

1. Molecular Models of Organic Molecules

Introduction

Organic chemistry is the chemistry of compounds that contain carbon. Several million organic compounds are now known. The large number of these compounds is due to the carbon atom's ability to bond to other carbon atoms as well as to atoms of many other elements. The diversity of the structural and geometric arrangements in organic compounds is one of these compounds' most intriguing aspects (Ebbing/Gammon, Chapter 24).

Purpose

Using molecular models, you will study the molecular geometries of alkanes and alkenes. You will also study compounds that are derived from these by replacement of one or more hydrogen atoms with a corresponding number of hydroxyl groups. You will look for constitutional and geometric isomers for each general formula that you are given. You will also learn to sketch a three-dimensional model in such a way that an understandable two-dimensional figure results.

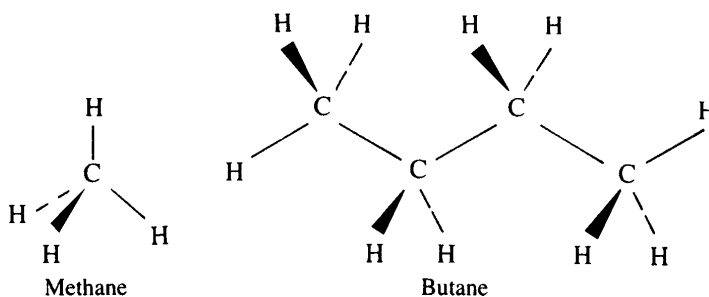
Concept of the experiment

Many kinds of kits for making molecular models are available, so specific instructions will not be given here. Your laboratory instructor will provide instructions for using your kit. However, any molecular model that is correctly assembled will allow you to see a molecule's three-dimensional structure. Correct assembly always means that you have chosen the correct hybridization for the central atom or atoms. For example, tetrahedral sp^3 bonding cannot be used if trigonal sp^2 bonding is required.

Your molecular models will provide an easy way to look for constitutional and geometric isomers (Ebbing/Gammon, Sections 24.2, and 24.3). If you did the experiment "Geometric Isomers," you will already understand geometric isomers. Make sure you are familiar with each of these types of isomers before you begin looking for them with your models.

You will also be required to provide understandable sketches. You will not need artistic or drafting ability to make these sketches. As a guide, consider methane (CH_4) and butane (C_4H_{10}) in Figure 1.1. Note that a solid line represents a bond in the plane of the paper, a wedge represents a bond coming out of the plane of the paper, and a dashed line represents a bond behind the plane of the paper. You will also note that the carbon-carbon bonds in butane have been rotated until a maximum separation between all of the hydrogen atoms has been attained. This is the most stable arrangement.

FIGURE 1.1
Sketches of methane (left) and butane (right) that are intended to show the three-dimensional aspects of the molecules.



Procedure

Getting started

1. Work with a partner.
2. Obtain a molecular model kit and instructions for its use. If possible, you and your partner should be able to examine simultaneously two models with the same general formula. This capability will help considerably when you are searching for isomers.

Doing the experiment

1. Build molecular models representing compounds with as many of the following general formulas as you can examine.
 - a. CH_4
 - b. CH_3OH
 - c. C_2H_6
 - d. $\text{C}_2\text{H}_5\text{OH}$
 - e. C_3H_8
 - f. $\text{C}_3\text{H}_7\text{OH}$
 - g. C_4H_{10}
 - h. C_2H_4
 - i. C_4H_8 (an alkene)
 - j. C_2H_4

Your laboratory instructor may give you formulas of additional compounds to model.

2. For each general formula, look for a structure, then look for constitutional and geometric isomers. Record the results of your search.
3. Provide a structural formula for each different molecule that you discover.
4. Sketch *one* molecule from each general formula in such a way that its three-dimensional structure is apparent. Use Figure 1.1 as a guide where possible.

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Prelaboratory assignment

1. Provide definitions for the following terms:
 - a. Structural formula

 - b. Constitutional isomer

 - c. Geometric isomer

2.
 - a. Give a general molecular formula for an alkane.

 - b. Give a general molecular formula for an alkene.

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Results

Complete the following requirements *for each general formula*.

1. Give one structural formula.
2. Give structural formulas for all constitutional and geometric isomers that exist. If none exist, be sure to record this information.
3. Sketch one molecule. For example, if you find three constitutional isomers, you need sketch only one of these.
4. You may need to use some of your own paper to complete your study.
5. Repeat Steps 1 through 3 for any compounds that your laboratory instructor has given you.

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Questions

1. Give a name to each alkane that you have found, using the IUPAC rules (Ebbing/Gammon, Section 24.5).

2. Draw structural formulas for the following compounds:

a. Pentane

b. 3-methylpentane

c. 2,3-dimethylpentane