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

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

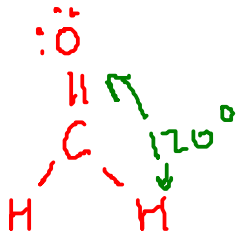
For a molecule to be polar, it must ...

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 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.

CO_2

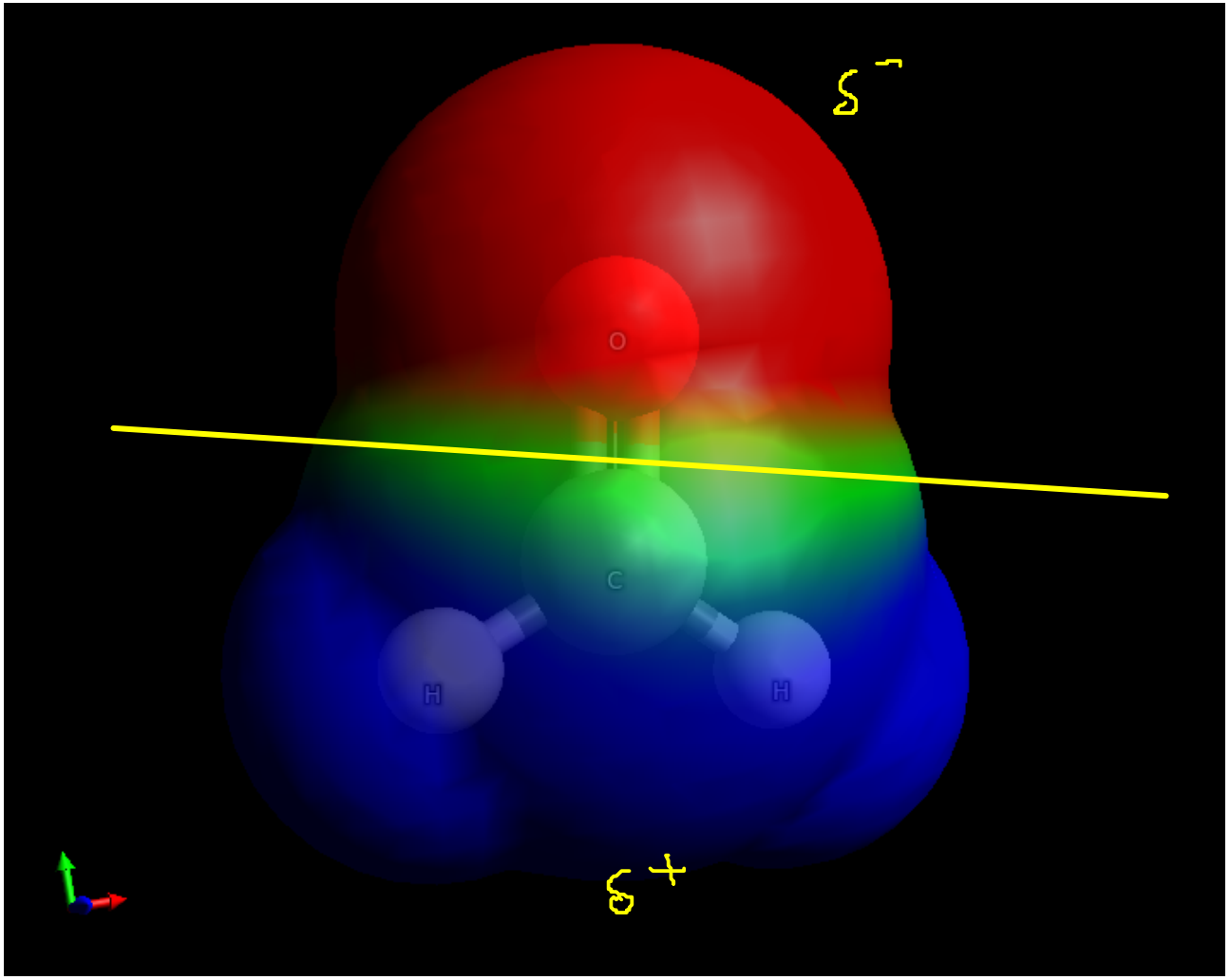
C : 4
O : 6x2
16

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.

H_2CO

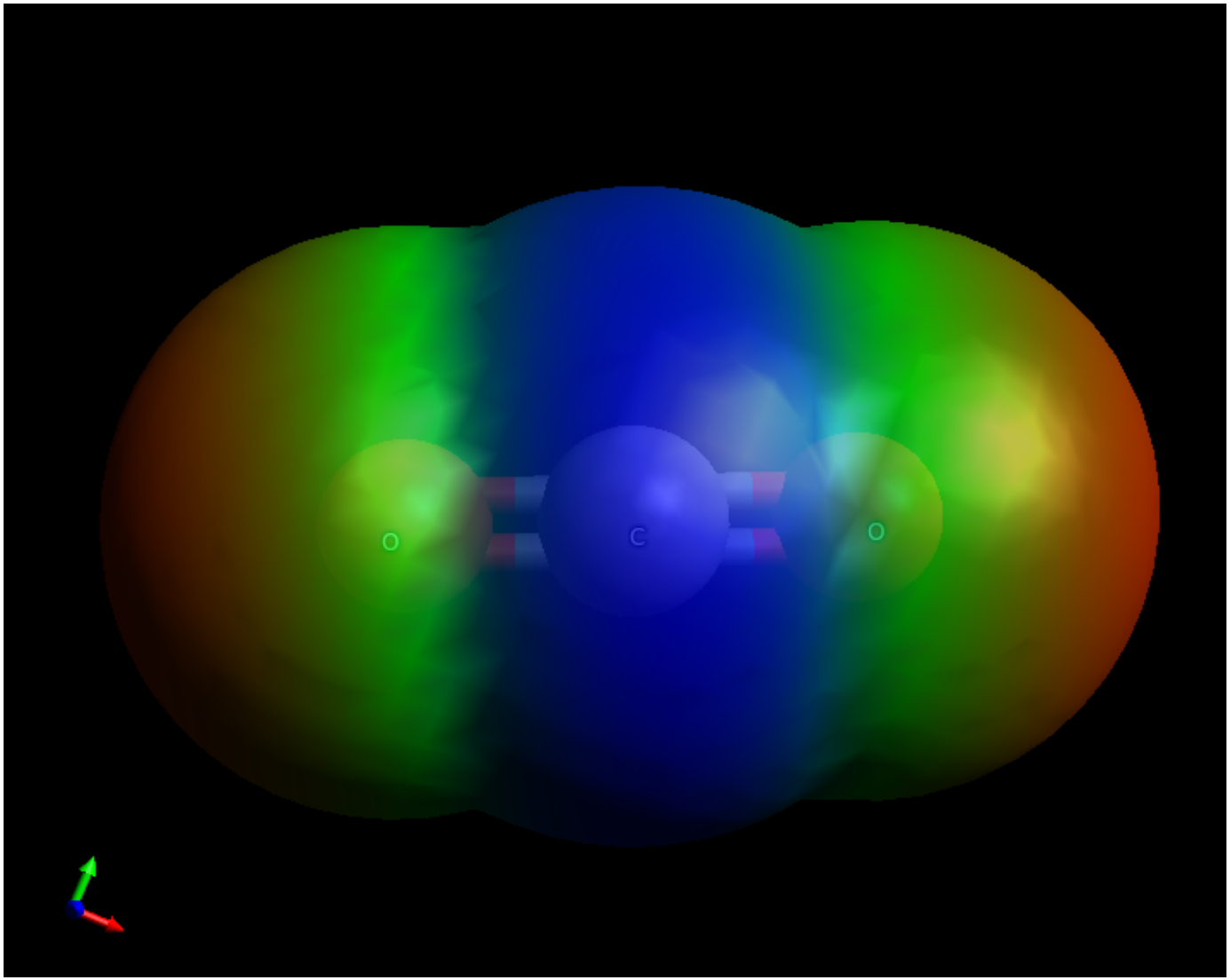
This ball-and-stick model shows electrostatic potential - red for more negative and blue for more positive



oxygen "side", slightly negative

hydrogen "side", slightly positive

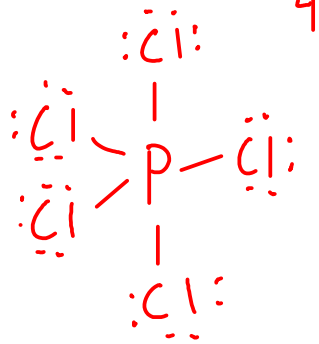
CO_2



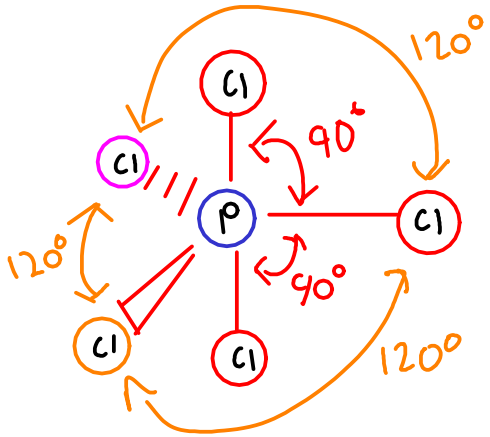
This molecule is NONPOLAR. No positive "side" or negative "side"

SHAPES OF EXPANDED VALENCE MOLECULES

PCl_5 : P : 5
Cl : 7 × 5
40

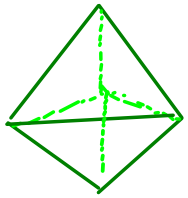


There are five atoms bonded to the central phosphorus atom, and they will attempt to get as far apart as possible from one another!



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.

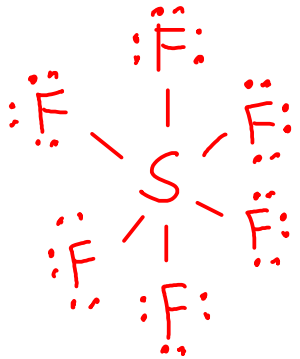


There are acually two DIFFERENT bond angles in this structure. It's called TRIGONAL BIPYRAMIDAL.

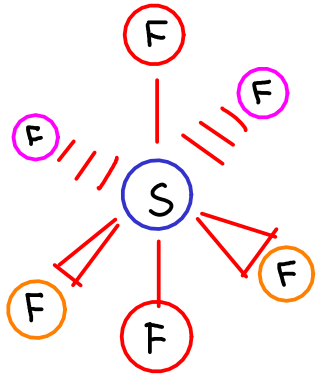
There are several derivatives of the trigonal bipyramidal shape (like the tetrahedral shape) - depending on how many things around the central atom are atoms!

SF_6 :

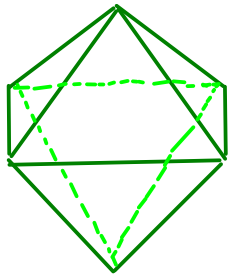
S : 6
F : 7x6
48



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



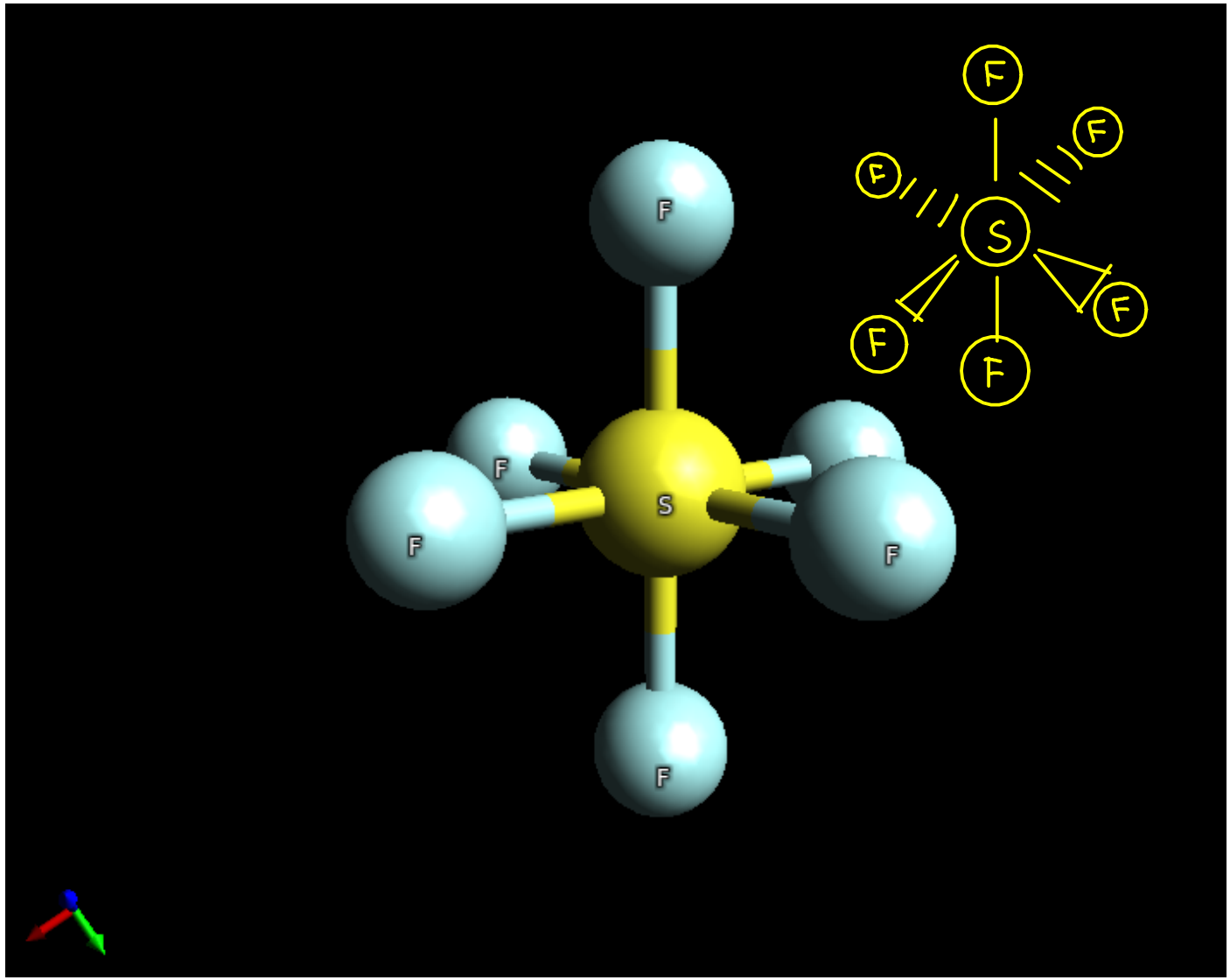
All bond angles in this arrangement are 90 degrees!



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:



Examples:

HCN

H: 1 x 1
C: 1 x 4 <- Pick C as central atom (needs more electrons than H or N...)
N: 1 x 5
10 valence e⁻

H – C – N Skeletal structure

H – C – N: Distribute remaining 6 electrons

H – C = N: Carbon doesn't have enough electrons. Let's make one of nitrogen's lone pairs into a bonding pair.

H – C ≡ N: Do it again, since carbon still needs more electrons.

Shape? LINEAR, since there are only two things attached to the central carbon atom.

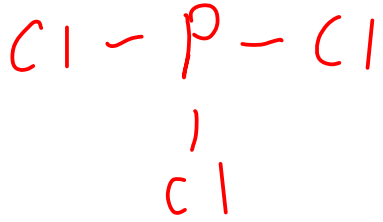
Polar? The carbon-nitrogen triple bond is polar. C-H is not. We expect electrons to be pulled towards the N side of the molecule ... POLAR.

PCl_3

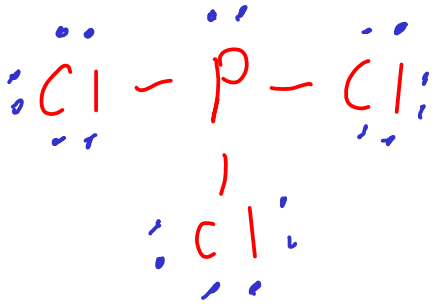
P: 1 x 5 ← Pick P as central atom (needs more electrons than Cl

Cl: 3 x 7 = 21

26 valence electrons



Skeletal structure



Distribute remaining 20 electrons...

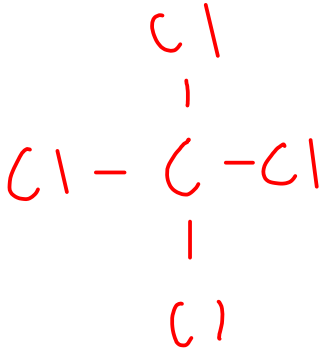
Shape? 4 thinngs around central atom gives tetrahedral (109.5) angles. Only three are other atoms (one lone pair), so this is a derivative of the tetrahedron. PYRAMIDAL
Polar? P-Cl bonds are polar. The molecule is POLAR since electrons would be pulled away from the phospohorus "tip" of the pyramid and towards the chlorine "base".

CCl_4

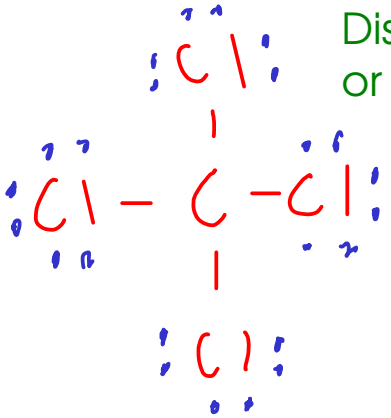
C: 1 x 4 = 4 <- Carbon atom is central

Cl: 4 x 7 = 28

32 e⁻



skeletal structore



Distribute electrons. No double or triple bonds needed here.

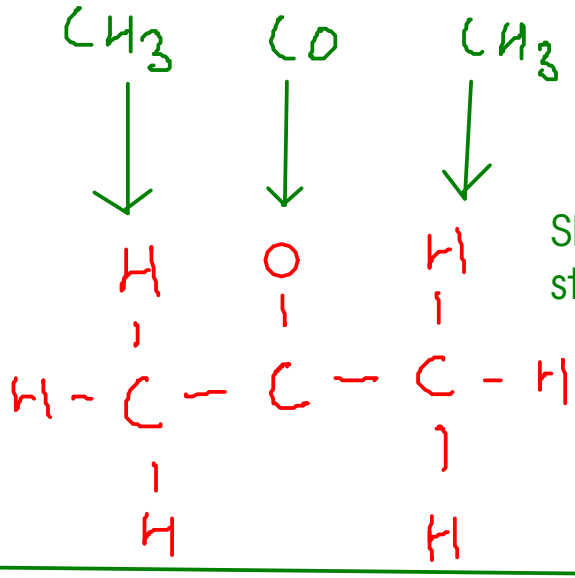
Shape? Four things around the central atom, all are other atoms. TETRAHEDRAL.

Polar? C-Cl bonds are polar. but they are arranged symmetrically around the central carbon and cancel each other out ... NONPOLAR.

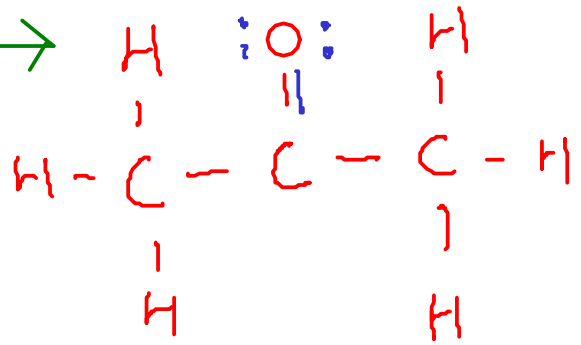
CH_3COCH_3

C: 3 × 4 = 12
H: 6 × 1 = 6
O: 1 × 6 = 6

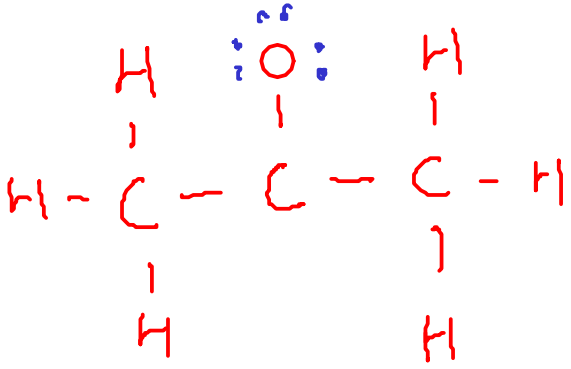
24 e⁻



Skeletal structure



Use a double bond to give carbon the remaining 2 electrons it needs!



Carbon has only six outer electrons, so ...

Shape? We can talk about the shape of the molecule around each of the three central carbon atoms. The left carbon has four things around it, all of which are atoms. The molecule is TETRAHEDRAL around the left carbon. Same with the right carbon ... TETRAHEDRAL. The center carbon has three things attached, all atoms, so it's TRIGONAL PLANAR.

Polar? The only polar bond in the molecule is C=O. Since the molecule is trigonal planar around that carbon atom, we expect the molecule to be polar as electrons are pulled towards the oxygen atom, while the other two corners of the triangle aren't as electronegative as O