Oleic Acid Pancake

Inform your students that the oleic acid solution will be mostly alcohol with a small amount of oleic acid in it, mainly to allow portioning out less than a drop of oleic acid. When they add a drop of solution to a tray of water, the alcohol dissolves in the water, but the oleic acid floats on top, just as a drop of oil floats on water.

Caution your students not to put too much powder on the water surface, which may interrupt spreading.

The computations that follow treat the oleic acid molecules as a sphere. The conclusion of the lab is an appropriate time to relate that the molecule is actually hot-dog shaped, and they are measuring the *length* of the molecule. Still, the method and the outcome are good.

Sample Calculations

In Step 3, a typical value for the average diameter is 30 cm. The radius, r is then:

$$r = d/2 = 30\text{ cm}/2 = 15\text{ cm}.$$

The area of the circle is:

$$A = \pi r^2 = (3.14)\ (15\text{ cm})^2 = 706\text{ cm}^2 = 7.06 \times 10^2\text{ cm}^2.$$

The number of drops in 1 cm^2 of 5% solution is about 38.

The volume of one drop is:

$$1\text{ cm}^3/38 = 0.026\text{ cm}^3 = 2.6 \times 10^{-2}\text{ cm}^3.$$

In Step 4, the volume of acid in a single drop equals 0.005 multiplied by the volume of one drop:

$$(0.005)(2.6 \text{ x } 10^{-2})\text{ cm}^3 = 1.3 \times 10^{-4}\text{ cm}^3.$$

In Step 5, the diameter of an oleic acid molecule equals the volume of oleic acid in one drop divided by the area of the circle:

$$\text{Diameter} = (\text{volume})/(\text{area}) = (1.3 \times 10^{-4}\text{ cm}^3)/(7.06 \times 10^2\text{ cm}^2) = 0.18 \times 10^{-6}\text{ cm} = 1.8 \times 10^{-7}\text{ cm}.$$

Good measurements yield values between $1.0 \text{ x } 10^{-7}$ and 2.0×10^{-7} cm. If time permits a second trial, be sure students clean the trays thoroughly before making a second measurement of the diameter.

Answers to Summing Up Questions

1. A monolayer is a layer one molecule thick.
2. At full strength, a single drop would cover a huge area.
3. Assume a rectangular shape for simplicity: The volume of one rectangular molecule would be its length multiplied by one-tenth the length multiplied by one-tenth the length—which means the volume of the long molecule is actually about one-hundredth the volume of a cube of the same thickness.

Bouncing Off the Walls

This tech lab uses the PhET simulation, “Gas Properties.” The simulator is robust and highly visual; it is very flexible and has many nice features. Of particular value is for students to see what random molecular motion looks like.

The Physics Education Technology Group (PhET) at the University of Colorado at Boulder has developed dozens of excellent, interactive physics computer simulations. You can find them at **http://phet.colorado.edu.** You can download all the PhET simulators from their web site, free of charge.

The PhET simulator used in this tech lab is "Gas Properties." Download and run it before class to make sure your computers can run it. This tech lab and corresponding key were written using "Gas Properties" version 3.12.

Answers to Procedure Questions

PART A: SIMULATOR MECHANICS

Step 1: a. Move the handle up and down quickly.
b. Use the "Gas in Chamber" section of the on-screen control panel to type in a specific number.

Step 2: a. Slide the chamber lid open so that particles can escape.
b**.** Use the "Gas in Chamber" section of the on-screen control panel to type in a lower number.

Step 3: Drag the on-screen Heat Control to "Add." A flame appears above the control.

Step 4: Drag the on-screen Heat Control to "Remove." Ice appears above the control.

Step 5: Drag "Scubie" to the right.

Step 6: Drag "Scubie" to the left.

PART B: THE NATURE OF THE IDEAL GAS LAW

Step 1: The pressure increases.

Step 2: The temperature increases.

Step 3: Ice appears from the Heat Control to cool the gas as it is compressed.

Step 4: The volume of chamber expands (Scubie moves to the left)

PART C: ALL SPECIES GREAT AND SMALL

Step 1: a. The light species moves faster.
b. Temperature is a measure of average kinetic energy, so lighter particles must move faster to have as much kinetic energy as slower, heavier particles.

Step 2: a. The particles move with high speed as shown in the Species Information window. But they move in random directions, so their overall motion is nearly zero, as shown by the center of mass markers.
b. Wind.

Answers to Going Further Questions

1. When the pressure in the chamber reaches 6 atm. The lid can be blown when only one particle is in the chamber.
2. The temperature can be made to increase, seemingly without an upper limit.
3. b. The particles still appear to have some vibrational motion.
4. The particles slowly wander outward into the empty space of the chamber. A light species particle always beats the heavy species particles to the far end of the chamber.

Water Waves in an Electric Sink

Ripple tanks were once very common in physics labs. And with good reason. Many wave characteristics and phenomena can be demonstrated and investigated with the ripple tank. Unfortunately, ripple tanks are bulky and can be difficult to work with and maintain. A high-tech alternative is the "virtual ripple tank."

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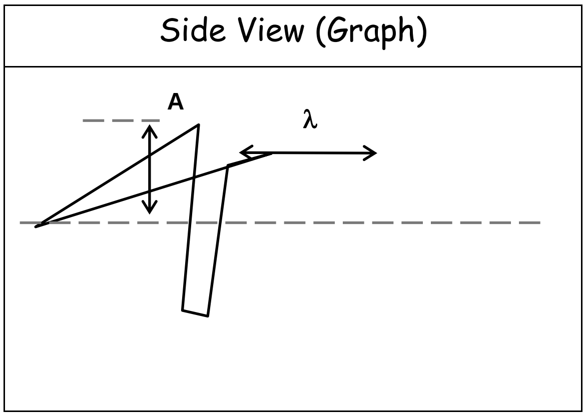
http://phet.colorado.edu. You can download all the PhET simulators from their web site, free of charge.

The PhET simulator used in this tech lab is "Wave Interference." Download and run it before class to make sure your computers can run it. This tech lab and corresponding key were written using "Wave Interference" version 1.07.

"Wave Interference" simulates water, sound, and light wave generators. This activity uses the water wave generator only.

Answers to Procedure Questions

Step 5:



Step 7: a. Large amplitude waves are made by large water drops; small amplitude waves are made by small water drops.
b. High-amplitude waves are taller in the side view, and have greater contrast (brighter brights and darker darks) in the top view.
c. See diagram in table above.
d. The side view is better suited for labeling amplitude.
e. Amplitude decreases as distance increases.

Step 8: a. High-frequency waves are packed more tightly—they have a smaller wavelength.
b. Same speed, same amplitude.
c. The waves travel at the same speed as one another. High-frequency waves are made by a faster-vibrating **source**.
d. Inverse proportionality
e. Nothing.

Answers to Summing Up Questions

1. a. **high** amplitude, **low** frequency
   b. **low** amplitude, **high** frequency
   c. **low** amplitude, **high** frequency
   d. **high** amplitude, **high** frequency
2. Energy
3. a. Volume
   b. Volume
   c. Area

Go! Go! Go!

This experiment affords students an opportunity to collect data from an observable event, make measurements, and plot a graph of the results. They can then interpret the graph. The car speed and size of table should allow at least four data points.

Answers to Summing Up Questions

1. a. The marks would be farther apart.
   b. The car would reach the edge in fewer seconds.
   c. The slope would have been steeper (more vertical).
2. A steeper straight line should be added to the graph.
3. a. The marks would be closer together.
   b. The car would take more seconds to reach the edge.
   c. The slope would have been shallower (more horizontal).
4. A shallower straight line should be added to the graph.
5. a. The marks would get closer and closer together.
   b. A curved line having a decreasing slope (concave down) should be added to the graph.
6. Line A shows an object moving in the opposite ("negative") direction compared to direction of the moving car with constant speed.
   Line B shows a car moving in the "positive" direction and speeding up.

Chain Reaction

Answers to Summing Up Questions

1. The close-spaced dominoes took a shorter time to fall.
2. For the straight-column reaction the number of dominoes being knocked over per second did not change. For the chain reaction, however, the number of dominoes being knocked over per second increased rapidly.
3. There were no more dominoes to fall over. Similarly, a nuclear fission chain reaction only stops when there are no more fissionable nuclei to fission.
4. Both are exponential functions. In other words, they each lead to rapidly increasing rates of reaction.
5. The domino chain-reaction occurs in two dimensions while the nuclear fission process is three-dimensional. Also, each domino reaction causes two additional reactions, while each uranium-235 nuclear reaction causes, on average, about three additional reactions.

Pinhole Camera

The word camera is derived from the Greek word *kamara*, meaning "vaulted room." Royalty in the 16th century were entertained by the "camera obscura"—a large "pinhole camera" without the film.

Answers to Summing Up Questions

1-4. Image is inverted in all directions; up and down as well as left and right.

5. All distances are in focus. Actually the consideration is the size of the pinhole compared to the distance to the screen. So openings of a few centimeters act as pinholes if the screen distance is in meters. Openings in the leaves of trees act as pinholes, for example, and cast images of the sun on the ground!
6. A lens gathers more light and is brighter.

7. There is much in common with the eye and a pinhole camera. Image formation is much the same for each.

Electroscopia

Most experiments in the lab manual are quantitative in nature. This one is qualitative. It is quite thorough in the explorations one can do with a simple electroscope.

I prefer the can-form electroscope with the flat plate on top, but the other two types work just as well.

This experiment requires fairly active participation by the instructor. You'll need to be prepared to provide a "mystery object," an object whose charge is unknown. And you'll need to be able to place a "mystery charge" on the electroscopes of the groups when they ask for it.

Here are options that work well for a "mystery object."

- a balloon rubbed on your head (assuming you are not follicle-challenged). Most balloons will gain a negative triboelectric charge.
- your head after having been rubbed by the balloon. Requires bowing down and getting your head right above the electrophorus, but students love it! And your head will be positive.
- an electrophorus charged inductively from a CRT TV screen (make sure the screen is on). Spare yourself a spark by keeping a finger on the plate until you touch the plate to the screen. Then remove the finger, then remove the plate.
- a Fun Fly Stick: its got a mini Van de Graaff generator that charges the stick positive.

You can use any of the "mystery objects" to place a "mystery charge" on students' electroscopes.

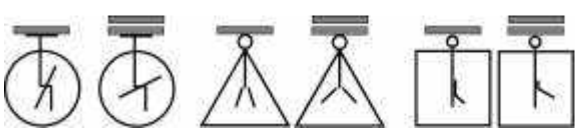
- The TV-charged electroscope can charge an electroscope using conduction or induction techniques.
- The balloon and Fun Fly Stick are best used as inductive charge sources.

Be careful not to overdo the "mystery charge" placed on student electroscopes. If the indicator registers maximum deflection, it's hard to test with the same charge. Limit the "mystery charge" to about half deflection. If the charge you put on is too much, simply press a cloth square (wool) against the top plate or ball. With careful pressure, you can gently bring down the charge without neutralizing the electroscope completely.

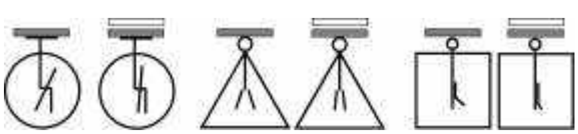
Answers to Procedure Questions

PART A: POLARITY

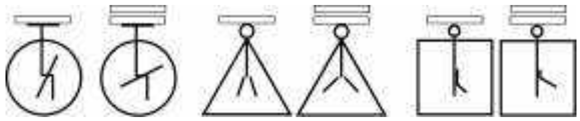
Step 2: c. The deflection increases. [Note, illustrations of all electroscope types are shown.]



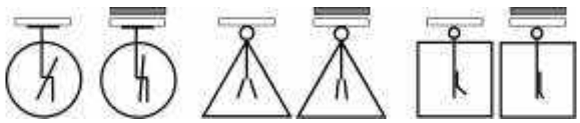
Step 3: c. The deflection is reduced. [Note, dark strips represent vinyl; light ones represent acetate.]



Step 4: c. The deflection increases.



Step 5: c. The deflection is reduced.



Step 6: a. Enhance: the deflection increased.
b**.** Enhance: the deflection increased.
c. Cancel: the deflection is reduced.

PART B: DETERMINING THE SIGN OF AN UNKNOWN CHARGE

Step 1: Set a charged strip (such as wool-rubbed vinyl) on the electroscope plate or touch it to the metal ball. Observe the deflection. Now bring in the unknown object. If the indicator deflection increases, then the object has the same charge as the strip (negative in the case of vinyl). If the deflection decreases, then the object has the opposite charge from the strip (positive if using a vinyl strip).

Step 3: Answers will vary, but consider one possibility: An electrophorus charged using vinyl chair will be positive. When brought near an electroscope charged with vinyl, the deflection is decreased.

Step 5: a. and b. Answers will vary.

Step 6: Test it with a known charge (vinyl: negative, acetate: positive). Greater deflection indicates the same charge; reduced deflection indicates opposite charge.

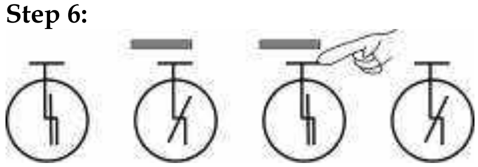
Step 7: a. and b. Answers will vary.

PART C: ELECTROSTATIC INDUCTION

Step 2: Negative

Step 5: The indicator suddenly deflects (jumps up)

Step 6:

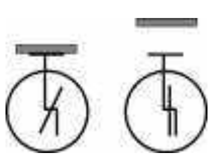


Step 7: a. positive
b**.** negative

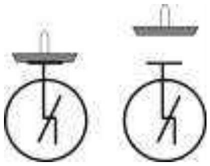
PART D: CONDUCTORS AND INSULATORS

Step 1: Selections will vary.

Step 2: The deflection ***goes away*** when the plastic is removed.



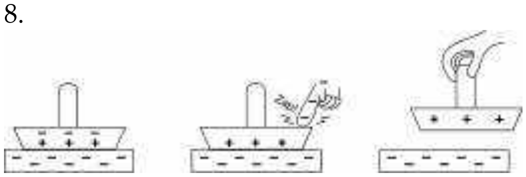
Step 3: The deflection ***remains*** when the metal plate is removed.



Step 4: Charge on the insulator remains on the insulator. Charge on the conductor is shared with/transferred to the electroscope.

Answers to Summing Up Questions

1. The sign of the charge is unknown; the object may be a conductor or an insulator.
2. The sign of the charge is unknown; the object is a conductor.
3. The charge is positive; the object may be a conductor or an insulator.
4. The sign of the charge is unknown; the object may be a conductor or an insulator.
5. The charge is positive; the object may be a conductor or an insulator.
6. The sign of the charge is unknown; the object is an insulator.
7. Charges easily move on or off a conductor; charges stick to an insulator.
8.



9. a. Conduction: touch / direct contact
   b. Induction: hold it nearby and touch the electroscope.