Heat of Vaporization of Water

Calorimetry

Introduction

A simple, quick, and easy demonstration in which students measure the amount of energy gained by one sample of water as another sample is vaporized. Students use this information to calculate the heat of vaporization of water with minimal error.

Concepts

- Thermochemistry
- Calorimetry
- Heat of vaporization

Materials

Water, distilled, 105 mL

Beakers, borosilicate glass, 150-mL, 2

Gloves, heat-resistant

Graduated cylinder, 100-mL

Graduated cylinder, 10-mL

Hot plate

Thermometer, digital

Safety Precautions

Exercise caution when using hot plates and handling hot glassware. Remember that "hot" glassware looks exactly the same as "cold" glassware. Do not hold the thermometer above the boiling liquid with bare hands—steam burns are possible. Wear chemical splash goggles and heat-resistant gloves. Please follow all normal laboratory safety guidelines.

Procedure

1. Measure 5 mL of distilled water into one of the beakers and 100 mL of distilled water into the other beaker. Place both on the hot plate.
2. Turn the hot plate to a medium setting and begin heating.
3. Ask a student volunteer to tell you when the 5 mL of water just starts to boil. At this time measure and record the temperature of the 100 mL of water.
4. Ask the student volunteer to tell you when the 5 mL of water has completely vaporized. At this time measure and record the final temperature of the 100 mL of water.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Water may be disposed of down the drain according to Flinn Suggested Disposal Method #26b.

Tip

- In the video presentation, the mass of water is approximated based on its volume and a density of 1.0 g/mL. For more accurate results, the mass can be measured or calculated based on the density of water at the specified temperature.

Discussion

The *heat of vaporization* of any liquid refers to the amount of heat energy that must be absorbed by a specific quantity of the liquid such that the liquid is completely evaporated. Thus, the vaporization of any liquid, in this case water, is an example of an endothermic physical change in which energy must be consumed in order for the change to occur.

Publication No. 91829
061616

In this demonstration we assume that both beakers are identical and that the hot plate distributes heat evenly to both beakers, and therefore we know that the heat energy gained by both beakers is identical. Thus, we can use the temperature change of the 100 mL sample of water to calculate the heat energy absorbed by both samples of water (Equation 1).

$$Q_{water} = m \times c \times \Delta T \qquad \textit{Equation 1}$$

Q_{water} is the energy (in Joules) absorbed by the water, m is the mass of the water in grams, c is the specific heat (for liquid water, 4.18 J/g·°C), and ΔT is the change in temperature. Because we allowed the 5 mL sample of water to completely vaporize, we can divide the energy absorbed by this sample by the mass of the sample in order to determine the heat of vaporization of water (in Joules per gram). We can compare this experimental value to the accepted value of 40.7 kJ/mol (2260 J/g).

Sample Data and Results

1	Initial temperature of 100 mL water sample (°C)	27.7
2	Final temperature of 100 mL water sample (°C)	56.0
3	Change in temperature (°C) (line 2 – line 1)	28.3
4	Amount of heat absorbed by 100 mL water sample (J) (Equation 1)	11829
5	Amount of heat absorbed per gram in 5 mL water sample (J/g) (line 4/5 g)	2370
6	Experimental value of heat of vaporization of water (J/g) (line 5)	2370
7	Percent error ([line 6 – 2260 J/g]/2260 J/g)	4.9%

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement

Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, conservation of energy and increase in disorder, interactions of energy and matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Heat of Vaporization of Water* activity, presented by Annis Hapkiewicz, is available in *Calorimetry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Heat of Vaporization of Water* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7234	Hot Plate, Flinn, 7″ × 7″
AP8716	Flinn Digital Thermometer
GP1015	Beaker, Borosilicate Glass, 150-mL
AP3240	Gloves, Zetex™, 11″ length

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.