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

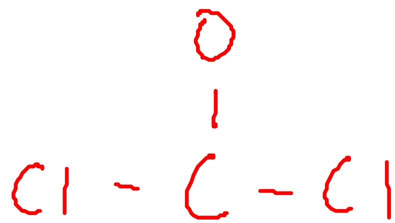
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

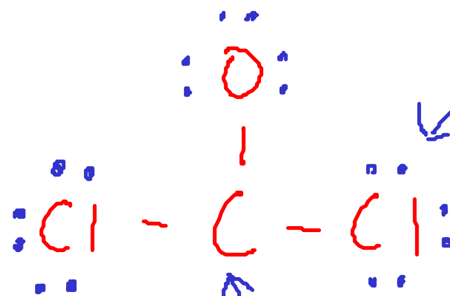
$COCl_2$

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

24 e^-

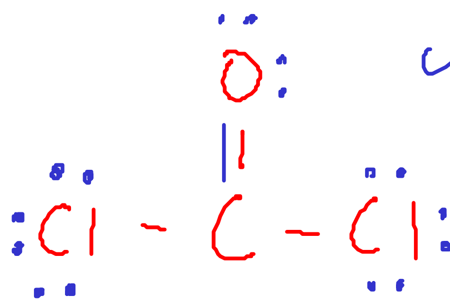


Choose CARBON as the central atom.



Distribute remaining electrons. We start with the outer atoms, and stop here because we have used all 24.

... but CARBON has a share in only six electrons. We're going to have to add a double bond to increase carbon's share.



We'll pick OXYGEN as the atom with the double bond. Based on the number of electrons oxygen starts with, we expect it to form two bonds...

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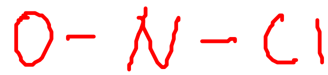
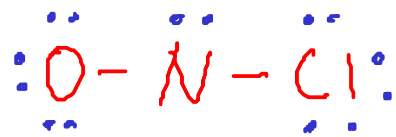
NOCl

N: 5
O: 6
Cl: 7

18 e^-

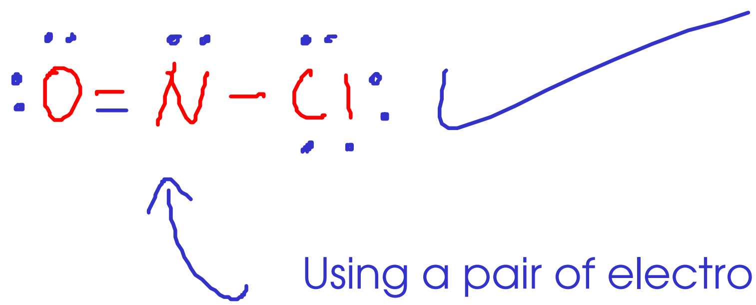


We put NITROGEN in the center, since it needs to gain more electrons than the other atoms.



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

... but NITROGEN only has a share in six electrons. We need a double bond somewhere. We pick oxygen again for the double bond.



Using a pair of electrons from oxygen to form a double bond "fixes" this structure.

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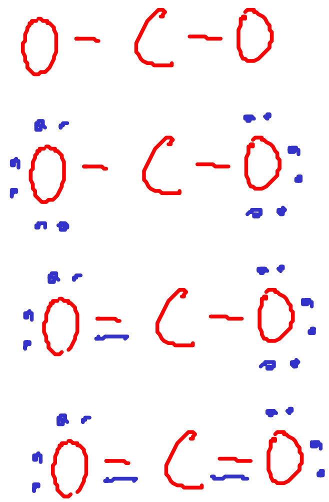
CO_2

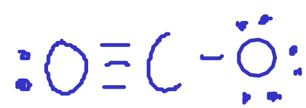
C: 4
O: 6 x 2
16 e^-



... but CARBON has only four electrons!

... now CARBON has SIX electrons.

Adding a second double bond with the other oxygen atom "fixes" this structure!



The two oxygen atoms are in identical chemical environments, and should bond to the carbon atom in the same way, NOT in the arrangement pictured on the left.

EXPERIMENTALLY, we find that the bond lengths in carbon dioxide are identical, and each oxygen atom is the same distance from the center. This does NOT agree with the triple-bond structure!

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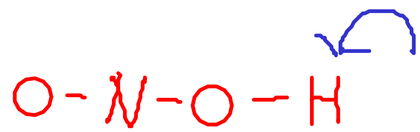
HNO_2 "nitrous acid"

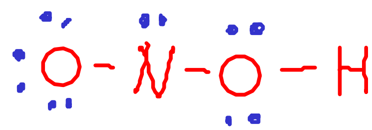
In oxyacids, the acidic hydrogen atoms are attached to OXYGEN atoms in the structure!

H: 1x1
N: 1x5
O: 2x6

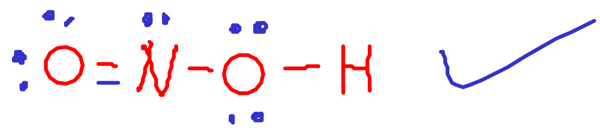
$18e^-$



OXYACID - attach H to O instead of N...



... but NITROGEN has a share in only six electrons.



Here, the two oxygen atoms are in DIFFERENT chemical environments, so they do not bond to the nitrogen atom in the same way!

A DOT STRUCTURE FOR A LARGER MOLECULE

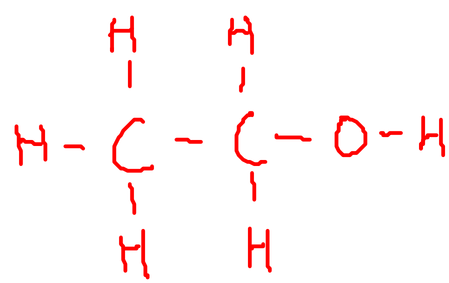
1. Count valence electrons
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds
3. Distribute remaining valence electrons around structure, outer atoms first. 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.

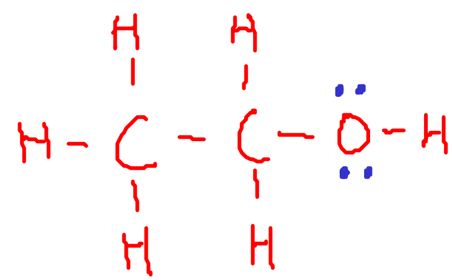
CH_3CH_2OH ETHANOL!

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

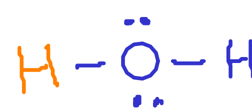
This formula gives us a hint to the structure of the molecule. Ethanol has THREE centers: the two carbon atoms and the oxygen atom.

CH_3 CH_2 OH





Notice: Structural similarity to:



... so we're not surprised that small-molecule ALCOHOLS like ethanol are water-soluble!

A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

O: 3 x 6 = 18

See text, 9,7
p 350 - 352

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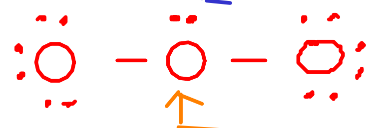
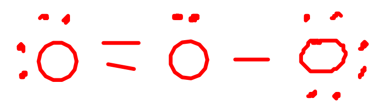
O_3 (OZONE)



OUT OF ELECTRONS

Central oxygen has only six electrons

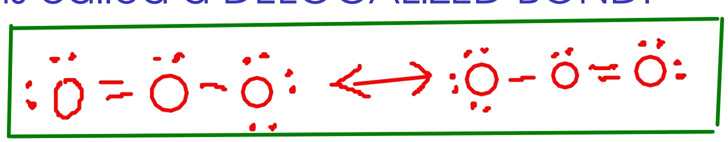


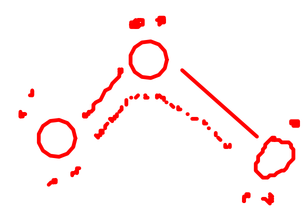
All atoms have a share in eight electrons!

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

A DOT STRUCTURE FOR A POLYATOMIC ION

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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.

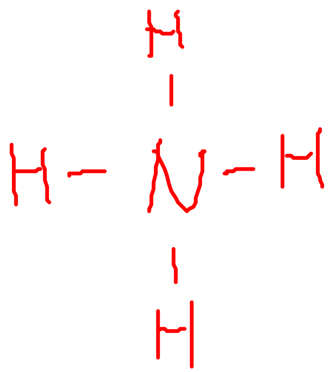
NH_4^+

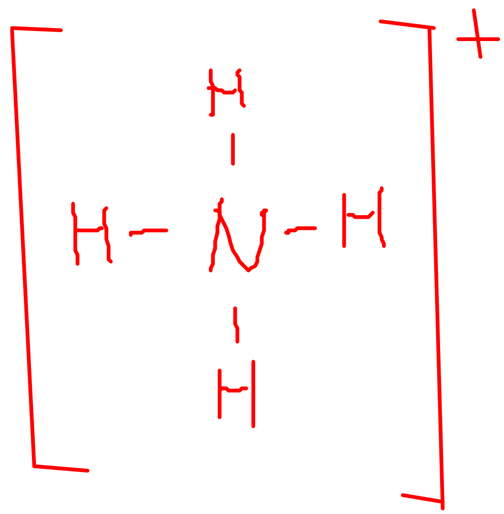
N: 1 x 5
H: 4 x 1

9 electrons
−1

8 electrons

Subtract one electron from the total to get a +1 charge.





Draw brackets around the ion's strcuture and indicate the charge of the ion ... similarly to how we indicate the charge on other ions!