Changes of Physical State

Introduction/Background Info: Matter can exist in three different physical states- the solid state, the liquid state, or the gas state. In a pure substance, changes of physical state take place at discrete temperatures, which are constant and which are characteristics for each substance. The temperature at which a substance changes state from a solid to liquid, at one atmosphere pressure, is called the *normal melting point* of that substance. The temperature at which the substance changed from liquid to gas, at one atmosphere of pressure, is called the *normal boiling point* of that substance. The temperatures at which state changes occur depend upon the prevailing pressure. This is why normal melting points and boiling points are defined as the temperature at which the relevant state changes occur when the pressure is equal to one atmosphere.

Purpose: In this experiment, you will closely examine what happens when a pure substance undergoes a change in physical state. Specifically, you will investigate the melting and freezing behavior of a sample of an organic compound lauric acid ($C_{12}H_{24}O_2$). Are the freezing point and melting point the same temperature and is this temperature independent of the direction in which the physical change takes place? Secondly, does the temperature of the lauric acid change (if it does change) between the time freezing or melting just begins and the time that freezing or melting is complete. In this experiment, you will also consider what happens to the energy that is put into or removed from the lauric acid system during melting or freezing.

Objectives:

1. To observe the behavior of lauric acid during melting and freezing.
2. To plot a heating and a cooling curve graph for lauric acid.
3. To determine the freezing point and melting point of lauric acid from the graph.
4. To consider what happens to the energy that is put into or removed from lauric acid during the processes of melting and freezing.

Prelab:

1. What kind of a compound is lauric acid-- molecular or ionic? How do you know?
2. What is lauric acid used in or used for? List 3.
3. What is meant by “normal” melting point?
4. What phase change will you study in lauric acid?
5. What is the difference between kinetic and potential energy? Which kind must change when temperature is changing? When temperature is not changing?

Procedure: **Part I - Change of State from Liquid to Solid**

1. Obtain a melted sample from your instructor and set up a ring stand set up with ring clamp and TT clamp.

2. Record the temperature of the sample as soon as you take it to your lab bench.

3. Immerse the test tube into the cold water so that the portion of the tube containing liquid is completely surrounded by water.

4. Stir gently and record the temperature thirty seconds from your first temperature reading and every thirty seconds after.

5. Stir the water bath from time to time to spread the heat evenly.

6. As the liquid begins to solidify hold the thermometer in a position against the side and just off the bottom of the test tube so that it will become embedded in that position when the lauric acid becomes a solid.

7. Continue reading and recording the temperature every thirty seconds until you reach a temperature of 25^{o}C.

Part II - Change of State from Solid to Liquid

8. Heat the beaker of water until it reaches a temperature between 60 and 65^{o}C. Shut off the burner. You may also choose to use a hot plate.

9. Read the temperature of the frozen lauric acid and record this as the temperature at time zero.

10. Lower the test tube into the hot water bath and take temperature readings every thirty seconds. Carefully use your copper stirrer to stir the contents of the test tube without touching the sides of the test tube.

11. Occasionally stir the hot water bath and monitor its temperature with a second thermometer. If the temperature of the hot water bath gets below 60^{o}C you will need to relight the burner and heat the water bath

while you continue to stir and take temperature measurements of the lauric acid.

12. Stir and measure the temperature of the lauric acid every 30 seconds until it reaches a temperature of 60^{o}C.

13. Remove your thermometer from the lauric acid (caution: don't force it!) and wipe it clean with a paper towel.

14. Leave the test tube of lauric acid stoppered and in the beaker on the table. Do not pour the lauric acid out or get any water in it.

Data: Appearance of lauric acid before, during and after experiment.

COOLING BEHAVIOR WARMING BEHAVIOR

Time in minutes	Temp in ^{o}C	Physical state		Time in minutes	Temp in ^{o}C	Physical state

Graph: Done by hand , Excel, or another graphing program.

1. Construct a smooth curve. You must extrapolate(using a dotted line) the temperature plateau to the vertical axis to find the freezing point of the compound. Please show this on your graph. Be sure to use more than half of the paper, but also use a scale that is simple.

2. Graph the heating behavior of lauric acid in a similar fashion on the same graph. Place a triangle around each point and construct the heating curve. You must extrapolate (using a dotted line) the temperature plateau to find the melting point of the compound. Please show on the graph.

Discussion:

1. Using the flat portion of your graph from Part I, determine the freezing point of lauric acid. It is an _____thermic process.
2. Using the flat portion from Part II, determine the melting point of lauric acid. It is an ____thermic process.
3. How do the two temperatures compare? Would they appear to be the same taking into account normal sources of error?

4. Both of the graphs had a fairly flat portion. Try to explain this flat portion in terms of energy, where it is going, molecular motion, and how it is being used. Use the melting point graph for this.
5. Would increasing the amount of solid change the melting point shown on the graph? Explain.

Error Analysis:

The actual melting point is 44 deg C. Calculate the percent error of your results. Show all work.

Explain any sources of error.

Resources:

Conclusion: Your conclusion must include the words endothermic, exothermic, enthalpy of fusion, heating and cooling curve, system, surroundings, and heat energy to explain phase change.