

Dougherty Valley HS AP Chemistry
Molecular Bonding and Structure of Covalent Compounds

For each group (pair):

Create a google doc and upload your pics into the document, then upload to Google Classroom Assignment. Each picture must have a **caption** including the following:

- > Name of molecule, Molecular Geometry, AXE formula, and Polarity
- > Each picture **MUST** have at least one partner in the picture w/ their face

Background Information

One of the most important topics in the study of molecules is how they are put together-how their atoms are arranged relative to each other in space. A theory of chemical bonding that explains **molecular shape** is a useful tool for the modern chemist because *the manner in which atoms are bonded together to make a molecule influences the chemical and physical properties of that molecule*. We have learned in class that the water molecule has a “bent” geometry. If the water molecule were linear instead of bent, the chemistry of life as we know it would be different.

The shape of a molecule cannot be easily predicted from its molecular formula. Molecules that have apparently similar molecular formulas do not necessarily have the same molecular shape. Why is it, for example, that a molecule of aluminum chloride (AlCl_3) is planar whereas nitrogen trichloride (NCl_3), a molecule that is similar to AlCl_3 in that it has one central atom and three different atoms bonded to it, is shaped like a pyramid? Similarly, why does CO_2 have a linear geometry, while sulfur dioxide, SO_2 , has a bent geometry? A better understanding of these three-dimensional structures of molecules will give better insight into these questions and will suggest explanations for them.

Refer to your notes for background information about draw Lewis structures and about the VSEPR theory.

Polarity of Molecules

An additional property of molecules that can be explained by their molecular shape is polarity. In many molecules, one end of the molecule has an excess of negative charge while the other end has an excess of positive charge, even though the molecule as a whole is electrically neutral. Molecules with this imbalance of electrical charge are called **polar molecules** and they are said to possess a **dipole moment**. Most such molecules contain **polar bonds**, which are bonds in which electrons are shared unequally by the bonding partners. The atom with the greater ability to attract the electrons pairs is said to have a higher **electronegativity** than the other atom. Several electronegativity scales have been established from experimental data.

Molecules without an imbalance of electrical charge are called **nonpolar** molecules and they may or may not contain polar bonds. Nonpolar molecules have a net zero dipole moment. Molecular polarity is dependent not only on the charge distribution around the individual atoms but also upon the molecular shape. **Homonuclear diatomic** molecules such as Br_2 are necessarily Nonpolar because the bond is between like atoms. Thus, the sharing of electrons between atoms is equal because the electronegativities of the atoms involved in the sharing is equal. **Heteronuclear diatomic molecules** such as HF are almost always polar. That is, the electrons are not shared equally. The more electronegative atom (in this case, fluorine) has the ability to attract electrons in the shared bond to itself and hence has the excess negative charge.

For polyatomic molecules, both of the polarities of the bonds and the orientation of the bonds contribute to the overall polarity of the molecule, as shown in Figure 8-3. The linear CO_2 molecule, for instance, contains two polar covalent bonds, yet is a Nonpolar linear molecule. The polarities of the two bonds are equal, but their charge separations are precisely in opposite directions, resulting in a zero dipole moment. The bent H_2O molecule, on the other hand, is a polar molecule. The two polar bonds are also equal in magnitude, but do not cancel each other.

A molecule having the symmetry of the structures in Figure 8.3 (without nonbonding electron pairs on the central atom such as found in BeCl_2 , CH_4 , PCl_5 , or SF_6) will have a zero net dipole moment because contributions of electron displacement in each bond cancel one another. In general, molecules on which the central atom carries only one nonbonding pair will be polar. For example, the SO_2 molecule described earlier is a polar molecule. Ammonia, NH_3 , has nitrogen atoms at the apex of the pyramid and the hydrogen atoms at the three corners of the bases and is also polar. However, CO_2 , a linear molecule with no non-bonding pairs is non-polar.

Materials

You will also need your model kit, using toothpicks for bonds and gumdrops (Candy DOTS) for atoms. Bring a protractor to measure bond angles. Each group must get this for their group. I don't have enough

Experimental Procedures

Molecules: CS₂, HCN, SO₃, NO₂⁻, CCl₄, NCl₃, H₂O, TeCl₄, XeF₂, SF₆, XeF₄, SbCl₅²⁻, IOF₅, I₃⁻, ICl₄⁻, AsF₅

For each molecule, do the following — see Building Molecules data table:

1. Draw the correct Lewis dot structures.
2. Build models for each molecule. Be sure to clearly indicate the location of lone pairs. You may use any materials you like in order to construct these models - creativity is highly encouraged and will be rewarded. **Take a digital picture of each of the 16 molecules made.**
3. Describe the molecular and electronic shapes as linear, trigonal planar, tetrahedral, trigonal pyramidal, bent, etc.
4. Give all bond angles (approximate using your protractor if necessary).
5. State whether or not the molecule is polar. If it is, indicate the direction of any dipole moments.
6. **Building Molecules** – [Recreate this data table in your lab notebook, but use a whole page or more]
GOOGLE DOC VERSION
7. Build molecules for the compounds and complete the table. This table is for your reference:

Molecular Formula	Lewis Structure (Only 1 if resonance)	VSEPR Formula (AXE)	Shape Molecular Geometry & (electronic)	Bond Angles (Approx.)	Polar or Nonpolar	Hybridization

Discussion Questions [individually on paper and insert image with POST LAB]

1. Describe the difference between electronic geometry and molecular geometry.
2. Describe the difference between bond polarity and molecular polarity.
3. Explain what makes a molecule polar or nonpolar.
4. Provide an example of each: a polar molecule and a nonpolar molecule, other than those in the lab. Draw their Lewis structures and indicate the polarities of each bond in both examples.
5. Explain using drawings and captions comparing the differences between the 4 types of molecular shapes of compounds with a steric number of 5. Write the chemical formulas for examples of each of those 4 types.