

# SPECIFIC HEAT OF A METAL

Chemists identify substances on the basis of their chemical and physical properties. One physical property of a substance is the amount of energy it will absorb per unit of mass. This property can be measured quite accurately and is called **specific heat** ( $c$ ). Specific heat is the amount of 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 energy to or from the surroundings. 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.

$$\text{heat lost} = \text{heat gained}$$

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 ( $\Delta T$ ), and knowing the specific heat of water ( $4.184 \text{ J/g}^\circ\text{C}$ ), the heat gained by the water (lost by the metal) can be calculated as follows:

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

The specific heat of the metal can now be calculated:

$$\text{Specific heat of metal } (C_p) = \frac{\text{heat gained by the water (J)}}{\text{mass of metal (g)} \times \Delta T \text{ of metal } (^\circ\text{C})}$$

## 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

hot plate      temperature probe      beaker ( $250 \text{ cm}^3$ )  
balance      plastic foam cup

## PROCEDURE

1. Fill a 100-mL beaker *about* half full of water. Place the beaker of water on a hot plate or a ring stand with wire gauze. Begin heating the water to the boiling point. Continue with the procedure while the water is heating.
2. Measure the mass of a metal cylinder. Record the mass and the kind of metal.
3. Place the metal cylinder into the beaker of water and continue heating. Leave the metal cylinder in the boiling water bath while you complete Steps 4–6.
4. Obtain a plastic foam cup to be used as a calorimeter and measure the mass carefully. Record.
5. Fill the plastic foam cup with just enough room temperature water to cover the cylinder. **DO NOT FILL TO THE TOP.** Record the mass.
6. Measure the temperature of the water in the cup with a temperature probe. Do not add the hot metal until a steady temperature has been reached (*at least* 30 seconds). (It will be assumed the temperature of the metal is the same as the boiling water.)
7. Remove the metal from the boiling water – it has to be in **BOILING WATER** for at least 2 minutes - and *immediately* put it into the plastic foam cup.
8. Stir the water in the plastic foam cup and continue to watch the temperature and stir the water until the temperature starts to drop. Write down the highest temperature reached.
9. Repeat steps 2 to 8 with 2 different metals. Return all metal samples to the reagent table.