

Chapter 10- Molecular Geometry and Chemical Bonding Theory

- ❖ In a *cis* compound, both H atoms are on the same side of the carbon bond; in the *trans* compound, they are on opposite sides
- ❖ Molecular Geometry- general shape of a molecule as determined by the relative positions of the atomic nuclei

10.1 The Valence-Shell Electron-Pair Repulsion (VSEPR) Model

- ❖ The VSEPR Model- predicts the shape of molecules and ions by assuming that the valence shell electron pairs are arranged about each atom so that the electron pairs are kept as far away from one another as possible thus minimizing electron pair repulsions
- ❖ When you determine the geometry of a molecule experimentally, you locate the positions of the atoms, not the electron pairs
- ❖ The direction in space of the bonding pairs gives you the molecular geometry
- ❖ Steps in the prediction of Geometry by the VSEPR Model
 - Step 1: Write the electron dot formula from the molecular formula
 - Determine from the electron-dot formula the number of electron pairs around the central atom, including bonding and nonbonding pairs. (Count a multiple bond as one pair. If resonance occurs, use the resonance formula to determine this number)
 - Determine the arrangement of these electron pairs about the central atom
 - Obtain the molecular geometry from the directions of the bonding pairs for this arrangement

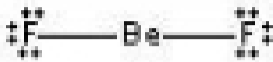

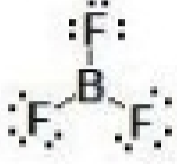
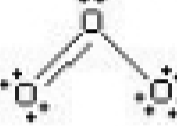

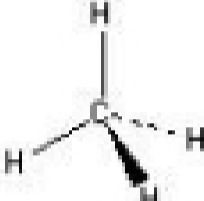



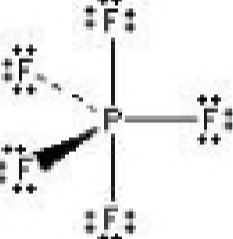
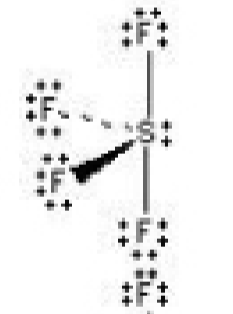
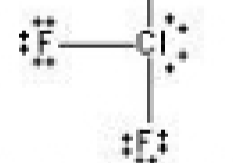

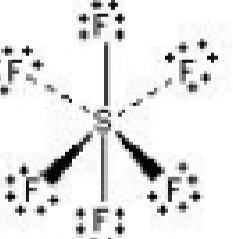
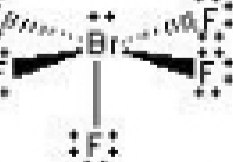

Bond Angles and the effect of Lone Pairs

- ❖ A lone pair tends to require more space than a corresponding bonding pair
- ❖ Multiple bonds require more space than single bonds because of the greater number of electrons

Central Atoms with Five or Six Valence-Shell Electron Pairs

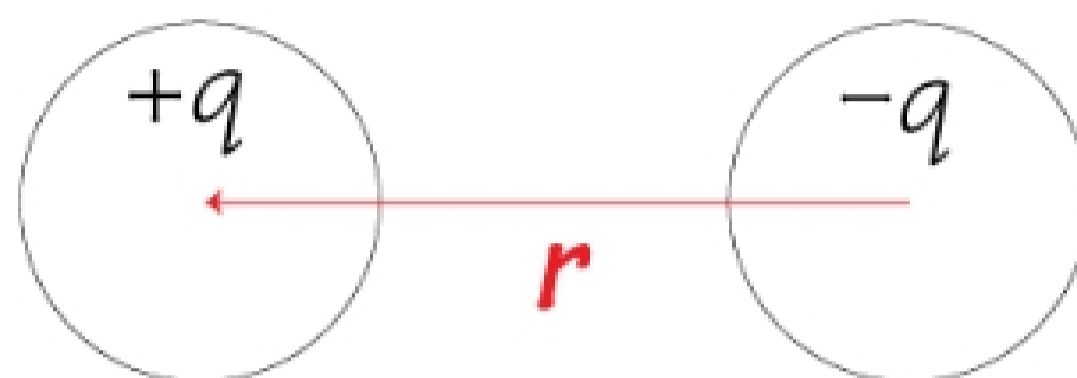
- ❖ Axial Directions- form through the central atom; 180 degrees apart
- ❖ Equatorial Directions- point through the corners of the equilateral triangle that lies on a plane through the central atom, perpendicular to the axial directions; are 120 degrees apart

Electron and Molecular Geometry On Central Atom.

Electron Regions & hybridization	Bonding Regions	Lone Pairs	Electron Region Geometry	Molecular Geometry	Examples
2	2	0	linear	linear	BeF ₂ , CO ₂ 
sp	1	1		linear	CO, N ₂ 
3	3	0	trigonal planar	trigonal planar	BF ₃ , CO ₃ ²⁻ 
				bent	O ₃ , SO ₂ 
				linear	O ₂ 
4	4	0	tetrahedral	tetrahedral	CH ₄ , SO ₄ ²⁻ 
				trigonal pyramidal	NH ₃ , H ₃ O ⁺ 
				bent	H ₂ O, ICl ₂ ⁺ 
				linear	HF, OH ⁻ 
5	5	0	trigonal bipyramidal	trigonal bipyramidal	PF ₅ 
				seesaw	SF ₄ , TeCl ₄ , IF ₄ ⁺ 
				T-shaped	ClF ₃ 
				linear	I ₃ ⁻ , XeF ₂ 
6	6	0	octahedral	octahedral	SF ₆ , PF ₆ ⁻ , SiF ₆ ²⁻ 
				square pyramidal	BrF ₅ , SbCl ₅ ²⁻ 
				square planar	XeF ₄ , ICl ₄ ⁻ 

10.2 Dipole Moment and Molecular Geometry

- ❖ Dipole Moment- A quantitative measure of the degree of charge separation in a molecule and is therefore an indicator of the polarity of the molecule



$$\mu = qr$$

- ❖ Q= the charge
- ❖ D= the distance
- ❖ Dipole Moments are usually measured in units of debyes (D)
- ❖ A polar substance is placed between two metal plates. The polar substance attracts to the sides of the metal plates. Why?
 - Because the polar molecules in the substance align themselves so that their negative end is pointing towards the positive plate and their positive end is pointing towards the negative plate
- ❖ The dipole moment arrow points from the positive partial charge to towards the negative partial charge
- ❖ Each bond dipole is like a vector quantity, it has both magnitude and direction
 - Two bond dipoles of equal magnitude but opposite direction cancel each other
- ❖ Molecules like linear, trigonal planar, and tetrahedral etc. give molecules of zero dipole moment. That is the molecules are nonpolar

Effect of Polarity on Molecular Properties

- ❖ A cis compound boils at a higher temperature because it's polar and therefore has higher intermolecular forces which increases the energy required for the liquid to boil which increases the boiling point

10.3 Valence Bond Theory

- ❖ Valence Bond Theory- an approximate theory to explain the electron pair or covalent bond by quantum mechanics
- ❖ A bond forms between two atoms when the following conditions are met
 - 1. An orbital on one atom comes to occupy a portion of the same region of space as an orbital on the other atom. The orbitals are said to overlap