DATE _____ PERIOD _____ NAME _____

EXPERIMENT 12.1 Specific Heat

Purpose

Use the law of conservation of energy to calculate the specific heat of a metal.

Concept and Skill Check

One of several physical properties of a substance is the amount of energy that it will absorb per unit mass. This property is called specific heat, C_s. The specific heat of a material is the amount of energy, measured in joules, needed to raise the temperature of one kilogram of the material one Celsius degree (Kelvin).

A calorimeter is a device that can be used in the laboratory to measure the specific heat of a substance. The polystyrene cup, used as a calorimeter, insulates the water-metal system from the environment, while absorbing a negligible amount of heat. Since energy always flows from a hotter object to a cooler one and the total energy of a closed, isolated system always remains constant, the heat energy, Q, lost by one part of the system is gained by the other:

$$Q_{\text{lost by the metal}} = Q_{\text{gained by the water}}.$$

In this experiment, you will determine the specific heat of two different metals. The metal is heated to a known temperature and placed in the calorimeter containing a known mass of water at a measured temperature. The final temperature of the water and material in the calorimeter is then measured. Given the specific heat of water (4180 J/kg · K) and the temperature change of the water, you can calculate the heat gained by the water (heat lost by the metal) as follows:

$$Q_{\text{gained by the water}} = (m_{\text{water}})(\Delta T_{\text{water}})(4180 \text{ J/kg} \cdot \text{K}).$$

Since the heat lost by the metal is found by

$$Q_{\text{lost by the metal}} = (m_{\text{metal}})(\Delta T_{\text{metal}})(C_{\text{metal}}),$$

the specific heat of the metal can be calculated as follows:

$$C_{\text{metal}} = \frac{Q_{\text{gained by the water}}}{(m_{\text{metal}})(\Delta T_{\text{metal}})}.$$

Materials

string (60 cm)
safety goggles
250-mL beaker
polystyrene cup
hot plate (or burner with ringstand, ring, and wire screen)
tap water
thermometer
balance
specific heat set (brass, aluminum, iron, lead, copper, etc.)

Procedure

1. Safety goggles must be worn for this laboratory activity. CAUTION: *Be careful when handling hot glassware, metals, or hot water.* Fill a 250-mL beaker about half full of water. Place the beaker of water on a hot plate (or a ringstand with a wire screen) and begin heating it.
2. While waiting for the water to boil, measure and record in Table 1 the mass of the metals you are using and the mass of the polystyrene cup.
3. Attach a 30-cm piece of string to each metal sample. Lower one of the metal samples, by the string, into the boiling water, as shown in the figure on the next page. Leave the metal in the boiling water for at least five minutes.

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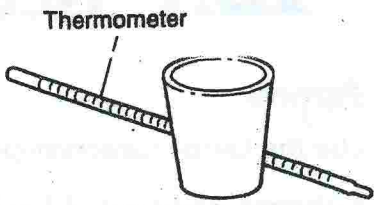
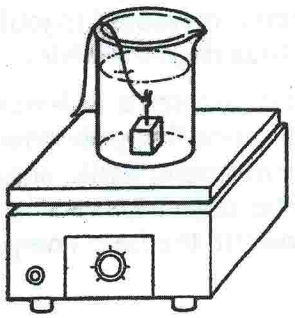
4. Fill the polystyrene cup half full of room temperature water. Measure and record in Table 1 the total mass of the water and the cup.
5. Measure and record in Table 1 the temperature of the room temperature water in the polystyrene cup and the boiling water in the beaker. The temperature of the boiling water is also the temperature of the hot metal.
6. Carefully remove the metal from the boiling water and quickly lower it into the room temperature water in the polystyrene cup.
7. Gently stir the water in the polystyrene cup for several minutes with the thermometer. CAUTION: *Thermometers are easily broken. If you are using a mercury thermometer and it breaks, notify your teacher immediately. Mercury is a poisonous liquid and vapor.* When the water reaches a constant temperature, record this value in Table 1 as the final temperature of the system.
8. Remove the metal sample and repeat Steps 3 through 7 with another metal sample.



Polystyrene cup calorimeter



Hot plate

The calorimeter is used to measure heat exchange by means of temperature changes.

Observations and Data

Table 1

	Trial 1	Trial 2
Type of metal		
Mass of calorimeter cup (kg)		
Mass of calorimeter cup and water (kg)		
Mass of metal (kg)		
Initial temperature of room temperature water (°C)		
Temperature of hot metal (°C)		
Final temperature of metal and water (°C)		

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Table 2

	Trial 1	Trial 2
Mass of room temperature water (kg) #2 #1		
ΔT metal (°C) #4 #5		
ΔT room temperature water (°C) #5 #3		

Analysis

1. For each trial, calculate the mass of the room temperature water, the change in temperature of the metal, and the change in temperature of the water in the polystyrene cup. Record these values in Table 2.

2 answers

2. For each trial, calculate the heat gained by the water (heat lost by the metal).

$$Q = (M_{water})(\Delta t_{water})(4180)$$

2 answers

3. For each trial, calculate the specific heat of the metal. For each metal sample, use the value for heat gained by the water that you calculated in Question 2.

$$C_{metal} = \frac{Q_{gained\ by\ water}}{(M_{metal})(\Delta t_{metal})}$$