1. Count valence electrons

2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

HCN

H: 1
C: 4
N: 5
10 electrons

H – C – N

H – C – N:

... but CARBON has a share in only FOUR electrons!

H – C = N:

... now carbon has a share in SIX electrons

H – C ≡ N:

With a triple bond between nitrogen and carbon, carbon has enough electrons!

A DOT STRUCTURE FOR A LARGER MOLECULE

1. Count valence electrons

2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

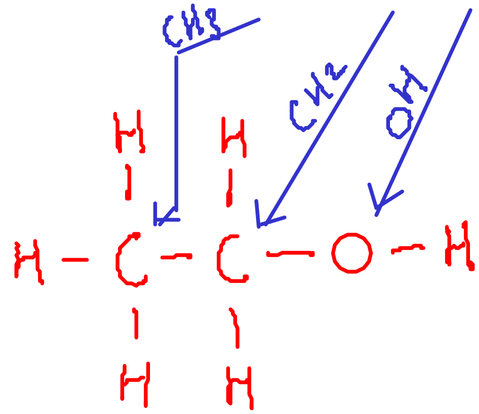
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

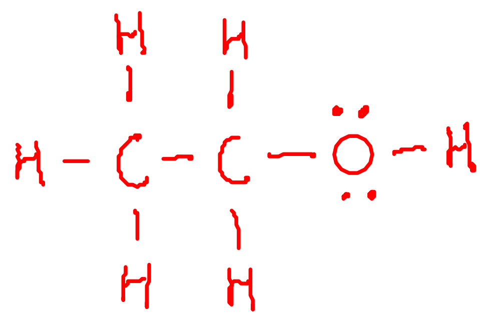
CH_3CH_2OH ← ETHANOL

C 2 x 4 = 8
H 6 x 1 = 6
O 6 = 6

20 electrons

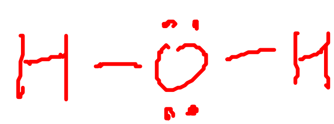
This molecule has THREE centers!





the remaining electrons go onto the OXYGEN atom, since the hydrogens and carbons already have enough electrons.

WATER



The ALCOHOLS (like ethanol, methanol, and isopropanol) are similar in structure to WATER. Small-molecule alcohols all dissolve very well in water due to this similarity!

A DOT STRUCTURE FOR A POLYATOMIC ION

1. Count valence electrons

2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

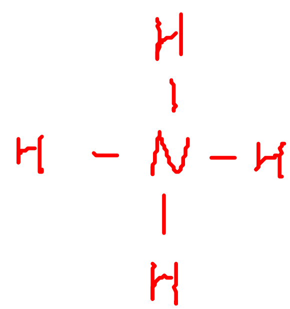
NH_4^+

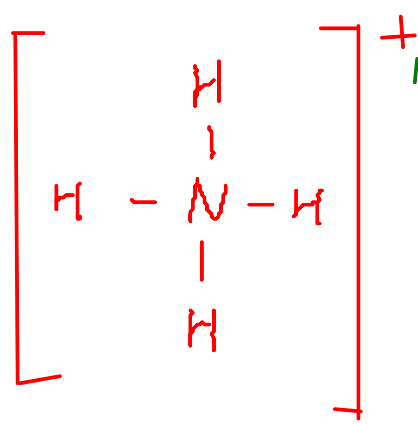
N: 5
H: 1 x4

9
-1

8 electrons

To get a +1 charge, the ammonium ion has to have LOST one of its valence electrons, so we subtract one electron from the total.





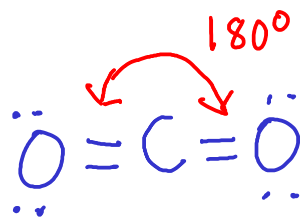
We typically draw bracets around the structure of polyatomic ions and indicate the charge in the upper right (just like we'd do for a single-atom ion)

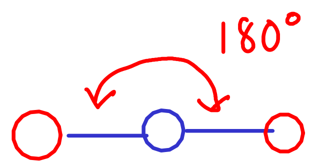
PREDICTING MOLECULAR SHAPE

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!

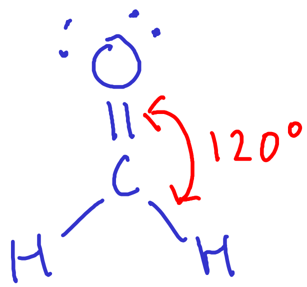


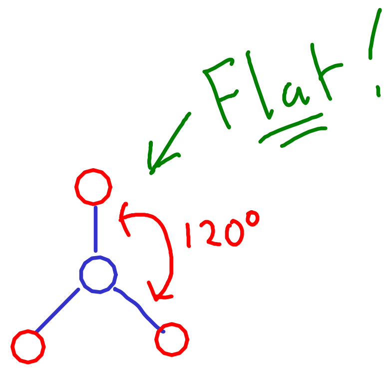


For the two red circles to be farthest apart, they must be 180 degrees apart

LINEAR MOLECULES

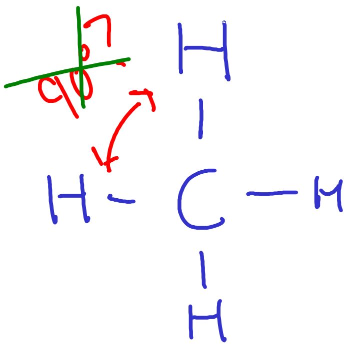
ANY diatomic (two-atom) molecule is linear, but only some three-atom molecules are!





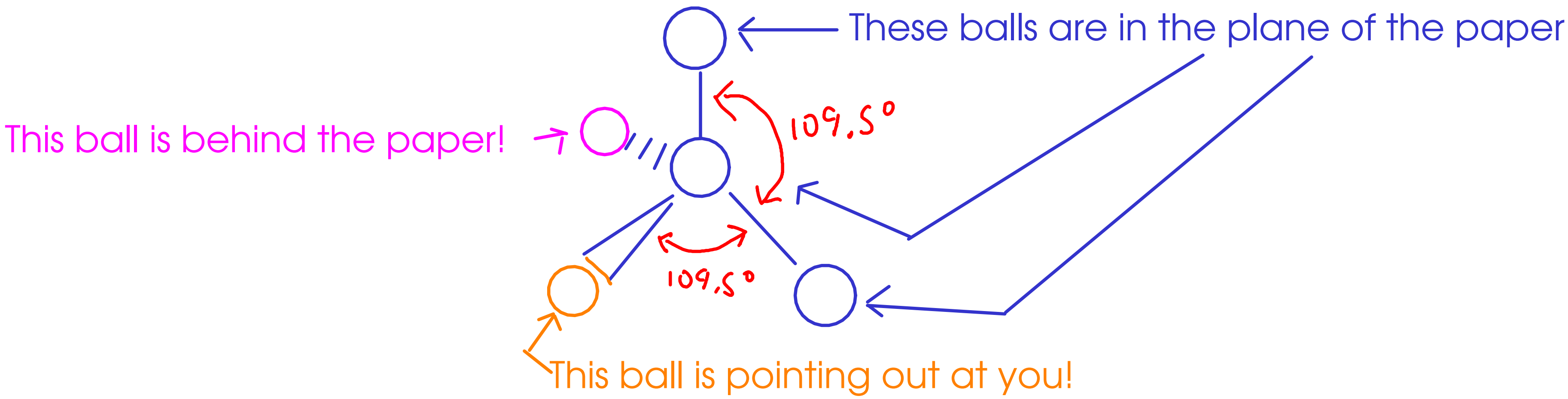
For the three red circles to be farthest apart, they spread out so that each is 120 degrees from the others!

TRIGONAL PLANAR MOLECULES



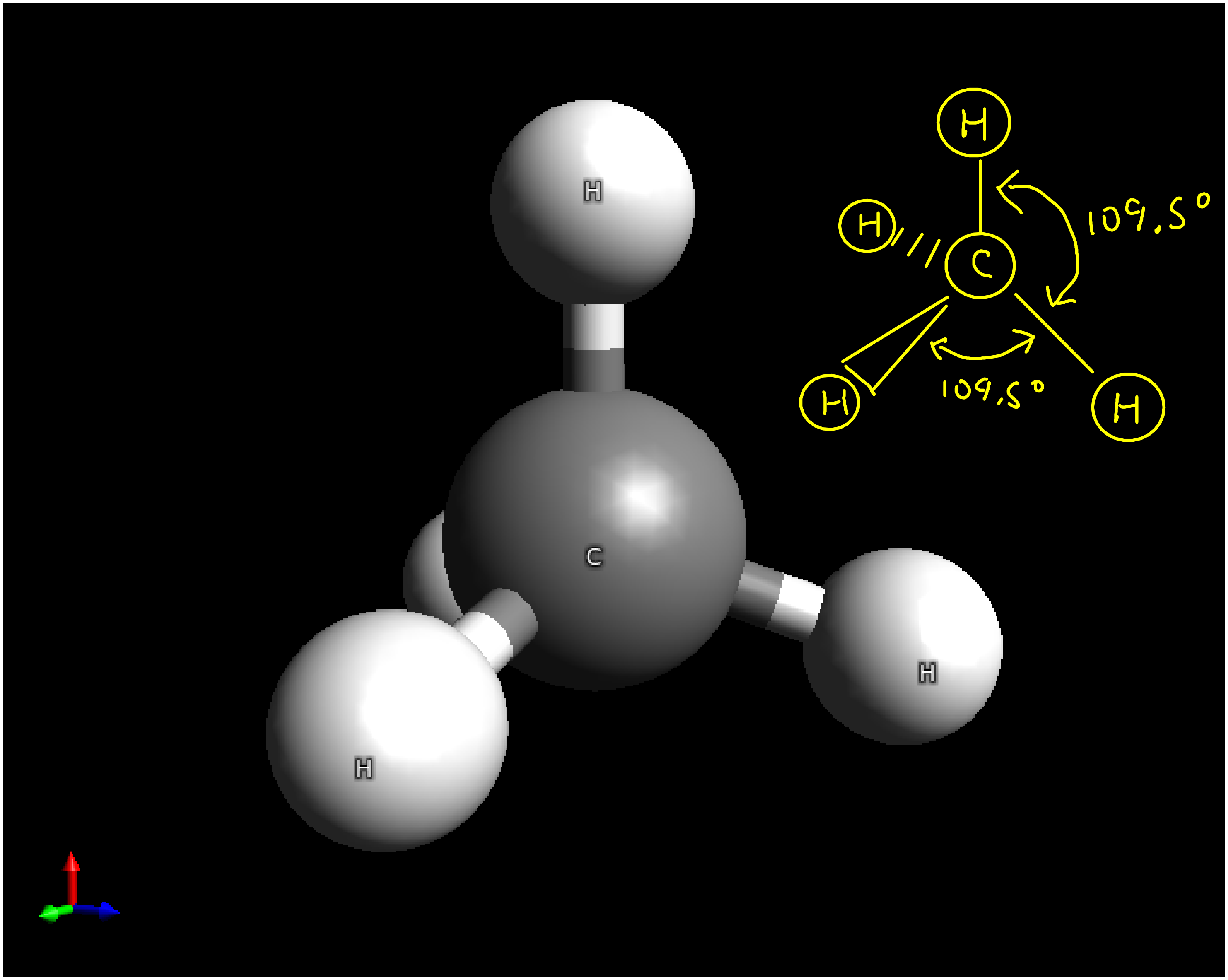
These hydrogen atoms might appear at first glance to be 90 degrees apart, but remember that molecules exist in THREE DIMENSIONS, not two!

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



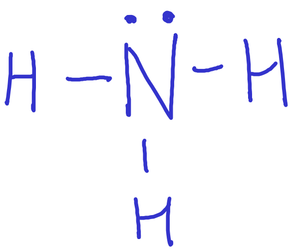
To see the tetrahedron in three dimensions WITHOUT buying a molecular model kit, just take four balloons, blow them up, and then tie them together. The knot will be the central atom, and the balloons will line themselves up to be 109.5 degrees apart.

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



DERIVATIVES OF THE TETRAHEDRON

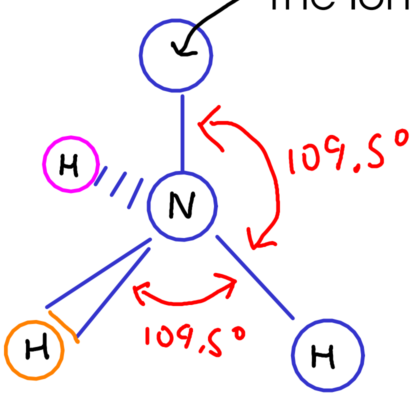
- What if there are lone pairs? The way the shape of a molecule is described depends on the ATOMS in the molecule, even though lone pairs play a role in the positions of the atoms.

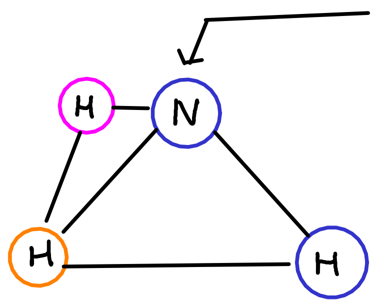


Since there are four "things" around the nitrogen atom, we would expect them to be approximately 109.5 degrees apart (in other words, TETRAHEDRAL). BUT ... only three of these things are atoms.

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

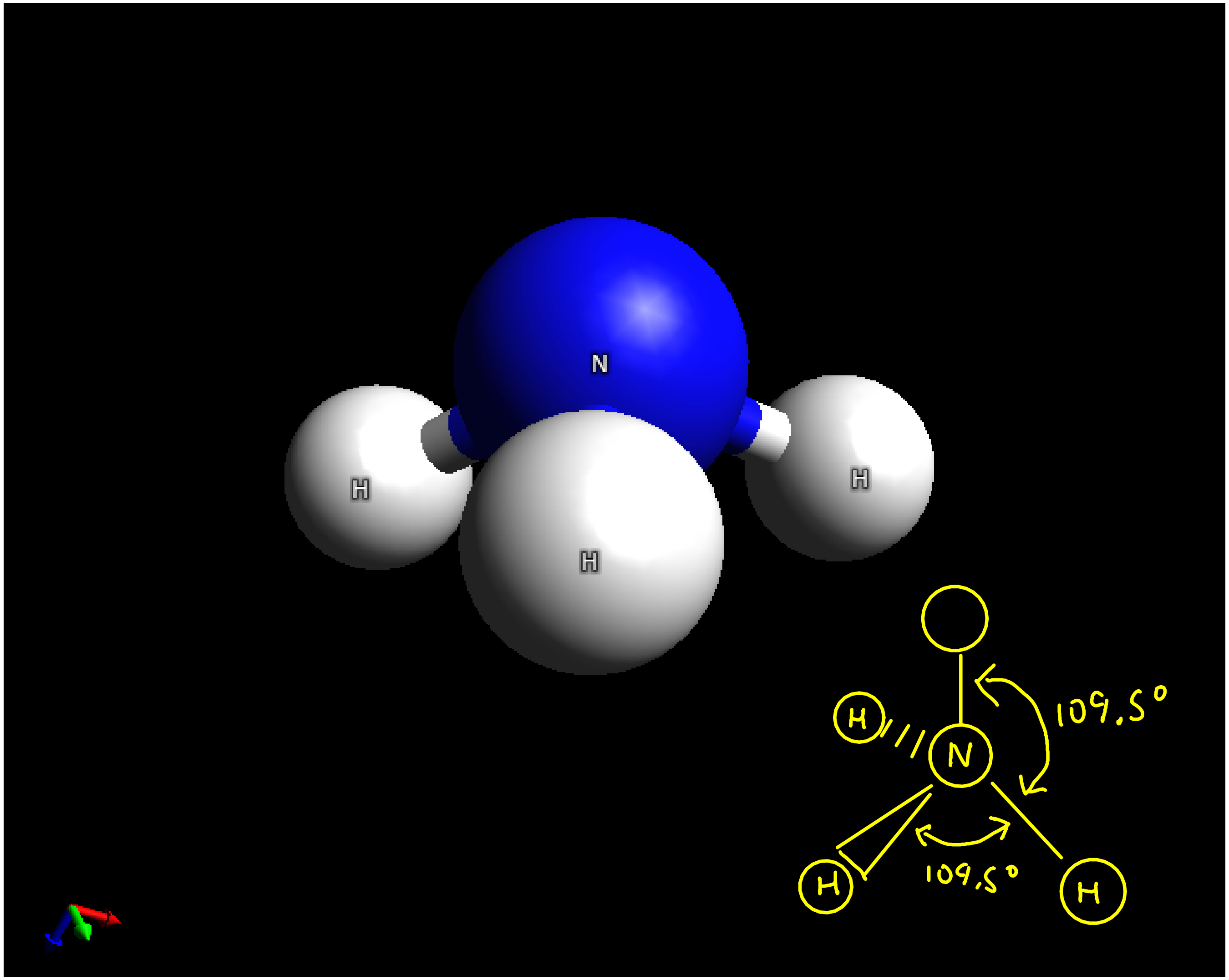
The lone pair takes one position in the tetrahedron

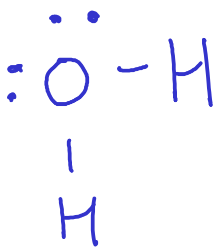




By just looking at the atoms,
you can see the pyramid -
with the central nitrogen atom
as the top and the hydrogen atoms
forming the base of the pyramid.

NH_3

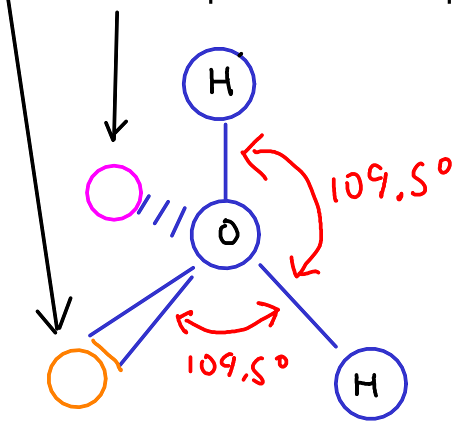




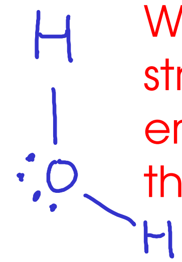
Since there are four "things" around the oxygen atom, we would expect them to be approximately 109.5 degrees apart (in other words, TETRAHEDRAL). BUT... only two of these things are atoms.

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

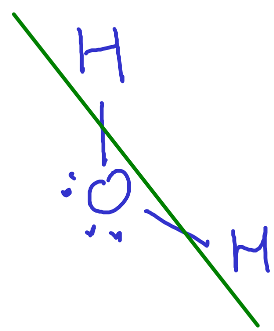


* Atoms are in one plane like CO_2, but bent instead of linear!



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.



H_2O