

Intermolecular Forces
An Inquiry-Based Experiment
for Introductory Chemistry

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Introduction to the Unit

The concept of intermolecular forces often occupies a minor fraction of the curriculum, even though these forces are responsible for many commonplace phenomena. In addition, the qualitative nature of this material makes it particularly accessible to students with weak mathematical skills. In this unit, students are introduced to intermolecular forces through a demonstration which is paired with a guided reflection as well as a student-designed and run experiment. This unit is designed to take from 4-5 days, depending on the class time allocated for the experiment.

Objectives and Massachusetts Curriculum Frameworks

The Massachusetts Curriculum Frameworks for Chemistry are currently undergoing revision. However, the development and integration of science inquiry skills into the study of chemistry is expected to be a substantial addition to the current Frameworks.

Basic Sequence

The unit will be accomplished through the following sequence of events:

- Introduction
- Magic Sand Demonstration, Student Response Worksheet
- Introduction of the Experiment
- Student-design and performance of the experiment
- Student presentation of results

Introduction to the Class

Show the class several pictures of a water droplet on a lotus leaf.

(Numerous images showing tightly-formed droplets of water on lotus leaves exist on the internet. The use of a direct internet connection and a projector will allow the teacher to show their class a variety of full-color images. A particularly good source of lotus leaf images with water droplets can be found in the Images section of www.google.com)

Discuss: Why does the water form into tight balls – and is not spread out in a thin layer?

Define for the class “hydrophobic.” Breaking the term into “hydro” and “phobic” will help students define it for themselves.

Ask the class to brainstorm: What could be some good uses for a material which is hydrophobic?

Continue the unit with the Introductory Demonstration.

Introductory Demonstration

A student-response worksheet follows. As the teacher performs each part of the demonstration, students should complete the Observation section. Ask the students to describe carefully what they have seen.

At the conclusion of the demonstration, students should complete the Question and Hypothesis sections. They should write down 2-3 questions that come to mind after watching the demonstration. Next, have the students break into groups and share their questions. After a set time, compile the questions on the board.

For the Hypothesis section, give the students 5 minutes to write down the answer for one of the questions. Encourage them to think and come up with an educated response. Discuss the questions and hypotheses as a class and share the solution with the class.

The sand is sold by Dunecraft.com and is called Space Sand, but it is more commonly known as Magic Sand. (See the materials list for further information.)

This worksheet was adapted from materials received at the Flinn Scientific Chemistry Summer Workshop.

Demonstration Procedure:

Part I

Fill a beaker $\frac{2}{3}$ full of water.

Slowly pour the Magic Sand in a continuous stream in the water. It will not settle to the bottom of the beaker like ordinary sand, but will rather form a self-supporting column of sand.

Pour of the water into a second beaker. Pass the first beaker which contains the (dry) Magic Sand around the room and let the students touch the sand. It will be completely dry.

Part II

Fill a small plastic soda bottle $\frac{2}{3}$ full with water. Add vegetable oil to the bottle, leaving 1 inch of the bottle unfilled to enable subsequent mixing.

Add a few drops of food coloring to the mixture. Let the food coloring settle to the water layer. Cap and shake the soda bottle. Let the layers separate.

Part III

Place a small amount of Magic Sand in a beaker of water. Add a teaspoon of liquid detergent to the water. Stir the mixture with a stirring rod.

Chemistry Mysteries

Name: _____ Date: _____ Period: _____

Observations (Describe what you have seen during the demonstration.)

Questions (From what you have just seen, what questions do you want answered?)

Hypothesis (Describe what you think is happening.)

Solution

Introduction to the Experiment

In the experiment, students are asked to devise a way to test the anti-wetting characteristics of some substances. This will be accomplished through a student-designed inquiry-based experiment. Each small group of 3-4 students will design the experiment, collect the data, and analyze the data. They will be provided with a variety of materials for testing, including car waxes and polishes and Teflon sheets. The car waxes and polishes will be applied to pieces of galvanized sheet metal. As car waxes and polishes come in liquid and spray form provide 3 of each kind if possible. Labeling each container with its price may be helpful for students; some may choose to use cost as a test variable.

The overall process follows:

- 1.) After discussion, each group will decide on the hypothesis that they want to examine. While all of the groups will be exposed to the same demonstration and introduction and therefore, have similar hypotheses, this allows each group to take this experiment and make it their own. Before continuing further, each group will be required to have their hypothesis approved by their teacher (see handout). This ensures that each group has a hypothesis from which to work, as well as gives the teacher the opportunity to make more materials available to students.

- 2.) Once their hypothesis is approved, each group will answer the Focusing Questions given on their handout. The answers to these questions will help each group devise their experimental procedure. Space is given in this section of the handout for teacher approval.

- 3.) Each group will then devise a step-by-step procedure for their experiment. Students should write a procedure which is sufficiently detailed so that another group could perform the experiment without further information. Included in each procedure should be clear directions on how to collect data, whether it is qualitative or quantitative. If the data is qualitative, a good description of the type(s) of data should be included. If the data is to be quantitative, a clear method which can be used to obtain reproducible data should be included. It may be very helpful for students to have access to the materials that they can use in the actual experiment. The procedure should be approved by the teacher before continuing.

- 4.) Each group will perform their experiment and collect data.

- 5.) Each group will examine their data and discuss what conclusions are suggested by it.

- 6.) Each group will prepare a poster that will include their hypothesis, procedure, data, and conclusions.

The student handout is designed to assist each student group design their experiment by focusing their discussions.

Student Handout for the Experiment

Your Name:

Names of Group Members:

Your group's hypothesis:

Teacher's Initials _____

Focusing Questions:

What car waxes and polishes will you test? How did you select these?

How will you apply the polish? (You need to use an even coat of polish.)

How will you place the water droplets so that they will be the same in size?

How many trials should be done?

What data will you collect? (Data can include observations as well as measurements.)

Teacher's Initials _____

Procedure:

Describe how you will perform the experiment. (Write out the list of steps you will take. Give enough detail so that another group could do your experiment without any extra help.)

Teacher Initials _____

Materials List

Teflon Sheet

Fishersci.com

Jensen Inert Products Teflon Sheet 12" x 12", 1/8" thick \$25.71

(Cut into 3" x 3" squares, one per student group)

Car Waxes – are available as liquids, sprays, and pastes

Available at supermarkets

Car polishes are available in liquid, spray, and in paste form.

Buy 2-3 of each type so that each student group to test polishes of the same type.

Galvanized sheet metal

Galvanized sheet metal squares (refer to Holiday Ornament Kit from Flinn Scientific)

(Also available at Ace Hardware)

Magic sand

Dunecraft.com

Space Sand 0.5lb (\$4.99) 1.0lb (\$7.99)