Experiment
3

Freezing and Melting of Water

Freezing temperature is the temperature at which a substance turns from a liquid to a solid. Melting temperature is the temperature at which a substance turns from a solid to a liquid. Freezing temperature and melting temperature are characteristic properties. In this experiment, you will determine and compare the freezing and melting temperatures of water.

OBJECTIVES

In this experiment, you will

- Use a computer to measure temperature.
- Analyze graphs of your data to determine the freezing and melting temperatures of water.
- Determine the relationship between the freezing and melting temperatures of water.
- Apply the concepts studied in a new situation.

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Vernier Temperature Probe
ring stand
utility clamp
one test tube
400 mL beaker
water
10 mL graduated cylinder
ice
salt
spoon

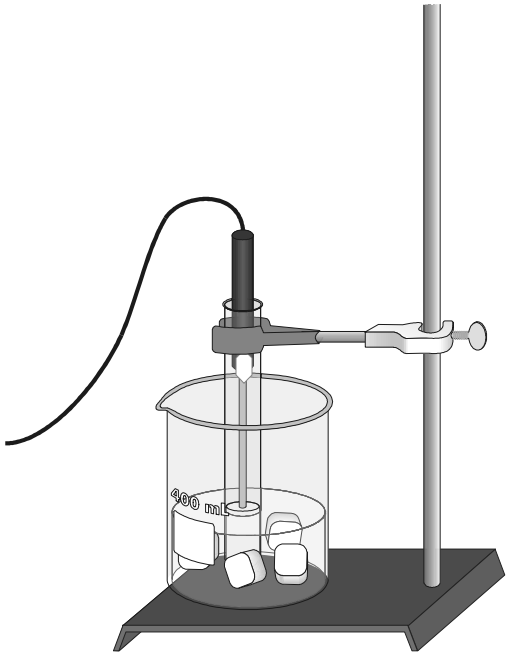


Figure 1

PROCEDURE

Part I Freezing

1. Fill a 400 mL beaker 1/3 full with ice, then add 100 mL of water.

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 clamped above the water bath. Place the Temperature Probe into the water inside the test tube.

3. Connect the Temperature Probe to the computer interface. Prepare the computer for data collection by opening the file "03 Freezing and Melting" from the *Physical Science w Computers* folder.

4. When everything is ready, click Collect to begin data collection. Then lower the test tube into the ice-water bath.

5. Soon after lowering the test tube, add 5 spoons of salt to the beaker and stir with a spoon. Continue to stir the ice-water bath during Part I.

6. Slightly, but continuously, move the 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 ice-water bath as the original ice cubes get smaller.

7. When 15 minutes have passed, data collection will stop. Keep the test tube *submerged* in the ice-water bath until Step 10.

8. On the displayed graph, analyze the flat part of the curve to determine the freezing temperature of water:
   - Move the mouse pointer to the beginning of the graph's flat part. Press the mouse button and hold it down as you drag across the flat part to *select* it.
   - Click on the Statistics button, . The mean temperature value for the selected data is listed in the statistics box on the graph. Record this value as the freezing temperature in your data table.
   - Remove the statistics box.

Part II Melting

9. Store your data by choosing Store Latest Run from the Experiment menu. This stores the data so it can be used later. To hide the curve of your first data run, click the Temperature vertical-axis label of the graph, click on More, and uncheck Run 1 Temperature. Click OK.

10. Click Collect to begin data collection. 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.

11. 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.

12. When 15 minutes have passed, data collection will stop.

13. On the displayed graph, analyze the flat part of the curve to determine the melting temperature of water:
    - Move the mouse pointer to the beginning of the graph's flat part. Press the mouse button and hold it down as you drag across the flat part to *select* it.
    - Click the Statistics button, . The mean temperature value for the selected data is listed in the statistics box on the graph. Record this value as the melting temperature in your data table.
    - To remove the statistics box, click on the upper-right corner of the box.

14. Print a graph of temperature *vs*. time showing both data runs:
    - Click the Temperature vertical-axis label of the graph. To display both temperature runs, click on More, and check the Run 1 and Latest Temperature boxes. Click OK.
    - Label both curves by choosing Text Annotation from the Insert menu, and typing "Freezing Curve" (or "Melting Curve") in the edit box. Then drag each box and its arrow to clearly identify each curve.
    - Print copies of the graph as directed by your teacher.

OBSERVATIONS

DATA

Freezing temperature of water sample _____ °C

Melting temperature of water sample _____ °C

PROCESSING THE DATA

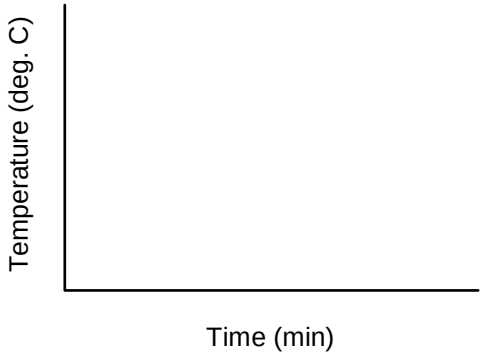
1. What happened to the water temperature during freezing? During melting?

2. According to your data and graph, what is the freezing temperature of water? The melting temperature?

3. How does the freezing temperature of water compare to its melting temperature?

4. Phenyl salicylate has a freezing temperature of 41.5°C. In the space to the right, sketch and label a freezing curve for phenyl salicylate. Be sure to indicate the freezing temperature on the graph.

5. Using another color, draw a melting curve for phenyl salicylate on the same graph. Indicate the melting temperature on the curve.



EXTENSION

1. Modify the procedure to study the freezing and melting temperatures of another substance suggested by your teacher.

TEACHER INFORMATION

Freezing and Melting of Water

1. This entire experiment requires a full 45–50 minute period. Students should have done Experiments 1 and 2 before this one. Be sure to prelab this experiment well, especially if it is one of the first computer-interfaced experiments to be done by your students. As the Sample Results below show, this procedure can give excellent results.

2. The stored calibration for the Stainless Steel Temperature Probe or Direct-Connect Probe works well for this experiment—the freezing and melting temperatures of water should be within ± 0.2°C of 0°C using these calibrations.

3. Size 20 × 150 mm test tubes work well. Sizes 25 × 150 mm and 18× 150 mm work, too.

4. A water sample size of 5 mL works well. Larger samples will take more time than is provided in this procedure.

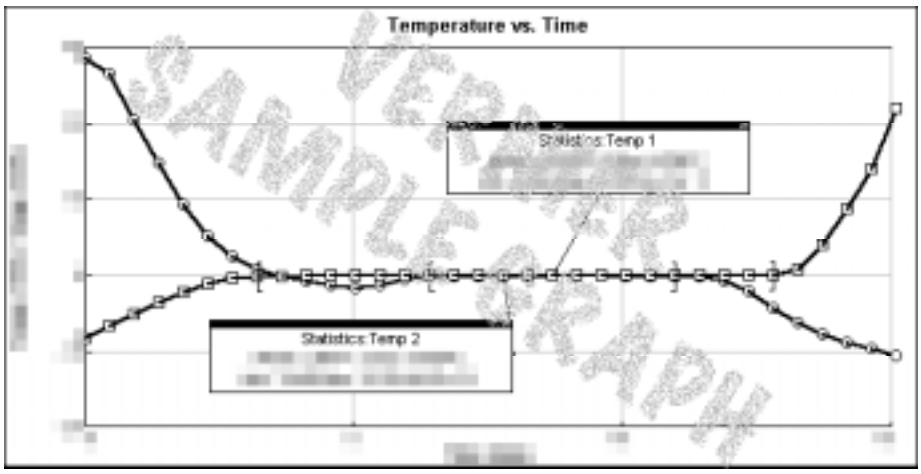
5. As it is written, this experiment directs students to print graphs. If you prefer to have your students graph "by hand," instruct them to record data from the table at half-minute intervals for this purpose.

6. Some possible substances for use in a modified version of this experiment are:

   Palmitic acid (Hexadecanoic acid) (m.p. = 63°C)
   Lauric acid (Dodecanoic acid) (m.p. = 44°C)
   tert-Butanol (2-Methyl-2-Propanol) (m.p. = 25.5°C)

7. Stirring during Part I gives more constant freezing temperature readings and delays the drop of temperature below freezing temperature. No stirring, in contrast, gives more constant temperature readings during Part II.

SAMPLE RESULTS



Freezing and Melting of Water

ANSWERS TO QUESTIONS

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.