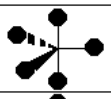
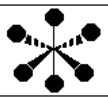
VSEPR

1. What is the premise of VSEPR theory?

Electron pairs orientate themselves in a manner which minimizes repulsion (i.e. maximizes distance between electron pairs).

2. VSEPR Chart

Areas of electron density	Number of Lone Pairs	Shape Name	Drawn
2	0	Linear	
3	0	Trigonal Planar	
3	1	Bent	
4	0	Tetrahedral	
4	1	Trigonal Pyramid	
4	2	Bent	
5	0	Trigonal Bipyramidal	
5	1	See Saw	
5	2	T shaped	
5	3	Linear	
6	0	Octahedral	
6	1	Square Pyramid	
6	2	Square Planar	
6	3	T Shaped	
6	4	Linear	

3. How do electronic and molecular structure differ?

Electronic structure is the shape that a molecule would take based solely on the number of areas of electron density (also known as steric number) – in this case we do not need to differentiate between bonding pairs and lone pairs. Meaning we are looking at how ALL of the electrons lone/bonding will be arranged

Molecular structure is the arrangement that focuses on how the bonding electrons will be orientated in space.

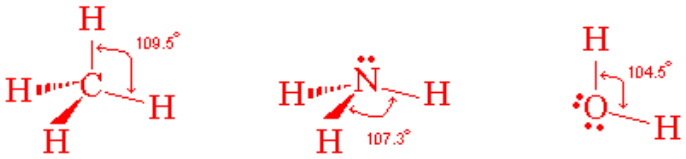
4. What are the bond angles of the non-lone pair bearing shapes?

a. Linear (2 areas of e^- density, no lone pairs) – 180^o
b. Trigonal Planar (3 areas of e^- density, no lone pairs) – 120^o
c. Tetrahedral (4 areas of e^- density, no lone pairs) – 109.5^o
d. Trigonal bipyramidal (5 areas of e^- density, no lone pairs) – 120^o and 90^o
e. Octrahedral (6 areas of e^-, no lone pairs) – 90^o

5. Do lone pairs affect bond angles?

Because lone pairs take up more room they essentially push the bonding pairs closer together, thus altering typical bond angles.

For example in NH_3 (which has one lone pair) the bond angle is 107.3^o and in H_2O (which has 2 lone pairs) the bond angle is 104.5^o. In both cases however, there are 4 areas of electron density around the central atom.



6. How do you determine if a molecule is polar?

Determining the electronegativity difference between the two atoms within the bond.
Remember that electronegativity is the ability of an atom to pull electrons towards oneself.

Generally:

ΔEN >1.8	indicates	Ionic Bond
0.4<ΔEN<1.8	indicates	Polar Covalent
ΔEN≤ 0.4	indicates	Non Polar Covalent

7. What is a handy way to remember electronegativity ordering?

F >O>N>Cl>Br>I>S>C>H (pronounced "FONClBrISCH" ☺)

Fluorine, Oxygen, Nitrogen, Chlorine, Bromine, Iodine, Sulfur, Carbon, Hydrogen (Fluorine being the most electronegative)

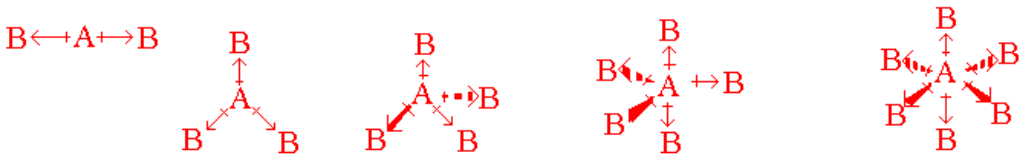
The further apart 2 atoms are the greater the difference in their electronegativities and more polar bond they would form. Notice that metals are not part of this list as metals tend to lose electrons, meaning they would have *very* weak electronegativity.

8. How can shape affect polarity?

Symmetry can cancel out a polar bond. If identical atoms are attached to an

atom and the molecule is symmetric, it will be non-polar overall.

Let's say that B is more electronegative than A, such that they form a polar bond. The following is a list of some examples of how symmetry can cancel out polarity (keep in mind, this list is *not* exhaustive).



Basically what you are looking for is a symmetry in which the electrons are being pulled with equal strength but in opposing directions.

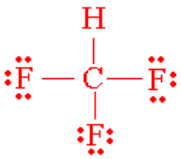
If you picture the pull on electrons as a tug of war… imagine that the opposing teams are identical in strength and are pulling at angles that perfectly counter each other. If this were the case the electrons would not be pulled in any one direction more strongly than the other – thus they would stay where they were.

9. Determine the molecular structure around each of the central atoms and whether the molecule is polar.

In order to do this we will first have to draw the Lewis Dot structure.

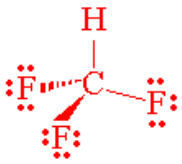
a. CHF_3

Following the rules described in preceding problems we would get the structure:



In this case, the central atom, carbon, has 4 areas of electron density. That means that electronic configuration around carbon would be tetrahedral configuration. Additionally, because there are no lone pairs on the carbon, the molecular structure would also be tetrahedral.

The molecular structure would look like:



In a tetrahedral the bond angles are 109.5°. This would be a polar molecule as F is more electronegative than C.

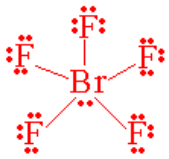
b. I_3^-

In this case, the central I has 5 areas of electron density. This means that the electronic configuration would be trigonal bipyramidal.

Because three of the areas of electron density are lone pairs, the molecular configuration would be a linear configuration.

With all atoms in the bond being identical, and it being symmetric, this would be a nonpolar molecule.

c. BrF_5



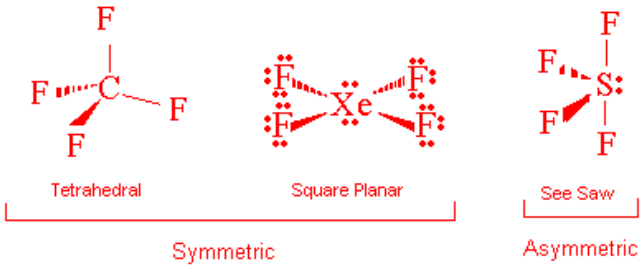
In this case, the central atom, bromine, has 6 areas of electron density. This means that the electronic configuration would be octahedral.

As one of these areas corresponds to a lone pair – the molecular configuration would be square pyramidal. Thus the molecule around bromine would look like:

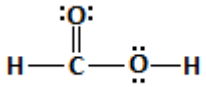
This would be a polar molecule. Due to the lone pairs, there would not be a canceling of polar bonds due to symmetry.

10. Explain why CF_4 and XeF_4 are non-polar yet SF_4 is polar.

In order to explain this, we will have to look at the shape as predicted by VSEPR. We'll start with our Lewis Dots:



11. Indicate the symmetry around all non-hydrogen atom



The carbon has three areas of electron density, no lone pairs. This would mean that around the carbon the arrangement would be trigonal planar. The oxygen oxygen in the C-O-H bond has four areas of electron density (with 2 lone pairs) so the atoms would be arrange in a bent (or v-shaped) fashin around that oxygen.

Putting all of this together the VSEPR structure would look like: