CHEM-01A
Exploring Lewis Structure and Molecular Geometry

(Modified version of the experiment in SJSU Chem.1A Lab Manual)

Objectives – In this lab you will

- Practice drawing Lewis Dot Structures
- Determine the molecular geometry and polarity of a variety of compounds.

Introduction

Lewis structures and geometry

Lewis structures are two-dimensional drawings in which the valence electrons of an atom are illustrated as dots. A chemical bond is illustrated by having dots shared by two atoms. A pair of electrons being shared by two atoms is called a bonding electron pair. Electrons belonging to only one atom are called lone pairs or unshared pairs.

To predict the geometry of a molecule, we use Valence Shell Electron Pair Repulsion Theory (VSEPR). (Refer to your textbook and/or your lecture notes for more information). This theory postulates that the geometry of a molecule is dictated by the number of electron groups at the central atom. These electron groups must be separated from one another as much as possible since they repel each other. One can calculate the Total Electrons Groups for an atom by counting how many other atoms are bound to it and adding to it the number of lone pairs around that atom.

Note that for the purpose of calculating the Total Electron Groups, it does not matter whether the bonds between two atoms are single, double, or triple. All the electrons in that bond correspond to one electron domain.

The molecular geometry of a molecule is associated with its particular total electron groups. For example, if the total electron groups is 2, the two electron domains around the central atom must be separated from one another as much as possible. The greatest separation is when these 2 electron groups are 180 ^{0} from each other, making the geometry linear. For three electron groups, the geometry will be trigonal planar, with each electron group separated by 120 ^{0}. Table 1 summarizes the names associated with certain Total Electron Groups.

In this lab you will practice drawing Lewis Dot structures. In addition, you will determine the molecular geometry and polarity of a variety of compounds. Constructing three-dimensional models of molecules hopefully helps you better visualize the molecular geometries.

Table 1 – Molecular Geometry and Total Electron Groups

Total Electron Groups	**# of Bonding Groups**	**# of Lone Pairs**	**Electron Geometry**	**Molecular Geometry**	**Bond Angle**
2	2	0	Linear	Linear	180^0
3	3	0	Trigonal Planar	Trigonal Planar	120^0
3	2	1	Trigonal Planar	Bent	120^0
4	4	0	Tetrahedral	Tetrahedral	109.5^0
4	3	1	Tetrahedral	Trigonal Pyramidal	109.5^0
4	2	2	Tetrahedral	Bent	109.5^0
5	5	0	Trigonal Bipyramidal	Trigonal Bipyramidal	120^0 and 90^0
5	4	1	Trigonal Bipyramidal	See-saw	120^0 and 90^0
5	3	2	Trigonal Bipyramidal	T-shaped	90^0 and 180^0
5	2	3	Trigonal Bipyramidal	Linear	180^0
6	6	0	Octagonal	Octagonal	90^0
6	5	1	Octagonal	Square Pyramidal	90^0
6	4	2	Octagonal	Square Planar	90^0
6	3	3	Octagonal	T-shaped	90^0 and 180^0
6	2	4	Octagonal	Linear	180^0

Polarity

It is possible to predict polarity from Lewis structures. Polar molecules have their center of positive charge at a different point than their center of negative charge. This separation of charge producs a dipole moment in the molecule. Covalent bonds between different kinds of atomes are polar; heteronuclear diatomic molecules are polar. In some molecules the polarity from one bond may be canceled by that from others. Carbon dioxide, CO_2, is nonpolar molecule due to its linear geometry. Methane, CH_4, is nonpolar due to its tetrahedral shape. C_2H_6 and C_2H_4 are also nonpolar due to their symmetrical geometry.

Resonance

Molecules with a fixed atomic geometry but having different electronic or bonding arrangements.are called resonance structures. Molecules such as benzene C_6H_6, which have two or more resonance structures, are said to exhibit resonance. The actual bonding in such molecules is considered as an average of the bonding present in the resonance structures. The stability of molecules exhibiting resonance is found to be higher than those with no resonance structure.

Isomers

Molecules with identical molecular formula may have different atomic arrangements that satisfy the octet rules. These molecules are called isomers. The two isomers CH_3CH_2OH and CH_3OCH_3 have the same molecular formula C_2H_6O but their properties markedly differ. Isomerism is very common, particularly in organic chemistry, and when double bonds are present. Isomeric structures are NOT interconvertible without bond breaking.

Name ______________________________ Date _______ Grade ____

PRE-LAB QUESTIONS

MUST be completed before an experiment is started. The COPY pages will be collected as you enter the lab.

Please answer the following questions and show all work and units. Express all answers to the correct number of significant digits.

Draw the Lewis Dot Structures of the following molecules:
CH_4, NCl_3, H_2O, CS_2, SO_2, CO_3^{2-}, BeH_2, BF_3, PCl_5, and SF_6.
Refer to your textbook and/or your lecture notes if you need assistance with drawing Lewis Dot structures.

Procedure

Part I – <u>Compounds that follow octet rule</u>

Note that if a compound follows the octet rule, it can have NO more than four pairs of electrons around it, whether they are used for bonding or not.

1. Locate the Lewis Structures (refer to the Prelab) for the molecules listed below.

CH_4 NCl_3 H_2O CS_2 SO_2 CO_3^{-2}

2. Use the molecular model kit to construct models of these compounds following the instructions below. Then fill out the table in the report sheet.

3. Fill out the report sheet. Describe the molecular geometry using the names discussed in class, which are included in Table 1. Indicate whether the molecule is planar or not, and polar or not. Note that all these molecules started out with a central atom that has the ability to form as many as four bonds, yet based on how many bonds the central atom forms and whether these are single, double or triple bonds, the molecular shapes are very different.

Keep your models assembled until your instructor signs your report sheet indicating that you have constructed these molecules.

Part II – <u>Compounds that do NOT follow the octect rule</u>

Some compounds cannot follow the octet rule because they have too many or too few electrons around the central atom. The ones listed below are in that category.

1. Locate the Lewis Dot Structures for the following molecules in your prelab.

BeH_2 BCl_3 PCl_5 SF_6

2. Construct the models for these molecules is more interesting since they each start with a different number of electron pairs around the central atom. Keep in mind that the electron groups around the central atom wish to be as far apart from one another as possible.

3. Fill out the Report Sheet.

Leave your models assembled until your instructor checks and signs on your report sheet.

Part III – <u>Practice</u>

For each of the molecules or ions below, draw the Lewis Dot structure, construct a model, and fill the report sheet. Table I will help you identify the molecular geometry correctly once you construct the model.

$GeCl_2$	IF_4^+	XeF_4	$SOCl_2$	ICl_5
SbF_6^-	NH_4^+	HCN	I_3^-	ICl_3

Part IV– <u>Carbon</u>

Carbon has the ability to form very long chains. This means that there are an enormous number of carbon-based compounds. So many, in fact, that a full year course is dedicated just to carbon chemistry (Organic Chemistry). Carbon follows the octet rule. So, each carbon must have eight electrons around it. Carbon is also very versatile in that it can form double and triple bonds with other carbons.

Draw the Lewis structure for the compounds below and construct the models for the molecules. Fill out the Report Sheet. Estimate what is the angle formed between the two carbons and any one of the hydrogens.

C_2H_6 C_2H_4 C_2H_2 C_3H_8 C_3H_6

C_4H_{10} (Note: There are two possible molecular arrangements with this same formula! See if you can come up with the two).

Post-Lab Questions and Exercises

(All questions must be answered during the lab and submitted with your lab report at the end of the lab period).

Please answer the following questions and show all work and units. Express all answers to the correct number of significant digits.

You should be able to do these problems WITHOUT using Table 1.

Q1. For the following molecules, draw the Lewis Dot Structure, determine the molecular geometry and polarity.

$SnCl_5^-$	H_3O^+	XeF_2	HOBr
H_2CO	BH_3	$AsCl_3$	

Q2. Assuming the stability requires that each atime obey the octet rule, predict the stability of the following species:

PCl_3	H_3O	CH_2	CO

Q3. Draw the Lewis structures, state the geometry and polarity of the following molecules or ions. Also give any likely isomers or resonance forms of the following molecules:

C_2H_2	C_2H_4	$C_2H_2Br_2$	$C_2H_4Cl_2$
$C_2H_2Cl_2$	CH_4O	H_2O_2	P_4
SCN^-	SO_2	SO_3	SO_3^{2-}
SO_4^{2-}	NO_3^-	HNO_3	H_2CO_3