6.5 THE PROPERTIES OF MOLECULAR COMPOUNDS — PAGE 183(197AT HOME)

<u>VSEPR Theory (valence-shell electron-pair repulsion)</u>

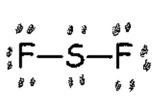
- Basis: it is assumed that electrons in molecules *repel* each other, and the electron pairs involved in bonding want to stay as far away from each other as possible. This is the basis for the *molecular geometry* of a molecule.
- To use **VSEPR→** molecules are classified according to haw many electron pairs surround a central atom.
- Use table 6-4 from your reference sheet or page 183(200) to predict molecular geometry. Remember: you must draw the **Lewis structure** first.
- Copy Sample Problem

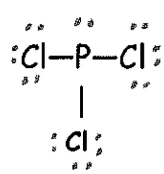
1. Sample Problem 6-5: Use VSEPR theory to predict the molecular geometry aluminum trichloride ($AlCl_3$). Copy the sample problem here: (or Sample E at home)

Practice Problems: Use **VSEPR** theory to predict the molecular geometry of each of the following: a) HI b) CBr_4 c) BF_3

2. Copy Sample Problem 6-6 (F at home)

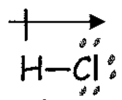
3. Use VSEPR theory to predict the shape of the molecules whose Lewis structures are given below.

a) 

b) 

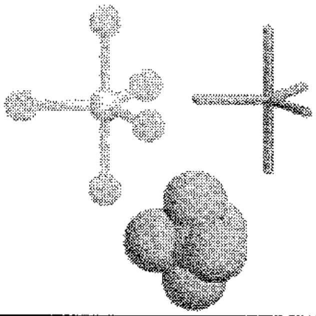
SECTION 6.5 (CONTINUED) INTERMOLECULAR FORCES
(P.# 189 IN SCHOOL, P. 203 AT HOME)

- Intermolecular forces are the forces of attraction between molecules.
- The strengths of the attraction between particles of various substances can be compared through their boiling points. See Table 6-7(7). The higher the boiling point the ________________ the force of attraction between particles.
- **Intermolecular forces:**____
- The strongest intermolecular forces exist between ________________ molecules. **Dipole**: created by equal but ____________________ charges separated by a short distance.
- The direction of a dipole is represented by an arrow pointing toward the negative pole with a tail crossed to indicate the positive pole.



- Dipole-dipole forces→ the negative area in one ___________ molecule attracts the positive area in an adjacent polar molecule. See figure 6-25.
- Hydrogen Bonding: a very strong type of dipole-dipole force that accounts for the very high ________________ of hydrogen containing compounds. Hydrogen bonding only occurs between compounds where hydrogen is bonding with the highly electronegative atoms of **fluorine**, **oxygen**, and **nitrogen**. The hydrogen bonding in water is shown on page 192(206). **Draw** the diagram of the water molecules from page 192(206).
- London dispersion forces: the electrons in polar and nonpolar molecules are in constant __________ causing a positive pole in one molecule and a negative pole in another when the electrons are unevenly distributed. These intermolecular forces result from the constant motion of electrons and the formation of ______________________. These are the only intermolecular forces in noble gases and nonpolar molecules. See figure 6-29 on page 193(207), **draw and label**.

Unit 7 – Molecular Structure



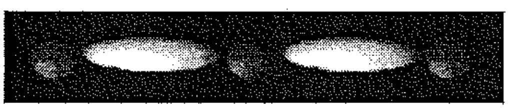
II. Molecular Geometry
(p. 183 – 187)

The specific three dimensional arrangement of atoms in molecules is referred to as ______________ ________________.

- There are various instrumental techniques such as X-Ray crystallography and other experimental techniques which can be used to tell us where the atoms are located in a molecule. Using advanced techniques, very complicated structures for proteins, enzymes, DNA, and RNA have been determined.
- Molecular geometry is associated with the chemistry of vision, smell and odors, taste, drug reactions and enzyme controlled reactions to name a few.
- Molecular geometry is associated with the specific orientation of bonding atoms. A careful analysis of electron distributions in orbitals will usually result in correct molecular geometry determinations.
- In addition, the simple writing of Lewis diagrams can also provide important clues for the determination of molecular geometry.

A. VSEPR Theory

- **V**alence Shell Electron Pair Repulsion Theory
- Electron pairs orient themselves in order to ________________ ________________ forces.



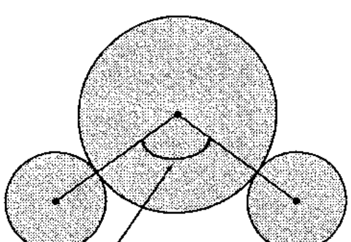
A. VSEPR Theory

- **Types of e^- Pairs**
  - Bonding pairs - ________ ________
  - Lone pairs - ______________ ____

Lone pairs repel more ____________ than bonding pairs!!!

A. VSEPR Theory

- Lone pairs reduce the _________ ___________ between atoms.



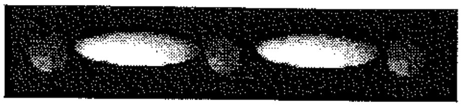
B. Determining Molecular Shape

- Draw the Lewis Diagram.
- Tally up e^- pairs on central atom.
  - double/triple bonds = ONE pair
- Shape is determined by the # of bonding pairs and lone pairs.

Know the 8 common shapes & their bond angles!

C. Common Molecular Shapes

2 total
2 bond
0 lone

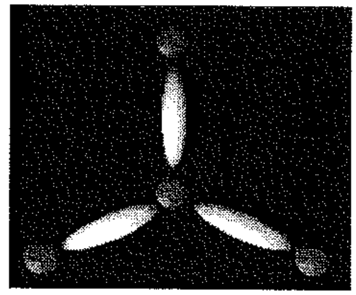


BeH_2

180°

C. Common Molecular Shapes

3 total
3 bond
0 lone

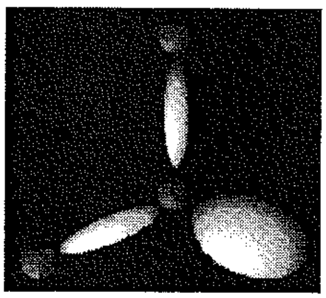


BF_3

120°

C. Common Molecular Shapes

3 total
2 bond
1 lone

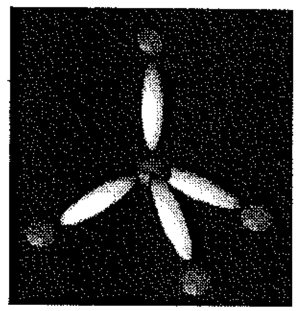


SO_2

<120°

C. Common Molecular Shapes

4 total
4 bond
0 lone

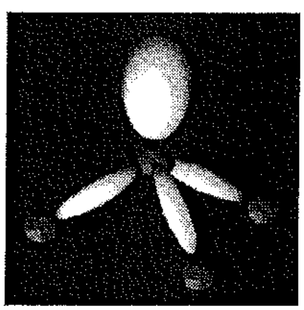


CH_4

109.5°

C. Common Molecular Shapes

4 total
3 bond
1 lone

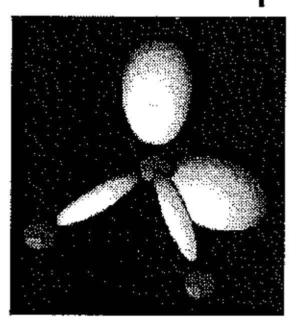


NH_3

107°

C. Common Molecular Shapes

4 total
2 bond
2 lone

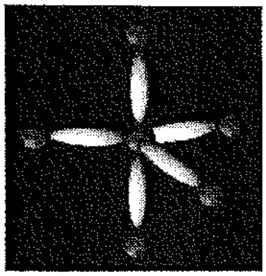


H_2O

104.5°

C. Common Molecular Shapes

5 total
5 bond
0 lone

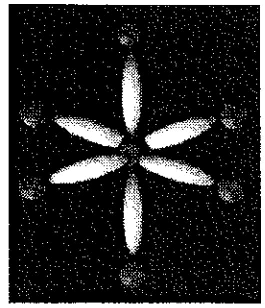


PCl_5 ________________

120°/90°

C. Common Molecular Shapes

6 total
6 bond
0 lone

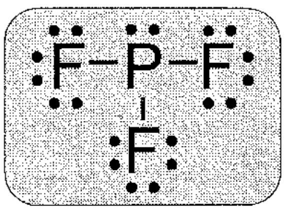


SF_6 ________________

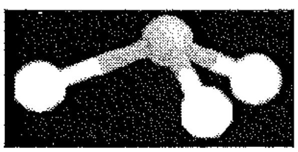
90°

D. Examples

- PF_3

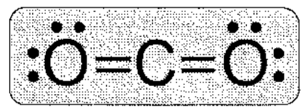


____total
___ bond
___ lone

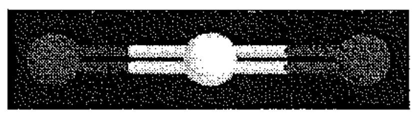


D. Examples

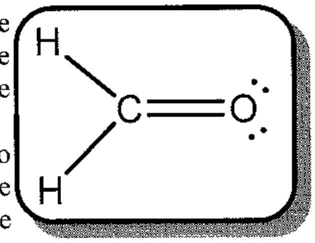
- CO_2

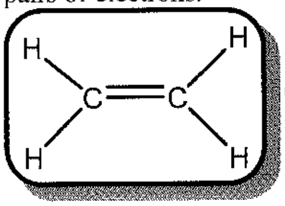


___total
__ bond
__ lone SHAPE: ____________



Double and triple bonds are treated like single bonds. As a result, CH_2O is trigonal planar. See the diagram to the right. The double bond between the oxygen and the carbon behaves like a single bond with one pair of electrons in the VSEPR model. This means that carbon has only three effective pairs of electrons.





For molecules in which there is no central atom, it is possible to predict the shape of sections of the molecule. In the molecule ethene (C_2H_4), for example, each of the carbons behaves like a central atom. The shape around each is trigonal planar. See the diagram to the left.

Draw the Lewis structures for each of the molecules below, and predict whether each is *Linear*, *Trigonal planar*, *Tetrahedral*, *Trigonal bipyramidal*, *Octahedral*, *Pyramidal*, or *Bent*.

1. C_2Cl_2
2. SO_3
3. CS_2
4. CF_4
5. AsF_5
6. SeI_6
7. H_2Te
8. AsF_3
9. SiO_2
10. NH_4^+
11. NO_3^-
12. PCl_5

MOLECULAR STRUCTURE LAB

Covalent bonds may be polar or nonpolar depending on the electronegativities of the two atoms. Shared electrons will be pulled toward the atom with the greater electronegativity.

Molecules composed of covalently bonded atoms may *also* be polar or nonpolar. For the molecule to be polar, it must be composed of polar bonds. However, the shape of the molecule is also a key factor. If the polar bonds (dipoles) are symmetrical around the central atom, they cancel each other and the molecule is nonpolar. If the dipoles are not symmetrical around the central atom, the electrons will be pulled toward one end of the molecule. The resulting molecule is polar.

Ball-and-stick models are often used to describe molecular shape. In this exercise, you will predict the shape of molecules based on the VSEPR Theory. Then, you will build a ball-and-stick model of each molecule and determine whether the molecule is polar or nonpolar.

PROCEDURE

PART 1:

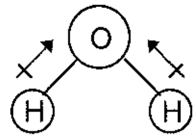
1. For each molecule or polyatomic ion, draw the Lewis Diagram and predict the shape and bond angle of the molecule. Record this information in your data table. Please list the molecules in order as follows:
    1. HOCl
    2. CCl_4
    3. SH_6
    4. NCl_3
    5. HCN
    6. PCl_5
    7. CO_3^{2-}
2. Once you have determined the shape of each molecule use your molecular model kit and construct a ball-and-stick model of the molecule using the provided instructions and supplies. Remember: you should have no empty holes in any atom for your molecule to be correct.
3. After constructing the model, draw a 3-D sketch of the molecule in your data table. Label each atom and draw the dipole moment of each bond. Use the table of electronegativities on your periodic table or reference to determine the direction of the dipole.
4. Determine whether each molecule is a polar or nonpolar molecule based upon its shape and the arrangement of the dipole moments. Record your answers in the data table.
5. Repeat steps 2 - 4 until you have constructed all seven molecules.

PART 2:

1. Two or more molecules can have the same molecular formulas but different structural formulas. Using the molecular formula C_4H_{10} create 2 **different** molecules using the molecular models. These are called structural isomers.

2. Draw each Lewis structure in your data table and sketch each. (you can skip the shape and molecular polarity for these)

DATA

MOLECULE/ION PART 1	LEWIS DIAGRAM	MOLECULAR SHAPE & BOND ANGLE	SKETCH – USE COLORED PENCILS	MOLECULAR POLARITY
Example: H_2O	H - Ö - H (two lone pairs on O)	Bent 104.5°		polar

Molecule Part 2	Lewis Diagram	Sketch – use color

CONCLUSIONS

Write a conclusion in paragraph form addressing the following issues:

- Explain the main concept behind the VSEPR theory of molecular shape. How do both *number* and *type* of electron pairs influence the shape of a molecule?
- Explain how you were able to determine molecular polarity. What two factors did you need to consider? Cite examples from this lab.
- Compare ball-and-stick models and Lewis Diagrams as ways of describing molecular structure. Discuss at least one advantage and one disadvantage of each method.