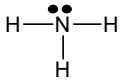
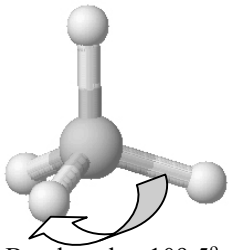
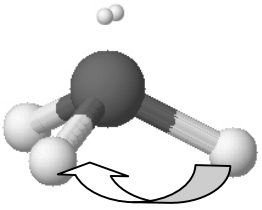
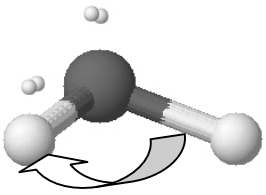
ChemQuest 22

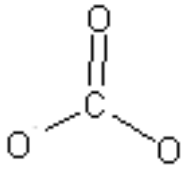
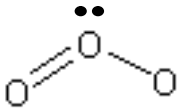
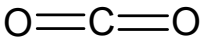
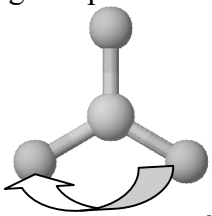
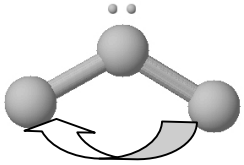
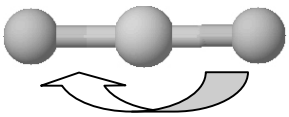
Molecular Geometry

Name: _____

Date: _____

Information: Shapes of Molecules

Name	Methane, CH_4	Ammonia, NH_3	Water, H_2O
Lewis Structure			
3-D Shape	Tetrahedral shape  Bond angle =109.5°	Trigonal pyramidal shape  Bond angle =106.5°	Bent shape  Bond angle =104.5°
Total # of electron regions	4	4	4
# of Bonding electron regions	4	3	2
# of lone pair electron regions	0	1	2

Name	Carbonate, CO_3^{2-}	Ozone, O_3	Carbon dioxide, CO_2
Lewis Structure			
3-D Shape	Trigonal planar shape  Bond angle =120°	Bent shape  Bond angle =118.6°	Linear shape  Bond angle =180°
Total # of electron regions	3	3	2
# of bonding electron regions	3	2	2
# of lone pair electron regions	0	1	0

Critical Thinking Questions

1. What is an electron region?
   A place around the central atom where electrons (either bonding or lone pair) can be found.

2. What is a "lone pair electron region"?
   A place around the central atom where electrons not bonding with another atom can be found.

3. What is a "bonding electron region"?
   A place around the central atom where electrons are shared with another atom.

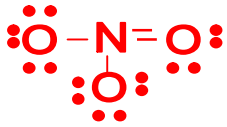
4. *The number of electron regions determines the bond angle.* With this in mind, complete the following sentence: "Any molecule that has bond angles of approximately 105-109° will have

   4 (how many?) total electron regions; any molecule that has bond angles of approximately 120°

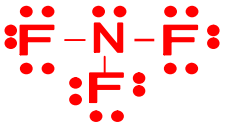
   will have 3 (how many?) total electron regions; and any molecule with bond angles of

   approximately 180° will have 2 (how many?) total electron regions."

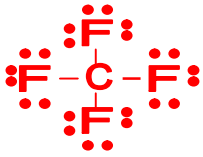
5. The molecules in the above table are representative of many other molecules. Therefore, it can be said that any molecule with 3 bonding electron regions and 1 lone pair electron region has a geometrical shape called "trigonal pyramidal". Draw Lewis dot structures for the following structures and name the geometrical shape.

   A) NO_3^- 

   trigonal planar

   B) NF_3 

   trigonal pyramidal

   C) CF_4 

   tetrahedral

6. A certain molecule has a bent shape with bond angles of about 119°. Is the molecule SO_2 or SH_2? Explain. (Hint: draw the Lewis structures for SO_2 and SH_2.)

   The molecule is SO_2 because SO_2 has 3 electron domains which corresponds to bond angles near 120°. SH_2 has 4 electron domains which would correspond to bond angles near 109°.

Information: VSEPR

The geometry of molecules is based on a theory called "**V**alence **S**hell **E**lectron **P**air **R**epulsion" (VSEPR) theory. The word "repulsion" is the key word because this theory states that all the electron pairs repel each other and so they want to get as far away from each other as possible. The atoms in a tetrahedral molecule are as far apart as geometrically possible at bond angles of 109.5°. There is no way that the atoms can get farther apart.

Critical Thinking Questions

7. In the tables on the first page, there are 3 molecules that have a total of 4 electron regions. The bond angles are slightly different because of lone pair electrons. What takes up more room--a lone pair of electrons or a bonding pair of electrons? Offer proof from the table above.

   A lone pair takes up more room, which "squeezes" atoms a little closer together and causes the smaller bond angles.

8. If you know how many bonding regions and lone pair regions surround an atom you can predict the bond angles around the atom, even in complex situations. Examine the following "big" molecules. By each arrow that points to an atom, write the bond angle for that atom; you should write 109.5°, 120°, or 180° to represent the *approximate* bond angle. One of them is done for you.