Freezing and Melting of Water

Name _____

Class _____

In this activity, you will explore the following:

- *the shapes of graphs of temperature vs. time for freezing and melting*
- *the relationship between freezing point and melting point*
- *the change in temperature during a phase change*

Freezing temperature, the temperature at which a substance turns from liquid to solid, and melting temperature, the temperature at which a substance turns from solid to liquid, are characteristic physical properties. In this experiment, you will investigate the cooling and warming behavior of a familiar substance, water. By examining graphs of temperature vs. time, you will determine and compare the freezing and melting temperatures of water.

Part 1 – Preliminary Questions

Step 1: Open the file **05_FreezingMelting.tns** and read the first two pages. Then, answer questions 1–3 using your current knowledge about melting and freezing.

Q1. How is the freezing point of water related to the melting point?
- o Freezing point is higher than melting point.
- o Freezing point is lower than melting point.
- o Freezing point is equal to melting point.
- o The relationship depends on pressure.

Q2. How does the temperature of water change as it freezes?
- o It increases.
- o It decreases.
- o It remains the same.
- o It decreases, then increases.

Q3. What happens to the kinetic and potential energy of water molecules when ice melts?
- o Potential energy increases, and kinetic energy decreases.
- o Potential energy decreases, and kinetic energy remains the same.
- o Potential energy increases, and kinetic energy remains the same.
- o Potential energy decreases, and kinetic energy increases.

Part 2 – Freezing Point

Step 1: Put about 100 mL of water and about 12 chunks of ice into a 400 mL beaker.

Step 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 end of the EasyTemp temperature probe into the water inside the test tube.

Step 3: Move to page 1.6 in the .tns file. Plug the EasyTemp probe into the TI-Nspire.

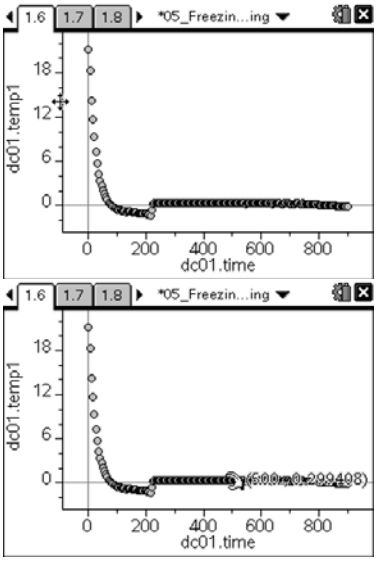
Step 4: A data collection window should appear. Set up the collection to produce a time graph (**Menu > Experiment > Set Up Collection > Time Graph**). Change the time between samples to 5 seconds and the experiment length to 900 seconds. Choose OK to exit the setup screen.

Step 5: Start the data collection. Lower the test tube into the ice water in the beaker. Make sure the opening of the test tube remains above the surface of the water.

Step 6: Add 5 spoonfuls of salt to the ice water in the beaker. Stir the ice-salt-water mixture with a stirring rod. Keep stirring during the entire data collection. Make sure none of the salt gets into the test tube. If necessary, add more ice cubes to the beaker as the other ice cubes melt. Make sure there are always at least three ice cubes in the water.

Step 7: Slowly stir the water in the test tube with the temperature probe during the first 10 minutes of sampling. 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.

Step 8: Data collection will stop after 15 minutes. Keep the test tube in the ice water bath, and leave the temperature probe in the test tube for Part 3.



Step 9: Study the graph of temperature vs. time on page 1.6. Analyze the graph to determine the freezing temperature for the water. To determine the freezing temperature, first identify the flat portion of the graph that represents the freezing of the water around the temperature probe. Click and hold a data point to see the data pair for the point. Repeat this procedure for several data points until you have identified the average temperature.

Step 10: Record the average freezing temperature in the FP row in the data table on page 1.7, in the column for trial 1.

Part 3 – Melting Point

Step 1: Restart the data collection. You will be prompted to save or discard the previous run. Choose **Store** and click on OK.

Step 2: Once data collection has begun, raise the test tube out of the beaker and fasten it so that it is completely out of the ice water. Do not move the temperature probe.

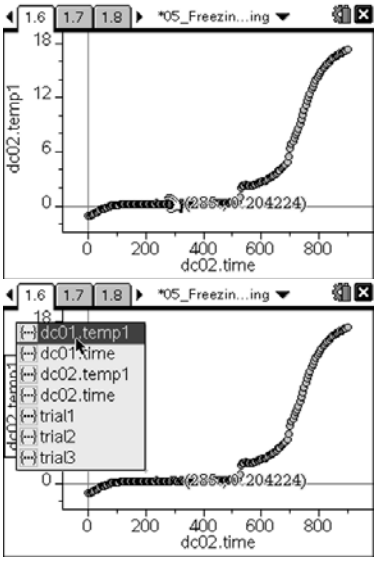
Step 3: Dispose of the ice water in the beaker as directed by your teacher. Rinse the beaker, and then put 250 mL of warm tap water in the beaker.

Step 4: After data collection has continued for 12 minutes, lower the test tube into the warm water. Make sure the opening of the test tube remains above the surface of the water.

Step 5: Data collection will stop after 15 minutes. Study the graph of temperature vs. time on page 1.6. Analyze the graph to determine the melting temperature for the water. Use the same procedure that you used in Part 2, Step 9.

Step 6: Record the melting point of the water in the MP row in the data table on page 1.7, in the column for trial 1.

Step 7: You can compare the melting and freezing point data sets by plotting them both on the same graph. To do this, move to the *Data & Statistics* application on page 1.6. It should already show the graph of temperature vs. time for the melting process. To add the data for the freezing process, add a new *y* variable (**Menu > Plot Properties > Add Y Variable**). Choose the data set **dc01.temp1**. Both data sets should now be displayed.



Step 8: Repeat Parts 1 and 2 twice more. Record the average freezing and melting temperatures in the data table on page 1.7, in the columns for trial 2 and trial 3. Then, answer questions 4–12.

Q4. According to your data, what is the freezing temperature of water?

Q5. According to your data, what is the melting temperature of ice?

Q6. What happened to the water temperature during the portion of the cooling curve where freezing took place?

Q7. What happened to the water temperature during the portion of the heating curve where melting took place?

Q8. According to your data, how do the freezing point and melting point of water compare?

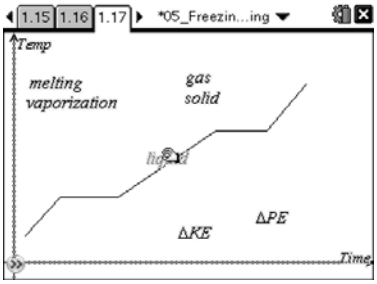
Q9. What happens to the kinetic energy of the water molecules in the test tube during Part 2?

Q10. What happens to the kinetic energy of the water molecules in the test tube as the temperature of the water rises?

Q11. What happens to the kinetic energy of the water molecules when the temperature of the water remains constant?

Q12. In general, what happens to the temperature of a substance during a phase change?

Step 9: Page 1.17 shows a heating curve for water. Drag the labels to the correct portions of the curve. Then, use the **Vector** tool (**Menu > Points & Lines > Vector**) to indicate where on the curve kinetic energy and potential energy are changing.



Step 10: Repeat Step 9 for the cooling curve on page 1.18.