DRAWING DOT STRUCTURES FOR SIMPLE MOLECULES

1. Count valence electrons

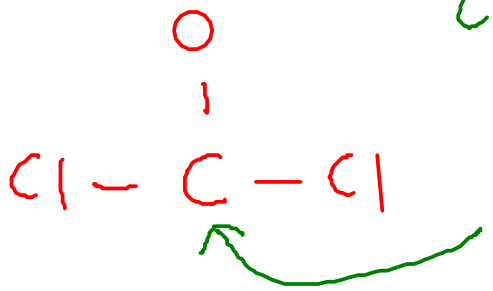
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

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

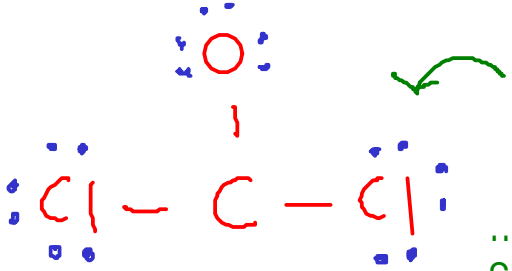
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

$COCl_2$

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

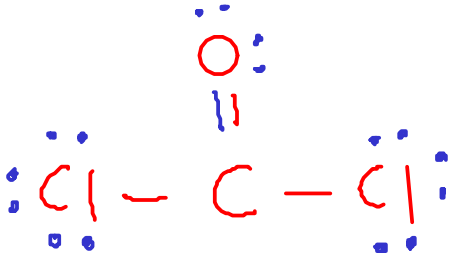


Choose CARBON as the central atom because it needs to gain more electrons than either oxygen or chlorine



Distribute remaining electrons, stop when you run out!

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



Which atom forms the double bond? Usually, the atom that needs more electrons forms more bonds, so we will choose OXYGEN.

With the double bond, all atoms have a share in eight electrons!

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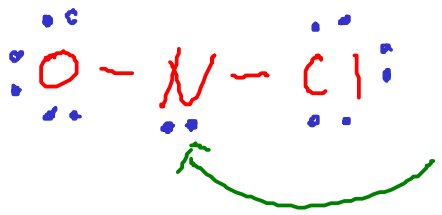
NOCl

N : 1 x 5
O : 1 x 6
Cl : 1 x 7
18 e⁻

O – N – Cl

We will pick NITROGEN as our central atom since it needs to gain more electrons than either O or Cl.



We ran out of space on the outside, so we put the last pair of electrons onto the central nitrogen.

Even with the pair of electrons on nitrogen, it still doesn't have enough! So we need a double bond. We'll pick OXYGEN for the double bond (as we did in the previous example)

Now all atoms have a share in eight electrons!

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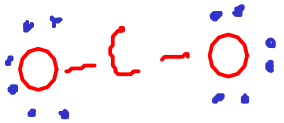
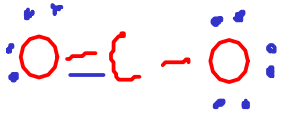
CO_2

C: 1 × 4
O: 2 × 6
16 e⁻

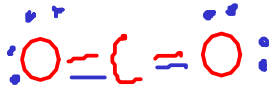
Skeletal



... but the carbon atom has a share in only FOUR electrons



... now six



Adding a second double bond with the other oxygen gives carbon a share in eight.

What about this structure?

The two oxygen atoms are in identical chemical environments and SHOULD bond the same way.

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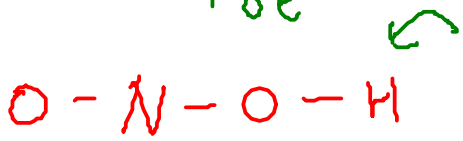
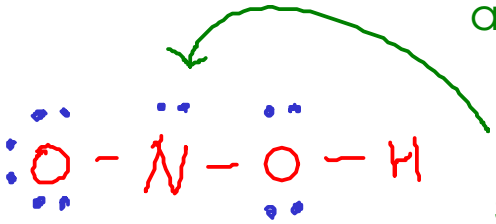
HNO_2 "nitrous acid"

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

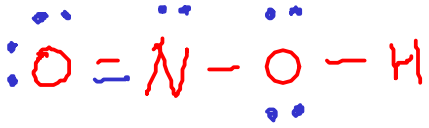
H: 1 x 1
N: 1 x 5
O: 2 x 6
18 e⁻



OXYACIDs have at least on hydrogen atom attached directly to an OXYGEN atom...



NITROGEN has a share in only six electrons!



Unlike the carbon dioxide molecule, these two oxygens are in DIFFERENT chemical environments ... so they bond to the nitrogen atom differently.

A DOT STRUCTURE FOR A LARGER MOLECULE

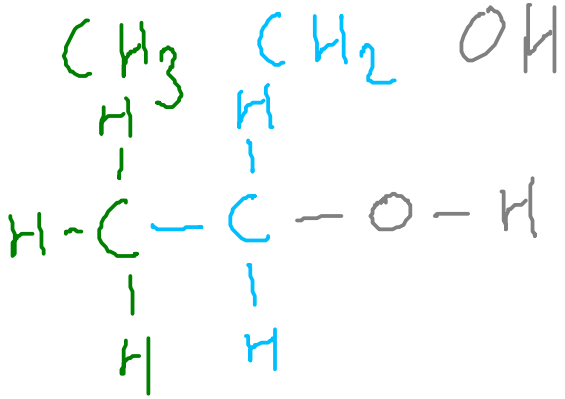
CH_3CH_2OH ETHANOL!

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

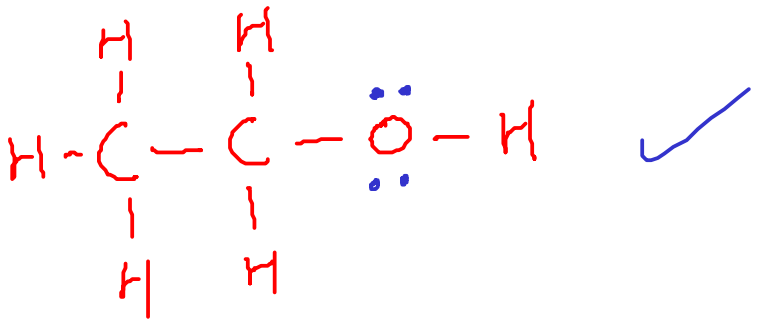
1. Count valence electrons

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

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



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.

A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

O: 3 x 6 = 18

See text, 9.7 p 356-357

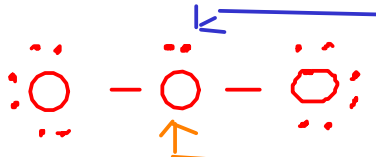
O_3 (OZONE)

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.

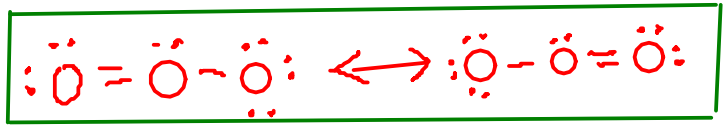


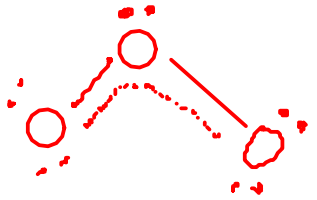
All atoms have a share in eight electrons!

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

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: 1 x 5

H: 4 x 1

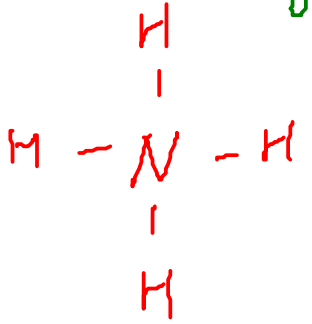
9 e^-

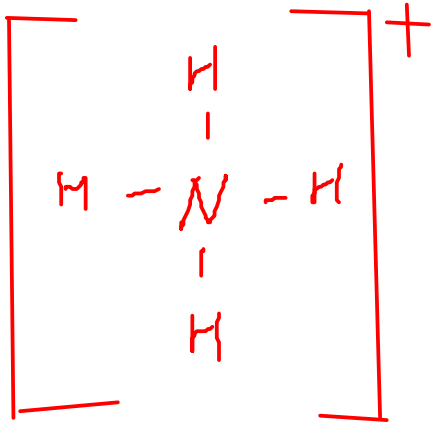
Wait ... an ODD number of electrons?

$-1\ e^-$

Subtract an electron ... since the ion has a +1 charge

8 e^-



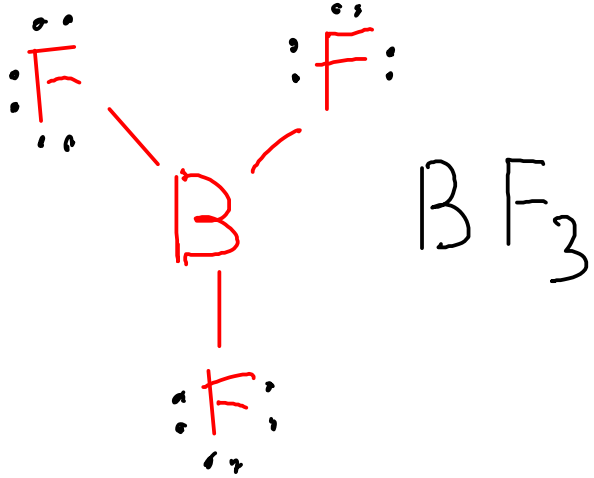


Draw brackets around the structure of the polyatomic ion, then indicate the charge in the upper right.

Similar to other ions ...

EXPANDED VALENCE and other exceptions to the "octet rule"

- Some atoms do not always obey the octet rule. A few, like BORON, will bond in such a way that they end up with less than eight electrons.



... but many more bond in such a way that they end up with a share in MORE THAN EIGHT electrons!

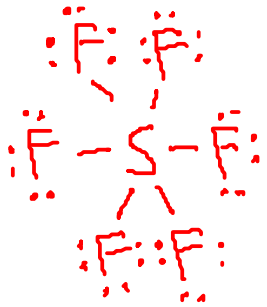
- Any atom in period three or greater can do this. SULFUR and PHOSPHORUS compounds commonly do this!

... these atoms have unfilled "d" orbitals that may participate in bonding!

- All noble gas compounds (example: XENON compounds with oxygen and fluorine) exhibit this behavior!

EXAMPLES:

SF_6



S: 6
F: 7 x 6
48

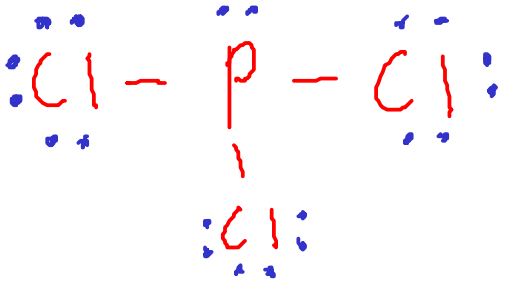
- The central SULFUR atom has a share in TWELVE total electrons, not eight!

- The SHAPE of the sulfur hexafluoride molecule in three dimensions agrees with the picture of six fluorine atoms each sharing a pair of electrons with a sulfur center.

PCl_3 vs PCl_5

PCl_3

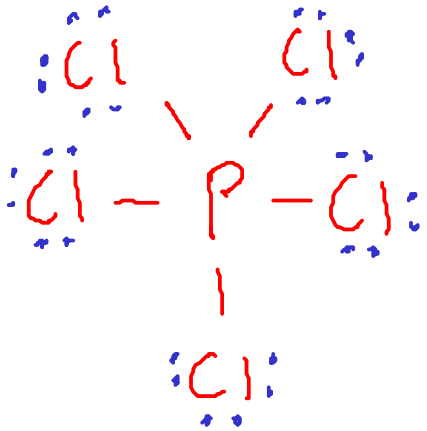
P : 5
Cl : 7 x 3 = 21
26



This structure obeys the octet rule.

PCl_5

P : 5
Cl : 7 x 5 = 35
40



This molecule does NOT obey the octet rule. Phosphorus ends up with ten electrons instead of eight.