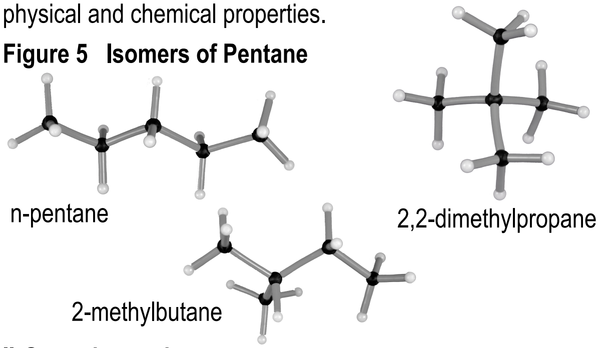
ISOMERS

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



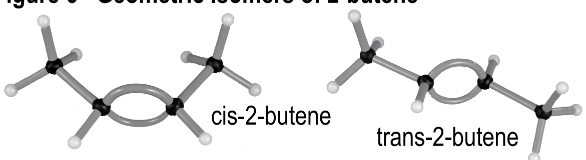
II. Stereoisomerism

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

The geometric isomers 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.

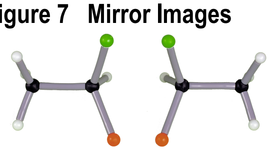
Figure 6 Geometric Isomers of 2-butene



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 Mirror Images



1-bromo-1-chloroethane

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

BOAT AND CHAIR CONFORMATIONS

Construct the "boat" conformation of cyclohexane by connecting six carbon atoms in a ring using the black bonds. Use the 25mm gray bonds to add the 12 hydrogen atoms. 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.

Figure 8
"Boat" Conformation

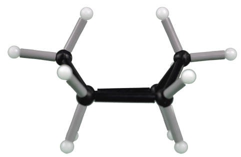
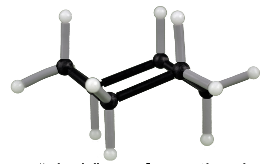


Figure 9
"Chair" Conformation

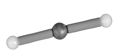
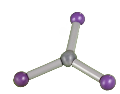
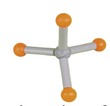


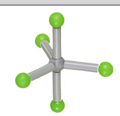
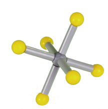
Convert the "boat" conformation to a "chair" conformation by rotating one of the carbon atoms downward below the plane containing the four carbon atoms. When placed on a flat surface, the model will set on the three hydrogen atoms that point downward as illustrated in Figure 9.

MOLECULAR GEOMETRY

The premise of the **Valence Shell Electron Pair Repulsion Theory, VSEPR**, is that valance electron pairs surrounding an atom mutually repel each other and adopt a shape that minimizes this repulsion.

TABLE 5 VSEPR MODELS

Linear BeH_2	Trigonal Planar BI_3	Tetrahedral CBr_4
 bond angle = 180^o hybrid orbitals = sp	 bond angle = 120^o hybrid orbitals = sp^2	 bond angle = 109.5^o hybrid orbitals = sp^3

Trigonal Bipyramidal PCl_5	Octahedral SF_6
 bond angles = 120^o and 90^o hybrid orbitals = sp^3d	 bond angle = 90^o hybrid orbitals = sp^3d^2

MEGA MOLECULES

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MOLECULAR MODEL SET

ISBN 978-0-9820869-4-0

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INTRODUCTION

The **Advanced Chemistry Molecular Model Set** is a vital tool in your study of chemistry. These models will help you visualize molecular structures, relate the physical and chemical properties of the compound to its structure, and understand chemical reactions.

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. The Advanced Chemistry Molecular Model Set has many atom models and a variety of hybrid orbitals.

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 ATOM MODELS

Color	Atom/Model	Symbol	Number
White	Hydrogen	H	36
Black	Carbon	C	15
Red	Oxygen	O	8
Blue	Nitrogen	N	6
Orange	Bromine	Br	6
Lime	Chlorine	Cl	6
Yellow	Fluorine	F	6
Purple	Iodine	I	6
Yellow	Sulfur	S	2
Green	Phosphorus	P	2
Silver	Alkali Metal	Li, Na, K	1
Silver	VSEPR Models	Be, B, Si, P, S	5
Silver	Square Planar Model	Pt	1

TABLE 2 THE BONDS

Color	Size (mm)	Use	Number
Gray	25	Use to link hydrogen atoms to the molecule	36
Gray	40	Use with all atoms, except hydrogen, to hold the atoms securely in the molecule	16
Black	40	Use to allow rotation around the C—C single bond	14
Gray	51	Use to construct double and triple bonds	14

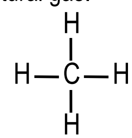
ALIPHATIC COMPOUNDS

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. The general formula for the alkanes is C_nH_{2n+2}. Methane, illustrated in Figure 1, is the simplest member of the alkanes and the major component of natural gas.

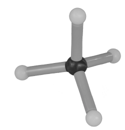
Figure 1 Methane

CH_4

Molecular Formula



Structural Formula



Molecular Model

TABLE 3 ALKANES

Formula	Name	Formula	Name
CH_4	<u>meth</u>ane	C_6H_{14}	<u>hex</u>ane
C_2H_6	<u>eth</u>ane	C_7H_{16}	<u>hept</u>ane
C_3H_8	<u>prop</u>ane	C_8H_{18}	<u>oct</u>ane
C_4H_{10}	<u>but</u>ane	C_9H_{20}	<u>non</u>ane
C_5H_{12}	<u>pent</u>ane	$C_{10}H_{22}$	<u>dec</u>ane

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}. To build 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.

Figure 2 Aliphatic Hydrocarbons with Multiple Bonds

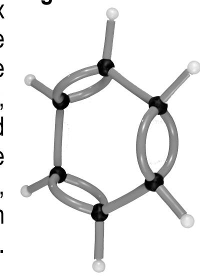
Ethene

Acetylene (Ethyne)

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 the 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.

Figure 4 Glycine

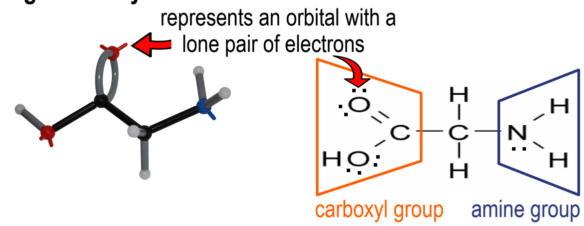
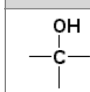
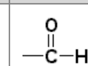
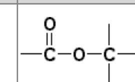
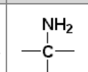
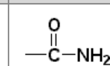


TABLE 4 FUNCTIONAL GROUPS

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