

11/14/05

CHM 123 - Lecture (Monday, 10:30 am)

- Quiz this week 11/15 and 11/17 (during recitation)
- Exam 3 next week 11/21/05 (Monday, 7-8:15 pm in EE 129)

CHAPTER 9 - Molecular StructuresPredicting Molecular Shapes

- Lewis structures show us connectivity in atoms, but don't tell us the actual shapes of the molecules.
- Molecules are three-dimensional. Hence an extension to Lewis theory is needed to help us predict the arrangement of atoms in space.
- VSEPR - (Valence Shell Electron Pair Repulsion) regions of high electron concentration repel each other (bonds, lone pairs, etc.)

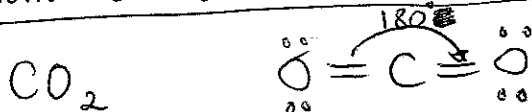
In this theory, we will focus only on the central atom of the molecule and what is connected to it.

VSEPR

(a) Central atom w/ Bonding Pairs only.

~~Central atom w/ lone pairs~~

• 2 atoms attached to central.

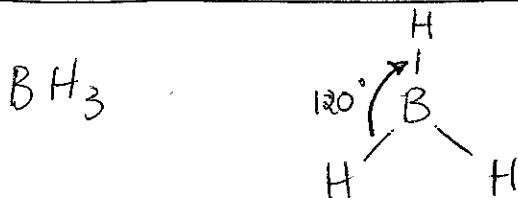


to be as far apart as possible, bonding pairs (and $\therefore$ oxygens) must be 180° apart.

Electron-pair geometry: linear
Molecular geometry: linear

- * Multiple bonds count as only one attachment. In CO_2 , 2 oxygen atoms are connected to carbon. 4 bonds are not required in this case. It's only the atoms that are connected to the central atom that concern us.

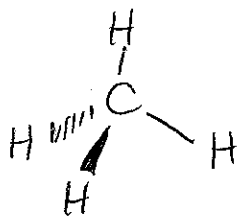
• 3 atoms attached to central atom



to be as far apart as possible, bonding pairs (and $\therefore$ hydrogens) must be 120° apart.

Electron-pair geometry: Trigonal (triangular) planar.
Molecular " : Trigonal (triangular) planar.

• 4 atoms attached to central

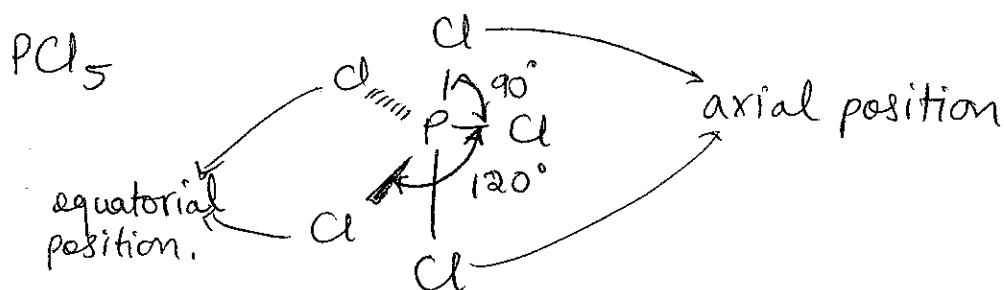


straight line: in plane of screen,
dark wedge; coming out of page
broken " : going into the page,

to be as ~~of~~ far apart: bonding pairs must ~~have to~~ be 109.5° apart

Electron-pair geometry: Tetrahedral
Molecular geometry: Tetrahedral.

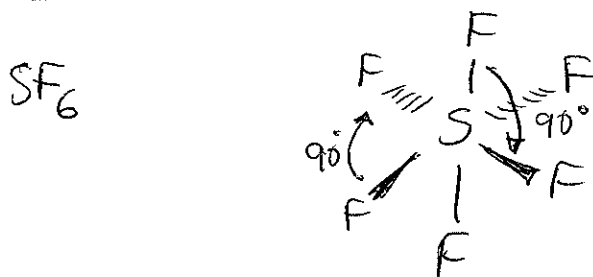
- 5 atoms attached to central atom



to be as far apart: bonding pairs must be a combination of 90° and 120° apart.

Electron pair geometry: Trigonal (triangular) bipyramidal.
 Molecular geometry: " " " "

- 6 atoms attached to central atom



to be as far apart: bonding pairs must be 90° apart.

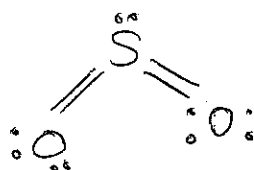
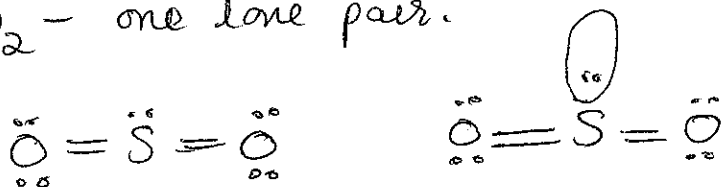
Electron pair geometry: Octahedral
 Molecular " : Octahedral.

VSEPR - Central Atom with Bonding & Lone pairs

- 3 electron pairs on central atom:

BH_3 - no lone pairs (trigonal planar)

SO_2 - one lone pair.



- lone pair of electrons
repels bonding pairs.

Lone pair repulsion
pushes bonded
pairs to result
in bent structure.

Electron pair geometry: Trigonal planar (in terms of electrons)
Molecular geometry: Bent (angular) $\Rightarrow$ geometry that atoms take on.

Lone pairs of electrons and Molecular geometry

- Lone pairs occupy more space than bonding pairs.
- Repulsive forces among valence pairs diminish in the following order:

lone pairs vs. lone pair $>$ lone pair vs. bonding pair $>$

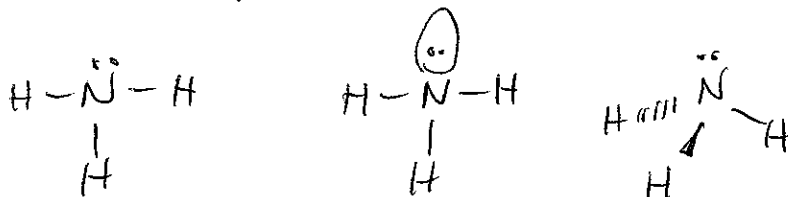
bonding pair vs. bonding pair

- Lone pairs prefer equatorial positions to axial positions in trigonal bipyramidal.

• 4 electron pairs on central atom

CH_4 - no lone pairs (tetrahedral)

NH_3 - one lone pair.

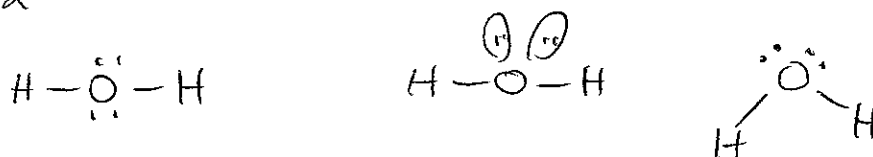


lone pair of electrons repels bonding pairs.

Electron pair geometry: tetrahedral (4 things connected to central atom)

Molecular geometry: trigonal pyramidal.

(ii) H_2O - two lone pairs

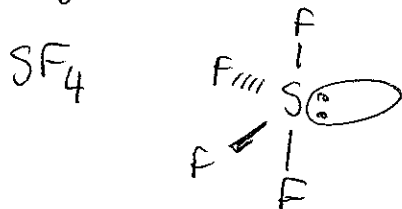


Electron pair geometry: Tetrahedral

Molecular geometry: Bent (Angular).

• 5 electron pairs on central atom

PCl_5 - no lone pairs (trigonal bipyramidal)

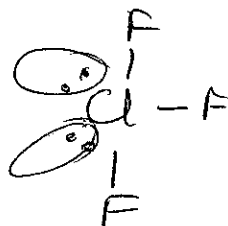
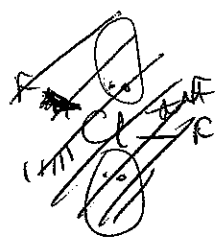


Lone pairs prefer equatorial position.

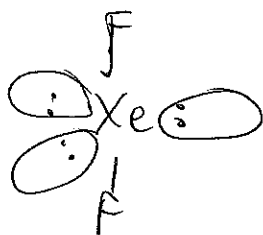
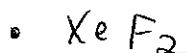
Electron pair geometry: Trigonal bipyramid

Molecular " : Seesaw

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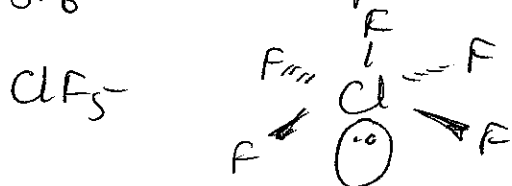
Molecular geometry: T-shaped.



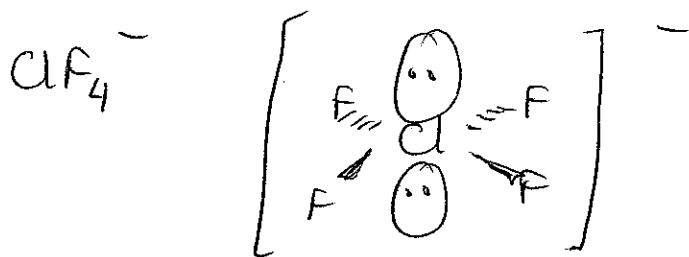
Electron pair geometry: trigonal bipyramid
Molecular geometry: Linear.

© 6 electron pairs on central atom

SF_6 - no lone pairs on S (octahedral)



electron pair geometry: octahedral
Molecular " : Square pyramidal.



electron pair geometry: octahedral
Molecular " : Square Planar