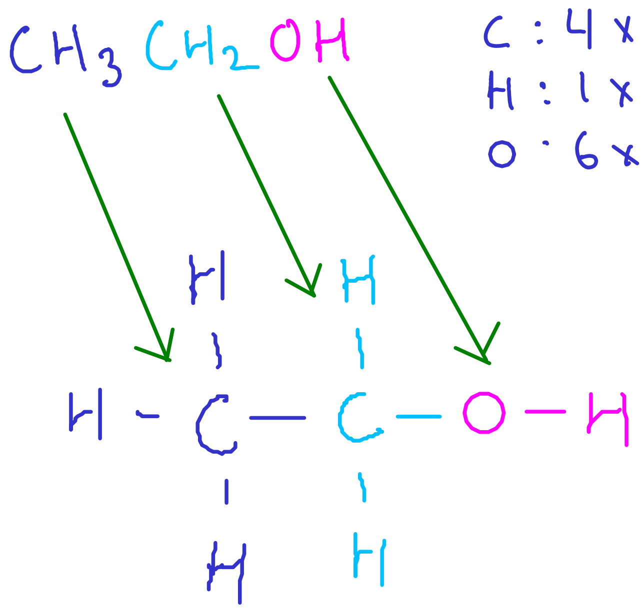
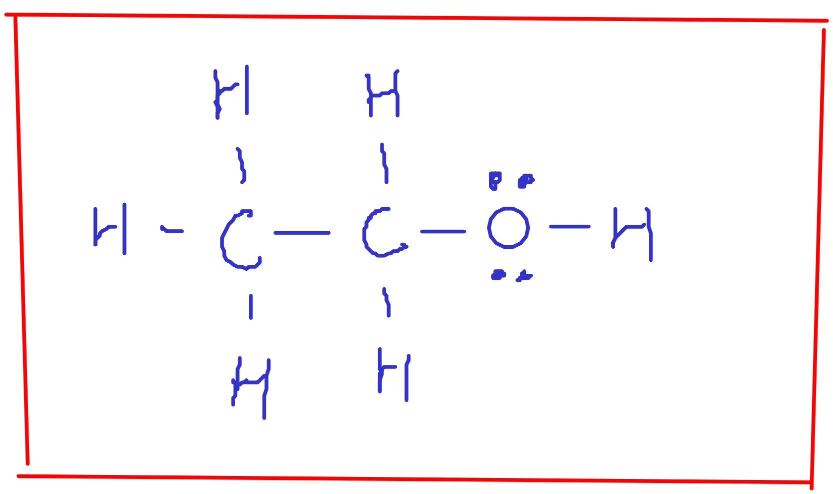
Larger molecules are often made of chains of smaller ones. Sometimes, the chemical formula will hint to this.



$C : 4 \times 2 = 8$
$H : 1 \times 6 = 6$
$O : 6 \times 1 = 6$

20 electrons

this skeletal structure has three central atoms. Each piece of the molecule has own central atom, and is chained to the next one to form the overall molecule.

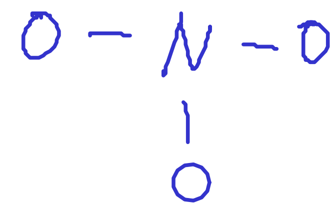


Some molecules have DELOCALIZED BONDING, where the same electrons are shared between more than two atoms. Lewis structures have a problem showing this type of bonding.

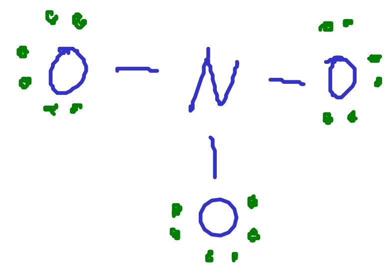
NO_3^- "nitrate ion"

N: 1 x 5
O: 3 x 6 = 18
23
+ 1
24

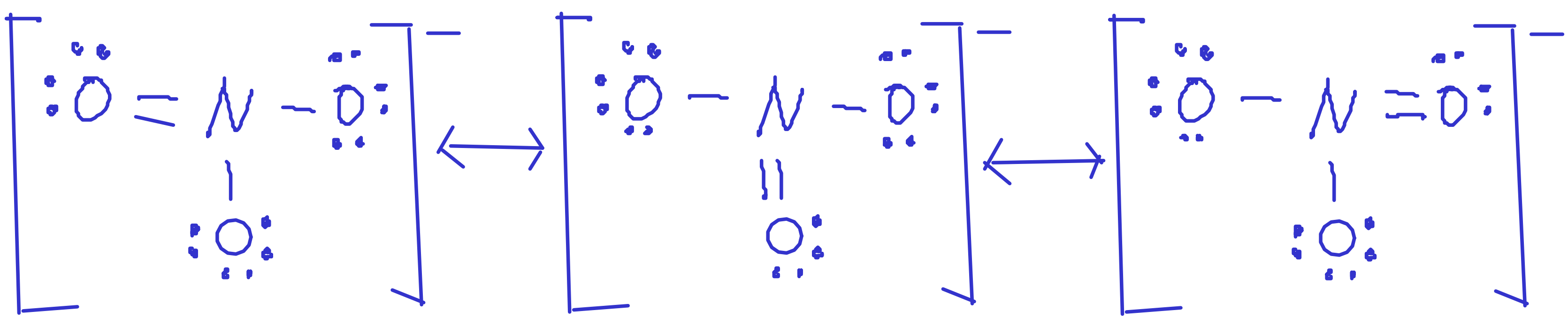
-1 charge requires one more electron!



Skeletal



All 24 electrons used.



Add a double bond to get enough electrons for N.

... but all the oxygen atoms should bond the same way!

So we draw three structures .. called "resonance structures"

There's not really a double bond in the structure that bounces around. The real molecule has some electrons that are shared between all of these atoms - and this is just how we show delocalized bonds with Lewis structures.

Not all atoms obey the octet rule all the time. Some atoms have EXPANDED VALENCE, which means they end up with more than eight valence electrons.

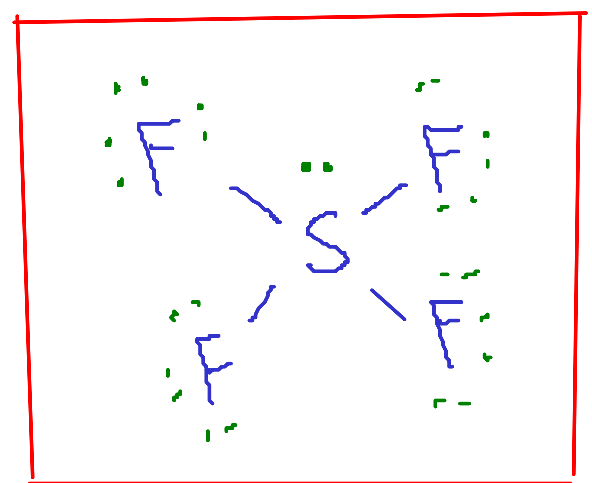
Atoms can fit more than eight electrons in their outer shells only if they have "d" subshells in their outer shell. So, to have expanded valence, an atom must be from period 3 or higher. So, sulfur can do expanded valence, but fluorine (period 2) cannot.

SF_4

S: 1 × 6
F: 4 × 7 = 28

34 electrons

Skeletal structure



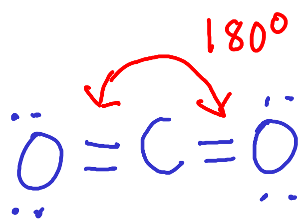
To use all 34 electrons, we put the last pair on the central sulfur atom, giving it 10. This is okay for sulfur, as it can accept the extra pair.

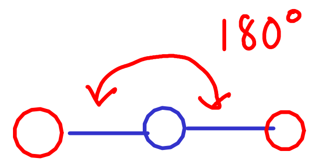
PREDICTING MOLECULAR SHAPE

The shape of simple molecules (and parts of larger molecules) can be easily predicted using the VSEPR model

VSEPR = Valence Shell Electron Pair Repulsion Model

- Each BOND or LONE PAIR OF ELECTRONS around an atom will try to move itself as far away from other bonds or lone pairs as possible!

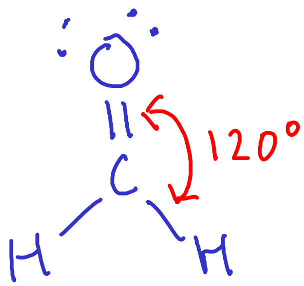


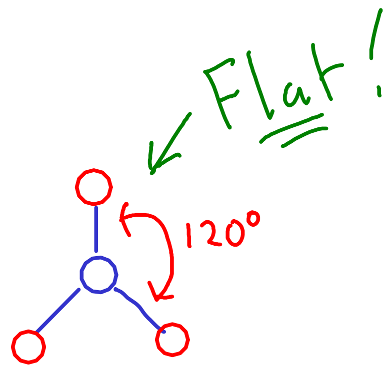


For the two red circles to be farthest apart, they must be 180 degrees apart

LINEAR MOLECULES

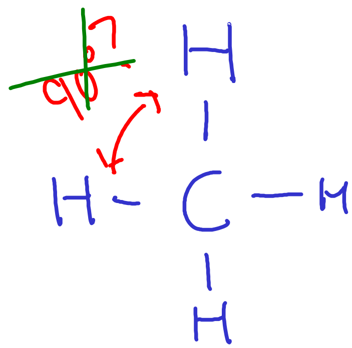
ANY diatomic (two-atom) molecule is linear, but only some three-atom molecules are!





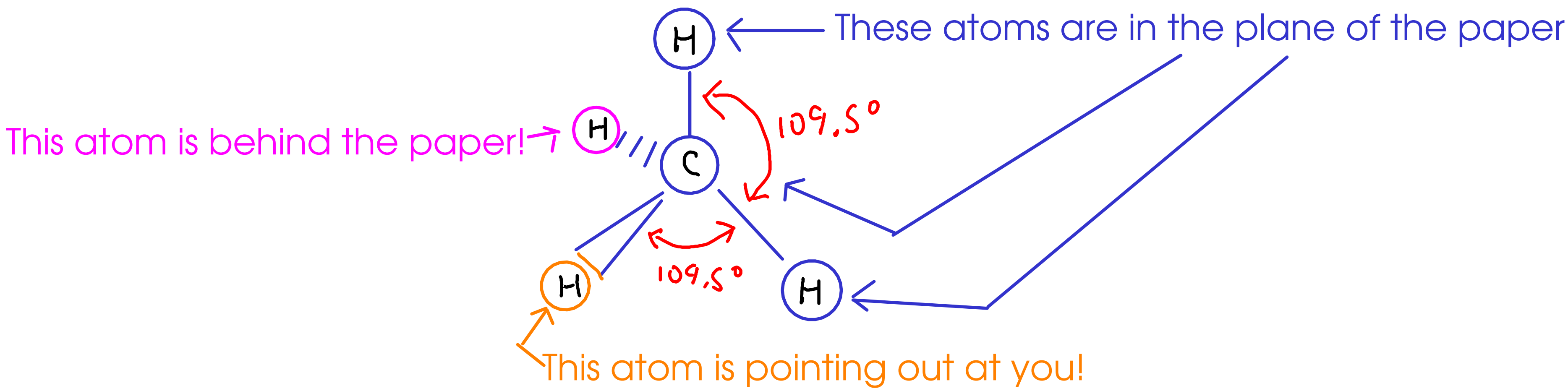
For the three red circles to be farthest apart, they spread out so that each is 120 degrees from the others!

TRIGONAL PLANAR MOLECULES



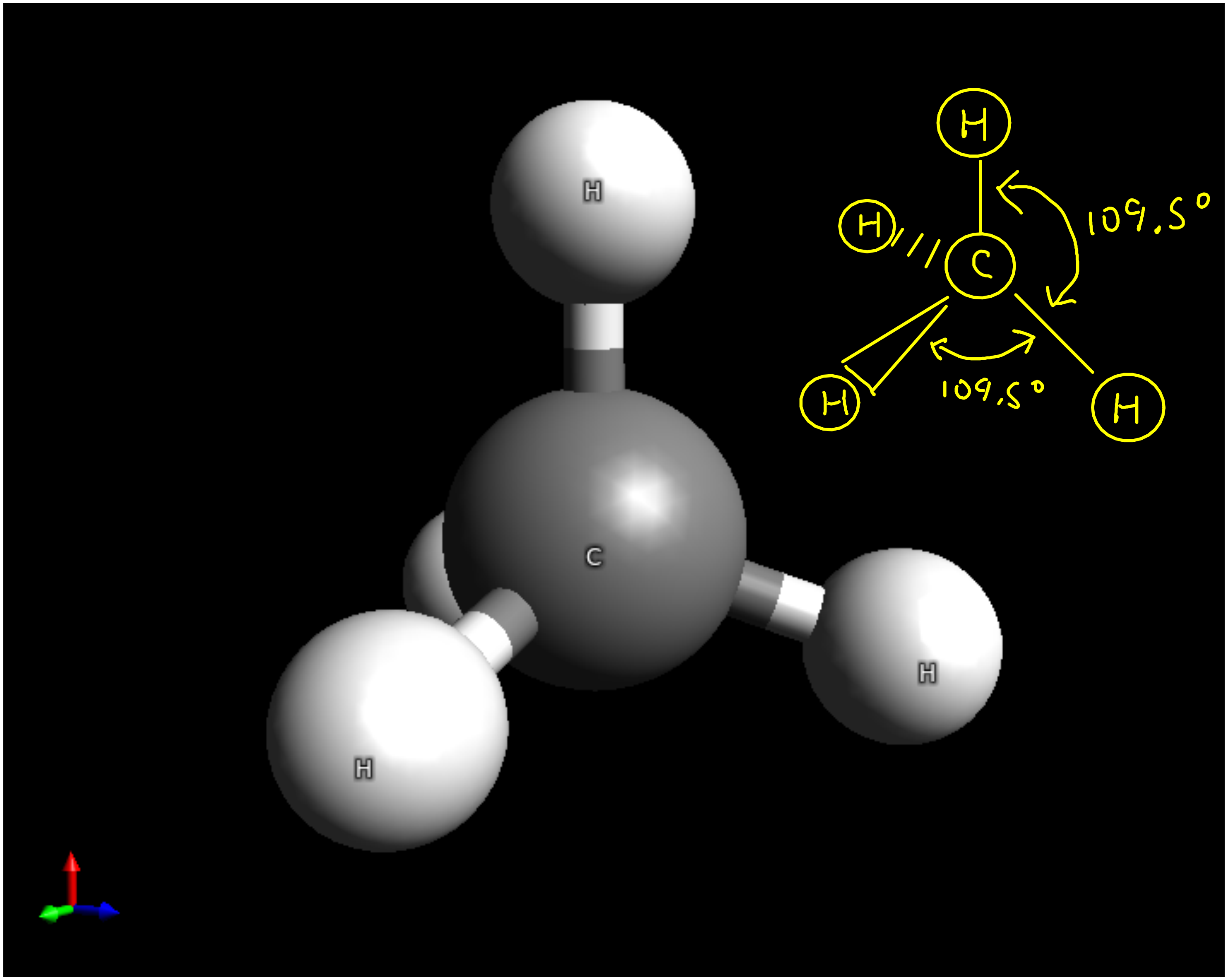
These hydrogen atoms might appear at first glance to be 90 degrees apart, but remember that molecules exist in THREE DIMENSIONS, not two!

Each hydrogen atom is actually 109.5 degrees apart, forming a TETRAHEDRON.



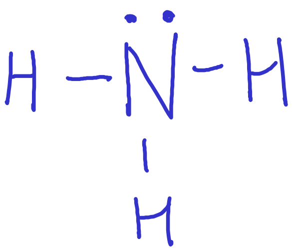
To see the tetrahedron in three dimensions WITHOUT buying a molecular model kit, just take four balloons, blow them up, and then tie them together. The knot will be the central atom, and the balloons will line themselves up to be 109.5 degrees apart.

Here's a computer ball-and-stick rendering of the methane molecule.



DERIVATIVES OF THE TETRAHEDRON

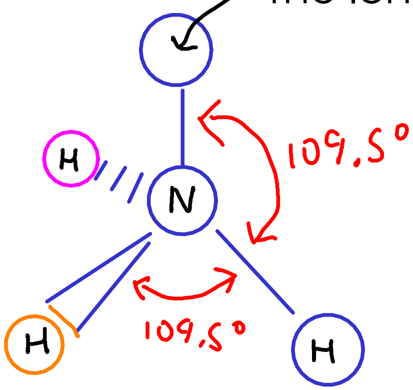
- What if there are lone pairs? The way the shape of a molecule is described depends on the ATOMS in the molecule, even though lone pairs play a role in the positions of the atoms.

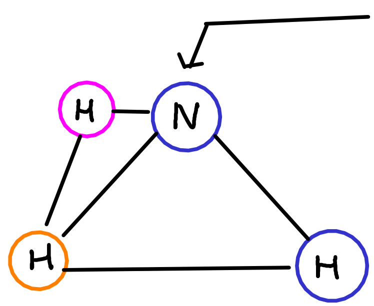


Since there are four "things" around the nitrogen atom, we would expect them to be approximately 109.5 degrees apart (in other words, TETRAHEDRAL). BUT ... only three of these things are atoms.

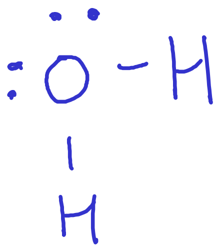
The atoms are arranged in a PYRAMID shape, so we call this molecule PYRAMIDAL!

The lone pair takes one position in the tetrahedron





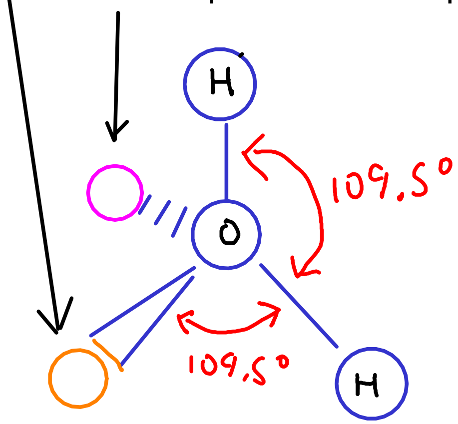
By just looking at the atoms,
you can see the pyramid -
with the central nitrogen atom
as the top and the hydrogen atoms
forming the base of the pyramid.



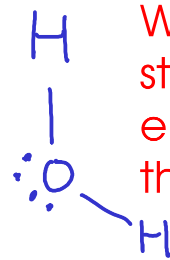
Since there are four "things" around the oxygen atom, we would expect them to be approximately 109.5 degrees apart (in other words, TETRAHEDRAL). BUT... only two of these things are atoms.

The atoms are all in a single plane, but they are not lined up in a straight line. We call this shape "BENT".

Lone pairs take up two positions in the tetrahedron



* These atoms are in the same plane, like carbon dioxide. But they are not arranged linearly!



We sometimes draw the Lewis structure of water this way to emphasize the "bent" nature of the molecule!

Notice that this molecule has two "sides", one with the oxygen atom and one with hydrogen atoms.