VSEPR Theory

Valence Shell Electron Pair Repulsion Theory

Linear

Trigonal planar

Tetrahedral

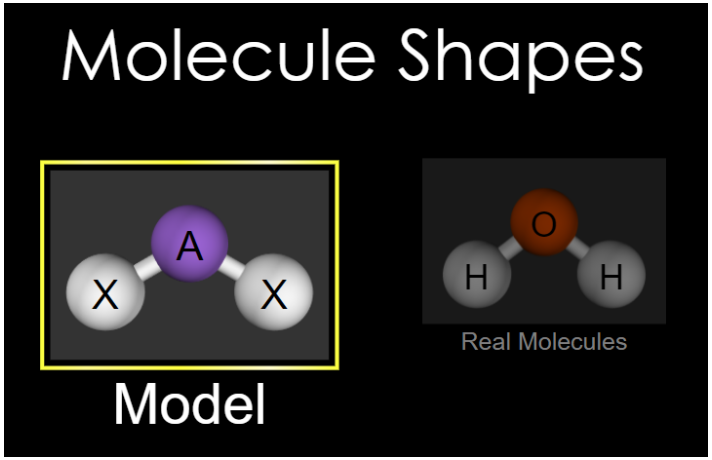
Trigonal bipyramidal and Octahedral Geometries will be studied in Grade 12/AP Chemistry

Before we start . . .

This lesson is about molecular shape:

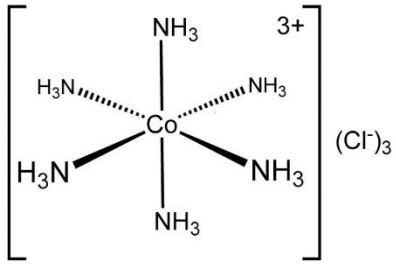
2-D and 3-D

Take a look at this simulation; play with it; see what you can come up with.



NOTE

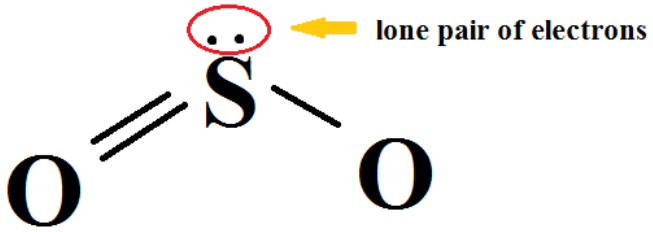
A = central atom



X = bonding atom or group (aka ligand).

In this case, the ligand is

E = lone pair of electrons



Take note . . .

An Electron Pair Domain (EPD) consists of any of the following on the central atom:

- single bond
- double bond
- triple bond
- lone pair of electrons

VSEPR Theory treats these ALL THE SAME WAY!!!!!!!!!!!

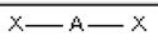
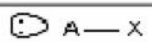
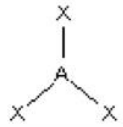
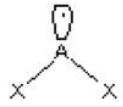
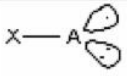
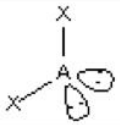
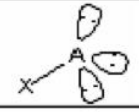
EPDs take up space—they repel one another to minimize repulsion. (See handout)

That is, they orient themselves in such a way as to be as far from one another as possible.

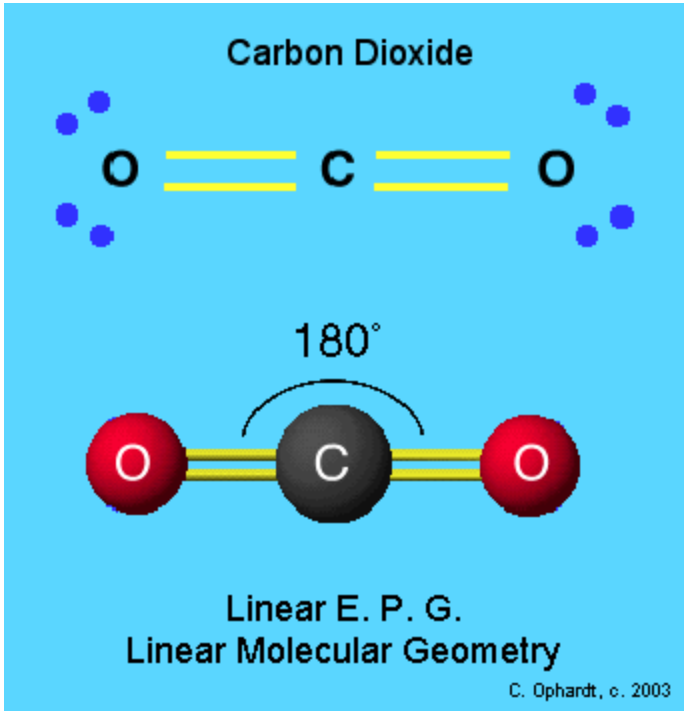
This is where this lesson is going . . .

A = the central atom, X = an atom bonded to A, E = a lone pair on A

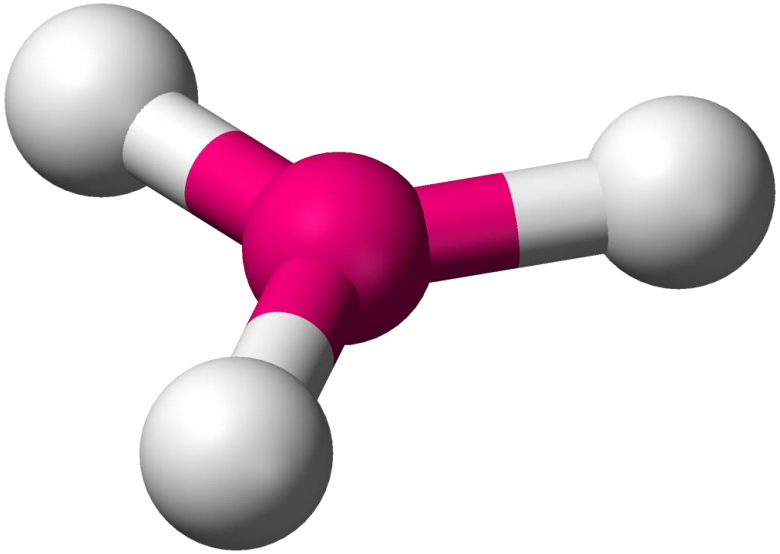
Note: There are lone pairs on X or other atoms, but we don't care. We are interested in only the electron densities or domains around atom A.

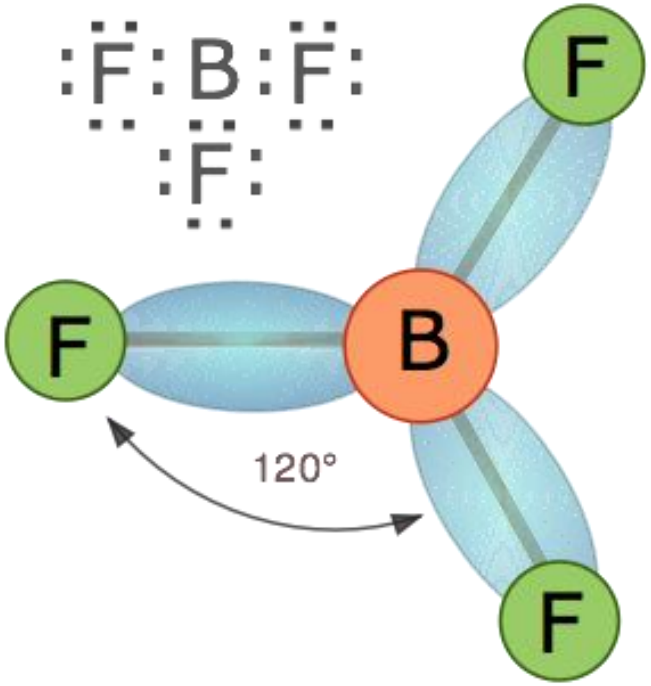
Total Domains	Generic Formula	Picture	Bonded Atoms	Lone Pairs	Molecular Shape	Electron Geometry	Example	Hybridi -zation	Bond Angles
1	AX		1	0	Linear	Linear	H_2	s	180
2	AX_2		2	0	Linear	Linear	CO_2	sp	180
	AXE		1	1	Linear	Linear	CN^-		
3	AX_3		3	0	Trigonal planar	Trigonal planar	$AlBr_3$	sp^2	120
	AX_2E		2	1	Bent	Trigonal planar	$SnCl_2$		
	AXE_2		1	2	Linear	Trigonal planar	O_2		
4	AX_4		4	0	Tetrahedral	Tetrahedral	$SiCl_4$	sp^3	109.5
	AX_3E		3	1	Trigonal pyramid	Tetrahedral	PH_3		
	AX_2E_2		2	2	Bent	Tetrahedral	$SeBr_2$		
	AXE_3		1	3	Linear	Tetrahedral	Cl_2		

Linear molecular geometry (AX_2)



Trigonal planar (AX_3)

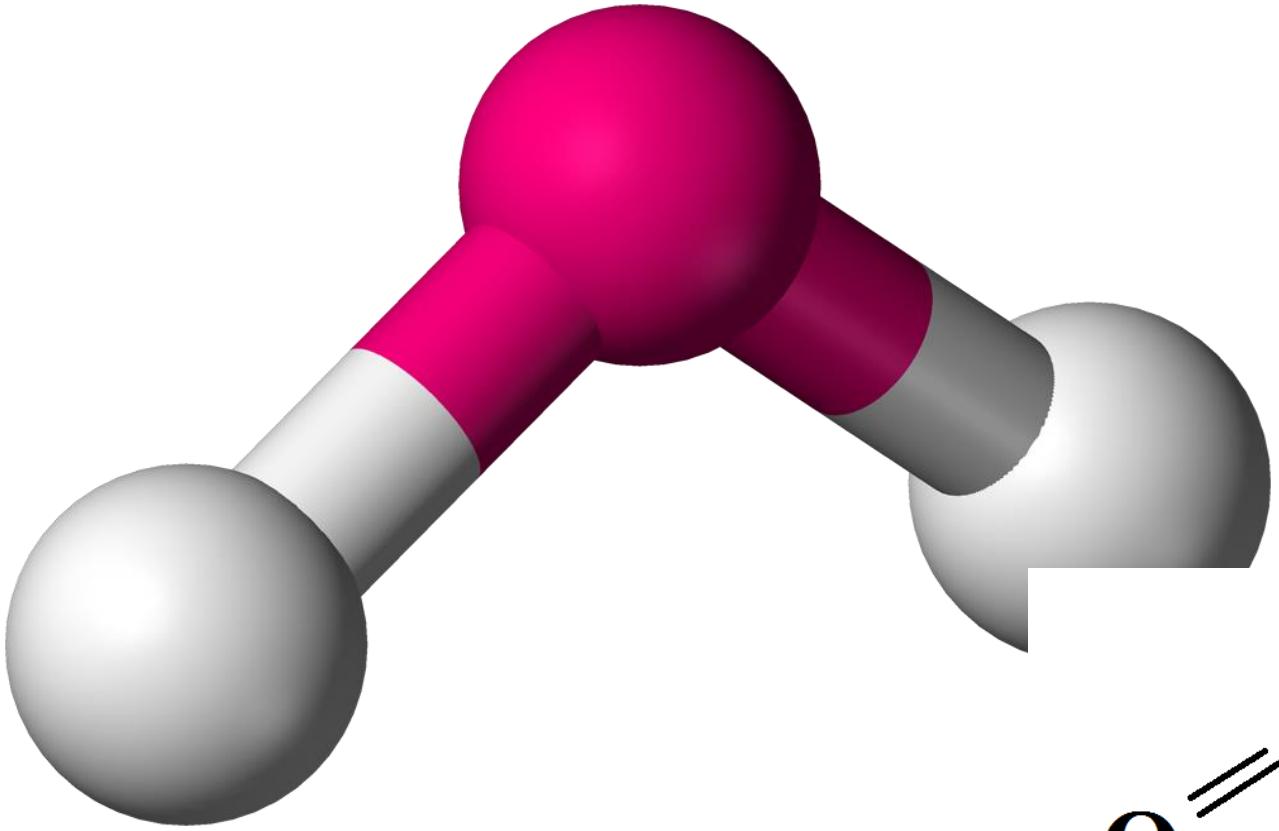


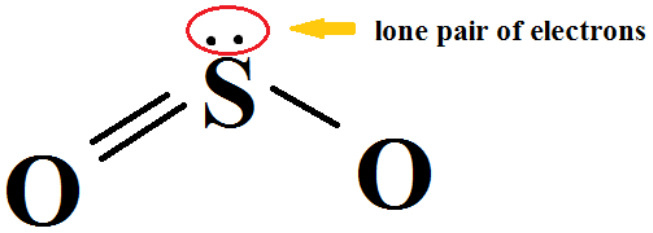


Bent molecular geometry #1

(AX_2E)

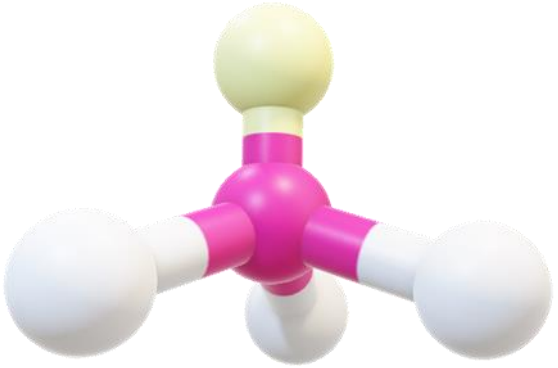
bond angle < 120°

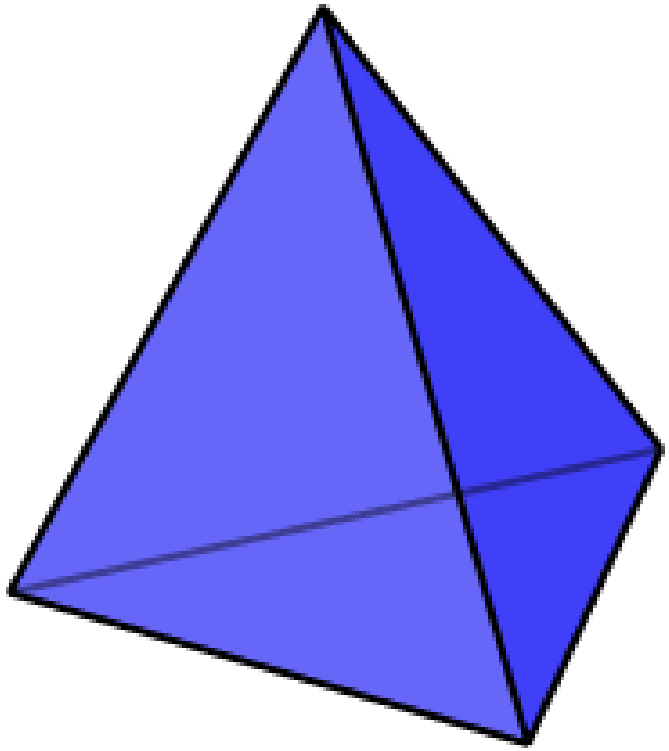


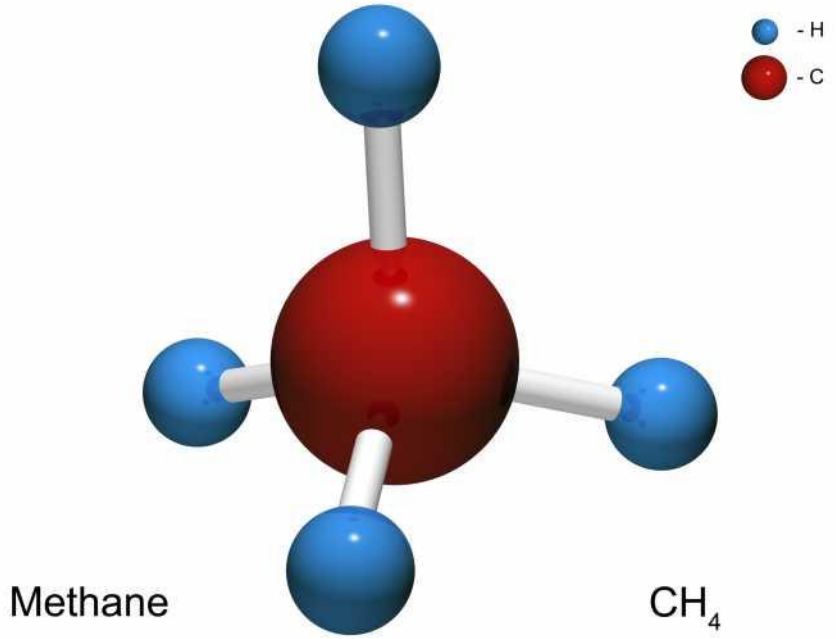


Tetrahedral molecular geometry (AX_4)

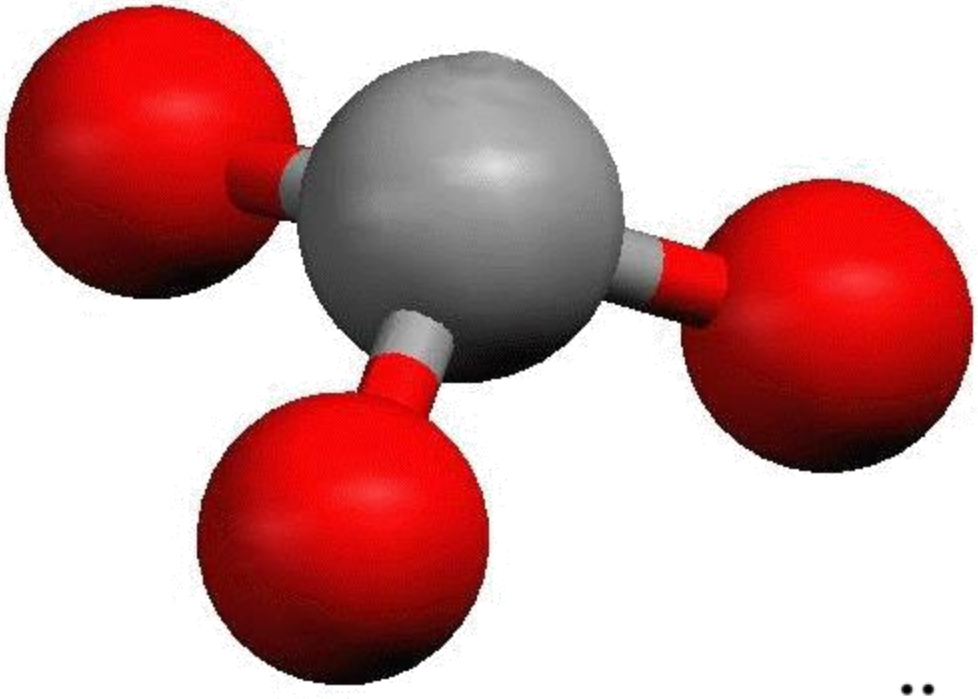
109.5^o bond angles

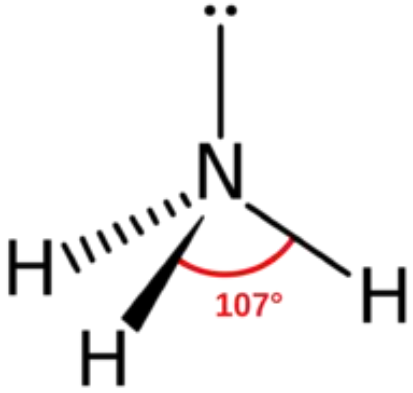


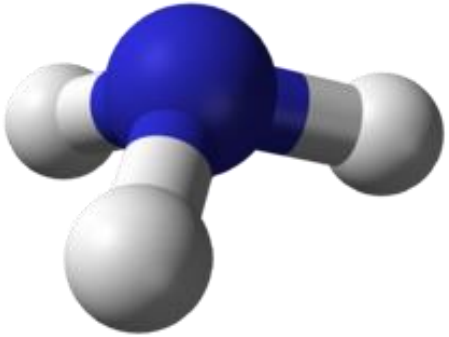




Pyramidal molecular geometry (AX_3E)



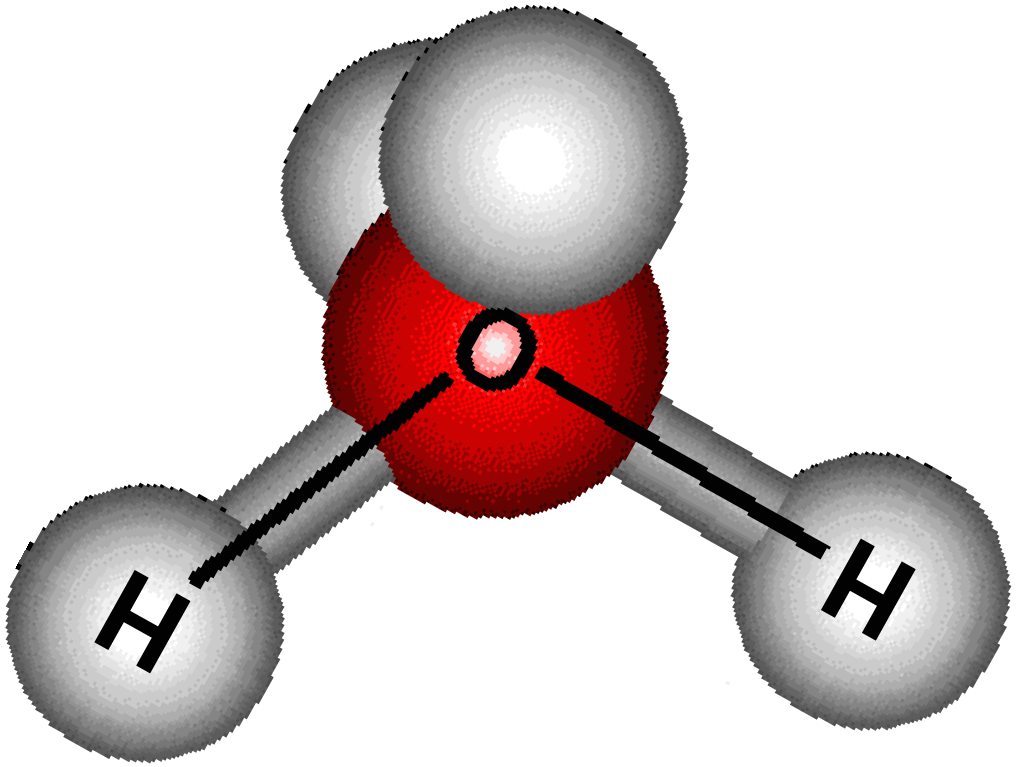


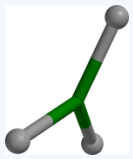
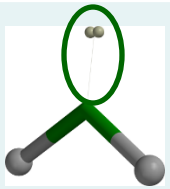
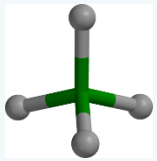
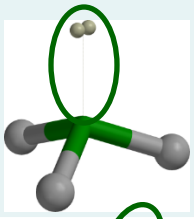
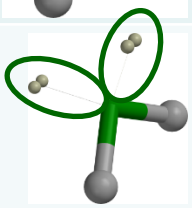


Bent molecular geometry #2

(AX_2E_2)

bond angle < 109.5°



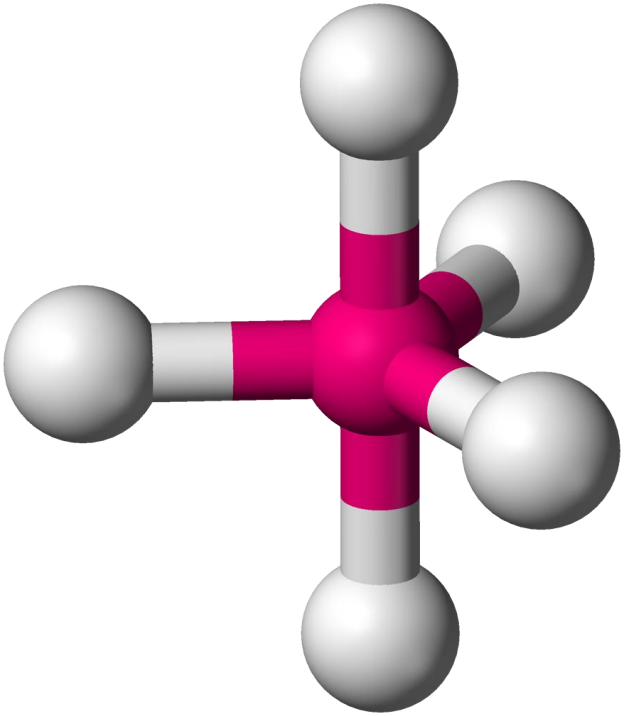
Lewis Structure	lone pairs on central atom	bonds on central atom	electronic geometry	molecular geometry	bond angles
	0	2	linear	linear	180° (1-D)
	a	b	c	d	e
	c	b	d	e	a
	a	b	c	d	e
	d	c	b	a	e
	e	d	c	b	a

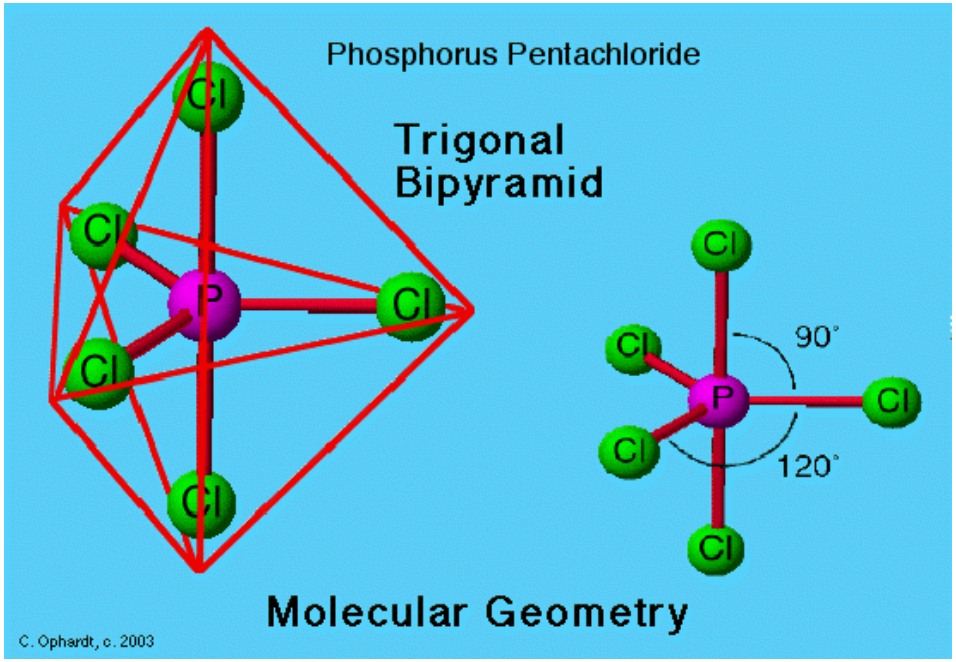
Grade 11 Chemistry students stop here!!

Trigonal Bipyramidal molecular geometry (AX_5)

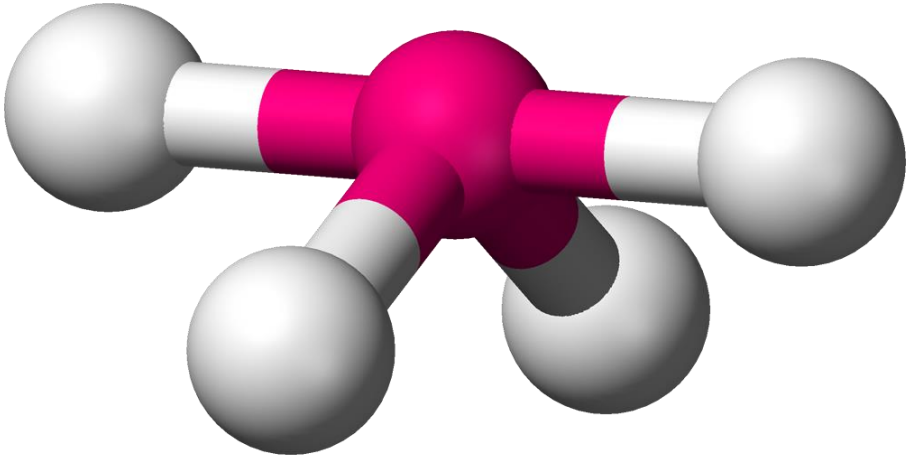
axial angle = 90°

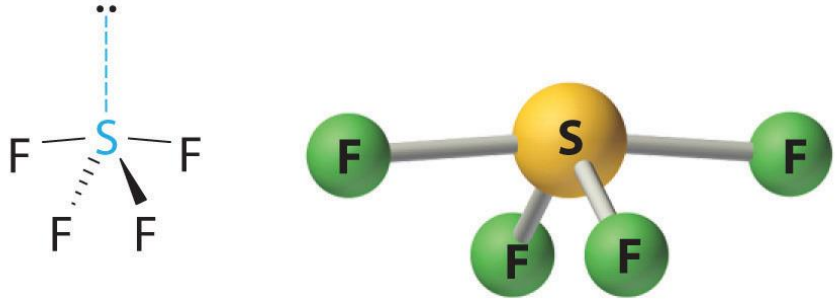
equatorial angle = 120°





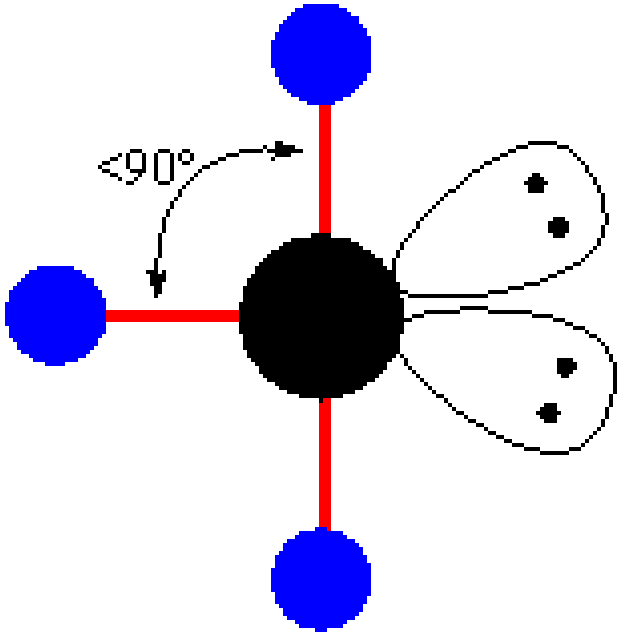
See-saw molecular geometry (AB_4E)

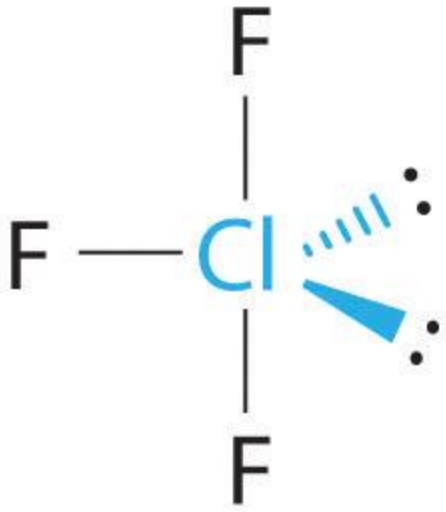




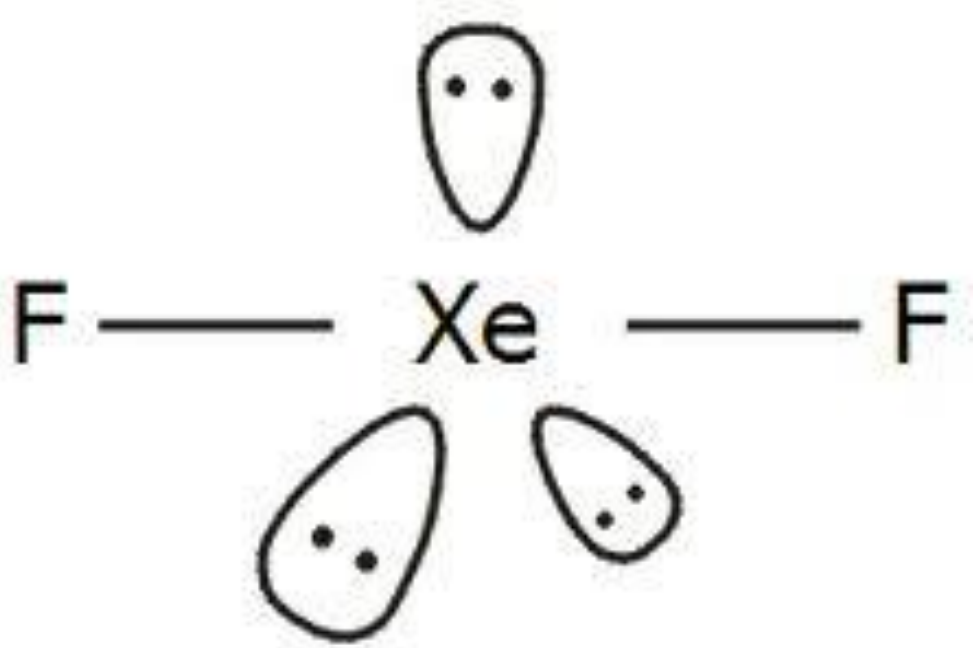
Molecular geometry (seesaw)

T-shaped molecular geometry (AX_3E_2)



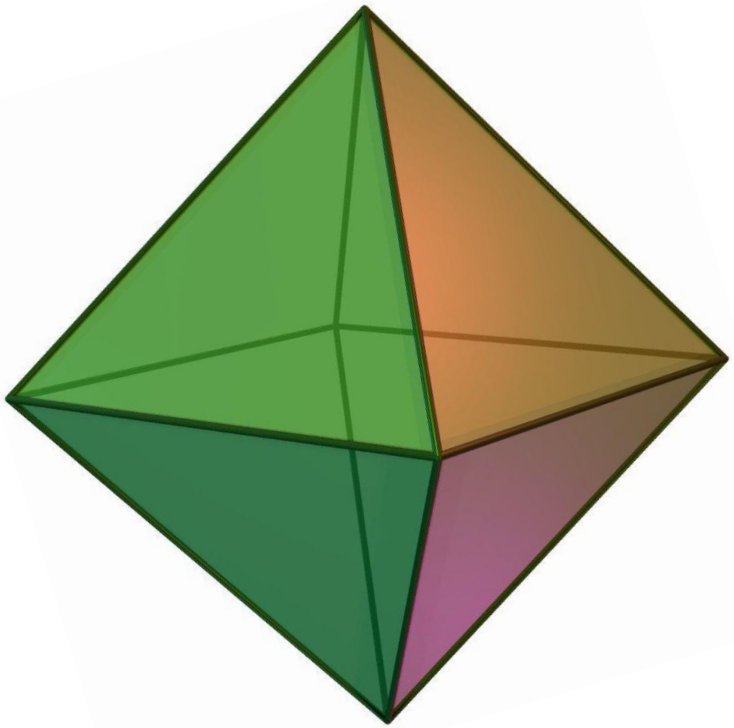


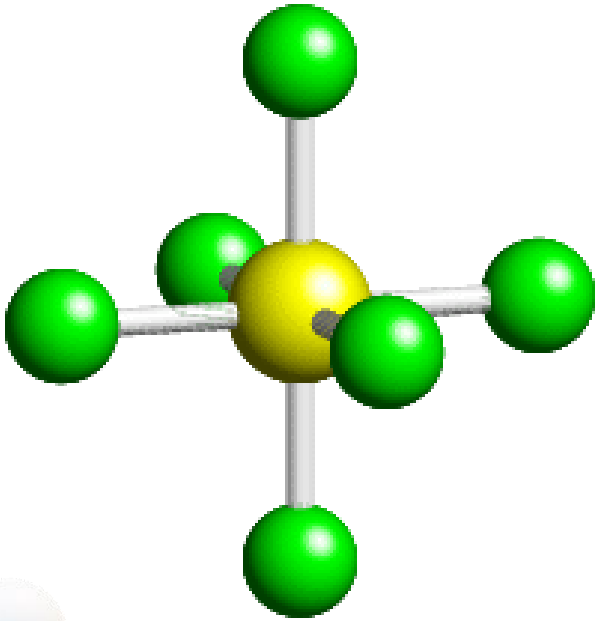
Linear molecular geometry (AX_2E_3)

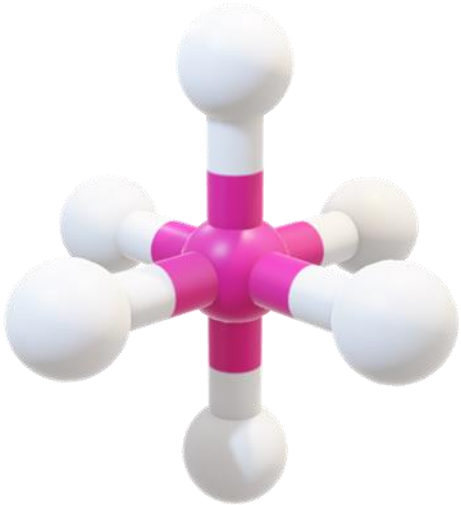


Octahedron (AX_6)

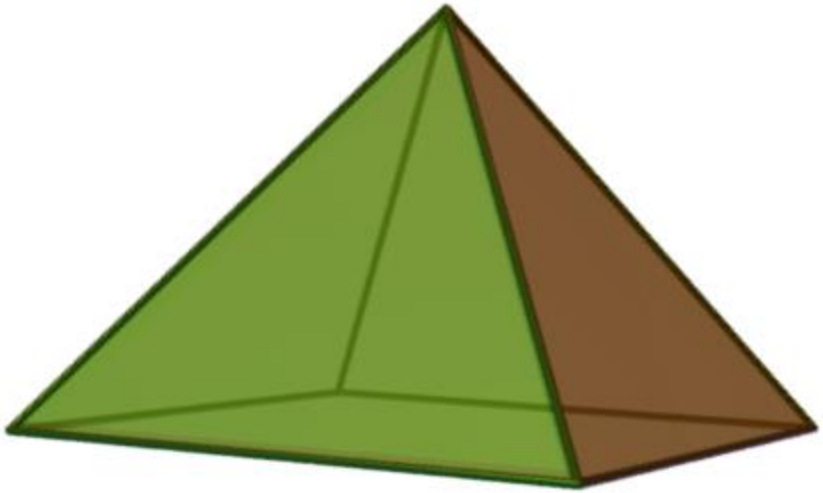
bond angles 90^o

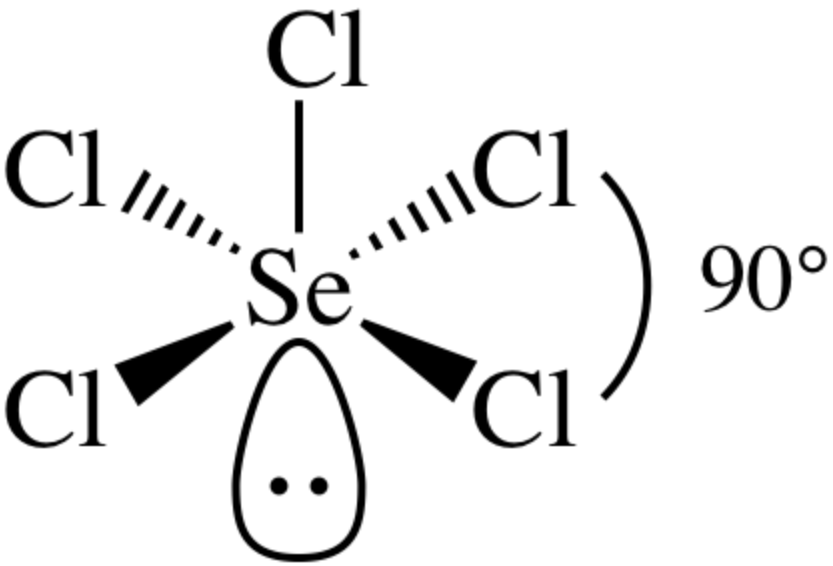


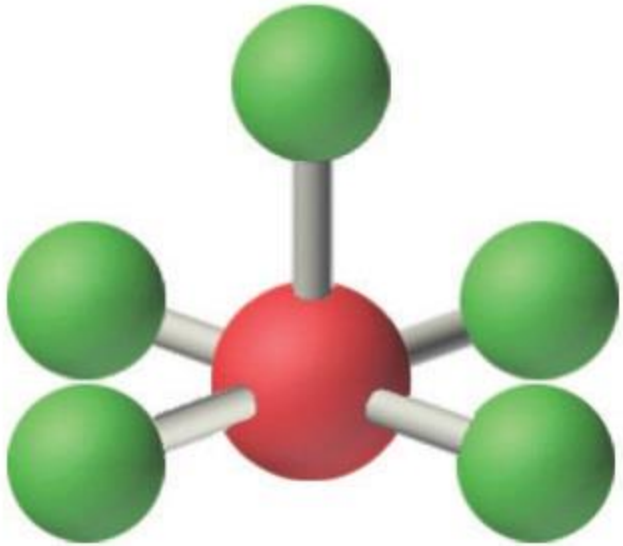




Square-based Pyramid (AX_5E)

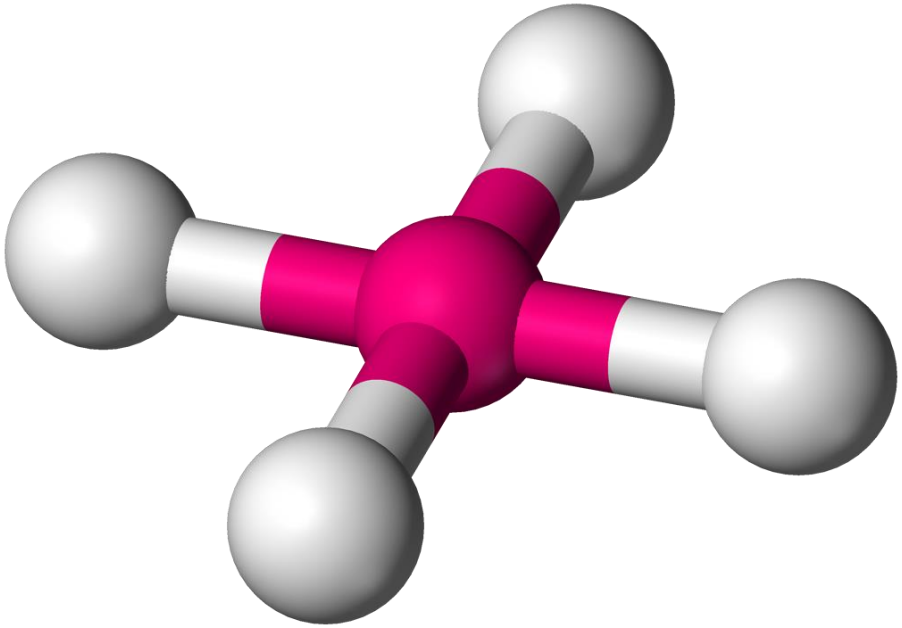


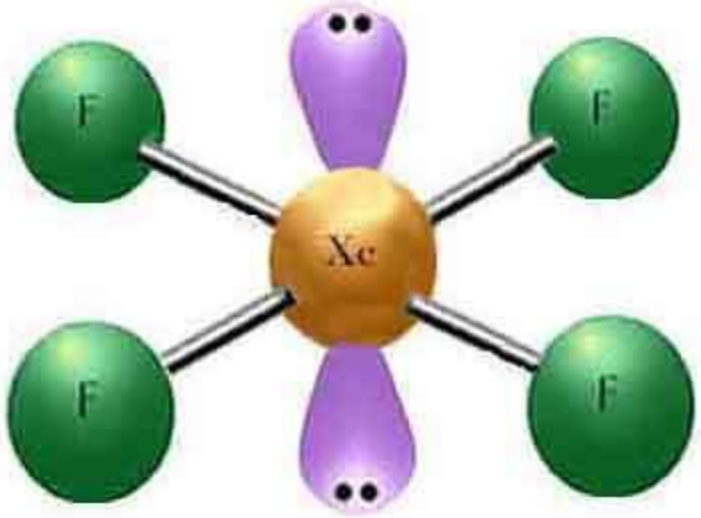




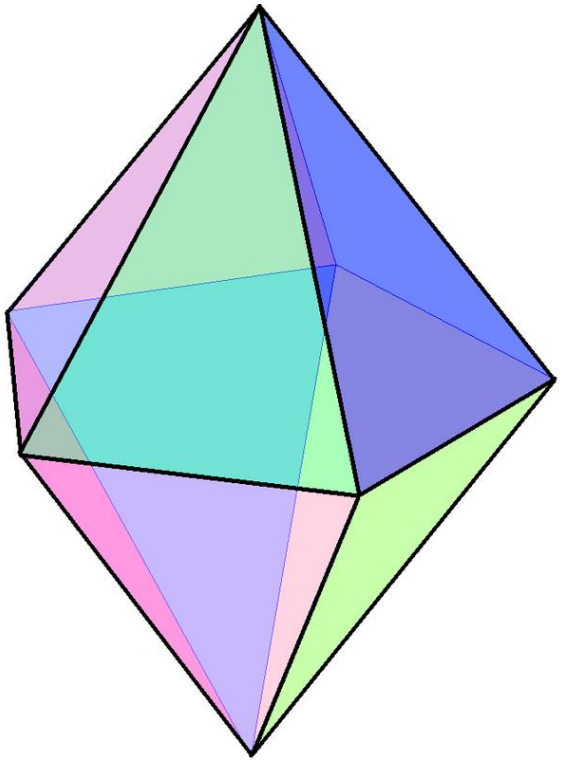
Molecular geometry
(square pyramidal)

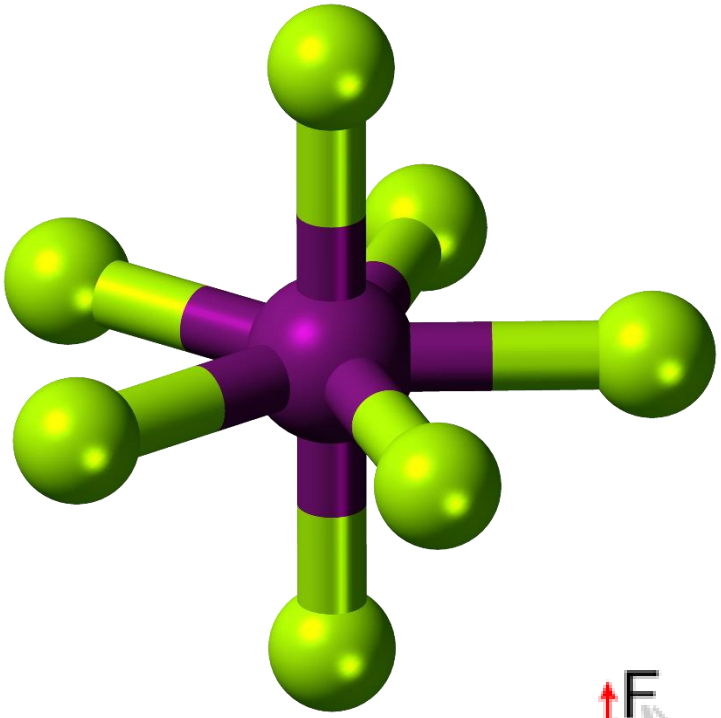
Square planar geometry (AX_4E_2)

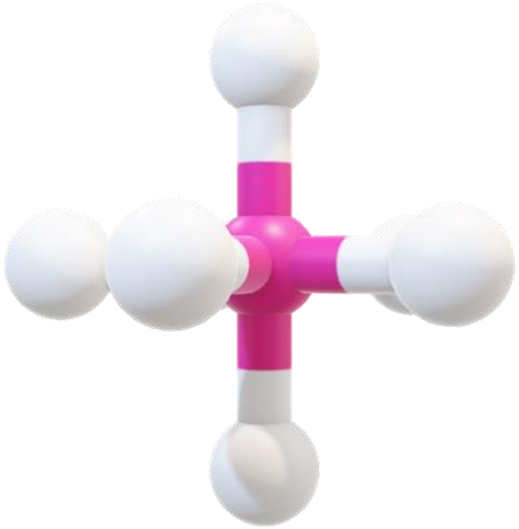


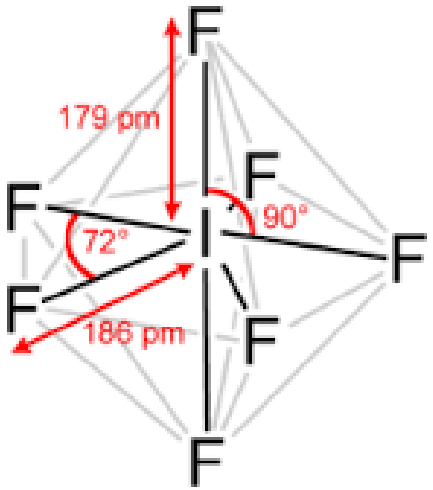


Pentagonal bipyramid (AX_7)



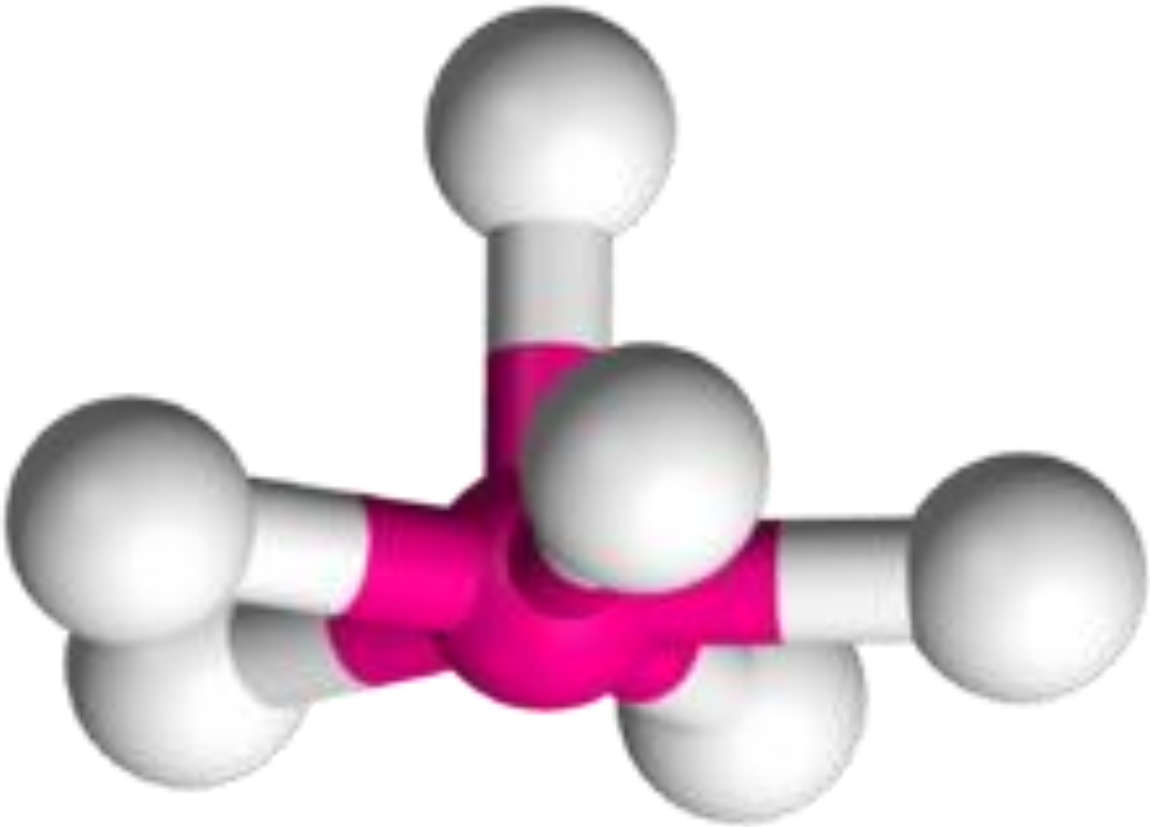




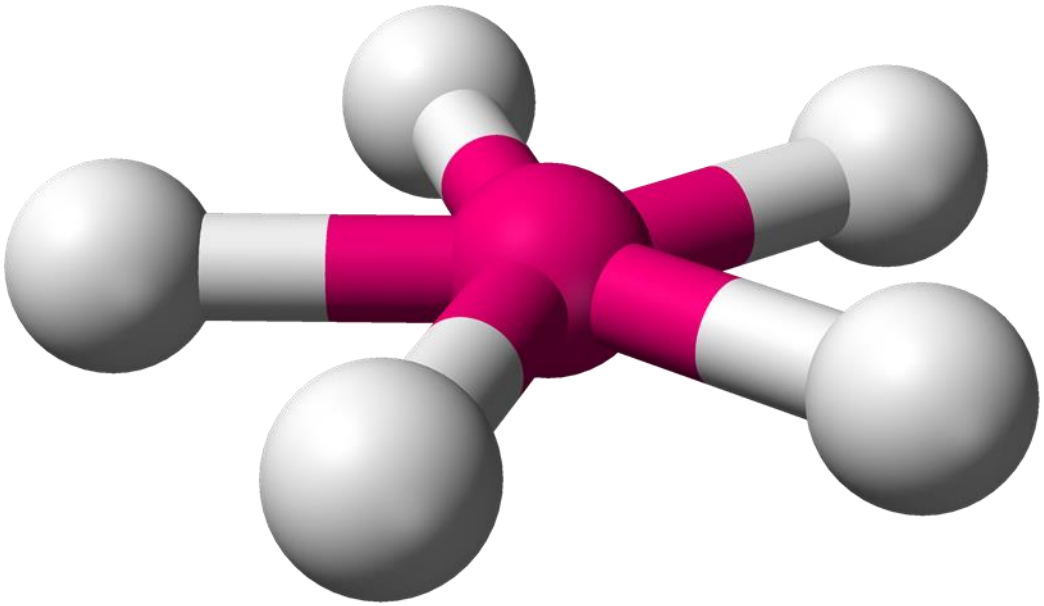


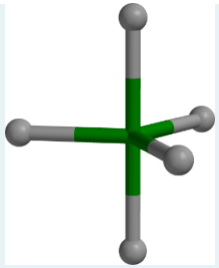
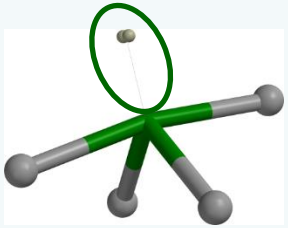
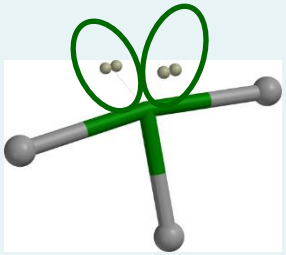
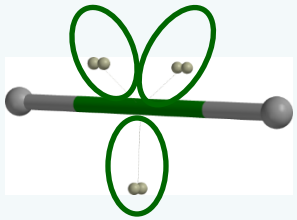
Pentagonal-based Pyramid

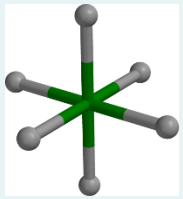
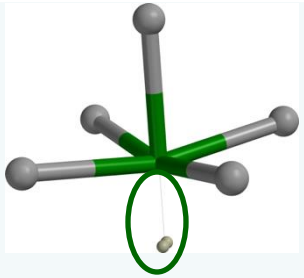
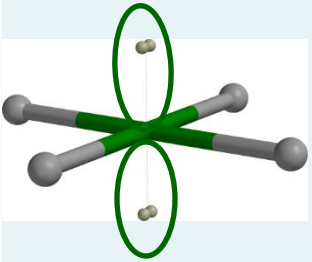
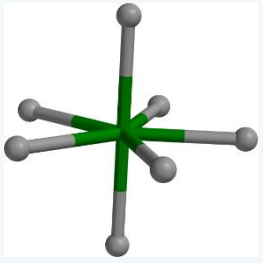
(AX_6E)

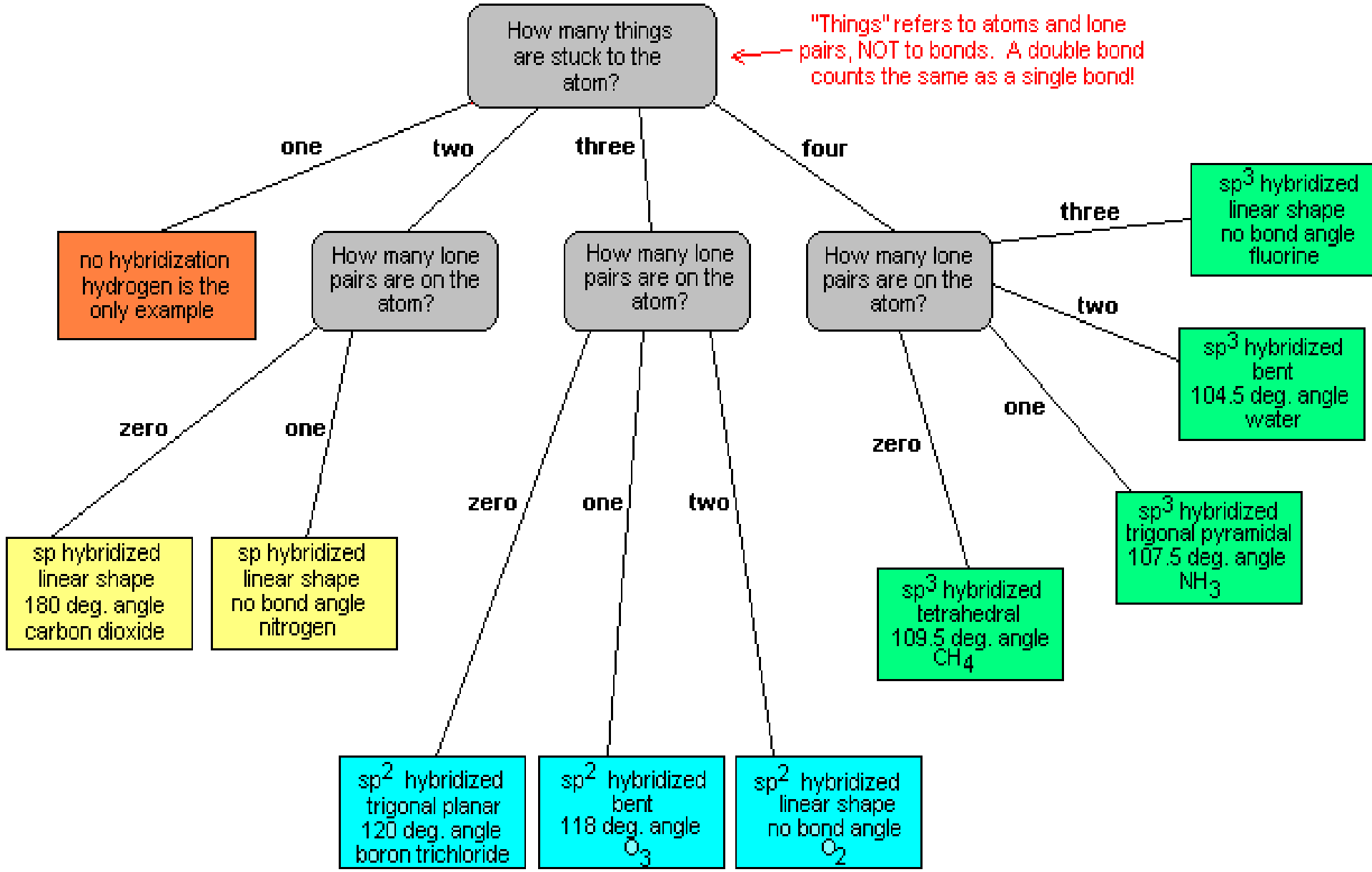


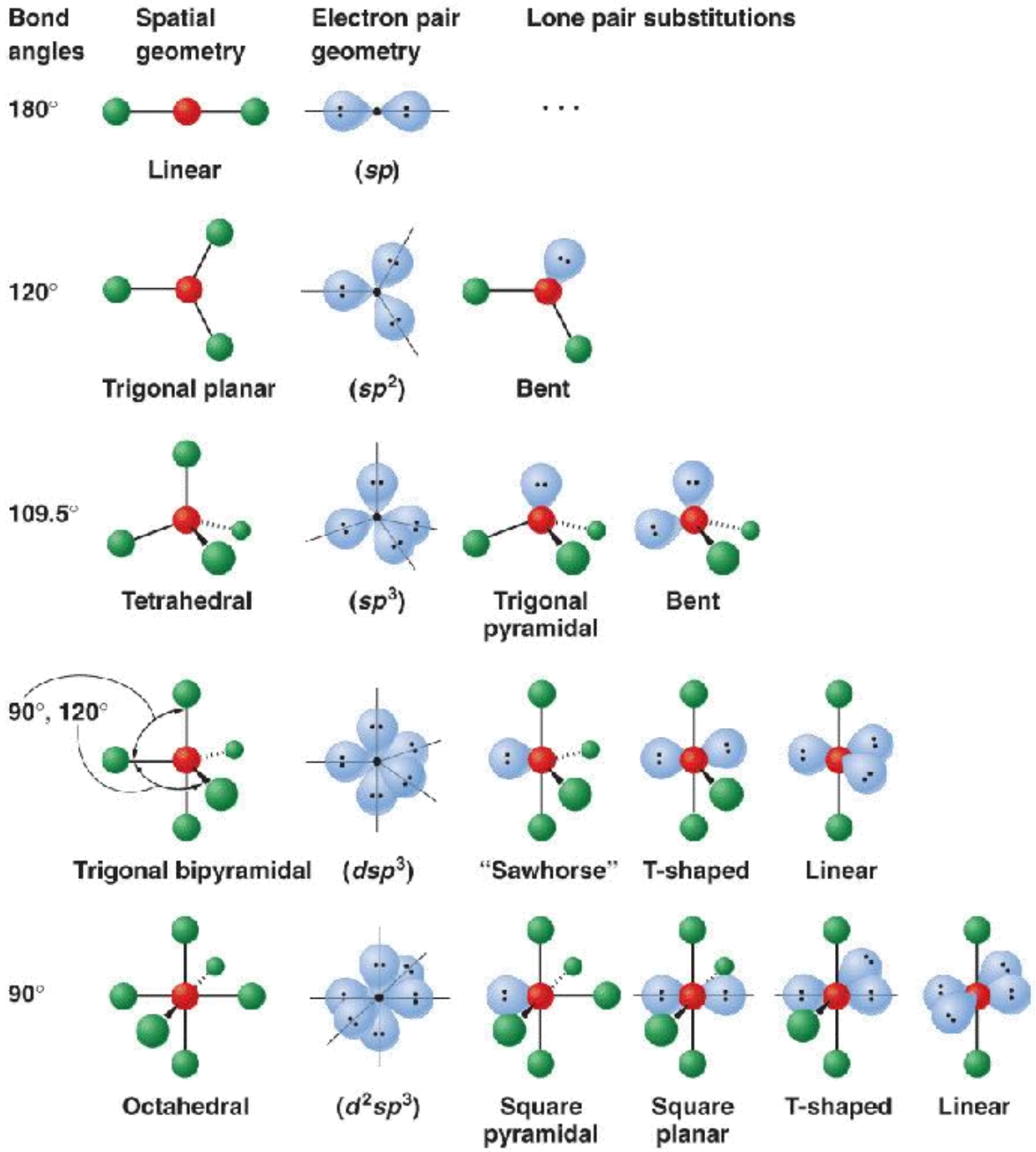
Pentagonal planar geometry (AX_5E_2)



Lewis Structure	lone pairs on central atom	bonds on central atom	electronic geometry	molecular geometry	bond angles
					
					
					
					

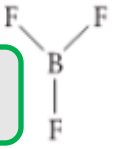
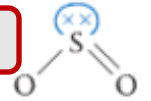
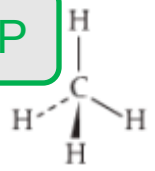
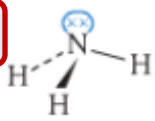
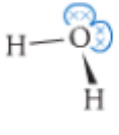
Lewis Structure	lone pairs on central atom	bonds on central atom	electronic geometry	molecular geometry	bond angles
					
					
					
					

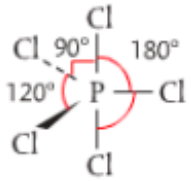
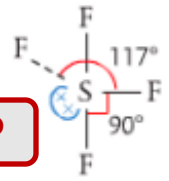
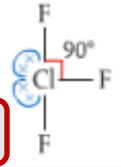
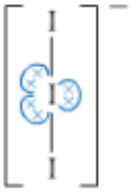

How many things are stuck to the atom?
"Things" refers to atoms and lone pairs, NOT to bonds. A double bond counts the same as a single bond!
one
two
three
four
no hybridization
hydrogen is the only example
How many lone pairs are on the atom?
How many lone pairs are on the atom?
How many lone pairs are on the atom?
zero
one
zero
one
two
zero
one
two
three
sp hybridized
linear shape
180 deg. angle
carbon dioxide
sp hybridized
linear shape
no bond angle
nitrogen
sp2 hybridized
trigonal planar
120 deg. angle
boron trichloride
sp2 hybridized
bent
118 deg. angle
O3
sp2 hybridized
linear shape
no bond angle
O2
sp3 hybridized
tetrahedral
109.5 deg. angle
CH4
sp3 hybridized
trigonal pyramidal
107.5 deg. angle
NH3
sp3 hybridized
bent
104.5 deg. angle
water
sp3 hybridized
linear shape
no bond angle
fluorine



More Review/Practice

Looking ahead: Add bond dipole vectors to determine if *molecule* is polar **(P)** or non-polar **(NP)**

Number of electron domains	Electron domain geometry	Number of bonding electron domains	Number of non-bonding pairs of electrons	Molecular geometry	Example
2	linear	2	0	linear	NP CO_2 O=C=O
3	planar triangular	3	0	planar triangular	BF_3 NP 
3	planar triangular	2	1	V-shaped	SO_2 P 
4	tetrahedral	4	0	tetrahedral	CH_4 NP 
4	tetrahedral	3	1	pyramidal	NH_3 P 
4	tetrahedral	2	2	V-shaped	H_2O P 

5	triangular bipyramidal	5	0	triangular bipyramidal	NP 
5	triangular bipyramidal	4	1	unsymmetrical tetrahedron/see-saw	SF_4 P 
5	triangular bipyramidal	3	2	T-shaped	ClF_3 P 
5	triangular bipyramidal	2	3	linear	I_3^- 
6	octahedral	6	0	octahedral	NP 
6	octahedral	5	1	square pyramidal	P BrF_5 
6	octahedral	4	2	square planar	NP