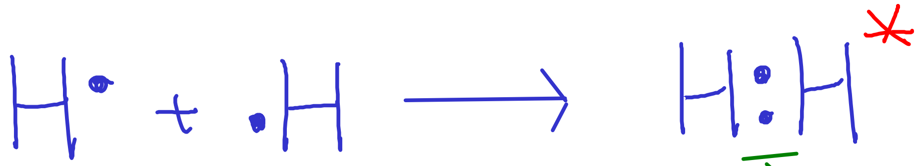
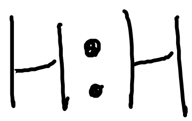
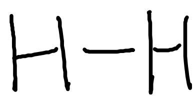
... so how would this look using dot notation?



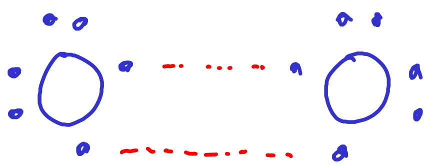
a shared pair of electrons. This is called a SINGLE BOND

In dot structures, SHARED PAIRS of electrons are often written as DASHES to make the structures look neater.

 becomes 

* Why doesn't hydrogen end up with eight electrons? Because hydrogen has only the first shell, which contains only a single "s" subshell (NO "p" subshell). This "s" subshell is full with two electrons, and that's all hydrogen needs to get.

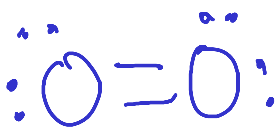
Let's look at OXYGEN ...



We know that oxygen exists in air as the diatomic molecule O_2

The oxygen atoms share TWO pairs of electrons. This is called a DOUBLE BOND

OR



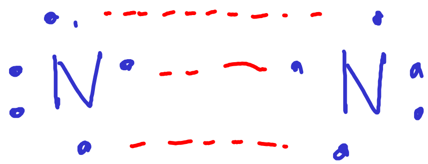
Each oxygen atom has a share in eight electrons!

A few notes on the double bond:

(1) - For atoms to share more than one pair of electrons, they have to move closer to one another than they would if they were only sharing one pair of electrons. This BOND DISTANCE is measurable!

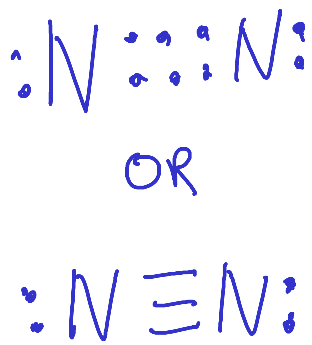
(2) - It takes more energy to break a double bond between two atoms than it would to break a single bond between the same two atoms. This BOND ENERGY is also measurable!

Let's look at NITROGEN ...



We know that nitrogen exists in air as the diatomic molecule N_2

The nitrogen atoms share THREE pairs of electrons. This is called a TRIPLE BOND



The STABILITY of the nitrogen molecule (in other words, its relative inertness compared to molecules like hydrogen and oxygen) is probably due to the triple bond.

A few notes on the triple bond:

(1) - For atoms to share three pairs of electrons, they have to move closer to one another than they would if they were sharing one or two pairs of electrons. Triple bonds have the shortest BOND DISTANCE of all covalent bonds.

(2) - It takes more energy to break a triple bond between two atoms than it would to break either a single or double bond between the same two atoms. The triple bond has the largest BOND ENERGY of all three kinds of covalent bonds.

SO FAR, we've seen that ...

1. Atoms may share one, two, or three pairs of electrons.

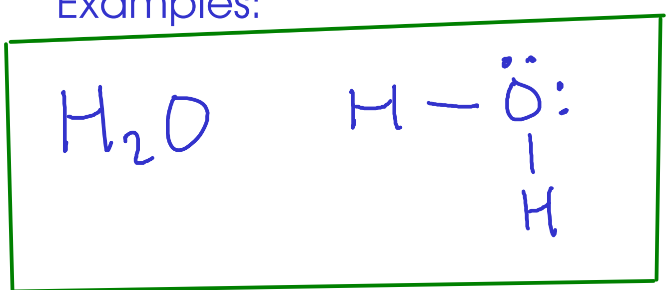
2. Atoms will usually share enough electrons so that each atom ends up with a share in EIGHT electrons - the "octet rule"

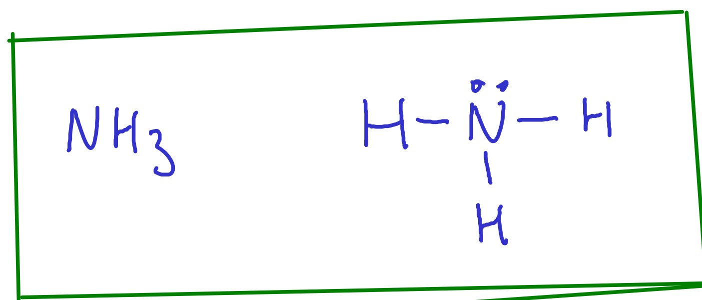
   - HYDROGEN will only end up with two electrons!

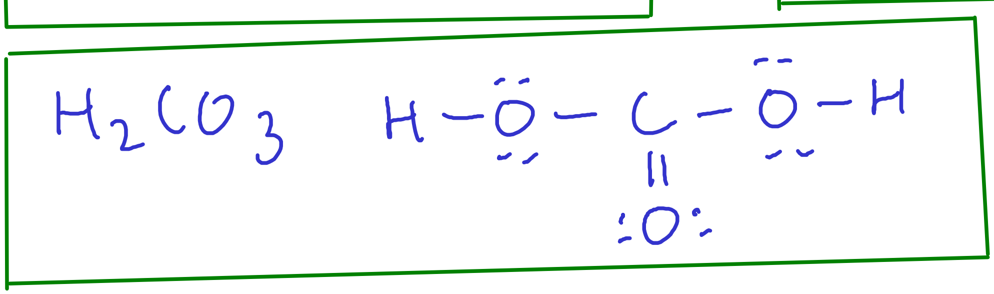
   - Some other atoms may end up with more or less than eight electrons ... but we won't worry about those in CHM 100!

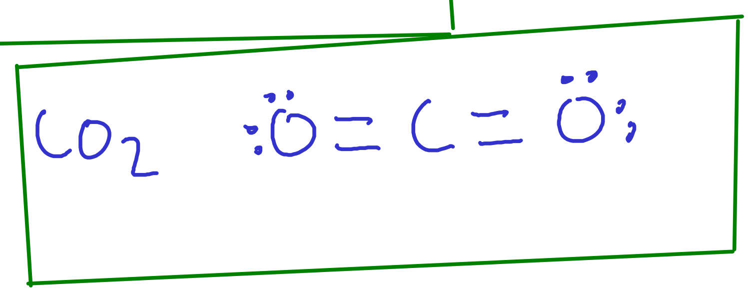
NOW, how could we come up with dot structures for some more complicated (and therefore, more interesting) molecules?

Examples:









179 DRAWING DOT STRUCTURES FOR SIMPLE MOLECULES

$COCl_2$

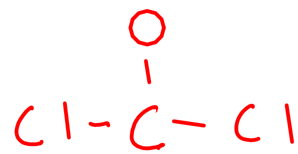
C : 4
O : 6
Cl : 2x7 = 14

24 electrons

(1) Count valence electrons

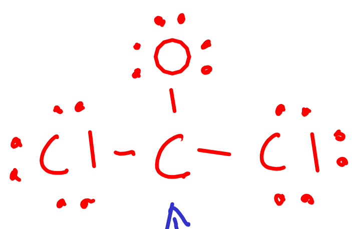
(2) Pick central atom and draw skeletal structure

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



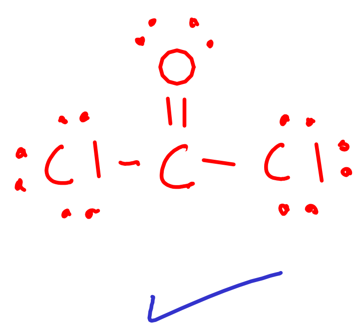
We chose carbon as the center because it needs to gain four electrons, more than either oxygen or chlorine!

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



... but the central carbon atom only has a share in SIX electrons.

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



Where to put the double bond? OXYGEN needed to gain TWO more electrons, so it's more likely to share two electrons than chlorine (which only needs one).

(1) Count valence electrons

(2) Pick central atom and draw skeletal structure

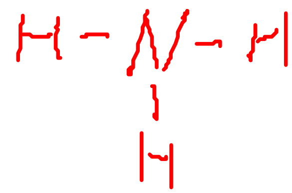
- central atom is usually the one that needs to gain the most electrons!
- skeletal structure has all atoms connected to center with single bonds

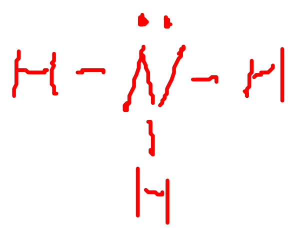
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

NH_3

N: 5
H: 3 × 1 = 3
8





We put the remaining electrons on the nitrogen atom, since all the hydrogen atoms were already "full" (they can hold only two electrons in their first shell - no "p" subshells!.)

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

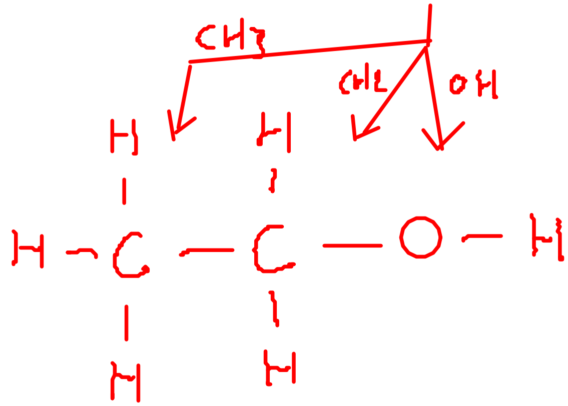
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

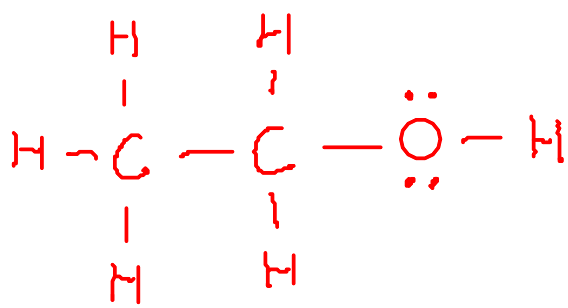
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CH_3CH_2OH ← ETHANOL

C 2x4 = 8
H 6x1 = 6
O 6 = 6
20 electrons

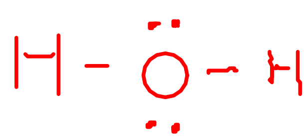
This molecule has THREE centers!





The remaining four electrons go onto the OXYGEN atom, since the carbons and hydrogens are full!

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 structural 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

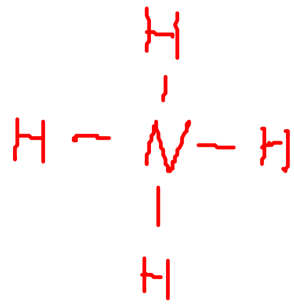
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

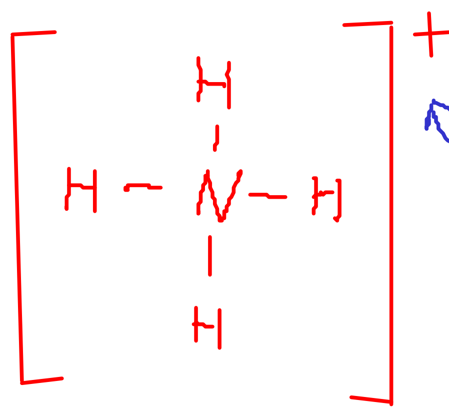
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

NH_4^+

N : 5
H : 4×1
9
−1
8 electrons

To get a +1 charge, the ammonium ion must have lost one of its valence electrons. So we subtract one from the total.





We typically draw brackets around Lewis structures for charged molecules, so that we know the whole molecule is charged.