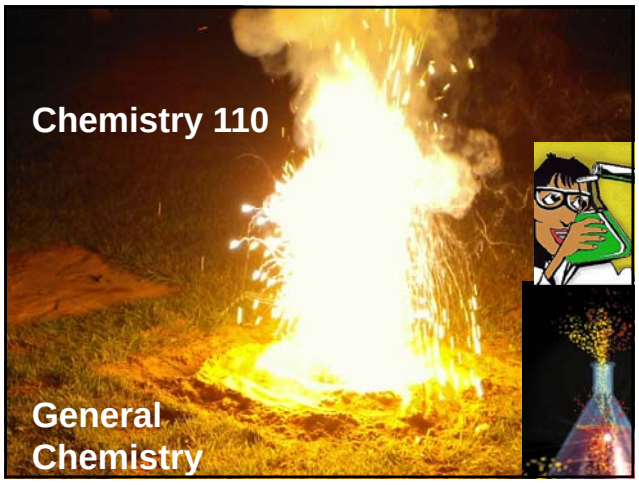


CHEMICAL BONDING

Lewis Theory: 10.1 – 10.6

V.S.E.P.R.: 10.7 – 10.8

Valence Bond Theory: 11.1-11.2

Hybridization: 11.3 -11.4

M.O. Theory: 11.5-11.6

Metallic Bonding: 11.7

THE SHAPE OF MOLECULES

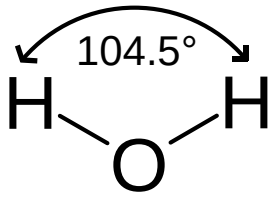
Factors that Affect Geometry

Bond length: The distance between atoms

A ⟷ B

Factors that Affect Geometry

Bond angles: The angles between the bonds joining different atoms



VSEPR Theory

- Molecules adopt the geometry which maximizes the distance between electron pairs around a central atom, and thus minimizes electrostatic repulsions.

VSEPR Theory

Molecular shape depends on:

- The number of electron pairs
- The type of electron pairs

VSEPR

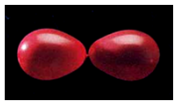
Molecules containing only bonding pairs around the central atom

VSEPR

Molecules containing only bonding pairs around the central atom

↓

The shape depends only on the number of electron pairs



2 e^- pairs

Linear

3 e^- pairs

Trigonal

4 e^- pairs

Tetrahedral

5 e^- pairs

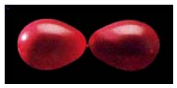
Trigonal bipyramidal

6 e^- pairs

Octahedral

APPLICATIONS

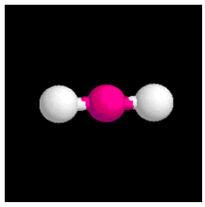
2 e^- pairs Linear

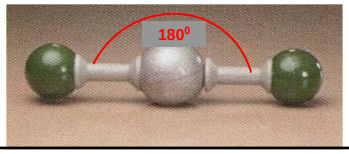


Formula: AB_2

Bond Angle: 180°

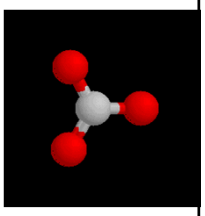
Example: BeI_2





3 e$^-$ pairs

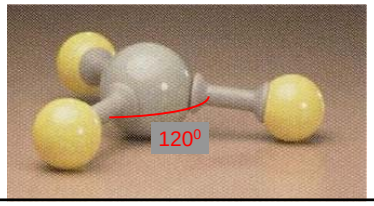
Trigonal

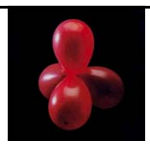


Formula: AB_3

Bond Angle: 120°

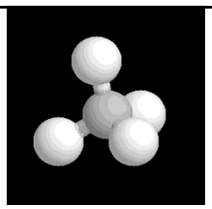
Example: BF_3





4 e$^-$ pairs

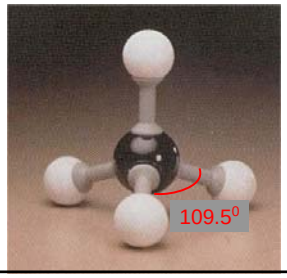
Tetrahedral



Formula: AB_4

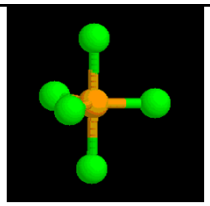
Bond Angle: 109.5°

Example: CH_4



5 e$^-$ pairs

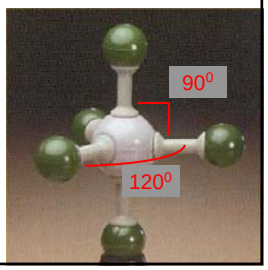
Trigonal bipyramidal



Formula: AB_5

Bond Angle: 90°, 120°

Example: PF_5



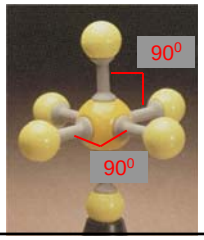
6 e$^-$ pairs

Octahedral

Formula: AB_6

Bond Angle: 90°

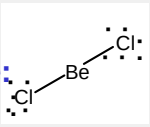
Example: SF_6



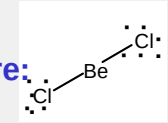
VSEPR Examples

Predict the geometry of the following molecules

$BeCl_2$

Lewis Structure: 

$BeCl_2$

Lewis Structure: 

Two electron pairs around Be

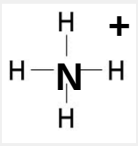
Linear molecule

$BeCl_2$

Linear molecule

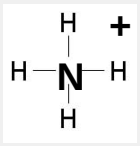
NH_4^+

Lewis Structure:



NH_4^+

Lewis Structure:



Four electron pairs around N

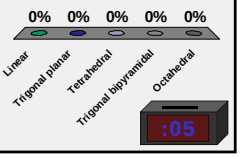
Tetrahedral molecule

NH_4^+

Tetrahedral molecule

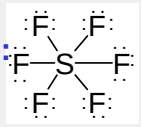
What is the molecular geometry of SF_6?

1. Linear
2. Trigonal planar
3. Tetrahedral
4. Trigonal bipyramidal
5. ✔ Octahedral



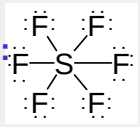
SF_6 48 e^-

Lewis Structure:



SF_6 48 e^-

Lewis Structure:



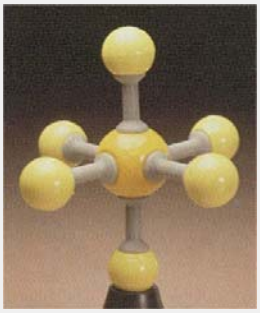
↓

Six electron pairs around S

↓

Octahedral molecule

SF_6



Octahedral molecule

VSEPR

molecules containing both, bonding and lone pairs, around the central atom

↓

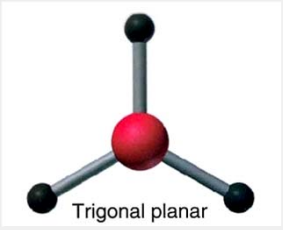
The shape depends on the respective number of pairs and their position

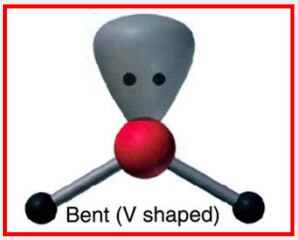
Lone pairs (l.p.) are not as localized as bonding pairs (b.p.), and thus cause stronger repulsions

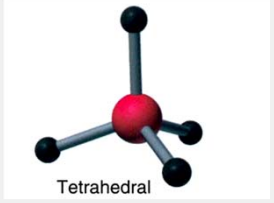
Lone pairs (l.p.) are not as localized as bonding pairs (b.p.), and thus cause stronger repulsions

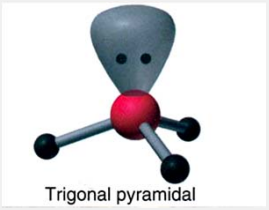
order of repulsion interactions:

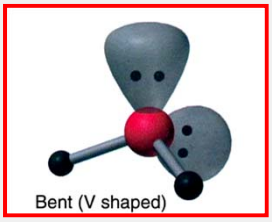
l.p. - l.p. > **l.p. – b.p.** > **b.p. – b.p.**

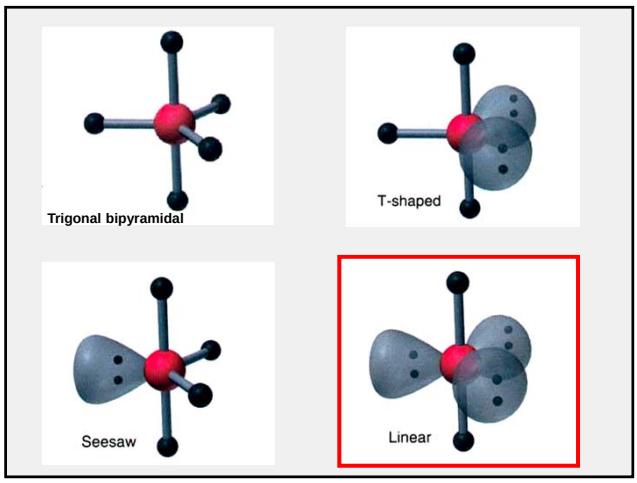


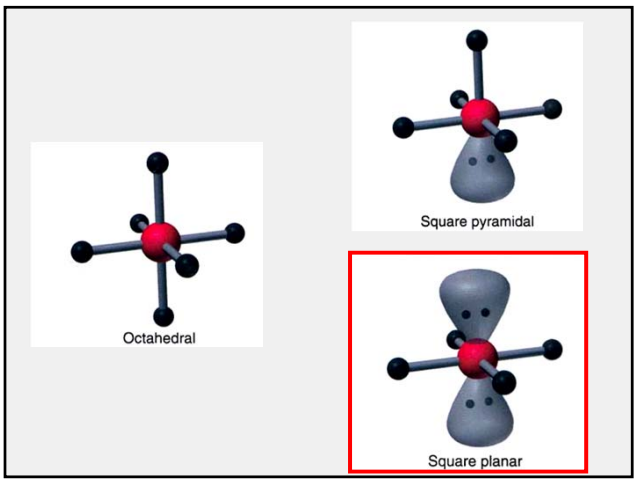










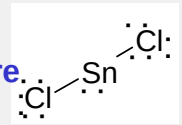


VSEPR Lone Pair Examples

Predict the geometry of the following molecules

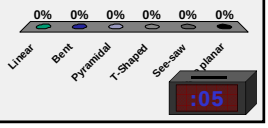
$SnCl_2$ **18 e^-**

Lewis Structure



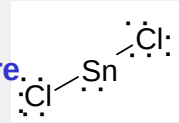
What is the molecular geometry of $SnCl_2$?

1. Linear
2. Bent
3. Pyramidal
4. T-Shaped
5. See-saw
6. Square planar



$SnCl_2$

Lewis Structure



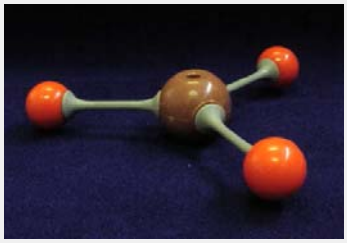
Bonding Pairs: 2

Lone Pairs: + 1

3

$SnCl_2$

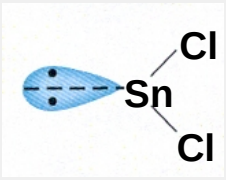
electron pairs geometry: trigonal planar



$SnCl_2$

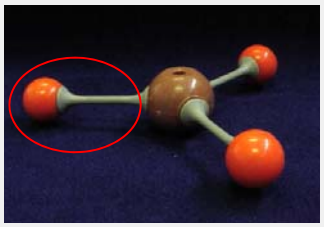
electron pairs geometry: trigonal planar

molecular geometry: bent



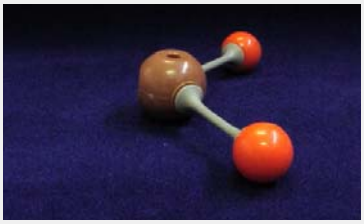
$SnCl_2$

electron pairs geometry: trigonal planar
molecular geometry: bent



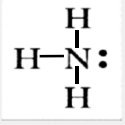
$SnCl_2$

electron pairs geometry: trigonal planar
molecular geometry: bent



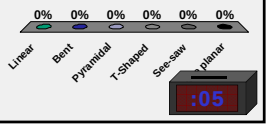
NH_3

Lewis Structure:



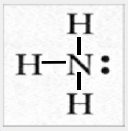
What is the molecular geometry of NH_3?

1. Linear
2. Bent
3. Pyramidal
4. T-Shaped
5. See-saw
6. Square planar



NH_3

Lewis Structure:



Bonding Pairs: 3

Lone Pairs: + 1

4

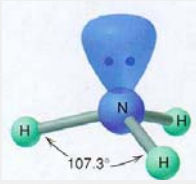
NH_3

electron pairs geometry: tetrahedral

NH_3

electron pairs geometry: tetrahedral

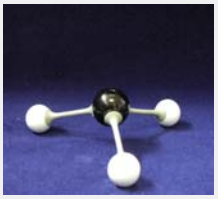
molecular geometry: pyramidal



NH_3

electron pairs geometry: tetrahedral

molecular geometry: pyramidal



H_2O

Lewis Structure: H–Ö–H

H_2O

Lewis Structure: H–Ö–H

Bonding Pairs: 2

Lone Pairs: + 2

4

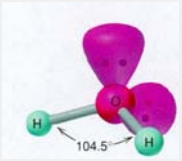
H_2O

electron pairs geometry: tetrahedral

H_2O

electron pairs geometry: tetrahedral

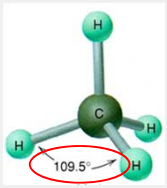
molecular geometry: bent

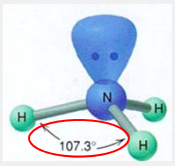


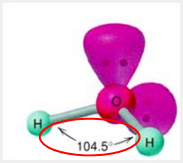
H_2O

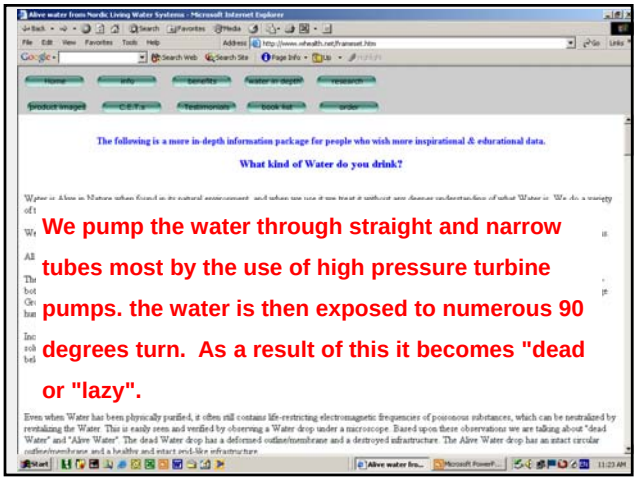
electron pairs geometry: tetrahedral

molecular geometry: bent









We pump the water through straight and narrow tubes most by the use of high pressure turbine pumps. the water is then exposed to numerous 90 degrees turn. As a result of this it becomes "dead or "lazy".

Chemically water is considered to be one atom of oxygen bonded to two atoms of hydrogen. The bond angle between the two atoms is known to be variable depending upon the amount of energy in the molecule.

Research has shown that water whose bond angle is 101^0 is "dead." When water is distilled, the bond angles expands to 120^0 upon evaporation but collapses to 101^0 upon condensation and is therefore "dead"

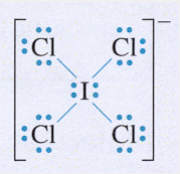
Shower of Life Water Revitalizer

PSEUDOSCIENCE

Claims , belief or practice posing as science but that are not supported by the scientific method.

ICl_4^-

Lewis Structure

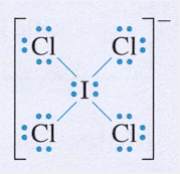


What is the molecular geometry of ICl_4^-?

1. Linear
2. Bent
3. Pyramidal
4. T-Shaped
5. See-saw
6. Square planar

ICl_4^-

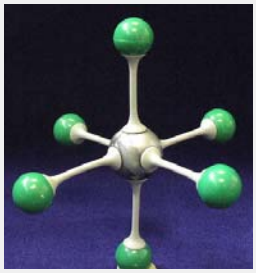
Lewis Structure



Bonding Pairs: 4
Lone Pairs: + 2
6

ICl_4^-

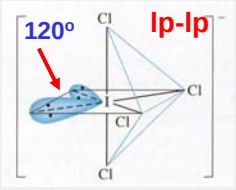
electron pairs geometry: octahedral



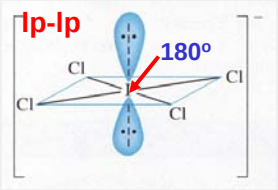
ICl_4^-

electron pairs geometry: octahedral

molecular geometry:



see-saw

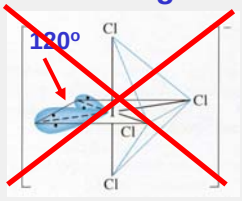


square-planar

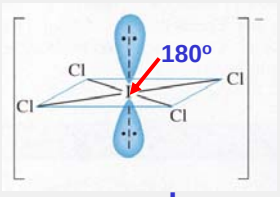
ICl_4^-

electron pairs geometry: octahedral

molecular geometry:



see-saw

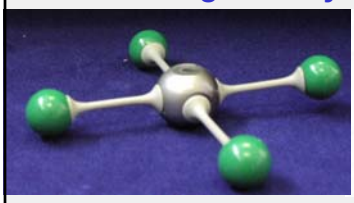


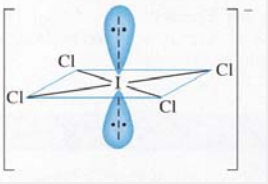
square-planar

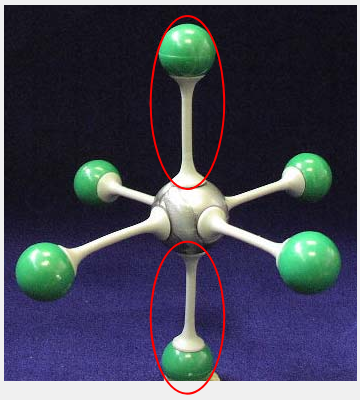
ICl_4^-

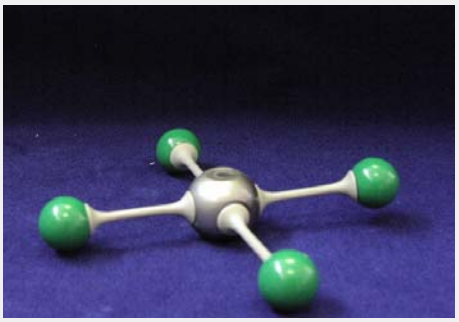
electron pairs geometry: octahedral

molecular geometry: square-planar



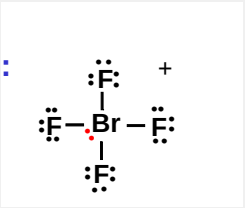






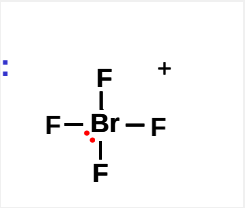
BrF_4^+ 34 e^-

Lewis Structure:



BrF_4^+ 34 e^-

Lewis Structure:



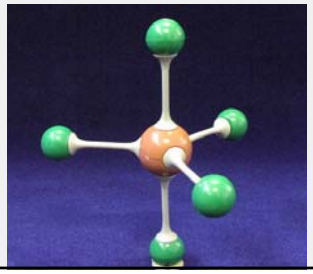
Bonding Pairs: 4

Lone Pairs: + 1

5

BrF_4^+ 34 e^-

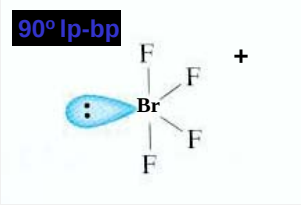
electron pairs geometry: trigonal bipyramidal



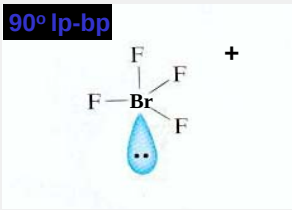
BrF_4^+ 34 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry:



see-saw

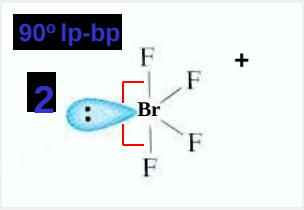


trigonal pyramidal

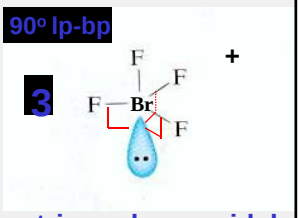
BrF_4^+ 34 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry:



see-saw

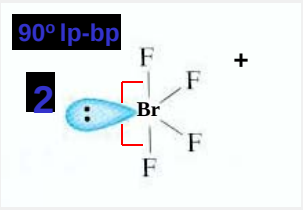


trigonal pyramidal

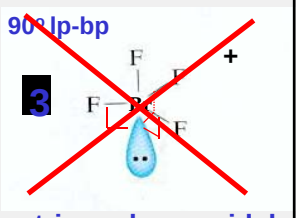
BrF_4^+ 34 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry:



see-saw

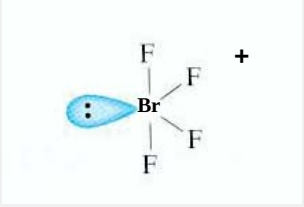


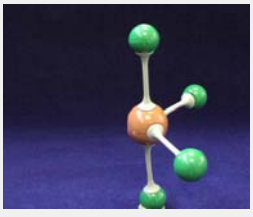
trigonal pyramidal

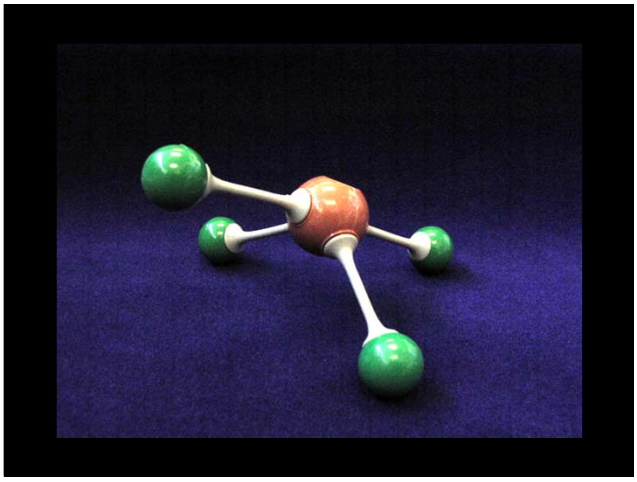
BrF_4^+ 34 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry: see-saw

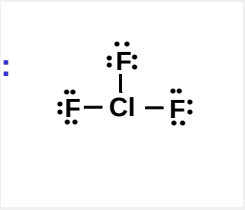






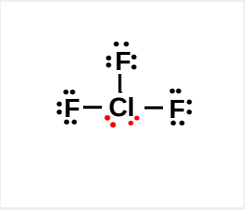
ClF_3 24/28 e^-

Lewis Structure:



ClF_3 28 e^-

Lewis Structure:



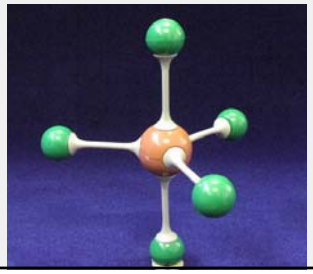
Bonding Pairs: 3

Lone Pairs: 2

5

ClF_3 28 e^-

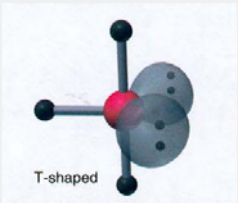
electron pairs geometry: trigonal bipyramidal



ClF_3 28 e^-

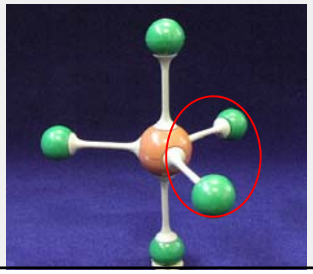
electron pairs geometry: trigonal bipyramidal

molecular geometry: T-shaped



ClF_3 28 e^-

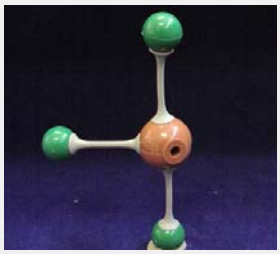
electron pairs geometry: trigonal bipyramidal



ClF_3 28 e^-

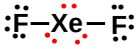
electron pairs geometry: trigonal bipyramidal

molecular geometry: T-shaped



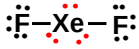
XeF_2 22 e^-

Lewis Structure:



XeF_2 22 e^-

Lewis Structure:



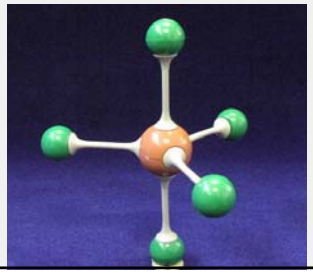
Bonding Pairs: 2

Lone Pairs: + 3

5

XeF_2 22 e^-

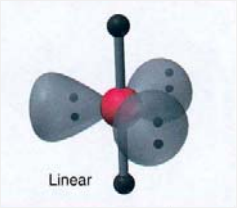
electron pairs geometry: trigonal bipyramidal



XeF_2 22 e^-

electron pairs geometry: trigonal bipyramidal

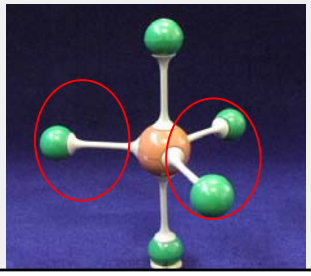
molecular geometry: linear



XeF_2 22 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry: linear



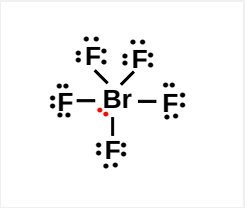
XeF_2 22 e^-

electron pairs geometry: trigonal bipyramidal

molecular geometry: linear

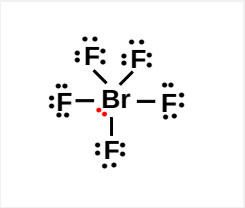
BrF_5 42 e^-

Lewis Structure:



BrF_5 42 e^-

Lewis Structure:



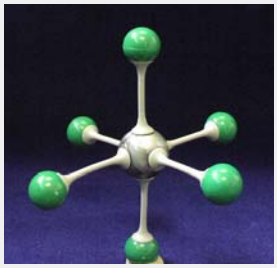
Bonding Pairs: 5

Lone Pairs: + 1

6

BrF_5 42 e^-

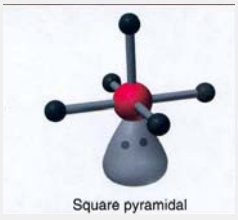
electron pairs geometry: octahedral



BrF_5 42 e^-

electron pairs geometry: trigonal bipyramidal

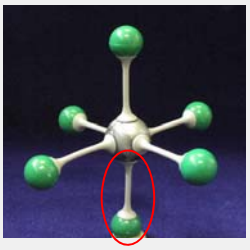
molecular geometry: square pyramidal



BrF_5 42 e^-

electron pairs geometry: octahedral

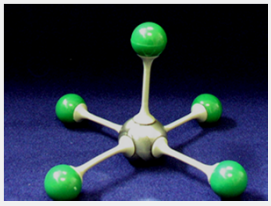
molecular geometry: square pyramidal



BrF_5 42 e^-

electron pairs geometry: octahedral

molecular geometry: square pyramidal



Molecules and Ions containing Multiple Bonds

For geometrical considerations, a multiple bond can be treated as if it were a single bond

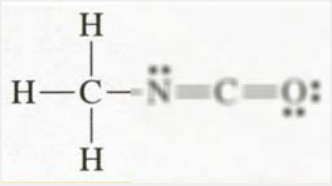
Electron groups

Electron groups = # of bonds ***
+ # of lone pairs

***** For geometric consideration multiple bonds count as single bonds**

CH_3NCO

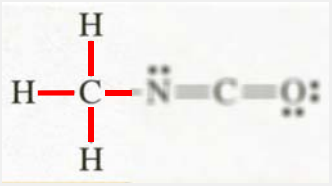
Recall



CH_3NCO

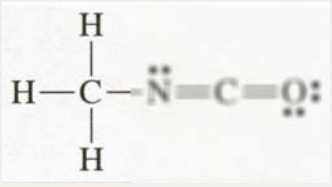
Recall

e^- groups: 4



CH_3NCO

Recall



***e*- groups: 4**

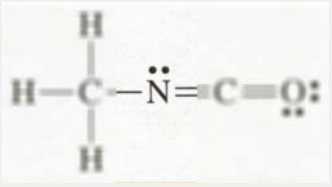
***e*- geometry: tetrahedral**

molecular geometry: tetrahedral

Angle: ~109.5°

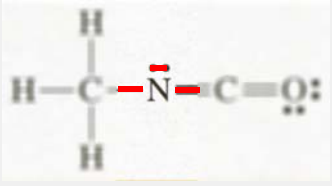
CH_3NCO

Recall



CH_3NCO

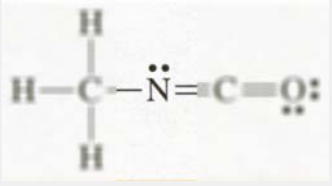
Recall



***e*- groups: 3**

CH_3NCO

Recall

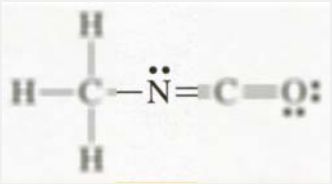


***e*- groups: 3**

***e*- geometry: trigonal planar**

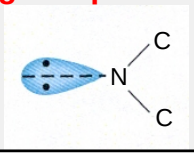
CH_3NCO

Recall



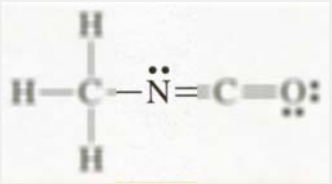
***e*- groups: 3**

***e*- geometry: trigonal planar**



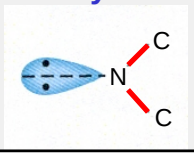
CH_3NCO

Recall



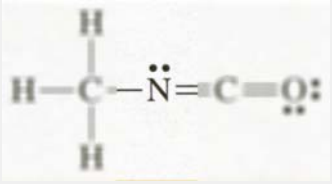
***e*- groups: 3**

Molecular geometry: bent



CH_3NCO

Recall



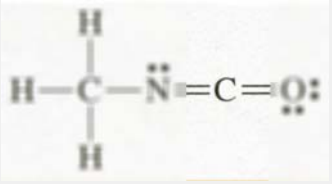
***e*- groups: 3**

Molecular geometry: bent

Angle: ~120°

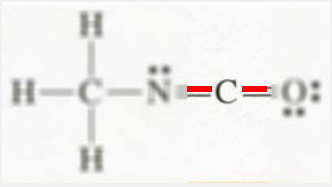
CH_3NCO

Recall



CH_3NCO

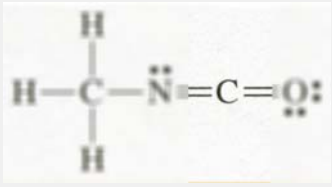
Recall



***e*- groups: 2**

CH_3NCO

Recall

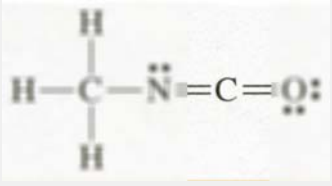


***e*- groups: 2**

***e*- geometry: linear**

CH_3NCO

Recall



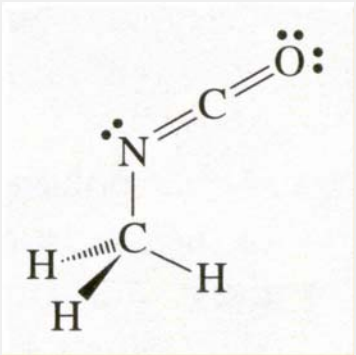
***e*- groups: 2**

***e*- geometry: linear**

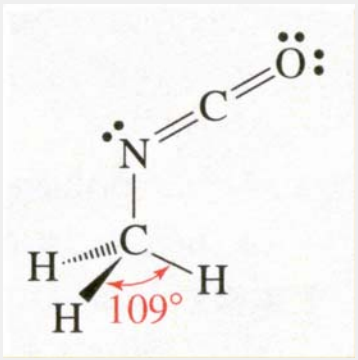
molecular geometry: linear

Angle: ~180°

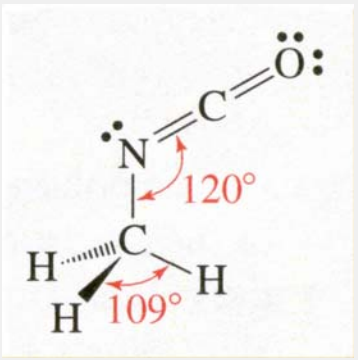
CH_3NCO



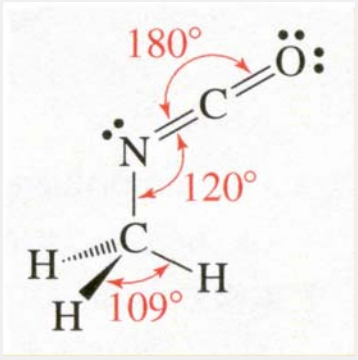
CH_3NCO

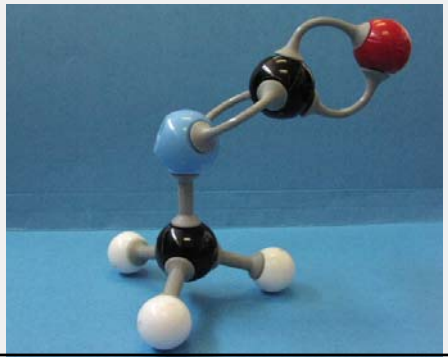


CH_3NCO



CH_3NCO





THE SHAPE OF MOLECULES

THE SHAPE OF MOLECULES

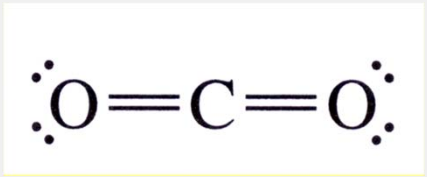
MOLECULAR POLARITY

POLAR MOLECULES: **NET DIPOLE MOMENT**

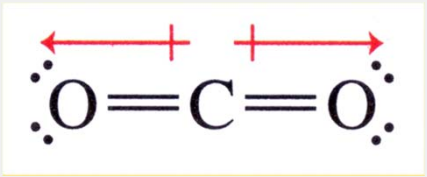
NON-POLAR MOLECULES: **NO NET DIPOLE MOMENT**

Predict if the following molecules are polar or non-polar

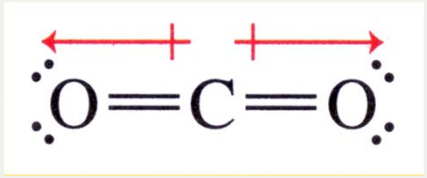
CO_2



CO_2

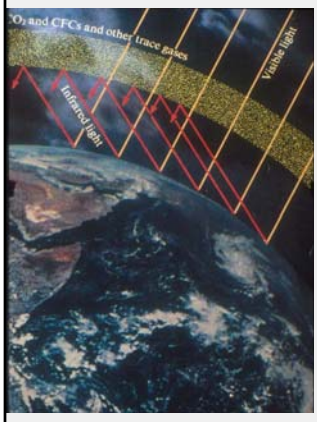


CO_2

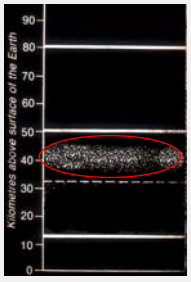


Non-polar
$\mu = 0$

CO_2



Stratosphere √



Riggs Glacier
Alaska

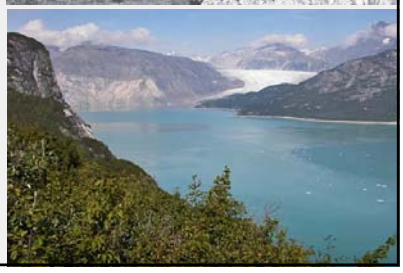
1941

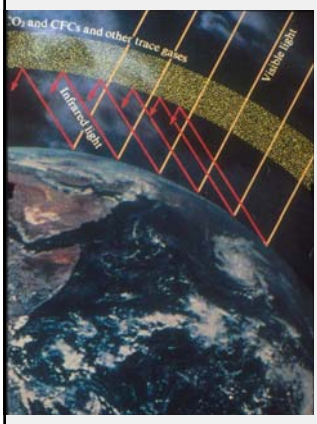
Riggs Glacier
Alaska

1941

Riggs Glacier
Alaska

Today



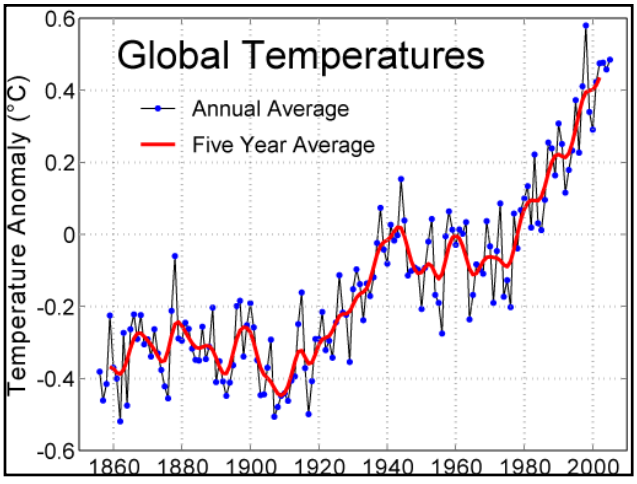


CO_2

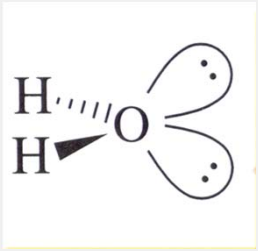
Average Global Temperature

With 15^0C

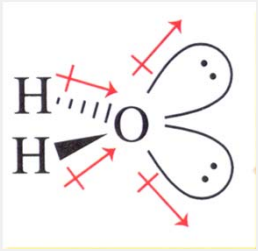
Without -15^0C



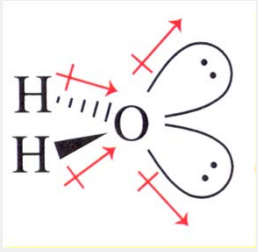
H_2O



H_2O

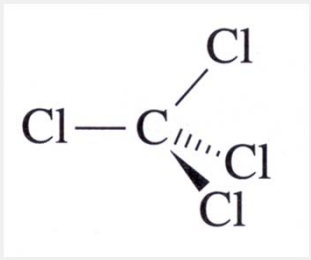


H_2O

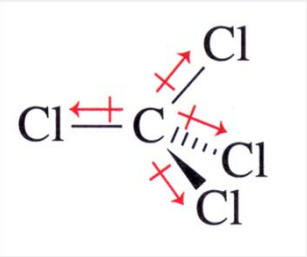


Polar
μ = 1.9 D

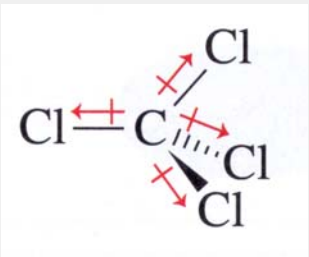
CCl_4



CCl_4

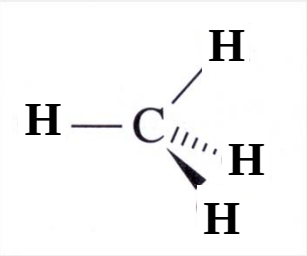


CCl_4

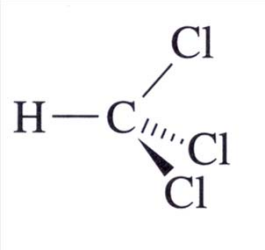


Non-polar
$\mu = 0$

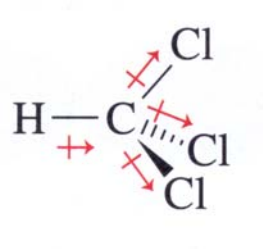
CH_4



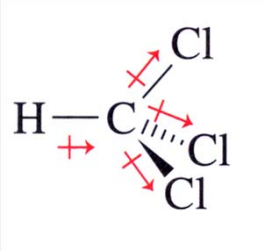
$CHCl_3$



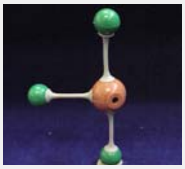
$CHCl_3$



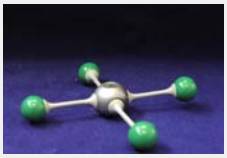
$CHCl_3$



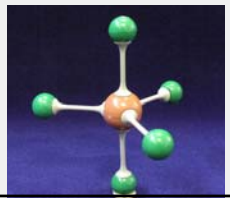
Polar
μ = 1.04 D



ClF_3
Polar



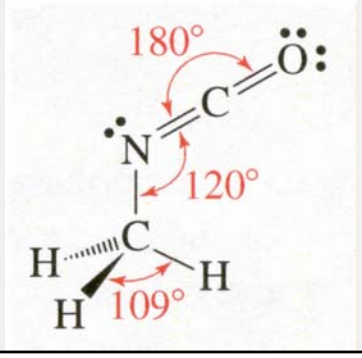
XeF_4
Non-polar



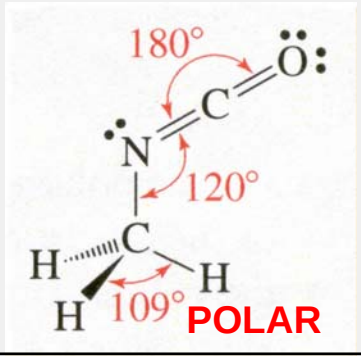
PF_5

Non-polar

CH_3NCO

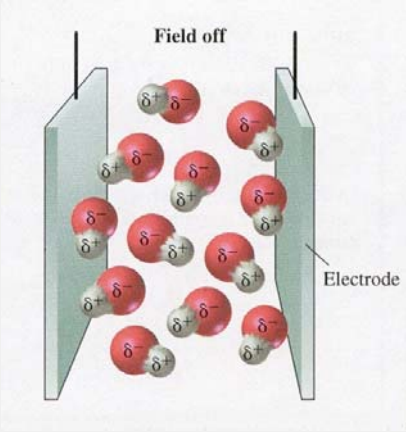


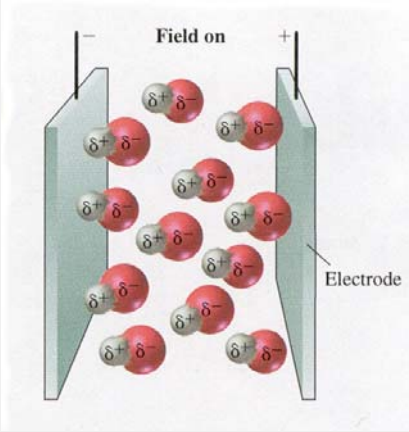
CH_3NCO



POLAR

Experimental Evidence for Dipole Moment





BOND ENERGIES
&
BOND LENGTHS

Bond Energy
(kJ/mol)

C—C 347

Bond Energy
(kJ/mol)

C—C 347

C=C 611

Bond Energy
(kJ/mol)

C—C 347

C=C 611

C≡C 837

	Bond Energy (kJ/mol)
C—C	347
C=C	611
C≡C	837

The 2nd bond in double bonds, and the 2nd and 3rd bonds in triple bonds, are weaker than single bonds

	Bond Energy (kJ/mol)	Bond Length (pm)
C—C	347	154
C=C	611	134
C≡C	837	120

	Bond Energy (kJ/mol)	Bond Length (pm)
C—C	347	154
C=C	611	134
C≡C	837	120

Bond lengths decrease with increasing bond strengths

	Bond Order
C—C	1
C=C	2
C≡C	3

V.S.E.P.R. THEORY
KEY OBJECTIVES

1. Predict the electron-pair geometry and molecular shape of a molecule or ion with VSEPR theory. Know that single bonds act similarly to multiple bonds to determine molecular shape.

2. Use electronegativities to determine if a bond is polar, and use bond polarities and molecular shape to predict whether a molecule has a dipole moment.

V.S.E.P.R. THEORY
LEARNING MATERIAL

Review: Ch.10.7 -10.9

Practice Examples: 10.10-10.13

Exercises: 59-84 (as many as you can until you feel comfortable with the material)

Self-Assessment Exercises:131-146

Mastering Chemistry: Petrucci website