Senior High School

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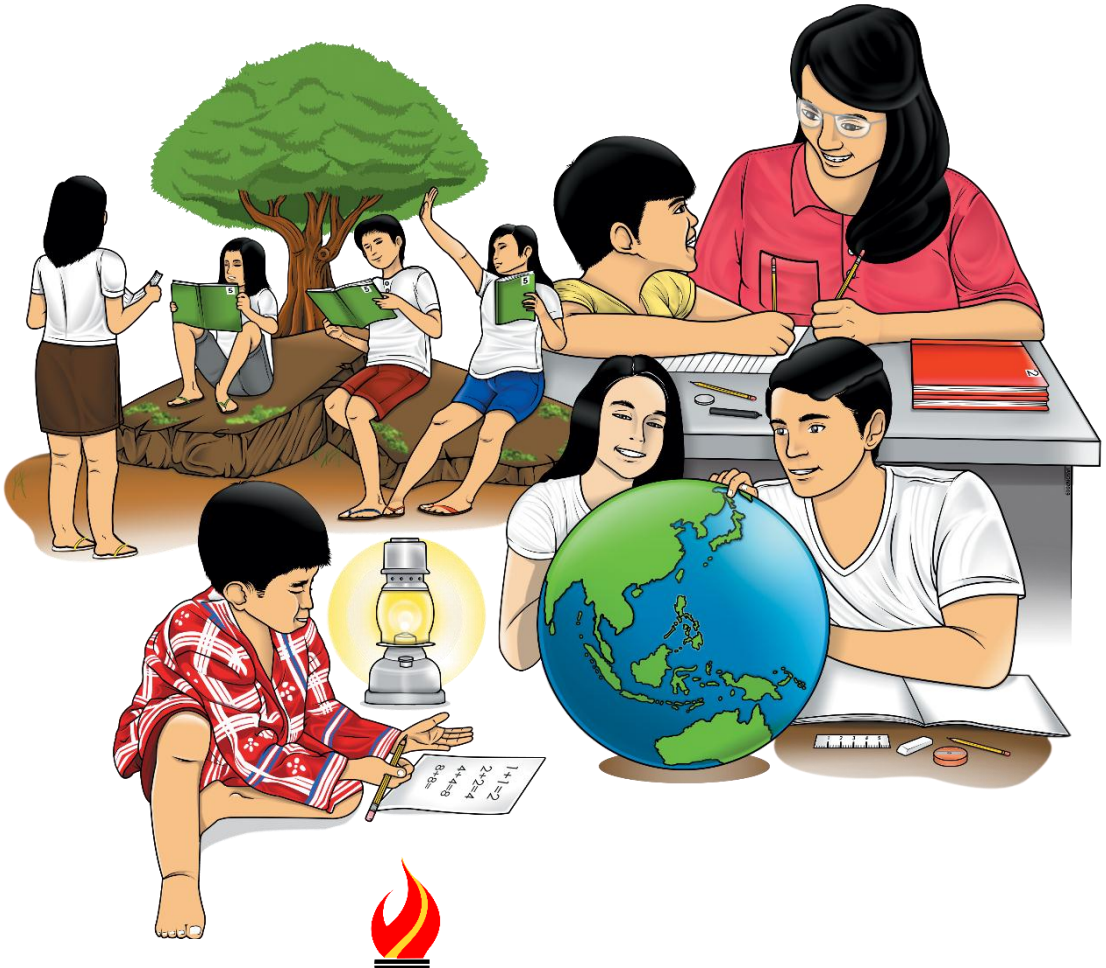
Physical Science

Quarter 1 – Module 3:
Polarity of Molecules



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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

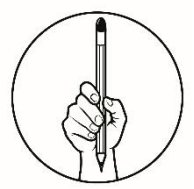
This module was designed and written with you in mind. It is here to help you determine if a molecule is polar or non-polar. The scope of this module permits it to be used in many different learning situations. The language used recognizes the varied vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

The module is divided into three lessons, namely:

- Lesson 1 – Polarity of Molecules

After going through this module, you are expected to:

1. differentiate polar and nonpolar bonds;
2. determine the polarity of chemical bonds between atoms using the concept of electronegativity;
3. familiarize with the different molecular shapes;
4. explain how polarity of bonds and molecular geometry affects the polarity of molecules.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following terms refer to the ability of an atom in a molecule to attract shared electrons?
   a. Electron affinity
   b. Electronegativity
   c. Ionization energy
   d. Electromotive force

2. Which is TRUE about polar bonds?
   a. They are present in metals.
   b. They are responsible for the formation of ionic compounds.
   c. They always result in the formation of polar molecular compounds.
   d. They may result in nonpolar covalent compounds depending on molecular geometry.

3. What type of chemical bond holds the atoms of water molecule together?
   a. Ionic bond
   b. Hydrogen bond
   c. Polar covalent bond
   d. Nonpolar covalent bond

4. Which of the following molecule is nonpolar?
   a. NaCl
   b. HCl
   c. CO_2
   d. NH_3

5. Which of the two pairs has the lowest electronegativity difference value?
   a. C-O
   b. H-N
   c. S-F
   d. Na-Cl

6. What is the type of chemical bond present in a hypothetical molecule which has an electronegativity difference of 0.5?
   a. Ionic
   b. Hydrogen
   c. Polar covalent
   d. Nonpolar covalent

7. What is the molecular shape of BeF_3?
    a. Linear
    b. Trigonal
    c. Tetrahedral
    d. Trigonal bipyramidal

8. A molecule can have a polar bond and still be nonpolar overall. The statement is?
    a. True
    b. False
    c. Maybe

9. A polar covalent bond would form in which of the following pairs of atoms?
    a. Cl-Cl
    b. Mg-O
    c. N-H
    d. C-S

10. A molecule shape is a three-dimensional arrangement of atoms or bonding groups around a central atom. The molecular shape is governed by the valence shell electron repulsion (VSEPR) theory.
    a. The first and second statements are true.
    b. The first and second statements are false.
    c. The first statement is true while the second statement is false.
    d. The first statement is false while the second statement is true.

True or False: Write TRUE if the statement is correct, otherwise write FALSE.

11. The general trend of electronegativity as you move from top to bottom of the periodic table is increasing.

12. Fluorine has the greatest electronegativity while cesium and francium have the least electronegativity value.

13. Water, with a bent molecular shape, is classified as a polar molecule.

14. Sulfur hexafluoride (SF_6) has six bonded electrons and no lone pair in its central atom.

15. Hydrogen cyanide (HCN) exhibits a linear geometry.

Lesson 1 Polarity of Molecules

It is interesting to have a quick glance at the lessons you have learned about compounds and chemical bonds when you were in Grades 8, 9, and 10. Can you still recall them? Great!

In Grade 8, you learned that atoms combine to form molecules or compounds thus making them more stable by achieving a stable configuration satisfying the Octet Rule. On the other hand, you learned about chemical bonds or intramolecular forces and its three types such as ionic, covalent, and metallic and the writing of Lewis dot symbol in Grade 9. While in your Grade-10 Science, you have learned the concepts of electronegativity and you were briefly introduced to the topic of polarity of molecules using the electronegativity values.

Studying this module will certainly increase your understanding of the polarity of molecules. This module is packed with interesting activities which will make you enjoy your Chemistry lessons even more. So, are you ready to delve into an exciting quest for chemistry learning? You may start now by doing the activity below. Good luck and happy learning!

What's In

Chemical bonds are formed when atoms lose, gain, or share electrons. An ionic bond occurs when there is a transfer of one or more valence electrons form one atom to another. It exists between metal and nonmetal atoms where a metal loses electron/s while the nonmetal element accepts the electron/s donated by metal. On the other hand, when two nonmetal atoms combine, neither of them loses or gains electron Instead, electron pairs are being shared by both atoms and the type of chemical bond formed is called covalent bond.

Notes to the Teacher

Periodic Table is an indispensable tool in studying chemistry. In order for the learners to answer the above activity, they must first be familiar on how to use all the information written on the periodic table. At this point, they should be able to effectively use the periodic table in order to classify elements as to metal, non-metal or semi-metals.

Tell whether the compound below is an ionic compound (IC) or a covalent compound (CC) based on the type of chemical bond present.

____1. NaCl
____2. CO_2
____3. $CaCl_2$
____4. CCl_4
____5. Fe_2O_3
_____6. N_2O
_____7. PCl_5
_____8.KBr
_____9. HCl
_____10.$AlCl_3$

Were you able to answer that NaCl, $CaCl_2$, Fe_2O_3, KBr, and $AlCl_3$ are all ionic compounds because the atoms involved are combination of metal and nonmetal while CO_2, CCl_4, N_2O, PCl_5 and HCl are all covalent compounds because the atoms involved are both nonmetals? Then you did a great job!

It's good that you were able to recall the difference between ionic bond and covalent bond.

You have learned that a covalent is a shared pair of electrons between two atoms. But are the electrons equally shared by the combing atoms? How does a polar covalent bond differ from a nonpolar covalent? Did you know that the electronegativity of an atom can be used to further classify covalent bond into polar and nonpolar?

As you perform the activity below, you will find out that substances have different polarities and this explains why there are substances that do not mix while others do.

What's New

Activity1: Polarity Experiment

Materials:

- Water
- Vinegar
- Oil
- Alcohol
- 6 disposable glasses
- spoon

Procedure:

1. Obtain 6 clean disposable glasses and prepare the following set-up.

   Set-up 1: 1 cup water + 5 tablespoons vinegar
   Set-up 2: 1 cup water + 5 tablespoons oil
   Set-up 3: 1 cup water + 5 tablespoons alcohol
   Set-up 4: 1 cup vinegar + 5 tablespoons oil
   Set-up 5: 1 cup vinegar + 5 tablespoons alcohol
   Set-up 6: 5 tablespoon oil + 5 tablespoons alcohol

2. Thoroughly stir each mixture and observe carefully.

Note:

- Do not forget to wash and dry the spoon after each use.
- Properly label each set-up.
- Samples with oil should first be mixed with dishwashing liquid before disposing of down the sink.

Set-up	Solubity (soluble or insoluble?)	Polarity Polar or non-polar?
1. (water + vinegar)		
2. (water + oil)		
3. (water + alcohol)		
4. (vinegar + oil)		
5. (vinegar + alcohol)		
6. (oil + alcohol)		

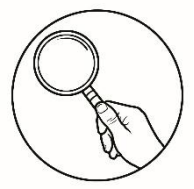
Guide Question:

a. Which of the following set-ups mixed well? Which did not?
b. What can you infer from the result of this activity?

Or if not feasible, this activity may be performed instead.

Calculate the electronegativity difference and give the type of bond that exists between the atoms in each of the following pairs.

Molecule	EN of the first atom	EN of the 2nd atom	Δ EN
1. NaCl			
2. NH_3			
3. CH_4			
4. H_2			
5. H_2O			



What is It

The polarity of molecules is determined by the two factors: the polarity of bonds based on the electronegativity difference of the atoms involved and the geometrical shape of the molecules which can be predicted via valence shell electron pair repulsion (VSEPR) theory.

A. Polarity of Bonds and Electronegativity

In your Grade 9 Chemistry, you have tackled the lesson on the periodic properties of elements such as atomic size, metallic property, ionization energy, electron affinity and electronegativity. Can you still recall the definition of electronegativity? If not, no problem because I will define it for you.

Electronegativity (EN) measures the relative tendency of an atom to attract electrons to itself when chemically combined with other atoms. Take a look at the electronegativity values of some elements on Fig.1. What have you noticed? Correct! It increases within period (from left to right) and decreases within a group (from top to bottom). Take note also that the higher the value of EN, the more it tends to attract electrons towards itself.

So what is the connection of electronegativity to the polarity of bonds? We could use the electronegativity values of the atoms involved to get the absolute electronegativity difference (ΔEN) which will help us in predicting what type of chemical bond (ionic, polar covalent or nonpolar covalent) that would exist between them. Table 1 shows the type of bond based on the electronegativity difference of bonded atoms.

Pauling Electronegativity Values

H 2.1																	He ---
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne ---
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.2	S 2.5	Cl 3.0	Ar ---
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La-Lu 1.1-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn ---
Fr 0.7	Ra 0.9	Ac-No 1.1-1.7															

Figure 1. Pauling Electronegativity values of some elements

Table 1. Type of bond based on electronegativity difference (ΔEN) of bonded atoms

Type of Bond	**Electronegativity Difference (ΔEN)**
Ionic	≥1.7
Polar Covalent	0.5 to 1.6
Nonpolar Covalent	≤ 0.4

For example, you are asked to predict what type of bond is present between the following pairs of atoms by determining their electronegativity difference.

1. Ca and Cl
2. Cl and Cl
3. H and Cl
4. S and O
5. C and N

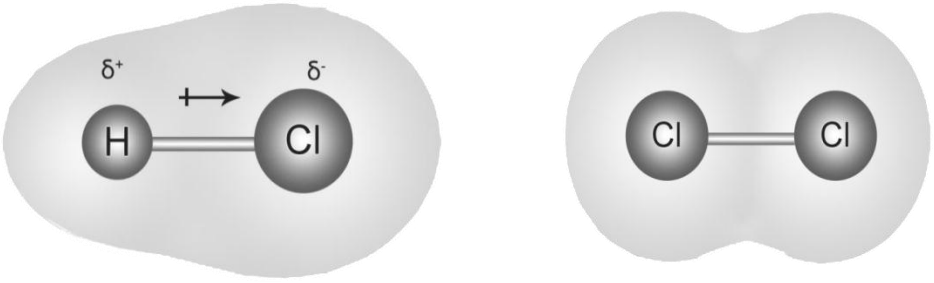
Solution:

1. $EN_{Ca} = 1.0$ $(\Delta EN) = 1.0 - 3.0 = |-2.0| = 2.0$ ionic bond
   $EN_{Cl} = 3.0$
2. $EN_{Cl} = 3.0$ $(\Delta EN) = 3.0 - 3.0 = 0$ nonpolar covalent bond
   $EN_{Cl} = 3.0$
3. $EN_{H} = 2.1$ $(\Delta EN) = 2.1 - 3.0 = |-0.9| = 0.9$ polar covalent bond
   $EN_{Cl} = 3.0$
4. $EN_{S} = 2.5$ $(\Delta EN) = 2.5 - 3.5 = |-1.0| = 1.0$ polar covalent bond
   $EN_{O} = 3.5$
5. $EN_{C} = 2.5$ $(\Delta EN) = 2.5 - 3.0 = |-0.5| = 0.5$ polar covalent bond
   $EN_{N} = 3.0$

Using the above examples, let us know more about polar and nonpolar covalent bonds. A polar covalent bond is formed when electrons are **shared unequally** by two atoms in a compound. The bonded pair of atoms form an electric dipole (represented by $\overset{+}{\longrightarrow}$). Dipole means "two poles" which means that a molecule has one positive end and one negative end. In this type of bond, the atom with the higher EN value becomes the partial negative pole (symbolized as δ^-) while the atom with the lower EN value becomes the partially positive (symbolized as δ^+) pole. Always bear in mind that the direction of the arrow is always pointing from a more electropositive pole to the more electronegative pole.

Take HCl for example, H has higher EN than Cl, thus the direction of the arrow is from H pointing to Cl and there is unequal electron density as represented by the size of the circle (refer to figure 2). On the other hand, a nonpolar covalent bond develops if both atoms **equally share** a pair of electrons between them.

This occurs when the bonding atoms have approximately equal EN value or equal ability to attract electrons to each side. A nonpolar covalent bond is an example of bond formed when two chlorine atoms combine.



(a) (b)

Figure 2. (a) Polar bond between H and Cl and (b) nonpolar bond between two Cl atoms

B. Polarity of Molecules and Molecular Geometry

You just have learned how to predict the type of bond polarity simply by calculating the electronegativity difference of atoms (specifically two atoms). The next question is, how about for those molecules consisting of more than two atoms like H_2O, CCl_4, NH_3 and CO_2? For polyatomic molecules, both the bond polarity and molecular shape determine the overall molecular polarity. In terms of molecular geometry, the valence shell electron pair repulsion (VSEPR) theory would help us to determine the spatial arrangement of atoms in a polyatomic molecule.

You can predict the shape or molecular geometry of a substance using the following steps:

Step 1: Determine the central atom of a molecule. The central atom is the least electronegative element.

Step 2: Draw the appropriate Lewis dot structure for the molecule.

Step 3: Count the number of bonding pairs of electrons and non-bonding (or lone pairs) around the central atom.

Step 4: Determine the electron pair orientation using the total number of electron pairs.

Step 5: Name the shape based on the location of the atoms

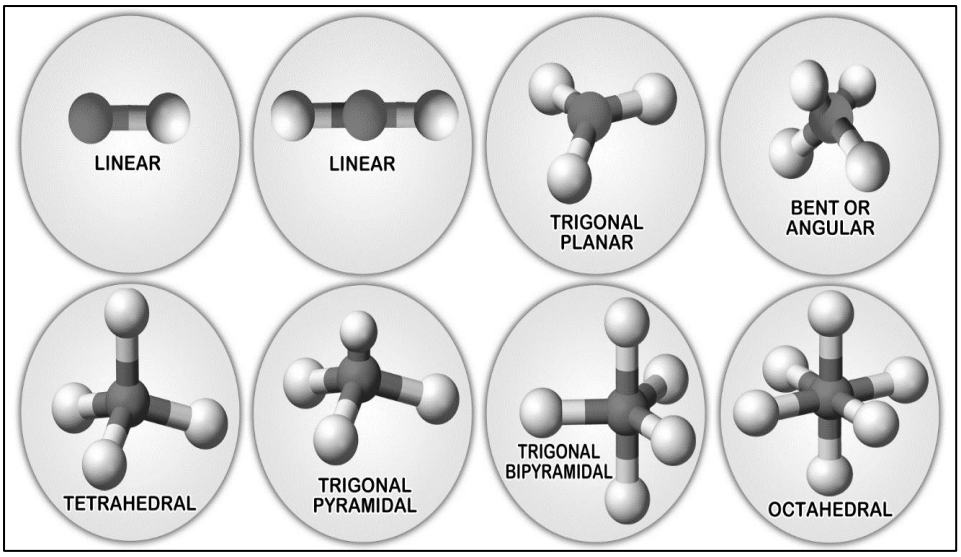


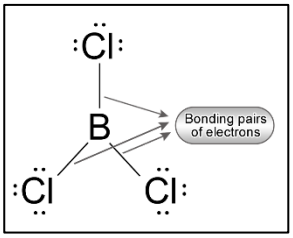
Figure 3. Different Molecular Shapes

Consider the examples below:

Example 1: Predict the molecular geometry of BCl_3

Step 1: EN_B = 2.0 EN_{Cl}= 3.0 therefore, B will be the central atom and three Cl atoms are attached to it. By looking at the chemical formula, you will also have an idea that boron will be the central atom and three atoms of choline are attached to it.

Step 2:



Step 3: The central atom has three electron pairs: 3 bonded pairs and no lone pair

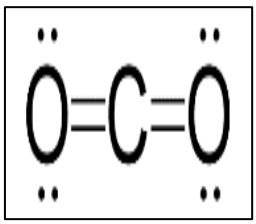
Step 4: The electron pair orientation for three electrons is trigonal planar.

Step 5: The molecular shape of BCl_3 is trigonal planar.

Example 2: Predict the molecular geometry of CO_2

Step 1: EN_C= 2.5 EN_O= 3.0 therefore, C will be the central atom and two O atoms will be the attached to it. (You may also use the chemical formula to predict which atom will be the central atom.)

Step 2:



Step 3: To determine the position of the bonding pairs, let us count the double bonds as one bonding pair. Therefore, CO_2 has two bonding pairs of electron.

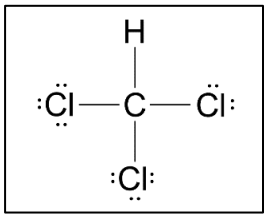
Step 4: The electron pair orientation for two-electron pairs is linear.

Step 5: The molecular shape of CO_2 is linear.

Example 3: Predict the molecular geometry of $CHCl_3$.

Step 1: $EN_C = 2.5$, $EN_H = 2.1$ and $EN_{Cl} = 3.0$. Because carbon is less electronegative than chlorine and hydrogen is normally terminal atom, C must be the central atom.

Step 2:



Step 3: There are four bonding electron pairs.

Step 4: The electron pair orientation for four electron pairs is tetrahedral.

Step 5: The molecular shape of $CHCl_3$ is linear.

Now that you have learned how to determine molecular geometry, let us now go on to our discussion of the polarity of molecules based on molecular shapes. You may study the diagram below and we will use it as our guide.

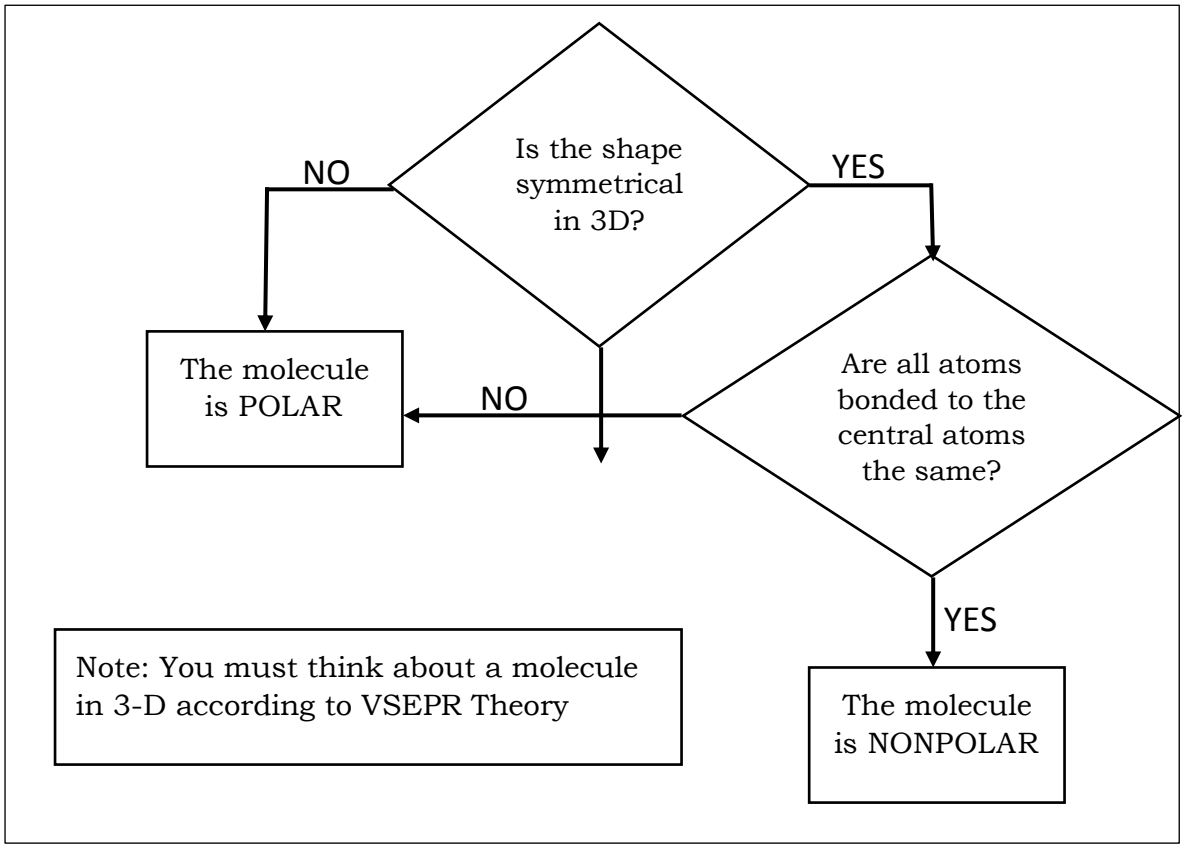


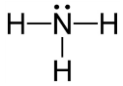
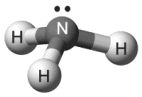
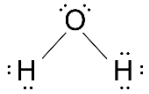
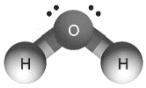
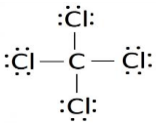
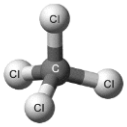
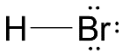
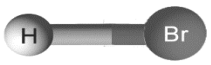
Figure 4. Flowchart to determine if a molecule is polar or nonpolar

Going back to our previous examples, let us try to determine the polarity of molecules of BCl_3, CO_2, and $CHCl_3$.

For both BCl_3 and CO_2, the atoms are symmetrically arranged (trigonal planar and linear) and the attached atoms to the central atom are also the same. You must also take note that in a symmetrical molecule, the sum of the bond dipole is equal to zero (because they cancel out) which leads to the formation of a nonpolar molecule. Therefore, both BCl_3 and CO_2 are nonpolar. On the other hand, $CHCl_3$, although it has a symmetrical arrangement (tetrahedral), the atoms attached to the central atom are not all the same (3 chlorine atoms and 1 hydrogen atom). This causes $CHCl_3$ to become a polar molecule.

Now, let us see if you fully understood our discussion. I want you to try answering the exercises below.

Identify which molecule is polar and which is nonpolar given the Lewis structure and molecular shapes of the following molecules.

Molecule	Lewis Structure	Molecular Geometry (based on VSEPR)	Molecular Shape
1. NH_3			Trigonal pyramidal
2. H_2O			Bent or angular
3. CCl_4			Tetrahedral
4.			Linear

If you were able to answer that NH_3 and H_2O are polar molecules because the bond dipole cannot be cancelled because of the presence of lone pairs on the central atom and CCl_4 and HBr are nonpolar molecules, you are correct. Job well done! You may now proceed to the rest of this module.

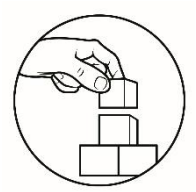
Figure 4. Flowchart to determine if a molecule is polar or nonpolar

Going back to our previous examples, let us try to determine the polarity of molecules of BCl_3, CO_2, and $CHCl_3$.

For both BCl_3 and CO_2, the atoms are symmetrically arranged (trigonal planar and linear) and the attached atoms to the central atom are also the same. You must also take note that in a symmetrical molecule, the sum of the bond dipole is equal to zero (because they cancel out) which leads to the formation of a nonpolar molecule. Therefore, both BCl_3 and CO_2 are nonpolar. On the other hand, $CHCl_3$, although it has a symmetrical arrangement (tetrahedral), the atoms attached to the central atom are not all the same (3 chlorine atoms and 1 hydrogen atom). This causes $CHCl_3$ to become a polar molecule.

Now, let us see if you fully understood our discussion. I want you to try answering the exercises below.

Identify which molecule is polar and which is nonpolar given the Lewis structure and molecular shapes of the following molecules.



What's More

Molecule	Lewis Structure	Δ EN	Bond Polarity	Molecular Geometry	Polarity of Molecule
1. PCl_5					
2. $BeCl_2$					
3. CH_4					
4. OF_2					
5. SF_6					

So far, we have discussed how the polarity of molecules is being determined. At this point, you will perform the activity below to find out if you fully understood our topic. If you think you need to go back to the discussion part of this module while answering this activity, please feel free to do so.

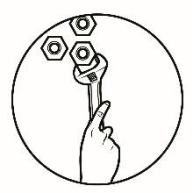
What I Have Learned

In your own words, differentiate polar and nonpolar covalent bonds.

1. What is electronegativity and how can it be used in determining the polarity of molecules?

2. Is it possible for a molecule to have a polar bond but have an overall polarity of nonpolar?

3. Differentiate bonding and non-bonding electrons.



What I Can Do

Answer the following questions below:

1. Ammonia (NH_3) is a polar molecule while boron trifluoride (BF_3) is a nonpolar molecule. Explain the difference in the polarity of these compounds.

2. Suppose that AB_3E, a hypothetical molecule, is discovered. Predict whether the molecule is polar or nonpolar by determining its molecular shape.

   Note: A – corresponds to the central atom,
   B - terminal atom
   E – lone pair (nonbonding electrons)

Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

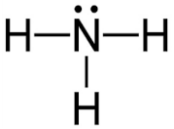
1. Which of the following molecules DO NOT have polar covalent bonds?
   a. NH_3
   b. CS_2
   c. BCl_3
   d. HBr

2. Which of the following bonds is the MOST polar?
   a. H-Cl
   b. C-Cl
   c. H-H
   d. N-F

3. What is the molecular shape of $CHBr_3$?
   a. Linear
   b. Tetrahedral
   c. Trigonal planar
   d. Trigonal bipyramidal

4. Which of the following pairs of atoms would form a nonpolar covalent bond?
   a. P-N
   b. C-S
   c. Ca-O
   d. Na-Cl

5. From the given Lewis structure of NH_3, how many nonbonding pair/s of electron are around the central atom?
   a. 0
   b. 1
   c. 2
   d. 3



6. Which of the following statements is INCORRECT?
   a. Polar covalent bonds can be present in a nonpolar molecule.
   b. Polar bond forms when electrons are unequally shared by two atoms in a compound.
   c. Polarity of bond and molecular geometry are the two factors that affect the polarity of molecules.
   d. Polar covalent bond is present if the electronegativity difference between atoms is equal or less than 0.4.

7. What do you call the relative ability of a bonded atom to attract shared electron pairs?
   a. Electron affinity
   b. Electronegativity
   c. Ionization energy
   d. Metallic property

8. Which description below correctly describes polar molecules?
   a. Have polar bonds present.
   b. The polar bonds are arranged so that they do not cancel.
   c. Lone pairs on the central atom are arranged so that they do not cancel.
   d. Lone pairs on the central atom are arranged so that they can be cancelled out.

9. Which of the following molecules is tetrahedral?
   a. BF_3
   b. SF_6
   c. CH_4
   d. H_2O

10. Which of the following is NOT TRUE about CO_2?
   a. Is a polar molecule
   b. Polar bond is present
   c. Has a linear molecular shape
   d. Has an electronegativity difference of 1.0

True or False: Write TRUE if the statement is correct, otherwise write FALSE.

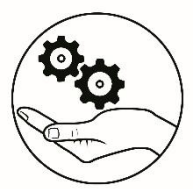
11. S and O are bonded by a polar covalent bond because its electronegativity difference value is 1.0.

12. Atoms with high electronegativity have a greater tendency to attract electrons toward itself.

13. Polarity of molecules are determined both by polarity of bonds and molecular geometry.

14. Among C-Cl, H-Cl, C-H and Cl-Cl, only Cl-Cl is polar.

15. Methyl alcohol, CH_3OH, is a nonpolar molecule.



Additional Activities

Analyze the following statements and determine if it is correct or wrong.

1. $SiCl_4$ is a nonpolar molecule.

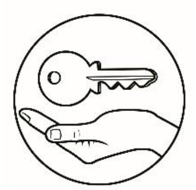
   _____

2. H_2S has a linear molecular geometry.

   _____

3. PF_5 is a polar molecule.

   _____



Answer Key

What I Know

1. B
2. D
3. C
4. C
5. D
6. C
7. B
8. A
9. C
10. A
11. F
12. F
13. T
14. T
15. T

What's More

1. IC
2. CC
3. IC
4. CC
5. IC
6. CC
7. CC
8. IC
9. CC
10. IC

Assessment

1. B
2. D
3. B
4. B
5. B
6. D
7. B
8. C
9. C
10. B
11. T
12. T
13. T
14. F
15. F

Molecule	Δ EN	Bond Polarity	Molecular Geometry	Polarity of Molecule
1. PCl_5	0.8	polar	Trigonal bipyramidal	polar
2. $BeCl_2$	0.5	Polar	Linear	nonpolar
3. CH_4	0.4	Non-polar	Tetrahedral	nonpolar
4. OF_2	0.5	Polar	Bent	polar
5. SF_6	1.7	Polar	Octahedral	non-polar

What I Have Learned

1. In your own words, differentiate polar and nonpolar covalent bond.

Answer: Polar bonds are formed when there is an unequal sharing of electrons between atoms, while nonpolar bonds are formed when there is equal sharing of electrons between atoms.

2. What is electronegativity and how can it be used in in determining the polarity of molecules?

Answer: Electronegativity measures the tendency of an atom in a molecule to attract shared electrons toward itself. The concept of electronegativity can be used to predict whether the bond will be polar or nonpolar. If the ΔEN is 0.4 or less, the bond is nonpolar. But if the ΔEN is beyond 0.4 but less than 1.7, the bond is polar.

3. Is it possible for a molecule to have a polar bond but have an overall polarity of nonpolar?

Answer: Yes. Because polarity of molecule is determined both by polarity of bond and molecular geometry. A molecule can have a polar covalent bond but still be classified as a nonpolar molecule as long as its molecular geometry satisfies the condition of VSEPR theory.

4. Differentiate bonding and non-bonding electrons.

Answer: Bonding electrons are those electrons involved in the formation of covalent bonds while lone pair (nonbonding electrons) refers to a pair of valence electrons that is not shared with another atom in a covalent bond.

Additional Activities:

1. $SiCl_4$ is a nonpolar molecule.
   Correct. Though polar bond is present because ΔEN is 0.8, $SiCl_4$ is still classified as nonpolar molecule because it has a tetrahedral geometry and the central atom does not have lone pair.

2. H_2S has a linear molecular geometry.
   Incorrect. H_2S has a bent molecular geometry which gives it an upwards net dipole moment. Two partially positive hydrogen atoms are attached to the more electronegative central atom, sulfur. The molecule is represented by AB_2E_2 representation wherein the central atom also has two lone pairs.
3. PF_5 is a polar molecule.
   Correct. Though the value Δ EN is 1.9 (polar bond is present), Phosphorus pentafluoride (PF_5) exhibits a trigonal bipyramidal based on VSEPR theory making the overall molecule nonpolar.

What I can do

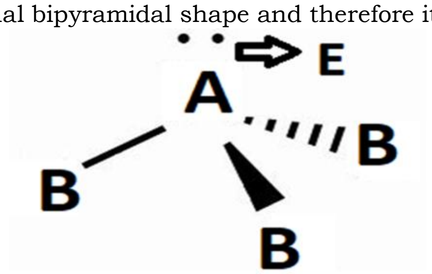
1. Ammonia (NH_3) is polar molecule while boron trifluoride (BF_3) is a nonpolar molecule. Explain the difference in the polarity of these compounds.

Answer: Polarity of molecule is determined by its molecular geometry. Since NH_3 has a trigonal pyramidal shape, with four electron pairs (3 bonding pairs and 1 nonbonding pair/lone pair), this makes it polar. On the other hand, BF_3 has a trigonal planar geometry with three bonding pairs of electron and central atom has no lone pair, making it nonpolar.

2. Suppose that AB_3E, a hypothetical molecule, is discovered. Predict whether the molecule is polar or nonpolar by determining its molecular shape.

   Note: A – corresponds to central atom,
   B - terminal atom
   E – lone pair (nonbonding electrons)

   Using the concept of VSEPR theory, a molecule with an AB_3E configuration will exhibit a trigonal bipyramidal shape and therefore it is nonpolar.



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