Experiment

49 Hydrocarbons: A Structural Study

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Text reference:
Section 24.1

Core Experiment
Estimated time: 50 minutes

For a shorter lab period: Have students omit Part A, step 5, until the remainder of the experiment has been completed. The omitted step can then be completed if time permits.

Background

The physical, chemical, and biological properties of molecules are determined, to a large extent, by their three-dimensional shapes. Molecular substances made up of molecules that pack tightly together often form large, beautiful crystals. Other substances made up of molecules that do not pack together remain liquids even at low temperatures. Many medicinal drugs are effective because their shapes resemble those of molecules in the body. Consequently, an understanding of molecular shape is very important to an understanding of chemistry or biology. Like many people, you may find it easier to work in three dimensions if you use molecular models. By working with models, you can learn to visualize and understand molecular shapes.

In this experiment, you will use ball-and-stick models to study the shapes of hydrocarbon molecules.

Overview: The students will use ball-and-stick molecular models to examine the diversity of bonding in alkanes, alkenes, alkynes, and arenes.

Goals

- **Make models** of hydrocarbon molecules.
- **Compare** the three-dimensional models with the structural formulas of chemical compounds.
- **Make models** of structural and geometric isomers.

Procedure

Refer to Table 49.1 for the color code of the atoms. As you construct each model, complete Table 49.2a and Table 49.2b.

Table 49.1 Color Code for Models

	Color	Atom Represented
10	black	carbon
28	yellow	hydrogen
6	red	oxygen
2	blue	nitrogen
4	green	chlorine
2	purple	iodine
2	orange	bromine

4 springs bonds
30 sm. sticks wood bonds

Part A. Continuous-Chain and Branch-Chain Alkanes

1. Make a model of methane, CH_4. Are all the angles formed by any two C—H bonds the same?

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2. Make a model of ethane, C_2H_6. Can you hold one carbon and hydrogens in a fixed position and rotate the other carbon and its hy gens, without breaking the C—C bond?

3. Make a model of propane, C_3H_8. Can this model be rearrange form a different molecule?

4. Make a model of butane, C_4H_{10}. Can this model be rearrange form a new molecule that has the same molecular formula but a diffe structural formula? If so, name the structures. Molecules that have same molecular formula, but different structural formulas, are ca *structural isomers.*

5. Make a model of pentane, C_5H_{12}. Construct as many structural mers of pentane as you can. For each of these structural isomers, give name of the structural formula here and draw a sketch in Table 49.2a

Part B. Cycloalkanes

6. Construct a model of hexane, C_6H_{14}. Manipulate the structure form a ring (you will have to remove two hydrogens to join the ring). T ring structure is cyclohexane.

Manipulate your cyclohexane molecule so that two carbons dire across the ring from each other are above the plane of the other four bons. This is called the *boat conformation.* Now manipulate the molec so that one of these carbons is above, and the other below, the plan the remaining four carbons. This is the *chair conformation.* In Ta 49.2a, draw these two conformations.

Is there free rotation about the C—C bond in cyclohexane?

Part C. Alkenes and Geometric Isomers

7. Make a model of ethene, C_2H_4. Can you rotate the carbons about double bond?

8. Remove one hydrogen from each carbon in ethene and ac with a chlorine. The name of the resulting compound is 1,2-dicl ethene, $C_2H_2Cl_2$. There are two structures possible for this compo They are called *geometric isomers,* and are distinguished by the prefix or the prefix *trans* added to the name. Construct models of both geom ric isomers.

9. Make a model of butene, C_4H_8. This compound has two structural isomers. Name these isomers and, in Table 49.2b, give their molecular and structural formulas. Are there also geometric ("cis" and "trans") isomers for butene?

Part D. Alkynes

10. Make a model of ethyne, C_2H_2. In the space provided in Table 49.2b, describe the shape of the molecule. Can you rotate the molecule about the triple bond?

Part E. Arenes

11. Make a model of benzene, C_6H_6, using alternating single and double bonds to approximate the aromatic bonds. Do all the atoms in this molecule lie in the same plane?

Can benzene exist in the boat and chair conformations?