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 of a pure substance. In this experiment, you will determine and compare the freezing and melting temperatures of water.

OBJECTIVES

In this experiment, you will

- Measure temperature.
- Record data.
- Make a graph of the data.
- Analyze your data and graphs 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

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

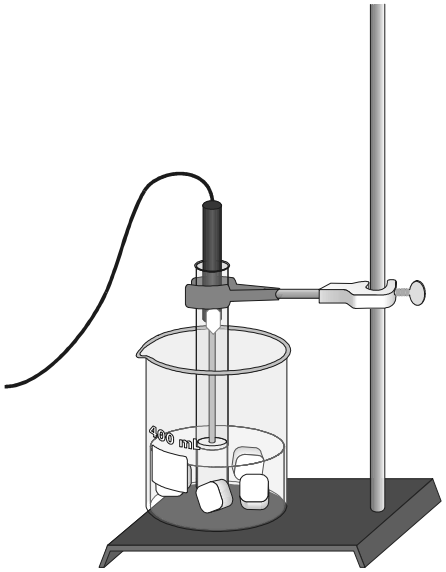


Figure 1

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

3. Turn on the calculator. Connect the Temperature Probe to the calculator. (This may require the use of a data-collection interface.)

4. Set up EasyData for data collection.
   a. Start the EasyData application, 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. Enter **30** as the time between samples in seconds.
   e. Select [Next].
   f. Enter **30** as the number of samples and select [Next]. Data collection will last 15 minutes.
   g. Select [OK] to return to the Main screen.

5. When everything is ready, select [Start] to begin data collection. **Note**: It will take 30 seconds for the graph to appear with the first data point plotted.

6. When a graph appears on the calculator screen, lower the test tube into the ice-water bath.

7. 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.

8. 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.

9. Data collection will stop after 15 minutes. **IMPORTANT:** Keep the test tube *submerged* in the ice-water bath until Step 14 below.

10. When data collection is complete, a graph of temperature *vs*. time will be displayed. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed above the graph. Record the temperature values in your data table (round to the nearest 0.1°C).

11. (Optional) Print a graph of temperature *vs*. time.

12. Select [Main] to return to the Main screen.

Part II Melting

13. Select [Start] and then [OK] to overwrite the latest run and collect another set of data.

14. Raise the test tube and fasten it in a position above the ice-water bath. Do not move the Temperature Probe during Part II.

15. 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.

16. When data collection is complete, a graph of temperature *vs*. time will be displayed. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed above the graph. Record the temperature values (round to the nearest 0.1°C).

17. (Optional) Print a graph of temperature *vs*. time.

18. Select Main to return to the Main screen.

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

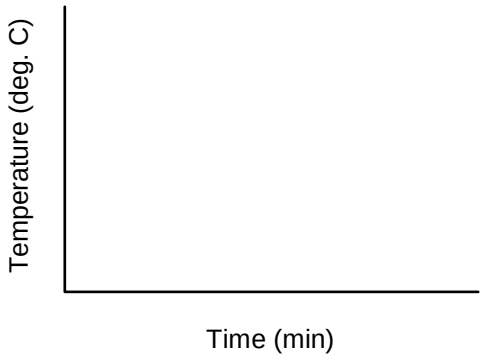
1. What happened to the water temperature during freezing? During melting?

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 calculator 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. There are several different combinations of equipment that will work for collecting temperature data. The most common method, which uses the USB port on a TI-84 Plus calculator, is to collect data with an EasyTemp or with a Temperature Probe connected to an EasyLink. For more information on EasyTemp and EasyLink refer to *Appendix G*.

   The other method, which works for both the TI-83 Plus and TI-84 Plus families of calculators, is to use a Temperature Probe attached to a LabPro or CBL 2.

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 *Physical Science with Calculators* experiments to be done by your students. As the Sample Results on the next page show, this procedure can give excellent results.

3. The stored calibration for all the different types of Temperature Probes works well for this experiment—the freezing and melting temperatures of water should be within ± 0.2°C of 0°C using these calibrations.

4. Size 20 X 150 mm test tubes work well. Sizes 25 X 150 mm and 18 X 150 mm work, too.

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

6. We suggest that you have a computer with a printer setup with the TI Connect software and a TI Connectivity cable or a TI unit-to-computer cable for the graph printing. In *Appendix B*, you will find instructions for using Macintosh and Windows versions of TI Connect to transfer and print graphs.

7. Graphing data by hand is an alternative to the graph printing procedure outlined above.

8. As a third alternative, you may elect to use Vernier Logger *Pro* software (for Macintosh or Windows) along with a TI Connectivity cable or a TI unit-to-computer cable. Logger *Pro* software has a file option for importing data lists from all of the TI graphing calculators supported in this book (TI-83, TI-83 Plus, TI-84, and TI-84 Plus). See *Appendix D* for more information about using Logger *Pro* with TI graphing calculators.

9. 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)

10. 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.

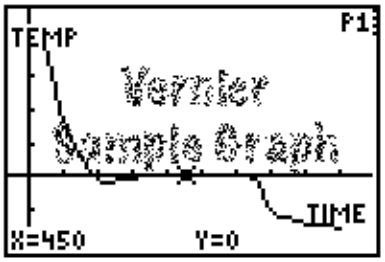
11. As shown in the first graph in the Sample Results, many of the samples will supercool. Stirring will bring the super-cooled water to the melting temperature plateau.

ANSWERS TO QUESTIONS

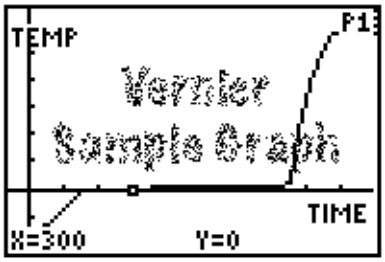
Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.

SAMPLE RESULTS

Time (s)	Temperature Part I (°C)	Temperature Part II (°C)	Time (s)	Temperature Part I (°C)	Temperature Part II (°C)



Part I: Freezing Water



Part II: Melting of Water