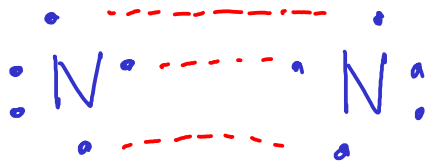
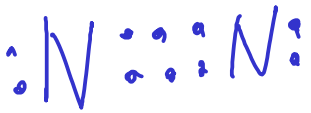
Let's look at NITROGEN ...



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



OR

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

Nitrogen gas is fairly inert ... it's hard to break the triple bond in nitrogen gas apart!

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 with each other.

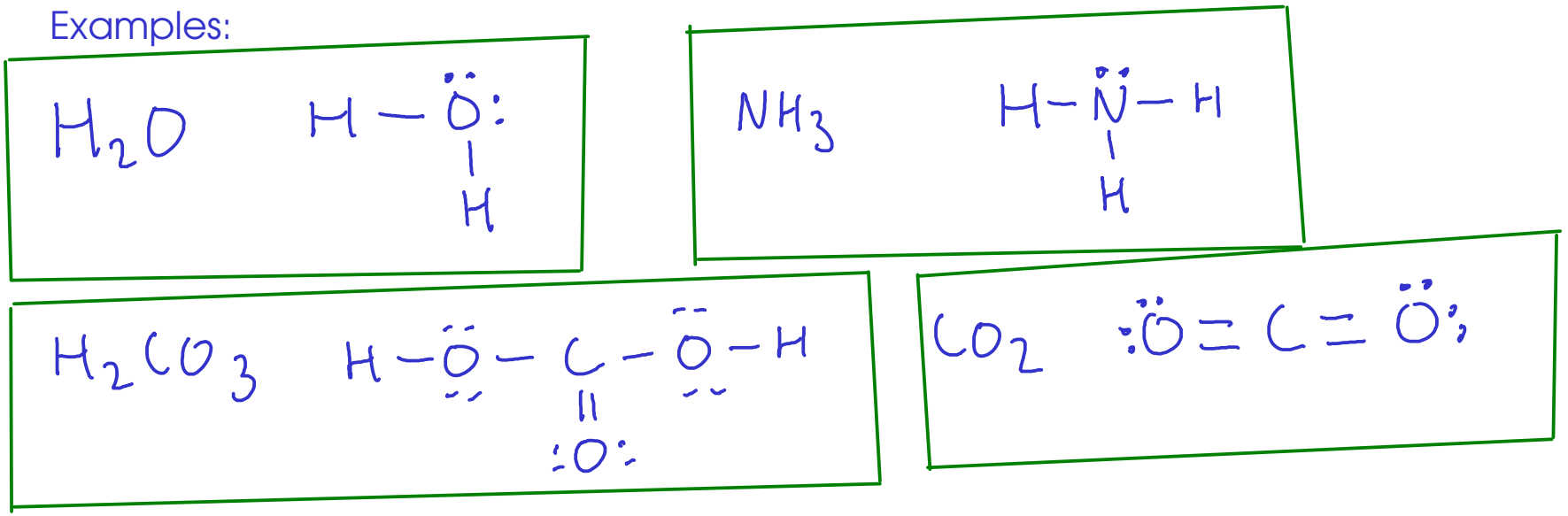
2. Atoms will usually share enough electrons so that each atom ends up with a share in EIGHT electrons - the "octet rule"

   - 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

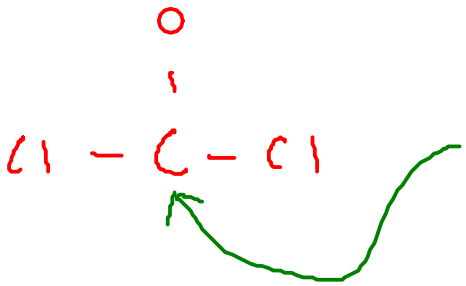
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

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

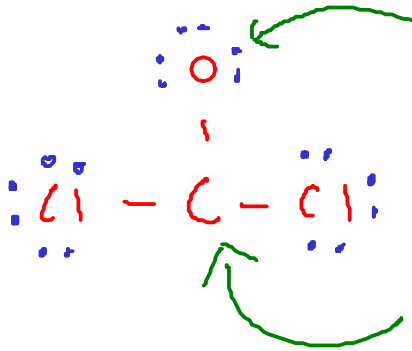
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

$COCl_2$

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



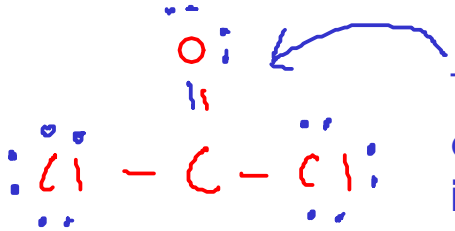
Choose CARBON as the central atom since it needs to gain more electrons than either O or Cl.



Distribute remaining electrons, stop when we run out (24)

... but the central carbon atom has a share in only six valence electrons!

To get carbon more electrons, we will make a DOUBLE BOND. But with which atom? We pick OXYGEN, since it needed to gain two electrons anyway (and is likely to form two bonds to get them!)



This structure looks better, as all atoms now have a share in eight valence electrons!

1. Count valence electrons

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

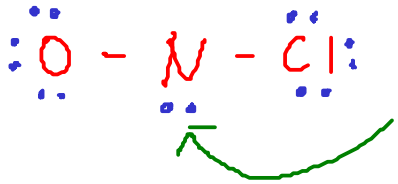
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

NOCl

N : 1 x 5
O : 1 x 6
Cl : 1 x 7
18 e⁻

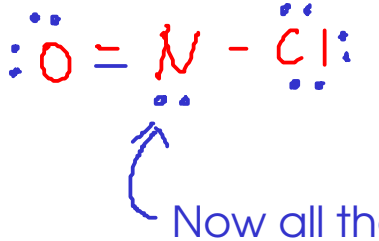
O - N - Cl

Pick NITROGEN as the central atom, since it needs to gain more valence electrons than O or Cl.



We ran out of space on the outer atoms, so the last pair goes on the central nitrogen atom.

Even with the lone pair of electrons on nitrogen, it still needs two more to follow the octet rule. Let's try a DOUBLE BOND with the oxygen atom (same reason as the previous molecule)



Now all the atoms have a share in eight valence electrons...

1. Count valence electrons

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   - central atom is usually the one that needs to gain the most electrons!
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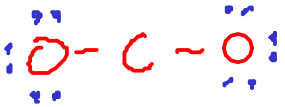
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

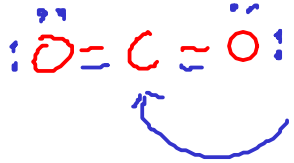
CO_2

C: 1 × 4
O: 2 × 6
16 e⁻



... but the carbon atom has a share in only four valence electrons.

... now six.



Adding a second double bond with the other oxygen atom gives each atom a share in eight outer electrons.

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

This structure says something that can be experimentally tested - one oxygen atom is closer to the center than the other.

Experimentally, we find both oxygens the same distance from the central carbon.

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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⁻

OXYACID, so there must be at least one H attached to an O.

... NITROGEN has a share in only six valence electrons!

Unlike the previous molecule, the two oxygens in nitrous acid 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

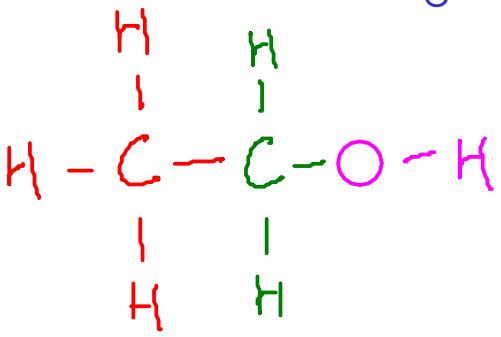
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

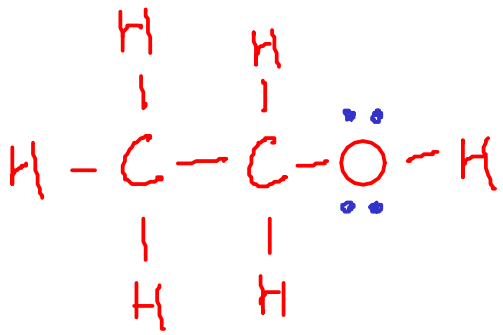
CH_3CH_2OH ETHANOL!

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.



CH_3 CH_2 OH



Once you draw the skeleton, you can treat ethanol like the small molecules we've done before!