

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 use an EasyTemp temperature probe to determine and compare the freezing and melting temperatures of water.

OBJECTIVES

In this experiment, you will

- Use an EasyTemp probe to 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-84 Plus or TI-84 Plus Silver Edition
graphing calculator
Vernier EasyTemp
Vernier EasyData application
ring stand
utility clamp
test tube

400 mL beaker
water
10 mL graduated cylinder
ice
salt
stirring rod

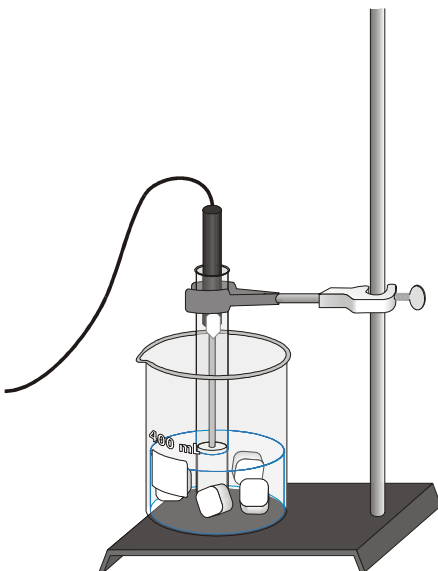


Figure 1





PROCEDURE

Part I Freezing

1. Fill a 400 mL beaker 1/3 full with ice, then add 100 mL of water.
2. Turn on your TI-84 Plus (or TI-84 Plus Silver Edition) graphing calculator and make sure that it is on the home screen. Plug the EasyTemp probe into the USB port of the graphing calculator. The EasyData application will automatically start and the Main screen will be displayed.
3. 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 EasyTemp probe into the water inside the test tube.
4. Set up the data collection.
 - a. Select $\overline{\text{F2}} \text{ (F1)}$ from the Main screen, and then select **New**.
 - b. Select $\overline{\text{F2}} \text{ (SETUP)}$ from the Main screen.
 - c. Select **Time Graph....**
 - d. Select $\overline{\text{F1}} \text{ (EDIT)}$.
 - e. Press $\overline{\text{CLEAR}}$ on the calculator and type **10** as the time between samples in seconds. Select $\overline{\text{F2}} \text{ (NEXT)}$.
 - f. Press $\overline{\text{CLEAR}}$ on the calculator and type **10** as the number of samples. Select $\overline{\text{F2}} \text{ (NEXT)}$. The length of the data collection will be 900 seconds (15 minutes).
 - g. Confirm that time graph settings are correct. Select $\overline{\text{F1}} \text{ (OK)}$.
5. When everything is ready, select $\overline{\text{F2}} \text{ (START)}$ to begin data collection, and then 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 during Part I.
7. 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.
8. Data collection will stop after 15 minutes. **IMPORTANT:** Keep the test tube *submerged* in the ice-water bath until Step 12 below.
9. When data collection is complete, a graph of temperature vs. time will be displayed. Use $\overline{\text{D}}$ to examine the data points along the curve. As you move the cursor, the time (X) and temperature (Y) values of each data point are displayed above the graph. Record the temperature readings in your data table. Note that the data table is set up for 30 second intervals.
10. Select $\overline{\text{F1}} \text{ (MAIN)}$ to return to the Main screen.

Part II Melting

11. Select $\overline{\text{F2}} \text{ (START)}$ to collect another set of data.

12. Raise the test tube and fasten it in a position above the ice-water bath. Do not move the EasyTemp probe during Part II.
13. 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.
14. When data collection is complete, a graph of temperature vs. time will be displayed. Use  to examine the data points along the curve. As you move the cursor, the time (X) and temperature (Y) values of each data point are displayed above the graph. Record the temperature readings in your data table. Note that the data table is set up for 30 second intervals.
15. Select  to return to the Main screen. Select  from the Main screen. Select  to exit the EasyData application.

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	_____		

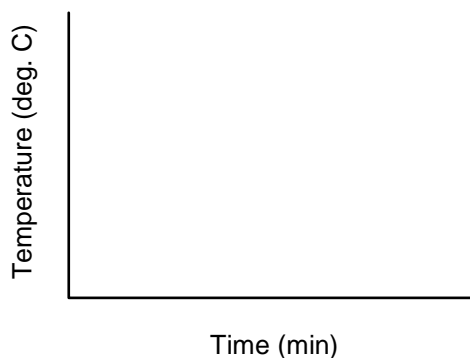
Part II Melting

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.