ACTIVITY 1.1
SOLID WATER AND LIQUID WATER

TEACHING SUGGESTIONS:

1. Separate the class into groups of about three students each and distribute the materials. Circulate around the room to monitor the activity and to encourage the students to write answers to the questions.

2. As part of your directions, stress that the students seal the ice cube in the ziplock bags so the water does not leak out. You may want to place a time limit on the activity. The students in each group should decide together how best to melt the ice fast. Caution the students not to roll or pound the ice cube and break the bag.

3. After the students have completed the activity, collect the materials and discuss the activity.

STUDENT RESPONSES:

Calculation time: Many students will find it easier to "count forward" from the starting time to the stopping time than to subtract the times.

1. Students' responses will vary. They might include placing the ice cube bag system between their hands, under their arms, etc.

2. This question is designed to help students focus on the key idea that a change of state does not change the substance: Ice and water are the same substance because ice melts to form only water.

3. This question gets at the major point of the activity: Water and ice are interconvertible, and thus two different states of the same substance.

   Students could change the liquid water back into ice by placing the plastic bag containing the water in a freezer or pouring the water into an ice cube tray and placing it in a freezer.

4. Adequate answers include the idea that when ice melted there was no water lost of gained and thus there would have to be the same amount remaining.

   (Students sometimes say that there would be <u>less</u> ice because some of it evaporates, or that there is <u>more</u> ice because ice weighs more than liquid water, perhaps because it's solid and hard. This is not true. The same amount of ice and water weight the same, as shown in the next question.)

5. Optional: You may want to do the experiment described in this question. If you want to check the weight before and after ice melts, check for leakage (which tends to decrease the weight) and condensation of water vapor in the air on the cold plastic bag (which tends to increase the weight).

   A problem in doing this experiment is that some students believe that the condensation on the outside of the bag is really water leaking from the inside of the bag. Condensation will be discussed in Lesson Cluster 9.

   The students' explanation should include the idea that the weight would have to remain the same since no water was lost or gained as the ice cube melted.

This is a very difficult idea for many students, and not of central importance for this unit. You should not expect all your students to master this idea (that mass is conserved in changes of state) and use it consistently.

DEMONSTRATION 1.2

TEACHING SUGGESTIONS:

If students see water in the tube, they may think that this water is water vapor. To prevent this confusion, set the distillation apparatus up about 10 minutes before class and let it operate several minuets before the students observe it closely. Make sure students understand that there is an invisible gas (water vapor) coming out of the tube and that water is accumulating in the test tube.

STUDENT RESPONSES:

1. Less. As the water boils in the flask, some of it changes to water vapor, moves through the gas tube, and collects in the test tube.

   (There is some confusion about the use of the terms "steam" and "water vapor." Scientists use them both to mean invisible water in the gas state. In common language, though, steam often refers to the visible condensate above boiling water. This is really tiny drops of water--liquid water! Our practice in this unit is to refer to the invisible gas as water vapor and to the visible droplets as "steam"--in quotation marks to indicate the non-scientific usage.)

2. Arrows should show water moving from the boiling water, through the tube, and into the test tube.

3. a. Liquid water to water vapor or gaseous water
   b. Water vapor
   c. Water vapor back into liquid water
   d. Water vapor. (Many students believe that the bubbles are made of air. They are not. The bubbles have only water in the gas state inside them.)

4. No. The bubbles coming up through the water consist of water vapor, not air. Water is changing to water vapor at the bottom of the flask where it is hottest, making the bubbles.

5. a. No--water vapor is invisible. But sometimes some water condenses in the tube--changes from water vapor back into liquid water.
   b. No
   c. You cannot see water vapor--water vapor is invisible.

6. Since liquid water can change into water vapor, and water vapor can change back into liquid water, liquid water and water vapor are two different states of the same substance.

QUESTION SET 1.3

THE SMALLEST PIECES OF WATER

1. Molecules
   Atoms (2 hydrogen atoms and 1 oxygen atom).

2.

3. Any illustration, like the one below, that shows the dust particle as much bigger than the water molecules is inappropriate.

4. The arrows should show water molecules moving in all directions, sometimes colliding with each other.

5. No. Water molecules in ice are moving more slowly than water molecules in water, but they continue to move all the time. If the ice cube is put in a colder freezer, the molecules will slow down more, but they are always moving.

   (Students sometimes think that molecules of ice are not moving because ice is so hard. This is not true: ice molecules are constantly vibrating. This is a difficult idea to grasp, but it will come up again in Lesson Cluster 7 on melting and solidifying.)

QUESTION SET 1.4

MOLECULES AND THE THREE STATES OF WATER

1. Ice, liquid water, and water vapor all consist of the same kind of molecules--water molecules.

2. Water molecules in ice are locked in a rigid pattern, vibrate in their places, but do not move past each other.

   Water molecules in liquid water slide and bump past each other.

   Water molecules in water vapor move freely and have much greater spaces between them than either ice or liquid water.

3. No. When water freezes, the molecules themselves do not change. As water is cooled the molecules slow down and move into a rigid array or pattern and vibrate in place.

   (The property of coldness actually indicates that the molecules are moving slowly, not that they themselves are cold. Hardness indicates that the molecules are locked in a rigid array, not that they themselves have become harder.)

4. No. All water is made of water molecules.

   (The molecules are close together, but there is some space between molecules of liquids. Spaces between the molecules are empty. There is nothing in these spaces. This is a difficult idea for some students, especially those who have the naive conception that molecules are like pieces of dust or little germs in air, or bacteria or dirt in water.)

5. No. The bubbles of boiling water are water vapor and water vapor consists of water molecules only.

   (Many students get confused between boiling water and the dissolved air that comes out of water when the water is first heated. When you first start heating a container of water, tiny bubbles form on the inside surface of the container. These are air bubbles from the dissolved air in water. But the bubbles in boiling water are water vapor or steam.)