**lab: Model Building with Covalent Compounds - Introduction**

Most of our learning is in two dimensions. We see pictures in books and on walls and chalkboards. We often draw representations of molecules on flat paper. Two-dimensional representations include electron-dot structures and structural formulas. In electron dot structures, a pair of "dots" or a pair of electrons is used to represent a single covalent bond. The hydrogen molecule is shown as H:H. In structural formulas, a single covalent bond is represented by a straight line. The hydrogen molecule is H-H. Although such "models" help us in understanding the structure of molecules, flat models do not give us the three-dimensional view that is necessary to truly visualize most molecules. In this experiment, you will build three dimensional molecular models and then compare them with the corresponding structural formulas.

In covalent molecules there are single, double, and triple bonds between atoms. In some cases, the molecules are in a straight chain-like arrangement. At other times, the atoms arrange themselves in a ring-like structure or in the form of branched chains. (See photos on next page.)

Sometimes a group of atoms may form more than one structure. Thus, a given molecular formula might represent more than one compound. For example, C₂H₆O represents ethyl alcohol and dimethyl ether, compounds with different structural formulas and quite different properties. Substances that have the same chemical formula but different structures are called structural isomers.

Scientists who are responsible for determining the structures of molecules often start with computer animation or molecular model kits like the ones you will use. Complicated molecules such as DNA, deoxyribonucleic acid, are most often shown in three-dimensional models. Without these models, we would not understand how the atoms of the molecule interact.

**Objectives:** You will construct models of some simple and more complicated covalent molecules. You will draw the structural formulas, using VSEPR theory to determine their shapes. You will also show all possible structural isomers for some molecules.
Often times, a student will construct the same molecule twice and think they are different molecules. Just rotating a bond or turning the molecule a different direction does not make it a different molecule. See the example to the right. To be an isomer of a molecule, it must have different bonds between the atoms. The arrangement must be different without rotation.

These are the same structures. They are NOT isomers.

C₅H₁₂ – straight chain (isomer of the branched chain)

How does one draw this straight chain as a Lewis Structure?

\[
\begin{align*}
\text{H} & \text{H} & \text{H} & \text{H} \\
\text{H} & \text{C} & \text{C} & \text{C} \\
\text{H} & \text{H} & \text{H} & \text{H}
\end{align*}
\]

How does an organic chemist draw these isomers of C₅H₁₂? (not required for you to know)

They assume that the end of each straight line contains a carbon (unless shown otherwise) and that carbon will have eight valence electrons around it. Therefore, it is assumed that hydrogens complete carbon’s octet (unless shown otherwise).

C₅H₁₂ – branched chain (isomer of the straight chain)

How does one draw this branched chain as a Lewis Structure?

\[
\begin{align*}
\text{H} & \text{H} \\
\text{H} & \text{C} & \text{C} & \text{H} \\
\text{H} & \text{H} & \text{H} & \text{H}
\end{align*}
\]

Challenge: What is the formula for this molecule? (not required for you to be able to do)
**Lab: Model Building with Covalent Compounds**

**Procedure:** Get a model kit. Use all of the same size (short) wooden sticks for your single bonds. Two springs will be used for a double bond and three springs will be used for a triple bond.  
**DO NOT OVERSTRETCH THE SPRINGS!  
ONCE DAMAGED, THEY CANNOT BE USED AND MUST BE REPLACED! $**

**Part I:** Build the model of the following molecules. There is only one structural isomer of each one. To confirm this, try making the atoms combine in some other way and you will find that once you turn the molecule around, it will be identical to the original structure. When you are satisfied that you have the correct structure, draw the Lewis Structure in the section below. Be sure that you have represented the correct number of valence electrons in the structure. (Show the lone pairs even though the models do not have them.)

<table>
<thead>
<tr>
<th>ATOM</th>
<th>COLOR</th>
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<tbody>
<tr>
<td>hydrogen</td>
<td>yellow</td>
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<tr>
<td>chlorine</td>
<td>green</td>
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<tr>
<td>oxygen</td>
<td>red</td>
</tr>
<tr>
<td>nitrogen</td>
<td>blue</td>
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<tr>
<td>carbon</td>
<td>black</td>
</tr>
<tr>
<td>phosphorus</td>
<td>blue</td>
</tr>
<tr>
<td>bromine</td>
<td>orange</td>
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a. water, $\text{H}_2\text{O}$  
b. methane, $\text{CH}_4$

c. ammonia, $\text{NH}_3$  
d. carbon tetrachloride, $\text{CCl}_4$

e. phosphorus trichloride, $\text{PCl}_3$  
f. bromomethane (methyl bromide), $\text{CH}_3\text{Br}$

g. propane, $\text{C}_3\text{H}_8$  
h. methanol, $\text{CH}_3\text{OH}$
**Part II:** For the following molecules, there can be more than one arrangement of the atoms. For each one, try to find as many different structural isomers as you can. Draw the Lewis Structures for each one. In parentheses, you will find the total number of isomers that are possible.

a. butane, $C_4H_{10}$ (2)

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b. $C_4H_{10}O$ (4 alcohols and 3 ethers)

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<tbody>
<tr>
<td>alcohol</td>
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c. hexane, C₆H₁₄ (5)
Part III: All of the preceding molecules included only single bonds. In the following group of molecules there are single, double, and triple bonds. Make each structure, then determine if any other isomers exist. Finally, draw the Lewis Structure for each of the molecules below. In parentheses, you will find the total number of isomers that are possible.

a. carbon monoxide, CO

b. nitrogen, N₂

c. butene, C₄H₈ (3) (use double bonds)

d. butyne, C₄H₆ (2) (use triple bonds)