Thermodynamics

Heating and Cooling Curves

Overview

In this lab a sample of a pure, solid substance is slowly heated in a warm water bath until the sample fully melts. The temperature of the sample is measured every 30 sec during this process and the data is recorded. Next, the liquefied sample is allowed to cool in a cool water bath until the sample solidifies (freezes). Again the temperature of the sample is measured every 30 sec and the data is recorded.

Data for the two phase changes is plotted on a single graph and the graph is used to determine the melting point and freezing points of the substance.

Purpose

- To graph the data for both the melting and freezing of a pure substance
- To determine the melting point (m.p.) and freezing point (f.p.) of the substance
- To consider the energy changes that occur during a change in phase.

Equipment, Materials, and Procedure

Your teacher will provide you with a list of the materials and equipment required for this lab, and the procedures to follow.

Suitable substances to use include lauric acid, acetamide, or p-dichlorobenzene (mothballs)

If you are unable to actually perform the experiment, use the following set of experimental data to plot the graphs and answer the questions at the end of the lab.

Sample Data for the Heating and Cooling of Lauric Acid, $C_{12}H_{22}O_2$

Heating		Cooling	
Time (min)	Temperature (°C)	Time (min)	Temperature (°C)
0	30.0	0	55.0
0.5	33.2	0.5	52.6
1.0	35.5	1.0	49.5
1.5	37.5	1.5	45.5
2.0	39.0	2.0	44.3
2.5	41.0	2.5	44.1
3.0	42.0	3.0	44.0
3.5	42.6	3.5	44.0
4.0	43.0	4.0	44.0
4.5	43.4	4.5	44.0
5.0	43.6	5.0	44.0
5.5	43.7	5.5	44.0
6.0	43.8	6.0	44.0
6.5	44.0	6.5	44.0
7.0	44.0	7.0	44.0
7.5	44.1	7.5	43.7
8.0	44.2	8.0	43.5
8.5	44.5	8.5	43.3
9.0	45.2	9.0	43.0
9.5	46.0	9.5	42.6
10.0	47.5	10.0	42.3
10.5	49.0	10.5	41.9
11.0	51.4	11.0	41.5

Results

Prepare a single graph that shows the results of both the heating and cooling data. The graph should be a plot of Temperature (°C) versus Time (min). Students are ***strongly encouraged*** to use the graphing capabilities of a spreadsheet such as Excel or Quatro Pro to create the graph. Computer generated graphs are preferable to hand-drawn graphs.

The following items apply to creating graphs:

- All graphs require an appropriate, descriptive title. The name of the substance used in the experiment should be included in the title. Please include your name on all graphs.
- Both axes must be labeled, including the units of measurement (°C and min)
- Graphs should fill the page, except for 1 inch margins on all sides.

Conclusions and Questions

1. Based on your graph, determine the melting point and freezing point of the substance used.

   How do these values compare?

2. Consider the diagonal region of the heating curve, as the sample is being heated. What does the temperature change indicate about the change in kinetic energy of the particles in the sample?

3. Describe the shape of your graph during the actual changes of state (while the substance is actually melting or solidifying)

4. During the heating process, heat is continually being supplied to the sample throughout the entire time of the experiment even though the temperature remains constant during the actual change of phase. How can this be explained at the molecular level, in terms of what is happening to the chemical bonds holding the particles together in the solid state?

   Hint – remember that temperature is a measure of the average kinetic energy of the particles in a sample of matter. If temperature remains constant, what does this say about the kinetic energy of the particles? If the energy being supplied is not changing the ***kinetic energy***, then what form of energy ***is*** changing?

5.. Consider the diagonal region of the cooling curve, as the sample is being cooled. What does the temperature change indicate about the change in kinetic energy of the particles in the sample?

6. During the cooling process, heat is continually being removed from the sample, yet the temperature remains constant during the actual freezing process. If the constant temperature indicates no change in ***kinetic energy***, then what form of energy ***is*** changing?