# Lewis Structure and Electron Dot Models

The Lewis Structure is a method of displaying the electrons present in any given atom or compound.

Steps:

1. Make a skeleton structure
2. Count all e- available
3. Give all atoms an octet
4. If there are too many e-, double/triple bonds are necessary

Terms:

Resonance - the same molecules with differently placed bonds

*Note for this to happen, there need to be double/triple bonds in the molecules and two of the same elements.

Formal Charge - hypothetical charge based upon the distribution of electrons. Formula:

FC = (valence e-) - (# of bonded e- contributed) - (# of lone e-)

Overall Charge - Sum of the formal charges of all atoms involved .

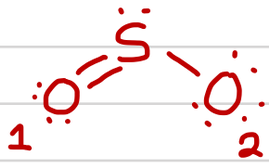
# Example

$SO_2$

skeleton structure: O–S–O

e⁻ count: S $O_2$
$6 + 2(6) = 18e^-$

given Octet:  ← 20 e⁻

adding double bond:  ← 18 e⁻

resonance structures: 

Formal Charge:

S = 6 − 3 − 2 = 1
$O_1$ = 6 − 2 − 4 = 0
$O_2$ = 6 − 1 − 6 = −1

Overall = 0

Note that unless the molecule is an ion (positive or negative charge), the overall charge should be neutral (0).

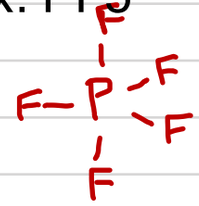
# Exceptions to the Octet Rule

The octet rule states that, in order to be stable, atoms want to have a full outer shell (8 e-). However, there are two noteworthy exceptions to this rule:

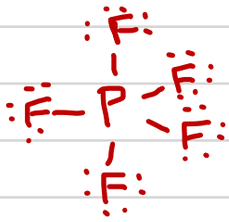
1. More than 8 electrons

2. Less than 8 electrons

Type 1: More than 8 electrons
Whenever there are more than 4 atoms connected to the central atom, Fluorine is usually involved (because of its strong pull on other elements' e-).
Ex: $PF_5$




$5+(5\times7)=40e^-$

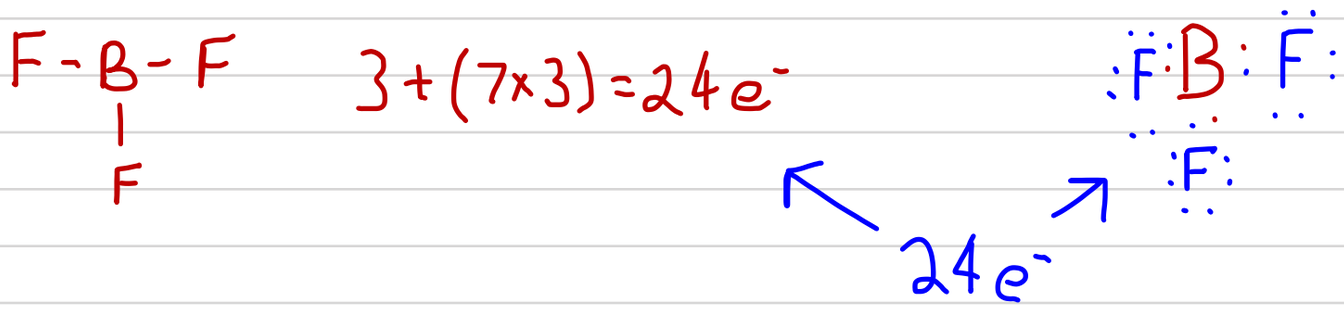



Fluorine can force atoms to unbond their bound e- to make 5 or even 6 unpaired e-.

# Exceptions Continued

Type 2: Less than 8 e-
In this case, the central atom usually comes from group 2 or 13 (it wants to give its e- away to obtain an octet). Therefore, bods are usually ionic.

Ex: BF3




# Bond Length Vs. Bond Order

Bond Order is basically a fancy way of describing the type of bonds present in a molecule.

| Bond Type: | Bond Order: | Bond Length: |
|---|---|---|
| Single | 1st | longest |
| Double | 2nd | shorter |
| Triple | 3rd | shortest |

Bond length decreases as the bond order increases. So, a single bond is the longest bond, a double bond is shorter than a single bond, a triple bond is shorter than a double bond, and so on.

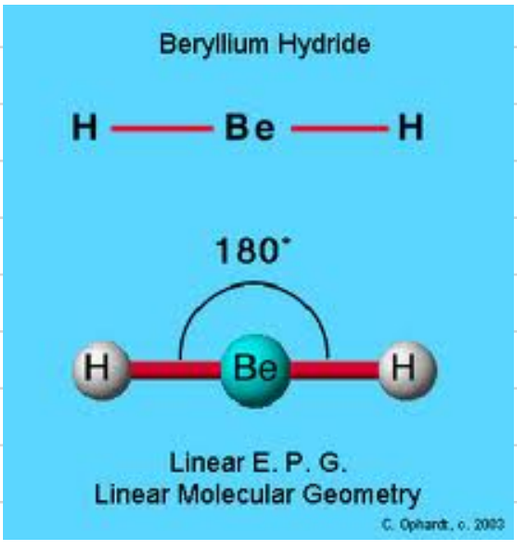
# Molecular Geometry

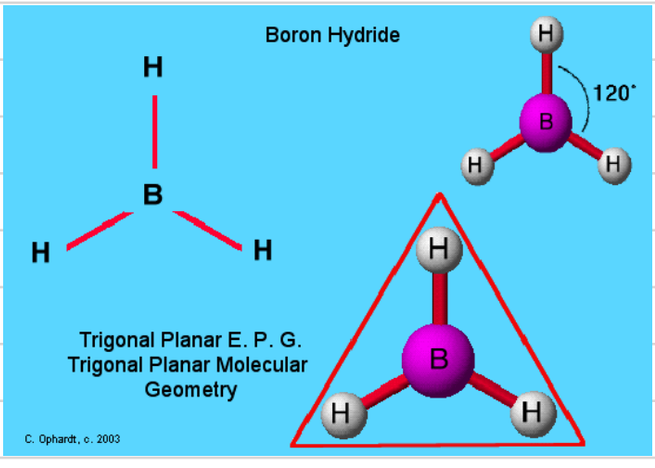
Molecular Geometry is based off of the VSEPR model. VSEPR stands for Valence Shell Electron Pair Repulsion.

This theory is based around the fact that electrons repel each other (because of their negative charge). Since the electrons are in contant motion, they orient themselves around the central atom in order to have the lowest possible electron repulsion

Each form has a unique name and angle measurements.

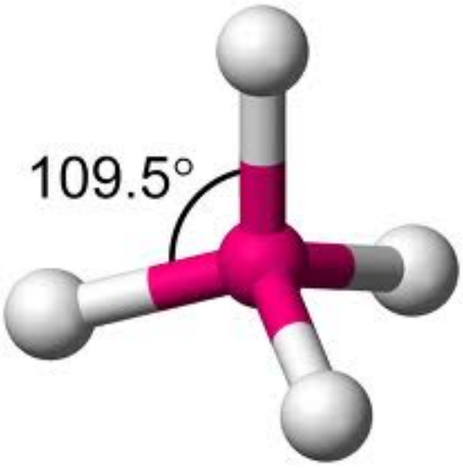
Any central molecule that has two spaces occupied around it is said to be LINEAR. It is arranged in a straight line and has an angle of 180 degrees.



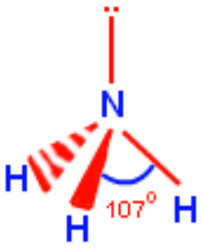

A central atom with three spaces around it occupied is called TRIGONAL PLANAR. The angle between each non-central atom is 120 degrees.

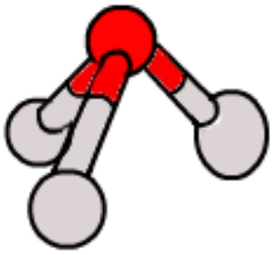
# Molecular Geometry Continued




A central atom with 4 spaces occupied around it is called TETRAHEDRAL. The distance between each non-central atom is 109.5 degrees

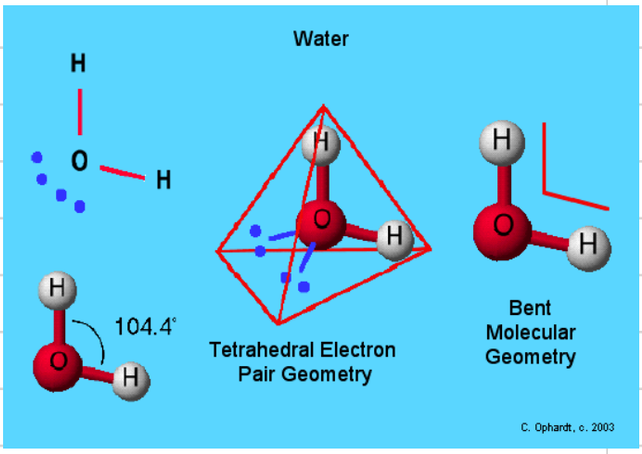
**Since lone pairs of electrons also take up a slot in space, it allows for some similar but different geometries. This is because lone pairs are more repulsive than a single or double bond.**



A central with 4 occupied spaces around it, consisting of 3 atoms and 1 lone pair is called PYRAMIDAL. Between each atom, there is a gap of 107 degrees, and between the lone pair and the atoms is a space greater than 109.5 degrees

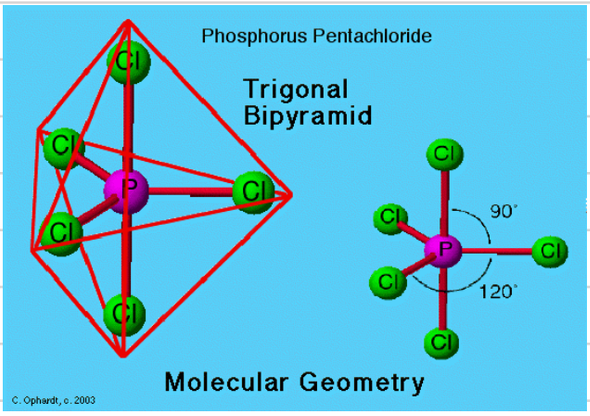
A central atom with 4 occupied spaces around it, consisting of 2 atoms and 2 lone pairs is called BENT. Between each atom, there is a gap of 105 degrees and between the lone pair and the atoms is a space greater than 109.5 degrees



# Geometric Exceptions to the Octet Rule

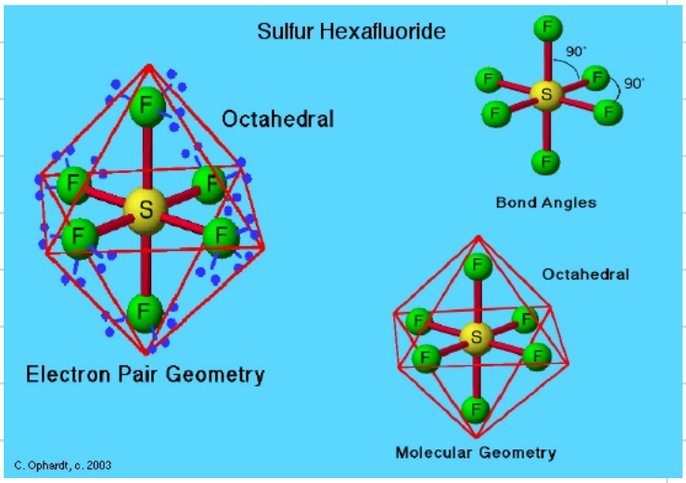
First, a few terms must be stated:

Axial - referring to the north and south poles
Equatorial - referring to the space around the middle




A central atom surrounded by 5 other atoms is called TRIGONAL BIPYRAMIDAL. The axial-axial angle is 180 degrees (top to bottom), the axial-equatorial angle is 90 degrees (top to center), and the equatorial-equatorial angle is 120 degrees (one equatorial atom to another).

A central atom surrounded by 6 occupied spaces is called OCTAHEDRAL. This is because, if faces were drawn between each set of 3 atoms, there would be 8 faces. The axial-axial angle is 180 degrees, and the axial-equatorial and equatorial-equatorial angles are both 90 degrees

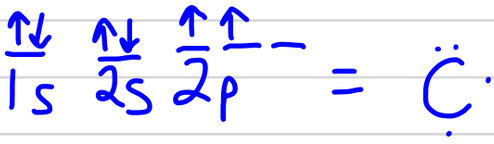


# Hybrid Orbitals (Valence Bond Theory)

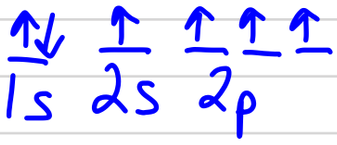
To explain the Valence Bond Theory, we must first observe the orbital notation of the Carbon in Methane (CH4)

$H = 1s^1 =$  $= H\cdot$

As we can see, the orbital and e- configuration notations of hydrogen are normal, however we see something different when we look at the configurations of Carbon.

$C = 1s^2 2s^2 2p^2 =$  $= \ddot{C}\cdot$

The orbital notation shows that carbon has a full s orbital and 2 e- in the p orbital. This is its 'unbound' state. When carbon decides to bond, its e- do something interesting. In order to fulfill the Octet Rule, one e- from the 2s orbital removes itself to the unocupied 2p orbital. The notation can then be written as such:

$C = 1s^2 2s^1 2p^3 =$  $= \cdot\dot{C}\cdot$

Now, 1 of carbons valence e- is in the s orbital and 3 are in p orbitals. When they bond with hydrogen, the bonds rearrange themselves to be the same size to keep stable. The bonds reshape themselves so they are the same length, and since 1 s and 3 p orbitals were involved, the resulting bonds are all called sp3 hybrid bonds.