PROCEDURE

In this experiment you will monitor the volume of water in a glass bottle as the temperature changes. The experimental procedure involves some details and, therefore, it is recommended that you read the procedure carefully before attempting it. Make sure you have all the items required and that you understand the steps involved. If you have any question or concern, contact your tutor.

Do not forget to take pictures at different stages of the experiment.

1. Fill the glass bottle with colored tap water. It is important that the bottle and the water inside are at room temperature when you start the experiment. The coloring (such as food coloring) improves the visibility of the water column as it rises in the pipette. Note that juice and soft drinks may not be suitable due to their sugar content. Pic 1 shows a bottle filled with tea (without sugar).
2. Insert the pipette into one of the holes in the cork, which should hold it tightly. Note that the pipette need not extend more than two centimeters below the cork (see Pic 2).
3. Print the file named **paper_ruler**, making sure it is not re-scaled during printing. To do that, select **Print** from the file menu and then, for the page scaling option, select **None**. Cut a strip of the printed page. Close the bottle tightly with the cork being careful not to trap air inside. Glue the ruler strip to the pipette with the zero mark at the bottom as in Pic 3.
4. Push the stainless steel rod of the temperature sensor through the other hole in the cork (see Pic 4). You should see the water rise in the pipette as it is displaced by the rod (see Pic 5). At this stage examine the cork carefully from all sides to make sure there is no water leak from anywhere.
5. Place the bottle in an empty bowl. Connect the other end of the temperature sensor to the USB port in your computer and start the **Logger Pro** program. The temperature on the screen should be near room temperature (see Pic 6). Record this temperature (in the table below) under the name T_0. Also record the water level in the pipette under the name h_0.
6. Prepare enough quantity of crushed ice that can fill the bowl. If you do not have an ice machine at home, you can get a bag of ice from a local convenience store. Add a small layer of ice around the bottom of the bottle and sprinkle salt generously on top of the ice. Add a second layer of ice and, again, sprinkle salt on top. Continue adding alternate layers of ice and salt until the bowl is completely full with ice and salt mixture. Make sure that the cork and the upper portion of the bottle neck stay above the ice (see Pic 7) and remain dry. The added salt helps to reduce the temperature of the ice-salt mixture to below the normal freezing temperature.
7. Observe the temperature on your computer screen, which should start to drop slowly. Your goal is to reach 0°C. Note that the water temperature inside the bottle may reach one or two degrees below zero (see Pic 8). This is called

supercooling! If this happens avoid shaking the bottle to avoid instant freezing of the water inside.

8. Slowly, take the bottle out before any of the water inside freezes. Dry the surface of the bottle and place it (very gently) on the table under room temperature (see Pic 9). Immediately after that, record (in the table below) the temperature and the water height in the pipette. Keep observing the pipette and record the temperature for every change of 1 mm in the water level. Continue taking measurements until the water temperature rises to about 15°C.
9. To continue taking measurements at higher temperatures place the bottle in a bowl filled with warm water (temperature about 30°C) as in Pic 10. You may notice a small (and almost instant) decrease in the water level before it starts to rise again! Can you explain why? Continue taking measurements as before but this time at 5 mm intervals until the temperature stops rising or if the water reaches the top of the pipette.
10. Before you finish the experiment, there are two important measurements that you need to make, which are needed later in the analysis. The first one is to measure the volume of the water inside the bottle, at room temperature. To do that, carefully pull the temperature probe from the cork and then remove the cork. Make sure that you do not spell any water from the bottle. Then use the graduated cylinders to accurately measure the water volume inside the bottle. Call this value V_0 and record it in the table below.
11. The second measurement you will need is the volume of the cross-sectional area of the water column in the pipette. This can be calculated using volume marks on the pipette. For example, the pipette in Pic 11 has a volume of 0.10 mL per 1.5 cm of length, which corresponds to a cross-sectional area of 0.067 cm^2. Note that 1 mL = 1 cm^3.

Experiment 2 Data

A (cm^2)	=
V_0 (cm^3)	=
T_0 (°C)	=
h_0 (cm)	=

T **(°C)**	***h*** **(cm)**	***T*** **(°C)**	***h*** **(cm)**	***T*** **(°C)**	***h*** **(cm)**