# Lab: Calorimetry and Specific Heat
## *Student Guide*

Edgenuity

## Pre-Lab Information

**Purpose** Explore how the specific heat of a substance can be determined using a "coffee cup" calorimeter.

**Time** Approximately 45 minutes

**Question** How can you determine the specific heat of a metal using a calorimeter?

**Scenario** You work for a company that wants to make cookware. You want to know which metal – aluminum, iron, copper, or lead – is best to use to make pots and pans. The specific heat is a valuable piece of information.

**Criteria** If a metal has a low specific heat, then the metal could make an excellent material for cookware because it takes less heat to raise the temperature of the metal to cook food.

**Summary** You will use a calorimeter to collect data that enables you to calculate the specific heat of all four metals. Then you will use this data and information about cost, density, and safety to determine which metal would make the best cookware.

## Safety

- Always wear a lab coat and safety goggles when performing an experiment.
- Behavior in the lab needs to be purposeful. Use caution when using the hot plate as burns can occur and nearby objects can catch on fire.
- Check glassware, such as beakers, for cracks and chips prior to use.
- Use the right gear such as a test-tube holder (when heating the metal in the test tube) and oven mitts when moving the hot beaker of water.
- Report all accidents—no matter how big or small—to your teacher.
- Do not touch the beaker with the boiling water as severe burns can occur.
- Use gloves when handling the metals. Lead is considered hazardous. Wash hands after the experiment is completed.

## Procedure

**Step 1: Gather Materials**

- Two polystyrene coffee cups
- Lid for polystyrene cup
- Thermometer
- 250 mL beaker
- 400 mL beaker
- Ring stand
- Two buret clamps
- Hot plate
- Four test tubes
- Test-tube holder
- 50 mL graduated cylinder
- Water
- aluminum, copper, iron, and lead powder
- analytical balance

**Step 2: Assemble a "Coffee Cup" Calorimeter**

**a)** Place one coffee cup inside the other. Then, put them inside a 250 mL beaker.

**b)** Cut a small hole in the center of the lid to hold the thermometer. Place the lid on the top cup.

**Step 3: Measure the Masses of the Metals**

Repeat steps (a) through (c) below for each of the four metals: aluminum, copper, iron, and lead.

**a)** Add a piece of weigh paper to the balance. Tare the balance.

**b)** Measure approximately 12 g of aluminum onto the weigh paper. Record the mass to the nearest 0.01 g.

**c)** Place the metal in a test tube, and label the test tube with the metal's name.

**Step 4: Heat the Metals to 100°C in a Hot Water Bath**

**a)** Using a hot plate, heat approximately 200 mL of water in a 400 mL beaker until boiling.

**b)** Place the four test tubes of metal into the boiling water bath. Wait 5 minutes.

Repeat steps 5 through 7 below for all four metals: aluminum, copper, iron, and lead. Before repeating, raise the thermometer and remove the coffee cups and lid. Discard the water down the drain and the metal according to your teacher's directions. Clean and dry the calorimeter.

**Step 5: Measure the Mass of the Water**

**a)** Tare the balance. Put calorimeter (no lid) on the balance. Measure the mass to the nearest 0.01 g. Record in the data table.

**b)** Use a graduated cylinder to add approximately 40 mL of water to the calorimeter. Measure the mass of the calorimeter (no lid) and water to the nearest 0.01g. Record in the data table.

**c)** Subtract to find the mass of the water. Record in the data table.

**Step 6: Reassemble the Calorimeter and Position the Thermometer**

**a)** Place the lid on the upper coffee cup, and place the calorimeter into a 250 mL beaker in order to prevent the calorimeter from wobbling.

**b)** Place the thermometer on a buret holder on a ring stand, and lower the thermometer into the hole in the lid until it makes contact with the liquid.

**c)** Swirl the thermometer slightly, and confirm that the thermometer is not touching the bottom of the cup.

**Step 7: Put the Metal in the Water, and Measure Temperature Changes**

**a)** Measure the initial temperature of the water to the nearest 0.1°C. Record in the data table.

**b)** Raise the thermometer and lid slightly, and add the metal to the calorimeter.

**c)** Observe the increase in temperature every 60 seconds for 300 seconds.

**d)** The temperature at 300 seconds (5 minutes) is the final temperature of both the metal and the water. Record it to the nearest 0.1°C in the data table.

**e)** Subtract to find the temperature changes for the water and the metal. (Remember that the metal was initially 100°C.) Record both values in the data table.

**Step 8: Compute the Specific Heats of Each Metal**

Use your data, the equation below, and the specific heat of water (4.184 J/g°C) to compute the specific heat values of each metal. Use a calculator, and round to the nearest hundredth place.

$$c_{\text{metal}} = -\frac{c_{\text{water}} m_{\text{water}} \Delta T_{\text{water}}}{m_{\text{metal}} \Delta T_{\text{metal}}}$$

**Step 9:** Dispose of all material according to the directions of your teacher.

## Data

**Record all mass data and calculations to the hundredths place**
**Mass of water – Use the following calculation:**
**(Mass of calorimeter no lid + water) – (Mass of calorimeter no lid)**
**Specific Heat of metal – Use the following calculation where ($C_{water}$ = 4.184 J/g°C):**

$$c_{\text{metal}} = -\frac{c_{\text{water}} m_{\text{water}} \Delta T_{\text{water}}}{m_{\text{metal}} \Delta T_{\text{metal}}}$$

| | Aluminum | Copper | Iron | Lead |
|---|---|---|---|---|
| **Mass of Metal $m_{metal}$ (g)** | | | | |
| **Mass of calorimeter no lid (g)** | | | | |
| **Mass of calorimeter no lid + water (g)** | | | | |
| **Mass of water $m_{water}$ (g)** | | | | |
| **Initial temperature of metal (°C)** | | | | |
| **Initial temperature of water (°C)** | | | | |
| **Final temperature of both (°C)** | | | | |
| **$\Delta T_{water}$ (°C)** (Final T both– Initial T water) | | | | |
| **$\Delta T_{metal}$ (°C)** (Final T both– Initial T metal) | | | | |
| **Specific heat of metal $c_{metal}$ (J / g·°C)** | | | | |
| **Cost of metal** | $1.00 / pound | $5.00 / pound | $0.10 / pound | $1.00 / pound |
| **Safety risk** | Slight: corrodes easily when exposed to acidic foods | Slight: toxic at high concentration; can leach from pans | None: source of beneficial dietary iron | Significant: toxic when ingested; can leach from pans |
| **Density of metal ($g/cm^3$)** | 2.70 | 8.92 | 7.87 | 11.30 |