Activity: Modeling Molecular Polarity

FOR THE TEACHER

Summary
In this activity, students will use electronegativity values and their knowledge of covalent bonding to model the bonds in a molecule. Using this information they will learn how to determine the overall polarity of a molecule.

Grade Level
High School

NGSS Alignment
This activity will help prepare your students to meet the performance expectations in the following standards:

- **Scientific and Engineering Practices:**
  - Developing and Using Models

Objectives
By the end of this activity, students should be able to

- Determine the difference in polarity given the electronegativity values for two elements in a bond.
- Identify the partial charges for each element in a polar bond.
- Successfully create a Lewis structure for a given molecule.
- Discuss how the polarity of the bonds in a molecule can affect the overall polarity of that molecule.
- Understand that the arrangement of bonds around the central atom in the molecule can affect the overall polarity of the molecule.

Chemistry Topics
This activity supports students’ understanding of

- Covalent Bonding
- Polarity
- Electronegativity
- Lewis Structures
- VSEPR Theory

Time
**Teacher Preparation:** 10 minutes
**Lesson:** 45 minutes

Materials
- Element cards (one set per group)
- String (approximately 1.5 meters)
- Styrofoam Balls

Safety
- No specific safety precautions need to be observed for this activity.

Teacher Notes
- Prior to this activity the students use a complimentary activity called, Modeling Bond Polarity to introduce students to determining differences in electronegativity in a bond, and differentiating between polar and non-polar bonds.
- Teachers need to prepare a set of element cards in advance of the activity. These are available for download/printing. After printing the cards put them in to plastic sleeves or laminate them so that students can fill in the information using a dry erase marker and they can be reused between classes.
- A set of cards must be made for each molecule, with each individual element in the molecule having its own card. Some examples of the compounds used are: Methane (CH₄), Carbon dioxide (CO₂), Ammonia (NH₃), Water (H₂O), and Hydrogen fluoride (HF).
- Each string should be threaded through the center of a Styrofoam ball by the teacher, prior to the activity. One string and Styrofoam ball combination will be needed for each bond in the assigned molecule.
- To begin, assign a different set of covalent compound cards for each group of 3-4 students.
- In their groups, the students work together to determine the arrangement in which the elements will bond together. If the students prefer, they may use white boards to draw their initial Lewis structure before they arrange their cards on the table.
- Next, the students fill in the first three pieces of information on the element card (element bonding with, electronegativity difference [ΔEN], and bond polarity). If the bond type is polar, students write the respective partial charges on their cards.
- Students will then stand up and “become” the compound. Each student will hold one of the element cards and be given the string with Styrofoam ball attached to it to represent the bond between it and another element.
- Students are asked to move the ball along the string depending on the electronegativity difference between the bonded elements.
- For NH₃ and H₂O there will be lone pairs on the atom. To represent this a student will need to hold a Styrofoam ball or balloon to represent a lone pair.
- Each group is asked to model their structures for the class and also lead a discussion by drawing their structures on the board and describing the overall molecular polarity. Students should recognize several important concepts:
  - If all the bond types around the central atom are nonpolar, the pull should be even and the compound will be non-polar.
  - If all the bond types around the central atom are polar, even though the electrons are not equally shared, the central atom experiences equal pull from all sides, canceling the bond dipole and making the molecule nonpolar. If some bond types are polar and others are nonpolar, or if the central atom has a lone pair of electrons, the central atom will experience a dipole, making the molecule polar.
  - There are some exceptions to the above rules. For example, in a square planar (or linear with two bonds and three lone pairs), the four bonds are polar and there are lone pairs on the central atom, but the molecule is nonpolar. Therefore, you will need to modify your discussion for the expectations of your class.

- For enrichment, teachers could introduce substances like ethanol that has both polar and non-polar parts. This could lead to interesting discussions about intermolecular forces of attraction.
FOR THE STUDENT

Lesson

Modeling Molecular Polarity

Complete the chart for your given substance. You will be doing a gallery walk to complete the other substances from your peers:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Bond Polarity Difference in Electronegativity</th>
<th>Shape</th>
<th>Molecular Polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (H₂O)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formaldehyde (CH₂O)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen (N₂)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride (CCl₄)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia (NH₃)</td>
<td></td>
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</tbody>
</table>