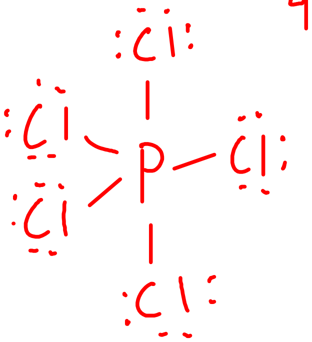
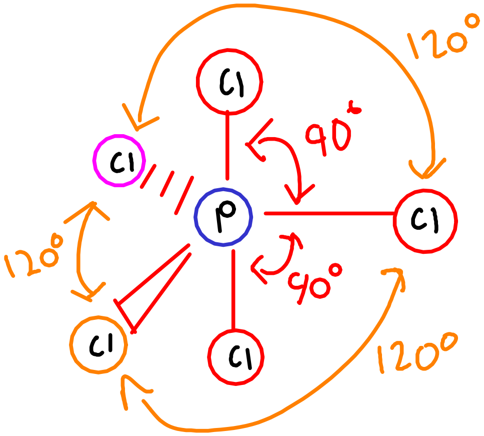
SHAPES OF EXPANDED VALENCE MOLECULES

PCl_5 :

P : 5
Cl : 7 × 5
40

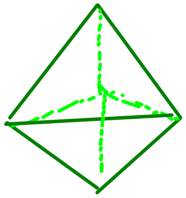


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



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.

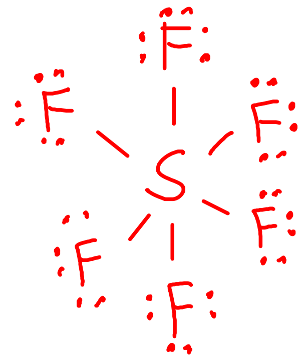


There are acually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

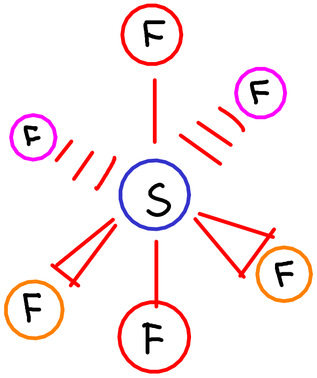
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!

SF_6:

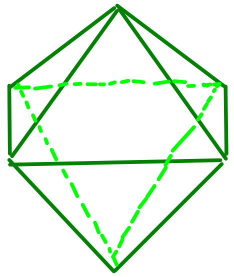
S: 6
F: 7x6
48



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!

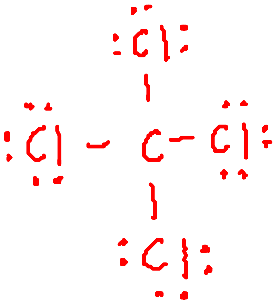
Examples:

CCl_4

C : 1x4

Cl : 4 x 7 = 28

$32e^-$



Molecular shape? The central atom has FOUR OTHER ATOMS bonded to it, and no lone pairs. This molecule is TETRAHEDRAL.

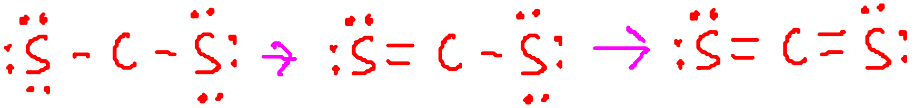
CS_2

C : 1x4

S : 2x6 = 12

$16e^-$

Shape? There are TWO ATOMS bonded to the central carbon atom and NO lone pairs. This is a LINEAR molecule.



skeletal

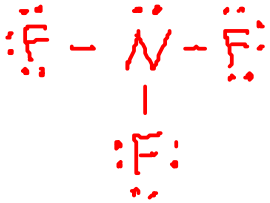
final structure

NF_3

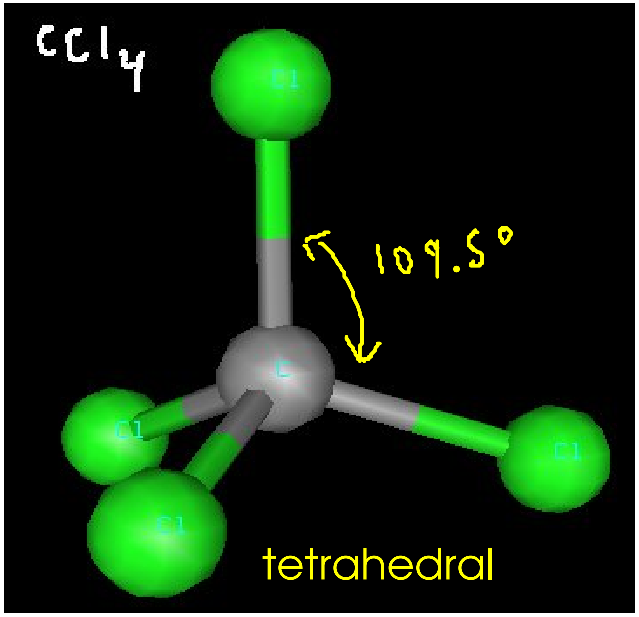
N : 1x5

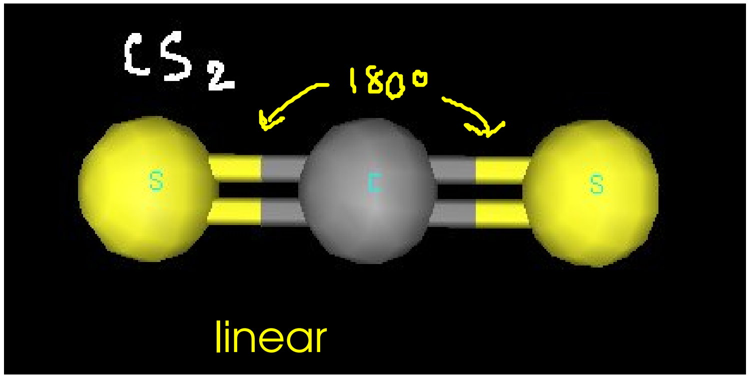
F : 3x7 = 21

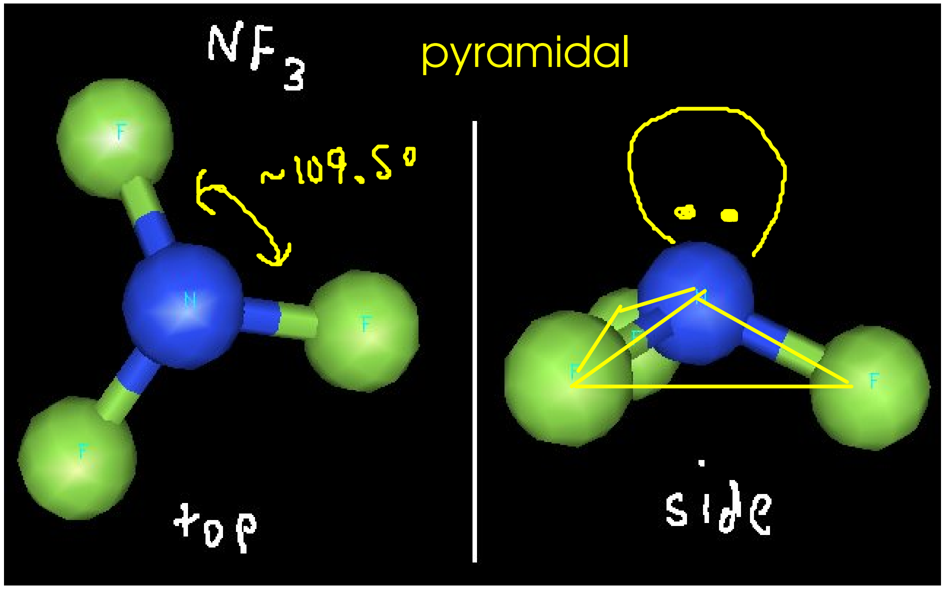
$26e^-$



Shape? There are THREE ATOMS bonded to the central nitrogen atom, which also has ONE LONE PAIR. This makes FOUR groups on the nitrogen which will push each other away. This is a PYRAMIDAL molecule (same angles as the tetrahedron, but only three atoms on the outside instead of four)


CCl4
109.5°
Cl
C
Cl
Cl
Cl
tetrahedral


CS2
180°
S
C
S
linear

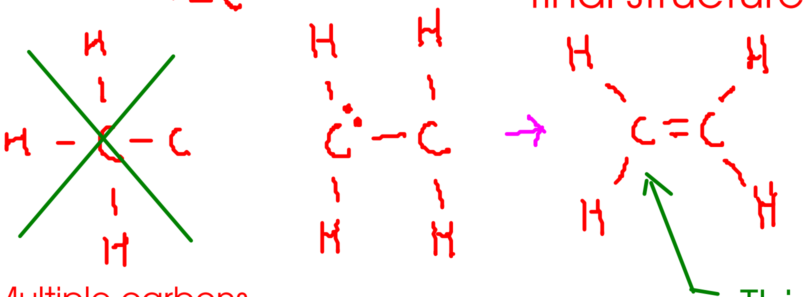

NF3
pyramidal
F
~109.5°
N
F
F
top
F
F
F
side

C_2H_4

$C: 2 \times 4 = 8$

$H: 4 \times 1 = 4$

$12e^-$

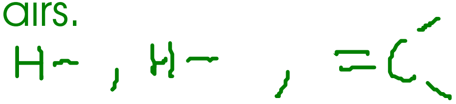


Multiple carbons usually mean multiple centers!

Shape? This molecule has TWO central atoms, so we need to describe the shape around each carbon center.

Each carbon center is TRIGONAL PLANAR.

This carbon has THREE atoms surrounding it, and no lone pairs.



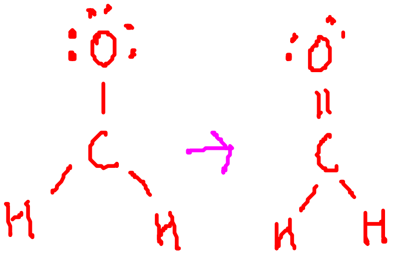
H_2CO

$H: 2 \times 1 = 2$

$C: 1 \times 4$

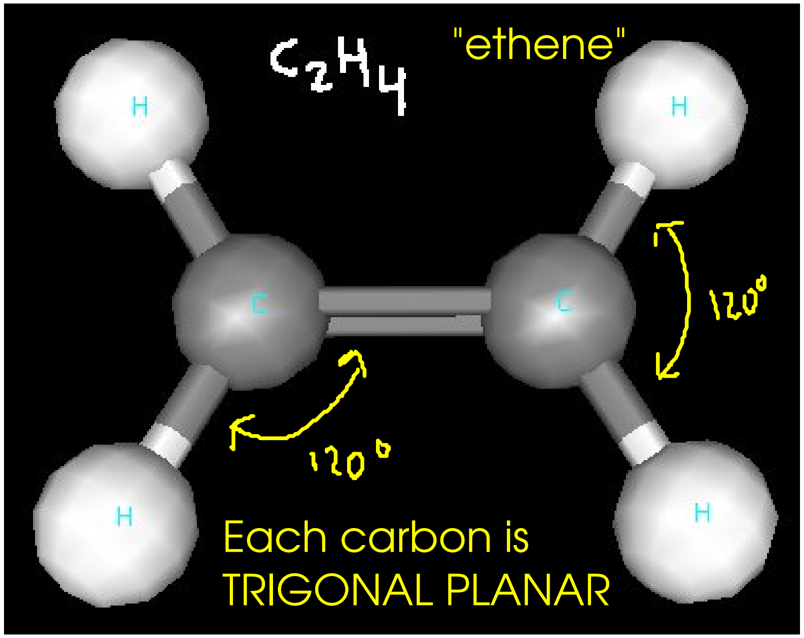
$O: 1 \times 6$

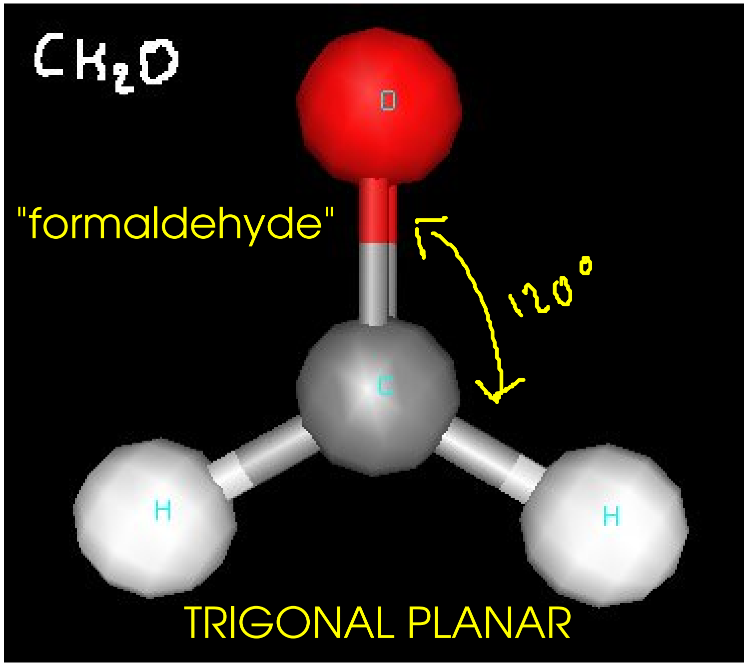
$12e^-$



final structure

Shape? The carbon center has THREE ATOMS attached, and no lone pairs. The molecule is TRIGONAL PLANAR.


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

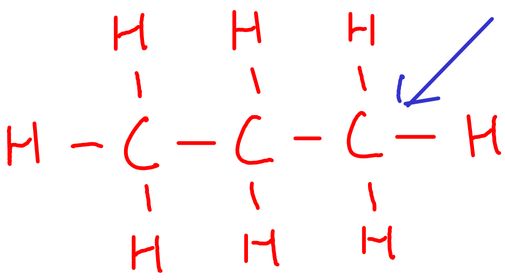

CH_2O
O
"formaldehyde"
120°
C
H
H
TRIGONAL PLANAR

VSEPR and large molecules

- Large molecules have more than one "center" atom

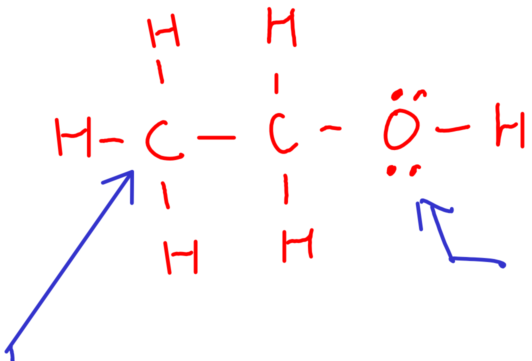
- Describe the molecule by describing the shape around each "center".

C_3H_8:



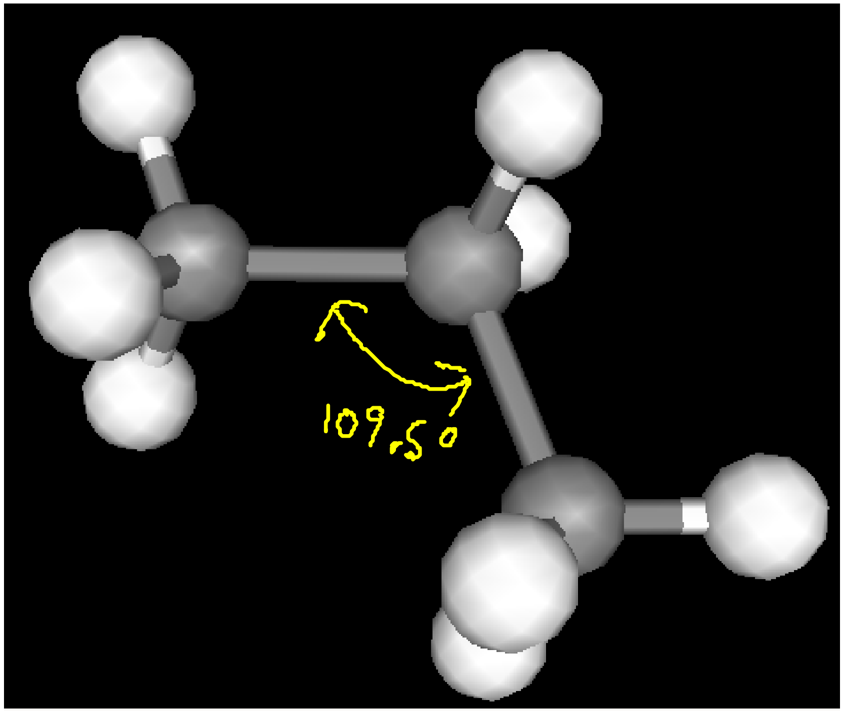
Each of the three carbon centers is TETRAHEDRAL, since each are surrounded by four groups.

CH_3CH_2OH:



The geometry around this oxygen atom is BENT.

These carbon atoms have TETRAHEDRAL geometry.

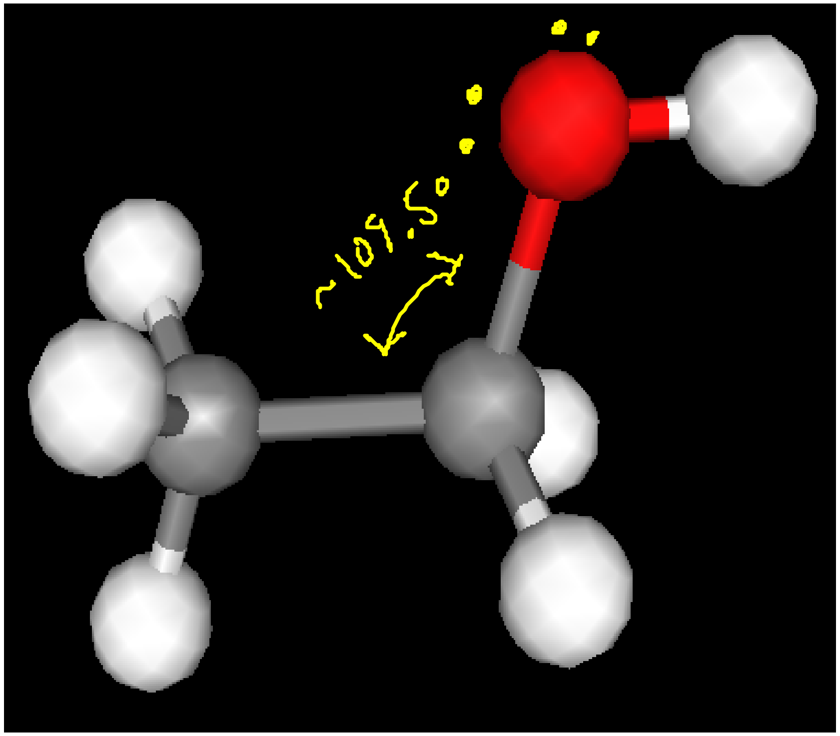


C_3H_8

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!

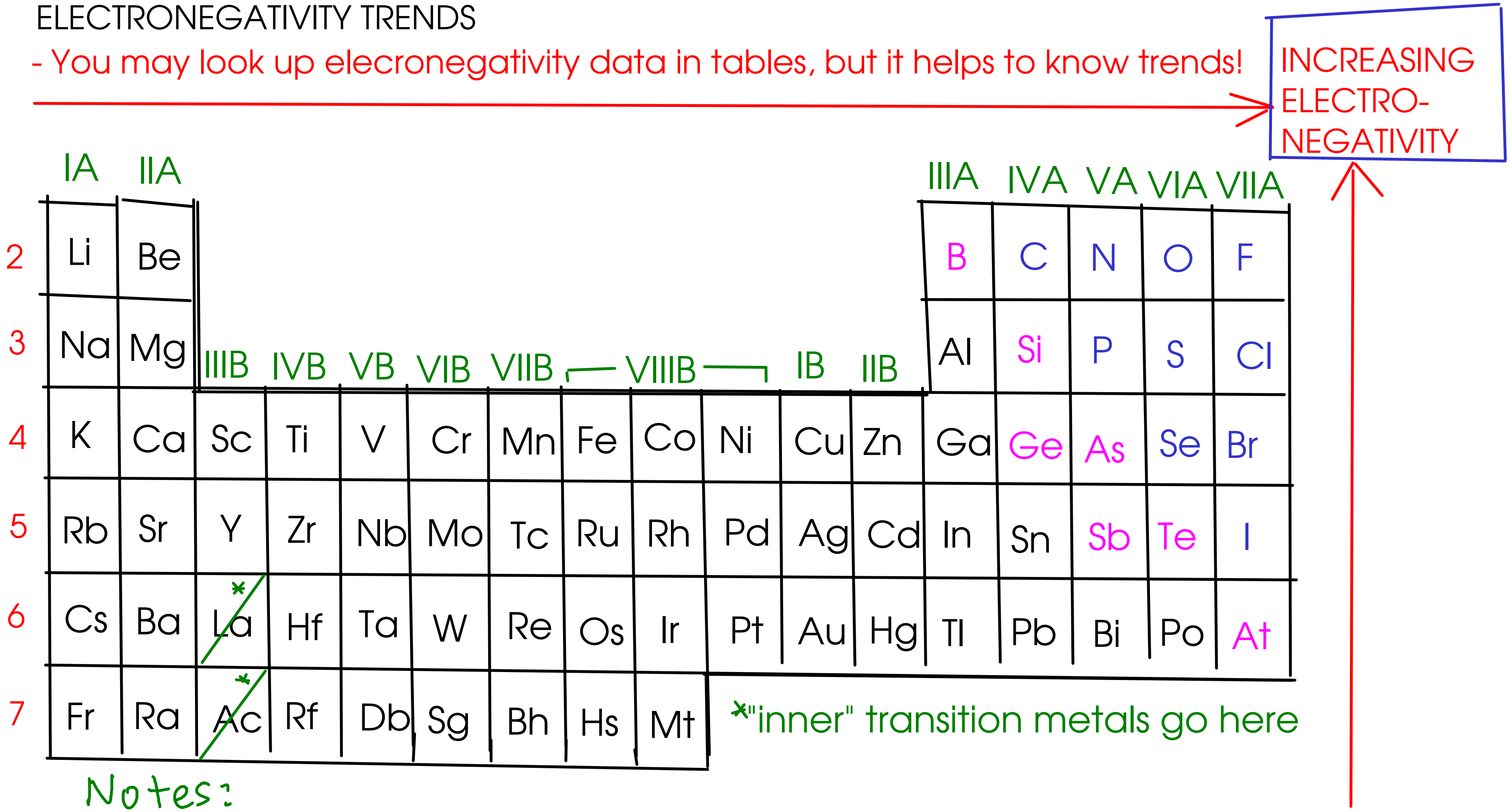
ELECTRONEGATIVITY:
-A measure of how closely to itself an atom will hold shared electrons

- A bond where there is a LARGE electronegativity difference between atoms will be either POLAR or (for very large differences) IONIC! (chart, p 346)

- 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!



	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA
2	Li	Be											B	C	N	O	F
3	Na	Mg											Al	Si	P	S	Cl
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
6	Cs	Ba	~~La~~ *	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
7	Fr	Ra	~~Ac~~ *	Rf	Db	Sg	Bh	Hs	Mt								

*"inner" transition metals go here

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

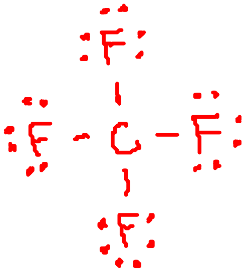
Examples:

CF_4:

C: 4

F: 7x4 = 28

32



Polar?

* POLAR BONDS? YES. Large electronegativity difference beween C and F.

* GEOMETRY? Tetrahedral. All these bonds are arranged symmetrically around the carbon, so electrons can't be pulled towards one "side" of the molecule. The molecule is NONPOLAR!

CH_3F

C: 4

F: 7

H: 1x3

14

CH_2F_2.

C: 4

F: 7x2=14

H: 1x2=2

20

CO_2

C: 4

O: 6x2=12

16