SPECIFIC HEAT OF A METAL 11

Chemists identify substances on the basis of their chemical and physical properties. One physical property of a substance is the amount of heat energy it will absorb per unit of mass. This property can be measured quite accurately and is called **specific heat** (C_p). Specific heat is the amount of heat energy, measured in joules, needed to raise the temperature of one gram of the substance one Celsius degree. Often applied to metallic elements, specific heat can be used as a basis for comparing energy absorption and transfer.

To measure specific heat in the laboratory, a **calorimeter** of some kind must be used. A calorimeter is a well-insulated container used in measuring energy changes. The calorimeter is insulated to reduce the loss or gain of heat energy from the surrounding room conditions. Heat energy always flows from an object at a higher temperature to an object at a lower temperature. The heat gained by the cooler substance equals the heat lost by the warmer substance, if we assume no loss of heat to the surrounding environment

$$heat\ lost = heat\ gained$$

In this experiment, you will determine the specific heat of a metal sample. The metal sample will be heated to a high temperature then placed into a calorimeter containing a known quantity of water at a lower temperature. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT), and knowing the specific heat of water (4.184 J/g·C°), the heat gained by the water (lost by the metal) can be calculated as follows:

$$\text{Heat gained by the water} = \text{Mass of water (g)} \times \text{Change in temperature } \Delta T\ (C°) \times \text{Specific heat of water (4.184 J/g·C°)}$$

From the measured heat lost by the metal, the specific heat of the metal can be calculated.

$$\text{Specific heat of metal } (C_p) = \frac{\text{Heat gained by the water}}{\text{Mass of metal (g)} \times \Delta T \text{ of metal } (C°)}$$

Objectives

In this experiment, you will

- measure the mass and temperature of water in a calorimeter;
- heat a metal sample of known mass to a specific temperature;
- calculate the change in water temperature caused by adding the hot metal sample; and,
- calculate the specific heat of the metal using your mass and temperature data.

EQUIPMENT

250 mL beaker
plastic foam cup
thermometer
18 × 150 mm test tube
ring stand and ring
wire gauze
laboratory burner

PROCEDURE

1. Prepare a data table for recording your observations as directed in Analysis.
2. Fill a 250 mL beaker about half full of water. Place the beaker of water on a ring stand with wire gauze. (See Figure 2-1.) Begin heating the water to the boiling point.
3. Measure the mass of an empty, dry 18 × 150 mm test tube and record.
4. Add the sample metal pieces until the test tube is half-full. Record the mass of the test tube and metal.
5. Place the test tube containing the metal into the beaker of water and heat the water to the boiling point. Leave the test tube in the boiling water bath while you complete Steps 6 and 7.
6. Obtain a plastic foam cup to be used as a calorimeter and measure the mass carefully. Record.
7. Fill the plastic foam cup about half-full with distilled water at room temperature and record the mass.
8. While the test tube containing the metal is still in the boiling water bath, measure the

temperature of the water with a thermometer and record. (It will be assumed the temperature of the metal is the same as the boiling water.)

9. Measure the temperature of the water in the plastic foam cup and record.
10. Remove the test tube containing the metal from the boiling water and immediately pour the metal into the plastic foam cup.
11. Stir the water in the plastic foam cup *slowly* (thermometers can be broken easily), then record the highest temperature reached.
12. Recover the metal by carefully pouring the water off (decanting). Spread the solid metal on a paper towel to dry. *Do not let any metal particles get into your laboratory sink.*
13. Repeat entire procedure with a different metal if time permits.

ANALYSIS

1. Prepare a table for your data, using Table 11-1 as a guide.
2. Calculate the heat gained by the water (lost by the metal) in the calorimeter using the equation in the Introduction.
3. Calculate the specific heat of the metal using the answer from number 2 and the equation in the Introduction.

CONCLUSIONS

1. What physical properties, other than specific heat, could you use to help you identify the sample(s) used in this experiment.
2. Why is water an excellent material to use in a calorimeter?

FURTHER INVESTIGATIONS

1. Calculate the specific heat of a metallic element if 314 joules of heat energy are needed to raise the temperature of a 50.0 g sample from 25.0°C to 50.0°C.
2. Propose a method for determining the specific heat, C_p, for a metal like sodium which reacts with water.

Table 11-1

MASS DATA		TEMPERATURE DATA	
Material	**Mass**	**Material**	**Temperature**
1. test tube	_____ g	1. boiling water	_____ °C
2. test tube + metal	_____ g	2. water in cup	_____ °C
3. metal	_____ g	3. water in cup after metal was added	_____ °C
4. plastic foam cup	_____ g		
5. cup + water	_____ g		
6. water	_____ g		
		heat gained by water = _____ J	
		ΔT_{water} = _____ C°	

ΔT_{metal} = _____ C°