

## 7.3: The Alkenes and Alkynes

### Learning Objectives

- To name alkenes given formulas and write formulas for alkenes given names.

As noted before, alkenes are hydrocarbons with carbon-to-carbon double bonds ( $R_2C=CR_2$ ) and alkynes are hydrocarbons with carbon-to-carbon triple bonds ( $R-C\equiv C-R$ ). Collectively, they are called unsaturated hydrocarbons because they have fewer hydrogen atoms than does an alkane with the same number of carbon atoms, as is indicated in the following general formulas:

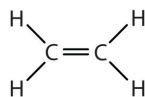


Some representative alkenes—their names, structures, and physical properties—are given in Table 7.3.1.

Table 7.3.1: Physical Properties of Some Selected Alkenes

IUPAC Name	Molecular Formula	Condensed Structural Formula	Melting Point (°C)	Boiling Point (°C)
ethene	$C_2H_4$	$CH_2=CH_2$	−169	−104
propene	$C_3H_6$	$CH_2=CHCH_3$	−185	−47
1-butene	$C_4H_8$	$CH_2=CHCH_2CH_3$	−185	−6
1-pentene	$C_5H_{10}$	$CH_2=CH(CH_2)_2CH_3$	−138	30
1-hexene	$C_6H_{12}$	$CH_2=CH(CH_2)_3CH_3$	−140	63
1-heptene	$C_7H_{14}$	$CH_2=CH(CH_2)_4CH_3$	−119	94
1-octene	$C_8H_{16}$	$CH_2=CH(CH_2)_5CH_3$	−102	121

We used only condensed structural formulas in Table 7.3.1. Thus,  $CH_2=CH_2$  stands for



The double bond is shared by the two carbons and does not involve the hydrogen atoms, although the condensed formula does not make this point obvious. Note that the molecular formula for ethene is  $C_2H_4$ , whereas that for ethane is  $C_2H_6$ .

The first two alkenes in Table 7.3.1, ethene and propene, are most often called by their common names—ethylene and propylene, respectively (Figure 7.3.1). Ethylene is a major commercial chemical. The US chemical industry produces about 25 billion kilograms of ethylene annually, more than any other synthetic organic chemical. More than half of this ethylene goes into the manufacture of polyethylene, one of the most familiar plastics. Propylene is also an important industrial chemical. It is converted to plastics, isopropyl alcohol, and a variety of other products.

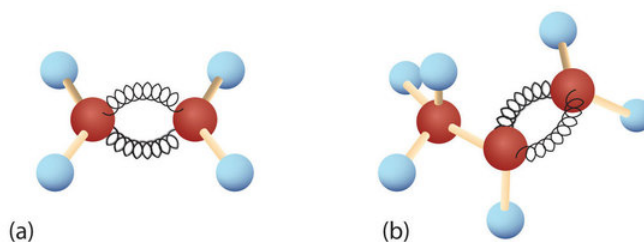
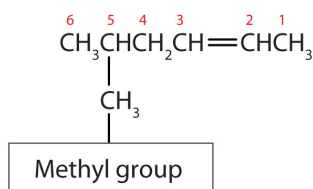


Figure 7.3.1: Ethene and Propene. The ball-and-spring models of ethene/ethylene (a) and propene/propylene (b) show their respective shapes, especially bond angles.

Although there is only one alkene with the formula  $C_2H_4$  (ethene) and only one with the formula  $C_3H_6$  (propene), there are several alkenes with the formula  $C_4H_8$ .

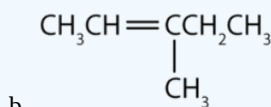
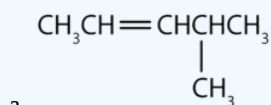
Here are some basic rules for naming alkenes from the International Union of Pure and Applied Chemistry (IUPAC):

1. The longest chain of carbon atoms *containing the double bond* is considered the parent chain. It is named using the same stem as the alkane having the same number of carbon atoms but ends in *-ene* to identify it as an alkene. Thus the compound  $CH_2=CHCH_3$  is *propene*.
2. If there are four or more carbon atoms in a chain, we must indicate the position of the double bond. The carbons atoms are numbered so that the first of the two that are doubly bonded is given the lower of the two possible numbers. The compound  $CH_3CH=CHCH_2CH_3$ , for example, has the double bond between the second and third carbon atoms. Its name is 2-pentene (not 3-pentene).
3. Substituent groups are named as with alkanes, and their position is indicated by a number. Thus, the structure below is 5-methyl-2-hexene. Note that the numbering of the parent chain is always done in such a way as to give the double bond the lowest number, even if that causes a substituent to have a higher number. *The double bond always has priority in numbering.*



### ✓ Example 7.3.1

Name each compound.



### Solution

- a. The longest chain containing the double bond has five carbon atoms, so the compound is a *pentene* (rule 1). To give the first carbon atom of the double bond the lowest number (rule 2), we number from the left, so the compound is a 2-pentene. There is a methyl group on the fourth carbon atom (rule 3), so the compound's name is 4-methyl-2-pentene.
- b. The longest chain containing the double bond has five carbon atoms, so the parent compound is a *pentene* (rule 1). To give the first carbon atom of the double bond the lowest number (rule 2), we number from the left, so the compound is a 2-pentene. There is a methyl group on the third carbon atom (rule 3), so the compound's name is 3-methyl-2-pentene.

### ? Exercise 7.3.1

Name each compound.

- a.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}=\text{CHCH}_3$   
 $\text{CH}_3\text{CH}_2\text{CHCH}=\text{CHCH}_2\text{CH}_3$   
 $\text{CH}_3$
- b.

### Answer

Just as there are cycloalkanes, there are *cycloalkenes*. These compounds are named like alkenes, but with the prefix *cyclo-* attached to the beginning of the parent alkene name.

### ✓ Example 7.3.2

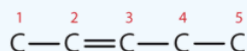
Draw the structure for each compound.

- a. 3-methyl-2-pentene  
 b. cyclohexene

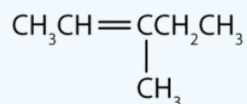
### Solution

a.

First write the parent chain of five carbon atoms: C–C–C–C–C. Then add the double bond between the second and third carbon atoms:

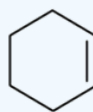


Now place the methyl group on the third carbon atom and add enough hydrogen atoms to give each carbon atom a total of four bonds.



b

First, consider what each of the three parts of the name means. *Cyclo* means a ring compound, *hex* means 6 carbon atoms, and *-ene* means a double bond.



### ? Exercise 7.3.2

Draw the structure for each compound.

- a. 2-ethyl-1-hexene  
 b. cyclopentene

### Key Takeaway

- Alkenes are hydrocarbons with a carbon-to-carbon double bond.

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