

Specific Heat of an Unknown Metal

Purpose

The purpose of this activity is to determine the specific heat of a metal object and identify the metal based on its specific heat.

Equipment

Computer with LoggerPro software, LabPro interface, temperature probe, two calorimeter cups, string, metal objects, triple beam balance, ice, beaker 400-mL, table support top rod clamp, lattice clamp, two support rods.

Introduction:

The amount of thermal energy that an object must absorb to change its temperature by one degree is called its heat capacity. The amount of thermal energy that a single gram of a specific material must absorb in order to change its temperature by one degree is the material's *specific heat capacity*, or *specific heat*. The specific heat of water is a standard to which specific heats of other substances are compared.

When thermal energy flows into or out of an object, its temperature changes. The amount of change depends on the mass of the object, the material from which the object is made, and the temperature of the environment. The specific heat of the material can be found using a known quantity of water and a *calorimeter*. The calorimeter is relatively well insulated so very little thermal energy will come from or go into the surrounding air. Assume that thermal energy is conserved inside the calorimeter. This means that whatever thermal energy is gained or lost by an object put into the calorimeter is equal to the thermal energy gained or lost by the water in the calorimeter. The equation describes that the change in thermal energy, ΔQ , depends on the mass, m , the specific heat, c , and the change in temperature, ΔT .

$$\Delta Q = mc\Delta T$$

When an unknown metal object is put into water in a calorimeter, the change in thermal energy of the object equals the change of thermal energy of the water.

$$m_{\text{object}} c_{\text{object}} \Delta T_{\text{object}} = m_{\text{water}} c_{\text{water}} \Delta T_{\text{water}}$$

The initial temperatures of the object and water will be different, but the final temperature—called the *equilibrium temperature*—will be the same.

Procedure

1. Connect the LabPro interface to the computer and the temperature probe to channel 1 of the LabPro. Turn on the computer and load the **Logger Pro** software by double clicking on its icon located within the **Physics Apps** folder. A file named temperature will be used to set up the computer for collecting the data needed for this experiment. To open this file, first select **File/Open** (with the mouse) and then open the **Thermodynamics** folder by double clicking on its icon. When this folder opens, double click on **temperature** to open the file.
2. Measure and record the mass of one of the metal objects. Put ice and water into one calorimeter cup to make an ice water bath. Tie a piece of string to the metal object and lower the object into the ice bath. Leave the metal object in the ice water for 10 minutes. Using a straw, stir the water until temperature is 0°C. Add more ice as the ice begins to melt.
3. Measure and record the mass of the second calorimeter cup. Add about 200 mL of water (at room temperature) to the calorimeter. Measure and record the total mass of the cup plus the water. Put the end of the temperature probe into the room temperature water. Add a glass stir rod to the water.
4. Press collect button to measure the signal from the temperature probe. After 1 minute, lift the cold metal object out of the ice water bath and quickly dry any droplets of water still on the sample. Suspend the sample in the room temperature water in the calorimeter. It should be completely covered by water but not touch the bottom of the calorimeter. Stir the water gently as you continue to record temperature data.
5. Wait until the graph of temperature stops changing (the sample and the water are in thermal equilibrium), and press stop to stop data recording. Remove the temperature probe and the metal object from the calorimeter. Clean up the equipment.
6. Use the graph of temperature versus time to find the initial temperature of the water and the equilibrium temperature, or final temperature, of the water and the metal sample after the object warms up and the water cools down. Click on the **X =** button at the top of the window so that the computer will display the temperature and time data that you just collected. Use the arrow key to move the cursor to the part of the graph that shows the initial temperature of the water. Record the value.
7. Repeat step 6 to find the final temperature (equilibrium temperature) of the water and the metal object. Use your data to calculate the specific heat of the metal object. Use your calculated value of the specific heat to identify the type of metal. Compare the value you obtained with your data (measured) to the value accepted. What are some possible sources of error?
8. Using the above equation, calculate the specific heat of the unknown metal. Record all data in the table.

Trial	Mass Object (kg)	Calorimeter Mass (kg)	Total Mass (kg)	Water Mass (kg)	T _{initial} water °C	T _{final} °C	T _{initial} object °C	C _{water} (J/g°C)	C _{experimental}	C _{accepted} (J/kg°C)	Error %
								4.186			
								4.186			
								4.186			

9. Repeat steps 2-8 with two other metal objects.