17: Molecular Geometry - VSEPR

Key Structure Terms

- **Valence Shell:** Electrons in the outermost shell that are involved in bonding.
- **Lewis Structure:** A 2D representation of a molecule and its bonds.
- **Lone Pair:** Pair of electrons not being shared in a bond.
- **Bonding Pair:** Pair of electrons used to make a bond. Both atoms sharing the electrons can "count" them in their valence shell.
- **Single bond:** One pair of shared electrons.
- **Double bond:** Two pairs of shared electrons. Shorter and stronger than a single bond.
- **Triple bond:** Three pairs of shared electrons. Shorter and stronger than a double bond.
- **Valence Shell Electron Pair Repulsion Theory (VSEPR):** Bonds and lone pairs are electrons, all electrons are negative, negative things repel other negative things, therefore all bonds and lone pairs arrange themselves in 3D as far away from each other as possible.
- **Electron Geometry:** 3D structure of a molecule determined by counting the electron regions around a central atom (bonds and lone pairs).
- **Electron Region:** Each bond (single, double or triple) and lone pair count as "1" electron region.
- **Molecular Geometry:** 3D structure determined by the atoms bonded to the central atom.
- **Ligand:** Atoms bonded to the central atom.

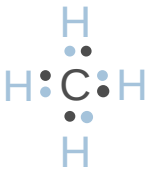
VSEPR Theory and Geometry

Electron geometry is determined by looking at the number of electron regions around the central atom.

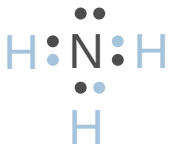
Molecular geometry is determined by looking at the number of atoms bonded to the central atom (ligand) and the number of lone pairs around the central atom.

Electronic Geometry Mnemonic: Linear(2) – Trigonal Planar(3) – Tetrahedral (4) – Trigonal Bipyramidal(5) – Octahedron(6) = "*Long TriP To TriBe Overseas*."

Examples:



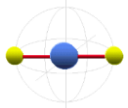
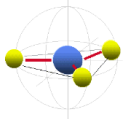
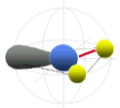
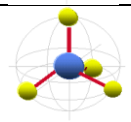
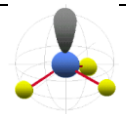
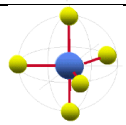
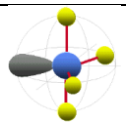
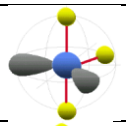
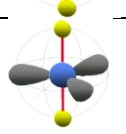
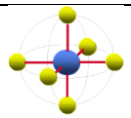
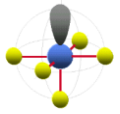
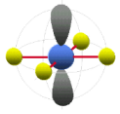
Electron geometry: Tetrahedron
Molecular geometry: Tetrahedron



Electron geometry: Tetrahedron
Molecular geometry: Trigonal pyramidal

Molecular Geometries

A = central atom; X = ligands; E = lone pairs

Electron Regions	Molecular Formula	Name	Shape
2	AX_2 ($BeCl_2$, CO_2)	Linear	
3	AX_3 (BF_3, CO_3^{2-}, NO_3^-, SO_3)	Trigonal Planar	
	AX_2E (NO_2^-, SO_2, O_3)	Bent	
4	AX_4 (CH_4, NH_4^+, PO_4^{3-}, SO_4^{2-}, ClO_4^-)	Tetrahedron	
	AX_3E (NH_3, H_3O^+, PCl_3, SO_3^{2-})	Trigonal pyramidal	
	AX_2E_2 (H_2O, ClO_2^-, OF_2, SCl_2)	Bent	
5	AX_5 (PCl_5)	Trigonal bipyramidal	
	AX_4E (SF_4, SCl_4)	See-saw	
	AX_3E_2 (ClF_3, ICl_3)	T-shaped	
	AX_2E_3 (XeF_2, I_3^-)	Linear	
6	AX_6 (SF_6, PCl_6^-)	Octahedron	
	AX_5E (BrF_5, IF_5)	Square pyramidal	
	AX_4E_2 (XeF_4)	Square planar	

How to Use This Cheat Sheet: These are the keys related to this topic. Try to read through it carefully twice then write it out on a blank sheet of paper. Review it again before the exams.