Molecular Geometry

Molecular Geometry

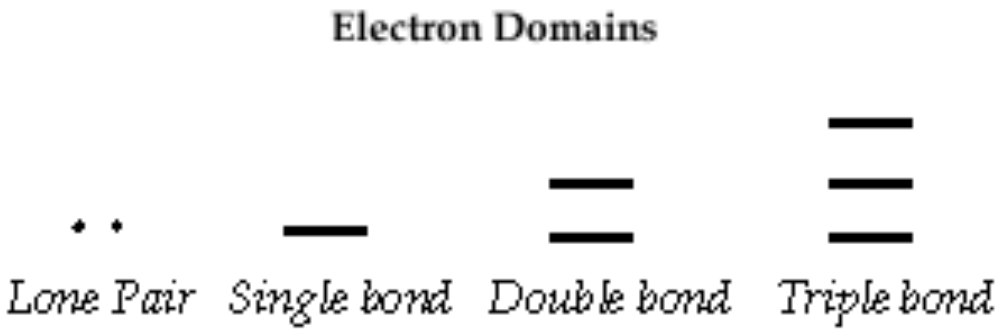
Background Information

- To this point, we have drawn 2 dimensional Lewis Dot representations of molecules
- While these representations are useful for understanding the order atoms bond and the types of bonds they form, they do not give us a 3 dimensional understanding of molecular shapes
- To push our study of molecules into the third dimension, we are going to look at how atoms orient themselves 3 dimensionally around central atoms
- But first, some terms...

Molecular Geometry

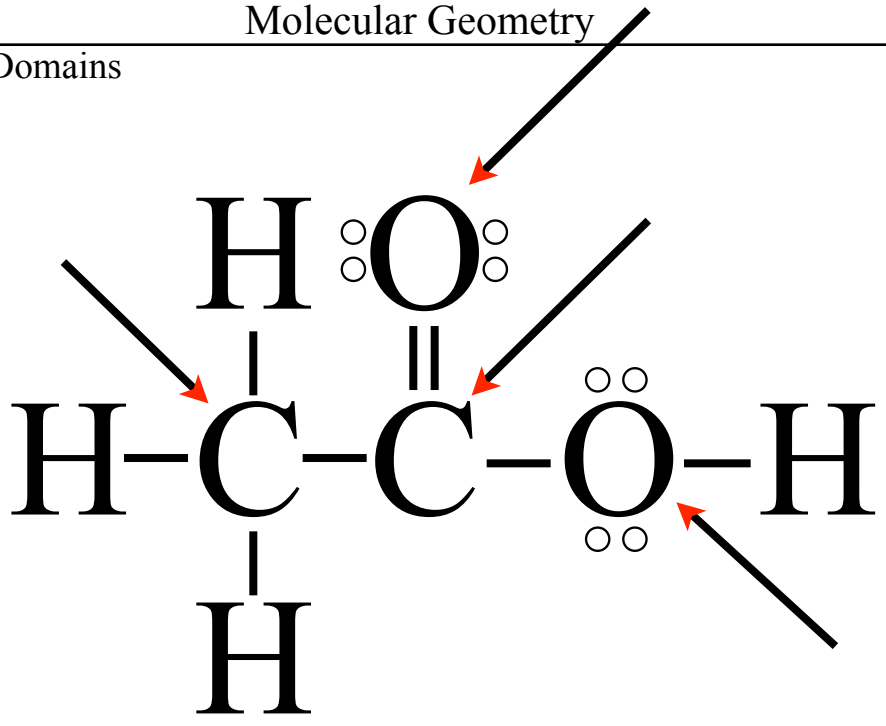
Important Terms

- Electron Domains
  - The spaces electrons occupy around the nucleus of an atom
  - Can be bonding domains or non-bonding domains
    - Bonding domains are shared pairs
      - Any bond type counts as one bonding domain
    - Non-bonding domains are lone pairs



Molecular Geometry

Electron Domains



Molecular Geometry

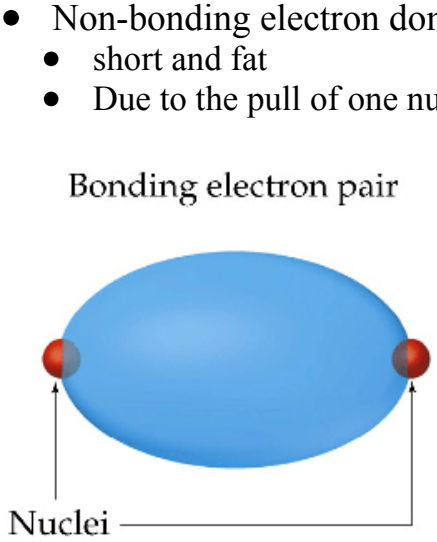
Important Terms

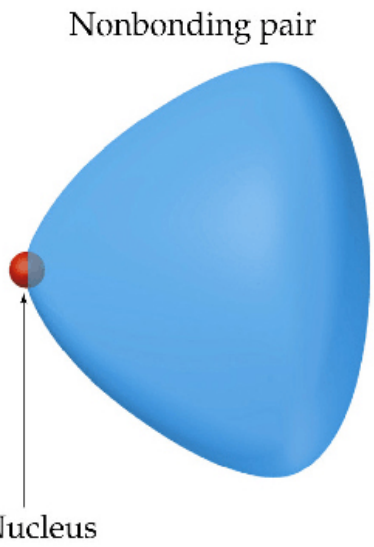
- VSEPR Theory
- **V**alence **S**hell **E**lectron **P**air **R**epulsion **T**heory
  - Electron domains repel each other
  - This repulsion causes them to get as far from each other as possible

Molecular Geometry

One Last Thing to Keep in Mind

- Not all electron domains are the same size
  - Bonded electron domains
    - long and skinny
    - Due to the pull of the two nuclei
  - Non-bonding electron domains
    - short and fat
    - Due to the pull of one nuclei





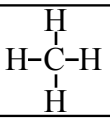
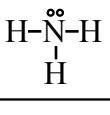
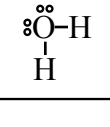
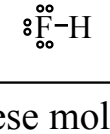
Molecular Geometry

Central Atoms with 4 Electron Domains

- When 4 objects surround a central point, what angles are created if these objects are as far apart as possible?
  - 109.5˚ angles
  - Tetrahedral

Molecular Geometry

4 Electron Domains - Tetrahedral Domain Geometries

Molecule	LDMS	Bonding	Non-Bonding	Angle	Molecular Geometry
CH_4		4	0	109.5˚	Tetrahedral
NH_3		3	1	<109.5˚	Trigonal Pyramid
H_2O		2	2	<109.5˚	Bent
HF		1	3	undefined	Straight

- All of these molecules have tetrahedral domain geometries
  - They all have 4 electron domains
- Their molecular geometries depend on the number of bonding and non-bonding domains

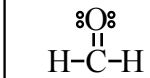
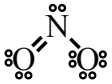
Molecular Geometry

Central Atoms with 3 Electron Domains

- When 3 objects surround a central point, what angles are created if these objects are as far apart as possible?
  - 120.0˚ angles
  - Trigonal Planar

Molecular Geometry

3 Electron Domains - Trigonal Planar Domain Geometries

Molecule	LDMS	Bonding	Non-Bonding	Angle	Molecular Geometry
CH_2O		3	0	120.0˚	Trigonal Planar
NO_2^{-1}		2	1	<120.0˚	Bent

- Both of these molecules have trigonal planar domain geometries
  - They both have 3 electron domains
- Their molecular geometries depend on the number of bonding and non-bonding domains
- Notice that we left off the example of 1 bonding domain
  - Anytime there is only one bonding domain the angle is undefined and the name is straight, regardless of the number of electron domains

Molecular Geometry

Central Atoms with 2 Electron Domains

- When 2 objects surround a central point, what angles are created if these objects are as far apart as possible?
  - 180.0˚ angles
  - Linear

Molecular Geometry

2 Electron Domains - Linear Domain Geometries

Molecule	LDMS	Bonding	Non-Bonding	Angle	Molecular Geometry
CO_2	Ö=C=Ö	2	0	180.0˚	Linear

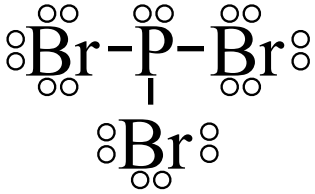
- Any molecule with 2 electron domains will have a linear domain geometry
- Notice, again, that we didn't include an example with 1 bonding domain

Molecular Geometry

Let's Practice

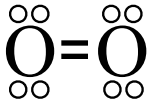
- Draw the LDMS for the following molecules. Then...
  - Identify the domain and molecular geometries
  - Determine the bond angle of the central atom

PBr_3



DG = Tetrahedral
MG = Trigonal Pyramid
Angle = <109.5˚

O_2



DG = Trigonal Planar
MG = Straight
Angle = undefined

HCN

DG = Linear
MG = Linear
Angle = 180.0˚