CHEMISTRY LAB: MOLECULAR MODEL BUILDING LAB (two days)

WHAT TO TURN IN:	Data Table

Objectives

- To construct 3-D models to visualize how molecules are arranged
- To practice drawing structures
- To review VESPR concepts

Introduction

The most common type of chemical bond between two atoms is a *covalent bond*. The covalent bond consists of a pair of shared electrons, one from each atom. If this pair of electrons is shared between two atoms of equal *electronegativities*, the bond is called a *nonpolar covalent bond*. However, in most cases, the pair of electrons is shared by two atoms of different electronegativities. Thus, the pair of electrons is shifted toward the more electronegative element. A partial negative charge results on one side of the bond and a partial positive charge on the other. This type of covalent bond is called *polar covalent.*

Molecules composed of covalently bonded atoms may also be polar or nonpolar. For the molecule to be polar, it must, of course, have polar bonds. But the key factor for determining the polarity of a molecule is its shape. If polar bonds are *symmetrical* around the central atom, they offset each other and the resulting molecule is *nonpolar.* However, if the polar bonds are *not symmetrical* around the central atom, the electrons will be pulled to one end of the molecule. The resulting molecule is *polar.*

Ball-and-stick models are often used to demonstrate molecular shape. In this lab you will build several covalent molecules and predict each molecule's polarity on the basis of its molecular shape.

A molecule can be represented on paper by either a molecular or a structural formula. A molecular formula indicates the number and kind of each atom present in a molecule. Some familiar molecular formulas are H_2O, NH_3, and CH_4 . These molecular formulas do not provide any information concerning the actual arrangement of atoms in a molecule. Such information is given by structural formulas such as the following.

```
                                 H
                                 |
H—O—H        H—N—H        H—C—H
                 |               |
                 H               H
```

These structural formulas are two dimensional. The angles shown are not true to the shape of the molecule. Structural formulas can be made to convey more information by using the following symbolism:

Straight line for a bond in the plane of the paper
Dashed line for a bond below the plane of the paper
Boldface line or wedge for a bond above the plane of the paper

In this lab, you will construct three-dimensional models to help you visualize the shapes of molecules. You will use ball-and-stick models, in which painted wooden balls represent atoms and short wooden sticks represent the bonds. Double and triple bonds are represented by springs. The wooden balls are drilled with holes to accept the sticks and springs. The number of holes in the ball represents the maximum number of bonds that a given atom can have. The balls are also color-coded so that atoms of different elements can be distinguished.

VSEPR (Valence-Shell Electron Pair Repulsion) is an important concept defining molecular geometry. Lewis (electron dot) structures are used to see the numbers of shared and unshared electron pairs around the central atom. A common way to place the dots follows the saying "right, left, up, down, top all the way around - counterclockwise."

	3 5	
2 6	SYMBOL	1 8
	4 7	

Based on the number of *bonding (shared)* and *nonbonding (unshared)* electron pairs in the valence or outer "shell" area of the central atom, the 3-D arrangement of a molecule can be determined. Multiple bonds—double and triple—are treated as only one bond for this purpose.

Here is a summary of the main geometric shapes:

# BONDING PAIRS OF CENTRAL ATOM	# NONBONDING PAIRS OF CENTRAL ATOM	SHAPE	BOND ANGLE
2	0	linear	180°
2	1	angular / bent	116°
2	2	angular / bent	104.5°
3	0	trigonal (triangular) planar	120°
3	1	pyramidal	107.3°
4	0	tetrahedral	109.5°
5	0	trigonal bipyramidal	90° & 120°
6	0	octahedral	90°

Procedure

1) Set up a data table with four columns and 10 rows. You can fit 4-5 rows on a page. It works better with the paper turned sideways. Use a ruler. Make sure you have plenty of room to draw.

FORMULA	DOT DIAGRAM	"BALL-&-STICK"	SHAPE

2) Write each compound *formula* in the data table.
3) Write the electron dot diagram for each formula. Use different colors for each type of atom.
4) Build each model as you go. Make sure all group members see each model, and take turns building. Use the kit's color key.
5) Draw the "ball-and-stick" structure for each. Use colors and include a color key. Try to get the correct bond angles as you see them.
6) Determine the shape of the molecule using the VSEPR chart provided.
7) NOTE: For Data #1-2, there is no VSEPR shape, as there is only one bonding area.

DATA

1) O_2 (use springs for double bond)
2) N_2 (use springs for triple bond)
3) H_2O
4) NH_3
5) CO_2 (use springs for double bonds)
6) CH_3Cl
7) H_2CO (use springs for double bond)
8) C_6H_6 (a ring, alternating stick-single and spring-double bonds)
9) C_3H_8 = build as $CH_3CH_2CH_3$
10) HCN (triple bond)