Pre-AP Activity

Answer Key

Experiment results: Students should be able to put about 40 drops of water, 24 drops of rubbing alcohol, and 14 drops of detergent solution on the penny before they spill over.

1. Diagrams should show that molecules in the interior of the pile have attractive forces in all directions, whereas molecules at the surface have a net force toward the interior.
2. Water should rank highest, rubbing alcohol second, and detergent solution last. Numbers of drops will vary by the size of the dropper and other factors.
3. Rubbing alcohol forms fewer hydrogen bonds between its molecules than water does.
4. Students may suggest a difference in drop size produced by different droppers, a difference in how clean the pennies were, or differences in how students handle the droppers.

Name:_____ Class:_____ Date:_____

Surface Tension and Cohesion

Pre-AP Activity

In Chapter 2, you have learned that water is a highly polar molecule that forms hydrogen bonds with other water molecules. Many of the physical properties of water—such as surface tension, capillarity, adhesion, and cohesion—result from hydrogen bonding.

INTERMOLECULAR FORCES CAUSE SURFACE TENSION

Many physical properties depend on the intermolecular forces that exist between the particles of the substance. The most important force that exists between water particles is the hydrogen bond. If you could see the forces of hydrogen bonds in a drop of water, you would see that molecules in the interior of the drop are surrounded by and acting upon one another in all directions, and there is no net force on any of them. Molecules at the surface of the drop are subject to the force of hydrogen bonds only from the side and from below. The result of this uneven force is that the water molecules on the surface are pulled toward the center. This net inward force makes the surface contract and act like an elastic skin. Because the intermolecular forces are so strong, it is hard to overcome them and break through the water's surface. In other words, water has a high surface tension.

INTERMOLECULAR FORCES CAUSE CAPILLARITY

When water is placed in a narrow tube, it rises. This property, typical of polar liquids, is called capillarity. Two kinds of forces are responsible for capillarity: cohesive forces and adhesive forces. Cohesive forces are the intermolecular forces that exist between the molecules of a liquid, such as the hydrogen bonds between molecules of water. Adhesive forces are the forces that exist between the liquid molecules and a solid, as in drops of water on a window, or a volume of water in a test tube. Adhesion occurs when the solid has polar bonds. For example, the glass of a test tube has many oxygen atoms with partial negative charges. These charges attract the positive ends of water molecules and cause the water molecules that touch the glass to cling to its surface. Because water also has strong cohesive forces, the water molecules in the interior of the tube are pulled slightly upward by those that are touching the glass. The concave shape of the water's surface in the tube, called the meniscus, shows that the adhesive forces between water molecules and the glass are stronger than the cohesive forces between water molecules.

SURFACTANTS AND SURFACE TENSION

Detergents are substances, known generally as surfactants, which have a polar head and a nonpolar tail. When surfactants interact with water, their polar heads form hydrogen bonds with water molecules, but their tails do not. This behavior reduces the cohesive forces in water because fewer hydrogen bonds are formed. As a result, the overall forces holding the water together are reduced, and the surface tension decreases.

You will investigate the forces that hold a drop of water together. Remember that the molecules on the surface of the drop are pulled toward the interior by unbalanced intermolecular forces. In order to balance this inward force, the molecules at the surface pack together, reducing the surface area and causing the surface of the drop to have a "skin."

EXPERIMENT

In this activity, you will count the number of drops of water, rubbing alcohol, and detergent solution that can be placed on a penny without spilling over. By comparing these numbers, you can compare the strengths of the intermolecular forces—and thus the surface tensions—of these substances.

MATERIALS

Detergent solution	Penny
(1 part liquid dishwashing detergent: 1 part water)	Rubbing alcohol
Dropper	
Paper towels (2)	Tap water

1. Place a penny heads up on a paper towel on your lab table. Be sure the penny is flat.
2. Make a data table for recording your data. If time allows, plan on doing several trials with each liquid and averaging the data.
3. Fill a dropper with tap water.
4. Holding the dropper close to the penny but not touching it, count the number of drops of water that you can drop onto the penny before they spill over the edge. Record your data in the data table. Rinse the dropper, and dry the penny with a paper towel.
5. Fill the dropper with rubbing alcohol and repeat step 4.
6. Fill the dropper with detergent solution and repeat step 4.

Pre-AP Activity *continued*

1. On a separate piece of paper, draw a diagram showing the intermolecular forces in the drop of water on the penny.
2. Rank the substances from highest to lowest in terms of surface tension, and list the number of drops of each substance the penny could hold before spilling occurred.

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3. Infer why rubbing alcohol has a lower surface tension than water.

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4. Compare your results with those of your classmates. What could account for differences in the number of drops of the same liquid that piled up on the pennies?

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