

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 situated above the water bath. Place a Temperature Probe into the water inside the test tube.
3. Plug the Temperature Probe into Channel 1 of the LabPro interface. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.
4. Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap **[New]** to reset the program.
5. Set up the handheld and interface for the correct Temperature Probe.
 - a. On the Main screen, tap **[Setup]**.
 - b. If the handheld displays TEMP(C) in CH 1, proceed directly to Step 6. If it does not, continue with this step to set up your sensor manually.
 - c. Tap **[CH1:]** to select Channel 1.
 - d. Press the Scroll buttons on the handheld to scroll through the list of sensors.
 - e. Select the correct Temperature Probe (in °C) from the list of sensors.
6. Setup the handheld and interface for data collection.
 - a. While still on the Setup screen, tap **[Settings:]**.
 - b. Enter “30” as the time between samples in seconds, using the onscreen keyboard (tap “123”) or using the Graffiti writing area.
 - c. Enter “30” as the number of samples. (Data will be collected for 15 minutes.)
 - d. Tap **[OK]** twice to return to the Main screen.
7. When everything is ready, tap **[Start]** to begin data collection. Note: It will take 30 seconds for the graph to appear with the first data point plotted.
8. When the first data point appears on the screen, lower the test tube into the ice-water bath.
9. 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 during Part I.
10. 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 beaker as the original ice cubes get smaller.
11. Data collection will stop after 15 minutes. **IMPORTANT:** Keep the test tube *submerged* in the ice-water bath until Step 14 below.
12. When data collection is complete, a graph of temperature vs. time will be displayed. To examine the data pairs on the displayed graph, tap **[▶]** or any data point. As you move the

examine line, the temperature values of each data point are displayed to the right of the graph. Record the temperature values in your data table (round to the nearest 0.1°C).

13. (Optional) Print a graph of temperature vs. time.

Part II Melting

14. Tap to collect another set of data.
15. Raise the test tube and fasten it in a position above the ice-water bath. Do not move the Temperature Probe during Part II.
16. 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.
17. When data collection is complete, a graph of temperature vs. time will be displayed. To examine the data pairs on the displayed graph, tap or any data point. As you move the examine line, the temperature values of each data point are displayed to the right of the graph. Record the temperature values in your data table (round to the nearest 0.1°C).
18. (Optional) Print a graph of temperature vs. time.

DATA

Part I Freezing

Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)
0	_____	240	_____	480	_____	720	_____
30	_____	270	_____	510	_____	750	_____
60	_____	300	_____	540	_____	780	_____
90	_____	330	_____	570	_____	810	_____
120	_____	360	_____	600	_____	840	_____
150	_____	390	_____	630	_____	870	_____
180	_____	420	_____	660	_____	900	_____
210	_____	450	_____	690	_____		

Part II Melting

Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)
0	_____	240	_____	480	_____	720	_____
30	_____	270	_____	510	_____	750	_____
60	_____	300	_____	540	_____	780	_____
90	_____	330	_____	570	_____	810	_____
120	_____	360	_____	600	_____	840	_____
150	_____	390	_____	630	_____	870	_____
180	_____	420	_____	660	_____	900	_____
210	_____	450	_____	690	_____		

OBSERVATIONS

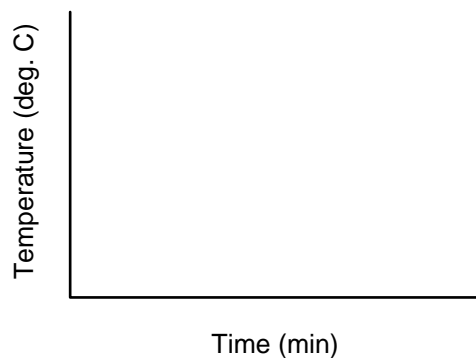
PROCESSING THE DATA

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.



EXTENSIONS

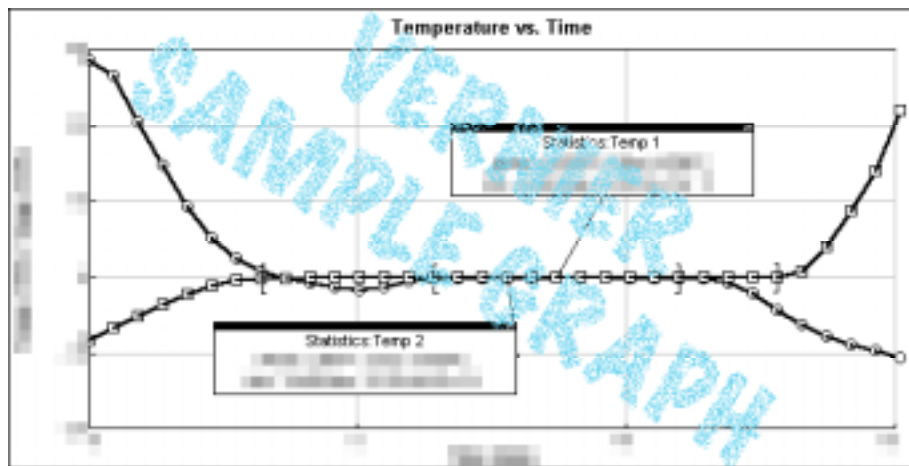
1. Explore the graphing capabilities of the handheld and display both the melting and freezing curves on the same graph.
2. Modify the procedure to study the freezing and melting temperatures of another substance suggested by your teacher.

TEACHER INFORMATION

Freezing and Melting of Water

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. 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.
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.