VSEPR Theory

Learning Target

Summarize the VSEPR bonding theory.

Predict the shape of, and the bond angles in, a molecule.

Main Idea

- **The VSEPR model is used to determine molecular shape.**

VSEPR Model

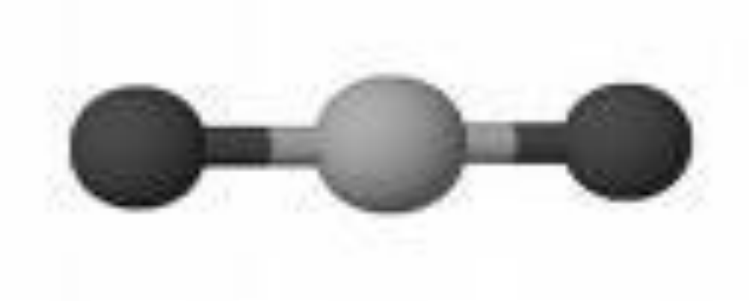
- The shape of a molecule determines many of its physical and chemical properties.
- Molecular geometry (shape) can be determined with the Valence Shell Electron Pair Repulsion model, or **VSEPR model** which minimizes the repulsion of shared and unshared atoms around the central atom.

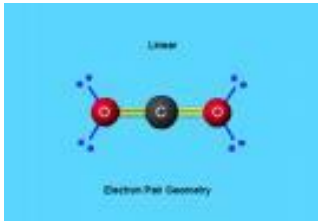
- Electron pairs repel each other and cause molecules to be in fixed positions relative to each other.
- Unshared electron pairs also determine the shape of a molecule.
- Electron pairs are located in a molecule as far apart as they can be.

- Bonding pairs: electrons that participate in bond formation (electrons that are shared)
- Lone pairs: electrons that don't participate in bond formation. (also called unshared pairs)

Linear

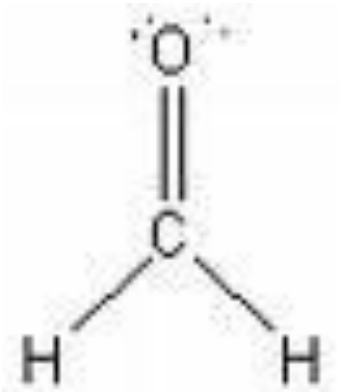
- Atoms are arranged in a straight line.
- Bond angle: 180°
- Ex: H—Cl, CO_2





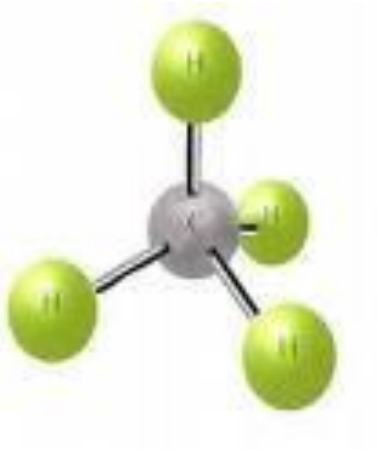
Trigonal Planar

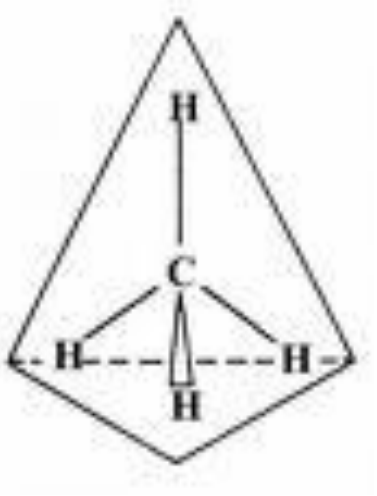
- Triangular and flat molecule
- Three atoms are attached to the central atom.
- No lone pairs on the central atom
- Bond angle: 120°
- Ex: HCHO



Tetrahedral

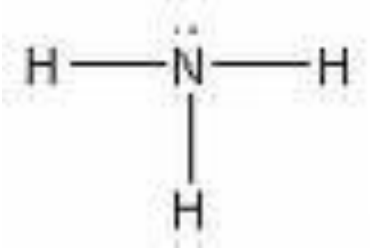
- Four atoms are attached to the central atom.
- Bond angle: 109.5°
- Ex: CH_4, CCl_4

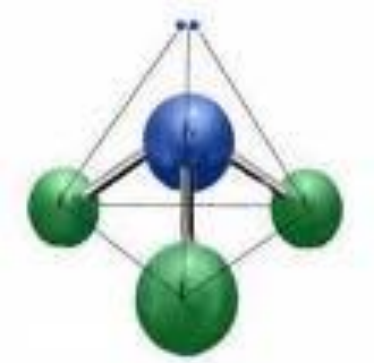




Pyramidal

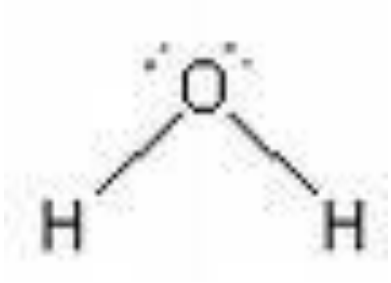
- Three atoms attached to the central atom.
- One lone pair on the central atom
- Bond angle: 107°
- Ex: NH_3

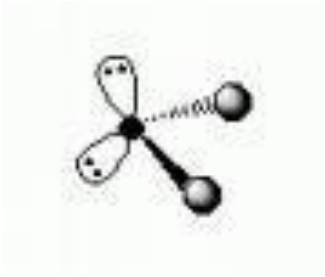


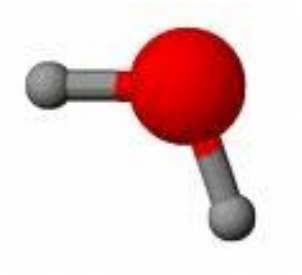


Bent

- Usually two atoms attached to the central atom.
- Two lone pairs on the central atom
- Bond angle: 105°
- Ex: H_2O







Assessment

- Use molecular geometry to predict the shape of the following molecules: (Hint: You have to draw the structual formula in order to predict)

1. HI
2. CBr
3. H_2S
4. PCl_3

Practice…

- Predict the shapes for the following molecules:
- N_2
- H_2O
- CO_2
- NH_3
- CH_4
- HF
- $CHCl_3$

Electronegativity & Polarity

Learning Target:

- **Describe** how electronegativity is used to determine bond type.
- **Compare and contrast** polar and nonpolar covalent bonds and polar and nonpolar molecules.
- **Generalize** about the characteristics of covalently bonded compounds.

Main Idea

- **A chemical bond's character is related to each atom's attraction for the electrons in the bond.**

Electronegativity

- The ability of the atoms to attract electrons in a chemical bond.
- In a chemical bond when one atoms in more electronegative than the other, it has a tendency to pull electrons towards itself.
- Hence, the more electronegative atom becomes slightly negative, while the other atom becomes slightly positive creating a dipole.

- Unequal sharing of electrons results in a **polar covalent bond**.
- Bonding is often not clearly ionic or covalent.

Electronegativity & Bond character

Electronegativity difference	Bond character OR Type of bond
≥ 2.0	Mostly ionic
0.4 – 2.0	Polar covalent
< 0.4	Nonpolar covalent

hydrogen and chlorine atoms hydrogen chloride molecule

$$\begin{array}{l} \text{Electronegativity Cl} = 3.16 \\ \text{Electronegativity H} = 2.20 \\ \hline \text{Difference} = 0.96 \end{array}$$

This unequal sharing of electrons results in a **polar covalent bond**

Example

- Find the electronegative different between the H—O bond, and predict its bond type.

- Answer:
  - Electronegativity for O = 3.44
  - Electronegativity for H = 2.20
  - Difference (3.44 – 2.20) = 1.24
  - **EN difference = 1.24, hence polar covalent**

Molecule Polarity

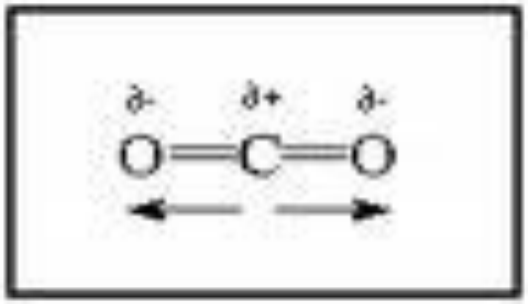
- Covalently bonded molecules are either polar or non-polar.
- Depends on the shape of the molecule, and bond polarity or dipole moment.

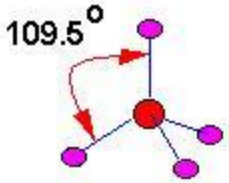
- Dipole moment: direction of a polar bond in a molecule.

Nonpolar molecules

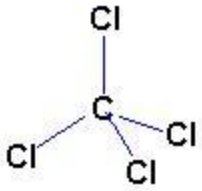
- If a bond is nonpolar, the entire molecule becomes nonpolar.
- Ex: Cl_2

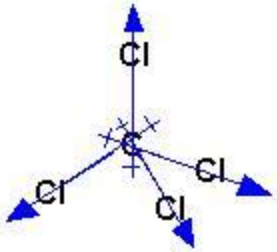
- If bonds are polar, but the dipole moments are symmetrical and they cancel out, the molecule becomes nonpolar.
- Ex: CO_2, CCl_4





Tetrahedral





vector cancellation
nonpolar molecule

Polar molecules

- Bonds are polar, but molecule is asymetrical
- Ex: H_2O
- Polar bonds in symmetrical molecules, but unequal dipole moment (does not cancel out)
- Ex: CH_3Cl

Assessment…

- Identify the bond character and polarity of the following molecules:
- H_2S
- NH_3
- CH_4
- HF
- O_2
- CCl_4