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Molecular Model Kit
#1863 & #1864

Warning:

- **Choking hazard – small parts**

Introduction

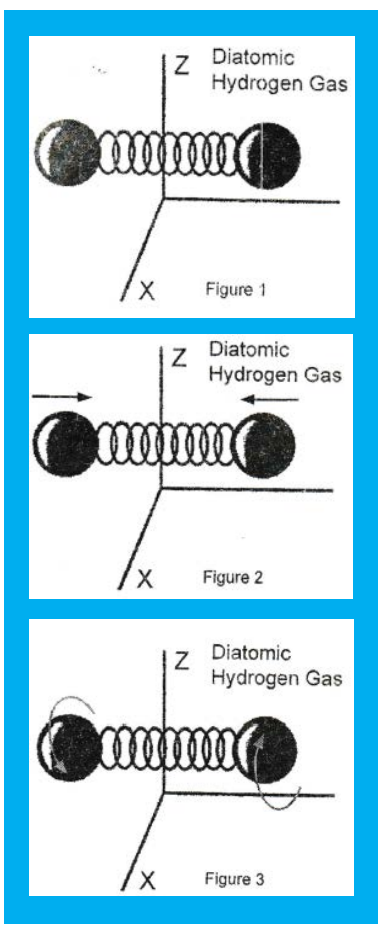
This kit has been designed to assist chemical education through university levels. Tapered plastic bonding rods help to simplify the construction process. Included in this set are 370 colored balls that represent a wide variety of atoms (see Appendix for details). Also included are ninety 1" bonding rods, sixty .75" bonding rods and ten 2" bonding rods. These varying length bonds represent the various relative bonding lengths that normally occur in molecules. The 1" bonding rods are designed to be used as a carbon-carbon alkane bond. The .75" bonding rods are designed to be used whenever there is a need for double or triple bonding. The remaining 2" bonds are included as extras that can be cut to any desired length.

What's in this kit?

In this kit you will find various colored balls with pre-formed holes, three different size bonding lugs and an instruction manual. A complete detailed parts list can be found at the end of this manual.

Why Atoms Form Molecules

To the left you will find a model of a diatomic hydrogen gas molecule. In this model you will see that it consists of two hydrogen atoms connected by a spring. Using this model you can envision how the two atoms could move in several different ways. The atoms could vibrate about the center as shown in Fig. 1. They could also rotate about any of the three axis as shown in Fig. 2. Or they could move in any direction labeled x, y, or z in Fig. 3. That makes seven different directions of movement that these two atoms could take.



Now imagine that the atoms were not bound at all. Each individual atom would only have three possible direction of movement, x, y, or z. If the two atoms were thought to be one unit there would then be nine possible configurations of movement that this system could take. In other words, the first atom may be moving in the x direction while the second atom was moving in the z direction. This means that as a system there is a lesser amount of movement possibilities for bound system than for an unbound system. For an unbound matrix of atoms there is randomness and disorder.

Entropy

Atoms that are bound have less freedom to move than unbound atoms. This results in bound atoms having less randomness and disorder. The measurement of the disorder in a molecular system is known as *entropy*. The more randomness an atom has the greater the entropy. Scientists believe that the entropy of the universe is ever changing and always increasing. This is in due largely to atoms continuously combing to form molecules.

The Three Forms of H_2O

Take a look at the molecular model of steam. You probably are aware that water, which makes up steam, has two hydrogen atoms and one oxygen atom (H_2O). But take a look at the angle between the two hydrogen atoms. You will find that it is consistently set at 105 degrees.

Electrons that surround the hydrogen atoms are drawn toward the oxygen atoms more strongly than they are attracted toward one another. This causes a positive charge to occur near the hydrogen atom and a negative charge to appear near the oxygen atom. This concept is what accounts for several properties known surrounding water molecules such as its ability to act as a solvent, high freezing and boiling points, and high dielectric constant.

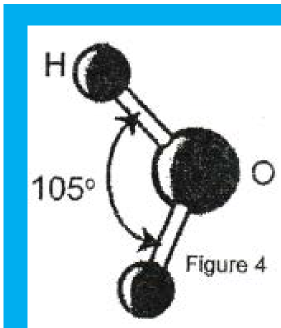


Figure 4

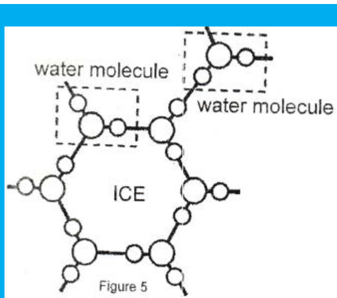


Figure 5

Ice is of course another form of H_2O, but in this situation the molecules are linked together in a geometric tetrahedral configuration. Ice is built of weaker bonds referred to as hydrogen bonds. The structure of the molecules is developed as the water expands as it freezes.

Use the black alkane carbon spheres in your kit to form a three dimensional model of an ice crystal. In this case the black spheres will represent water molecules not carbon atoms.

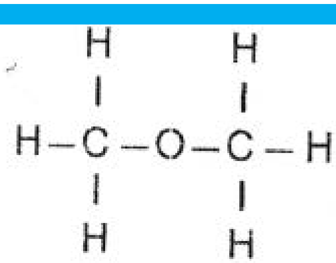
Organic Chemistry

The field of chemistry that is specifically concerned with molecules that are made up primarily of carbon is known as *organic chemistry*. The number of organic compounds reaches into the millions and can include compounds from the food that we eat to the fuel that is in our automobiles. The reason for this lies in the fact that the carbon atom has four electrons in its outer shell and these electrons have the tendency to be shared in covalent bonds. Thus the carbon can easily bond with other carbons, hydrogens, halogens, oxygens, and several other elements.

Hydrocarbons

Hydrocarbons are a category of organic chemistry in which all of the compounds contain only carbon and hydrogen. The simplest form of a hydrocarbon is methane, CH_4. Chemical formulas written in this manner is known as *nomenclature.* However, in organic chemistry this way of depicting the formula does not provide enough information. For example the formula C_2H_6O could represent either ether or ethyl alcohol. So another method of depicting the structure known as the empirical formula was developed. A comparison of the two is as follows:

C_2H_6O



Because the atoms are bound by single bonds they are known as *saturated.* Hydrocarbon molecules that contain double or triple covalent bonds are known as *unsaturated.*

Within the family of hydrocarbons fall Alkanes, Alkenes, Isomers, Alkynes, Aldehydes, Ketones, Amines, and several others.

Alkanes

Alkane molecules are comprised of the formula C_nH_{2n+2}. In this formula "n" is equal to the number of carbon atoms. As mentioned earlier CH_4, which is methane, is the simplest form of this and is the least reactive of all organic compounds. When used as a fuel, the combustion reduces these molecules to carbon dioxide and water. If however there is an insufficient amount of oxygen during combustion carbon monoxide gas is also produced which can be very dangerous.

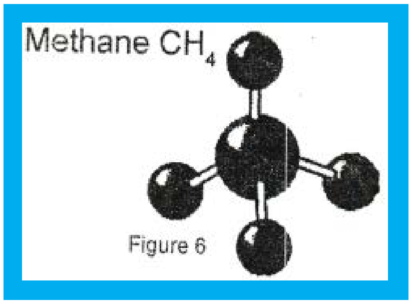


Figure 6

All of the molecules that fall into the alkane group end with the suffix "ane". Propane, Methane, and Butane are three types of alkane molecules that are used as fuel today. Here are the structural formulas for two of these alkanes.

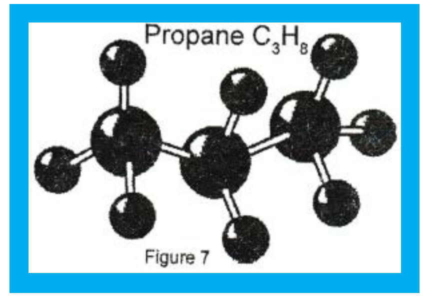


Figure 7

Alkenes

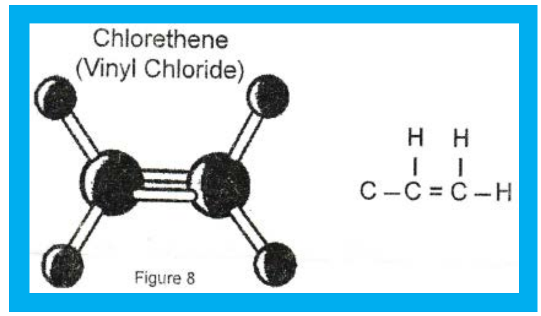


Figure 8

Alkene molecules consist of double covalent bonds that join two adjacent carbon atoms. As noted earlier this denotes them as unsaturated. Alkenes are more reactive than alkanes. When they do react, they sometimes actually transform themselves into alkanes or alkane-like substances with only a single bond. One type of alkene is shown to the right. This molecule is known as chloroethene or more commonly known as vinyl chloride. This is the basic structure of plastics referred to as poly vinyl chloride or PVC. Poly vinyl chloride is probably one of the most widely used plastic in the world. It is used in everything from the water pipes in our homes to the chairs and counter tops. All alkenes end with the suffix "ene".

Alkynes

Alkynes consist of triple covalent bonds between two adjacent carbon atoms. The suffix for all alkynes end with "yne". Alkynes are even more reactive than alkenes. The general formula is C_nH_{2n-2} and the empirical structure for ethyne and propyne are shown below.

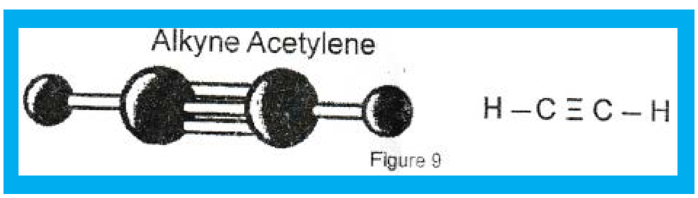


Figure 9

Keytones

When a secondary alcohol is oxidized it forms a compound called a keytone. The suffix for keytones is "one" such as dimethyl ketone or better known as acetone.

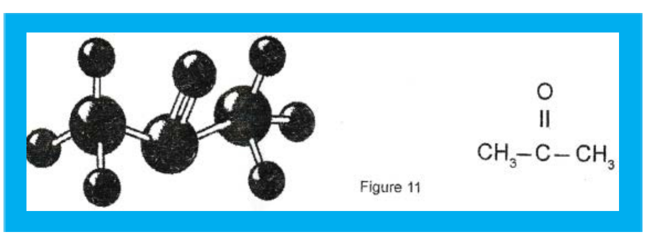


Figure 11

Aldehydes

Aldehydes are molecules with a general structure shown in Figure 10. Aldehydes are prepared by oxidation of an alcohol. For example this can be done by simply placing a hot copper wire into alcohol. A typical aldehyde is formaldehyde. The empirical structure is as follows:

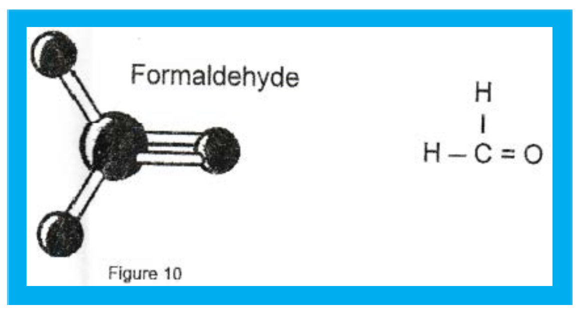


Figure 10

Amines

When a molecule contains the radical NH_2 - it is called the amide ion or the amino group. If the conditions are right this ion can replace a hydrogen atom in a hydrocarbon compound. When this occurs it is referred to as an amine. For example:

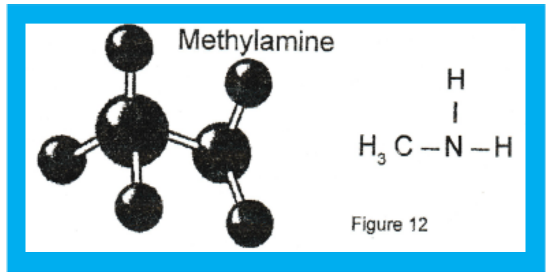
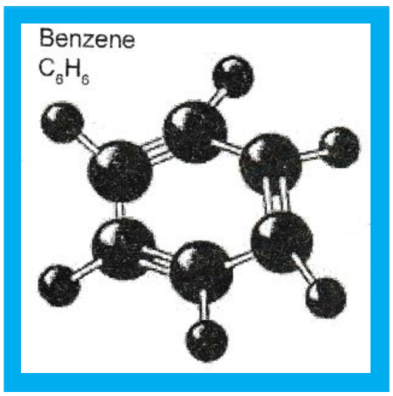


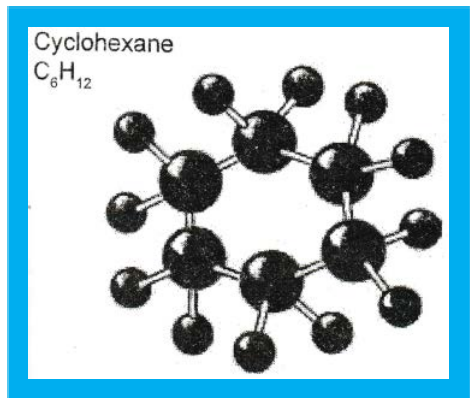
Figure 12

Amino acids are organic acids that contain one or more amino groups. There are more than twenty amino acids that are known, the simplest which is glycine or also known as amino acetic acid, NH_2CH_2 - COOH. Many of these are required by the human body to help form body proteins.

Benzene & Cyclic Molecules

Dyes, fats, proteins, nucleic acids and other organic compounds contain one or more benzene rings. Benzene is known as a cyclical compound because the carbon atoms that form the molecule are joined together in a closed ring. This benzene ring and carbon bending is extremely strong. As a matter of fact it is sometimes so strong that reactions involving these types of molecules quite often leave the ring intact and either substitute or eliminate elements that connect the ring. Two molecules, cyclohexane and benzene, are shown below. Note that although similar in appearance, the cyclohexane is an alkane and benzene is an aromatic molecule.





Amines & the Nitrogen Cycle

Proteins are essential to the growth and development of humans, plants, and animals. It is an important part of the immune and repair system. As a matter of fact proteins are necessary in all living cells. Plants obtain protein by synthesizing it from material in the soil. Animals obtain it by feeding on plants or by eating plant-eating animals. But one of the major constituents of protein is nitrogen. Nitrogen can be detrimental to living cells. Most mammals and reptiles expel this nitrogen through their urine or otherwise known as urea. Water dwelling animals however, expel this nitrogen by first converting it to ammonium molecules which passes through their bodies and then into the water. Urea is more efficient than monomial because twice as many nitrogen atoms can be expelled per molecule.

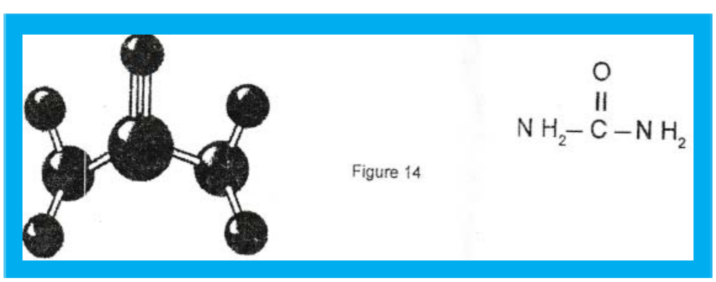


Figure 14

L & D Amino Acids

Another major constituent of protein is amino acids. All amino acids except glycine can exist in a variety of isomers of structures. One pair of amino isomers are shown below.

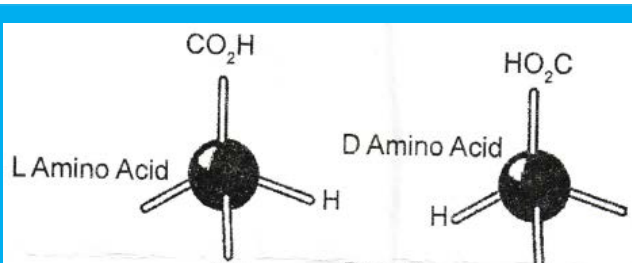


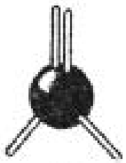
Figure 15

The L and D that differentiates these two amino acids come from the Latin words *Levo* meaning left and *Dextro* meaning right. This is because the two are basically mirror images of one another. Although the L and D amino acids appear almost identical to one another it has been found that almost all living creatures consist of L amino acids.

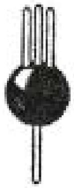
Packing List:	**Student Kit #1864**	**Instructor Kit #1863**
Blue Trivalent/Pentavalent spheres	6	30
Green Monovalent Halogen spheres	5	25
Orange Monovalent Sodium/Potassium spheres	4	20
Orange Bivalent Calcium/Magnesium spheres	6	30
Yellow Sulfur/Selenium spheres	4	20
Black Alkane Carbon spheres	6	30
Black Alkene Carbon spheres	4	20
Black Alkyne Carbon spheres	2	10
Red Bivalent Oxygen spheres	6	30
Yellow Aluminum/Chromium spheres	6	30
White Hydrogen atoms with bonds	25	128
Bonding Lugs (3 sizes)	81	164
Instruction Manual	1	1

Appendix

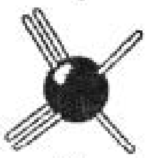
Alkane Carbon Black 1" Ball



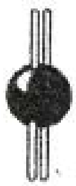
Alkene Carbon Black 1" Ball



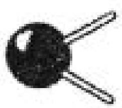
Alkyne Carbon Black 1" Ball



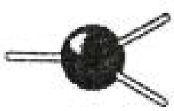
Hexavalent Sulfur / Selenium
Yellow 1" Ball



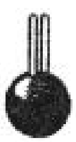
Double Bounded Sulfur /
Selenium Yellow 1" Ball



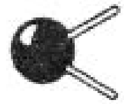
Bivalent Sulfur / Selnium
Yellow 1" Ball



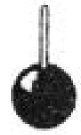
Trivalent Aluminum / Chromium Metals
Yellow 3/4" Balls



Oxygen / Calcium / Magnesium
Double Bounded Oxygen (Red),
Calcium / Magnesium (Orange) 3/4" Ball

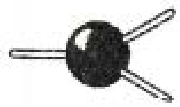


Oxygen / Calcium / Magnesium
Bivalent Single Bounded Oxygen (Red),
Calium / Magnesium (Orange) 3/" Ball



Sodium / Potassium Monovalent Metals
Orange 1" Ball

Pentavalent Nitrogen / Phosphorus
Blue 3/4" Ball



Trivalent Nitrogen / Phosphorus
Blue 3/4" Ball