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

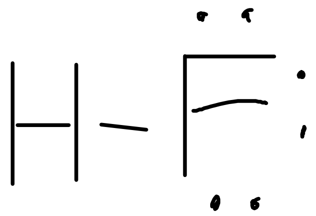
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA
2	Li	Be											B	C	N	O	F
3	Na	Mg											Al	Si	P	S	Cl
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I
6	Cs	Ba	~~La~~ *	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At
7	Fr	Ra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

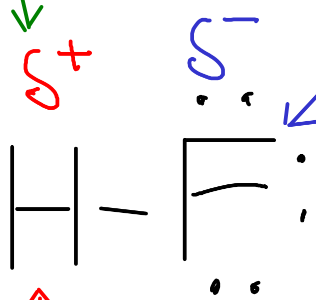


2.1 4.0 — Electronegativity values

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!

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

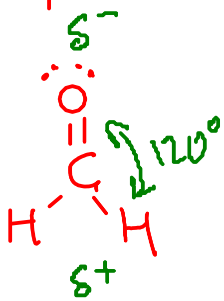
For a molecule to be polar, it must ...

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:

H_2CO

H : 1x2
C : 4
O : 6
| 12

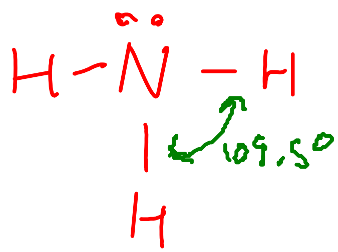


Shape? TRIGONAL PLANAR, since there are three things (O=, H-, H-) around the central carbon.

Polar? POLAR, because the C=O bond is polar and not "canceled" out by any other equally polar bonds.

NH_3

N : 5
H : 1 x3
8

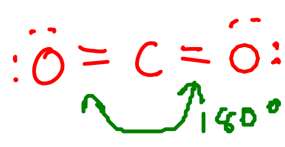


Shape? PYRAMIDAL molecule. There are three atoms attached to nitrogen, and a lone pair (which functions as another atom, at least in terms of taking up space). Angles are tetrahedral, but shape is described as pyramidal.

Polar? N-H bonds are polar, and the molecule has a nitrogen "side" (top of the pyramid) and a hydrogen "side" (bottom of the pyramid). Electrons are drawn to nitrogen, giving a POLAR molecule.

CO_2

C : 4
O : 6 x2
16

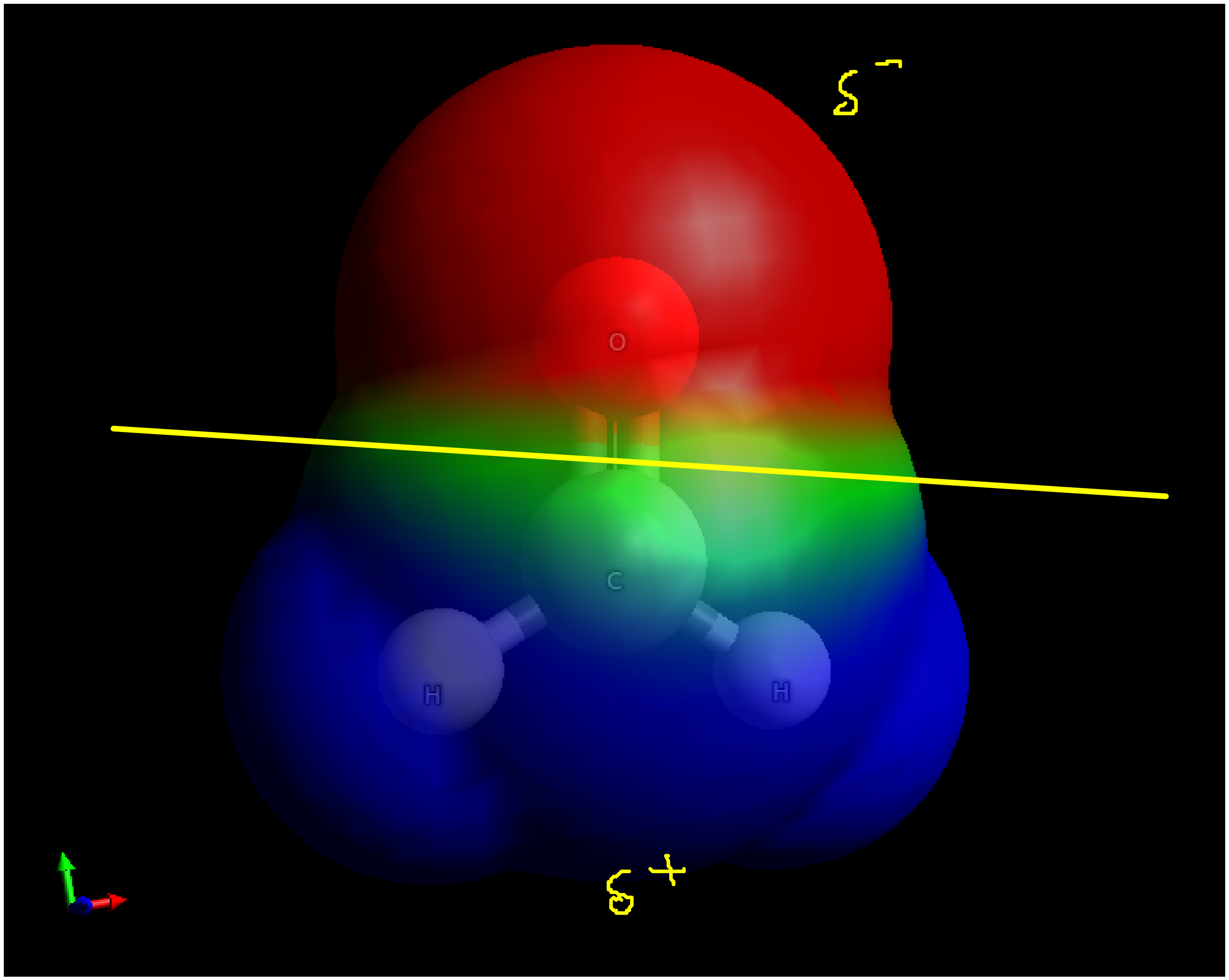


Shape? LINEAR, since there are two oxygen atoms bonded to the carbon and no lone pairs on the carbon.

Polar? C=O bonds are polar. BUT they pull against one another and the overall result is a NONPOLAR molecule.

H_2CO

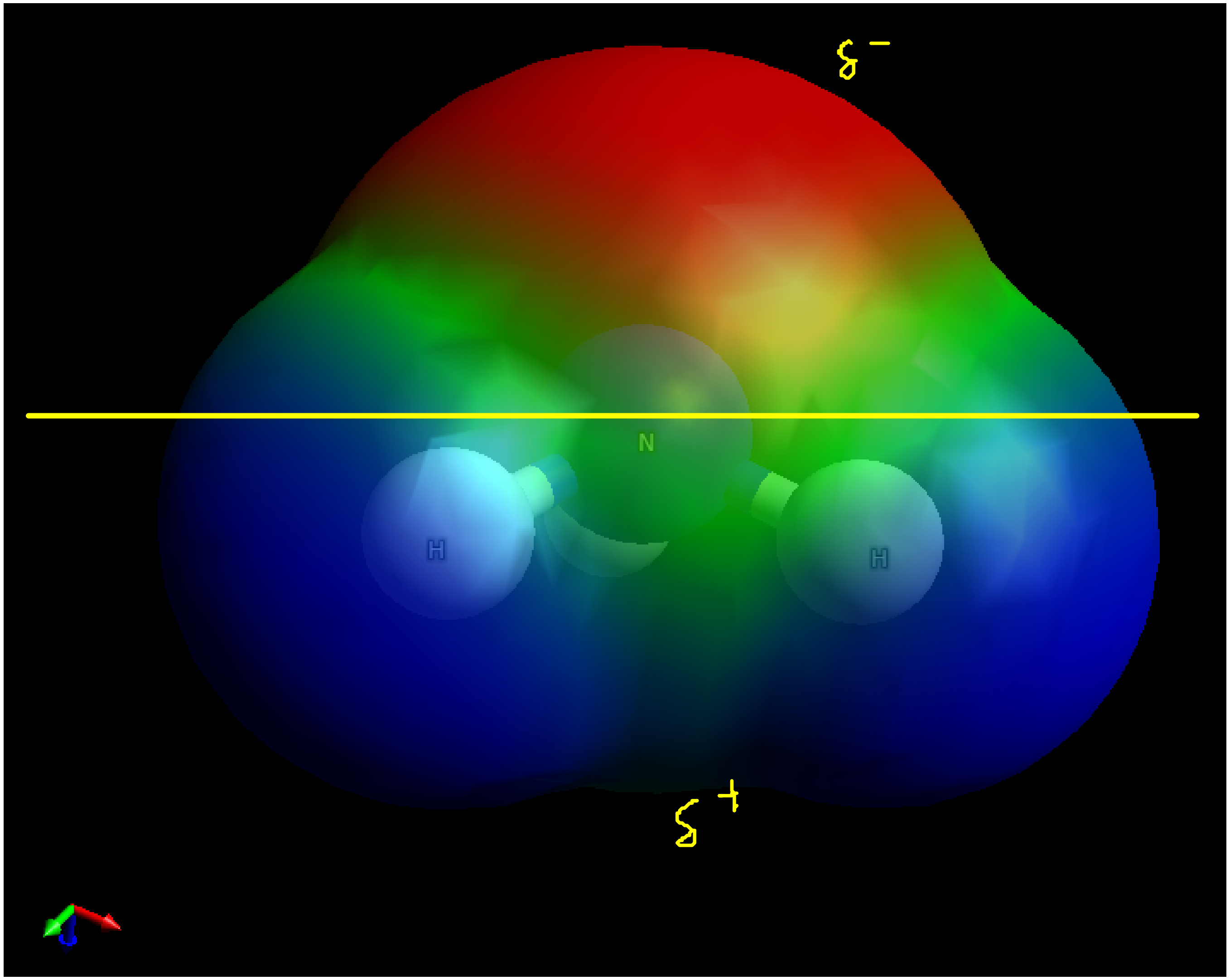
This ball-and-stick model shows electrostatic potential - red for more negative and blue for more positive



oxygen "side", slightly negative

hydrogen "side", slightly positive

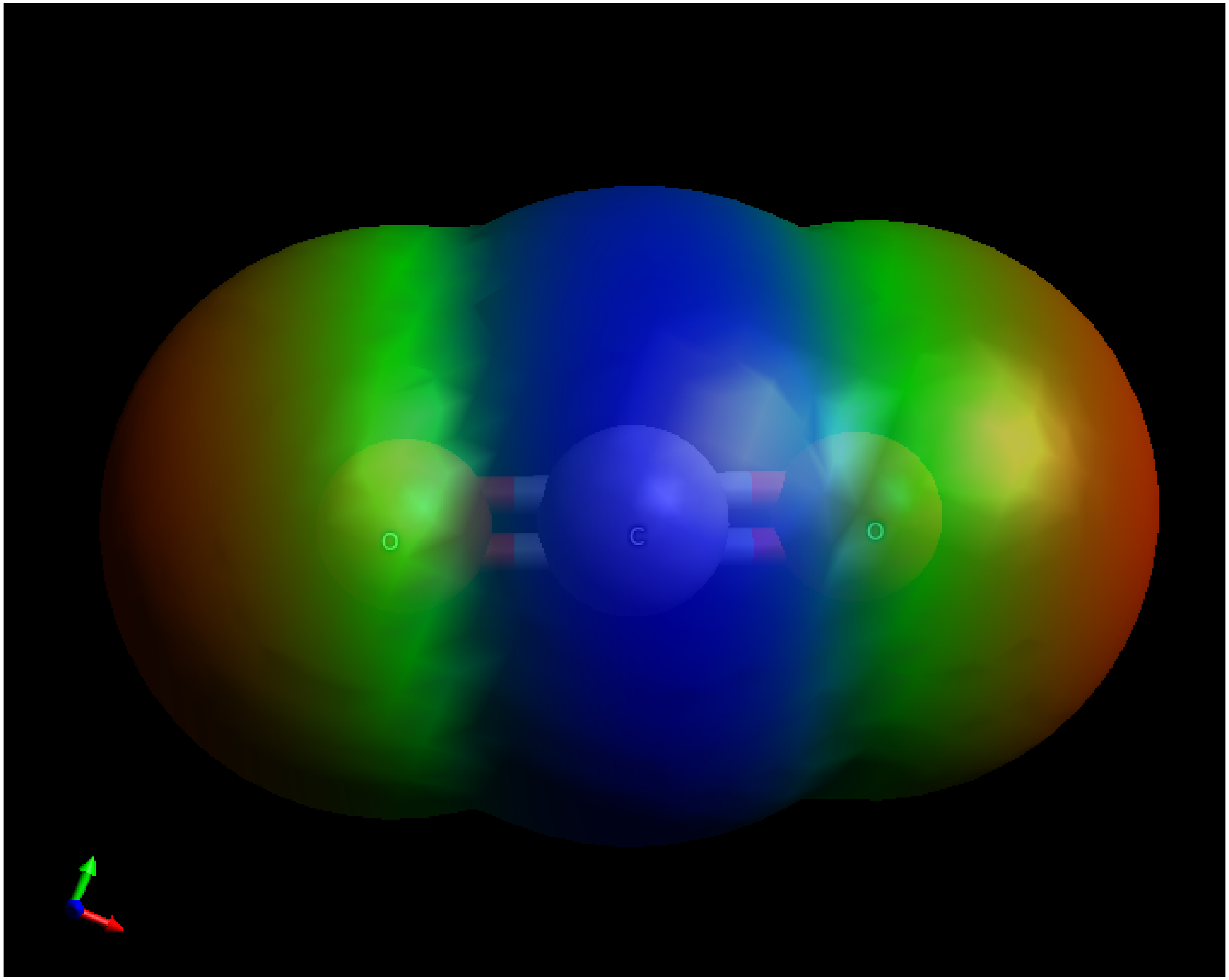
NH_3



nitrogen "side"
slightly negative

hydrogen "side"
slightly positive

CO_2



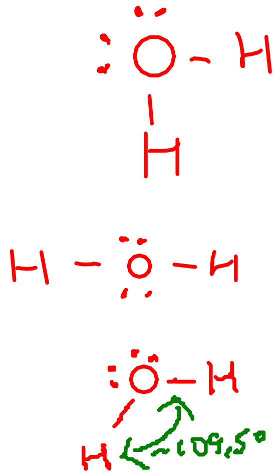
This molecule is NONPOLAR. No positive "side" or negative "side"

EXAMPLES

Water, H_2O

H: 2 x 1
O: 6

8



Shape? Two hydrogen atoms around the oxygen, AND two lone pairs. So, the bond angles are tetrahedral, and the shape is described as BENT.

Polar? POLAR molecule, since electrons are pulled towards the OXYGEN end of the molecule. Oxygen is slightly negative and the hydrogen atoms are slightly positive

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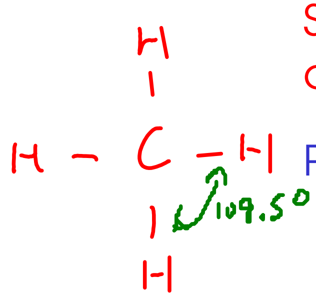
methane, CH_4

C: 4
H: 4 x 1

8



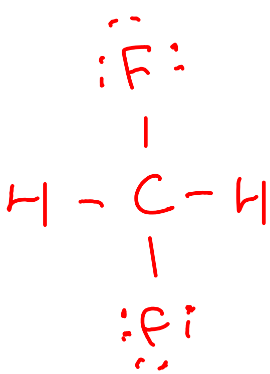
Shape? Four hydrogen atoms around the carbon center and no lone pairs, so TETRAHEDRAL.

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

CH_2F_2

C: 4
H: 2 x 1 = 2
F: 2 x 7 = 14

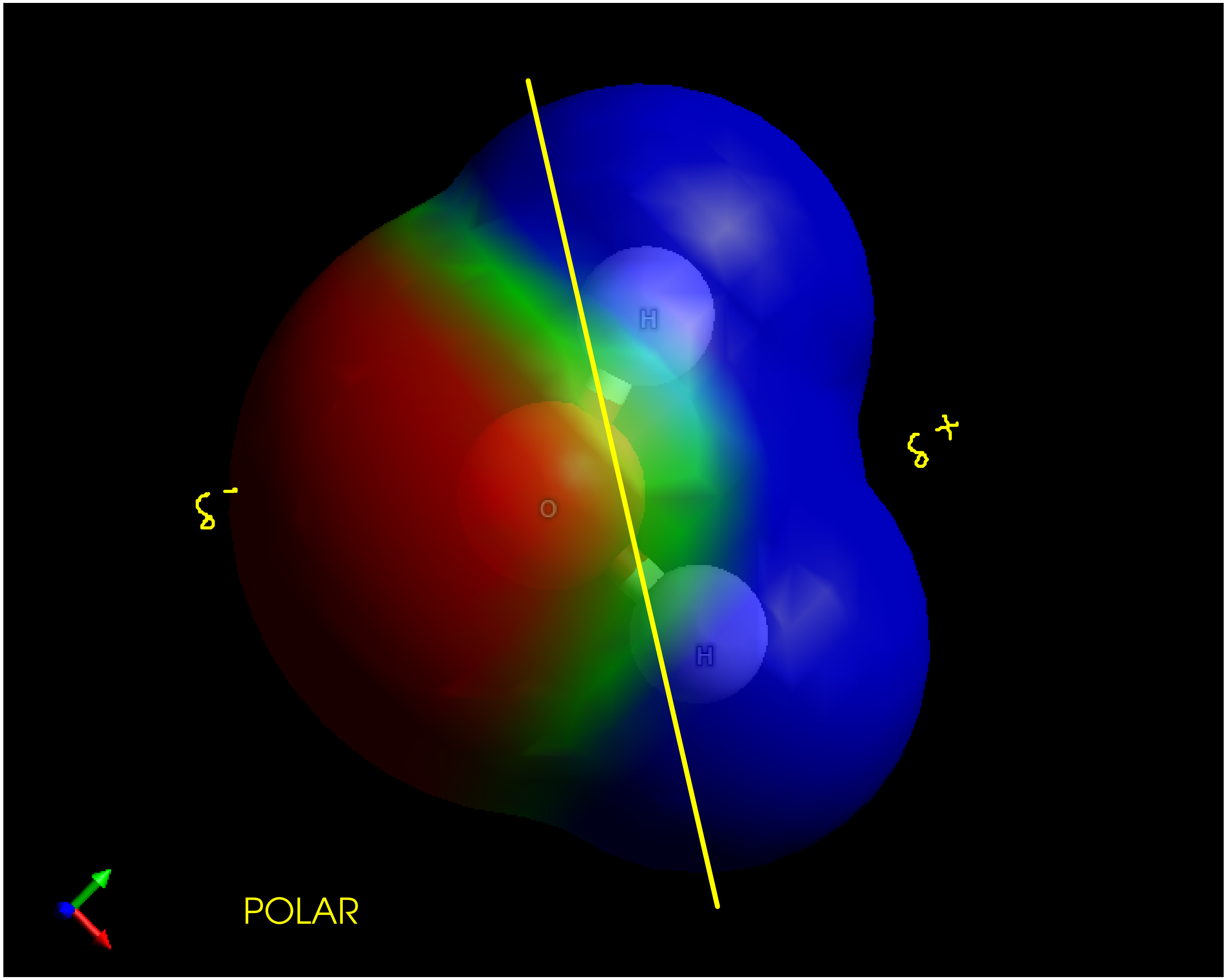
20



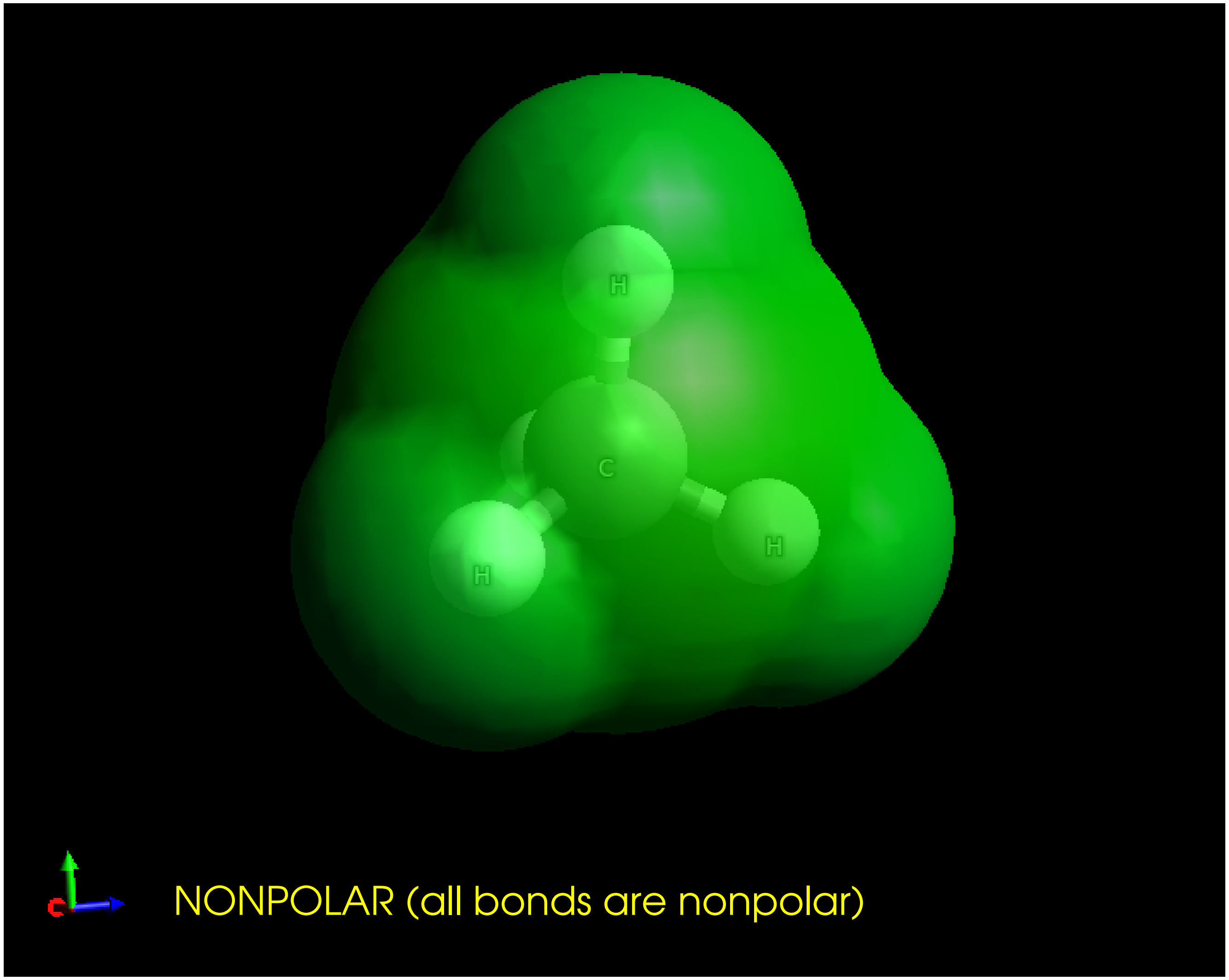
Shape? TETRAHEDRAL (like the methane molecule)

Polar? C-F bonds are polar, C-H bonds are nonpolar. In three dimensions, we see that the fluorine atoms are on the same side of the molecule, while the hydrogen atoms are on the other, This will give a POLAR molecule, with the fluorine side being slightly negative, and the hydrogen side being slightly positive.

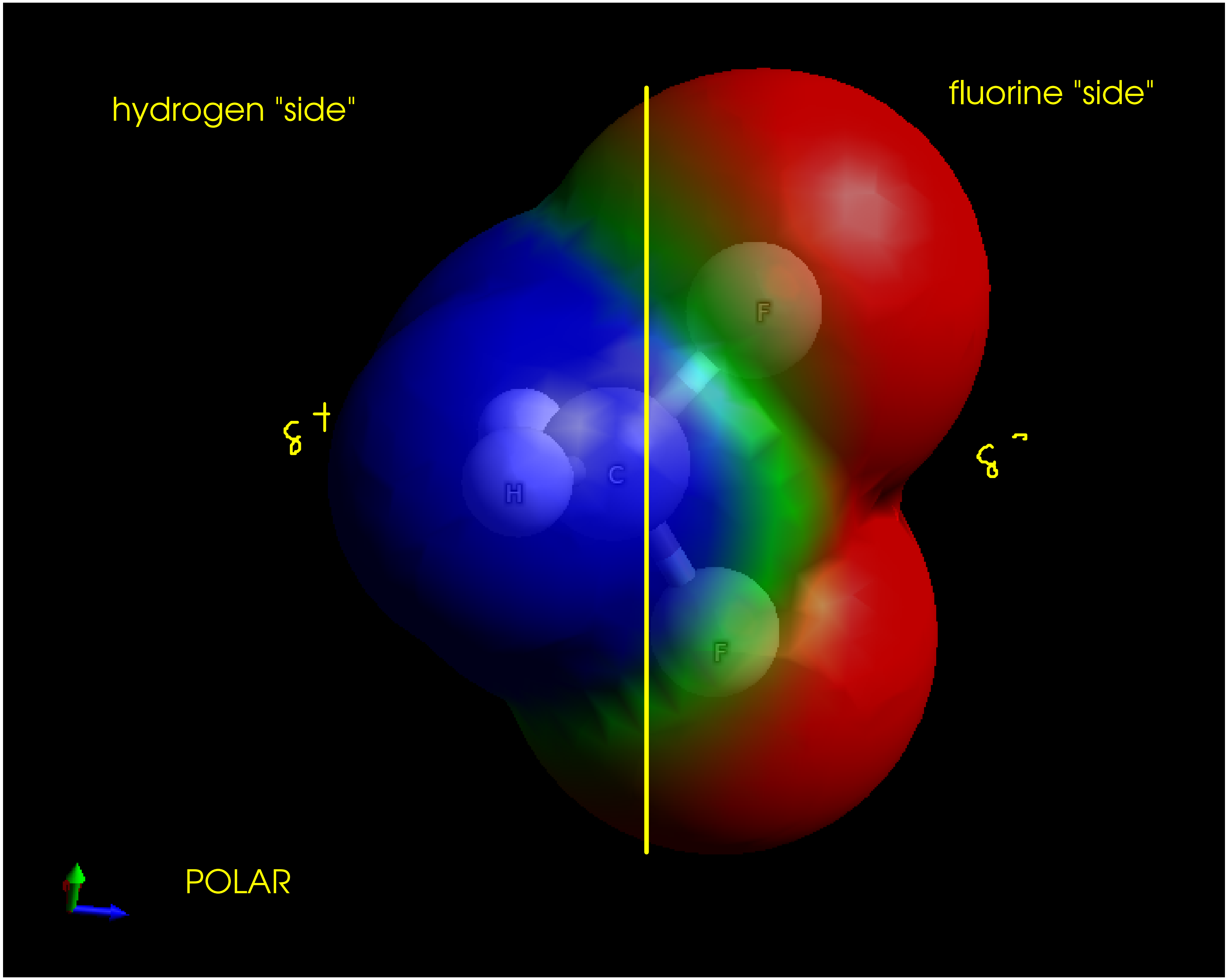
H_2O



CH_4



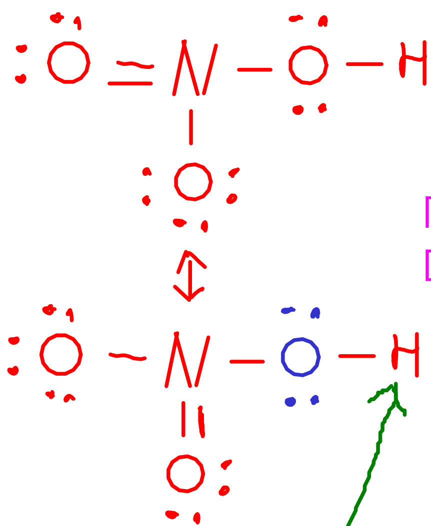
CH_2F_2



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? This molecule has TWO central atoms, the NITROGEN and the oxygen (with hydrogen attached). Around the nitrogen atom, the shape is TRIGONAL PLANAR, since there are three oxygen atoms and no lone pairs around nitrogen. Around the oxygen center (in blue), the shape is BENT - two atoms and two lone pairs.

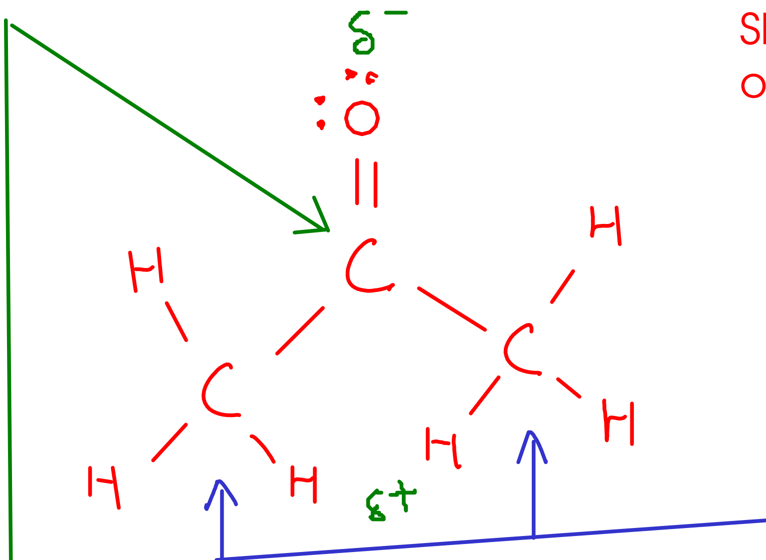
Polar? The N-O bonds should be slightly polar, but the O-H bond is quite polar. Electrons are withdrawn from hte hydrogen, making it the positive end of the molecule, while the oxygen atom serves as the negative side.

In water, this "acidic" hydrogen atom can be removed from,the HNO3 moelcule by a water molecule, forming "H+" and nitrate ion.

CH_3COCH_3 (acetone)

C : 4 x 3
H : 1 x 6
O : 6
24

The formula provides a clue to the skeletal structure of the molecule. There are three carbon centers in this molecule!



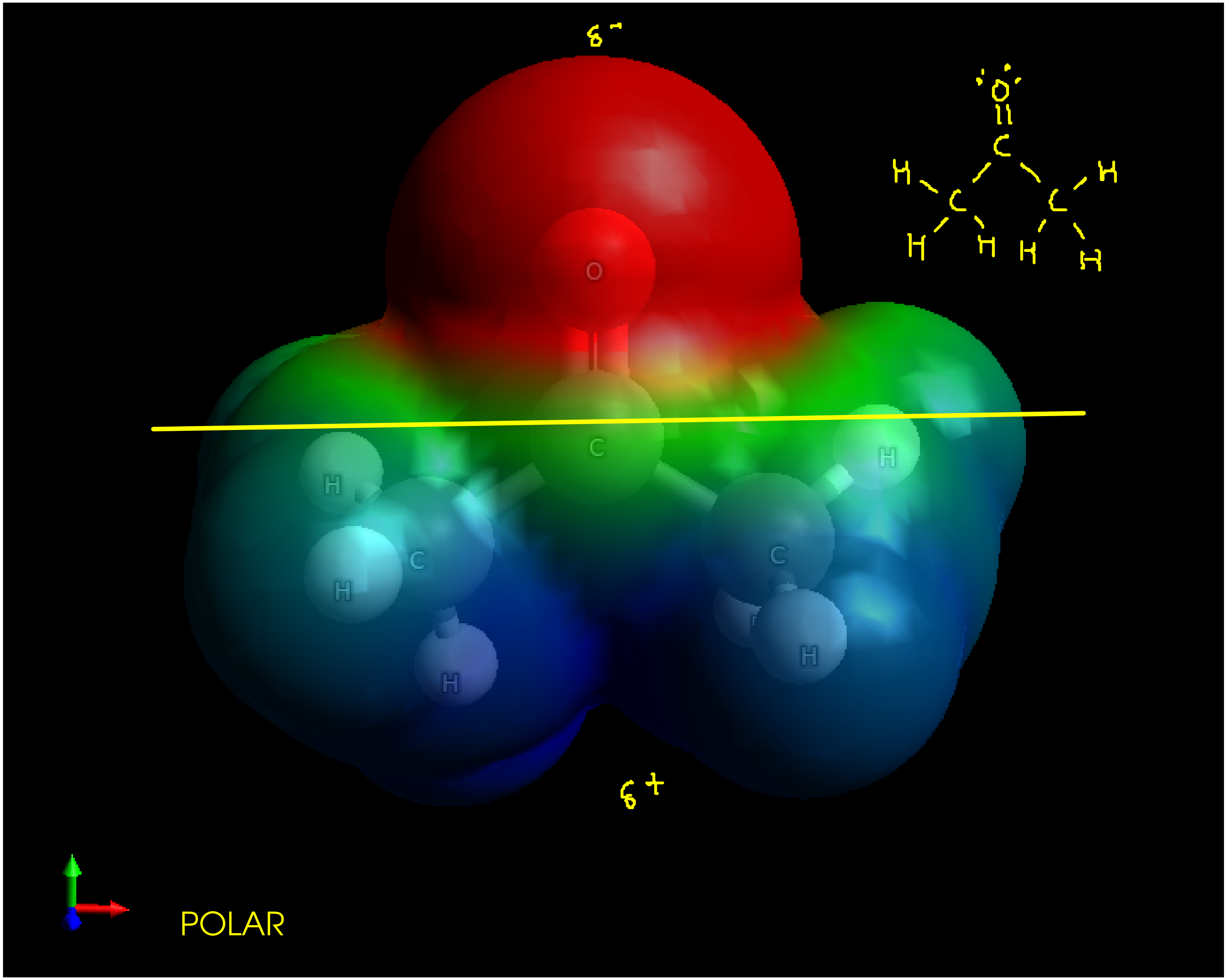
Shape? We need to describe the shape around each of the three carbon centers.

These two carbon atoms are both TETRAHEDRAL, since each is surrounded by four atoms and no lone pairs.

This carbon atom is TRIGONAL PLANAR, since it's surrounded by three atoms and no lone pairs.

Polar? C-H and C-C bonds are nonpolar, but C=O is polar. Electrons will be pulled towards the oxygen end of the molecule, resulting in a POLAR molecule.

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