(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.

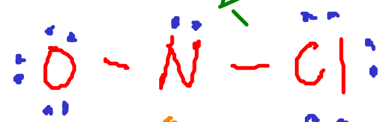
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

NOCl

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

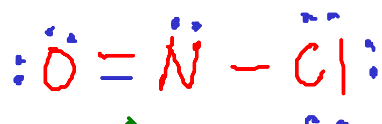
18 electrons

We use NITROGEN as the central atom, since it needs to gain more electrons than either chlorine or oxygen.



We ran out of "space" on the outside, so the last pair of electrons goes to nitrogen.

Nitrogen has a share in only SIX electrons, so we need a double bond somewhere.



Using a pair of electrons we originally assigned to oxygen, we make a double bond between oxygen and nitrogen. This "fixes" the strcuture.

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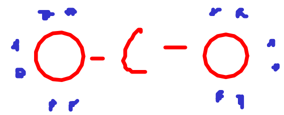
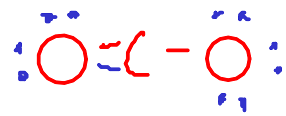
4. Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CO_2

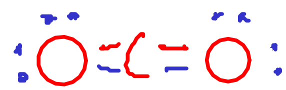
C: 4
O: 6 x2
16 e-



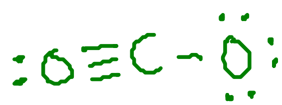
Carbon has a share in only FOUR electrons.



Adding a double bond gives carbon a share in SIX electrons



Adding a second double bond gives carbon a share in EIGHT electrons.



The two oxygen atoms are in identical environments and SHOULD bond the same way to the carbon, not in different ways (like the structure on the left)

EXPERIMENTALLY, we find that the two oxygen atoms are the same distance from the central carbon. This does not agree with the triple bond structure, since the triple bond has a shorter bond distance than the single bond.

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

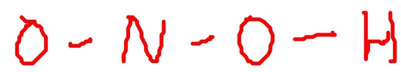
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

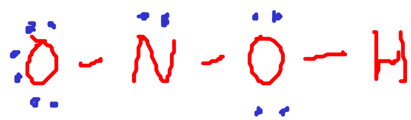
HNO_2 "nitrous acid"

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

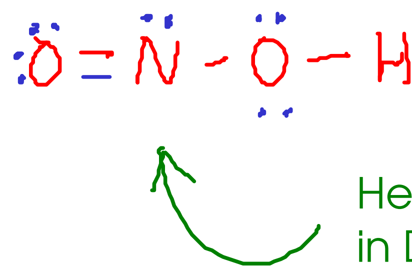
H : 1 x 1
N : 1 x 5
O : 2 x 6

18 electrons





But NITROGEN has a share in only six electrons.



Here, the two oxygen atoms are in DIFFERENT environments, so we're not surprised to see that they bond differently to the central 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

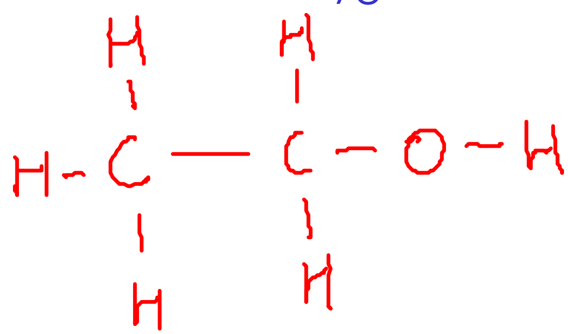
(3) Distribute remaining valence electrons around structure, outer atoms first. Follow octet rule until you run out of electrons.

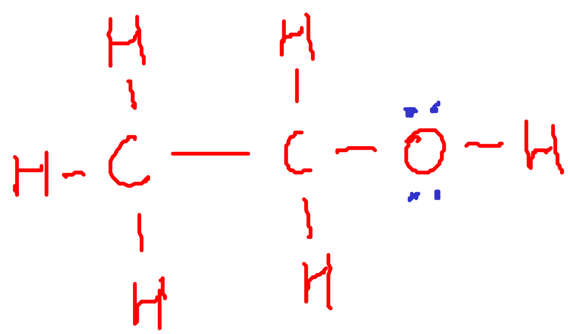
(4) Check octet rule - each atom should have a share in 8 electrons (H gets 2). if not, make double or triple bonds.

CH_3CH_2OH ETHANOL!

C : 4 x 2 = 8
H : 1 x 6 = 6
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.





A DOT STRUCTURE FOR A MOLECULE WITH DELOCALIZED BONDS

O: 3 x 6 = 18

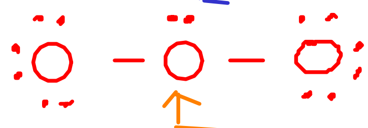
See text, 9,7
p 350-352

O_3 (OZONE)

(1) Count valence electrons

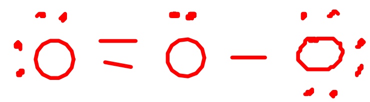
(2) Pick central atom and draw skeletal structure

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



OUT OF ELECTRONS

Central oxygen has only six electrons



All atoms have a share in eight electrons!

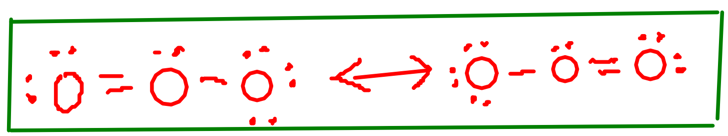
The structure we drew implies that one of the outer oxygen atoms is closer to the central oxygen atom than the other one.

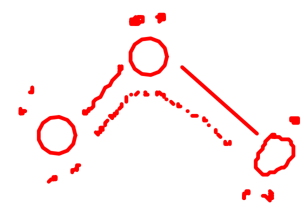
Experimentally, though, we find the two oxygen atoms to be the SAME distance from the center.

In the ozone molecule, electrons are actually being shared between ALL THREE oxygen atoms at the same time. This is called a DELOCALIZED BOND.

(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.





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 : 1 x 5
H : 4 x 1

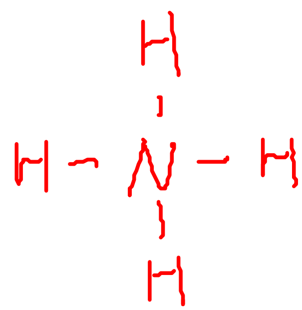
9

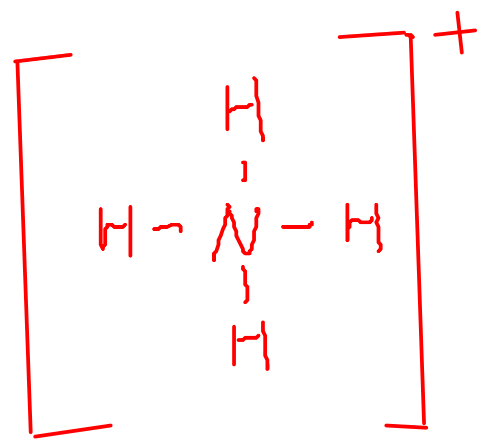
− 1

8

An ODD number of electrons? But Lewis structures for molecules generally involve PAIRS of electrons!

Subtract an electron to account for the +1 charge

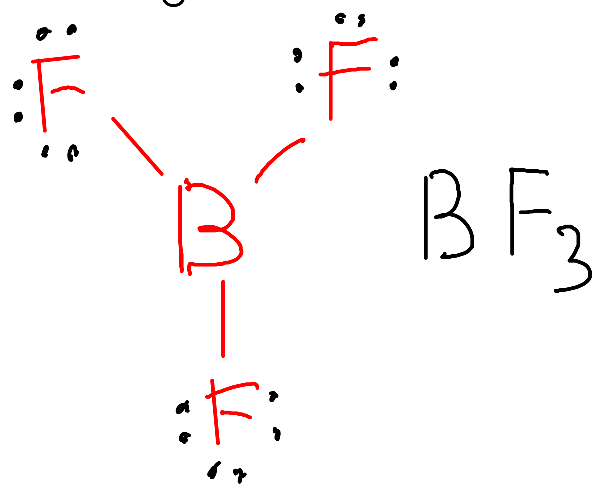




Draw brackets around the ion's structure, then put the charge on the upper right corner - just like you would for a monatomic ion - ex: Mg^{2+}

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!

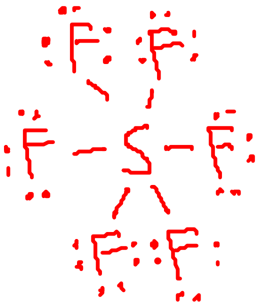
- Any atom in period three or greater can do this. SULFUR and PHOSPHORUS compounds commonly do this!

  ... 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

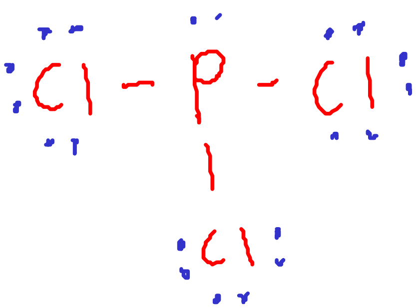
- The central SULFUR atom has a share in TWELVE total electrons, not eight!

- 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

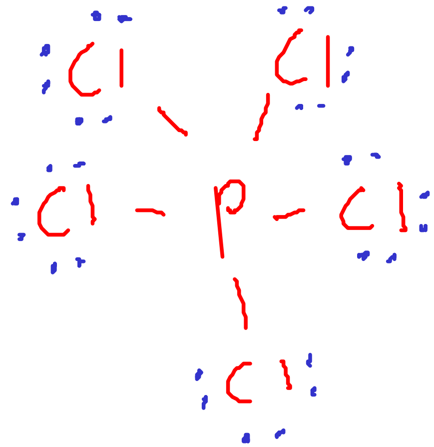
P : 5
Cl : 7 x 3 = 21
26



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 has a share in TEN electrons in this structure.