RAFT IDEAS

Topics: Surface Tension, Forces, Properties of Matter, Nanoscale

Materials List

- ✓ Container with a round opening at least 1 cm (3/8") in diameter, such as a test tube or vial
- ✓ Container with a round opening that is .5 cm (3/16") or smaller in diameter, such as a small vial or straw with one end sealed
- ✓ Water faucet or tub of water
- ✓ A straw having a diameter smaller than the smaller container's mouth
- ✓ Net fabric
- ✓ Tape or rubber band
- ✓ Tray to catch liquid

This activity can be used to teach:
Next Generation Science:

- Structure of matter (Physical Science, Grade 5, 1-1; Middle School, 1-1)
- Forces & Motion (Physical Science, Middle School, 2-2; High School, 2-1)
- Electrical forces between particles (High School, Physical Science, 1-3)

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Pour It Out

The tiny world can have some big surprises!

If everything in a house were 1/20th normal size why would you need lots of straws?

To Do and Notice

1. Fill the larger container by dipping into a tub of water or by pouring water into the container. Tip the container over the tub or a sink. What is happens?
2. Attempt to fill the smaller mouthed container by one of the methods listed in step 1. Could the smaller container be filled? (Usually not or at least not fully filled).
3. The smaller container can be fully filled by inserting a smaller diameter straw into a tub of water, sealing the top end of the straw with a finger, putting the straw into the bottom of the smaller container, removing the finger, and withdrawing the straw. Repeat as needed to fill the smaller container with water.
4. Turn the smaller container upside down over the tub or sink. What happens?
5. How can the water be removed from the smaller container?
6. Fill the larger container with water and cover the top with a piece of net fabric. Secure the fabric to the sides of the container with tape or a rubber band.
7. Quickly invert the larger container over a tub or sink. Does the water come out?

The Science Behind the Activity

Decreasing the size of an object leads to an increase in the ratio of surface area to volume. Surface effects will then become increasingly important. For the smaller mouthed container a greater percentage of the water molecules at the mouth are close enough to the lip of the container to experience an electrostatic attraction to the lip's molecules. This attractive force, the van der Waals force, is much greater than the downward force of gravity. The water is thus more strongly attracted to the container than downward by gravity - even when the container is turned upside down! A similar effect occurs with the net covered container. The increased importance of surface effects with reductions in size is even more noticeable for nanometer-sized (10^{-9} m) objects. For example, when the surface area-to-volume ratio is increased, chemical reactions occur faster because of the greater contact between the chemical reactants.

In a container with a larger opening, most of the water at the container's mouth is too far from the container's lip to experience an electrostatic attraction to the lip. The greater downward force of gravity prevails and water pours out. A few small drops may cling to the container where the electrostatic attraction is greater than gravity. Water in the container with a smaller opening can be shaken out since the downward motion adds to the downward force of gravity. Wetting the outer rim of a full container can make emptying easier as the nearby water molecules are slightly pulled outward from the container. Using a straw to empty the smaller container, doing the reverse of filling, see step 3, is another way to empty the smaller container.

Taking it Further

Repeat with different liquids (water with soap added, for example) that have surface tensions that are greater or less than water. See the RAFT idea sheet ***Stop the Drop***.

Web Resources (Visit www.raft.net/raft-idea?isid=555 for more resources!)

- Hands-on nano-scale activities - http://nanoteachers.stanford.edu/activities/

Based on a Stanford Center for Probing the Nanoscale activity, written by Michael Pollock (RAFT)