(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.

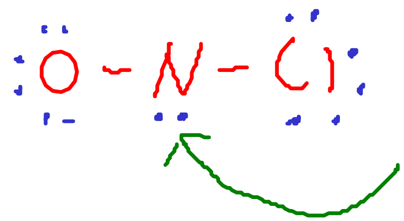
NOCl

N : 1 x 5
O : 1 x 6
Cl : 1 x 7

18 e^-

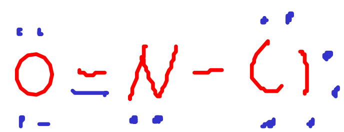
O – N – Cl

We'll pick NITROGEN as central atom, since it needs to gain more electrons than either O or Cl.



We ran out of space on the outer atoms, so we put the final pair of electrons on the central nitrogen atom.

But even with the lone pair, nitrogen still has a share in only six electrons! So, try a double bond.



As before, we choose OXYGEN to form the double bond, since oxygen needs two more electrons and is likely to form two bonds to get them!

Now each atom has a share in eight valence electrons.

(1) Count valence electrons

(2) Pick central atom and draw skeletal structure

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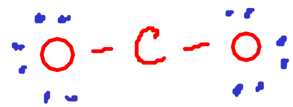
CO_2

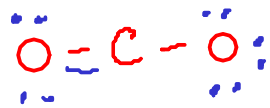
C: 1 x 4
O: 2 x 6

16 e^-

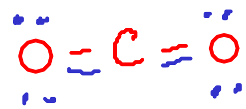
Carbon is the central atom.



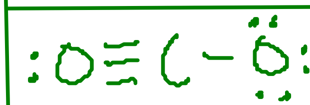
... but carbon has a share in only FOUR valence electrons!



... now SIX valence electrons



Adding a second double bond gives all atoms a share in eight valence electrons.



Why not this structure? The two oxygen atoms are in identical environments and should bond the same way.

This structure says something we can test experimentally. It says that one oxygen atom (the triple-bonded one) is much closer to the central carbon than the other oxygen atom is. Experimentally, we can measure the bond length via x-ray diffraction. X-ray diffraction experiments on carbon dioxide confirm that both oxygen atoms are the SAME distance from the carbon ... consistent with the double bond structure.

200

(1) Count valence 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.

HNO_2 "nitrous acid"

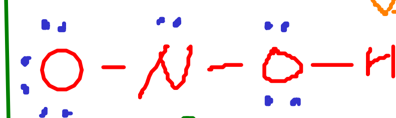
In oxyacids, the acidic hydrogen atoms are attached to OXYGEN atoms in the structure!

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

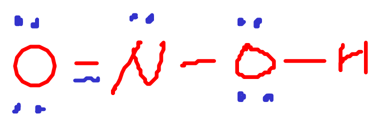
18 e⁻

Since this is an OXYACID, we must have at least one H bonded directly to an O...

Remember: H can only hold TWO valence electrons!



We run out of electrons after putting a lone pair onto the central nitrogen. But nitrogen still has a share on only six valence electrons!



Unlike the carbon dioxide molecule, these oxygen atoms are in different environments and thus bond differently to the nitrogen atom!

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

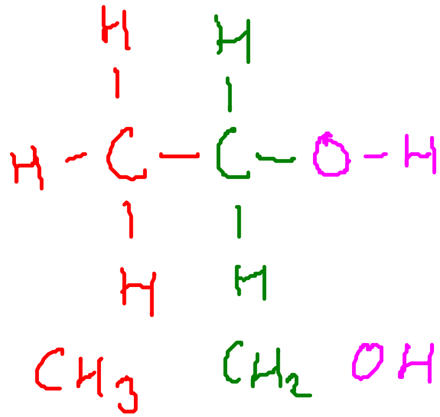
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

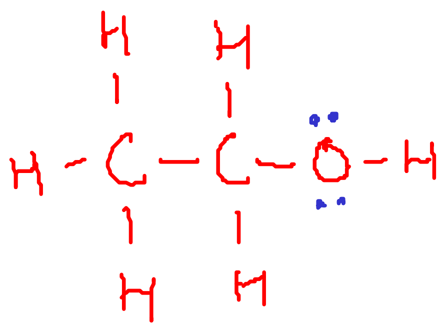
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CH_3CH_2OH ETHANOL!

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

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





A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

$O: 3 \times 6 = 18$

See text, 9,7
p 356-358

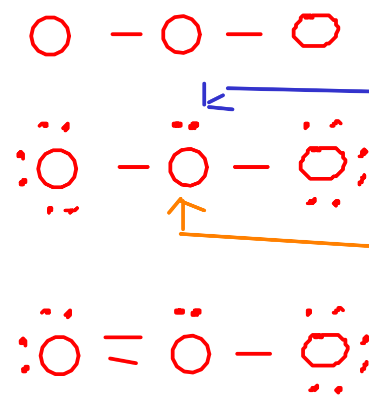
O_3 (OZONE)

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.



OUT OF ELECTRONS

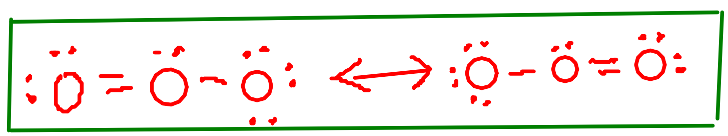
Central oxygen has only six electrons

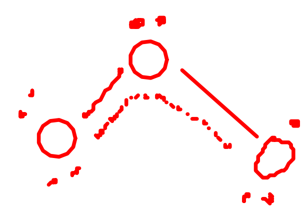
All atoms have a share in eight electrons!

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

(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.

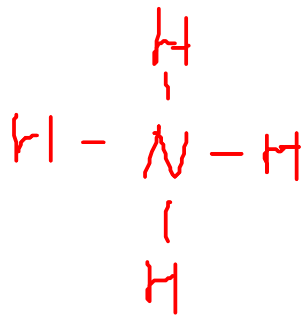
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

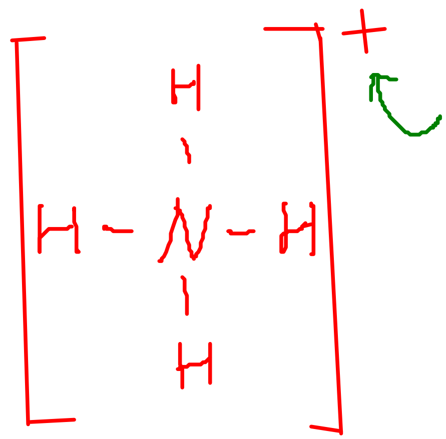
NH_4^+

N: 1x5
H: 4x1

9 electrons
− 1 electron (+1 charge)

8

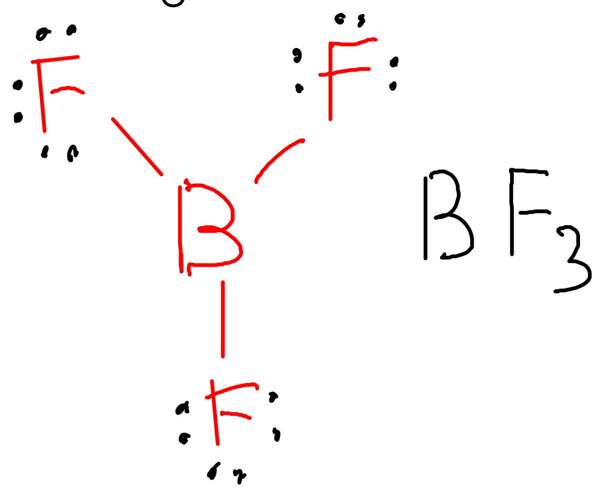




For an ion, draw brackets around the structure and put the charge in the upper right ... the usual position for charges.

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!

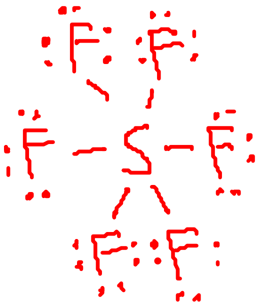
- Any atom in period three or greater can do this. SULFUR and PHOSPHORUS compounds commonly do this!

... 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

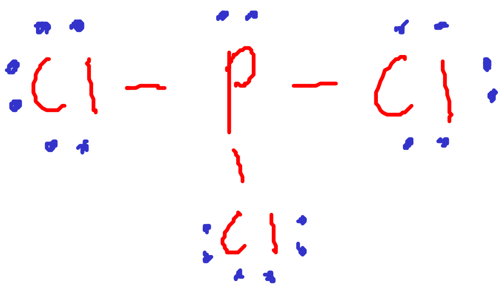
- The central SULFUR atom has a share in TWELVE total electrons, not eight!

- 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

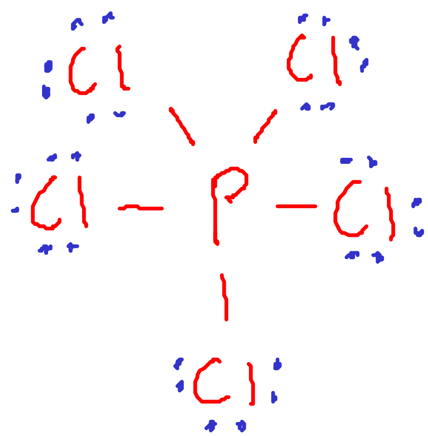
P : 5
Cl : 7 x 3 = 21
26



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.