

Molecular Geometry

Valence shell electron-pair repulsion (VSEPR)

Geometry of a molecule is governed primarily by minimizing electron pair repulsions.

Lone (nonbonding) pairs will stay as far away from each other as possible

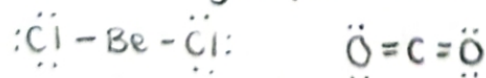
Bonds or nonbonding electron pairs around a central atom dictate the geometry around that atom

Electron group: $- = \equiv \dots$

Basic Shapes

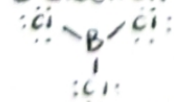
1. Linear

2 electron groups Bond angle: 180°



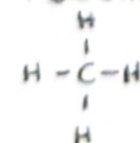
2. Trigonal Planar

3 electron groups Bond angle: 120°



3. Tetrahedral

4 electron groups Bond angle: 109.5°



Basic Shapes

4. Trigonal Bipyramidal

5 electron groups

Bond angle: $120^\circ, 90^\circ$



5. Octahedral

6 electron groups

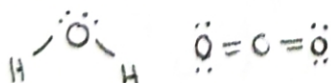
Bond angle: 90°



The effect of lone pairs around the central atom

H_2O vs CO_2

Lewis structures:



	Electron Groups (around the central atom)	Bonding Groups	Lone Pairs	Electron Geometry	Molecular Geometry	Bond Angle
H_2O	4	2	2	Tetra- hedral	Bent	104.5°
CO_2	2	2	0	Linear	Linear	180°

$< 109.5^\circ$

Double and Triple Bonds

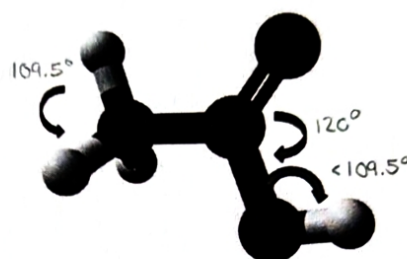
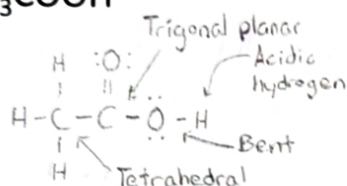
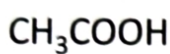
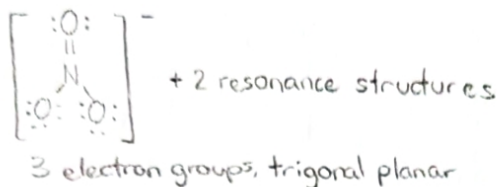
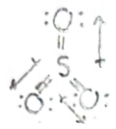
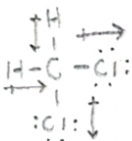


TABLE 13.1 • Electron and Molecular Geometries


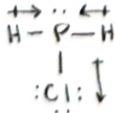
Electron Groups*	Bonding Groups*	Nonbonding Pairs	Electron Geometry	Molecular Geometry	Approximate Bond Angles	Example
2	2	0	Linear	Linear	180°	$\text{Cl}-\text{Be}-\text{Cl}$
3	3	0	Trigonal planar	Trigonal planar	120°	BF_3
3	2	1	Trigonal planar	Bent	<120°	$\text{Cl}-\text{Be}-\text{Cl}$
4	4	0	Tetrahedral	Tetrahedral	109.5°	$\text{H}-\text{C}-\text{H}$
4	3	1	Tetrahedral	Trigonal pyramidal	<109.5°	$\text{H}-\text{N}-\text{H}$
4	2	2	Tetrahedral	Bent	<109.5°	$\text{H}-\text{O}-\text{H}$
5	5	0	Trigonal bipyramidal	Trigonal bipyramidal	120° (equatorial) 90° (axial)	Cl_5P
5	4	1	Trigonal bipyramidal	Seesaw	<120° (equatorial) <90° (axial)	SF_4
5	2	3	Trigonal bipyramidal	T-shaped	<90°	ClF_3
5	2	3	Trigonal bipyramidal	Linear	180°	XeF_2
6	6	0	Octahedral	Octahedral	90°	SF_6
6	5	1	Octahedral	Square pyramidal	<90°	BrF_5
6	4	2	Octahedral	Square planar	90°	XeF_4

* Lone pairs are shown as pairs of dots around the central atom. Each of the following is considered one electron group: a lone pair, a single bond, a double bond, or a triple bond.

Examples

	Lewis Structure	Electron Geometry	Molecular Geometry	Polar or Nonpolar?
SO ₃		Trigonal planar	Trigonal planar	Nonpolar
CH ₂ Cl ₂		Tetrahedral	Tetrahedral	Polar

Examples

	Lewis Structure	Electron Geometry	Molecular Geometry	Polar or Nonpolar?
TeF ₄		Trigonal Bipyramidal	Seesaw	Polar
H ₂ PCl		Tetrahedral	Trigonal Pyramidal	Polar