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| Molecular Structure Laboratory |
| C4.4a & C4.4b |
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Molecular Structure Laboratory

**Background:**

The shape of many molecules determines how, or even whether, they will react with other molecules. For example catalysts are shaped so that they will either weaken key bonds on their substrate or expose appropriate charged areas for bonding to occur. Molecular shape also determines the charge distribution on the molecule. Thus molecular shape accounts for much of the physical and chemical behavior of the compound.

**Purpose:**

In this lab the student will: construct a three dimensional ball & stick model of a molecule, illustrate the bond angle(s) for the molecule, determine the dipole moments of the molecule, evaluate whether the molecule is polar or not and explain the behavior of the compound based on its molecular structure.

**Materials:**

The materials for this lab will be supplied by the students. The materials should be chosen so as to minimize cost. It should be kept in mind that different atoms should have different colors, lone pair electrons may have to be illustrated, the bond angles will have to be illustrated and that the model is to be three dimensional.

**Procedure/Data/Analysis:**

1. Your group will be assigned a molecule that your will illustrate including the following criteria:
   1. Except for instances in which the molecule illustrates some unique molecular feature the molecule should have at least four atoms in it.
   2. There should be something about the structure of the molecule that the group can use to explain its behavior.
   3. The group should be able to obtain the materials to build the model inexpensively.
      1. Once a molecule has been assigned draw a diagram of it and **have the molecule okayed by the teacher before you leave on the first day of this lab**. This diagram should have the geometry(ies) and bond angles of the molecule.
         1. Start with the Lewis structure for each element in the molecule. Lone electrons are likely to pare with other lone electrons to form a bond in the molecule, so the number of bonds that an atom is likely to form may be predicted.
         2. Draw the Lewis structure of the molecule to satisfy a noble gas configuration for each of the atoms in the molecule. The central atom is usually the one with the lowest electron affinity, and hydrogen will form only one bond, and thus can’t be a central atom.
         3. Use the Lewis structure of the molecule and VSEPR theory to determine molecular shape and bond angle.
            1. For each central atom determine the number of electron pairs around it then determine the angle these electrons must be at in, **three dimensional space,** to be as far apart as possible.
2. Inventory and obtain the materials necessary to build the model:
   1. Decide how the bonds will be depicted and how bond angle will be accurately reproduced.
   2. Determine the number of atom types in the model and how many of each. If resonance exists all possible structures must be illustrated. Then determine how each atom type will be illustrated. Don’t forget lone electron pairs! To illustrate relative atom size, use atomic radius for molecular compounds, ionic radius for ionic compounds.
      1. Assign group members to obtain and bring these materials to the next class. Each group member should contribute equally to the cost.
3. Research the molecule:
   1. To what uses is the molecule put?
   2. What features of its structure allow it to be used this way?
   3. Are there some limitations to the use of this molecule, and how does the structure create this limitation?
   4. What are the dipole moments of the bonds in the molecule and is it polar?
   5. Other interesting things you can explain to the class.
4. Construct the model as accurately as possible:
   1. Use different colors for different elements.
   2. Be sure bond angles and number are correct.
   3. Make a key indicating all of the parts of the molecule, its name, formula, structural formula, internal dipoles, overall polarity and geometry. This key should have the actual materials used in the model, not a description.
   4. If resonance exists all possible structures must be illustrated. If lone pair electrons affect geometry they **must** be illustrated.

**Conclusion:**

1. Prepare a brief presentation of your group’s molecule, including:
   1. The name of the compound.
   2. Its uses.
   3. How its structure allows it to be used this way.
   4. The precautions/limitations to the molecules uses and how its structure contributes to these precautions/limitations.
   5. An illustration of the molecular dipole moments and how they contribute to its polarity or lack thereof.
   6. Other interesting things.
2. Present to the class :-).
   1. All group members must have some part in the presentation, and no one should have to read during the presentation. Holding the model does not constitute participation.
   2. All components from step five should be included.
   3. If technical terms or concepts are used in the presentation, **any** group member should be able to explain what they mean and give examples.

Teacher Companion Notes to Molecular Structure Laboratory

**High School Content Expectations:**

**C4.4a:** Explain why at room temperature different compounds can exist in different phases.

**C4.4b:** Identify is a molecule is polar of nonpolar given a structural formula for the compound.

A thorough background in determining Lewis structures, VSEPR and molecular geometry is strongly advised prior to the undertaking of this laboratory. A useful resource for geometry: <http://employees.csbsju.edu/hjakubowski/classes/ch123/Bonding/vsepr.gif>.

Pacing: introduce the laboratory the second half of the class prior to compound assignments, and general question clarification and student group assignments will take place at this time. The subsequent class will begin with compound assignments. It is highly advised that the teacher make the Lewis structures and molecular geometries due at the end of this day. Otherwise students will simply look this information up on the internet without going through the though process. Sign off on these, and make the paper due with the assignment. Three days to complete the models, and prepare the presentations are appropriate. This allows leeway for students that forget to bring materials on the first day of model building. Pace the students as they go so they can not claim they didn’t know about deadlines. Make it clear that there will be no working on models/presentations on presentation day, because the students are to learn from their class mates on this day.

It is suggested that the teacher make 3"x5" cards with compound names, formulas and any other valuable information on them, so they can be shuffled and drawn from randomly to assign compounds. This way the students won’t feel the teacher has been playing favorites. Choose enough compound types to insure all geometries are covered, and so no two groups are working on the same molecule in the same class. Include ionic compounds (no determination of geometry here), water, ammonia and so on. Later in the year the models can be retrieved to illustrate, solubility, solid liquid equilibrium, formation of electrolytes and so on. The students very much enjoy seeing their own work used to teach.

**Contact Information:**

Please contact the author if it is found that the safety precautions are incomplete or inaccurate, factual information is inaccurate, or there are any modifications/augmentations that could improve this laboratory. [KingChemistry@comcast.net](mailto:KingChemistry@comcast.net) .

**Please Provide Feedback:**

If this material was useful in improving student understanding of the content, please let me know. If this material could use revision to improve student learning, again, please let me know. [KingChemistry@comcast.net](mailto:KingChemistry@comcast.net) .