

Models of Molecular Compounds

Lab 22

Text reference: Chapter 8

Introduction

Why should people care about the shapes of molecules? Consider that the properties of molecules, including their role in nature, depend not only on their molecular composition and structure, but their shape as well. Molecular shape determines a compound's boiling point, freezing point, viscosity, and the nature of its reactions.

The geometry of a small molecule can be predicted by examining the central atom and identifying the number of atoms bonded to it and the number of unshared electron pairs surrounding it. The shapes of molecules may be predicted using the VSEPR rule, which states that electron pairs around a central atom will position themselves to allow for the maximum amount of space between them.

Covalent bonds can be classified by comparing the difference in electronegativities of the two bonded atoms. If the difference in electronegativities is less than or equal to 0.4, the bond is called a nonpolar covalent bond. If the difference in electronegativities is between 0.5 and 1.9, a polar covalent bond exists. (If the difference in electronegativities is greater than 2.0, an ionic bond results.) In a polar covalent bond, the electrons are more attracted to the atom with the greater electronegativity, resulting in a partial negative charge on that atom. The atom with the smaller electronegativity value acquires a partial positive charge.

Molecules made up of covalently bonded atoms can be either polar or nonpolar. The geometry of the molecule determines whether it is polar or not. For example, if polar bonds are symmetrically arranged around a central atom, their charges may cancel each other out and the molecule would be nonpolar. If, on the other hand, the arrangement of the polar bonds is asymmetrical, the electrons will be attracted more to one end of the molecule and a polar molecule or dipole will result.

Ball-and-stick models can be used to demonstrate the shapes of molecules. In this experiment, you will construct models of covalent molecules and predict the geometry and polarity of each molecule.

Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. What is a covalent bond? _____

2. What is a dipole? _____

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3. What two factors determine whether a molecule is polar or not?

4. List the five different molecular geometries that you will be studying in this investigation. _____

5. Calculate the electronegativity difference and predict the type of bond for the following examples: (Refer to Figure 7-19 in your text for a list of electronegativities.)
 - a. Na—Cl _____
 - b. C—H _____
 - c. S—O _____
 - d. N—N _____

Problem

How can the polarity of molecules be predicted from their geometry and the types of bonds they contain?

Materials


safety goggles
ball-and-stick model set


Safety



Wear your goggles at all times during the investigation. Note the caution alert symbols here and with certain steps of the Procedure. Refer to page xi for the specific precautions associated with each symbol.

Procedure

-  1. Put on your goggles. Construct ball-and-stick models of the following compounds:

H ₂	HBr	H ₂ O
PH ₃	CH ₄	HClO
N ₂	CH ₃ NH ₂	CH ₃ Cl
H ₂ CO	C ₂ H ₂	H ₂ O ₂
HCOOH	HCN	
2. For each of the preceding compounds, complete the Data Table in the Observations section. As an example, the first line of the Data Table has been filled in for you.
-  3. When you have completed this investigation, take apart your models and return the model set to your teacher. Clean up your work area and wash your hands before leaving the laboratory.

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22**Observations****DATA TABLE Structure and Polarity of Molecules**

Formula	Electron Dot Structure (Lewis)	Structural Formula	Shape of Molecule	Molecular Polarity
H ₂	H:H	H—H	Linear	Nonpolar
HBr				
H ₂ O				
PH ₃				
CH ₄				
HClO				
N ₂				
CH ₃ NH ₂				
H ₂ CO				
C ₂ H ₂				
CH ₃ Cl				
HCOOH				
HCN				
H ₂ O ₂				

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Critical Thinking: Analysis and Conclusions

1. Explain how you used the molecular shapes to predict molecular polarity. Support your answer with examples from the results of this investigation. (*Classifying*) _____

2. List the advantages and disadvantages of using ball-and-stick models to construct molecules. (*Developing models*) _____

Critical Thinking: Applications

1. Based on your results, predict the type of bonding, molecular geometry, and molecular polarity of the following molecules. (*Making predictions*)
 - a. HI _____
 - b. SH_2 _____
 - c. NH_3 _____
 - d. CO_2 _____
2. The polarity of a substance can have a great effect on its reactivity and solubility. A rough rule of thumb for solubility is "like dissolves like." Knowing this general rule, what can you predict about the polarity of alcohol if you know that alcohol dissolves in water? Why do you think that water is not used to dissolve greasy stains and dirt at dry cleaners? (*Applying concepts*) _____

Going Further

1. Use balloons to create three-dimensional models of the five different molecular geometries discussed in this investigation.
2. Research what is meant by the term *isomer*. Give examples of molecular isomers.