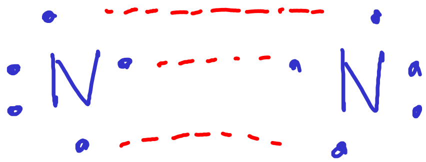
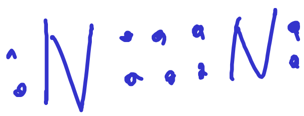
Let's look at NITROGEN ...

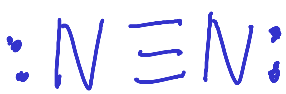


We know that nitrogen exists in air as the diatomic molecule N_2



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

OR



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.

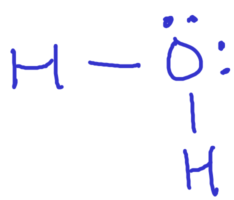
(2) Atoms will usually share enough electrons so that each atom ends up with a share in EIGHT electrons - the "octet rule"

- 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.

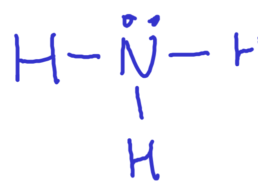
NOW, how could we come up with dot structures for some more complicated (and therefore, more interesting) molecules?

Examples:

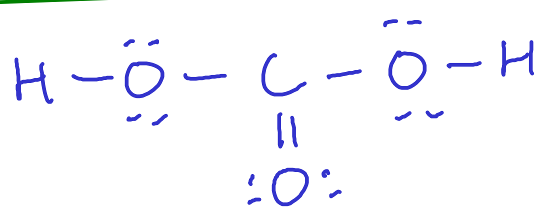
H_2O



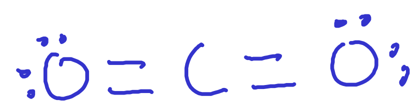
NH_3



H_2CO_3



CO_2



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

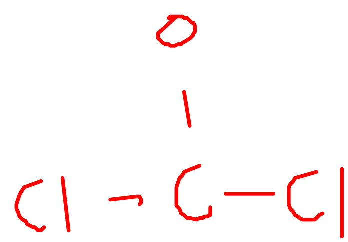
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

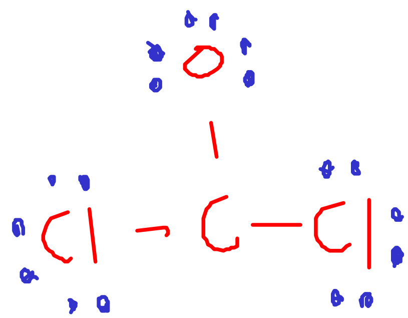
$COCl_2$

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

24 e^-



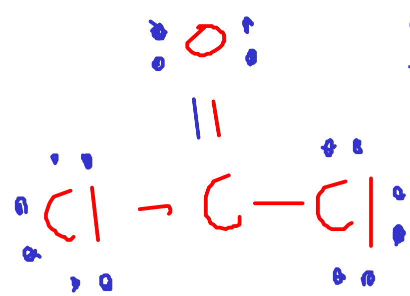
Pick CARBON as central atom, since it needs to gain more valence electrons (4) than either oxygen (2) or chlorine (1).



Distribute remaining electrons, then stop when you reach the total number of valence electrons (24, here)

... but CARBON has a share in only SIX valence electrons! How to fix? Make a double bond with carbon. This will get carbon a greater share in the electrons without changing the overall count. But which "lone pair" will be shared?

Pick OXYGEN, as it needs two electrons and would normally form two bonds to get them!



Now all atoms have a share in eight 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

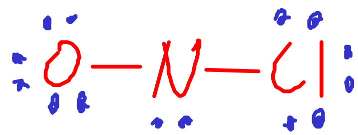
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

NOCl

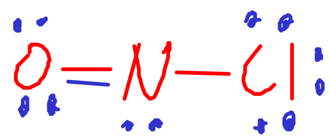
N : 1 x 5
O : 1 x 6
Cl : 1 x 7
———
18 e^-

Pick N as central atom, as it needs to gain more valence electrons (3) than either O (2) or Cl (1).



Distribute remaining electrons. The last two electrons go on N here because we ran out of space on O and Cl ...

... We've only got 6 electrons on N, so let's make a double bond with oxygen (same reason as last example)



Creating a double bond between N and O gives each atom a share in eight valence electrons...

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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.

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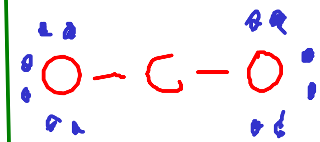
CO_2

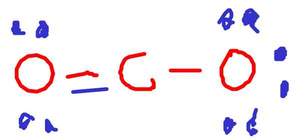
C: 1 × 4
O: 2 × 6

16 e^-

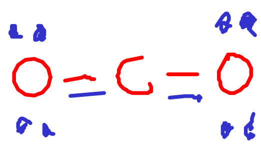
Pick C as central atom ...



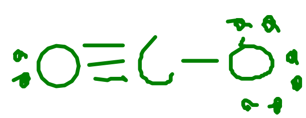
... but C only has a share in 4 valence electrons ...



... now 6



... now 8.



This structure is incorrect because we expect atoms of the same element (oxygen) to behave the same way when in the same environment (each bonded to a single C and to nothing else).

Also, it's beem experimentally determined that there's only one bond distance in carbon dioxide and not two different distances. This supports the O=C=O structure and not the triple/single bond structure.

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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.

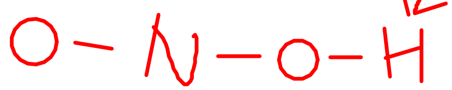
HNO_2 "nitrous acid"

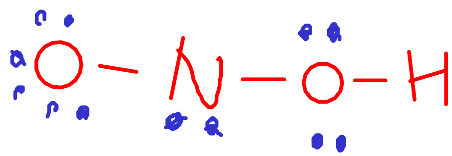
In oxyacids, the acidic hydrogen atoms are attached to OXYGEN atoms in the structure!

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

18 e^-

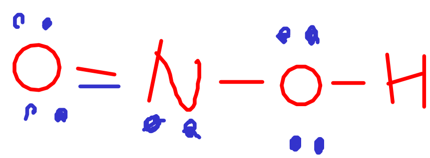
Since nitrous acid is an OXYACID, we know that at least one H atom must be bonded directly to O ...





Distribute electrons ...

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



Create a double bond between the O on the left and the N to give each atom a share in 8 electrons (except H, which is "full" with only 2).

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.