5E Lesson Plan

Lesson Title: The Disk Game

Subject area / course / grade level: Chemistry II (10-12 grade)

Introduction: Intermolecular forces are attractive forces that exist between atoms and molecules. There are three kinds of intermolecular forces London forces, dipole-dipole forces and hydrogen bonding. These forces differ from ionic and covalent bonds in that they exist between one molecule and another while bonds exist within a molecule. London forces exist between all atoms and molecules and are due to the temporary instantaneous dipoles that form with an uneven distribution in the electron clouds. Dipole-dipole interactions are permanent dipoles due to the electronegativity differences between the atoms creating a polar molecule with a positive side and a negative side. Hydrogen bonding occurs when fluorine, oxygen or nitrogen are bonded with hydrogen. This type of intermolecular force is very strong and is the reason behind such phenomena such as viscosity, surface tension and high boiling points.

Lesson Length: 2-5 hours

Materials: (for each team of 3/4 students)

- **goggles, one for each student**
- **2 100 mL bottles with stoppers**
- **1 50 mL graduated cylinder**
- **30 mL of cyclohexane, 30 mL of dichloromethane and 60 mL of water**
- **a few crystals of iodine**
- **16 paper disks that have been colored on one side with graphite (pencil lead)**
- **1 computer with internet access**

Note: The cyclohexane and dichloromethane can be reused after separating from the water with a separatory funnel and filtering out the paper disks if iodine is not added to the mixtures.

Lesson Overview: Students are going to investigate how intermolecular forces affect the orientation of paper disks when placed in a bottle containing a cyclohexane/water mixture and a dichloromethane/water mixture. From their observations, Lewis structures each substance, and information gained from the internet, the students will determine what type of intermolecular force is acting on the paper disks.

TPACK Framework: Students will be using technology to support learning about intermolecular forces. Students will search the internet to find structures for cyclohexane, dichloromethane and water. They will also use the internet to find information about intermolecular forces.

NETS-T:
1a. Promote, support, and model creative and innovative thinking and inventiveness
1b. Engage students in exploring real-world issues and solving authentic problems using digital tools and resources
1c. Promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes
1d. Model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments
2a. Design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity.
3d. Model and facilitate effective use of current and emerging digital tools to locate, analyze, evaluate, and use information resources to support research and learning.

4a. Advocate, model, and teach safe, legal, and ethical use of digital information and technology, including respect for copyright, intellectual property, and the appropriate documentation of sources

Tennessee Standards:
CLE 3224.Inq.2 Design and conduct scientific investigations to explore new phenomena, verify previous results, test how well a theory predicts, and compare opposing theories.
CLE 3224.Inq.4 Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias.
CLE 3224.Inq.5 Compare experimental evidence and conclusions with those drawn by others.
CLE 3224.2 Determine the intermolecular forces that exist between ions and molecules.
CLE 3224.3 Explain how the physical characteristics of matter are governed by kinetic molecular theory and intermolecular forces.
3224.2.9 Determine the types of intermolecular interactions that occur in a pure substance or between the components of a mixture.
3224.2.10 Compare the strengths of intermolecular forces between ions, molecules, and ion-molecule mixtures.

NETS-S:
1c. Use models and simulations to explore complex systems and issues
2d. Contribute to project teams to produce original works or solve problems
3b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media

Lesson objective(s):
1. Students will be able to describe, in words, the definition intermolecular force.
2. Students will be able to distinguish between London forces, dipole-dipole forces and hydrogen bonding.
3. Students will use observations, structural diagrams and animations of intermolecular forces to determine the type of force acting on paper and graphite with polar and nonpolar liquids.

ENGAGEMENT: Part A

NOTE: Part A will be done in groups of three or four.

Part 1: Give each group two 100 mL bottles with each bottle containing two colorless liquids. One of the bottles contains equal volumes of cyclohexane and water, 30 mL each. The other bottle contains dichloromethane and water, 30 mL each. Ask the students to correctly predict which liquid is on top in each bottle by drawing sketches of the bottles in their lab book. Have the students give a reason for their ideas.

After completing their sketches and reasons, have each group discuss their predictions. When each group has reached a consensus, have them put their ideas on a whiteboard. The board should include a sketch of the bottles, and the reason for why one liquid would be on the top and the other is on the bottom.
After listening to each group's explanation ask the following questions:

1. Why do the two liquids stay separate in the bottles?
2. If none of the groups mentions density, ask them to define the term. Which substance has the highest density in each bottle?

3. If you added a few crystals of potassium permanganate to each solution, what do you think would happen? (Why?)
4. If you added a few crystals of iodine to each solution, what do you think would happen? (Why?)

After the discussion is complete, give each group a few crystals of potassium permanganate to help them correctly identify the water layer in each bottle. (Note: if you decide to test with the iodine, you will not be able to reuse the organic liquids.)

1. Do your results agree with your explanations?

EXPLORATION:

Part B

Give each group a baggie with 16 paper disks that have been blackened on one side with pencil lead. Ask each group to predict what you think will happen when these disks are added to each bottle. Have the students sketch a new diagram in their lab notebooks showing the two bottles, each liquid and the paper disks. Give a reason for putting the disks at the location you put them.

After completing your sketches and reasons, have each group discuss their ideas. When each group has reached a consensus, have them put ideas on a white board. Allow each group to describe their predictions and why they think the disks are located and orientated the way they are.

After the white boards and discussions, give each group a baggie of paper disks and ask them to test their predictions. After testing their predictions, allow each group time to correct their whiteboards if necessary. Have another presentation of group ideas and whiteboards now showing the correct location and orientation of the paper disks. Ask the following questions to guide them toward the correct model as needed.

1. What information do you need to know to determine why they disks are orientated the way they are? (The students will need the structure of water, cyclohexane, dichloromethane, paper (glucose) and graphite.)
   a. What is paper made of? (Paper is obtained from wood and primarily contains a polysaccharide known as cellulose which is made up of several hundred glucose molecules linked together.)

2. What type of interactions do you think are occurring between these substances? (Students will need to know about intermolecular forces)

EXPLANATION:

Ask each group to use the internet to find Lewis structures for each of the substances and draw them in their lab notebook. Ask the groups to research intermolecular forces. They should have a definition and a sketch for each type of force. To save time, assign one intermolecular force to each group. For example, if you have six groups, then 2 groups will research London forces, 2 groups will research dipole-dipole and 2 groups will research hydrogen bonding. After collecting the data, have a class discussion where each type of intermolecular is described. Use the following web-sites as needed:

http://www.wisc-online.com/Objects/ViewObject.aspx?ID=GCH6804
http://ab.mec.edu/abrhs/science/baumritter/#liquidsandsolidsanchor
http://edtech2.boisestate.edu/craigj/573/jigsaw.html

(Note: a google search using the phrase "Lewis structure for water" will yield several diagrams. Use the same phrase for each of the other substances.)

ELABORATION: Each group needs to use the information the class gathered and determine what type of intermolecular force is acting on each side of the paper disk. Have each group white board their results and present them to the class.

Based on their internet investigations and class discussions, students should come to the conclusion that both water and paper (glucose) are capable of hydrogen bonding. Because of this, the white side of the paper disks is always facing water. The students should also be able to realize that cyclohexane and graphite are both nonpolar and therefore only capable of London forces. Dichloromethane is slightly polar, but will behave as a nonpolar substance with water. This is because the water molecules are too attractive to each other to interact much with dichloromethane. The students should realize that the graphite side of the paper disks is always towards the cyclohexane or dichloromethane.

Questions to ask to relate content to the real world.

1. How do you think hydrogen bonding relates to surface tension? to viscosity?
2. Why does water pour out of a spout in a single stream but automobile gasoline does not?
3. Would water exist as a liquid or a gas at room temperature if it could not hydrogen bond?

EVALUATION:

The evaluation of this lab is based on the quality of their lab write up. In conclusion, students will be required to describe the three types of intermolecular forces. They will need to describe why the paper disk has the orientation it does in each mixture and the type of intermolecular forces that are causing this orientation. They need to describe what evidence supports this decision.

Reference

University of Wisconsin–River Falls Chemistry 116 Lab Manual; K. Craighead, B. Nielsen, and R. J. Scott; 1996; pp 85 - 88. "Intermolecular Forces."