DETERMINATION OF ENTHALPY OF FUSION

This experiment investigates the transition that occurs in a substance when it is heated or cooled. The temperature at which a transition from solid to liquid occurs is called the melting point; from liquid to solid is the freezing point.

In order to melt a solid, enough energy must be supplied to overcome the forces that have been holding the molecules in fixed position. When a solid melts, its molecules move faster and lose their 3-dimensional order. While melting (or freezing) occurs the temperature remains constant for a pure substance. The temperature of a melting substance cannot rise above the melting point until all the solid has become liquid. Impure solids or mixtures melt over a range of temperatures. Therefore, melting point data can be used to determine the purity of a solid.

The energy required to convert 1.0 gram of a specific substance from solid to liquid state is called the enthalpy of melting or enthalpy of fusion. The enthalpy of fusion is expressed in joules per gram. For example, the enthalpy of fusion for ice is 334 J/g.

In this experiment you will determine the melting and freezing point of 1,4-dichlorobenzene. You will then determine the enthalpy of fusion for 1,4-dichlorobenzene using a simple calorimeter. Finally you will compare the freezing points of pure and impure 1,4-dichlorobenzene.

Objectives

In this experiment, you will

- determine the melting and freezing point of 1,4-dichlorobenzene,
- calculate the enthalpy of fusion for 1,4-dichlorobenzene, and
- determine the freezing point range of impure 1,4-dichlorobenzene.

EQUIPMENT

goggles and apron
test tube (large, 18 × 150 mm)
balance
thermometer
hot plate or burner
ring stand, ring, and wire gauze
utility clamp or test tube holder
clock or watch with second hand
plastic foam cup (9-10 oz)
beaker (400 cm³)

PROCEDURE

A. Melting Point of a Substance

1. Prepare a data table as directed in the Analysis. Safety goggles and lab apron must be worn for this experiment.
2. Obtain a test tube (18 × 150 mm). Measure and record its mass to the nearest 0.01 gram.
3. Fill the test tube one half full of 1,4-dichlorobenzene (or other substance as directed by your teacher). Measure the mass of the test tube and the substance to the nearest 0.01 gram. Record.
4. Place a thermometer in the test tube so the bulb does not touch the side or bottom and heat slowly in a water bath on a hot plate or as shown in Figure 25-1. After the substance begins to melt, remove the burner or turn down heat on hot plate. Observe and record the temperature, while stirring, each 30 seconds. CAUTION: Thermometers can be broken easily. If a thermometer breaks, there is danger of a mercury spill; notify your teacher immediately. Mercury is poisonous as a liquid and as a vapor.

FIGURE 25-1. Apparatus for heating 1,4-dichlorobenzene.
5. While melting, note that the temperature remains constant. After complete melting, heat until the temperature is 15°C above the melting point. **CAUTION:** Vapor of 1,4-dichlorobenzene can be irritating; avoid inhalation.

6. Obtain a plastic foam cup and measure and record its mass. Fill three-fourths full with tap water. Place the cup in a 400 cm³ beaker for support (Figure 25-2).

![Diagram of apparatus for cooling 1,4-dichlorobenzene](image)

**FIGURE 25-2.** Apparatus for cooling 1,4-dichlorobenzene.

7. Remove the test tube from the water bath and let cool in the air until the bottom of the substance looks cloudy or crystals begin to form along the sides. With a thermometer in the test tube, place it in the plastic foam cup of water to cool. Gently swirl and record the temperature of the substance each 30 s until the material has cooled 10 C° below the freezing point. Save test tube for Part B. **CAUTION:** Do not pour 1,4-dichlorobenzene in sink. Follow your teacher’s directions for disposing of this chemical.

**B. Enthalpy of Fusion**

1. Reheat the test tube of 1,4-dichlorobenzene again to 15 C° above melting point.

2. Using the same cup, refill to three-fourths full with tap water. Measure and record the mass to the nearest 0.01 gram. Place cup in beaker, as above.

3. Remove the test tube from the water bath and the thermometer from the test tube. Let the substance cool until crystals begin to form. Measure the temperature of the water in the cup to the nearest 0.5°C and record as T₁. Immediately place the test tube in the cup and gently swirl. Note the temperature change of the water as the substance solidifies, and record the highest reading, to nearest 0.5°C as T₂.

4. Return the test tube containing the solid to the reagent table.

**ANALYSIS**

1. Prepare a table for your data using Table 25-1 as a guide. You will also need a table in which to record temperatures of melting and freezing at 30 second intervals for approximately 6 minutes.

2. To calculate the enthalpy of fusion you should assume the following.

   a. If a plastic foam cup is used as a calorimeter you may disregard its mass in calculating the energy absorbed by the water. If another type of container is used for the calorimeter your teacher will explain how you should calculate the energy absorbed by the water and calorimeter.

   b. The specific heat of water (calculation 10) is 4.18 J/g°C.

   c. The specific heat of glass (calculation 11) is 0.843 J/g°C.

3. Prepare a graph of your freezing point data for pure 1,4-dichlorobenzene. Plot time in 30 second intervals along the abscissa and temperature in °C along the ordinate.

<table>
<thead>
<tr>
<th>Table 25-1</th>
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<tbody>
<tr>
<td>1. Mass of test tube</td>
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<tr>
<td>2. Mass of test tube + substance</td>
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<tr>
<td>3. Mass of substance</td>
</tr>
<tr>
<td>4. Mass of cup</td>
</tr>
<tr>
<td>5. Mass of cup + water</td>
</tr>
<tr>
<td>6. Mass of water</td>
</tr>
<tr>
<td>7. Temperature of water in cup, T₁, °C</td>
</tr>
<tr>
<td>8. Temperature of water in cup, T₂, °C</td>
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<tr>
<td>9. Temperature change (ΔT = T₂ - T₁), °C</td>
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<tr>
<td>10. Total energy absorbed by water</td>
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<tr>
<td>11. Total energy released by test tube</td>
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<tr>
<td>12. Total energy released by substance (10-11)</td>
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<tr>
<td>13. Enthalpy of fusion (12 ÷ 3)</td>
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</tbody>
</table>

**CONCLUSIONS**

1. What is the melting point/freezing point temperature of 1,4-dichlorobenzene?

2. Why does the temperature remain constant during the melting/freezing phase change?

3. If the theoretical enthalpy of fusion for 1,4-dichlorobenzene is 163 J/g, what is your percentage error? Describe some possible sources of error in your methodology.

4. Using your data, calculate the amount of energy required to melt one mole of 1,4-dichlorobenzene, C₆H₄Cl₂.