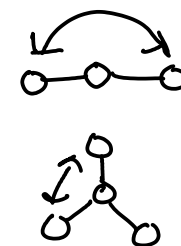


VSEPR shapes

\* "Groups" can be either BONDS or LONE PAIRS!

VSEPR shapes:

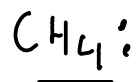
Groups* around central atom	Shape	Bond angle(s) in degrees
2	linear	180
3	trigonal planar	120
<u>4</u>	tetrahedral / pyramidal / bent	109.5
5	trigonal bipyramidal (and derivatives)	90 and 120
6	octahedral (and derivatives)	90



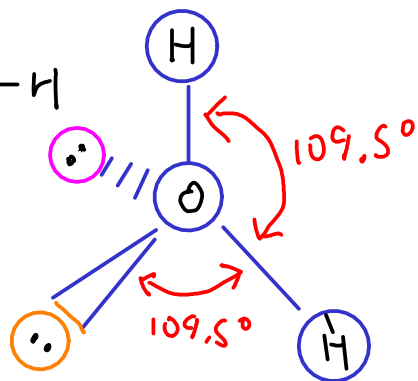
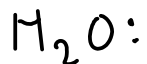
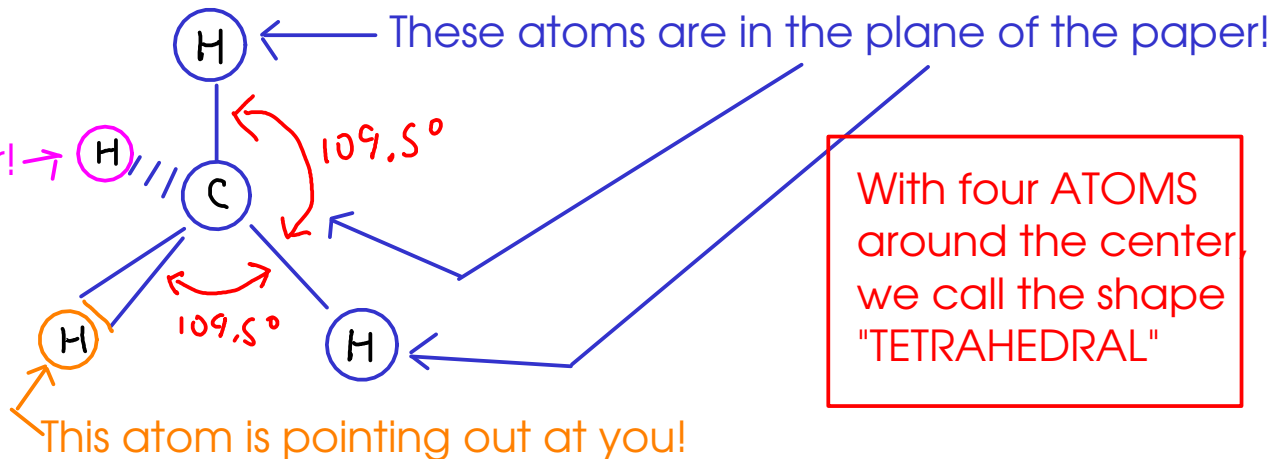
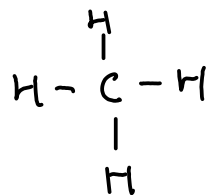
5 and 6 violate "octet rule"

5 More on "4 things around a central atom":

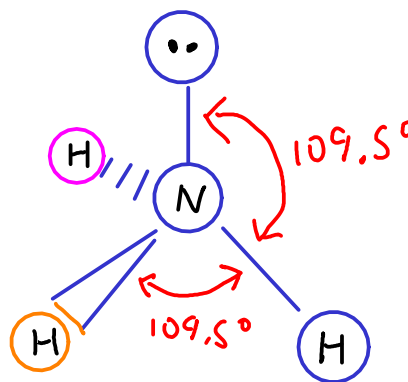
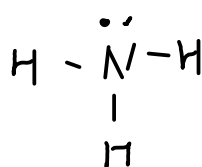
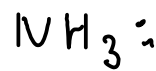
- A compound that obeys the octet rule can have a maximum of four groups around its central atom. But we describe the molecular shape based on how ATOMS are arranged around the center. What if some of those groups aren't atoms, but pairs of UNSHARED electrons?



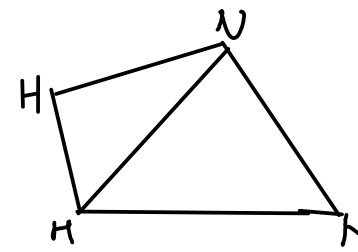
This atom is behind the paper! →



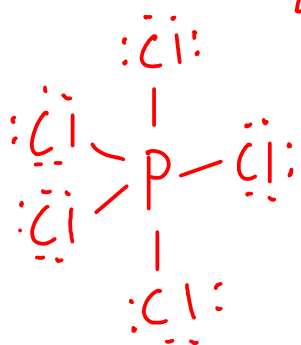
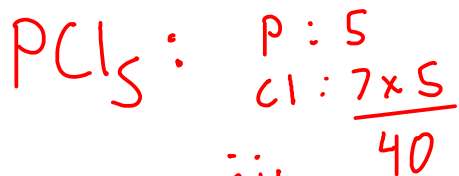
With two ATOMS and two LONE PAIRS, we call the shape "BENT"



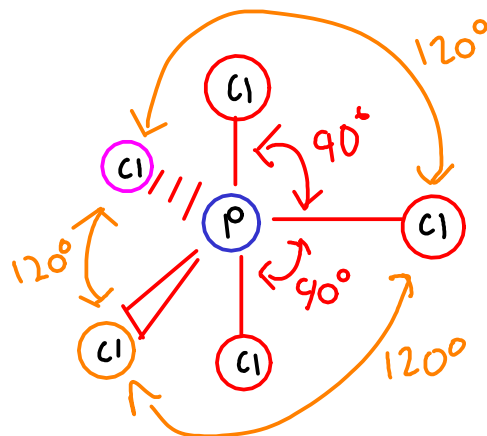
With three ATOMS and one LONE PAIR, we call the shape "PYRAMIDAL"



## 6 SHAPES OF EXPANDED VALENCE MOLECULES

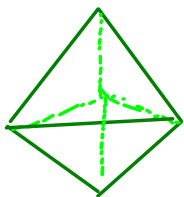


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



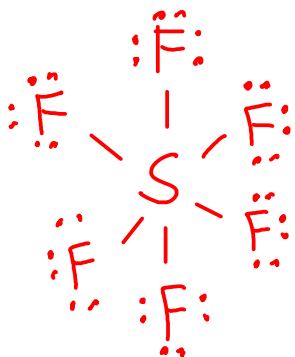
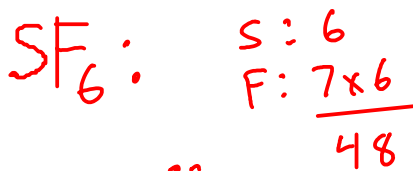
The top and bottom atoms are 90 degrees apart from the atoms around the center.

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

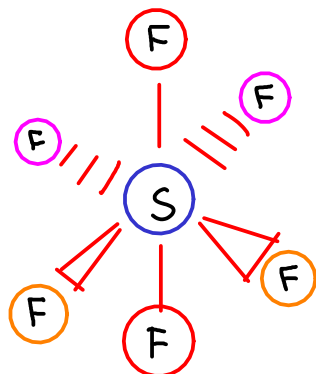


There are actually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

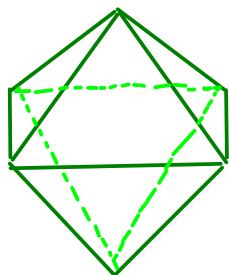
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!



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



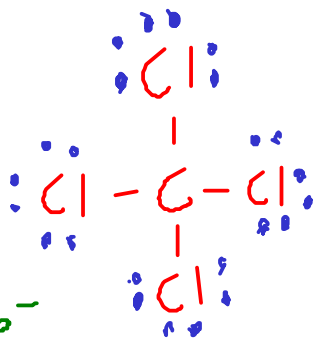
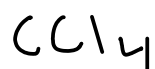
All bond angles in this arrangement are 90 degrees!



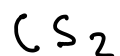
This shape is called OCTAHEDRAL, since it has eight sides.

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!

8 Examples:



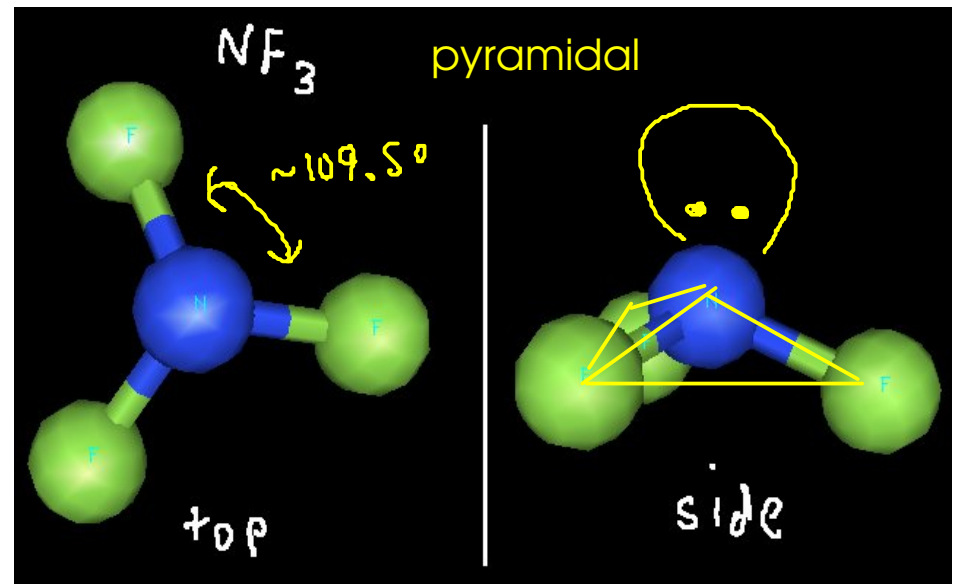
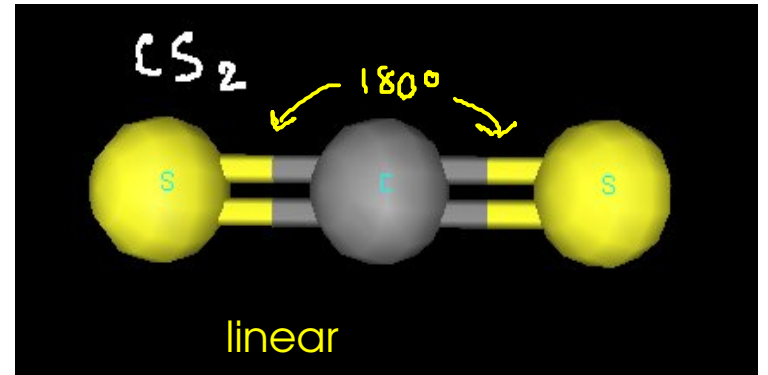
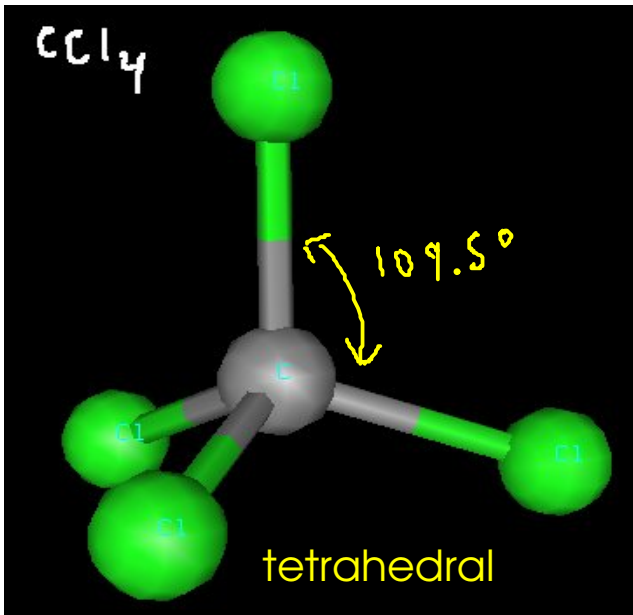
Geometry? There are four groups around the central atom, so TETRAHEDRAL. Shape? Since all four groups are other atoms, shape is also TETRAHEDRAL.

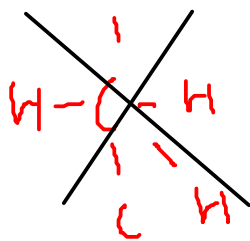
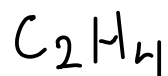


Geometry? Two groups around central atom, so LINEAR. Both are atoms, so shape is also LINEAR. (In this case, atoms vs lone pairs don't matter since a two-atom molecule would be linear by definition!)

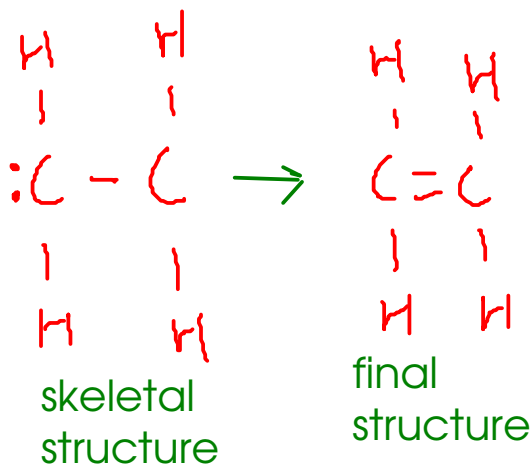


Geometry? Four groups around the central atom, so TETRAHEDRAL geometry. Shape? Only three of the groups are atoms (one is an "invisible" lone pair), so PYRAMIDAL.

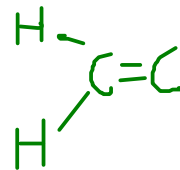




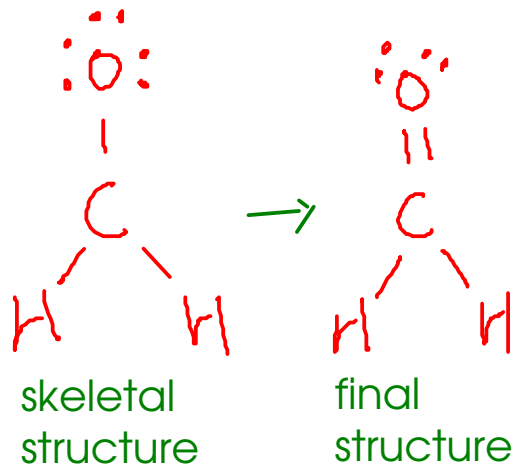
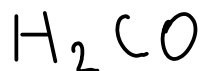
Structure tip: Multiple carbon atoms mean multiple "central atoms"



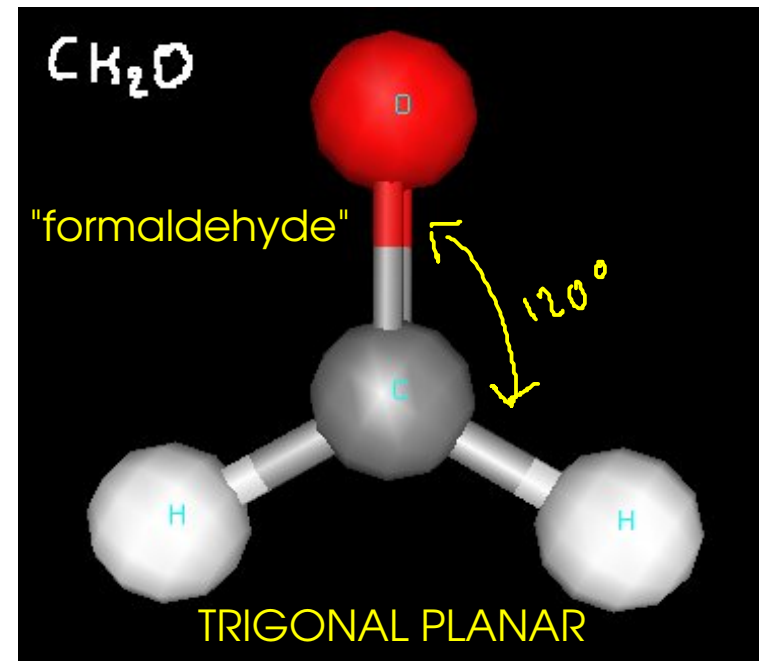
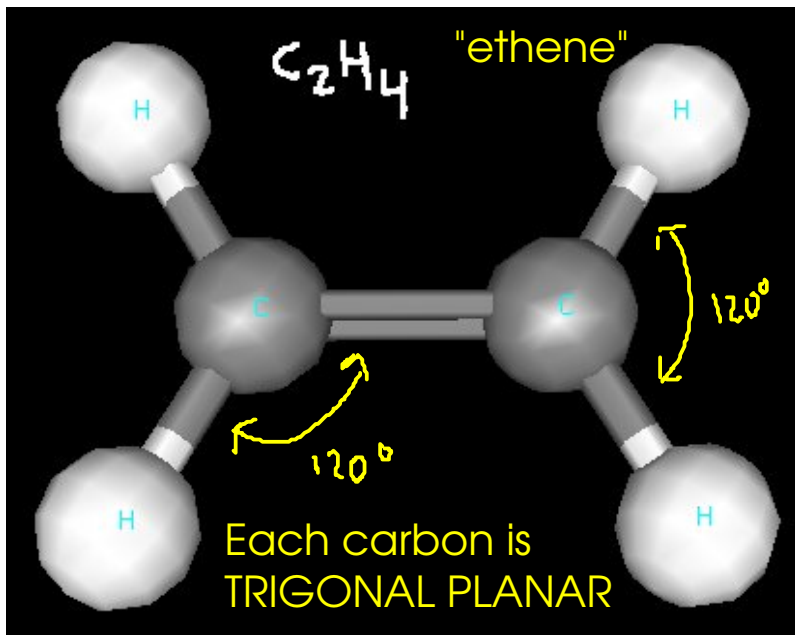
Geometry? EACH central carbon atom has THREE groups surrounding it, and all are atoms. So each carbon atom is TRIGONAL PLANAR.



Each carbon has three groups attached.



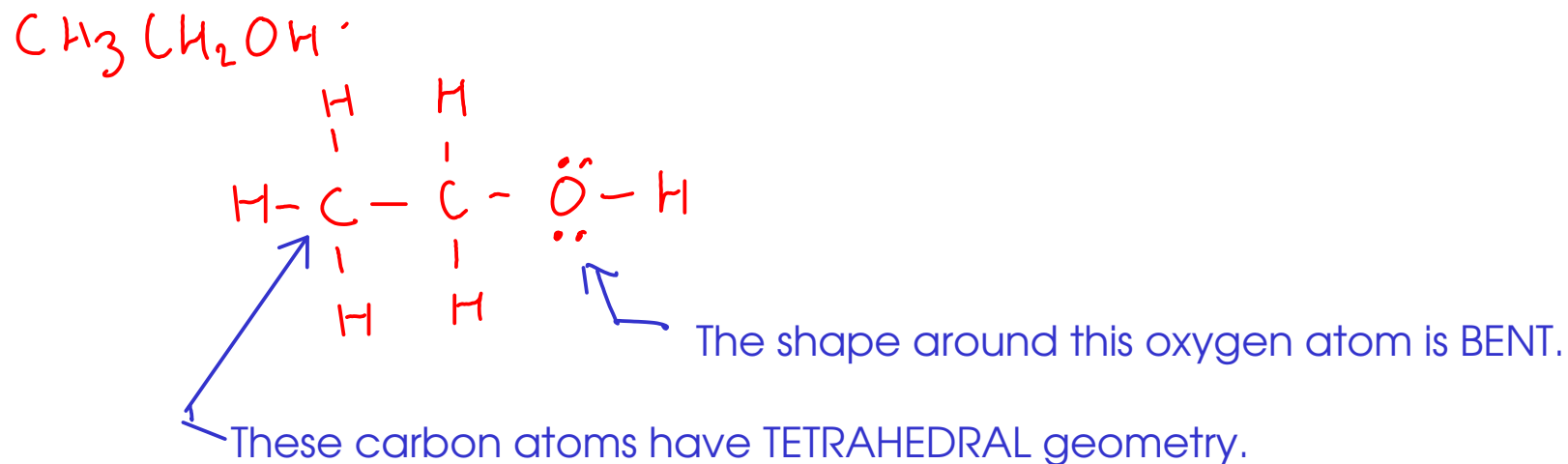
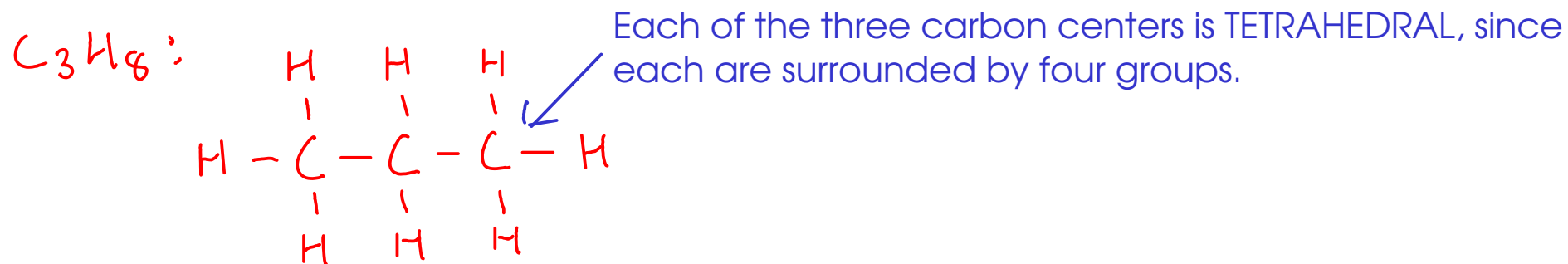
Geometry? Three groups around central atom, and all of them are other atoms, so both geometry and shape are TRIGONAL PLANAR.

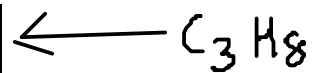
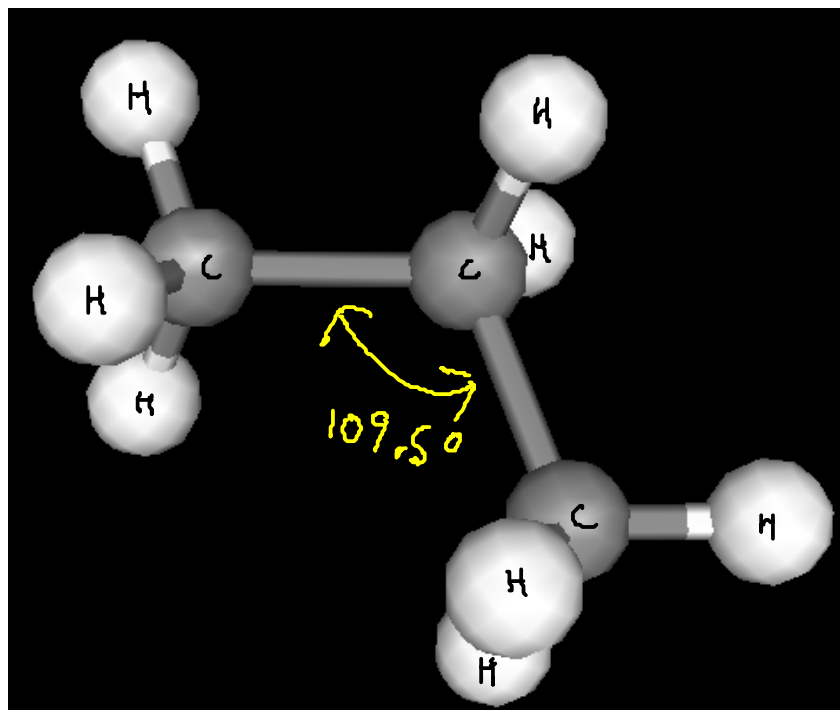




12  
VSEPR and large molecules

- Large molecules have more than one "center" atom
- Describe the molecule by describing the shape around each "center".

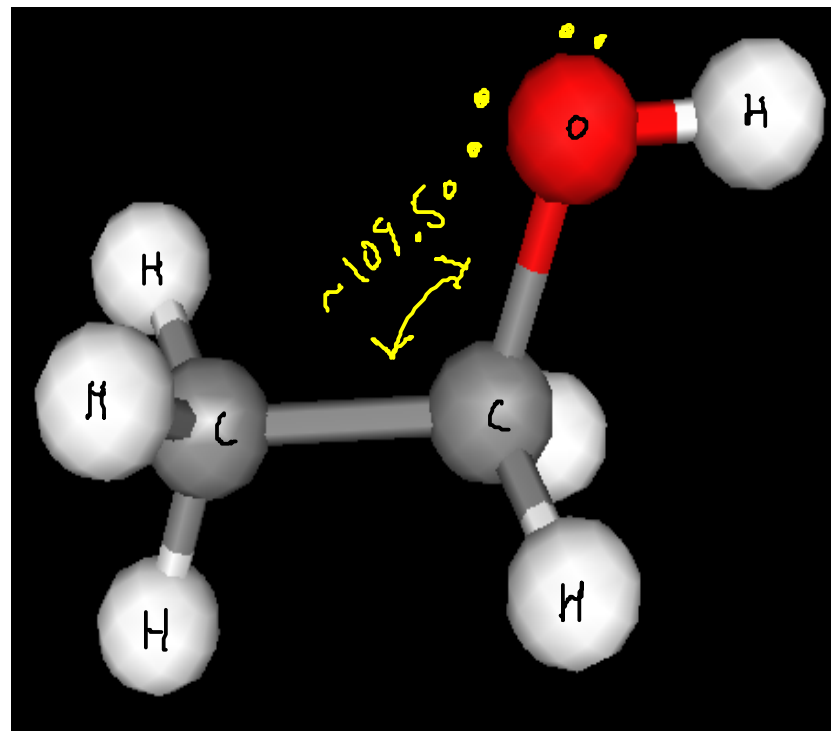




All bond angles in the propane molecule are 109.5 degrees



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



## 14 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 dissolve 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 electronegativity data in tables, but it helps to know trends!

INCREASING  
ELECTRO-  
NEGATIVITY

	IA	IIA											IIIA	IVA	VA	VIA	VIIA
2	Li	Be											B	C	N	O	F
3	Na	Mg	IIIB	IVB	VB	VIB	VII B	VIII B	IB	IIB			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							

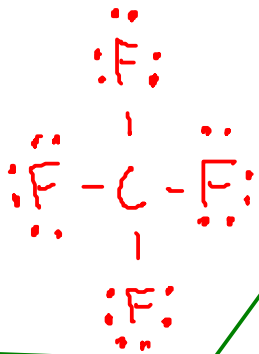
### Notes:

- ① - FLUORINE is the most electronegative 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

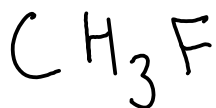
## Examples:



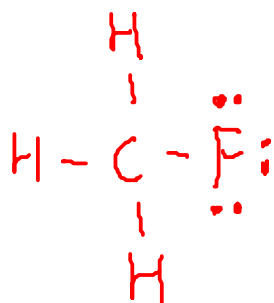
$$\begin{array}{l} \text{C: } 1 \times 4 \\ \text{F: } 4 \times 7 \\ \hline 32 e^- \end{array}$$



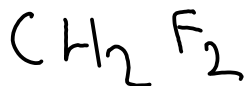
Polar? 1 - C-F bonds are polar. 2 - Geometry? This molecule is TETRAHEDRAL. Since the fluorine atoms are arranged SYMMETRICALLY around the center, they all pull against one another and the overall molecule is NONPOLAR.



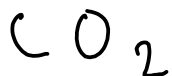
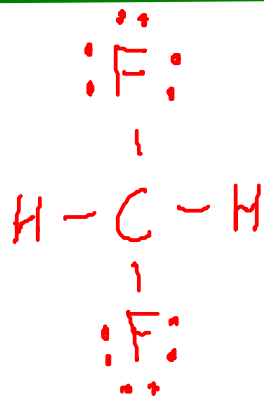
$$\begin{array}{l} \text{C: } 1 \times 4 \\ \text{H: } 3 \times 1 \\ \text{F: } 1 \times 7 \\ \hline 14 e^- \end{array}$$



Polar? 1 - The C-F bond is polar. 2 - Geometry? Tetrahedral again, like carbon tetrafluoride. But since there's only one fluorine in the structure, electrons are pulled towards the fluorine atom and away from the other side of the molecule (with the hydrogens). This is a POLAR molecule.



$$\begin{array}{l} \text{C: } 1 \times 4 \\ \text{H: } 2 \times 1 \\ \text{F: } 2 \times 7 \\ \hline 20 e^- \end{array}$$



$$\begin{array}{l} \text{C: } 1 \times 4 \\ \text{O: } 2 \times 6 \\ \hline 16 e^- \end{array} \quad \text{:O}=\text{C}=\text{O:}$$