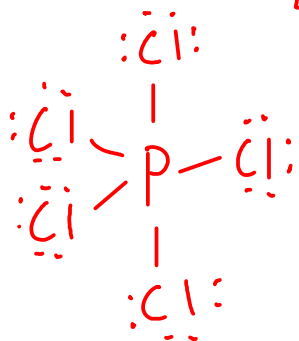
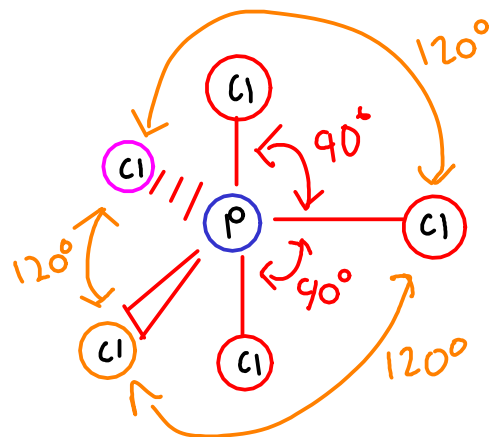


186 SHAPES OF EXPANDED VALENCE MOLECULES

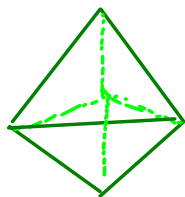


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



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.

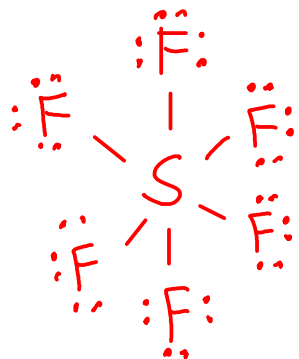


There are actually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

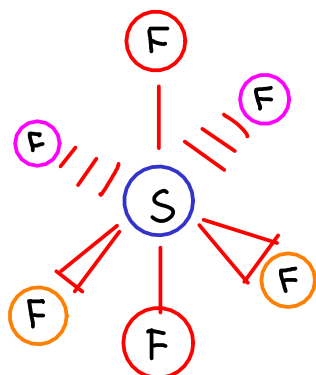
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!



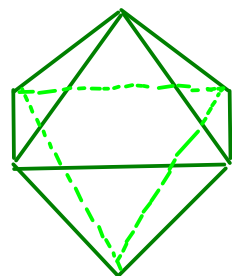
$$\begin{array}{r} S: 6 \\ F: 7 \times 6 \\ \hline 48 \end{array}$$



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



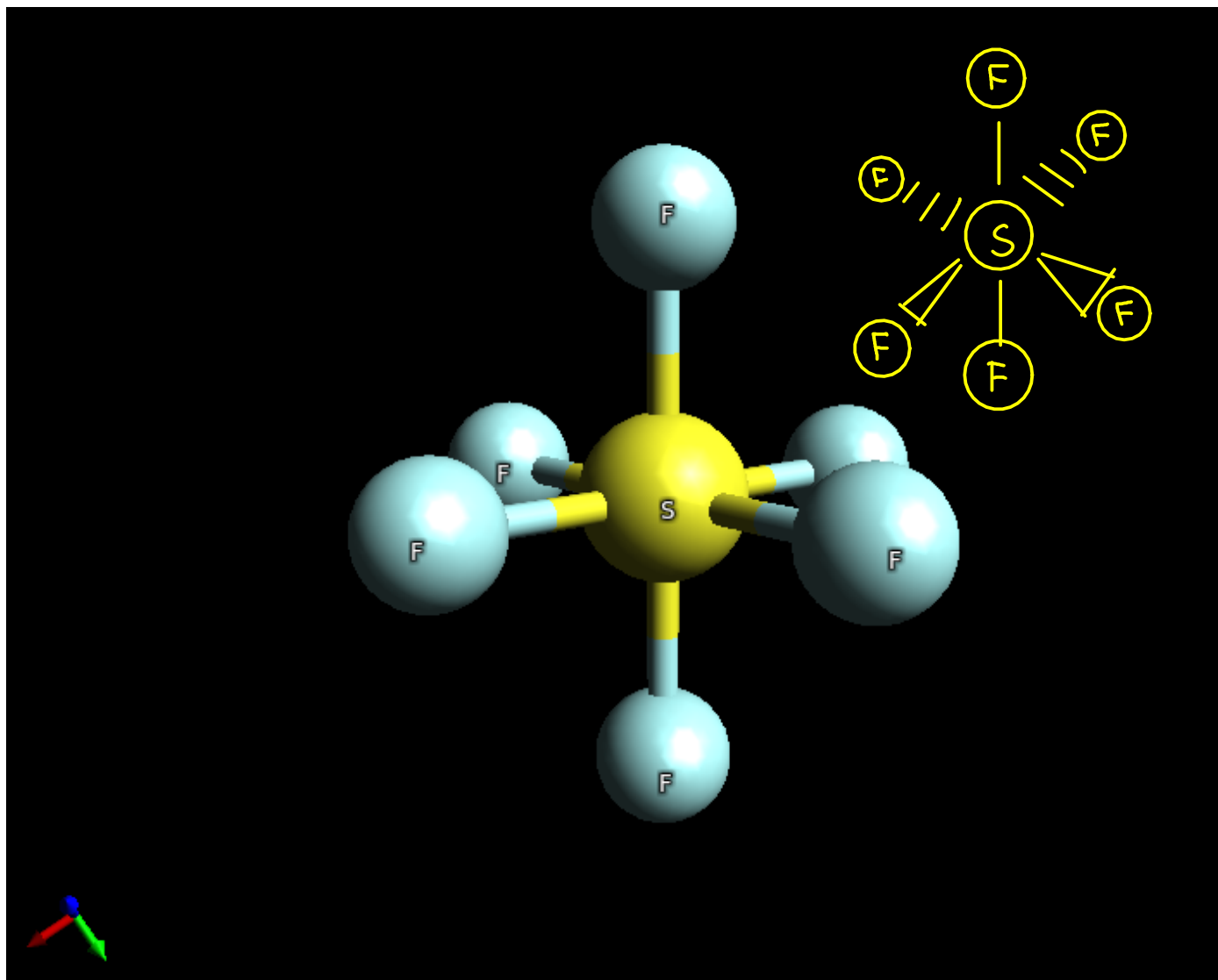
All bond angles in this arrangement are 90 degrees!



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!

Here's a ball-and-stick rendering of the sulfur hexafluoride molecule:



POLARITY

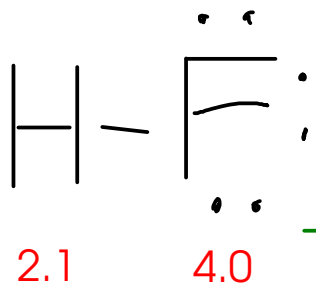
- When atoms share electrons, the electrons might not be EVENLY shared. Shared electrons may spend more time around one atomic nucleus than the other.
- When electrons are shared UNEVENLY, this results in a POLAR BOND.

... but how can we tell whether or not a bond will be POLAR? Use ELECTRONEGATIVITY!
Usually no actual calculation is required - trends are often good enough to see whether a bond is polar.

REMINDER: ELECTRONEGATIVITY

- A number that describes how tightly 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!
- A bond with little or no electronegativity difference between atoms will be NONPOLAR

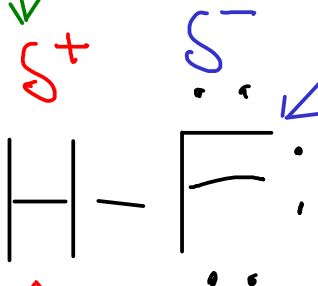
¹⁹⁰ ELECTRONEGATIVITY EXAMPLE



Electronegativity values
Difference = 1.9

Fluorine is much more electronegative than hydrogen. This is a POLAR BOND, and the shared electrons will be held more closely to FLUORINE!

δ means "small" here



This end of the molecule will have a slight NEGATIVE charge, since the shared electrons are closer to FLUORINE!

This end of the molecule will have a slight POSITIVE charge, since the shared electrons are pulled away from HYDROGEN!

POLARITY OF MOLECULES

So what can a molecule's LEWIS STRUCTURE, SHAPE, and the POLARITY of its bonds tell us?

... the POLARITY of the overall molecule, which will tell us (among other things) what a given molecule will mix with or dissolve in!

POLAR MOLECULES

- Will dissolve in or dissolve other polar molecules
- Will dissolve some ionic compounds
- Will NOT easily dissolve nonpolar molecules

Example:
WATER

NONPOLAR MOLECULES

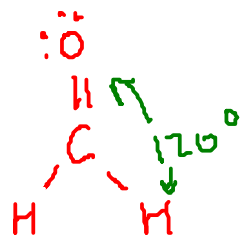
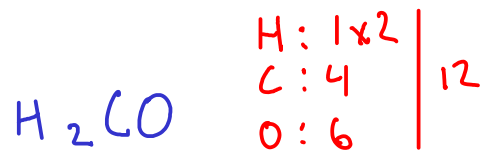
- Will dissolve in or dissolve other nonpolar molecules
- Will NOT easily dissolve polar molecules or ionic compounds

Example:
OILS

For a molecule to be polar, it must ...

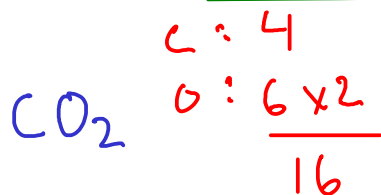
- ① Have polar bonds! (Any molecule that contains no polar bonds must be nonpolar!)
- ② Have polar bonds arranged in such a way that they don't balance each other out! (This is why you need to know the structure and shape of the molecule)

Examples:



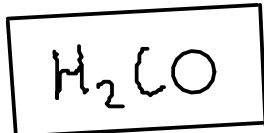
Shape? This molecule is TRIGONAL PLANAR. There are THREE THINGS around the central carbon: =O, -H, and -H

Polar? 1) Polar bonds? YES ... C=O is polar. C-H is nonpolar
2) Arrangement? Electrons are pulled towards the oxygen end of the molecule, making the H side positive, so POLAR.

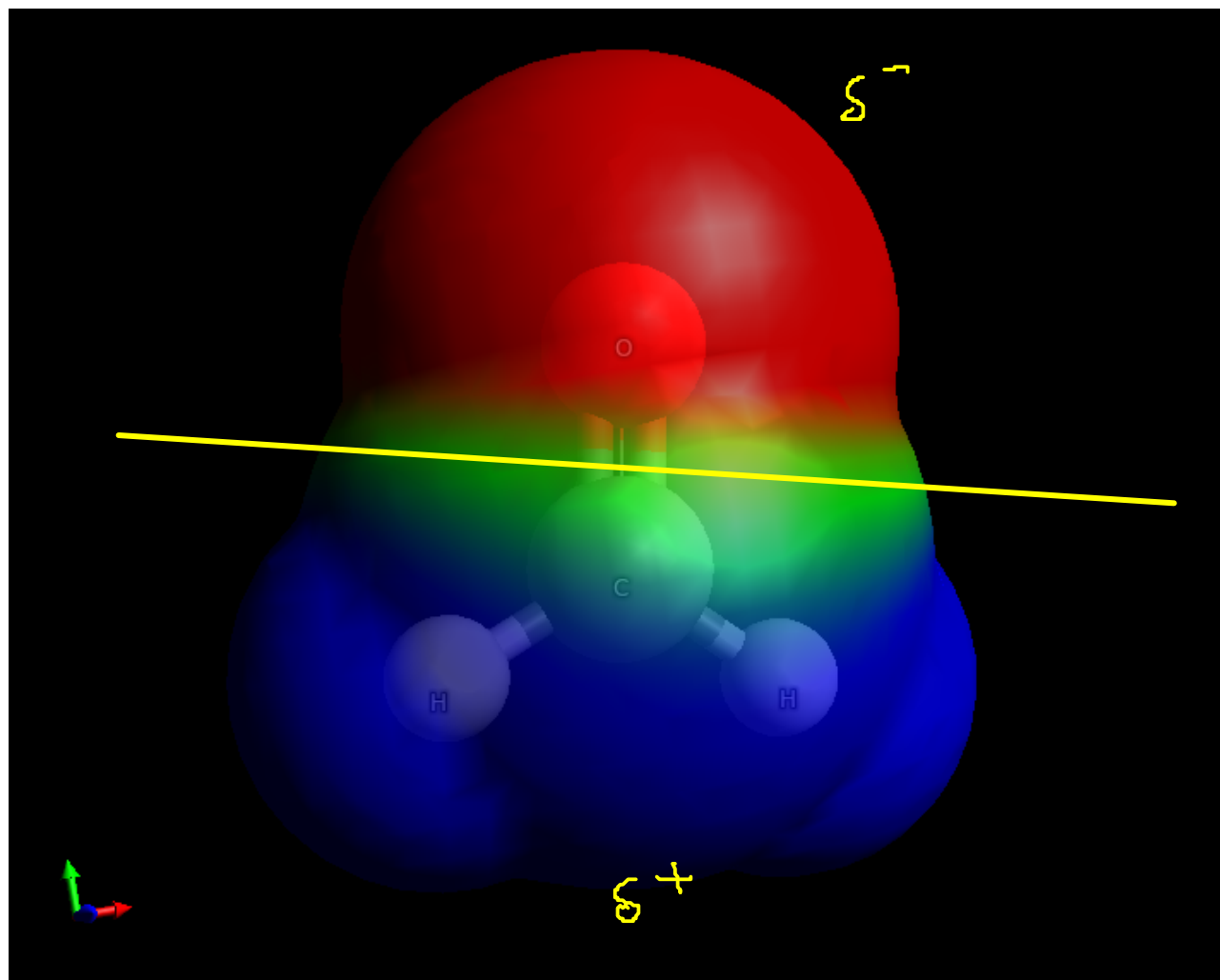


Shape? LINEAR. There are only two things around carbon, and they will be 180 degrees apart.

Polar? 1) Polar bonds? C=O bonds are polar.
2) Arrangement? The oxygen atoms are electronegative, but are on opposite sides of the molecule, so there's no negative "side". This is a NONPOLAR molecule.

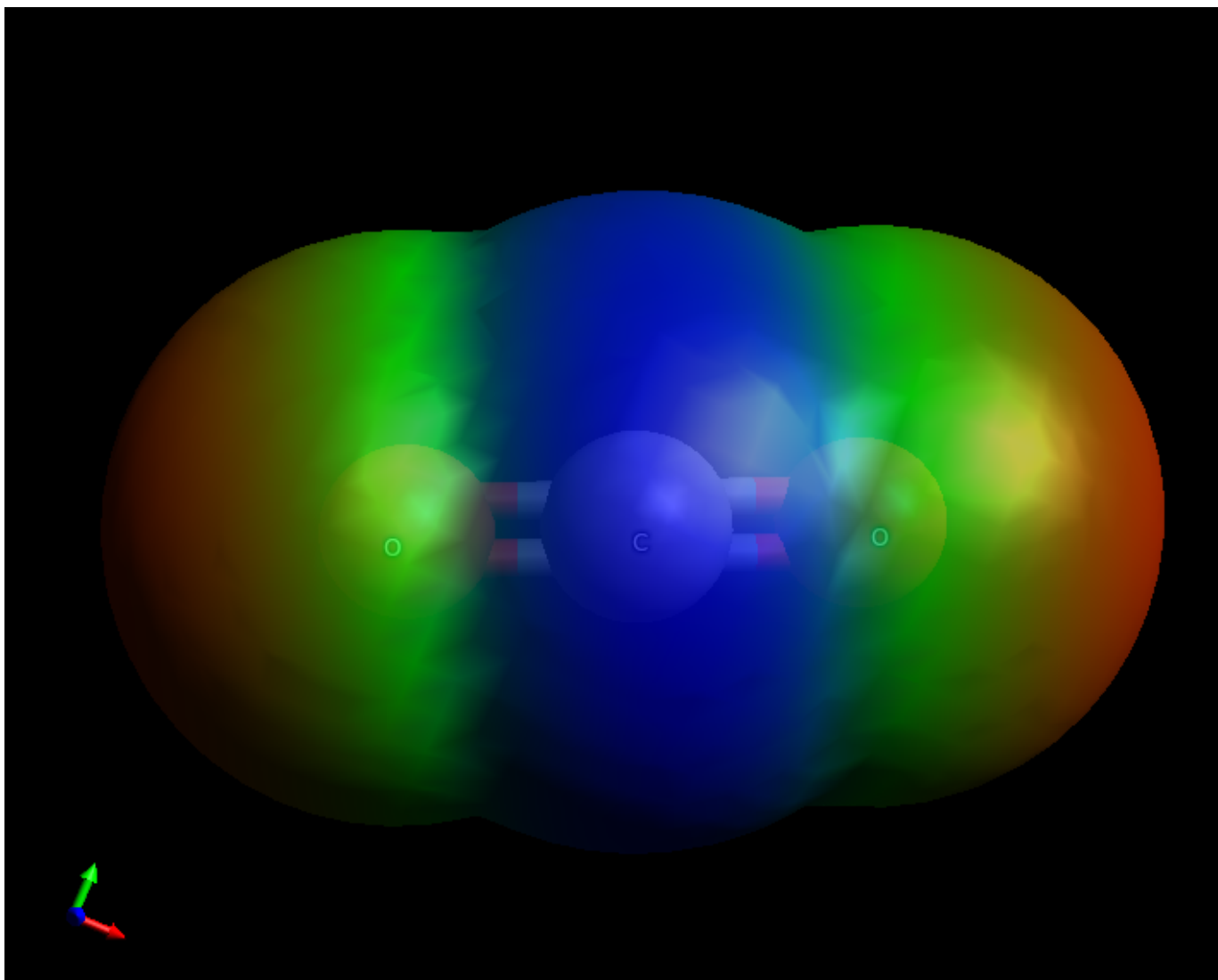
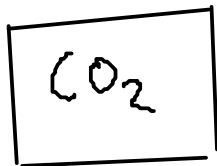


This ball-and-stick model shows electrostatic potential - red for more negative and blue for more positive



oxygen "side",
slightly negative

hydrogen "side",
slightly positive

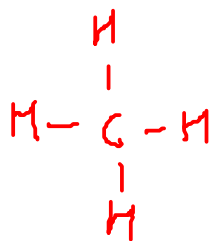


This molecule is NONPOLAR. No positive "side" or negative "side"

methane, CH_4

C: 4

H: 4×1

8

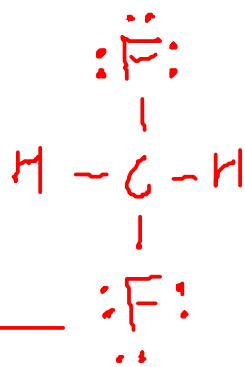
Shape? TETRAHEDRAL. Four atoms around the central carbon atom, all 109.5 degrees apart.

Polar? 1) Polar bonds? C-H bonds are nonpolar. **NONPOLAR MOLECULE.**

 CH_2F_2

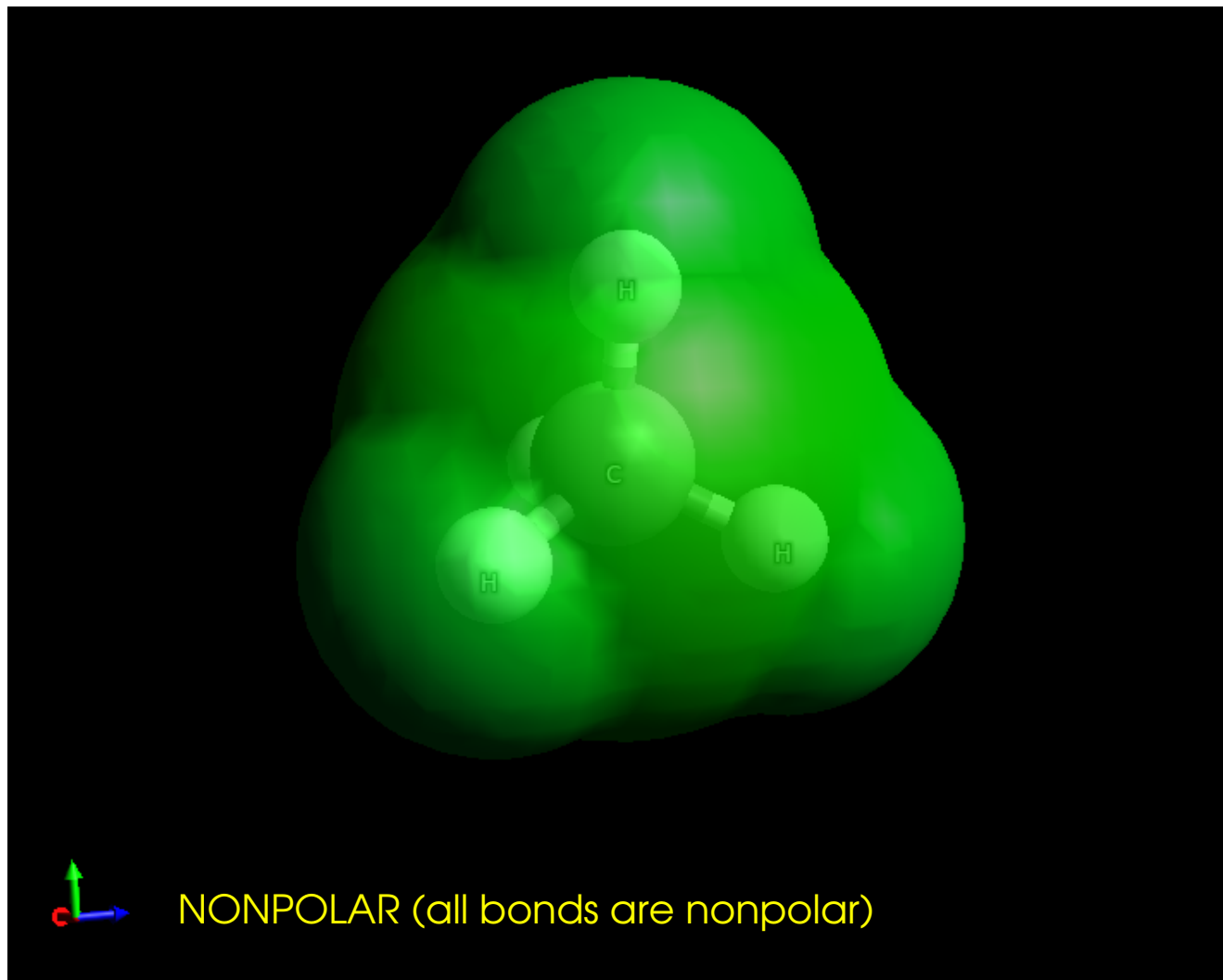
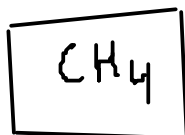
C: 4

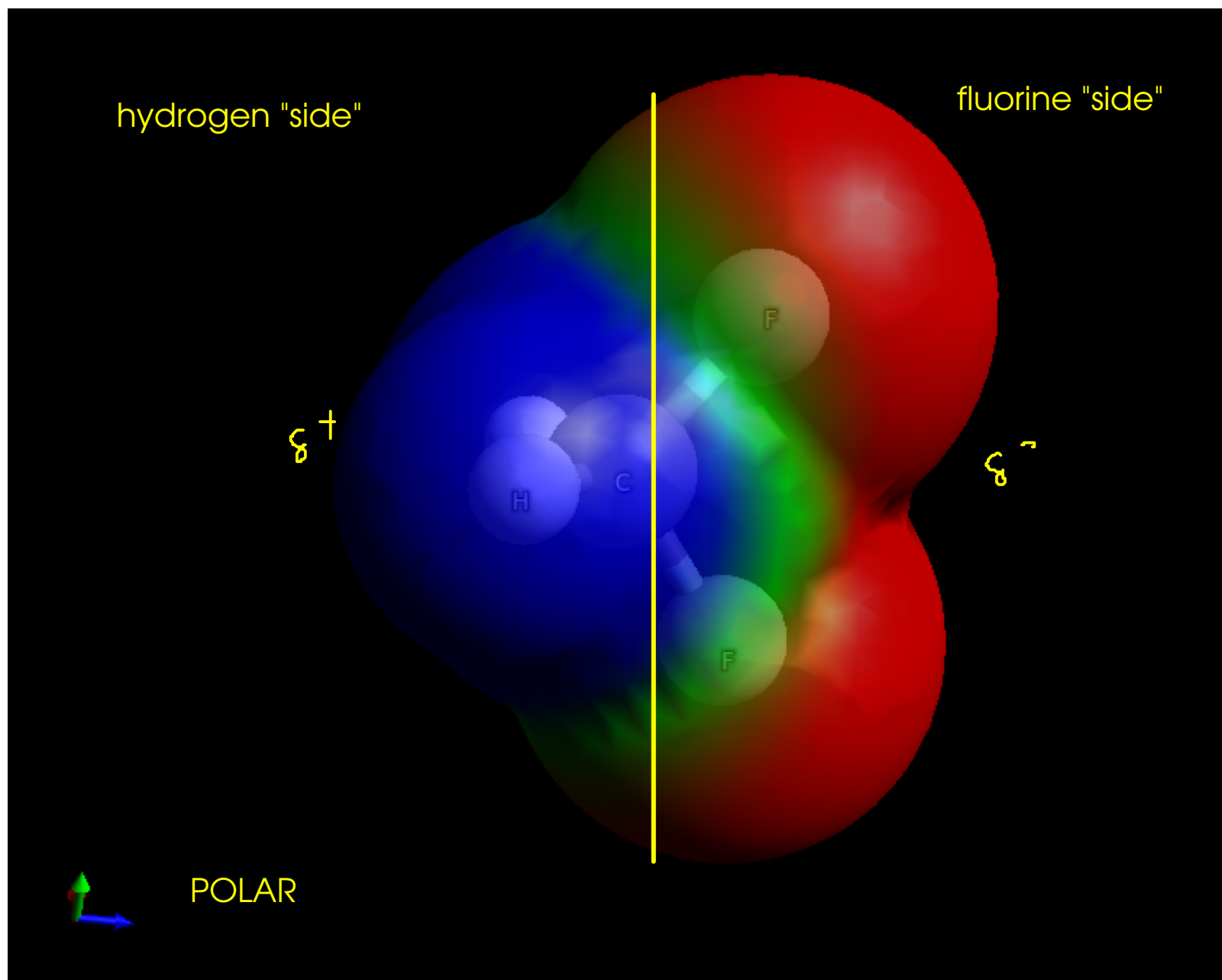
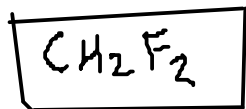
H: $2 \times 1 = 2$ F: $2 \times 7 = 14$

20

Shape? TETRAHEDRAL. Four atoms around the central carbon atom, just like methane.

Polar? 1) Polar bonds? YES ... C-F is polar
2) Arrangement? We have an uneven tetrahedron, which has a fluorine side and a hydrogen side, so the molecule is **POLAR.**





POLARITY AND MOLECULAR PROPERTIES

- POLAR MOLECULES have
 - higher boiling points and melting points that comparably sized nonpolar molecules.
 - higher solubility in polar solvents like water than nonpolar molecules

"LIKE DISSOLVES LIKE"

- NONPOLAR MOLECULES have
 - lower boiling points and melting points that comparably sized polar molecules.
 - higher solubility in nonpolar solvents like carbon tetrachloride or oils

GASES

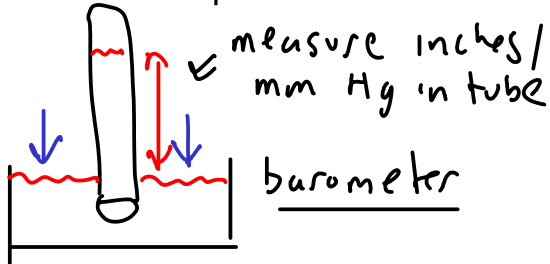
- Gases differ from the other two phases of matter in many ways:
 - They have very low viscosity (resistance to flow), so they flow from one place to another very easily.
 - They will take the volume of their container. In other words, gas volumes are variable.
 - They are the least dense of all three phases.
 - Most gases are transparent, and many are invisible.
 - Gases show a much larger change of volume on heating or cooling than the other phases.
- Gases react to changes in temperature and pressure in a very similar way. This reaction often does not depend on what the gas is actually made of.

↙ thermal expansion!

KINETIC THEORY

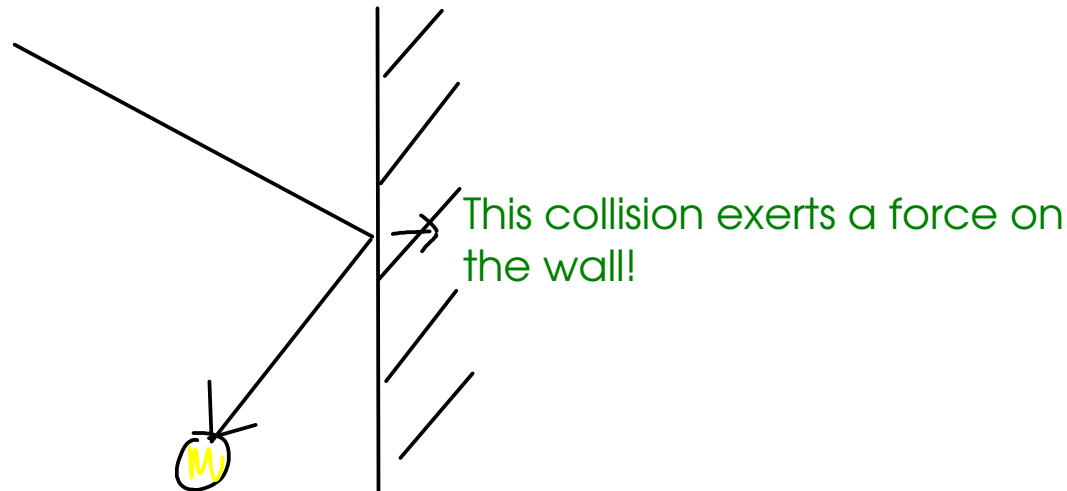
- is a way to explain the behavior of gases.
 - views the properties of gases as arising from them being molecules in motion.
-

- Pressure: force per unit area. Units: Pascal, bar, mm Hg, in Hg, atm, etc.



$$760 \text{ mm Hg} = 1 \text{ atm}$$

- According to kinetic theory, pressure is caused by collisions of gas molecules with each other and the walls of the container the gas is in.



201 - Temperature:

- a measure of the average kinetic energy of the molecules of the gas

$$E_k = \frac{1}{2} m v^2$$

velocity
mass

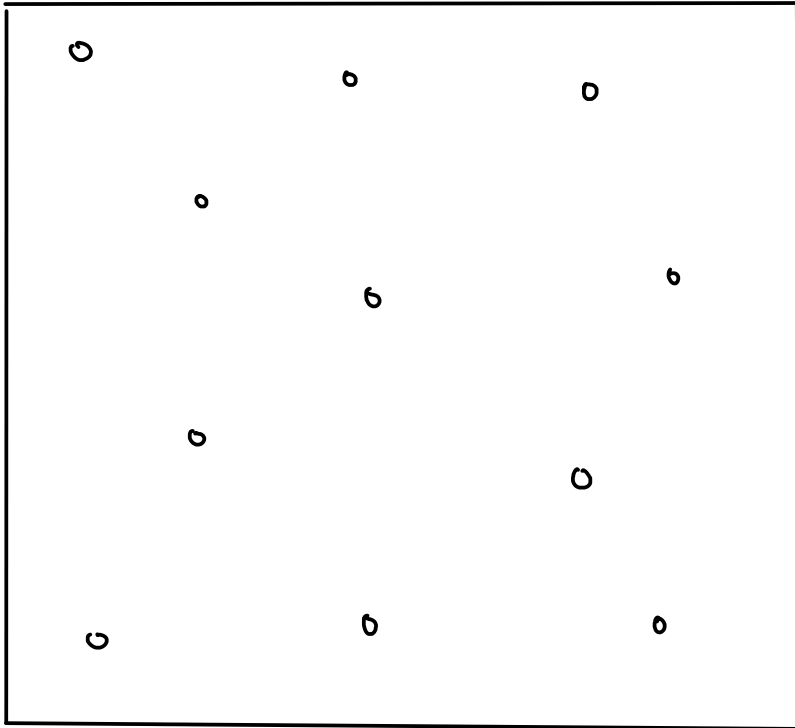
- The faster the gas molecules move, the higher the temperature!
- The temperature scales used when working with gases are ABSOLUTE scales.
 - ABSOLUTE: scales which have no values less than zero.
 - KELVIN: metric absolute temperature scale.

Quick comparison of temperature scales!

$$K = 273.15 + ^\circ C$$

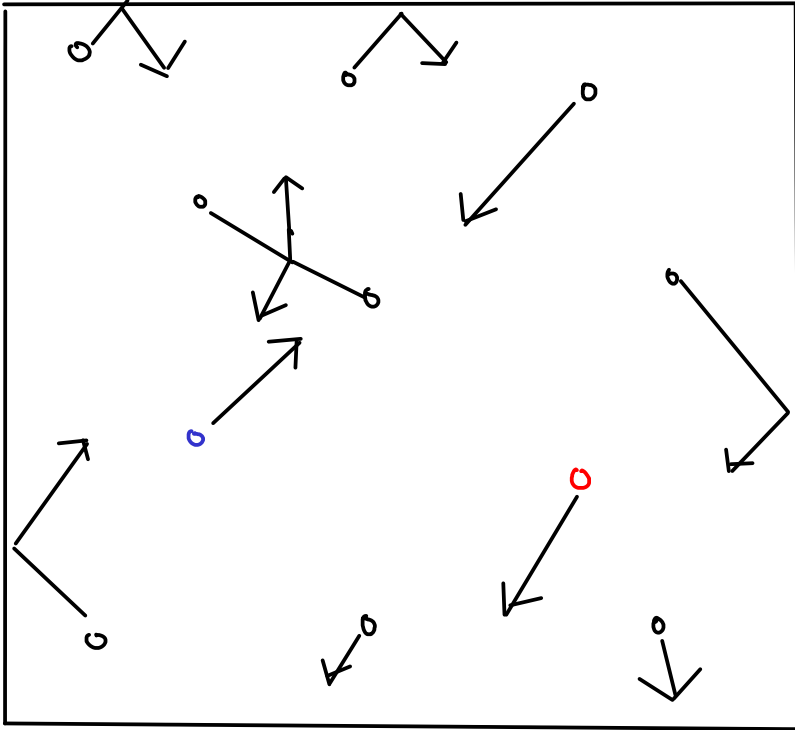
212	100	373	Water boils
77	25	298	Room temperature
32	0	273	Water freezes
-460	-273	0	Absolute zero!
$^{\circ}F$	$^{\circ}C$	K	

THE KINETIC PICTURE OF GASES



LOW DENSITY!

① Gas molecules are small compared to the space between the gas molecules!



- ② Gas molecules are constantly in motion. They move in straight lines in random directions and with various speeds.
- ③ Attractive and repulsive forces between gas molecules are so small that they can be neglected except in a collision.
 - Each gas molecule behaves independently of the others.
- ④ Collisions between gas molecules and each other or the walls are ELASTIC.

⑤ The average kinetic energy of gas molecules is proportional to the absolute temperature.

How does this picture explain the properties of gases?

- Gases expanding to fill their container? Agrees with kinetic picture, since gas molecules are independent
- Thermal expansion of gas at constant pressure? Agrees, because the container has to EXPAND to keep the pressure (from collisions) constant when the gas molecules move faster.
- Pressure increases with temperature at constant volume: Agrees, because the number and force of collisions increases with molecular speed.