SO FAR, we've seen that ...

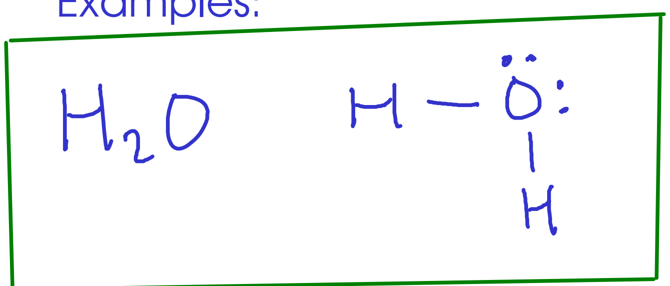
(1) Atoms may share one, two, or three pairs of electrons with each other.

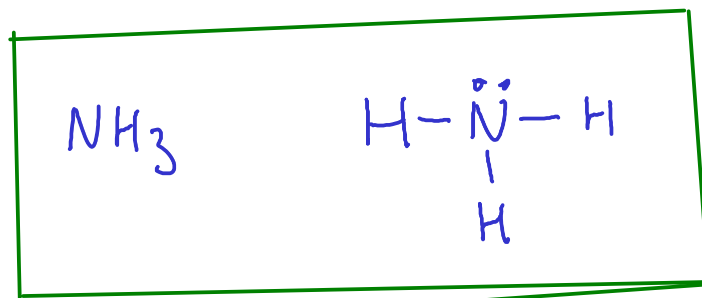
(2) Atoms will usually share enough electrons so that each atom ends up with a share in EIGHT electrons - the "octet rule"

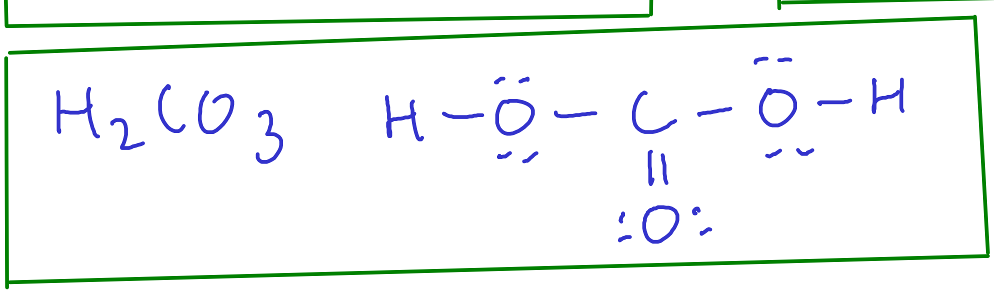
- HYDROGEN will only end up with two electrons!
- Some other atoms may end up with more or less than eight electrons. Exceptions to the octet rule are covered in Chapter 9.

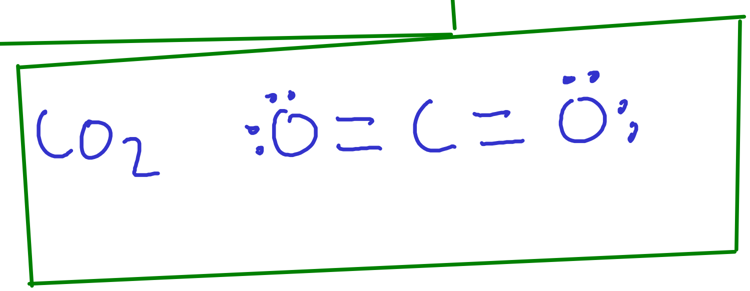
NOW, how could we come up with dot structures for some more complicated (and therefore, more interesting) molecules?

Examples:









DRAWING DOT STRUCTURES FOR SIMPLE MOLECULES

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

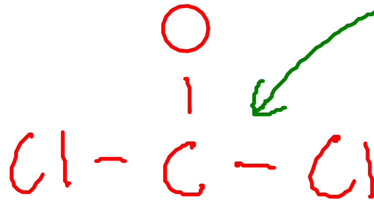
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

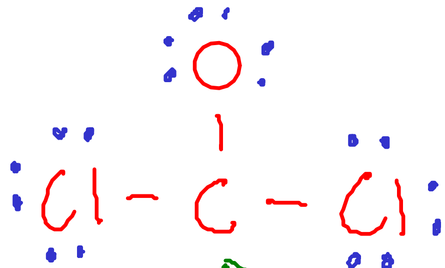
$COCl_2$

C: 1x4
O: 1x6
Cl: 2x7 = 14

24 e^-



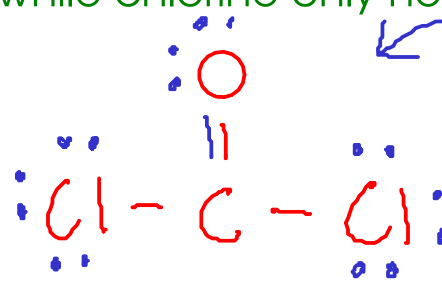
Choose CARBON as the central atom, since it needs to gain more electrons (4) than either chlorine (1) or oxygen (2). That means it'll form more bonds to gain those electrons!



Distribute remaining electrons ... Stop when we reach 24.

... but the CARBON atom only has a share in SIX electrons!

To get carbon more electrons, we'll need to have it share more ... by making a DOUBLE BOND. We'll pick oxygen for the double bond since it needed to gain TWO electrons, while chlorine only needed one,



This structure looks better, as all atoms now have a share in eight 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.

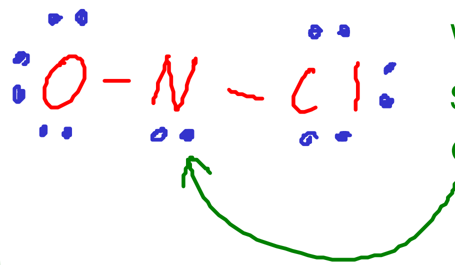
NOCl

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

18 e^-

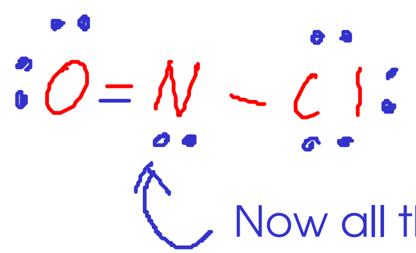
O – N – Cl

We pick NITROGEN as the central atom, since it needs more electrons than either O or Cl.



We ran out of space on the outer atoms, so we put the last pair of electrons on the central nitrogen atom

Even with the pair of electrons we added last, NITROGEN still has a share in only SIX electrons. So, we need a double bond. As before, we'll choose oxygen for the double bond (for the same reason as the previous molecule)



Now all the atoms have a share in eight 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

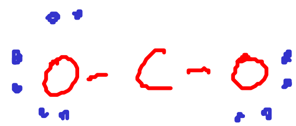
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

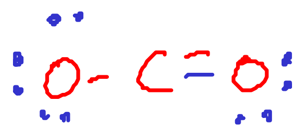
CO_2

C: 1 x 4
O: 2 x 6

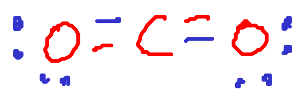
16 e^-



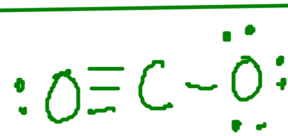
... but carbon has a share in only FOUR electrons!



... now it has six



... and now eight!



the two oxygen atoms are in identical chemical environments and should bond the same way!

This structure also says sometiing that we can directly test experimentally! This structure says the oxygens are at different distances from the carbon center.

Experimentally, we find the oxygen atoms are the same distance from the center ... which agrees with the double-bond structure!

1. Count valence electrons

2. Pick central atom and draw skeletal structure
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   - 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.

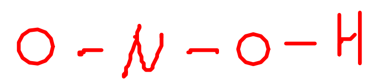
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

HNO_2 "nitrous acid"

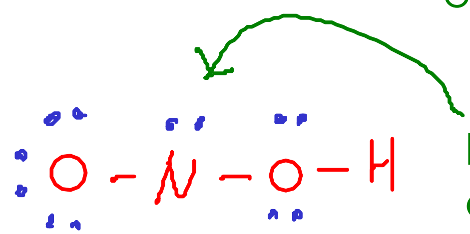
In oxyacids, the acidic hydrogen atoms are attached to OXYGEN atoms in the structure!

H: 1 x 1
N: 1 x 5
O: 2 x 6 = 12

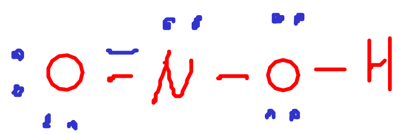
$18 e^-$



OXYACID: We know that a hydrogen atom must be attached to an oxygen.



NITROGEN has a share in only six electrons...



Unlike the carbon dioxide molecule, these two oxygen atoms are in DIFFERENT chemical environments!

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

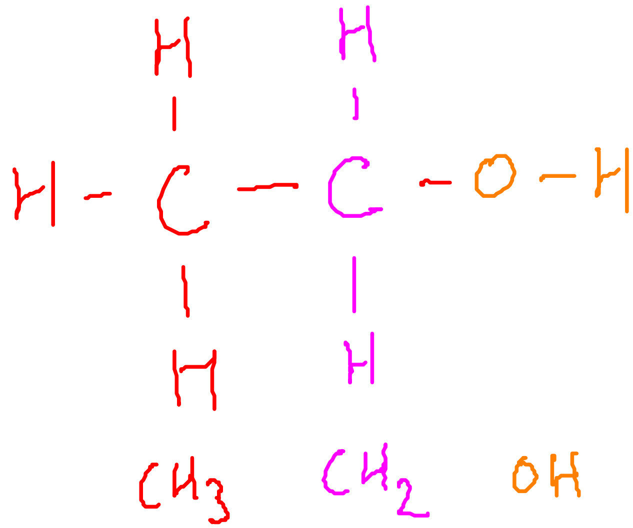
③ Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

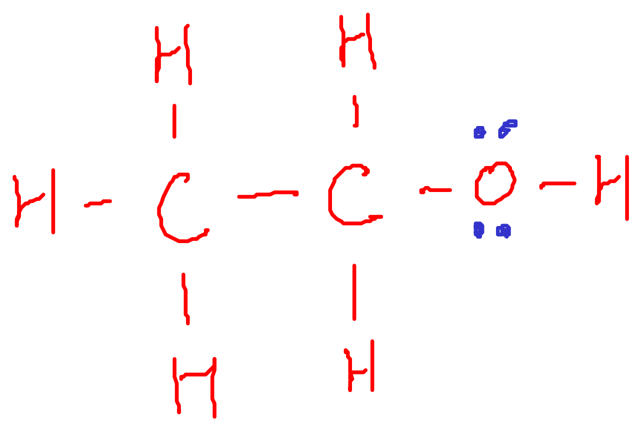
④ Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

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 MOLECULE WITH DELOCALIZED BONDS

$O: 3 \times 6 = 18$

See text, 9,7 p 356-357

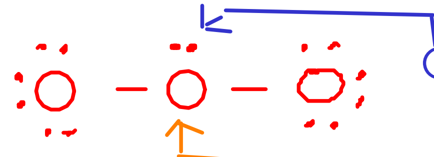
O_3 (OZONE)

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

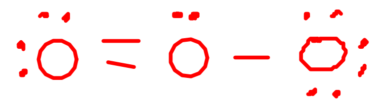
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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



OUT OF ELECTRONS

Central oxygen has only six electrons

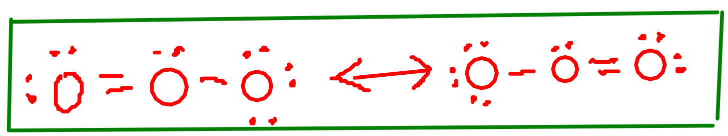


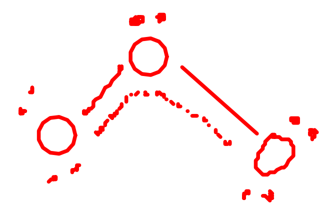
All atoms have a share in eight electrons!

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