SO FAR, we've seen that ...

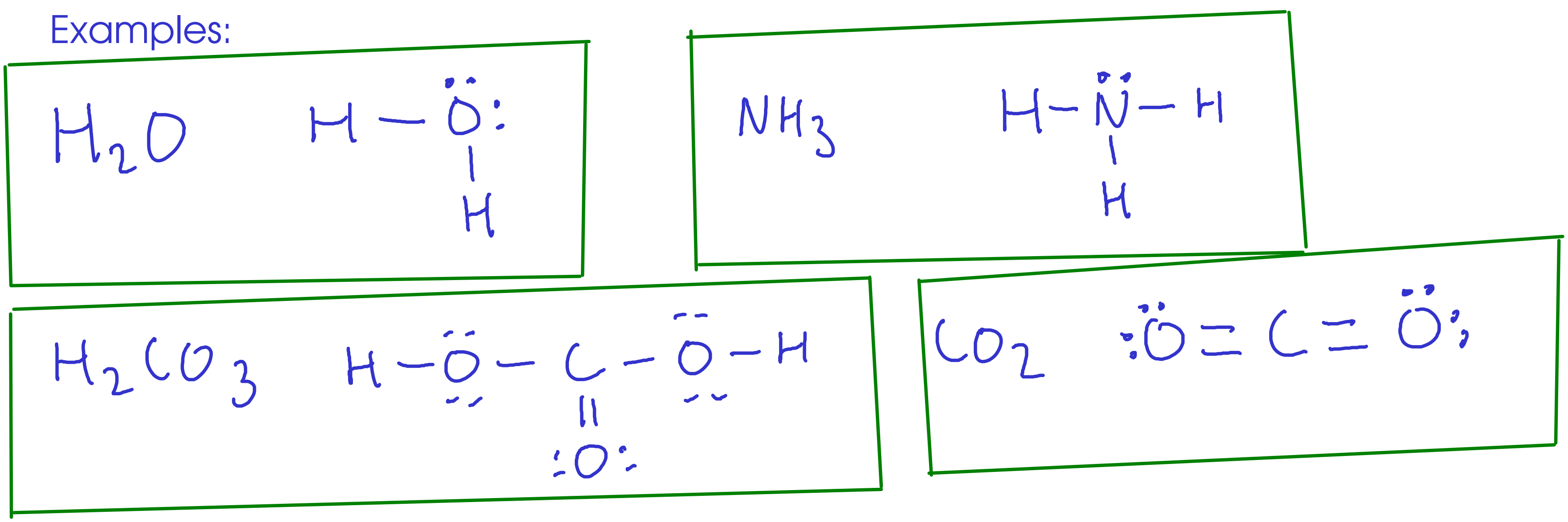
(1) Atoms may share one, two, or three pairs of electrons with a single other atom.

(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.

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

Examples:



DRAWING DOT STRUCTURES FOR SIMPLE MOLECULES

$COCl_2$

C: 1 x 4
O: 1 x 6
Cl: 2 x 7 = 14

24 valence electrons

(1) Count valence electrons

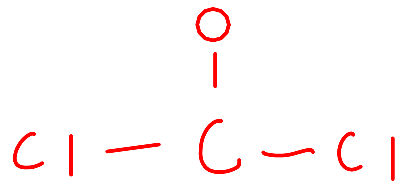
(2) Pick central atom and draw skeletal structure

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

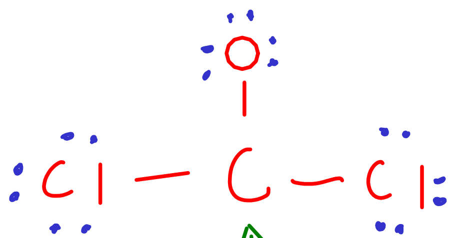
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

Pick CARBON as my central atom, since it needs to gain more electrons than either oygen or chlorine. Since it needs more, it's likely to form more bonds!



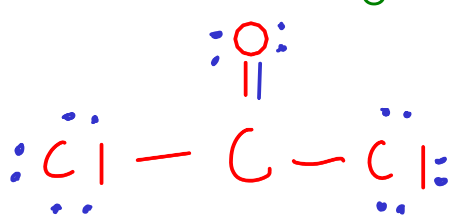
<-- Skeletal structure



<- Distributed remaining electrons, stop at 24 (our count from above)

... but CARBON has a share in only six valence electrons!

Let's reallocate one of the lone pairs of electrons as a bonding pair instead. But which lone pair do we pick? Pick OXYGEN to form the second bind, since we noticed it needed two more electrons anyway (and would probably form two bonds to get them!



Making a double bond with C=O "fixes" this structure.

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.

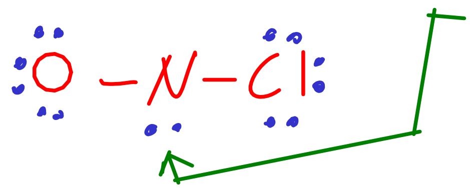
NOCl

N : 1 x 5
O : 1 x 6
Cl : 1 x 7

18 e^-

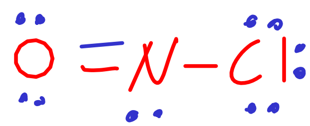
Pick NITROGEN for central atom, since it needs more electrons than either O or Cl.

O – N – Cl <-- Skeletal



Outer atoms were "full" when we still had electrons left, so put the last pair on N.

Problem: N has a share in only six valence electrons. Make a double bond. Where? Oxygen ... for the same reasons as last example.



Adding the double bond "fixes" the structure.

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.

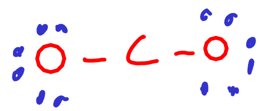
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CO_2

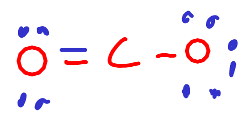
C: 1 x 4
O: 2 x 6

16 e^-

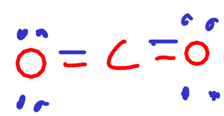
Pick CARBON as central atom...



<- C only has a share in 4 valence electrons!



<- C only has a share in 6 valence electrons!



Making a second double bond fixes this structure!

What if we'd used a triple bond instead of the second double bond? We don't like this structure because it suggests that two identical oxygen atoms put in the same situation would bond in different ways. (Oxygen is an element, so this should not happen!)

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

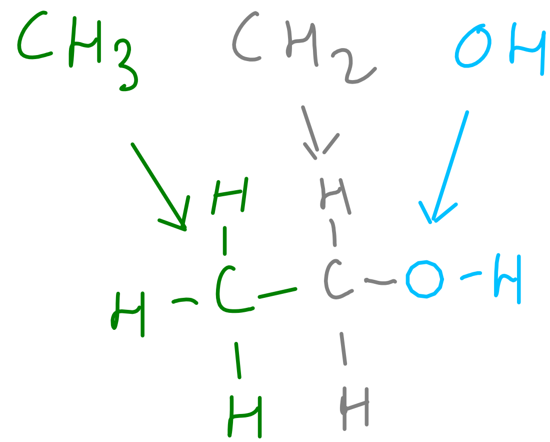
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

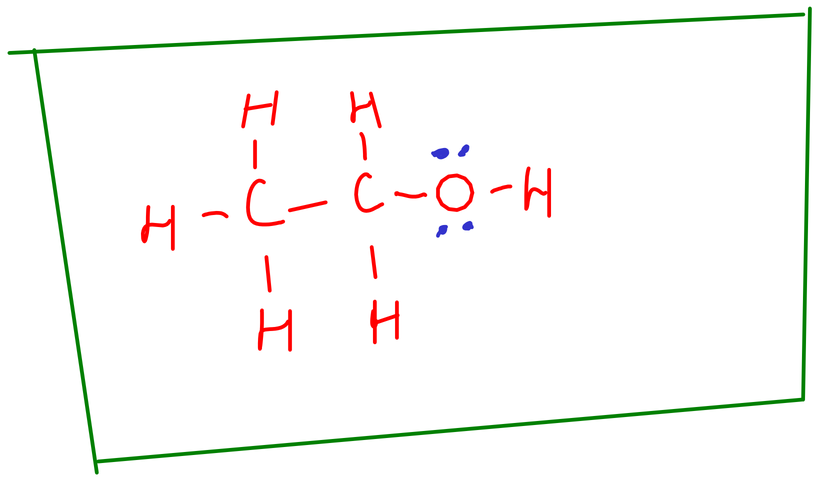
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CH_3CH_2OH ETHANOL!

C : 4 x 2 = 8
H : 1 x 6 = 6
O : 6 x 1 = 6
| 20

This formula gives us a hint to the structure of ethanol. Ethanol has THREE central atoms chained together.





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^+

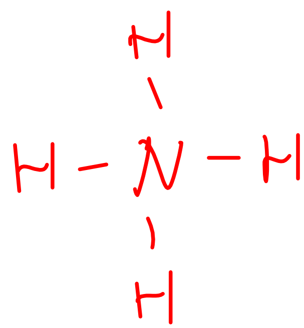
N: 1x5
H: 4x1

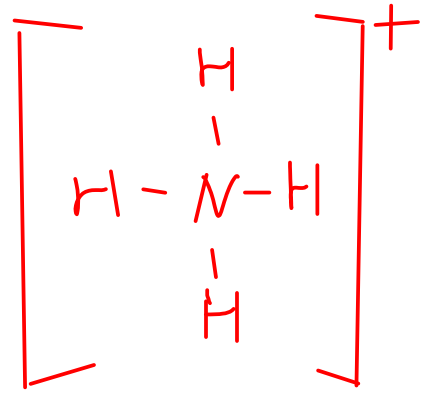
9 valence e^-
$-1\ e^-$ (+1 charge)

$8\ e^-$

Since ammonium ion has a +1 charge, we subtract one electron from the total.

(If a negative charge, add electrons ... one electron for each charge unit.)





To indicate the charge, draw brackets around the stucture, then write the charge in the upper right corner.

A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

1. Count valence electrons

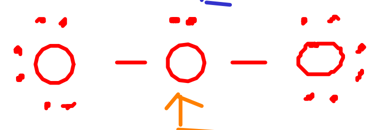
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

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.

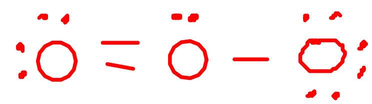
O_3 (OZONE) O: 3 x 6 = 18

See Openstax p362-363



OUT OF ELECTRONS

Central oxygen has only six electrons

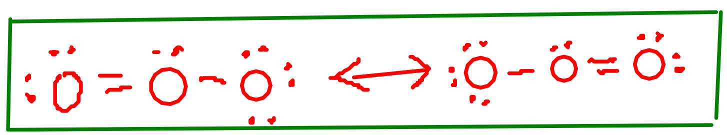


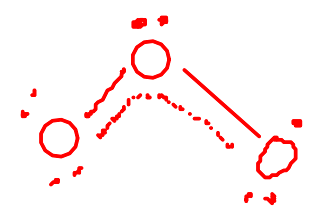
All atoms have a share in eight electrons!

The structure we drew implies that one of the outer oxygen atoms is closer to the central oxygen atom than the other one.

Experimentally, though, we find the two oxygen atoms to be the SAME distance from the center.

In the ozone molecule, electrons are actually being shared between ALL THREE oxygen atoms at the same time. This is called a DELOCALIZED BOND.





The structures in the green box are called RESONANCE STRUCTURES. The "real" structure of ozone is an "average" of the two resonsnce structures. The "double bond" electrons in these structures are actually shared between all three oxygen atoms