Experiment
2

Freezing and Melting of Water

Freezing temperature, the temperature at which a substance turns from liquid to solid, and melting temperature, the temperature at which a substance turns from a solid to a liquid, are characteristic physical properties. In this experiment, the cooling and warming behavior of a familiar substance, water, will be investigated. By examining graphs of the data, the freezing and melting temperatures of water will be determined and compared.

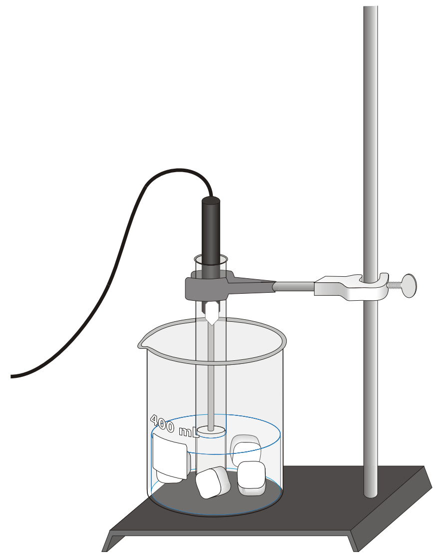

Figure 1

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator	400 mL beaker
EasyData application	10 mL graduated cylinder
Temperature Probe and data-collection interface	test tube
or EasyTemp	salt
ring stand	ice
utility clamp	water

PROCEDURE

Part I Freezing

1. Put about 100 mL of water and 6 ice cubes into a 400 mL beaker.

2. Put 5 mL of water into a test tube and use a utility clamp to fasten the test tube to a ring stand. The test tube should be situated above the water bath. Place the Temperature Probe into the water inside the test tube.

3. Turn on the calculator. Connect the Temperature Probe, data-collection interface, and calculator. (If you are using an EasyTemp, you do not need a data-collection interface.)

4. Set up EasyData for data collection.
   a. Start EasyData if it is not already running.
   b. Select File from the Main screen, and then select **New** to reset the application.
   c. Select Setup from the Main screen, then select **Time Graph…**
   d. Select Edit on the Time Graph Settings screen.
   e. Enter **10** as the time between samples in seconds.
   f. Select Next.
   g. Enter **90** as the number of samples and select Next (data will be collected for 15 minutes).
   h. Select OK to return to the Main screen.

5. When everything is ready, select Start to begin collecting data. Lower the test tube into the ice-water bath.

6. Soon after lowering the test tube, add 5 spoons of salt to the beaker and stir with a stirring rod. Continue to stir the ice-water bath throughout the remainder of Part I.

7. Slightly, but continuously, move the Temperature Probe during the first 10 minutes of Part I. Be careful to keep the probe in, and not above, the ice as it forms. When 10 minutes have gone by, stop moving the probe and allow it to freeze into the ice. Add more ice cubes to the beaker as the original ice cubes get smaller.

8. Data collection will stop after 15 minutes. Keep the test tube *submerged* in the ice-water bath until Step 11.

9. Analyze the flat part of the graph to determine the freezing temperature of water. To do this:
   a. Select Anlyz, and then select **Statistics…**
   b. Use ▶ and ◀ to move the cursor to the beginning of the flat section of the curve. Select OK to set the left boundary of the flat section.
   c. Move the cursor to the end of the flat section of the graph, and select OK to set the right boundary of the flat section. The program will now calculate and display the statistics for the data between the two boundaries.
   d. Record the mean value as the freezing temperature in your data table (round to the nearest 0.1°C).
   e. Select OK, then Main to return to the Main screen.

10. Store the data from the first run so that it can be used later. To do this:
    a. Select File, and then select **Store Run**.
    b. Select OK to store your latest data and overwrite the data in Lists 3 and 4 (L3 and L4).

Part II Melting

11. Select Start, then OK to begin data collection (the stored data will not be overwritten). Then raise the test tube and fasten it in a position above the ice-water bath. Do not move the Temperature Probe during Part II.

12. Dispose of the ice water as directed by your teacher. Obtain 250 mL of warm tap water in the beaker. When 12 minutes have passed, lower the test tube and its contents into this warm-water bath.

13. Data collection will stop after 15 minutes. Analyze the flat part of the graph to determine the melting temperature of water. To do this:
    a. Select Anlyz, and then select **Statistics…**
    b. Use ▶ and ◀ to move the cursor to the beginning of the flat section of the curve. Select OK to set the left boundary of the flat section.
    c. Move the cursor to the end of the flat section of the graph, and select OK to set the right boundary of the flat section. The program will now calculate and display the statistics for the data between the two boundaries.
    d. Record the mean value as the freezing temperature in your data table (round to the nearest 0.1°C).
    e. Select OK to return to the Graph screen.
14. A good way to compare the freezing and melting curves is to view both sets of data on one graph.
    a. Select Adv, then select **L2 and L3 vs L1**.
    b. Both temperature runs should now be displayed on the same graph. Each point of Part I (freezing) is plotted with a square, and each point of Part II (melting) is plotted without a marker.
15. Print a graph of temperature *vs*. time (with two curves displayed). Label each curve as "freezing of water" or "melting of ice."

DATA TABLE

Freezing temperature of water	°C
Melting temperature of water	°C

PROCESSING THE DATA

1. What happened to the water temperature during freezing? During melting?
2. According to your data and graph, what is the freezing temperature of water? The melting temperature? Express your answers to the nearest 0.1°C.
3. How does the freezing temperature of water compare to its melting temperature?
4. Tell if the *kinetic energy* of the water in the test tube increases, decreases, or remains the same in each of these time segments during the experiment when:
    a. the temperature is changing at the beginning and end of Part I
    b. the temperature remains constant in Part I
    c. the temperature is changing at the beginning and end of Part II
    d. the temperature remains constant in Part II
5. In those parts of Question 4 in which there was no kinetic energy change, tell if *potential energy* increased or decreased.