General Chemistry 1
Quarter 2 - Module 3
Covalent Bonds, Lewis Structures and Molecular Geometry

Name of Learner: ____________________________
Grade & Section: ____________________________
Name of School: _____________________________
What I Need to Know

Covalent bonding occurs when pairs of electrons are shared by atoms. Atoms will covalently bond with other atoms in order to gain more stability, which is gained by forming a full electron shell. By sharing their outer most (valence) electrons, atoms can fill up their outer electron shell and gain stability. Nonmetals will readily form covalent bonds with other nonmetals in order to obtain stability, and can form between one to three covalent bonds with other nonmetals depending on how many valence electrons it poses. Although it is said that atoms share electrons when they form covalent bonds, they do not usually share the electrons equally.

This module will provide you with information and simple activities that will help you demonstrate an understanding of covalent bond formation in terms of atomic properties.

After going through this module, you are expected to:

1. Apply the octet rule in the formation of molecular covalent compounds (STEM_GC11CB-IId-g-76)
2. Write the formula of molecular compounds formed by the nonmetallic elements of the representative block (STEM_GC11CB-IId-g-77)
3. Draw Lewis structure of molecular covalent compounds (STEM_GC11CB-IId-g-78)
4. Describe the geometry of simple compounds (STEM_GC11CB-IId-g-81)

What’s In

You were equipped with the basic knowledge about the number of protons, electrons and valence electrons from the previous lesson. Try this activity for some learning adventure in connection with the new topic on covalent bonds.

ACTIVITY 1. Bonding Basics of Covalent!

Directions: Use the Periodic Table in supplying the required data in Table 1.

Q1. Complete the chart for each element.

Table 1.Elements with Valence Electrons

<table>
<thead>
<tr>
<th>Element</th>
<th># of Protons</th>
<th># of Electrons</th>
<th># of Valence Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Directions: Identify the Lewis dot structure of the covalent compounds. Choose from the pool of Lewis dot structures given below. Write the letter of your answer on the space provided before each number.

Q2. Hydrogen + Hydrogen
Q3. Hydrogen + Oxygen
Q4. Chlorine + Chlorine
Q5. Oxygen + Oxygen
Q6. Carbon + Oxygen

What’s New
Activity 2. Write it the Lewis Way!

Directions: Complete Table 2 by choosing the correct answers from the box.

<table>
<thead>
<tr>
<th>Nitrate (NO₃)</th>
<th>Fluorine gas (F₂)</th>
<th>Benzene (C₆H₆)</th>
<th>Ammonia (NH₃)</th>
</tr>
</thead>
</table>

Table 2. Chemical Name and Symbol (Covalent Compounds)

<table>
<thead>
<tr>
<th>Lewis Structure</th>
<th>Chemical Name and Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q7.</td>
<td></td>
</tr>
<tr>
<td>Q8.</td>
<td></td>
</tr>
<tr>
<td>Q9.</td>
<td></td>
</tr>
</tbody>
</table>

Q10. Draw Lewis Dot Structures for the following Covalent Compounds. O₂ is done for you as an example. Write your answer in the space provided in Table 3.

Table 3. Lewis Dot Structure

<table>
<thead>
<tr>
<th>Compound</th>
<th>Lewis Dot Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td></td>
</tr>
</tbody>
</table>
Activity 3. Chemists’ Formula!

These are examples of covalent bonds and covalent compounds. Covalent compounds also are known as molecular compounds. Organic compounds, such as carbohydrates, lipids, proteins, and nucleic acids, are all examples of molecular compounds. You can recognize these compounds because they consist of nonmetals bonded to each other.

Directions: You are provided with a box containing the chemical formulas of covalent (molecular) compounds. Write the correct chemical formula on the space provided.

Write the Chemical Formula
Q11. Carbon tetrafluoride__________________
Q12. Silicon dioxide________________________
Q13. Phosphorous mononitride________________
Q14. Carbon disulfide_______________________
Q15. Dinitrogen trichloride_________________
Q16. Disulfur trioxide_______________________
Q17. Sulfur dibromide_______________________
Q18. Boron trisulfide_______________________
Q19. Nitrogen trifluoride____________________
Q20. Tricarbon tetranitrogen______________

Activity 4. Shape your Molecules!

The shapes of molecules can be predicted from their Lewis structures by using the VSEPR (Valence Shell Electron Pair Repulsion) model, which states that electron pairs around a central atom will assume a geometry that keeps them as far apart from each other as possible.

Directions: Use the Lewis structure of water, (H₂O) to answer the following questions below. Shade the square that correspond to your answer.

H₂O Lewis Structure. Source: google.com

Q21. How many atoms and lone pairs surround the central oxygen?
   - 1 atom + 1 lone pair
   - 2 atoms + 2 lone pairs

Q22. What is the geometry of this molecule?
   - Tetrahedral
   - Trigonal bipyramidal

Q23. What is the shape of the molecule?
   - bent
   - linear
Q24. Now fill in the missing information in Table 4. NH₃ (Ammonia) is done as an example.

Table 4. Geometry of Simple Compounds

<table>
<thead>
<tr>
<th>Compound</th>
<th>Geometry</th>
<th>Polar (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>TETRAHEDRAL</td>
<td>Yes</td>
</tr>
<tr>
<td>SF₆</td>
<td><em>C</em> A _ E <em>R</em> _</td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>L _ _ E A _</td>
<td></td>
</tr>
<tr>
<td>PF₅</td>
<td>B _ _ P _ _ A _ D _ L</td>
<td></td>
</tr>
</tbody>
</table>

What is it

COVALENT BONDS

A covalent bond, also called a molecular bond, is a chemical bond that involves the sharing of electron pairs between atoms. These electron pairs are known as shared pairs or bonding pairs, and the stable balance of attractive and repulsive forces between atoms, when they share electrons, is known as covalent bonding.

Only when two atoms of the same element form a covalent bond are the shared electrons actually shared equally between the atoms. When atoms of different elements share electrons through covalent bonding, the electron will be drawn more toward the atom with the higher electronegativity resulting in a polar covalent bond. When compared to ionic compounds, covalent compounds usually have a lower melting and boiling point, and have less of a tendency to dissolve in water. Covalent compounds can be in a gas, liquid, or solid state and do not conduct electricity or heat well. The types of covalent bonds can be distinguished by looking at the Lewis dot structure of the molecule. For each molecule, there are different names for pairs of electrons, depending if it is shared or not. A pair of electrons that is shared between two atoms is called a bond pair. A pair of electrons that is not shared between two atoms is called a lone pair.

The Octet Rule

The Octet Rule requires all atoms in a molecule to have 8 valence electrons—either by sharing, losing or gaining electrons—to become stable. For Covalent bonds, atoms tend to share their electrons with each other to satisfy the Octet Rule. It requires 8 electrons because that is the amount of electrons needed to fill a s- and p- orbital (electron configuration); also known as a noble gas configuration. Each atom wants to become as stable as the noble gases that have their outer valence shell filled because noble gases have a charge of 0. Although it is important to remember the “magic number”, 8, note that there are many Octet rule exceptions. Example:

As you can see in Figure 1 below, Phosphorus has only 5 electrons in its outer shell (bolded in red). Argon has a total of 8 electrons (bolded in red), which satisfies the Octet Rule. Phosphorus needs to gain 3 electrons to fulfill the Octet Rule. It wants to be like Argon who has a full outer valence shell.
A **single bond** is when two electrons--one pair of electrons--are shared between two atoms. It is depicted by a single line between the two atoms. Although this form of bond is weaker and has a smaller density than a double bond and a triple bond, it is the most stable because it has a lower level of reactivity meaning less vulnerability in losing electrons to atoms that want to steal electrons.

**Example 1: HCl**

Below is a Lewis dot structure of Hydrogen Chloride demonstrating a single bond. As we can see in *Figure 2* below, Hydrogen Chloride has 1 Hydrogen atom and 1 Chlorine atom. Hydrogen has only 1 valence electron whereas Chlorine has 7 valence electrons. To satisfy the Octet Rule, each atom gives out 1 electron to share with each other; thus making a single bond.

A **Double bond** is when two atoms share two pairs of electrons with each other. It is depicted by two horizontal lines between two atoms in a molecule. This type of bond is much stronger than a single bond, but less stable; this is due to its greater amount of reactivity compared to a single bond.

**Example 2: Carbon Dioxide**

Below is a Lewis dot structure of Carbon dioxide demonstrating a double bond. As you can see in *Figure 3* below, Carbon dioxide has a total of 1 Carbon atom and 2 Oxygen atoms. Each Oxygen atom has 6 valence electrons whereas the Carbon atom only has 4 valence electrons. To satisfy the Octet Rule, Carbon needs 4 more valence electrons. Since each Oxygen atom has 3 lone pairs of electrons, they can each share 1 pair of electrons with Carbon; as a result, filling Carbon’s outer valence shell (Satisfying the Octet Rule).
A **Triple bond** is when three pairs of electrons are shared between two atoms in a molecule. It is the least stable out of the three general types of covalent bonds. It is very vulnerable to electron thieves!

**Example 3: Acetylene**

Below is a Lewis dot structure of Acetylene demonstrating a triple bond. As you can see in *Figure 4* below, Acetylene has a total of 2 Carbon atoms and 2 Hydrogen atoms. Each Hydrogen atom has 1 valence electron whereas each Carbon atom has 4 valence electrons. Each Carbon needs 4 more electrons and each Hydrogen needs 1 more electron. Hydrogen shares its only electron with Carbon to get a full valence shell. Now Carbon has 5 electrons---1 single bond and 3 unpaired electrons---the two Carbons can share their unpaired electrons, forming a triple bond. Now all the atoms are happy with their full outer valence shell.

**Polar Vs. Nonpolar !**

A **Polar Covalent Bond** is created when the shared electrons between atoms are not equally shared. This occurs when one atom has a higher electronegativity than the atom it is sharing with. The atom with the higher electronegativity will have a stronger pull for electrons (Similar to a Tug-O-War game, whoever is stronger usually wins). As a result, the shared electrons will be closer to the atom with the higher electronegativity, making it unequally shared.

**Example:** Water, Sulfide, Ozone, etc.
As you can see in Figure 5 above, Oxygen is the big buff creature with the tattoo of "O" on its arm. The little bunny represents a Hydrogen atom. The blue and red bow tied in the middle of the rope, pulled by the two creatures represents--the shared pair of electrons--a single bond. Because the Hydrogen atom is weaker, the shared pair of electrons will be pulled closer to the Oxygen atom.

A **Nonpolar Covalent Bond** is created when atoms share their electrons equally. This usually occurs when two atoms have similar or the same electron affinity. The closer the values of their electron affinity, the stronger the attraction. This occurs in gas molecules; also known as diatomic elements.

Examples of gas molecules that have a nonpolar covalent bond: Hydrogen gas atom, Nitrogen gas atoms, etc.

As you can see in Figure 6 above, Hydrogen gas has a total of 2 Hydrogen atoms. Each Hydrogen atom has 1 valence electron. Since Hydrogen can only fit a max of 2 valence electrons in its orbital, each Hydrogen atom only needs 1 electron. Each atom has 1 valence electron, so they can just share, giving each atom two electrons each.
ACTIVITY 5. Let’s Bond It!

Directions: Determine which molecules are polar and which molecules are nonpolar given its Lewis structure. Write the letter of the correct answer on the space provided before the number.

A. Nonpolar covalent bond
   B. Polar covalent bond
   C. Polar covalent bond

1. Oxygen gas (O₂)
2. Hydrochloric acid (HCl)
3. Carbon dioxide (CO₂)

Match each atom or molecule with its corresponding letter(s): Write your answers on the space provided for.

<table>
<thead>
<tr>
<th>COLUMN A</th>
<th>COLUMN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____4. Nitrogen gas</td>
<td>a) Nonpolar covalent bond</td>
</tr>
<tr>
<td>_____5. Argon</td>
<td>b) Polar covalent bond</td>
</tr>
<tr>
<td>_____6. Carbon monoxide</td>
<td>c) Follows the Octet Rule</td>
</tr>
<tr>
<td>_____7. Hydrogen gas</td>
<td>d) Noble gas</td>
</tr>
</tbody>
</table>

What I Have Learned

Score: ___/20

1. Apply the octet rule in the formation of the following covalent compounds below. Write your answer on the box provided.
   A. Cl₂
   B. CO₂

2. Write the molecular formula of the following covalent compounds. Choose the correct answer from the box.
   | O₃   | HCl  | CO₂   |
   | H₂O  | PCl₃ | CH₃CH₂OH |
   | CH₄  | NH₃  | H₂     |

   _____1. Phosphorus trichloride
   _____2. Ethanol
   _____3. Ozone
   _____4. Hydrogen
   _____5. Water
   _____6. Hydrogen chloride
   _____7. Methane
   _____8. Ammonia
   _____9. Carbon dioxide
3. Draw the best Lewis Dot Structure for each of the following species and describe each Molecular Geometry. BeF₂ is done for you. Write your answer in the box.

### Tale 5. Lewis Structure and Molecular Geometry

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Lewis Dot Structure</th>
<th>Molecular Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>BeF₂</td>
<td><img src="image" alt="Lewis Dot Structure" /></td>
<td>linear</td>
</tr>
<tr>
<td>BCl₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCl₄</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBr₅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI₆</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Directions:** Fill up this success criteria chart to assess your reaction about the lessons in this module.

<table>
<thead>
<tr>
<th>Circulatory System Level of Confidence</th>
<th>STATEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>🧡 😁 😞</td>
<td>I can apply the octet rule in the formation of molecular covalent compounds.</td>
</tr>
<tr>
<td>🧡 😁 😞</td>
<td>I can write the formula of molecular compounds formed by the nonmetallic elements of the representative block.</td>
</tr>
<tr>
<td>🧡 😁 😞</td>
<td>I can draw Lewis structure of molecular covalent compounds.</td>
</tr>
<tr>
<td>🧡 😁 😞</td>
<td>I can describe the geometry of simple compounds.</td>
</tr>
</tbody>
</table>

**What I Can Do**

**ACTIVITY 5. FILL ME!**

**Score___/10**

**Directions:** Fill in the graphic organizer, ALPHABOXES with the appropriate words learned from the lesson about Covalent Bonds, Lewis Structures and Geometry of Covalent Compounds. Write your answers in the box.

### ALPHABOXES

1. **Table 6.** TOPIC: COVALENT BONDS

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q31. Select 5 words from the alpha boxes and use it in constructing a paragraph reflecting your significant learning about the topic in this module. Write your answers in the space provided below.

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
Thank you for sharing your knowledge. Now, you can already answer the post-test to evaluate how much you have learned from the module.

Assessment

Directions: Read and understand each question and encircle the letter of the best answer among the given choices.

1. Which element will have 5 electrons in its Lewis dot symbol?
   A. Argon  
   B. Boron  
   C. Carbon  
   D. Phosphorus

2. Which of the following elements can only form one bond in a Lewis structure?
   A. O  
   B. C  
   C. H  
   D. Al

3. Write the correct Lewis dot structure for O₂. Which statement correctly describes the structure of the whole molecule?
   A. There is a double bond and four lone pairs.  
   B. There is a double bond and six lone pairs.  
   C. There is a single bond and four lone pairs.  
   D. There is a single bond and six lone pairs.
4. The electron pair in a C - F bond could be considered...
   A. Closer to C because Carbon has a larger radius and thus exerts greater control over the shared electron pair
   B. Closer to F because Fluorine has a higher electronegativity than Carbon
   C. Closer to C because Carbon has a lower electronegativity
   D. An inadequate model since the bond is ionic

5. Which bond is the strongest?
   A. carbon - Nitrogen triple bond   C. carbon - Hydrogen bond
   B. carbon - Nitrogen double bond   D. carbon - Carbon triple bond

6. Which of the following represents a non-polar covalent bond?
   A. H-O               C. C-C
   B. C-N               D. Li-F

7. When does covalent bonding take place?
   A. It takes place when atoms share electrons with one another.
   B. It takes place when the attraction between atoms is strong.
   C. It takes place when atoms collide with one another.
   D. It takes place when atoms attain stability.
   E. It takes place when atoms gain electrons.

8. Which of the following contains a covalent bond?
   A. Li₂O   B. NaO₃   C. Mg₃N₂   D. NaCl

9. What kind of bond will form between two oxygen atoms?
   A. Single bond       C. polar covalent bond
   B. Double bond       D. nonpolar covalent bond

10. Write a Lewis structure for the covalently bonded ion ClO₂⁻.

11. Which Lewis structure below best represents B₂Cl₄
   A.                  C.                 
   B.                  D.                 

12. Which Lewis structure below is incorrectly paired with its formula?

\[ \text{CH}_3\text{NH}_2 = \quad \text{HCN} = \]

\[ \text{B. C}_2\text{H}_2 = \text{H}\text{-C}\equiv\text{C-H} \quad \text{D. C}_2\text{H}_4 = \]

13. Which of the following elements is incorrectly paired with its Lewis symbol?

\[ \text{A. arsenic} = \quad \text{C. silicon} = \]

\[ \text{B. rubidium} = \quad \text{D. calcium} = \]

14. Write the simplest Lewis structure for the molecule BrF$_3$.

\[ \text{A.} \quad \text{B.} \quad \text{C.} \quad \text{D.} \]

15. Which is the correct Lewis structure for the CCl$_4$ molecule?

\[ \text{A.} \quad \text{B.} \quad \text{C.} \quad \text{D.} \]
Great job!
You have reach this far.
   Take time to answer the succeeding pages for a little more exciting activities to enrich what you have learned from this module.

**Additional Activities** [Score: __/8]

### Activity 10. Search for Covalent Compounds

**Directions:** You will look for at least 2 examples of covalent compounds that can be found in nature or can be used in everyday life. They must include the following information:

a. Chemical formula and chemical name of the covalent compound  
b. Lewis Structure of the compound  
c. Brief information about the use of the covalent compound  
d. Molecular Geometry

Use the Table below for the presentation of your answers.

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Chemical Formula</th>
<th>Lewis Structure</th>
<th>Brief Information</th>
<th>Molecular Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>