Drawing Lewis Structures

Skills to Develop

- Establish a general procedure for drawing Lewis structures
- Describe the interactions between atoms using Lewis structures (what happens to the valence electrons)

Everyone who has studied chemistry should be able to draw Lewis structures. Although there are many complicated situations, and some people try to stretch Lewis structures to be an accurate description of molecules even when they don't work well, the basic idea is simple. Here's how I draw Lewis structures.

1. You count the valence electrons. Count the valence electrons for each atom, add them up, and add or remove electrons if there is an overall charge.
2. You figure out what the connections between atoms are. Sometimes you might look this up. Other times, you have to guess. If the molecule is linear (like HCN) usually it is written in the correct order. If it is a polyatomic ion, like sulfate or nitrate, usually you put the heavy atom, or the atom to the left in the periodic table, in the center. You should probably not put all the atoms in a line if there are more than 4 (single-bonded chains are usually very unstable, except for carbon). Elements like N, C, S, P, Cl and the heavier elements in these groups can easily connect to 4 other atoms, so often they go in the middle. O should not connect to more than 2 atoms, and often only connects to one. If O connects to 2 atoms, usually at least one is C or H. H and F will almost always make just one bond. (Hydrogen bonds, which you may have heard of, are much weaker than the covalent bonds shown by Lewis structures.)
3. Once you have chosen an arrangement of atoms, add the right number of electrons. Try to make sure every element gets the right number of electrons, using **lone pairs** of electrons which are not shared, or shared pairs (which are bonds). You can draw single, double, or triple bonds. Make sure that H has 2 electrons (never more) and C, N, O, F have 8 electrons (never more, and not less unless the molecule has an odd number of electrons). The heavy elements under C-F should have at least eight electrons, and they can also connect to 6 or even 7 other atoms. B often has 6 electrons, and Be often has 4. Move the electrons around until it works. Make sure your final structure has the right total number of electrons, and that none of the atoms have too many or too few.
4. Unpaired electrons are called **radicals**, and you should avoid them. When you draw the Lewis structure, make all the electrons paired unless there is an odd number of electrons. All electrons should be in lone pairs or bonding pairs. (There are molecules, like O_2, which have unpaired electrons even though they could all be paired, but you can't predict that with Lewis structures, so assume they are all paired.)

Table 1*: Acceptable Numbers of Electrons and Connected Atoms for Common Elements*

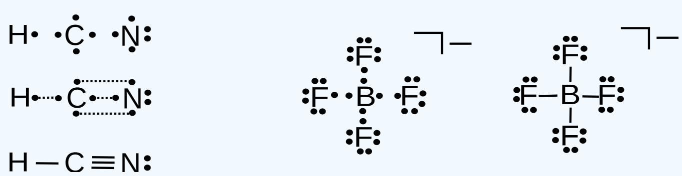
Element	Number of Electrons (including shared)	Number of Connected Atoms	Exceptions
H	2	1	Sometimes connects to 2 atoms, in H-bonding or with boron
Be	0, 4, 6, 8	2 - 4	Can be shown as ionic (0 electrons) or covalent (4, 6, 8)
B	6, 8	3, 4	Sometimes has less than 8 electrons
C	8	1 - 4	Less electrons if compound is a radical
N	8	1 - 4	Less electrons if compound is a radical
O	8	1 - 2	Sometimes connects to 3 atoms, such as in H-bonding
F	8	1	Sometimes connects to 2 atoms, such as in H-bonding

Element	Number of Electrons (including shared)	Number of Connected Atoms	Exceptions
P and below	8 or more	3 - 6	
S and below	8 or more	2 - 6	
Cl and below	8 or more	1 - 6	Can connect to 7 atoms
Xe	8 or more	0 - 6	Xe compounds with O and F are known

Example 1

First, let's do hydrogen cyanide, the poison that might have killed Lewis. The formula is HCN. As usual, this is the correct order of the atoms. The number of valence electrons in the molecule is (1 + 4 + 5) = 10. When I'm putting the electrons in, I usually start by putting each atom's valence electrons around it, then I connect the dots into lines. (These steps are shown in the picture).

For a second example, let's do the tetrafluoroborate ion, BF_4^-. In this case, we have to put B in the middle, because F shouldn't make more than 1 bond. We count electrons: (3 + 7 x 4 + 1) = 32. Remember to count +1 for the negative charge on the ion. Because B needs to make 4 bonds, we'll give it the extra electron. Then we'll connect the electrons into bonds. In this case, you know that F pulls on electrons much harder than B, so the "shared pairs" will probably be closer to F, even though the picture doesn't show that.



The construction of Lewis dot structures for HCN on the left and BF_4^- on the right.

Outside Links

- readysetorgo: dot structures I (7 min)
- readysetorgo: dot structures II (6 min)
- CrashCourse Chemistry: Bonding Models and Lewis Structures (12 min)

Contributors and Attributions

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