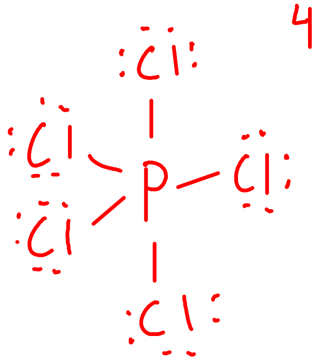
SHAPES OF EXPANDED VALENCE MOLECULES

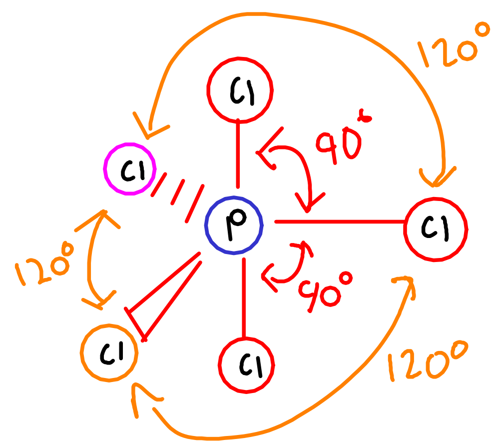
PCl_5: P : 5

Cl : 7 × 5

40

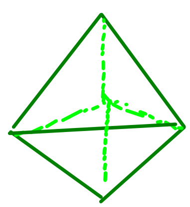


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



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.

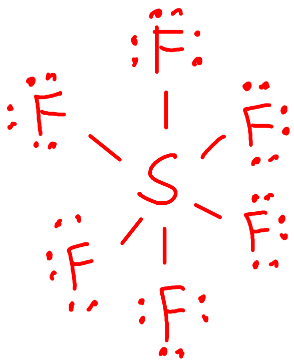


There are acually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

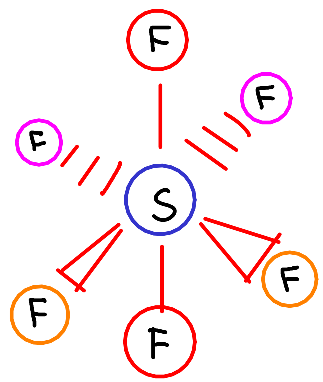
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!

SF_6:

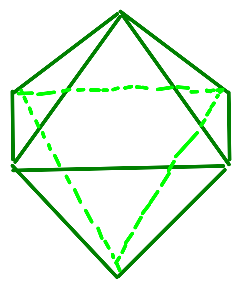
S: 6
F: 7x6
48



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



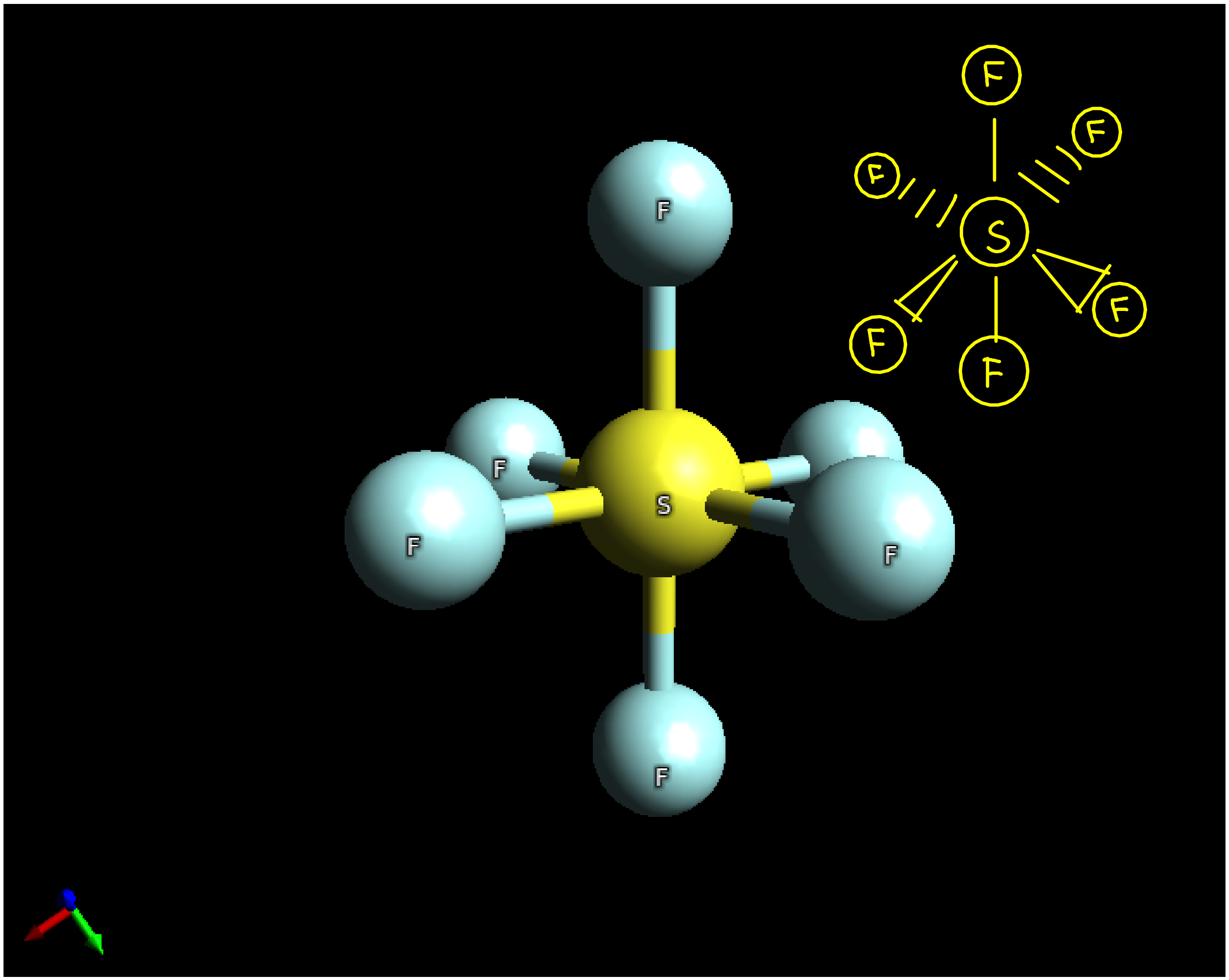
All bond angles in this arrangement are 90 degrees!



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!

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 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!

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

ELECTRONEGATIVITY TRENDS (AGAIN!)

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

INCREASING ELECTRO-NEGATIVITY

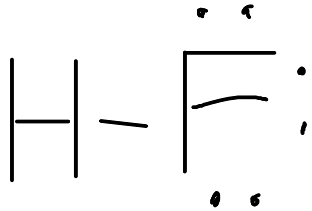
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA
2	Li	Be											B	C	N	O	F
3	Na	Mg											Al	Si	P	S	Cl
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
6	Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
7	Fr	Ra	Ac*	Rf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

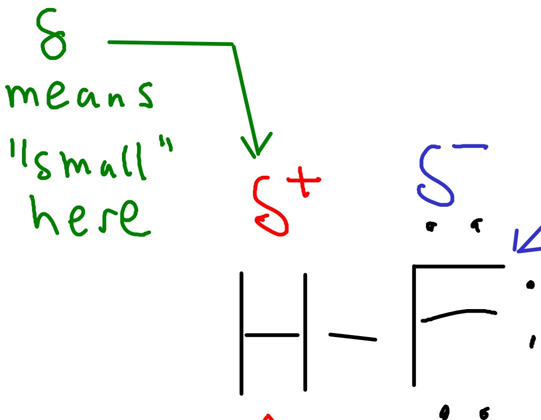
ELECTRONEGATIVITY EXAMPLE



2.1 4.0 — 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!



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

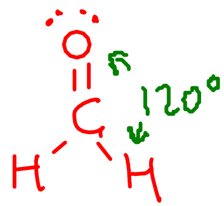
For a molecule to be polar, it must ...

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:

H_2CO

H : 1x2
C : 4
O : 6
12

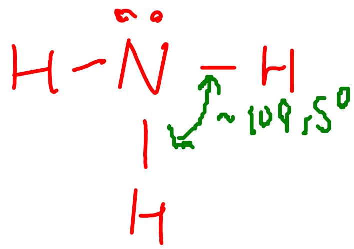


Shape? This is a TRIGONAL PLANAR molecule. There are THREE THINGS around the central atom: =O, -H, -H

Polar? C-H bonds are NONPOLAR, but C=O bonds are POLAR. We expect the molecule to be POLAR, since the oxygen end of the structure should pull electrons away from the other end, giving the molecule a negative side and a positive side.

NH_3

N : 5
H : 1 x 3
8

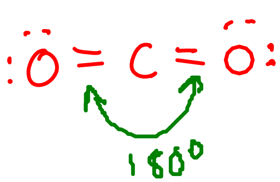


Shape? PYRAMIDAL. There are four things around the central nitrogen, but only three are atoms. Tetrahedral bond angles (109.5), but pyramidal shape.

Polar? N-H bonds are polar. We expect nitrogen to pull electrons towards itself, making the "top" of the pyramid negative and the "bottom" of the pyramid positive. This molecule should be POLAR.

CO_2

C : 4
O : 6 x 2
16

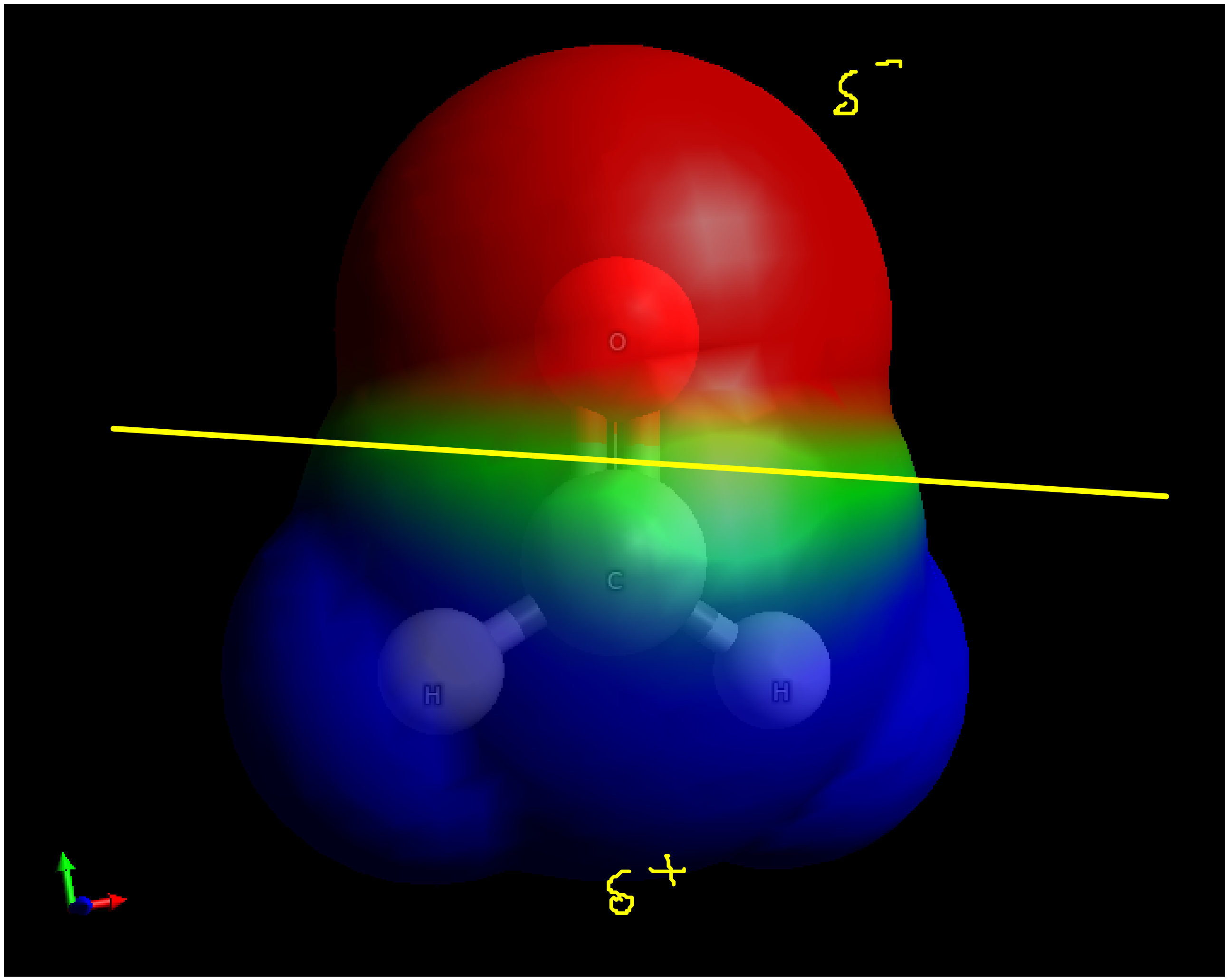


Shape: LINEAR. Only two groups around the central atom

Polarity: C=O bonds are POLAR, but they're arranged symmetrically around the carbon atom. They balance each other out, and the result is a NONPOLAR molecule!

H_2CO

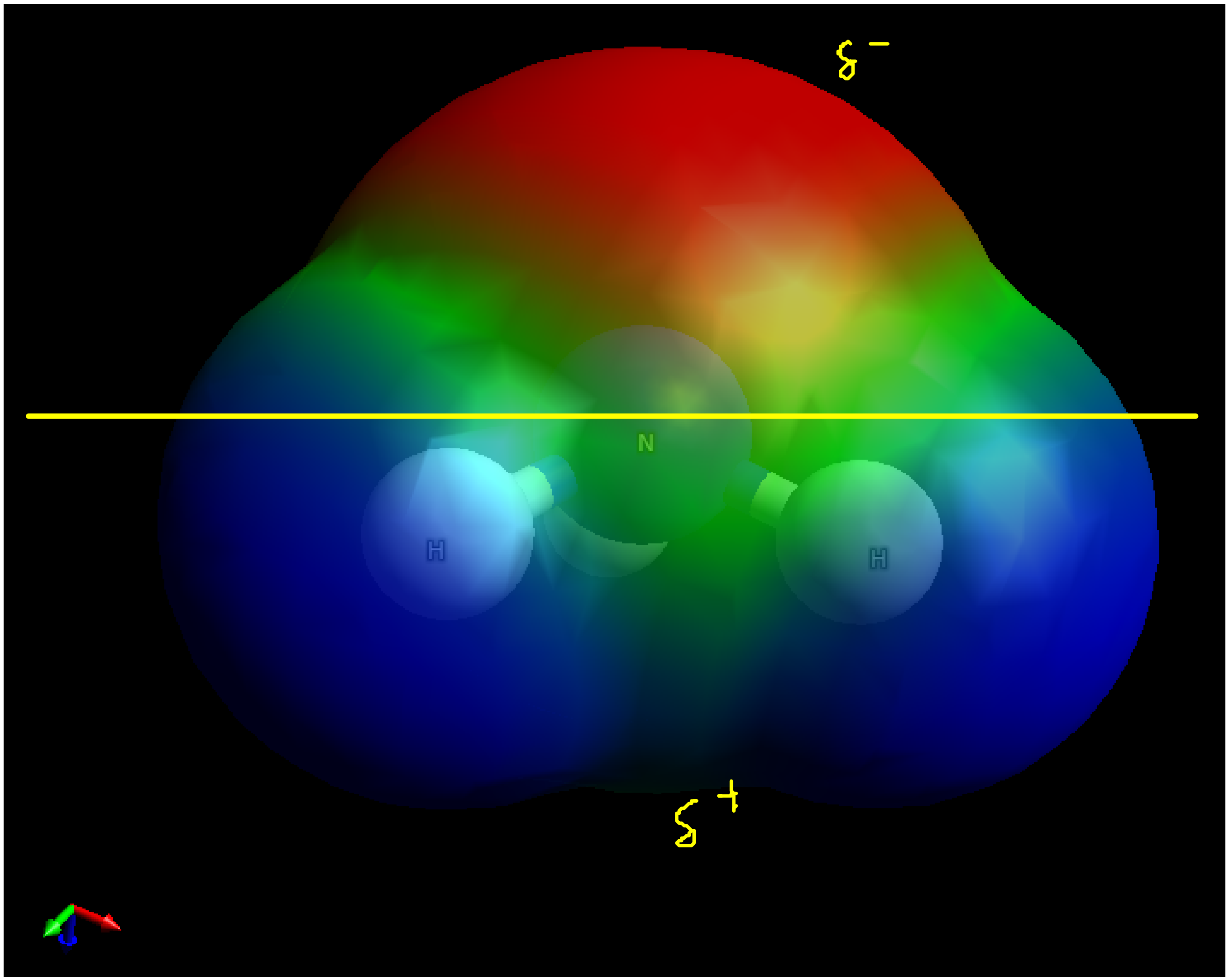
This ball-and-stick model shows electrostatic potential - red for more negative and blue for more positive



oxygen "side", slightly negative

hydrogen "side", slightly positive

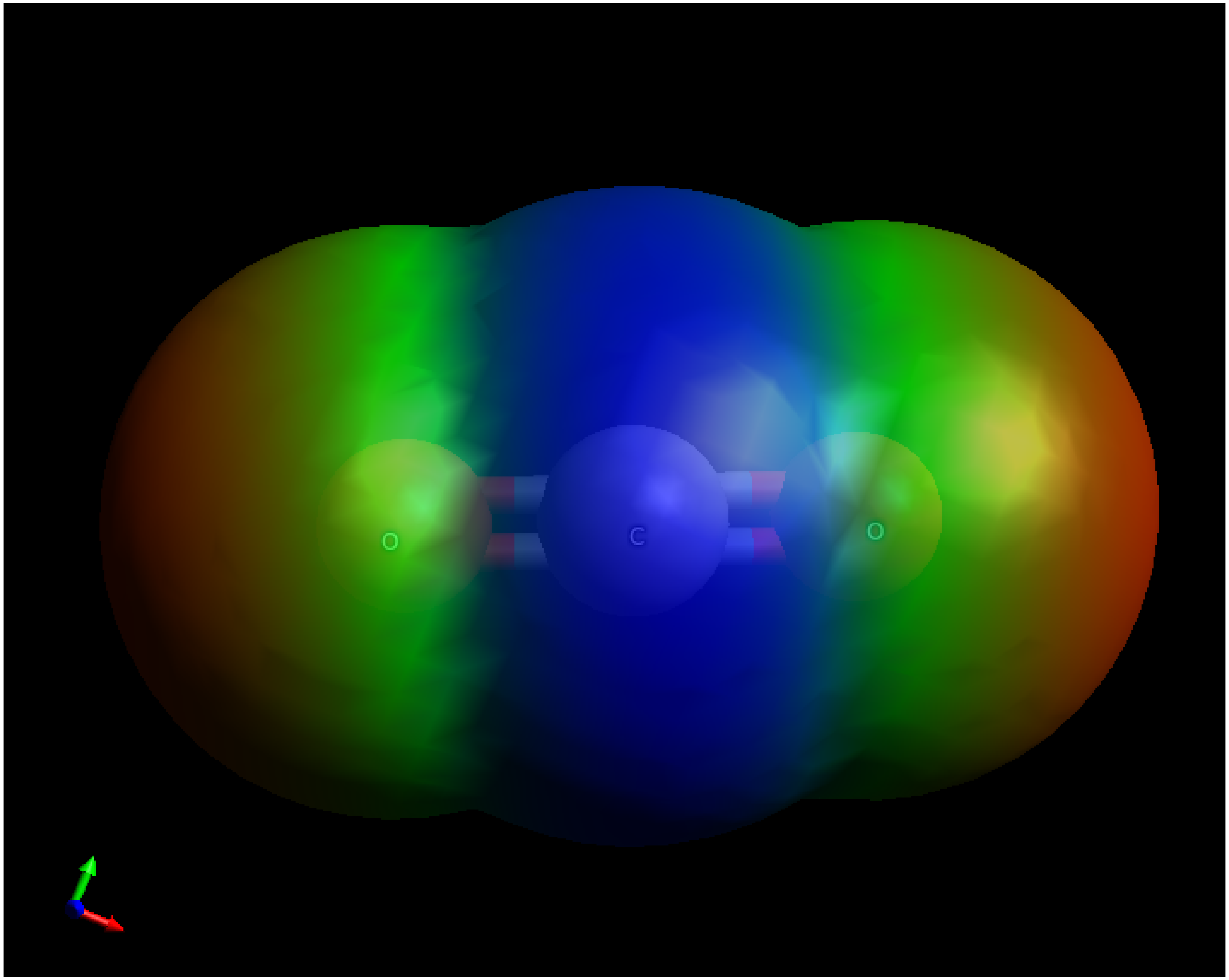
NH_3



nitrogen "side"
slightly negative

hydrogen "side"
slightly positive

CO_2

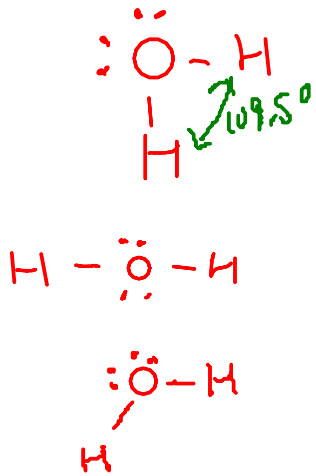


This molecule is NONPOLAR. No positive "side" or negative "side"

EXAMPLES

Water, H_2O

H: 2x1
O: 6
—
8



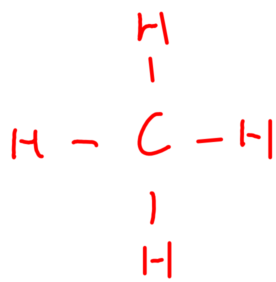
Shape: BENT. Four things around the central atom (so tetrahedral bond angles), but only two are atoms.

Polarity? POLAR. O-H bonds are polar.Oxygen pulls electrons towards itself, giving the oxygen "side" of the molecule a negative charge and the hydrogen "side" a positive charge.

---

methane, CH_4

C: 4
H: 4x1
—
8



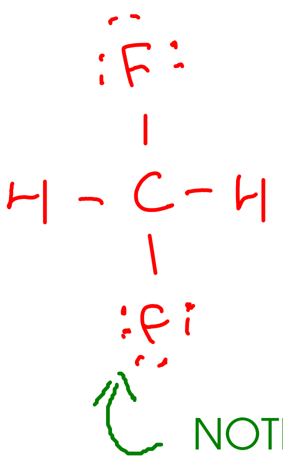
Shape? TETRAHEDRAL. Four atoms around the central carbon atom.

Polar? C-H bonds are nonpolar, so molecule is NONPOLAR

"difluoromethane"

CH_2F_2

C: 4
H: 2x1 = 2
F: 2x7 = 14
—
20

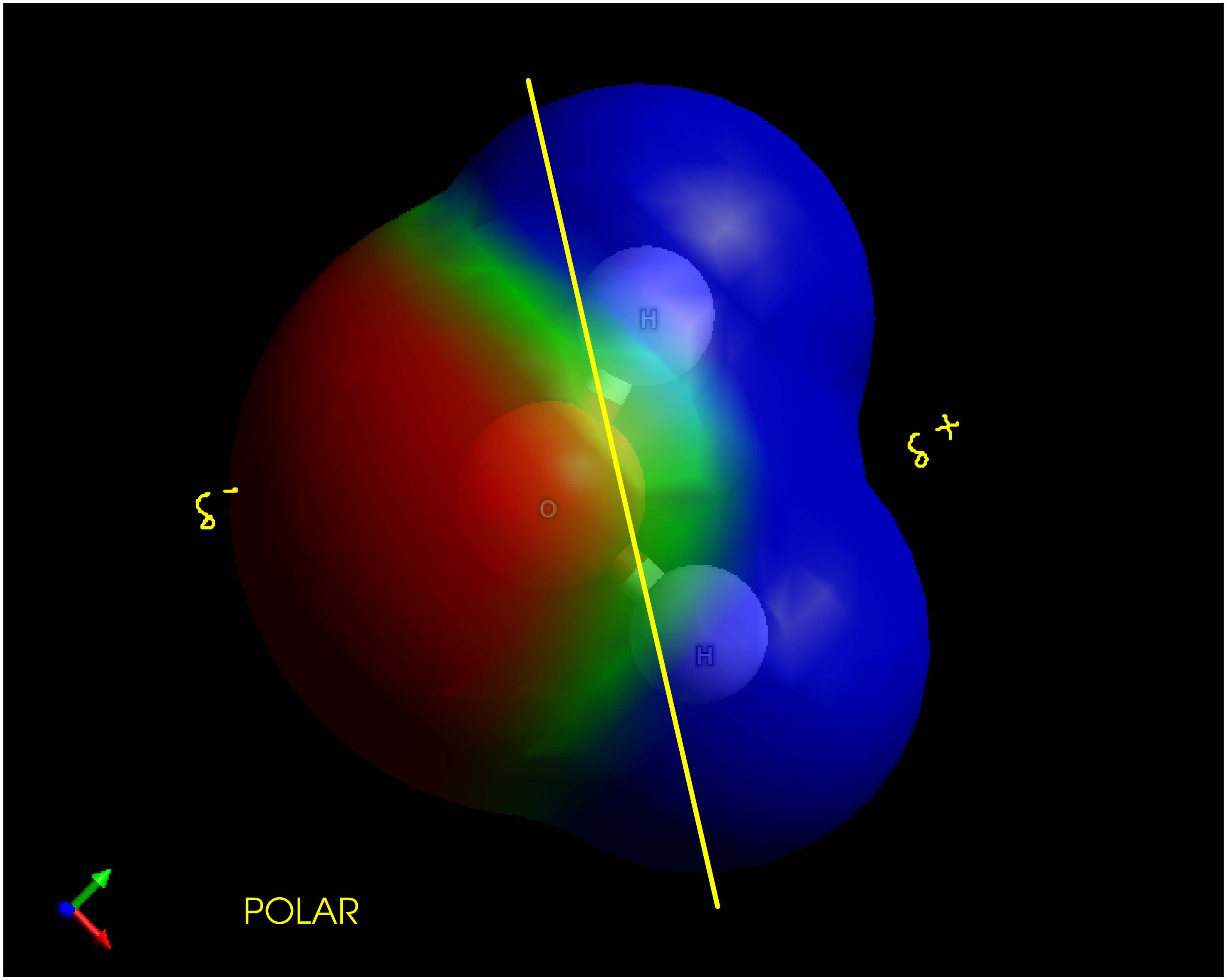


Shape? TETRAHEDRAL. Four atoms around the central carbon atom.

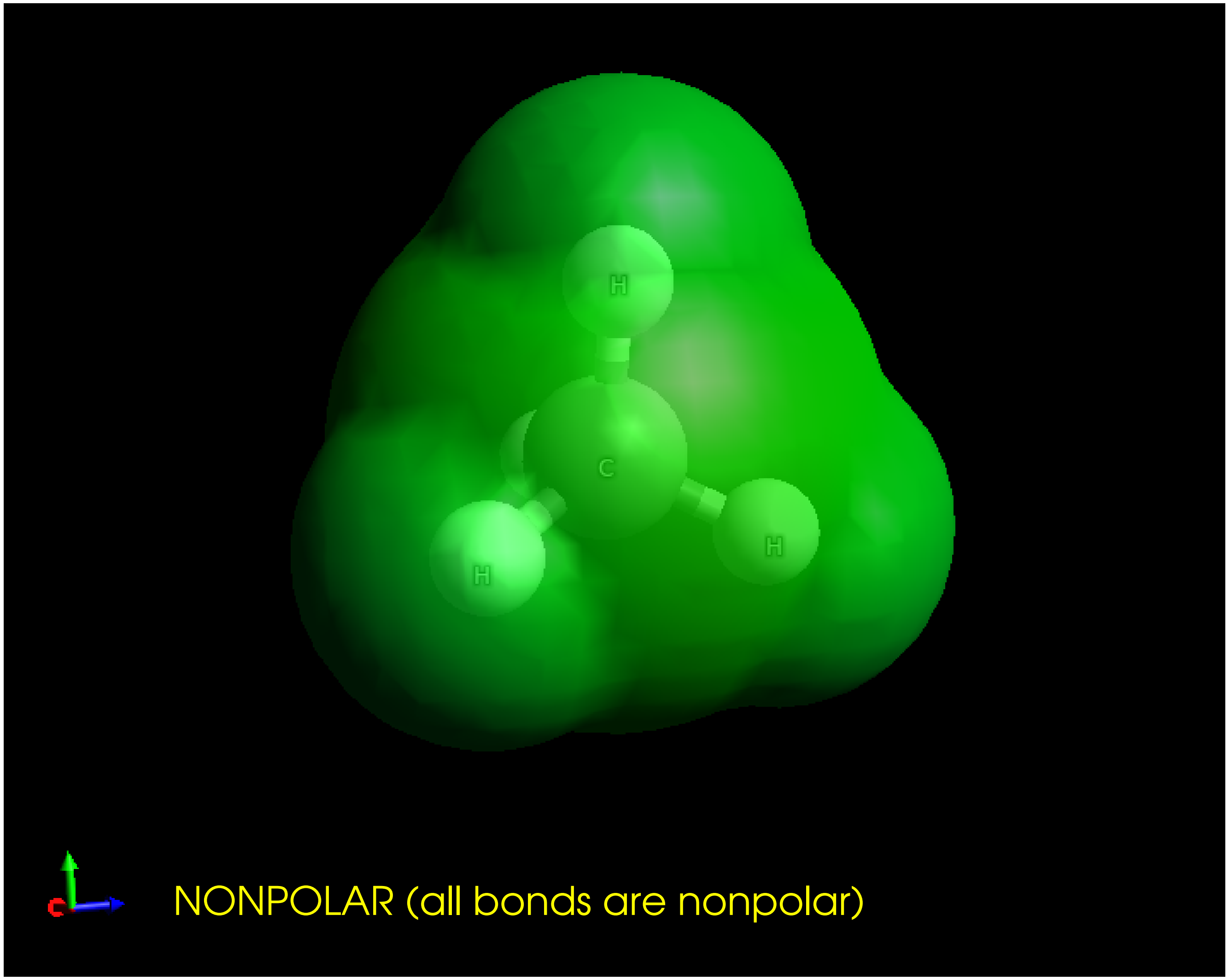
Polar? C-H bonds are nonpolar, but C-F bonds are polar. The molecule is POLAR, since the fluorine atoms will pull electrons towards their "side" of the structure.

NOTE: This lewis structure is correct, but a bit deceptive, since the fluorines APPEAR to be on opposite sides of the molecule

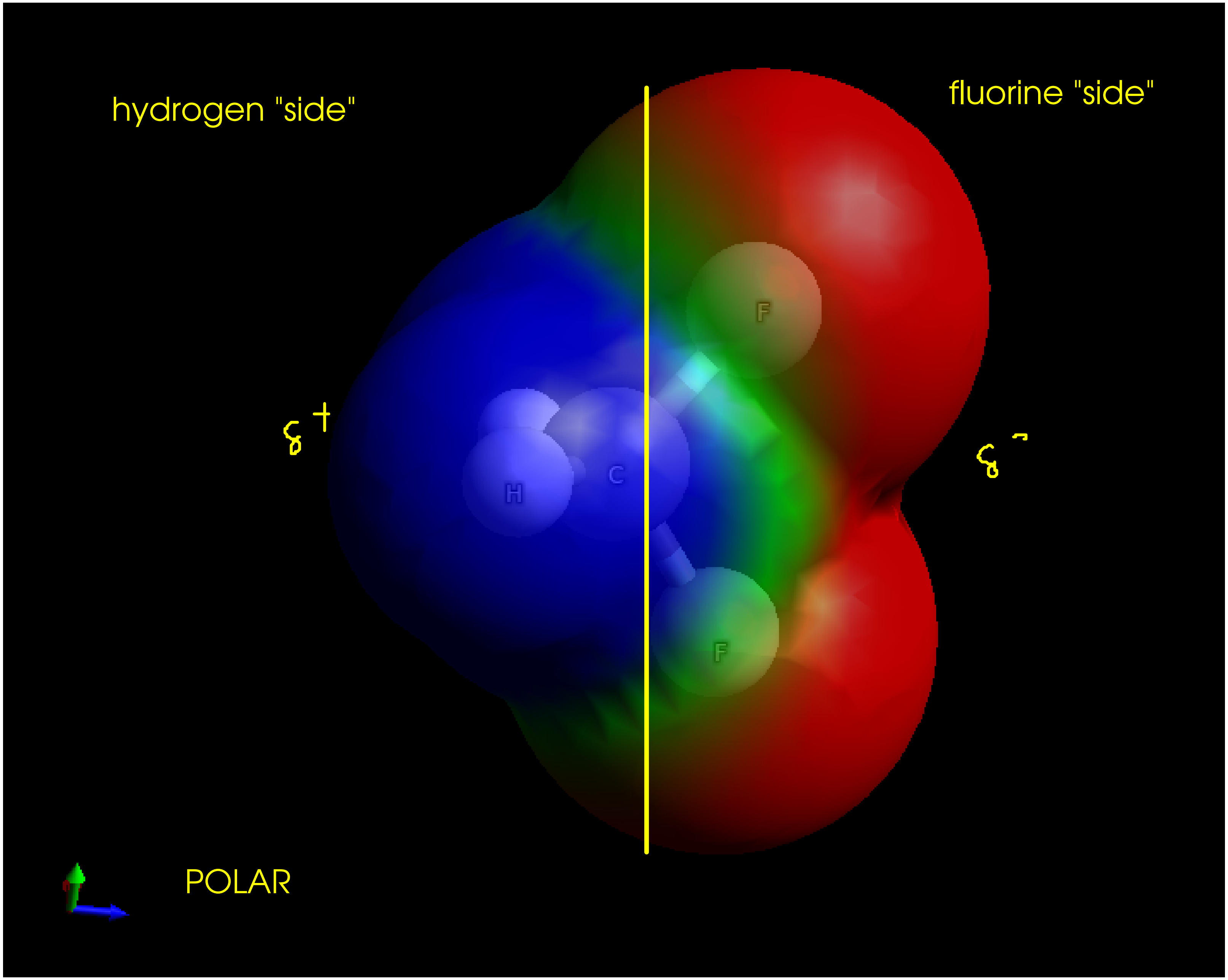
H_2O



CH_4



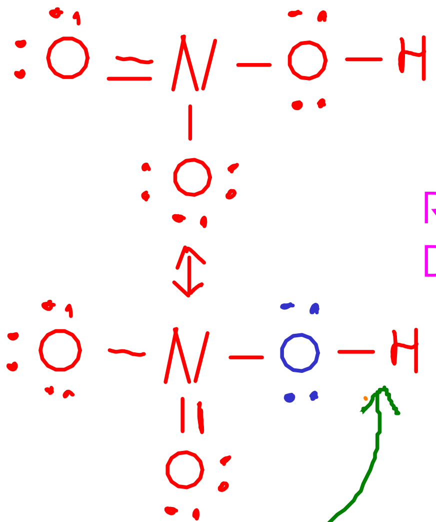
CH_2F_2



HNO_3

H : 1
N : 5
O : 6 x 3
24

Start drawing skeleton by recognizing that this compound is an OXYACID .... hydrogen attached to a polyatomic ion.



Resonance structures. The oxygen bonded to the nitrogen have a DELOCALIZED bond.

Shape? The nitric acid molecule has TWO "central" atoms - nitrogen and one oxygen, so we should describe the shape around each one. Around the NITROGEN, the shape is TRIGONAL PLANAR. The molecule is BENT around the OXYGEN atom (in blue)

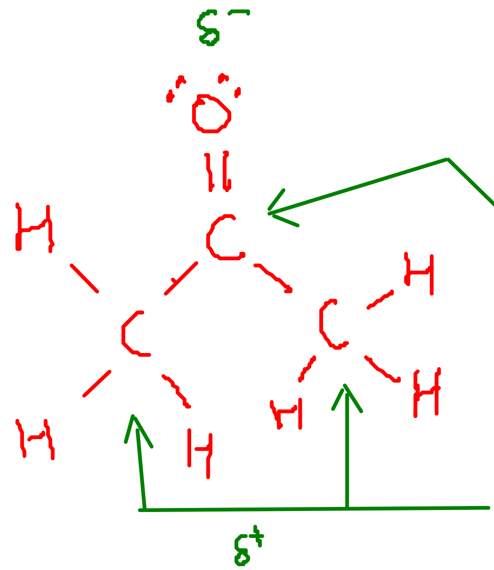
Polar? We expect a polar molecule because electron density will be pulled away from the acidic HYDROGEN atom, giving that side of the molecule a slight positive charge.

In water, the acidic hydrogen can be pulled off of the molecule by a water molecule, losing its shared electrons to the oxygen atom!

CH_3COCH_3 (acetone)

C: 4x3
H: 1x6
O: 6
24

Look at the formula of acetone. The way it's written gives us a clue to the structure. There are THREE carbon centers in this molecule!



Shape? Describe the shape around each carbon center.

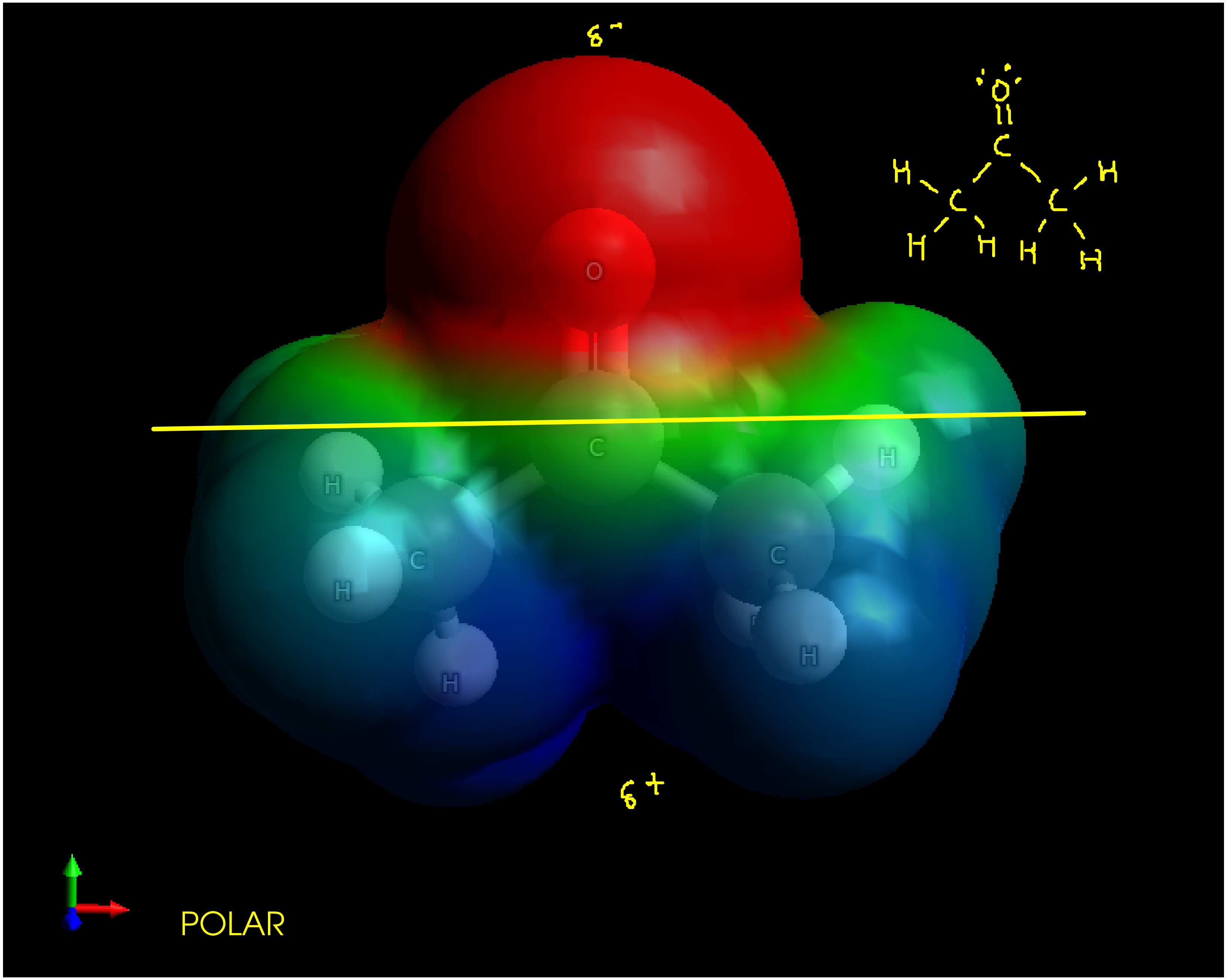
this carbon has a TRIGONAL PLANAR shape, since it's surrounded by three atoms and no lone pairs.

These two carbon atoms are TETRAHEDRAL, since each is surrounded by four atoms.

Polar? C-H bonds are nonpolar, but C=O bonds are polar. Electron density should be pulled towards the oxygen atom, creating a POLAR molecule

Experimentally, we find that acetone mixes very well with polar solvents like WATER.

CH_3COCH_3 "acetone"



POLARITY AND MOLECULAR PROPERTIES

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