# DRAWING DOT STRUCTURES FOR SIMPLE MOLECULES

1. Count valence electrons

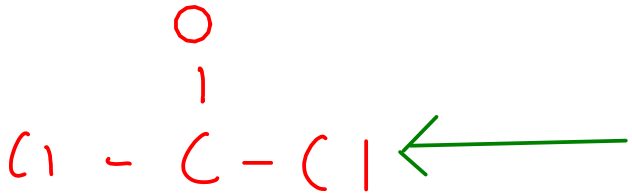
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

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

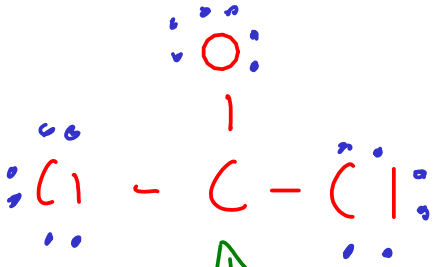
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

$COCl_2$

C : 1 x 4
O : 1 x 6
Cl : 2 x 7
24 valence e⁻

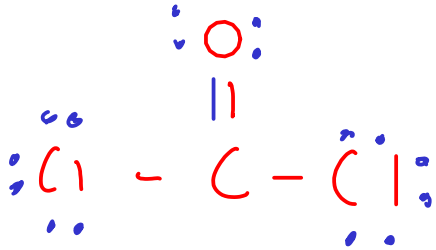


Choose CARBON as the central atom, since it needs to gain four more electrons (more than O or Cl)



Distribute remaining electrons; stop when all electrons are shown (here, that's 24)

Problem: Carbon has a share in SIX electrons, not eight (octet rule). How to fix? Try a double bond. But with which atom?



Choose OXYGEN for the double bond, since oxygen needs to gain two electrons and chlorine needs to gain only one!

The addition of a double bond "fixes" phosgene's structure!

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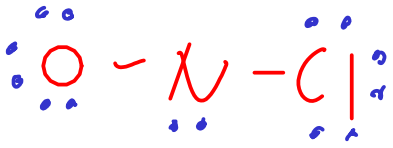
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

NOCl

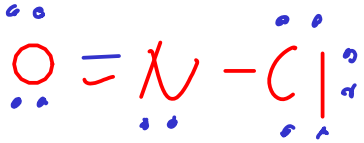
N : 1 x 5
O : 1 x 6
Cl : 1 x 7
18 e⁻

Pick NITROGEN as central atom since it needs to gain more electrons than the others.



Distribute remaining electrons, stop at 18. Since there was no room on O or Cl, last pair goes on N.

Only six electrons on N. Fix? Try a double bond! Choose oxygen to form the double bond for the same reasons as last example.



Adding the double bond "fixes" this structure.

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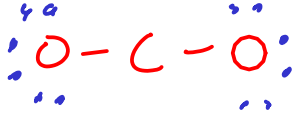
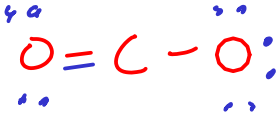
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

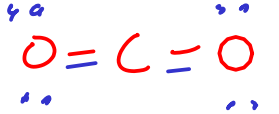
$CO_2$

C: 1 x 4
O: 2 x 6
16 e⁻

O – C – O Choose CARBON as central atom.


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


... now six


... now eight!

Why not this structure? It has the same element (oxygen) bonding in two completely different ways when put into the same situation (bonding to a single carbon atom and nothing else). Since atoms are chemically identical, this shouldn't happen!

# 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.

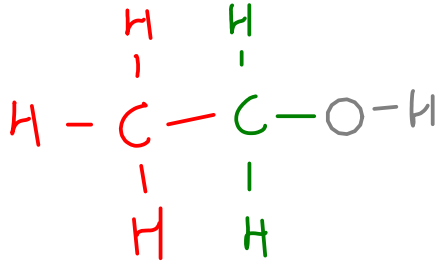
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

$CH_3CH_2OH$ ETHANOL!

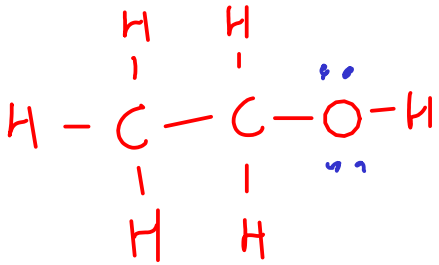
C : 4 x 2 = 8
H : 1 x 6 = 6
O : 6 x 1 = 6
| 20

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

$CH_3 \quad CH_2 \quad OH$



Draw skeleton. Link each "mini" molecule together



Distribute remaining electrons

# 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

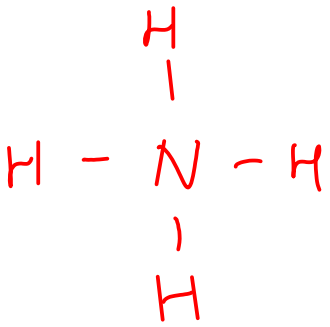
3. Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

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

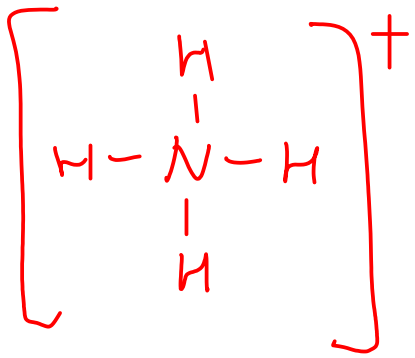
$NH_4^+$

N: 1x5
H: 4x1
9 valence e⁻
−1 e⁻ (+1 charge)
8 e⁻

For a poyatomic ion, account for the ion's charge by adding or subtracting electrons. ("+" means subtract electrons, "-" means add them)



All electrons accounted for, but we need to indicate that this is an ion!



Draw brackets around the structure and indicate the charge at the upper right.

# A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

1. Count valence electrons

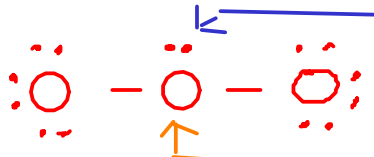
2. Pick central atom and draw skeletal structure
   - central atom is usually the one that needs to gain the most electrons!
   - skeletal structure has all atoms connected to center with single bonds

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.

$O_3$ (OZONE) $0 : 3 \times 6 = 18$

See Openstax p362-363

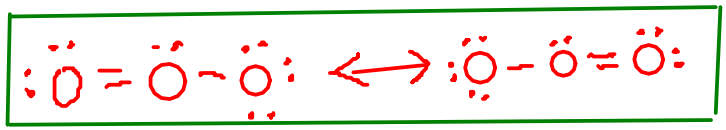


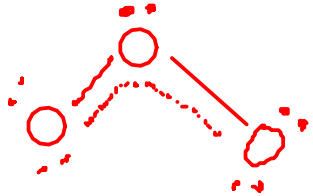

All atoms have a share in eight electrons!

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.

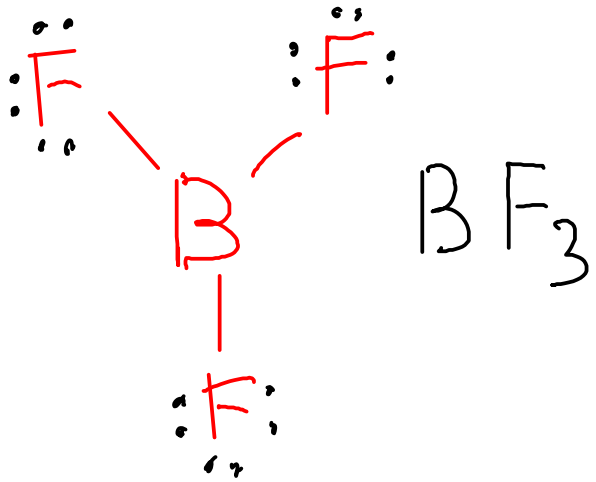




The structures in the green box are called RESONANCE STRUCTURES. The "real" structure of ozone is an "average" of the two resonsnce structures. The "double bond" electrons in these structures are actually shared between all three oxygen atoms

# 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!