CHAPTER 9: Molecular Geometry and Bonding Theories

Electron Pair Geometries in VSEPR Theory

- Linear: 180°
- Trigonal planar: 120°
- Tetrahedral: 109.5°
- Trigonal Bipyramidal: 120 and 90°
- Octahedral: 90°
Electron Pair Repulsions

- Electron Pair Repulsion Order:
  - Lone pair—Lone pair = greatest repulsion.
  - Lone pair—Bonding pair is next.
  - Bonding pair—Bonding pair = least repulsion.
    » Double bonds exert more repulsion than single bonds.

- Bond angles around central atom decrease as repulsive forces increase.

**Electron Pair Geometry**  
**Molecular Geometry**

linear  
Linear (AB₂)
Electron Pair Geometry | Molecular Geometry

Trigonal planar

Bent \((AB_2E)\)

Tetrahedral

Pyramidal \((AB_3E)\)

Bent \((AB_2E_2)\)
Note: Bond angles decrease as number of lone pairs increases.

Sample Exercise 9.2

Rank NH$_3$, CH$_4$, and H$_2$O in order of increasing bond angles in their molecular structures.
Electron Pair Geometry

Trigonal Bipyramidal

Molecular Geometry

- Trigonal Bipyramidal (AB₅)
- Unsymmetrical Tetrahedron (AB₄E)
- T-shaped (AB₃E₂)
- Linear (AB₂E₃)

Electron Pair Geometry

Octahedral

Molecular Geometry

- Octahedral (AB₆)
- Square pyramidal (AB₇E)
- Square planar (AB₄E₂)
1. Determine the Lewis structure

2. Determine the number of electron pairs (or clouds) around the CENTRAL ATOM – multiple bonds count as ONE CLOUD (see next slide).

3. Find out the appropriate VSEPR geometry for the specified number of electron pairs, both bonding and lone pairs.

4. Use the positions of atoms to establish the resulting molecular geometry.

Multiple Bonds and Molecular Geometry

Multiple bonds count as one

4 bonding pairs around C, but trigonal planar instead of tetrahedral.
LINEAR - $AB_2$ e.g. $BeCl_2$

TRIGONAL PLANAR - $BF_3 (AB_3)$
- $SO_2 (AB_2E)$
TETRAHEDRAL

- CH₄ (AB₄)
- NH₃ (AB₃E)
- H₂O (AB₂E₂)

TRIGONAL BIPYRAMIDAL

- PCl₅ (AB₅)
- SF₄ (AB₄E)
- ClF₃ (AB₃E₂)
- I₃⁻ (AB₂E₃)
OCTAHEDRAL

- $\text{SF}_6$ ($\text{AB}_6$)
- $\text{BrF}_5$ ($\text{AB}_5\text{E}$)
- $\text{XeF}_4$ ($\text{AB}_4\text{E}_2$)

Molecular Geometries of Molecules with more than 1 Central Atom

cysteine
Polar Bonds and Polar Molecules

- Requirements for Polar Molecule:
  1. Molecule must contain polar bonds (i.e., covalent bond between atoms with $\Delta EN$).
  2. Orientation of polar bonds results in charge separation from one part of the molecule to another.

- Bond Dipole:
  - Separation of charge within a covalent bond.

- Polar Molecule:
  - Vectors of bond dipoles sum > zero.
Sample Exercise 9.4

Does formaldehyde gas (CH$_2$O) have a permanent dipole moment?