

The **specific heat capacity** of a substance is the amount of heat energy necessary to raise the temperature of 1 gram of a substance by 1°C. It may be thought of as 'heat storing ability.' Every substance has its own specific heat capacity – this physical property relates energy change to temperature change. Materials with low specific heat values need low energy to increase/decrease temperature. The opposite is true of materials with high specific heat – they need high energy to increase/decrease temperature.

Metals have relatively low specific heats. On the other hand, the specific heat of water is relatively high: it is **1 cal / g * °C**. Water will absorb much energy before its temperature increases even slightly. This helps to explain why the climate near a large lake is generally warmer in the winter and cooler in the summer, and why your body (which is nearly 60% water) can tolerate rapid changes in external temperatures.

The relationship between heat and temperature is shown in Big Equation #1 of Thermochemistry:

$$\text{Energy} = (\text{mass of material}) \times (\text{its specific heat}) \times (\text{its change in temp})$$

$$\Delta H = m \times C \times \Delta T$$

Finally, remember that calorimeters work because they let no heat in or out. As a result, the heat energy gained by the water in a calorimeter is assumed to be equal to the heat loss by the metal:

$$\Delta H_{\text{water}} = -\Delta H_{\text{metal}}$$

PROCEDURE: *Reading what your classmates did in the lab will be helpful to answer questions!*

1. Select a metal sample and record its mass.
2. Create a 'Hot Water Bath' using a 250 mL beaker - filled halfway with tap water. Bring the water to a boil.
3. Using crucible tongs or, if your metal sample has a hook, the end of a test tube brush, carefully transfer your metal sample into the boiling water and **continue to boil for an additional 5 minutes** (to ensure that the piece of metal reaches the same temperature as the boiling water).
4. In the meantime, assemble your calorimeter. Place a Styrofoam cup into a 400 mL beaker. Have a thermometer and cardboard lid ready. Finally, measure **exactly** 100 mL of tap water in a graduated cylinder and carefully pour this water into the calorimeter. *Due to water's density 1 mL H₂O = 1 g of H₂O.*
5. Record the temperature of the cool tap water in the calorimeter. This is the initial temperature of water.
6. Following the 5-minute boiling period of your metal sample, record the temperature of boiling water. This is the initial temperature of the metal.
7. Turn off Bunsen burner to stop heating the boiling water.
8. Using tongs, carefully transfer the piece of boiling-hot metal to the calorimeter and cap with lid. Place the thermometer through the center of the lid and be sure the tip is submerged in the water. **DO NOT PUSH TOO HARD OR THE CALORIMETER MAY BREAK!**
9. Gently swirl the sample and container. Watch the thermometer and record the highest temperature reached. This is the final temperature for both the water and the metal.
10. Answer the discussion questions. Note that you will be working in calories. *1 cal = 4.184 J*

DATA TABLE (2 points):

CALORIMETER WATER DATA		METAL DATA	
Mass of tap water (in calorimeter)	100.0 g	Mass of metal	31.93 g
Initial temperature of water (°C)	18.5 °C	Initial temperature of metal (°C)	100.5 °C
Final temperature of water (°C)	20.5 °C	Final temperature of metal (°C)	20.5 °C
Specific Heat Capacity of Water (cal/g•°C)	1 cal/g•°C	Experimental Specific Heat Capacity of Metal (cal/g•°C)	<i>TO BE CALCULATED (in Question # 3)</i>

Actual Specific Heat Capacities (cal/g•°C): Al: 0.215; Cu: 0.092; Zn: 0.093; St. Steel: 0.107; Sn: 0.056; Pb: 0.031 c; Cd: 0.060

ANALYSIS AND CONCLUSION QUESTIONS:

1. The water in the calorimeter gained energy directly from the piece of metal. Determine the amount of **heat** gained by the water. Show the calculation. Express this number in *J* and *cal*. (*HINT: Solve for ΔH*)
2. Assuming a very efficient transfer of energy within the “calorimeter,” how much **energy** was “lost” by the piece of metal? Express this number in *J* and *cal*. (*HINT: Read the introduction*)
3. Determine the **specific heat** of the metal. Show the calculation. (*HINT: You know ΔH from #2*)
4. Determine the **percent error** of your calculated specific heat. The theoretical value is in the footnotes on the first page in $\text{cal/g}\cdot^{\circ}\text{C}$ – make sure your units match. You must show work.
5. Aside from human error, list several experimental conditions/techniques that could lead to inaccuracy of the result. (*HINT: This should be about the calorimeter*)
6. A silver-colored necklace with a mass of 43.0 grams is heated in the drying oven to a temperature of 120.0°C . It is then dropped into a calorimeter containing 95.0 grams of water at 20.0°C . The water and necklace reach a final temperature of 25.5°C . Determine, in Joules and in calories, how much energy the water gained. Calculate the specific heat of the metal.

Silver’s specific heat is $0.0558 \text{ cal/g}\cdot^{\circ}\text{C}$. Was the necklace pure silver? Provide an explanation for your answer.