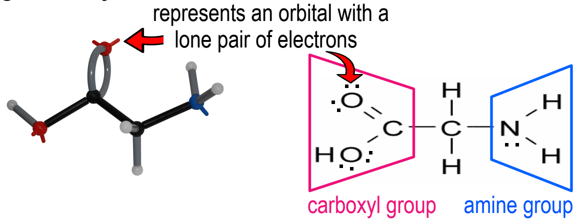
Figure 4 Glycine



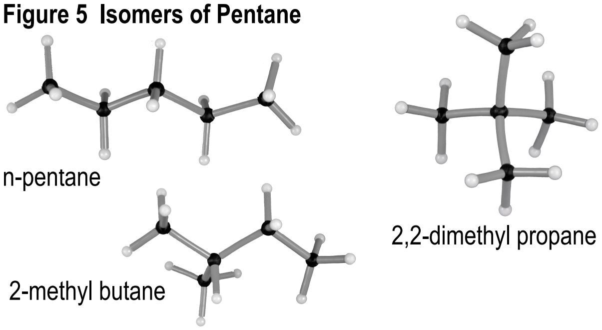
ISOMERS

Isomers are compounds that have identical molecular formulas but different structures.

I. Structural Isomerism

The isomers of pentane in Figure 5 have the same molecular formula, C_5H_{12}, but the atoms are bonded together in different orders. As a result, the compounds have different physical and chemical properties.

Figure 5 Isomers of Pentane



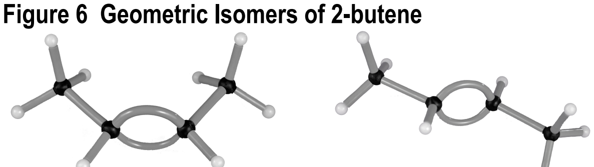
II. Stereoisomerism

Two molecules are described as stereoisomers of each other if they are made of the same atoms, connected in the same sequence, but the atoms are positioned differently in space.

A. Geometric Isomers

Geometric isomers, shown in Figure 6, are often referred to as cis-trans isomers. In the *cis* isomer, the hydrogen atoms are on the same side of the double bond. In the *trans* isomer, the identical groups are on opposite sides of the double bond.

Figure 6 Geometric Isomers of 2-butene

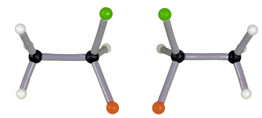


cis-2-butene trans-2-butene

B. Optical Isomers

Optical isomers are forms of a compound that have a similar structure but are mirror images of each other and typically differ in how they rotate plane-polarized light. The molecules in Figure 7 are optical isomers and are called enantiomers.

Figure 7 Nonsuperimposable Mirror Images



1-bromo-1-chloroethane

If the two molecules are rotated, they do not match.

BOAT AND CHAIR CONFORMATIONS

Construct a model of cyclohexane by connecting 6 carbon atoms in a ring using the black bonds. Use the 25mm gray bonds to add the 12 hydrogen atoms to the model of cyclohexane. Set the model on a flat surface and rotate two of the carbon atoms so they are above the plane containing the other four carbon atoms as pictured in Figure 8. This represents the "boat" conformation of cyclohexane.

Figure 8
"Boat" Conformation

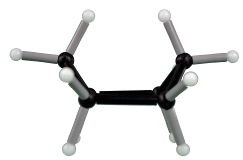
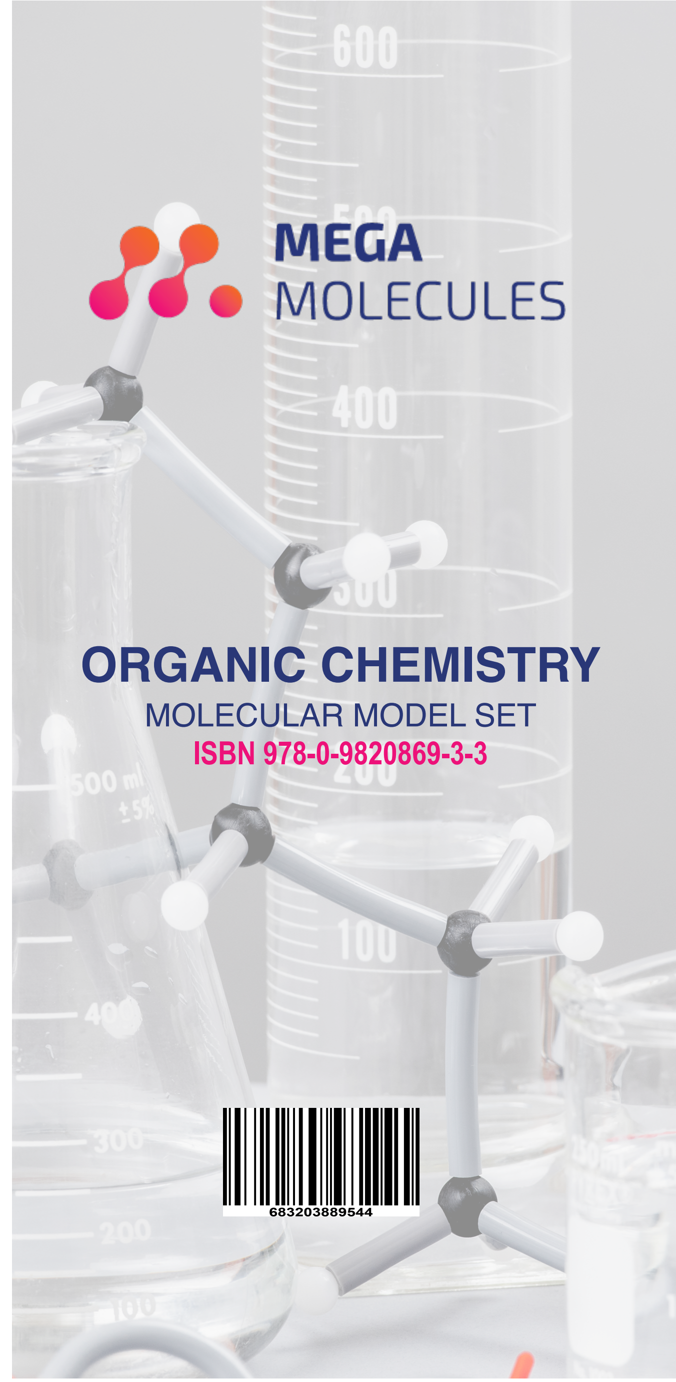


Figure 9
"Chair" Conformation

Convert the "boat" conformation to a "chair" conformation by rotating one of the carbon atoms downward below the plane containing the four carbon atoms. Three hydrogen atoms will point straight up. When placed on a flat surface, the model of cyclohexane will set on the three hydrogen atoms that point downward as illustrated in Figure 9.

MODELING CHEMICAL REACTIONS

One major goal of chemists is to understand the reactions of organic molecules. Molecular models are useful when studying organic reactions to account for all of the atoms in the reactants and products. Molecular models aide in understanding which chemical bonds are broken in the reactants and which new chemical bonds are formed in the products. The mechanisms in many organic reactions, such as addition, elimination, substitution, and rearrangement, can be demonstrated using Mega Molecules™ Models.



MEGA MOLECULES

ORGANIC CHEMISTRY

MOLECULAR MODEL SET

ISBN 978-0-9820869-3-3

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INTRODUCTION

Molecular models are a vital tool for the study of organic chemistry. Models will help you visualize molecular structures, relate the physical and chemical properties of the compound to its structure, and understand chemical reactions. The **Organic Chemistry Molecular Model Set** can be used to build models of thousands of organic compounds, including aliphatic and aromatic hydrocarbons, ethers, alcohols, aldehydes, ketones, organic acids, esters, amines, amides, and halogen-containing organic compounds.

The design of Mega Molecules™ models is based on the hybridization of atomic orbitals and the valence bond theory. Hybridization is the concept of mixing atomic orbitals into new hybrid orbitals with new shapes and energies in order to form chemical bonds. The poles on the atom models represent orbitals, a volume of space in which there is a probability of finding an electron or pair of electrons with a certain amount of energy. Carbon, oxygen, nitrogen, sulfur, and phosphorus have four sp^3 orbitals in a tetrahedral shape.

According to the valence bond theory, a covalent bond is formed when an electron pair is shared between atoms by the overlap of orbitals. A bond slides easily over the poles of the atom models using a twisting motion and represents the region of orbital overlap. The scale of the bonds is 25mm = 1.0 **Å**. Do not throw or ingest parts. Ingesting may cause choking. For use with ages 12 and up.

Use Tables 1 and 2 to familiarize yourself with the atom models and bonds in your molecular model set.

TABLE 1 THE ATOMS

Color	Atom	Symbol	Number
White	Hydrogen	H	28
Black	Carbon	C	14
Red	Oxygen	O	8
Lime	Chlorine	Cl	6
Blue	Nitrogen	N	5
Orange	Bromine	Br	2
Yellow	Fluorine	F	2
Purple	Iodine	I	2
Yellow	Sulfur	S	2
Green	Phosphorus	P	2

TABLE 2 THE BONDS

Color	Size (mm)	Use	Number
Gray	25	Use to link hydrogen atoms to the molecule	28
Gray	40	Use with all atoms, except hydrogen, to hold the atoms securely in the molecule	14
Black	40	Use to allow rotation around the C—C single bond	13
Gray	51	Use to construct double and triple bonds	14

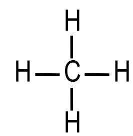
ALIPHATIC HYDROCARBONS

Aliphatic hydrocarbons are organic compounds containing only the elements hydrogen and carbon in the form of straight or branched chains. One group of aliphatic hydrocarbons, the alkanes, have only single covalent bonds and are known as saturated hydrocarbons. Methane, illustrated in Figure 1, is the simplest member of the alkanes and the major component of natural gas.

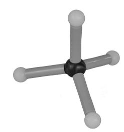
Figure 1 Methane

CH_4

Molecular Formula



Structural Formula



Molecular Model

The first ten molecules of the alkane series are listed in Table 3. The general formula for the alkanes is C_nH_{2n+2}.

TABLE 3 ALKANES

Formula	Name	Formula	Name
CH_4	methane	C_6H_{14}	hexane
C_2H_6	ethane	C_7H_{16}	heptane
C_3H_8	propane	C_8H_{18}	octane
C_4H_{10}	butane	C_9H_{20}	nonane
C_5H_{12}	pentane	$C_{10}H_{22}$	decane

Two groups of unsaturated aliphatic hydrocarbons are the alkenes and the alkynes, shown in Figure 2. An alkene has a double bond and the general formula, C_nH_{2n}. An alkyne has a triple bond and the general formula, C_nH_{2n-2}. The unsaturated hydrocarbons are highly reactive.

Figure 2 Aliphatic Hydrocarbons with Multiple Bonds

Ethene

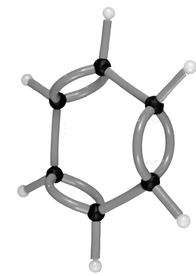
Acetylene (Ethyne)

To build molecular models containing double or triple covalent bonds, use two or three 51mm gray bonds. Bend the gray bonds and slide the bonds over two or three of the poles on the atom models.

AROMATIC HYDROCARBONS

The most common aromatic compounds contain the benzene ring, a ring of six carbon atoms. Benzene is a resonance structure and the bonds between the carbon atoms are identical. However, one contributing structure is represented by using alternating single and double bonds. To construct the benzene ring, use six 51mm gray bonds, three 40mm gray bonds and six 25mm gray bonds. Connect atoms as shown in Figure 3.

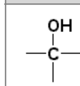
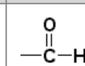
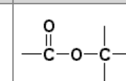
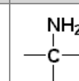
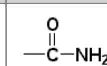
Figure 3 Benzene



FUNCTIONAL GROUPS

A functional group makes up part of a larger molecule and confers specific chemical properties to the molecule. The amino acid, glycine, has two functional groups, a carboxyl group and an amine group, which are displayed in Figure 4. The identification of functional groups and the ability to predict reactivity based on functional group properties is one of the cornerstones of organic chemistry.

TABLE 4 FUNCTIONAL GROUPS

Alcohol	Aldehyde	Ester	Amine	Amide
				
Ketone	**Carboxyl**	**Ether**	**Alkyl Halide**	**Phenyl**