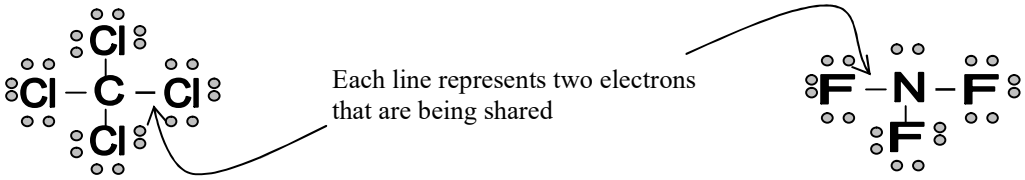
Lewis Structures

Name: _____

Date: _____

Information: Drawing Covalent Compounds

For covalent bonding, we often want to draw how the atoms share electrons in the molecule. For example, consider CCl_4 and NF_3 as drawn below:



Notice that the atoms share electrons so that they all have 8 electrons. If you count the electrons around carbon, you will get a total of eight (each line is two electrons). If you count the electrons around each chlorine atom, you will find that there are eight of them.

Critical Thinking Questions

1. How many valence electrons does a carbon atom have (before it bonds)? Hint: find this based on carbon's column on the periodic table.
   4; since carbon is in column 14 (or "4A") on the periodic table it has 4 valence electrons.
2. How many valence electrons does a chlorine atom have (before it bonds)?
   7; since chlorine is in column 17 (or "7A") it has 7 valence electrons.
3. Since CCl_4 is made up of one carbon and four chlorine atoms, how many total valence electrons does CCl_4 have? Hint: add your answer to question 1 and four times your answer to question 2.
   $4 + 4(7) = 4 + 28 = 32$
4. Verify that there are 32 electrons pictured in the drawing of CCl_4.
   Count each dot in the picture above: there are 24. There are also 8 more electrons represented by the 4 lines (each line represents two electrons).

5. Find the sum of all the valence electrons for NF_3. (Add how many valence electrons one nitrogen atom has with the valence electrons for three fluorine atoms.)
   26; nitrogen has 5 valence electrons; fluorine has 7. Since there are one nitrogen and 7 fluorine atoms, the total is obtained as follows: $5 + 7(3) = 5 + 21 = 26$

6. How many electrons are pictured in the drawing of NF_3 above?
   26; count each dot in the picture above: there are 20. There are also 6 more electrons represented by the 3 lines (each line represents two electrons).
7. In CCl_4 carbon is the "central atom". In NF_3 nitrogen is the "central atom". What is meant by "central atom"?
   The central atom is the atom that is in the middle of other atoms in the Lewis structure. Other atoms branch off from the central atom.

8. In SF_3 sulfur is the central atom. You can tell which atom is the central atom simply by looking at the formula. How does the formula give away which atom is the central atom?
The central atom is usually the first atom written in the formula. Also, you can recognize the central atom in the formula because there is only one of the atom. For example, in the above formula for SF_3 there is only one sulfur atom.

9. Identify the central atom in each of the following molecules:

A) CO_2	B) PH_3	C) SiO_2
carbon	phosphorus	silicon

10. For each of the compounds from question 9, add up how many valence electrons should be in the bonding picture. A is done for you.

A) CO_2	B) PH_3	C) SiO_2
$4 + 2(6) = 16$	**$5 + 3(1) = 8$**	**$4 + 2(6) = 16$**

11. The number of electrons that should appear in the bonding picture for CO_3 is 22. The number of electrons that appear in the picture for CO_3^{2-} is 24. Offer an explanation for why CO_3^{2-} has 24 electrons instead of 22. (Where did the extra two electrons come from?)
The -2 charge on CO_3^{2-} means that it has two extra electrons.

12. The number of electrons that should be included in the picture of NH_4 is 9. The number of electrons in the picture for NH_4^+ is 8. Offer an explanation for why NH_4^+ has 8 electrons instead of 9.
The +1 charge on NH_4^+ means that it has one fewer electron.

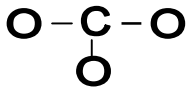
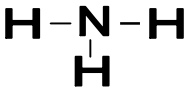
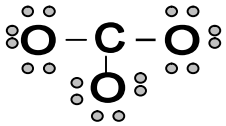
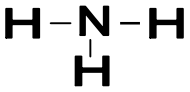
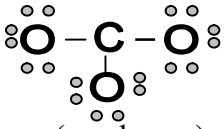
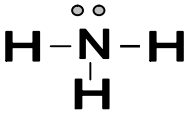
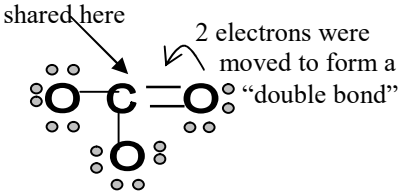
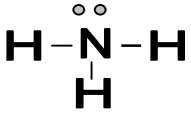
13. Considering questions 11 and 12, we can formulate a rule: For each negative charge on a polyatomic ion, we must ____add____ (add or subtract) an electron and for each positive charge we must ____subtract____ (add or subtract) an electron.

14. For each of the polyatomic ions or molecules below, determine the total number of valence electrons.

a) NO_3^-	b) SCl_4	c) H_3O^+	d) PO_4^{3-}
$5 + 3(6) + 1 = 24$	$6 + 4(7) = 34$	$3(1) + 6 - 1 = 8$	$5 + 4(6) + 3 = 32$

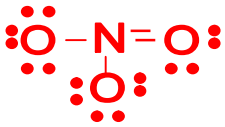
Information: Steps for Drawing Lewis Structures for Covalent Compounds

Study the two examples in the table of how to write structures for CO_3^{2-} and NH_3. Make sure you understand each of the five steps.

	CO_3^{2-}	**NH_3**
Step #1: Add up the number of valence electrons that should be included in the Lewis Structure.	4 + 3(6) + 2 = **24** (carbon has four and each oxygen has six; add two for the -2 charge)	5 + 3(1) = **8** (nitrogen has five; each hydrogen has one)
Step #2: Draw the "skeleton structure" with the central atoms and the other atoms, each connected with a single bond.		
Step #3: Add six more electron dots to each atom *except* the central atom. Also, never add dots to hydrogen.		 (no change)
Step #4: Any "leftover" electrons are placed on the central atom. Find the number of leftovers by taking the total from Step #1 and subtracting the number of electrons pictured in Step #3.	24 – 24 = 0 leftover electrons  (no change)	8 – 6 = 2 leftover electrons; placed around nitrogen 
Step #5: If the central atom has 8, then you are done. If not, then move two electrons from a different atom to make a multiple bond. Keep making multiple bonds until the central atom has 8 electrons.		(no change) 

Critical Thinking Questions

15. Write the Lewis Structure for nitrate, NO_3^{-1}. Hint: when you are done it should look very similar to CO_3^{2-} in the table above.



16. Draw the Lewis Structure for SO_2.