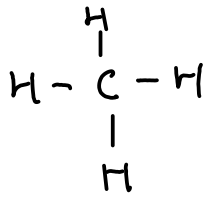
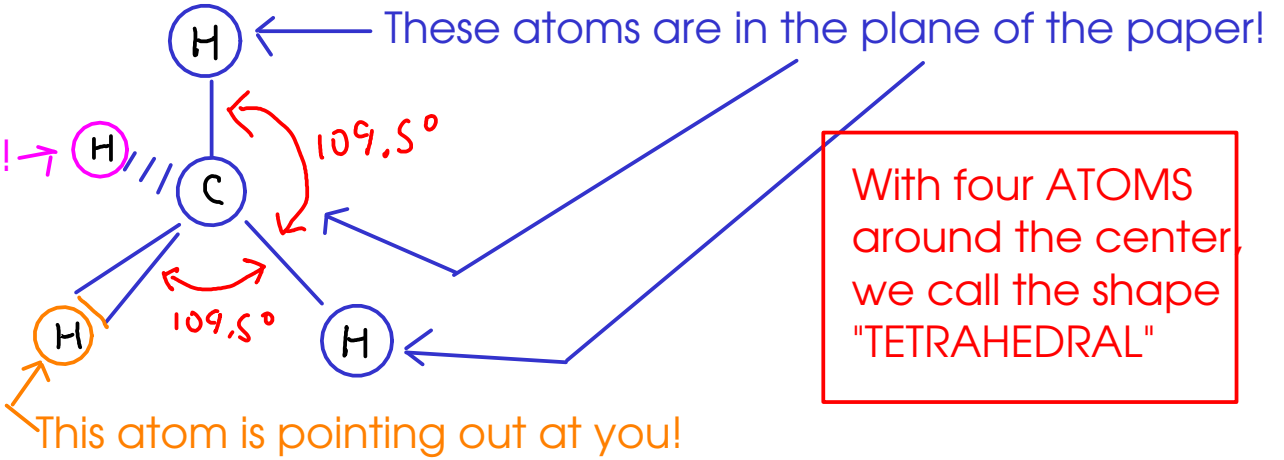
More on "4 things around a central atom":

- A compound that obeys the octet rule can have a maximum of four groups around its central atom. But we describe the molecular shape based on how ATOMS are arrnaged around the center. What if some of those groups aren't atoms, but pairs of UNSHARED electrons?

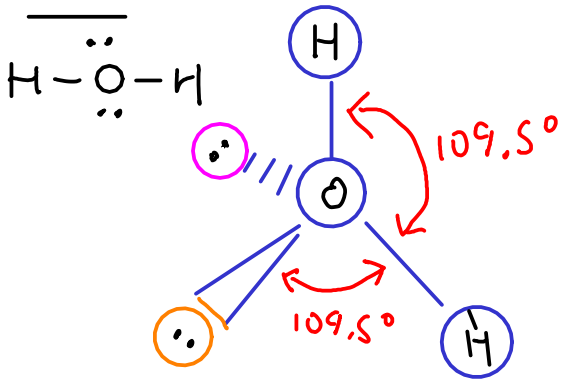
CH_4:





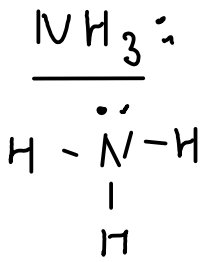
With four ATOMS around the center, we call the shape "TETRAHEDRAL"

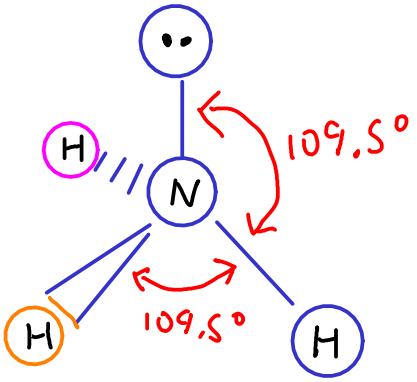
H_2O:

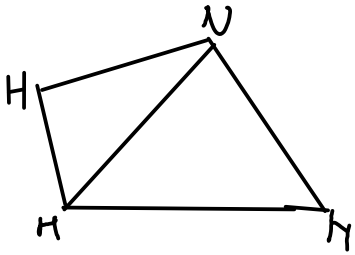


With two ATOMS and two LONE PAIRS, we call the shape "BENT"

NH_3:



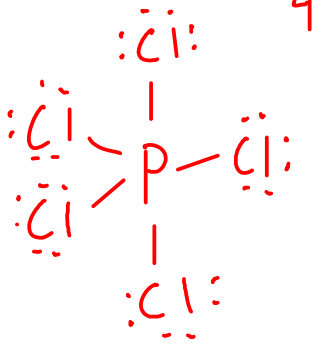




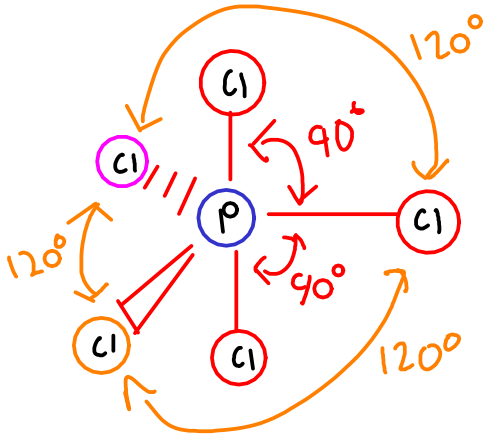
With three ATOMS and one LONE PAIR, we call the shape "PYRAMIDAL"

SHAPES OF EXPANDED VALENCE MOLECULES

PCl_5 : P : 5
Cl : 7 × 5 = 40

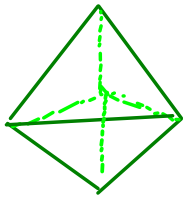


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



The top and bottom atoms are 90 degrees apart from the atoms around the center.

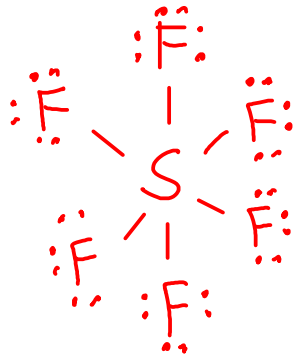
The atoms around the center are 120 degrees apart from each other.



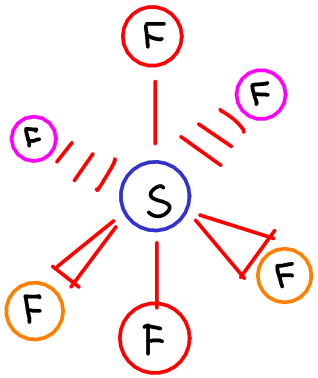
There are acually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!

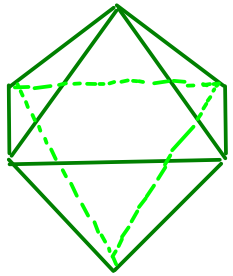
SF_6 : S : 6
F : 7x6
48



There are six atoms bonded to the central sulfur atom, and they will attempt to get as far apart as possible from one another!



All bond angles in this arrangement are 90 degrees!



This shape is called OCTAHEDRAL, since it has eight sides.

Like the tetrahedral and trigonal bipyramidal arrangements, there are several derivatives of the octahedron - depending on how many of the six things around the center are atoms!

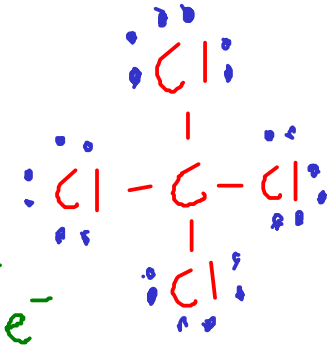
Examples:

CCl_4

C: 1 x 4

Cl: 4 x 7

32 e^-



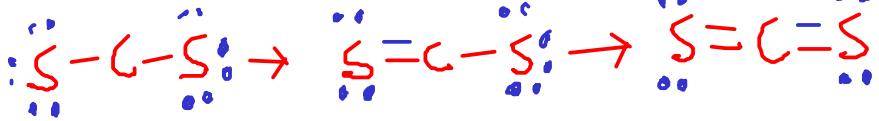
Geometry? Surrounded by FOUR groups (so, tetrahedral)/
Shape? All four groups are atoms, so shape is tetrahedral as well!

CS_2

C: 1 x 4

S: 2 x 6

16 e^-



skeletal

final structure

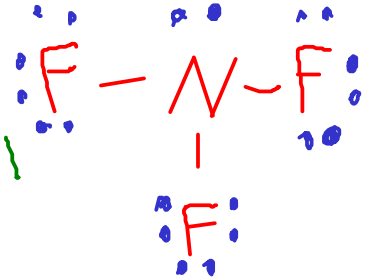
Geometry? Two groups around cetral atom, so LINEAR.
Shape? Also linear (both groups are other atoms)

NF_3

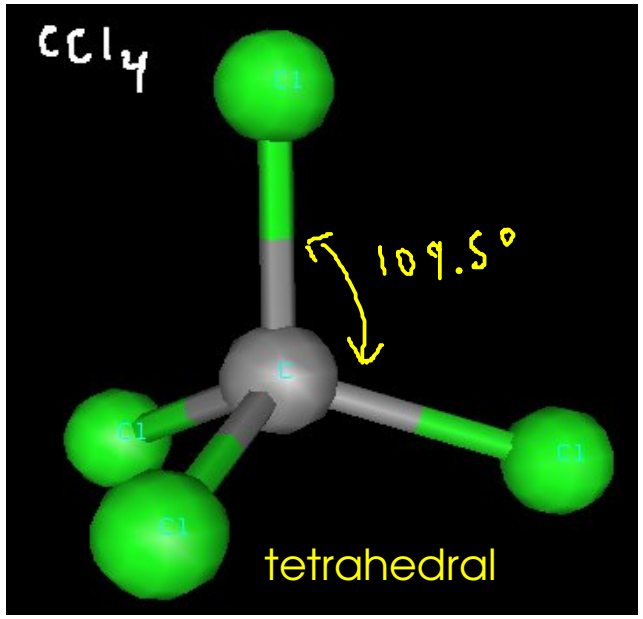
N: 1 x 5

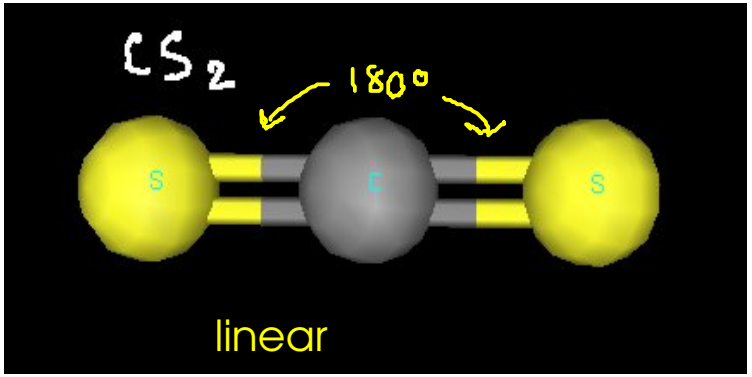
F: 3 x 7 = 21

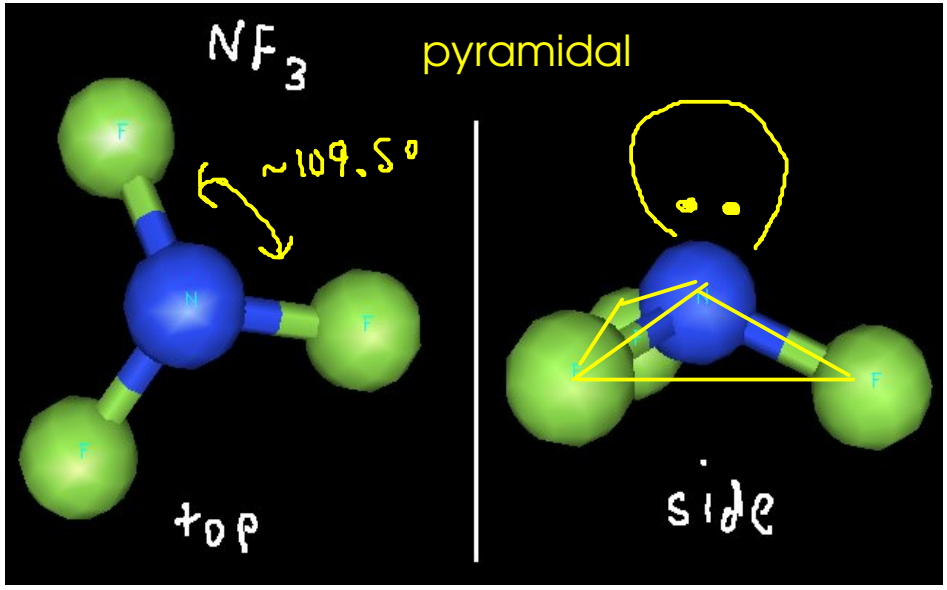
26 e^-



Geometry? Four groups around central atom (three atoms, one lone pair), so tetrahedral geometry.
Shape? 3 atoms and one lone pair, so PYRAMIDAL.


CCl_4
Cl
109.5°
C
Cl
Cl
Cl
tetrahedral


CS_2
180°
S
C
S
linear

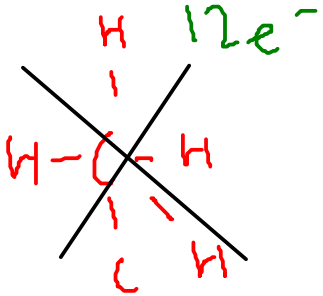

NF_3
pyramidal
F
~109.5°
N
F
F
top
side

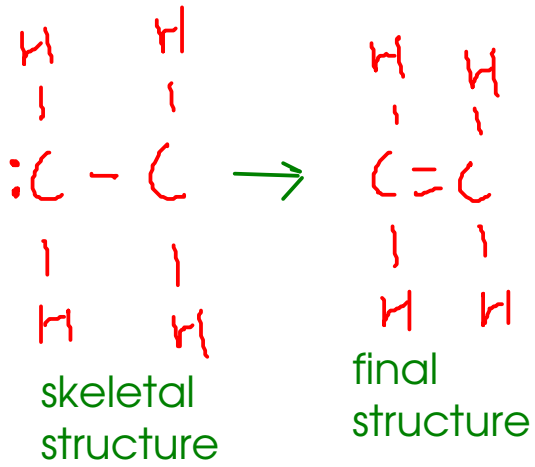
C_2H_4

C: 2 × 4

H: 4 × 1

12 e⁻

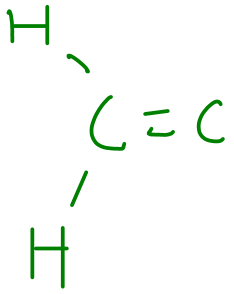




skeletal structure

final structure

How do we determine shape? Look around each of the two central atoms.



This carbon has three groups attached, and all three are other atoms. It's TRIGONAL PLANAR (geometry and shape)

Both carbon atoms in this molecule are trigonal planar.

Structure tip: Multiple carbon atoms mean multiple "central atoms"

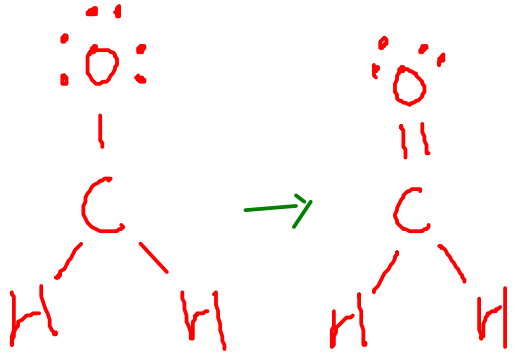
H_2CO

H: 2 × 1

C: 1 × 4

O: 1 × 6

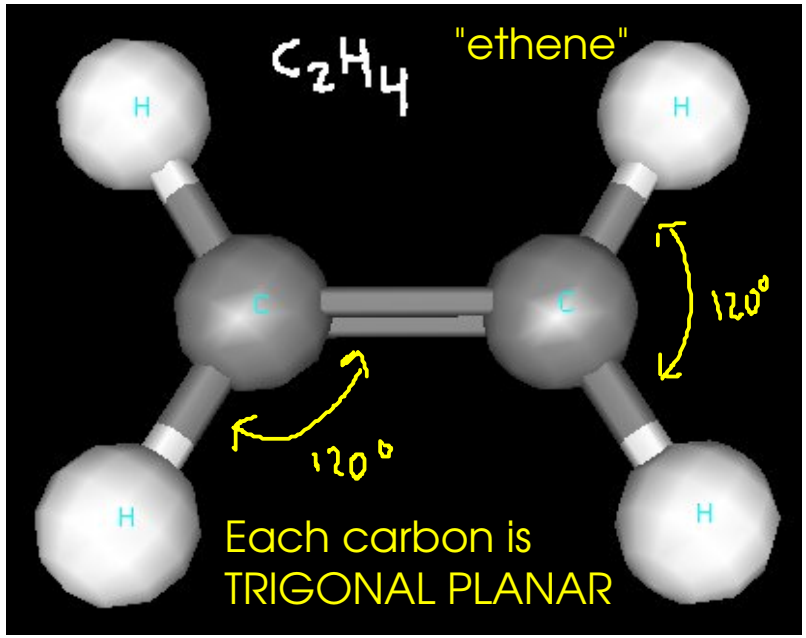
12 e⁻

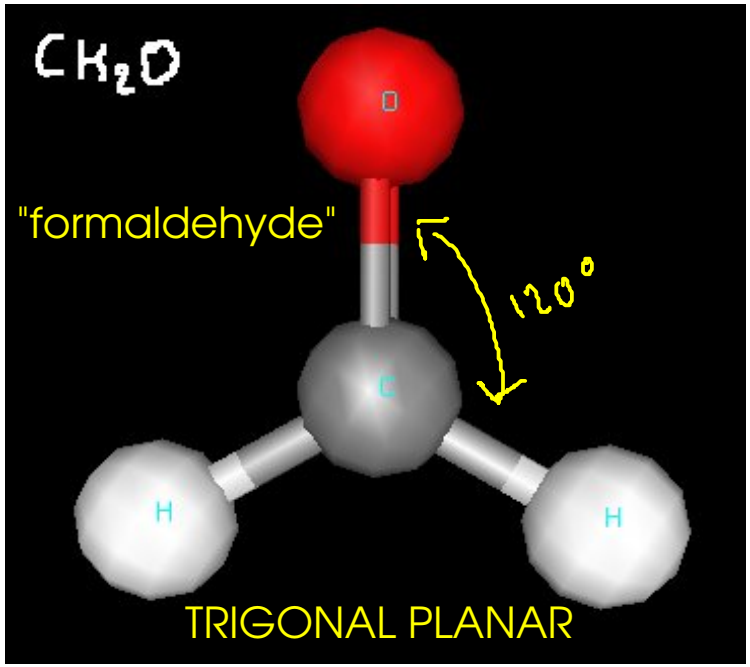


skeletal structure

final structure

In formaldehyde, the central carbon is surrounded by three groups, all of which are other atoms. This molecule is trigonal planar (geometry and shape)!


C_2H_4
"ethene"
H
H
C
C
120°
120°
H
H
Each carbon is
TRIGONAL PLANAR

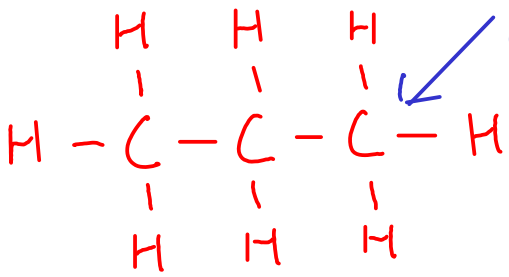

CH_2O
O
"formaldehyde"
120°
C
H
H
TRIGONAL PLANAR

VSEPR and large molecules

- Large molecules have more than one "center" atom

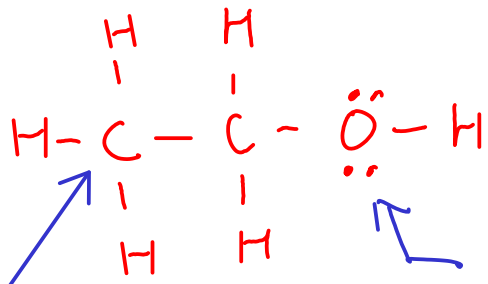
- Describe the molecule by describing the shape around each "center".

C_3H_8:



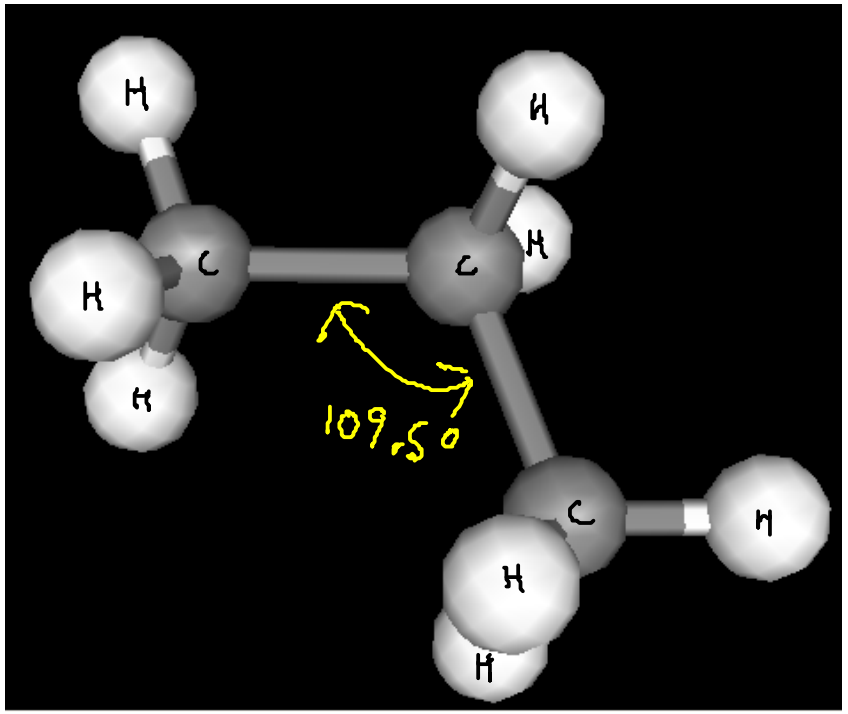
Each of the three carbon centers is TETRAHEDRAL, since each are surrounded by four groups.

CH_3CH_2OH:



The shape around this oxygen atom is BENT.

These carbon atoms have TETRAHEDRAL geometry.

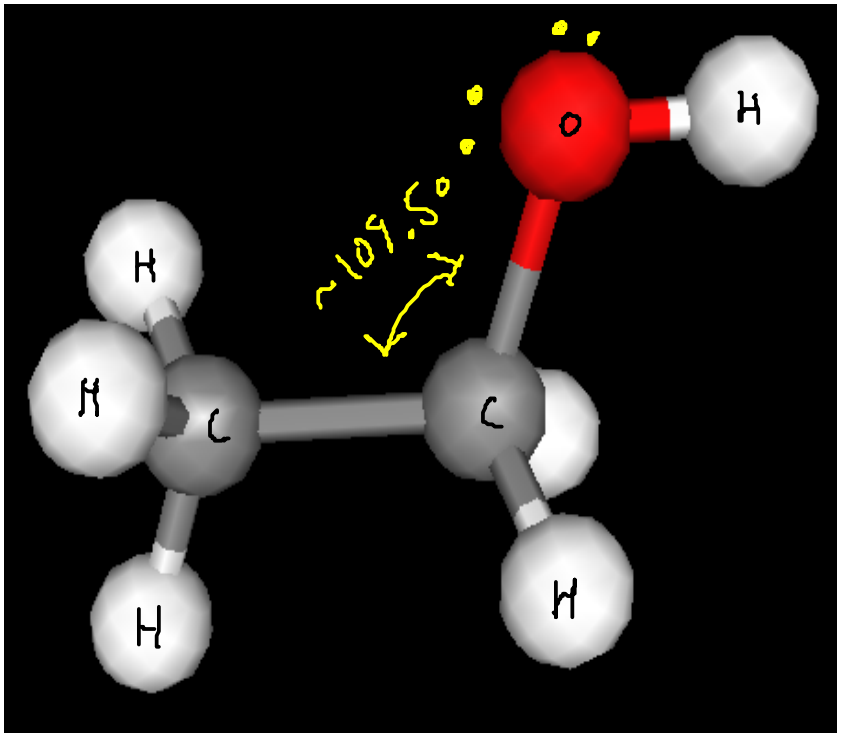


C_3H_8 ←

All bond angles in the propane molecule are 109.5 degrees

CH_3CH_2OH →

Like propane, the bond angles in ethanol are also close to 109.5 degrees.



POLARITY and shape:

- A polar molecule has an uneven distribution of electron density, making it have ends (poles) that are slightly charged.

POLARITY influences several easily observable properties.

- Melting point. (Polar substances have higher melting points than nonpolar substances of similar molecular weight.)

- Boiling point. (Polar substances have higher boiling points than nonpolar substances of similar molecular weight.)

- Solubility. (Polar substances tend to dissolve in other polar substances, while being insoluble in nonpolar substances. Nonpolar substances dissove other nonpolar substances, and generally have poor solubility in polar solvents.)

- Polar molecules contain POLAR BONDS arranged in such a way that they do not cancel each other out.

... but how can we tell whether or not a bond will be POLAR? Use experimental data on ELECTRONEGATIVITY!

ELECTRONEGATIVITY:
-A measure of how closely to itself an atom will hold shared electrons

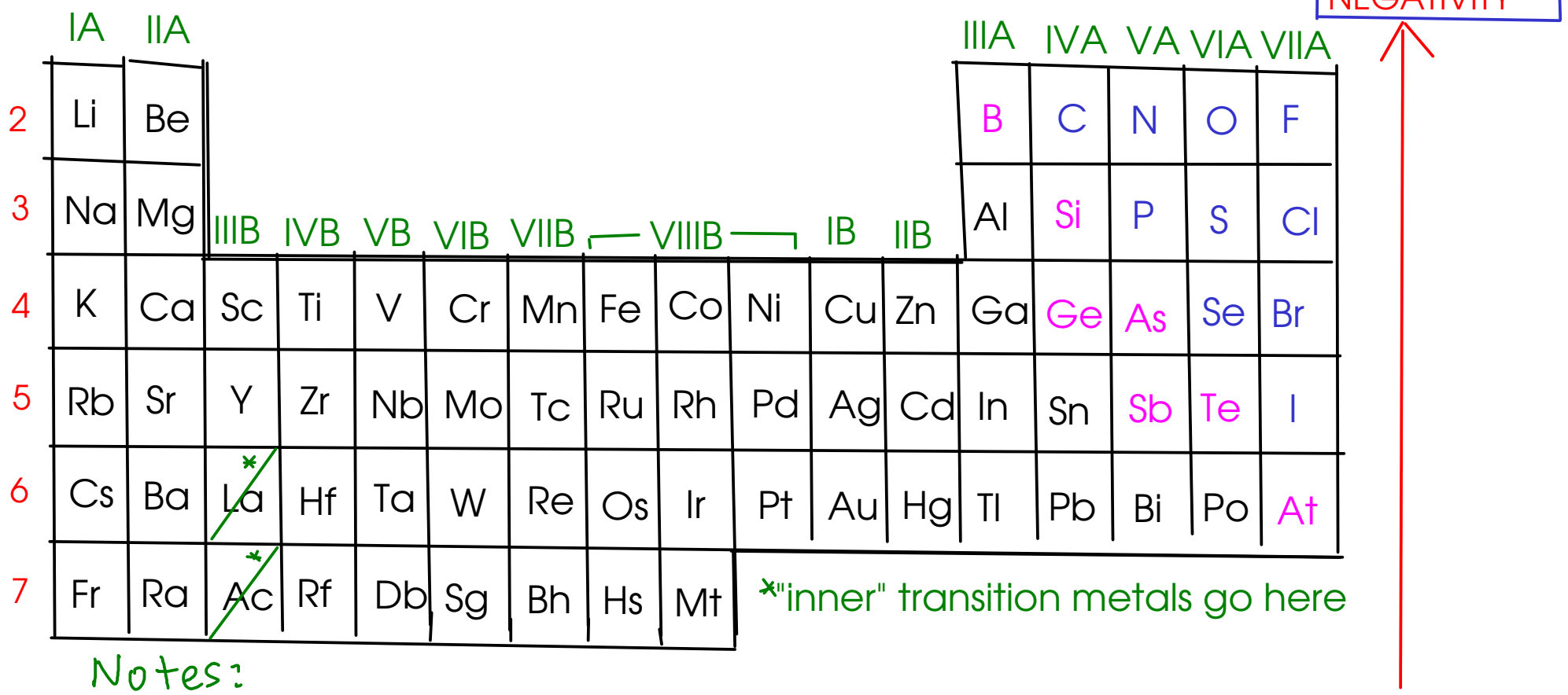
- A bond where there is a LARGE electronegativity difference between atoms will be either POLAR or (for very large differences) IONIC! (chart, p 352)

- A bond with little or no electronegativity difference between atoms will be NONPOLAR

ELECTRONEGATIVITY TRENDS

- You may look up elecronegativity data in tables, but it helps to know trends!

INCREASING ELECTRO-NEGATIVITY



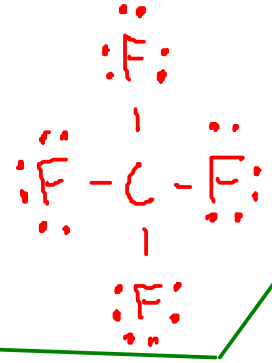
Notes:

1. - FLUORINE is the most elecronegative element, while FRANCIUM is the least!
2. - All the METALS have low electronegativity, and metal/nonmetal combinations form IONIC bonds
3. - HYDROGEN is similar in electronegativity to CARBON, so C-H bonds are considered NONPOLAR

Examples:

CF_4

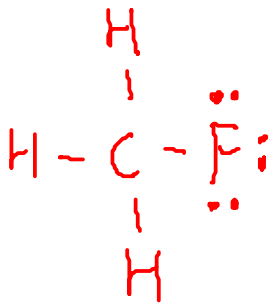
C: 1 x 4
F: 4 x 7
32 e⁻



Polar bonds? Yes (C-F bonds are polar)
Shape? Tetrahedral. Since each identical polar bond is symmetrically arranged around the center, there are no positive or negative sides to the molecule. It's NONPOLAR.

CH_3F

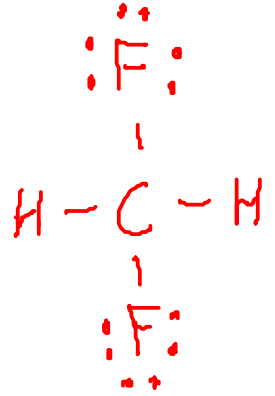
C: 1 x 4
H: 3 x 1
F: 1 x 7
14 e⁻



Polar bonds? Yes (C-F bonds are polar, though C-H are not)
Shape? Tetrahedral. This time, though, the bonds are not all identical - so there's a F side (which is negative) and a H side (which is positive). POLAR.

CH_2F_2

C: 1 x 4
H: 2 x 1
F: 2 x 7
20 e⁻

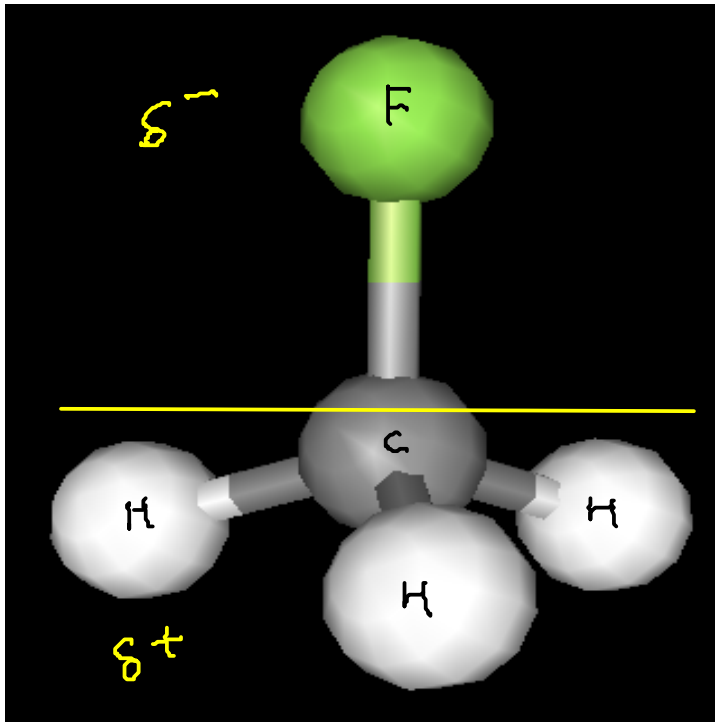


Polar bonds? Yes (C-F bonds are polar, though C-H are not)
Shape? Tetrahedral. This time, though, the bonds are not all identical - so there's a F side (which is negative) and a H side (which is positive). POLAR. Hint: You have to look at the 3D structure for this one, as the "flat" Lewis structure on the left of the page can be deceiving!

CO_2

C: 1 x 4
O: 2 x 6
16 e⁻

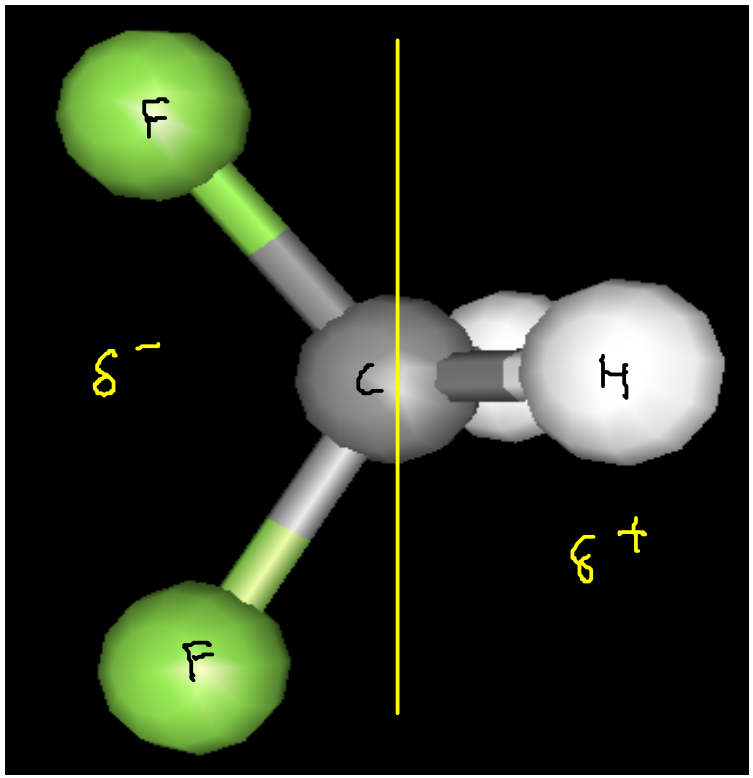
Polar bonds? Yes (C=O bonds are polar)
Shape? Linear. Since these identical bonds are arranged symmetrically, the molecule is NONPOLAR.



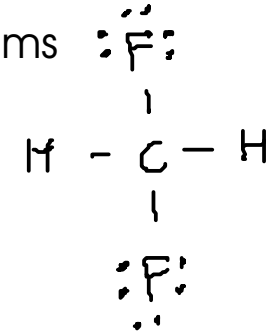
← CH_3F "fluoromethane"

Fluorine is able to pull electron density through the molecule, as it is being opposed by much less electronegative hydrogen atoms.

"difluoromethane" CH_2F_2 →



In 2D, the fluorine atoms appear to be on the opposite sides of the molecule, but in 3D they are on the same side.



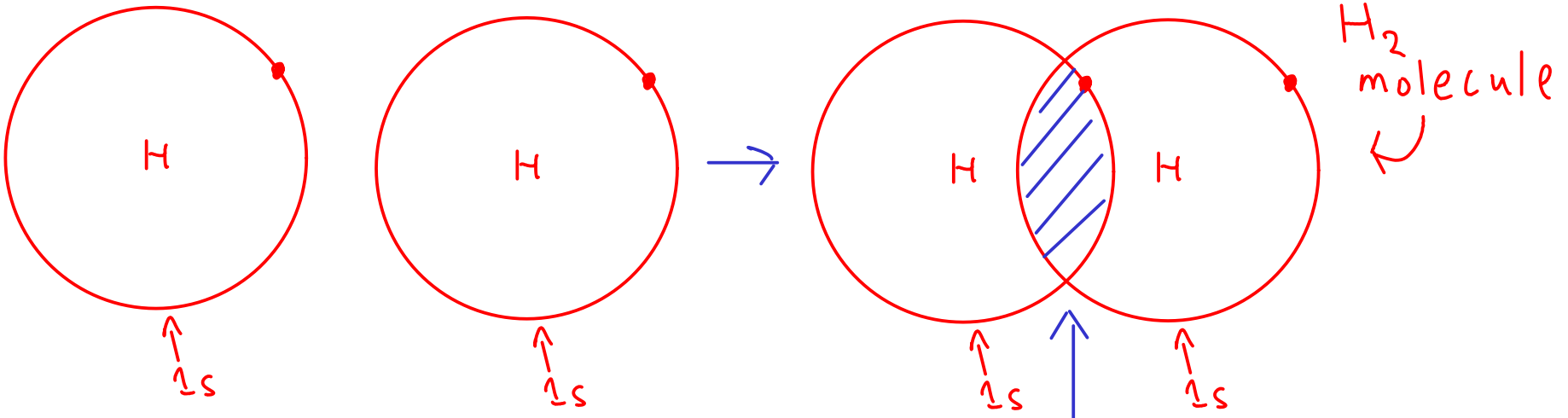
VALENCE BOND THEORY

- an attempt to explain why molecules behave in the way that the VSEPR model predicts.

- Describes the formation of bonds in terms of the OVERLAP of ORBITALS from the bonding atoms.

1. Bonds are formed when two atoms are close enough together so that their ORBITALS OVERLAP (share the same space).

2. Each SET of overlapping orbitals can contain at most a total of TWO electrons. So, two orbitals with one electron each may bond. An orbital with two electrons can only bond with an EMPTY orbital (This is called a COORDINATE COVALENT BOND.) * Ag^+ with $:NH_3$ ... the cleanup in the AgCl lab



These 1s orbitals overlap to form what we call a "sigma bond" with overlap BETWEEN the two atomic nuclei.