**Lecture 5 – Molecules**

**Drawing Structures and Molecular Shapes**

In this week’s exercise, you will have the opportunity to draw structures and visualize the geometric shapes defined by VSEPR theory and you will be practicing drawing Lewis dot structures and calculating formal charges.

Collect the following items and place them in a zip lock bag: 2 large gum drops, 8 small gum drops and 10 toothpicks.

Rules for drawing a Lewis dot structure:

8 easy steps:

1. Draw skeleton of structure

2. Total up the number of valence electrons for all of the atoms

3. Connect the “outer” atoms to the “inner” atoms using pairs of electrons

4. Add electron pairs to outer atoms so that they all have their full octet

5. Count the electrons that you have used so far. If you have any left, put them on the central atom

6. Count the electrons on the central atom. If there is less than a full octet, take a lone pair of electrons from one of the outer atoms and make a double bond

7. Calculate the formal charge [fc] = ve – ½ be - le

(# of valence electrons - ½ # bonded electrons - # of lone electrons)

8. Add up all the formal charges. If you started with a neutral molecule, the sum should be zero. If you started with a charged species, then the sum should equal that charge

**Procedure:**

**1.** Connect two small gum drops with one toothpick. Obviously, the only way you can connect these is in a straight line. This geometry is called **linear** and is similar to any diatomic molecule, like O2. Draw the Lewis dot structure for O2 and sketch the tree-dimensional shape.

**2. A.** Connect three small gumdrops to one large central gum drop. Place them all in the same plane. The angle defined by small-large-small should be 120°. This geometry is similar to NO3-1. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for NO3-1.

**B.** Remove one of the toothpicks and small gum drops. The remaining two small gum drops and one large gum drop define a “bent” or “angular” molecule similar to SO2. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for SO2.

**3. A.** Now connect four small gum drops to one central large gum drop in the shape of a tetrahedron (kind of like a jack from the game “jacks”). This geometry is similar to CH4. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for CH4.

**B.** Remove one of the small gumdrops and toothpicks. The remaining system is a trigonal pyramid. This shape is the same as that of an NH3 molecule. Draw the three-dimensional structure, draw the Lewis dot structure and calculate formal charges for NH3.

**C.** Remove another small gumdrop and toothpick. You should have two small gumdrops connected to one large gumdrop. This is another “bent” or “angular” geometry. Notice that it is different than the geometry in 2b. [In 2b the small-large-small angle was 120°, in this case the single is about 109.5°, the tetrahedral angle]. This geometry is similar to that of H2O. Sketch the three-dimensional structure, draw the Lewis dot structure and calculate formal charge for H2O.

**4. A.** Remake the shape from 2A (connect three small gumdrops to one large central gumdrop). Add two more small gum drops perpendicular to the defined plane. These five small gum drops surrounding the one large central gum drop define a trigonal bipyramid. This is the same shape as PCl5. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for PCl5.

**B.** Notice there are two different “kinds” of small gum drops in this structure. The first here you put on are called equatorial, the second two are called axial. Remove one of the equatorial gumdrops and toothpicks. The remaining shape is called an irregular tetrahedron or “seesaw” shaped. This is the same geometry of SF4. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for SF4.

**C.** Remove another equatorial gum drop and toothpick. This leaves the two axial gum drops and one equatorial gum drop. We call this geometry, for obvious reasons, “T-shaped”. ClF3 adopts this geometry. Sketch the three dimensional shape, draw the Lewis dot structure and calculate formal charges for ClF3.

**D.** Remove the last equatorial gum drop and toothpick. You should now be left with a linear geometry with the small-large-small gum drops in a straight line. This is the same geometry and XeF2. Sketch the three-dimensional geometry, draw the Lewis dot structure and calculate formal charges for XeF2.

**5. A.** Assemble six small gum drops around one large gum drop. You should have three pairs of small gum drops at 180° angles. This shape is called octahedral. SF6 is an example of a molecule that has this geometry. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for SF6.

**B.** Remove one of the gum drops and toothpicks. It doesn’t matter which one, they should all be the same. The shape that is left is called a square pyramid. BrF5 adopts this geometry. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for BrF5.

**C.** Remove the gum drop and toothpick opposite the one you removed in 5b. This should leave four small gum drops in the same plane as the large gum drop. This shape, called square planar, is the geometry that describes a XeF4 molecule. Sketch the three-dimensional shape, draw the Lewis dot structure and calculate formal charges for XeF4.

**D.** What shape do you get when you remove one of the gumdrops and toothpicks? Which shape is this?

**E.** Which gumdrop would you remove next and what does it look like?