonds in saturated fats are single bonds.

Evaluate

Informal Assessment

Have students explain why hydrocarbons with double or triple bonds are called unsaturated hydrocarbons. Then, have students complete the 22.2 Lesson Check.

Reteach

Have students construct ball-and-stick models of ethene, ethyne, and ethyne. Ask students to write and compare the complete structural formulas for the molecules and to describe the molecular geometry of each.
Arson Investigator

Arson is a dangerous crime in which a person starts a fire with the intent to cause property damage or to harm another person. The person responsible, an arsonist, often uses an accelerant to initiate the fire. Gasoline and lighter fluid—both ignitable fluids composed of hydrocarbons—are two of the most commonly used accelerants. If arson is suspected, an arson investigator carefully examines the fire scene and looks for evidence of a crime.

Arson investigators often collect debris from the scene to take back to the laboratory to analyze for accelerants. Investigators frequently analyze the samples with an instrument called a gas chromatograph. The output of the analysis is sometimes called a “fingerprint” because, like a human fingerprint, each accelerant shows a characteristic pattern. With the knowledge of the molecules in each accelerant, the investigator can identify the accelerant from the fingerprint. Knowing which accelerant was used in the crime can help police narrow the search for the arsonist.

Take It Further

1. Describe One of the hydrocarbons found in gasoline is the branched-chain alkane 3-methylhexane. Write the condensed structural formula for this compound.

2. Analyze Data Use the data in the gas chromatographic analysis above to compare the number of hydrocarbon compounds in gasoline and lighter fluid.

Connect to TECHNOLOGY

Gas Chromatographic Analysis

ACCELERANTS Gasoline and lighter fluid are complex mixtures of hydrocarbons. Each peak in the chromatograph represents a different chemical compound.

WHO’S YOUR PARTNER? Trained dogs with keen noses are often used to guide the evidence collection.

Differentiated Instruction

ENGLISH LANGUAGE LEARNERS Relate the word accelerant to accelerate. Act them out to visually show that both words imply to go faster, to hasten, to move quickly, to speed up, and then act out the opposite meaning, slowing down.

LESS PROFICIENT READERS Have students hypothesize why there is a dog in the photograph of a fire scene. Then, ask these students to perform an Internet search on arson dogs and to orally explain what they learned.

ADVANCED STUDENTS Have students compile a list of hydrocarbons typically found in liquid fuel and determine the properties of these compounds that allow for the separation and identification with the gas chromatography equipment.

Answers

TAKE IT FURTHER

1. \( \text{CH}_3 \text{CH}_2 \text{CHCH}_2 \text{CH}_3 \)

2. Gasoline contains a wider range of compounds, with a majority of lighter compounds. Lighter fluid consists of a narrower range of compounds, which are in the heavier range.