ChemQuest 22

Covalent Bonding

Name: _____

Date: _____

Hour: _____

Information: Terminology

Recall that an ionic bond results from the combination of a metal and a nonmetal. A covalent bond is the type of bond between two nonmetals. Covalent bonds are formed by neutral atoms that share electrons rather than by charged ions. When a compound is formed by sharing electrons, the compound is called a molecule or molecular compound. It is important to note that ionic compounds are not called molecules. The largest class of molecules are called organic molecules. Carbon is the distinguishing mark of organic compounds.

Critical Thinking Questions

1. Circle any of the following compounds that would properly be called a "molecule".

   a) H_2O b) CO_2 c) NaCl d) Mg_3P_2 e) N_2O_5

Information: Naming Covalent Compounds

There are several prefixes used to name molecules. The name "carbon oxide" is not sufficient because carbon and oxygen sometimes form CO_2 and sometimes CO. Prefixes are necessary to distinguish between them.

Formula	Name
N_2O_4	dinitrogen tetraoxide
SF_6	sulfur hexafluoride
$XeCl_5$	xenon pentachloride
SO_3	sulfur trioxide
CO	carbon monoxide

Critical Thinking Questions

2. Fill in the table to indicate which prefix is used to represent the numbers. The first one is done for you.

Number	Prefix
1	mono
2	
3	
4	
5	
6	

3. Name each of the following molecules using the appropriate prefixes.
   a) N_2O_5 b) CF_4 c) SCl_3 d) SO

4. Which of the above compounds would be classified as "organic"?

Information: Empirical Formulas

Molecules can be represented by using either a molecular formula or an empirical formula. The molecular formula tells you exactly how many atoms of each element are in the compound. For example, in the table below, compound #2 has exactly 4 carbons and 8 hydrogens in each molecule. Observe the table below that shows four organic molecules along with a molecular and empirical formula for each one:

Molecule	Molecular Formula	Empirical Formula
#1	C_2H_4	CH_2
#2	C_4H_8	CH_2
#3	C_3H_8	C_3H_8
#4	C_8H_{18}	C_4H_9

Critical Thinking Questions

5. What is an empirical formula?

6. How can molecules #1 and #2 have the same empirical formula even though they are different molecules?

7. Given the empirical formula for a compound is it possible to determine the molecular formula? If so, explain how.

8. Given the molecular formula for a compound is it possible to determine its empirical formula? If so, explain how.

9. Give the empirical formula for each of the molecules below:
   a) N_2O_6 b) $C_2H_4O_2$ c) C_4H_{14} d) C_3H_5

ChemQuest 23

Lewis Structures

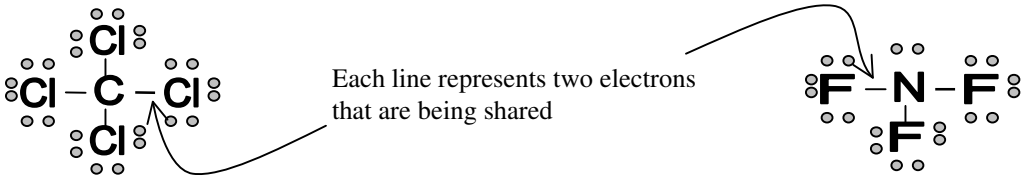
Name: _____

Date: _____

Hour: _____

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.

2. How many valence electrons does a chlorine atom have (before it bonds)?

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. Verify that there are 32 electrons pictured in the drawing of CCl_4.

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.)

6. How many electrons are pictured in the drawing of NF_3 above?

7. In CCl_4 carbon is the "central atom". In NF_3 nitrogen is the "central atom". What is meant by "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?

9. Identify the central atom in each of the following molecules:
   A) CO_2 B) PH_3 C) SiO_2

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

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?)

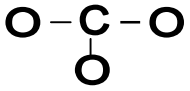
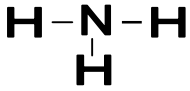
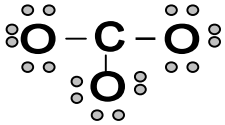
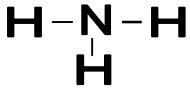
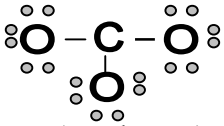
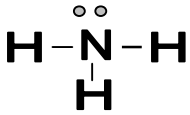
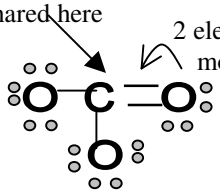
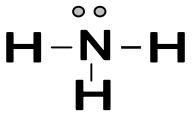
12. The number of electrons that should be included in the picture of NH_4 is 9. The number of electrons in the picture for NH_4^+ is 8. Offer an explanation for why NH_4^+ has 8 electrons instead of 9.

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

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-}

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.	a total of 4 electrons are shared here; 2 electrons were moved to form a "double bond" 	(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.