Graphical Analysis 4

Heat of Fusion for Ice

Melting and freezing behavior are among the characteristic properties that give a pure substance its unique identity. As energy is added, pure solid water (ice) at 0°C changes to liquid water at 0°C.

In this experiment, you will determine the energy (in joules) required to melt one gram of ice. You will then determine the molar heat of fusion for ice (in kJ/mol). Excess ice will be added to warm water, at a known temperature, in a polystyrene foam cup. The warm water will be cooled down to a temperature near 0°C by the ice. The energy required to melt the ice is removed from the warm water as it cools.

To calculate the heat that flows from the water, you can use the relationship

q = Cp•m•Δt

where q stands for heat flow, Cp is specific heat capacity, m is mass in grams, and Δt is the change in temperature. For water, Cp is 4.18 J/g°C.

OBJECTIVES

* Determine the energy (in Joules) required to melt 1 g of ice.
* Determine the molar heat of fusion for ice (in kJ/mol).

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|  |
| Figure 1    |

MATERIALS

Chromebook, computer, or mobile device

Graphical Analysis 4 app

Go Direct Temperature

Stir Station

Electrode Support

400 mL beaker

100 mL graduated cylinder

tongs

polystyrene foam cup

ice cubes

stirring rod

warm water

PROCEDURE

1. Launch Graphical Analysis. Connect the Temperature Probe to your Chromebook, computer, or mobile device.
2. Use an Electrode Support to secure the Temperature Probe on a Stir Station as shown in Figure 1.
3. Place a polystyrene foam cup into a 400 mL beaker as shown in Figure 1.
4. Use a 100 mL graduated cylinder to obtain 100.0 mL of water at about 60°C from your instructor and pour the water into the cup. Record this as V1.
5. Obtain 7 or 8 large ice cubes.
6. Click or tap Mode to open Data Collection Settings. Change Rate to 1 samples/s and End Collection to 480 s. Click or tap Done.
7. Lower the Temperature Probe into the warm water (to about 1 cm from the bottom).
8. Click or tap Collect to start data collection. Wait until the temperature reaches a maximum (it will take a few seconds for the cold probe to reach the temperature of the warm water). This maximum will determine the initial temperature, t1, of the water. As soon as this maximum temperature is reached, fill the polystyrene foam cup with ice cubes. Shake excess water from the ice cubes before adding them (or dry them with a paper towel).
9. Use a stirring rod to stir the mixture as the temperature approaches 0°C. Important: As the ice melts, add more large ice cubes to keep the mixture full of ice!
10. When the temperature reaches about 4°C, quickly remove the unmelted ice using tongs. Continue stirring until the temperature reaches a minimum (and begins to rise).
11. Data collection will stop after 8 minutes, or you can stop before 8 minutes has elapsed if the temperature starts to rise above the minimum. Use the 100 mL graduated cylinder to measure the volume of water remaining in the polystyrene foam cup to the nearest 0.1 mL. Record this as V2.
12. To confirm the t1 and t2 values you recorded earlier, examine the data points along the curve on the displayed graph by clicking or tapping any data point. Determine the initial (maximum temperature, t1, and the final (minimum) temperature, t2. Note: You can also adjust the Examine line by dragging the line.

Processing the data

1. Use the equation Δt = t1 – t2 to determine Δt, the change in water temperature.
2. Subtract to determine the volume of ice that was melted (V2 –V1).
3. Find the mass of ice melted using the volume of melt (use 1.00 g/mL as the density of water).
4. Use the equation given in the introduction of this experiment to calculate the energy (in joules) released by the 100 g of liquid water as it cooled through Δt.
5. Now use the results obtained above to determine the heat of fusion, the energy required to melt one gram of ice (in J/g H2O).
6. Use your answer to Step 5 and the molar mass of water to calculate the molar heat of fusion for ice (in kJ/mol H2O).
7. Find the percent error for the molar heat of fusion value in Step 6. The accepted value for molar heat of fusion is 6.01 kJ/mol.

DATA and calculations

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| --- | --- |
| Initial water temperature, t1 | °C |
| Final water temperature, t2 | °C |
| Change in water temperature, Δt | °C |
| Final water volume, V2 | mL |
| Initial water volume, V1 | mL |
| Volume of melt | mL |

|  |  |
| --- | --- |
| Mass of ice melted  | g |
| Heat released by cooling water (q = Cp•m•Δt)  | J |
| J/g ice melted (heat of fusion) | J/g |
| kJ/mol ice melted (molar heat of fusion)  | kJ/mol |
| Percent error | % |

A demonstration of the experimental set-up can be found at [https://youtu.be/suwuxB0S-Ko](https://youtu.be/suwuxB0S-Ko%20)