# 1.6: Cycloalkanes

**Learning Objectives**

- To name cycloalkanes given their formulas and write formulas for these compounds given their names.

The hydrocarbons we have encountered so far have been composed of molecules with open-ended chains of carbon atoms. When a chain contains three or more carbon atoms, the atoms can join to form ***cycloalkanes***. Cycloalkanes are ring or cyclic structures containing carbon-carbon single bonds. They have the general formula $C_nH_{2n}$ and the simplest of these cyclic hydrocarbons has the formula $C_3H_6$. Each carbon atom has two hydrogen atoms attached (Figure 1.6.1) and is called cyclopropane.

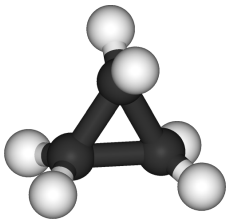
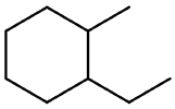


Figure 1.6.1: Ball-and-Stick Model of Cyclopropane.

## Naming Cycloalkanes

Cycloalkanes are cyclic hydrocarbons, meaning that the carbons of the molecule are arranged in the form of a ring. These compounds are named in a similar manner as alkanes. The principal difference in the rules and procedures occurs in the numbering system. Since a ring has no ends like a chain does, all the carbon atoms of a ring are equivalent.



Applying the rules for naming cycloalkanes to the above molecule:

1. **Determine the parent chain.** Count the number of carbon atoms in the ring and in the largest alkyl substituent.
   a. If the number of carbon atoms in the ring is greater than or equal to the number of carbon atoms present in the largest substituent, the compound is named as an alkyl-substituted cycloalkane. Therefore, the parent chain is named as cyclo____ane, based on the number of carbon atoms in the ring.
   b. If the number of carbon atoms in the ring is less than the number of carbon atoms in the substituent, it is named as a cycloalkyl-substituted alkane. The compound is named based on the rules for naming alkanes.

*The longest continuous chain of carbon atoms in this example is the ring which contains six carbon atoms. Therefore, the parent name is cyclohexane.*

2. **Identify the substituents** in the same manner as with alkanes.

*There are two substituents: one substituent consists of a single carbon atom making it a methyl group (derived from methane) and a substituent that contains two carbon atoms making it an ethyl group (derived from ethane).*

3. **Number the carbon atoms in the ring**. If substituents are present, Carbon 1 will always have a substituent.
   a. If there is one substituent, there is no need to show the number 1 for the location of the substituent.
   b. If two or more substituents are present, assign carbon 1 to the site of a substituent. Continue numbering such that the remaining substituents have as low a number as possible. When two or more different substituents could receive the same number, the numbers are assigned in alphabetical order.

*Since there are two substituents present that could both receive the same number, the substituent to receive the lower number is determined based on alphabetical order. Therefore, the ethyl group is assigned to carbon 1. The ring should then be numbered to give the methyl group the lowest number possible. which is 2.*

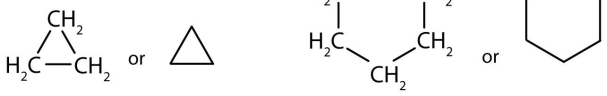
4. Put the name together as in alkanes with the order of: location and identity of substituent(s) followed by the parent name of the compound.

*Utilizing these steps indicates that the name of the compound is 1-ethyl-3-methylcyclohexane.*

## To Your Health: Cyclopropane as an Anesthetic

With its boiling point of −33°C, cyclopropane is a gas at room temperature. It is also a potent, quick-acting anesthetic with few undesirable side effects in the body. It is no longer used in surgery, however, because it forms explosive mixtures with air at nearly all concentrations.

The cycloalkanes—cyclic hydrocarbons with only single bonds—are named by adding the prefix *cyclo-* to the name of the open-chain compound having the same number of carbon atoms as there are in the ring. Thus the name for the cyclic compound $C_4H_8$ is cyclobutane. The carbon atoms in cyclic compounds can be represented by *line-angle formulas* that result in regular geometric figures. Keep in mind, however, that each corner of the geometric figure represents a carbon atom plus as many hydrogen atoms as needed to give each carbon atom four bonds.




cyclopropane cyclohexane

Some cyclic compounds have substituent groups attached. Example 1.6.1 interprets the name of a cycloalkane with a single substituent group.

## Properties of Cycloalkanes

The properties of cyclic hydrocarbons are generally quite similar to those of the corresponding open-chain compounds. So cycloalkanes (with the exception of cyclopropane, which has a highly strained ring) act very much like noncyclic alkanes. Cyclic structures containing five or six carbon atoms, such as cyclopentane and cyclohexane, are particularly stable. We will see later that some carbohydrates (sugars) form five- or six-membered rings in solution.

The cyclopropane ring is strained because the C–C–C angles are 60°, and the preferred (tetrahedral) bond angle is 109.5°. (This strain is readily evident when you try to build a ball-and-stick model of cyclopropane; see Figure 1.6.1.) Cyclopentane and cyclohexane rings have little strain because the C–C–C angles are near the preferred angles.

### Example 1.6.1

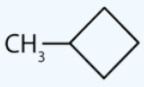
Draw the structure for each compound.

a. cyclopentane
b. methylcyclobutane

**Solution**

a. The name *cyclopentane* indicates a cyclic (cyclo) alkane with five (pent-) carbon atoms. It can be represented as a pentagon.

b. The name *methylcyclobutane* indicates a cyclic alkane with four (but-) carbon atoms in the cyclic part. It can be represented as a square with a $CH_3$ group attached.

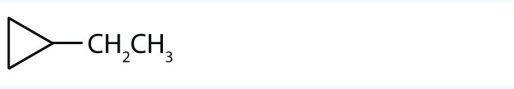


## Exercise 1.6.1

1. Draw the structure for each compound.
    a. cycloheptane
    b. ethylcyclohexane

## Example 1.6.2

1. What is the molecular formula of cyclooctane?
2. What is the IUPAC name for this compound?

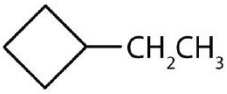



**Solution**

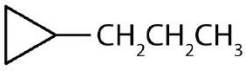
a. The name *cyclooctane* indicates a cyclic (cyclo) alkane with eight (oct-) carbon atoms. It can be represented as an octagon. Since the general formula of cycloalkanes is $C_nH_{2n}$, the molecular formula for cyclooctane is $C_8H_{16}$.
b. The parent chain is a ring that contains three carbon atoms, so it represents *cyclopropane*. There is one substituent that has two carbon atoms, so it represents *ethyl*. Since there is only one substituent present, no number is needed. Therefore, the IUPAC name ofo the compound is *ethylcyclopropane*.

## Exercise 1.6.2

1. Give the IUPAC name of the following molecules:

a. 


b. 


c. 


## Key Takeaway

- Cycloalkanes are cyclic hydrocarbons that are named in a similar manner as alkanes.