



Laboratory Activity

Specific Heats of Metals

The amount of heat needed to change the temperature of a metal is much less than that needed to change the temperature of a similar amount of other materials. You probably were aware of this fact if you ever tried to cool a can of soft drink quickly in the freezer. Metal cans tend to cool more quickly than their contents.

A measure of how much energy is needed to change the temperature of a material is called specific heat. The specific heat, C , is the amount of heat needed to change the temperature of 1 kilogram of a substance by 1 degree Celsius. As you recall, the specific heat of water is $4190 \text{ J/kg}\cdot^\circ\text{C}$. The specific heat of a substance is a physical property of that substance. Therefore, a substance can be identified by its specific heat.

Strategy

You will use a calorimeter to determine the specific heat of a piece of metal. You will identify the metal by its specific heat.

Materials



250-mL beaker

one-hole paper punch

metric balance

paper towels

2 plastic cups with lids

plastic pipette

rubber band

test tube, thick walled

test-tube holder

test-tube rack

thermometer

sample of unknown metal X, Y, or Z

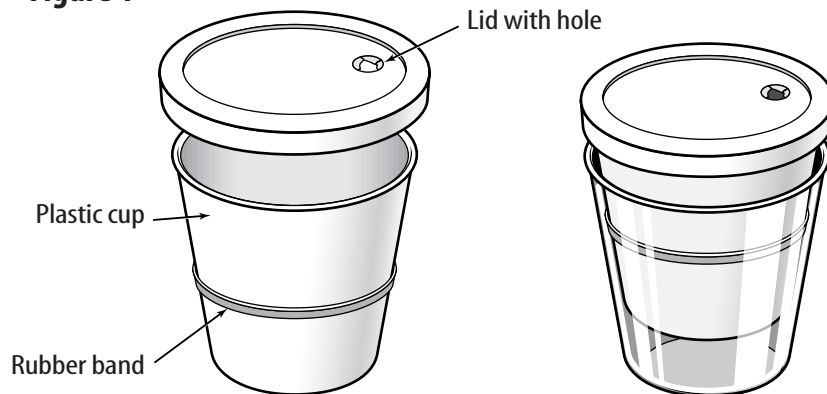
water

Procedure

Part A—Building a Calorimeter

- Place about 50 mL of water in the 250-mL beaker and allow the temperature of the water to come to room temperature.
- Punch a hole for the thermometer in one of the lids of the plastic cups with a paper punch.
- Wrap a rubber band around one of the plastic cups.
- Place this cup inside the second plastic cup. Assemble the calorimeter as shown in Figure 1.
- Measure the mass of the calorimeter. Record this value in the Data and Observations section.

Figure 1



Assembled calorimeter

Laboratory Activity 1 (continued)

Part B—Measuring Specific Heat of Metals

- Use the plastic pipette to add 5 pipettefuls of room-temperature water to the calorimeter.
- Measure the mass of the calorimeter and water. Record this value in the Data and Observations section.
- Measure the mass of the sample of unknown metal. Record this value in Table 1.
- Place the piece of metal in the test tube. Use the test-tube holder to place the test tube containing the metal into the boiling water bath prepared by your teacher. Note the time.
- After ten minutes, measure the temperature of the water in the calorimeter with the thermometer. Remove the thermometer. Place the calorimeter on a paper towel on a flat surface and remove its lid.
- Measure the temperature of the boiling water bath using the thermometer provided by your teacher. Record this value as the *temperature of metal* in the Data and Observations section.
- Using the test-tube holder, carefully remove the test tube containing the sample from the boiling water bath.
CAUTION: *The test tube and its contents are extremely hot. Avoid touching the test tube or the piece of metal.*
- Quickly slide the piece of hot metal into the calorimeter. Place the test tube in the test-tube rack.
- Immediately cover the calorimeter with its lid and insert the thermometer into the calorimeter.
- Gently swirl the water. Measure the temperature of the water in the calorimeter for several minutes. Record the value of the *highest* temperature reading in the Data and Observations section.

- Calculate the mass of the water that you added to the calorimeter by subtracting the mass of the empty calorimeter from the calorimeter and water. Record this value in Table 1.
- Calculate the temperature change in the water. Record this value in Table 1.
- The heat gained by the water can be determined by the following equation.

$$Q = C \times m \times (T_f - T_i)$$

In this equation, C represents the specific heat of water, m represents the mass of the water, and T_f is the final temperature and T_i is the initial temperature of the water. Calculate the value of Q and record it in Table 1.

- Assume that all the heat from the metal was transferred to the water in the calorimeter. Thus, the heat lost by the metal is equal to the heat gained by the water. Enter the value of the heat lost by the metal in Table 1. Remember to record a heat loss as a negative value.
- Calculate the change in temperature of the metal.
- The specific heat of a substance can be calculated by the following equation.

$$C = \frac{Q}{(T_f - T_i)}$$

In this equation, Q represents the amount of heat gained or lost, m represents the mass of the substance, and $(T_f - T_i)$ represents the change in temperature of the substance. Calculate the specific heat of the metal. Record this value in Table 1.

- Use the values of specific heats in Table 2 to identify the sample. Record the letter of the sample and name of the metal in the Data and Observations section.

Laboratory Activity 1 (continued)

Data and Observations

Mass of calorimeter: _____ g

Mass of calorimeter and water: _____ g

Temperature of cool water: _____ °C

Temperature of metal: _____ °C

Temperature of water-metal mixture: _____ °C

Table 1

Metal	Specific heat (J/kg·C°)

Table 2

Measurement/Calculation	Material	
	Water	Metal
Mass (kg)		
Temperature change (°C)		
Specific heat (J/kg · °C)		
Heat gained or heat lost (J)		

Sample _____; Name of metal: _____

Questions and Conclusions

- How well were you able to identify the metal using its specific heat?

- In this experiment, the masses of the metal and the hot water were almost equal. However, the temperature decrease of the metal was much greater than the temperature rise of the water even though they had equal masses. Why?

Laboratory Activity 1 (continued)

3. In step 11 of the procedure, you recorded the temperature of the water bath as the temperature of the metal in it. Explain why you could do this.

4. Could you improve your calorimeter by using two metal cans and aluminum foil in place of the two plastic cups and lids? Explain.

Strategy Check

- _____ Can you find the specific heat of a metal?
- _____ Can you identify a metal when given its specific heat?