Name ________________________________

6. Viscosity is a property described as a measure of the resistance of a liquid to flow. This resistance is affected by the same intermolecular forces as is surface tension. Which of the liquids you tested for surface tension in Part B of this investigation do you predict will exhibit the greatest relative viscosity and the least relative viscosity? *(Making predictions)* ________________________________

____

____

Going Further

1. Investigate the effect of temperature on the surface tension of a liquid. First, hypothesize how varying the temperature of a liquid might affect its surface tension. Then design an experiment to test your hypothesis, taking into consideration any safety precautions you must follow. Under the supervision of your teacher, perform the experiment and present your findings to the class.

Name ____________________ Date __________ Class __________

Changes of State

Lab 41

Text reference: ***Chapter 14***

Introduction

Think about a hot summer day when you have had a glass of water served with ice. You may have noticed that although the ice cubes melted slowly and steadily, your drink remained cold as long as ice was present in the glass. Only after the ice was completely melted, did the liquid begin to warm up. The reason the water stayed cold while the ice cubes melted has to do with the manner in which pure substances undergo physical changes related to temperature.

Matter can exist in one of three physical states—solid, liquid, or gas. For a pure substance, changes in state (also called phase changes) occur at a definite temperature, which is characteristic of that substance. Water, for example, changes from a solid to a liquid at 0°C. In comparison, sodium chloride liquefies at 801°C, and mercury at just under −39°C.

In a crystalline solid, the particles—either atoms, ions, or molecules—are arranged in an orderly, repeating, three-dimensional pattern. These particles vibrate and rotate around fixed positions. As the solid is heated, the kinetic energy of the particles increases, and the vibrations become more intense. Eventually, at some temperature, which is called the melting point, the vibrations become strong enough to overcome the forces of attraction holding the particles of the solid together, and the solid changes to a liquid. Once this melting begins, if the solid is pure, the temperature remains constant until the entire sample becomes a liquid. Further heating will raise the temperature of the liquid.

When a liquid is cooled, the reverse process occurs. The temperature of the liquid decreases until the freezing point is reached. Only after the liquid is completely changed to a solid will the temperature begin to decrease again. The temperature at which a substance changes between solid and liquid is one of the defining physical properties of that substance and may be used to identify it.

In this investigation, you will observe the melting and freezing behavior of lauric acid ($C_{12}H_{24}O_2$). You will measure the temperature at timed intervals as the lauric acid is heated and cooled and determine experimentally its freezing point and melting point.

Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. Define melting point and freezing point. ________________________________

____

____

Name ______________________

2. Why is it necessary to have two water baths? ______________________

3. Describe what happens to the particles of a solid at its melting point.

4. What two phase changes will you observe in this investigation?

5. What is the greatest safety hazard in this investigation, and what precautions should you take? ______________________

6. Why is it necessary to stir the lauric acid as it is heated or cooled?

Problem

How can you determine the melting point and the freezing point of lauric acid?

Materials

chemical splash goggles
laboratory apron
2 beakers, 400-mL
hot and cold tap water
hot plate
2 thermometers
large test tube
lauric acid ($C_{12}H_{24}O_2$)
test-tube holder
stop watch
2 pens or pencils of different colors

Safety

Wear your goggles and lab apron at all times in the laboratory. Hot plates and heated glassware can cause burns. Avoid touching the hot plate or the heated beaker of water. Handle the heated test tube with a test-tube holder. Note the caution alert symbols here and with certain steps of the Procedure. Refer to page *xi* for the specific precautions associated with each symbol.

Procedure

Part A

1. Put on your goggles and laboratory apron. Construct a data table similar to the one shown, leaving enough lines for about 25 time and temperature readings.

Name ______________________

2. Fill one 400-mL beaker about three-fourths full of tap water and heat it on the hot plate. Use a thermometer to monitor the water's temperature, and adjust the hot plate as needed to keep the temperature constant at about 60°C. **CAUTION:** *Do not touch the hot plate or beaker.*
3. Use hot and cold tap water to fill the second 400-mL beaker three-fourths full of water that is adjusted to a temperature of about 30°C.
4. Obtain a large test tube containing about 15 g of lauric acid from your teacher. Attach a test-tube holder near the top of the test tube and place the test tube in the 60°C water bath, as shown in Figure 41–1.
5. As the solid begins to melt, place a thermometer into the test tube and stir carefully. **CAUTION:** *The thermometer is fragile. Do not bang it against the sides of the test tube or force it through the lauric acid crystals.* Record the approximate temperature at which melting occurs, and continue heating the lauric acid until the temperature is about 10°C higher.
6. Using the test-tube holder, remove the test tube from the 60°C water bath and place it in the 30°C water bath. Make sure that the level of the water in the beaker is above the level of the liquid in the test tube.
7. Gently stir the liquid with the thermometer. When the temperature of the liquid decreases to 55°C, begin taking temperature readings every 30 seconds. (One lab partner should stir and read the thermometer, while the other partner watches the clock and records the temperature readings.) Record the temperature to the nearest 0.2°C.
8. When the sample is mostly solid, stop stirring. Continue to take temperature readings until the temperature of your sample has fallen to about 40°C. Record your findings in the data table.

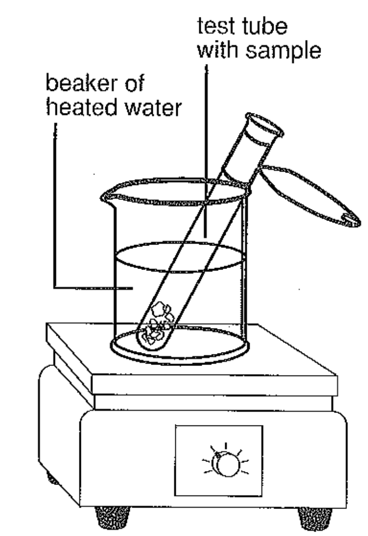

Figure 41–1

Part B

9. Check the temperature of the hot-water bath and adjust it to 60°C if necessary.
10. Remove the test tube from the 30°C water bath and place it in the beaker of water at 60°C. Immediately begin to take temperature readings every 30 seconds. Begin stirring gently as soon as you are able to move the thermometer easily. Continue to measure and record the temperature until the lauric acid is at approximately 50°C.
11. Turn off the hot plate. Carefully remove the thermometer from the sample of lauric acid and return the test tube to your teacher. Pour the water in the beakers down the drain, and clean and dry the thermometers.
12. Clean up your work area and wash your hands before leaving the laboratory.

Name

Observations

Approximate melting point of lauric acid ______

DATA TABLE Freezing and Melting of Lauric Acid

	Part A: Liquid to Solid	Part B: Solid to Liquid
Time (min)	**Temperature (°C)**	**Temperature (°C)**

Critical Thinking: Analysis and Conclusions

1. Make a graph of your data from Part A. Plot time (min) on the horizontal axis and temperature (°C) on the vertical axis. Connect the points in a smooth curve. *(Interpreting data)*
2. Using a pen or pencil of a different color, plot the data from Part B on the same graph. *(Interpreting data)*

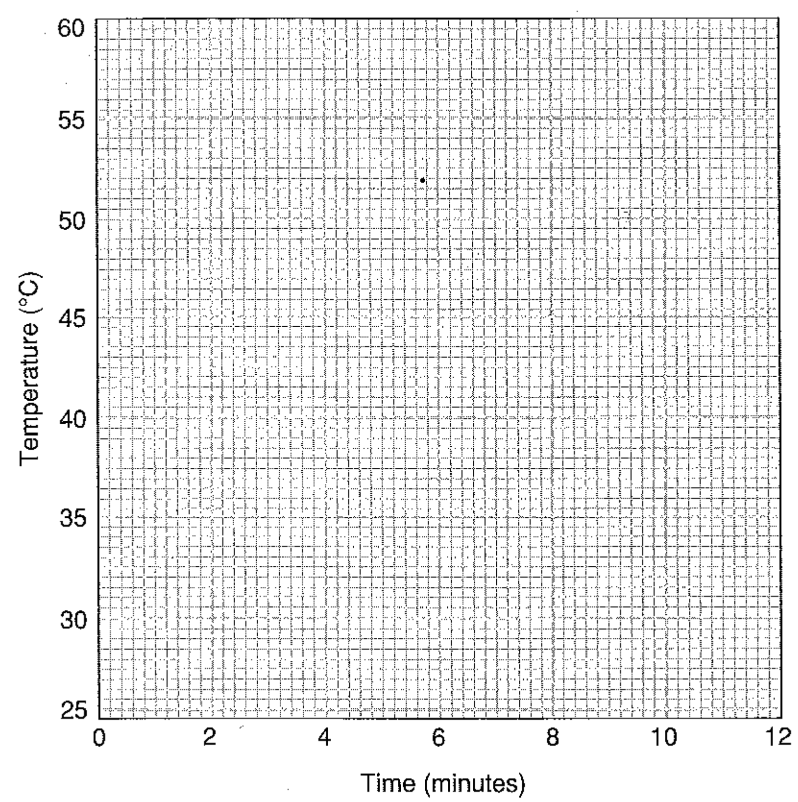

Figure 41–2

Name

3. Using your graph, determine the freezing point and melting point of lauric acid. *(Interpreting diagrams)* ______
4. Does lauric acid freeze and melt at the same temperature? How do you know? *(Drawing conclusions)* ______
5. Explain the shapes of the graphs in terms of energy changes that occur as the lauric acid heats up and melts and as it cools down and freezes. *(Making inferences)* ______
6. Compare the value you obtained for the freezing point of lauric acid with the values obtained by your classmates. Account for any similarities or differences. *(Making comparisons)* ______

Critical Thinking: Applications

1. What effect would increasing the amount of lauric acid have on the melting point? On the shape of the graph? *(Making predictions)* ______
2. Look back at the discussion about the ice water in the Introduction to this investigation. Write a brief paragraph that explains, in terms of temperature and physical changes, what happened to the ice and liquid from the time the glass was first filled until after the ice melted. *(Using the writing process)* ______

Lab 41

Name ____________________

Going Further

1. Find out which freezes faster, hot or cold water. Make a prediction and devise an experiment to be conducted at home that tests your hypothesis. Remember to eliminate all variables except the initial temperature of the water. Report your experimental procedure and explain your results.
2. People tend to think of freezing and boiling in terms of water. Yet, some substances freeze at temperatures hotter than 100°C while others boil at temperatures lower than 0°C. Research the freezing points and boiling points of some elements and familiar compounds, and develop a list of substances that freeze "hot" or boil "cold."