Building VSEPR Candy Models

Molecular Bonding and the Structure of Covalent Compounds

Background

One of the most important topics in the study of molecules is how they are put together—how their atoms are arranged relative to each other in space. A theory of molecular shape is important because the manner in which atoms bond together influences the chemical and physical properties of that molecule. The water molecule has a “bent” geometry. If water was linear instead of bent, the chemistry of life as we know it would be different.

Why does CO$_2$ have a linear geometry, while sulfur dioxide, SO$_2$, has a bent geometry? A better understanding of these three-dimensional structures of molecules will give better insight into these questions and will suggest explanations for them.

Lewis Dot Structures

The first step in the prediction of the three dimensional geometry of a molecule is to write a valid Lewis Dot Structure. The Lewis structure gives a two-dimensional representation of the molecular structure. The key consideration in drawing a Lewis structure is the application of the octet rule, which states that a molecule’s atoms share electrons so that each is surrounded by eight valence electrons.

The first step in drawing a Lewis structure is to determine the skeletal structure of the molecule. The skeletal structure shows which atoms are bonded to a central atom using at least a single bond (represented by a dash). The central atom is usually the first atom in the chemical formula for the molecule.

Now that we have a valid Lewis Dot Structure, we use it to determine molecular geometry using Valence Shall Electron Pair Repulsion theory. The basic assumption of VSEPR is that electron pairs repel each other because they have like charges. The “best” geometry is one that minimizes the repulsive force between the electron pairs found in the valence shell of the central atom. Molecular shape is determined by counting the regions of electron density or the total number of bonds (single or multiple bonds) and lone pairs of electrons on the central atom. In general, the combination of bonds and lone pairs will determine the molecular shape of the molecule.

Rules used to determine the molecular shape of molecules using VSEPR theory:
1. Determine a valid Lewis Dot Structure for the molecule (see above).
2. Count the regions of electron density around the central atom, determined by the number of ligands and lone electron pairs attached to the central atom.
3. Using the number of ligands and lone pairs around the central atom, enter the VSEPR table to determine molecular geometry of the molecule. Note that in the table, A = central atom, X = ligands, and E = lone pairs.
**Building VSEPR Candy Models**

**Procedure:**
For each selected molecule, build a three-dimensional model using different colored gumdrops, toothpicks and marshmallows. Use different colored gumdrops to model different atoms (for example, large red: carbon, large white: hydrogen). Use toothpicks to represent bonds and marshmallows to represent lone electron pairs. **(NOTE: you may not be able to build all models at one time.)**

<table>
<thead>
<tr>
<th>Molecular Formula</th>
<th>Lewis Dot Diagram</th>
<th>Shape Drawing</th>
<th>Shape Formula &amp; Name</th>
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Post lab Questions:

1. What does VSEPR stand for?

2. Explain how VSEPR is used to predict the geometry of molecules. Be specific.

3. Why do you need a correct Lewis structure before you can use VSEPR to predict a molecule’s geometry?

4. Consider the Lewis structure for water. Explain why the water molecule is not linear.