MiraCosta College
Introductory Chemistry Laboratory
Experiment 6

Molecular Models and Covalent Bonding

EXPERIMENTAL TASK

To use the Lewis structure theory of covalent bonding to generate three-dimensional models of small molecules.

Objectives

After completing this experiment, the student will be able to:

1. Draw Lewis structures for simple molecules
2. Use these Lewis structures as a guide to construct models of these molecules, using a ball-and-stick model kit.
3. Determine the relative bond polarity of each bond in a molecule, using electronegativities.

Additional Reading

- General, Organic and Biological Chemistry, by Timberlake, sections 4.5 – 4.10.

Background

Chemistry, being the science of matter and the changes it undergoes, encompasses a wide variety of phenomena. However, whether a chemist studies the dynamics of explosives or the mechanism of DNA transcription, theories of chemical bonding are at the core of the work she or he does. A thorough understanding of chemical bonding is necessary to predict and explain the properties and behavior of the systems a chemist studies.

A chemist's interpretation of the behavior of a particular system often takes the form of a *model*. According to Hawley's Condensed Chemical Dictionary, a model is "a representation, either abstract or physical, of a system, arrangement, or structure that cannot be perceived objectively." In this experiment one covalent bonding theory, Lewis structures, will be used in conjunction with the ball-and-stick kits to construct models of simple molecule, and these models will be used to predict the geometry of molecules, and the whether each molecule has a dipole moment or not.

The final result for this experiment will be a table consisting of: the Lewis structure of the molecules used; a drawing of the model of the molecule; the polarity for each type of bond in the molecule; and the conclusion as to whether or not each molecule has a dipole moment or not.

Pre-lab Questions

1. Draw the Lewis structure for each of these species:
   A. CO_2
   B. H_2O

2. What are the bond polarities for each type of bond in each molecule given in #1?

BEFORE STARTING THE EXPERIMENT

Safety

Always keep in mind the rules presented in both the "MCC Laboratory Safety Rules" and the Laboratory Handbook for General Chemistry. It is your responsibility to make sure that you follow all safety rules at all times, and to graciously help everybody else in the laboratory (including the instructor) to do the same. While this experiment has no inherent hazards, please do not forget that you are still working in a chemistry laboratory, and that there are some hazards that are always present.

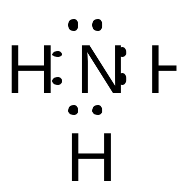
EXPERIMENT PROCEDURE

Construct a table in your notebook that looks like the Table of Species for Molecular Modeling (see the last page of this handout), making each row large enough to draw Lewis structures and pictures of the models.

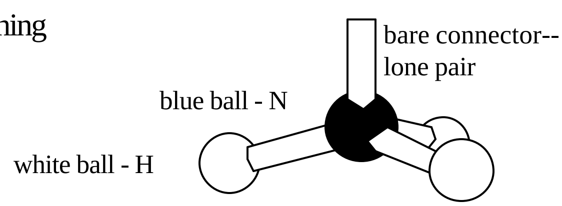
1. Use the procedure from the textbook (Timberlake, section 4.5) to draw a Lewis structure for each species.

2. Use the ball-and-stick model kit to construct the model that represents the molecule, based on these guidelines:
   A. **Atoms:** IGNORE the color code given on the outside of the box. Instead, use balls that have the same number of holes as the atom has pairs of valence electrons in the Lewis structure—any atom that has an "octet" of electrons must be represented by a ball that has 4 holes. Use black balls for carbon atoms, and yellow or blue for other atoms that have four electron pairs. Use the white balls for hydrogen (1 hole).
   B. **Non-bonding electrons:** Each unshared pair of electrons ("lone pair") will be represented by 1 short, rigid connector, with no ball at the other end of it.
   C. **Bonding electrons:**
      i. Single bonds will be represented by 1 connector--use the short, rigid connectors for bonds involving hydrogen atoms and use the longer, more flexible connectors for all other bonds.
      ii. Double bonds will be represented by 2 longer, more flexible connectors
      iii. Triple bonds will be represented by 3 long, flexible connectors.

Example:



will look something like this:

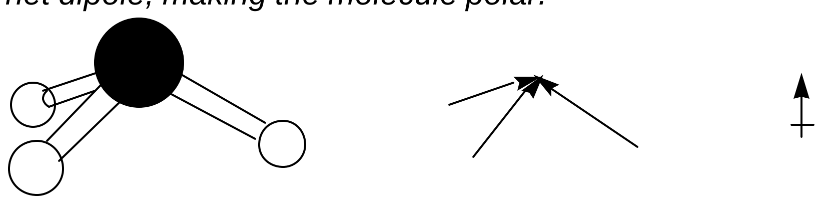


3. Determine the Bond Polarity for each type of bond. List the electronegativity values for each pair of bonded atoms and calculate the difference between them (see figure 4.4 in Timberlake, page 137, for electronegativity values of the elements). Use this difference to determine if the bond is nonpolar, polar, or ionic, as follows: if the electronegativity difference is 1.7 or greater, the bond is ionic; if the difference is more than 0.3 but less than 1.7, the bond is polar covalent, and if the difference is 0.3 or less, the bond is nonpolar covalent. Do this separately for each different type of bond. For example, CH_2O has two types of bonds: C—H bonds and C—O bonds, so calculate the polarity for C—H bonds first, and then calculate the polarity for the C—O bond.

Example: *NH_3 has one type of bond, N—H. N has an electronegativity of 3.0 and the electronegativity of H is 2.1: 3.0–2.1 = 0.9, so each N—H bond is polar covalent.*

4. Use the concepts in section 4.10 of Timberlake to determine whether the molecule is polar or non-polar, based on the combination of bond polarities and the shape of the molecule.

Example: *NH_3 has polar covalent bonds between the N atom and each H atom, and N has the higher electronegativity. The shape of the molecule shows the N atom is not in the same plane as the H atoms, so the N atom pulls the electrons toward itself, and up out of the plane of the H atoms. This gives a net dipole, making the molecule polar.*



RESULTS

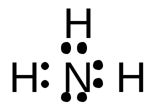
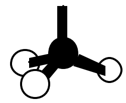
The table on the next page, once it has been completed during the experiment, will be sufficient -- you will not need a separate Results section.

DISCUSSION

For EACH molecule, briefly describe how the model and bond polarities combine to give the overall molecular polarity.

Fill in the following table for each of the molecules shown.

SPECIES FOR MOLECULAR MODELING

Molecule	Number of Electrons	Lewis Structure	Model Made?	Bond Polarities	Molecular Polarity
NH_3 (example)	**8 e$^-$**			N=3.0, H=2.1 3.0-2.1=0.9 **Polar Covalent**	**Polar Molecule (Y/N)**
CH_4					
CS_2					
H_2S					
N_2					
CH_3Cl					
CH_2O					
OF_2					
O_2					
Cl_2					