# CHEMISTRY IH LAB: SPECIFIC HEAT OF A METAL

| WHAT TO TURN IN: Hypothesis, Data Tables (3), Calculations, Error Analysis, Conclusion, Questions #1-7 |
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## Introduction

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 or $c_p$). 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.

**heat lost by hot metal = heat gained by calorimeter water**

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. The specific heat of water is 4.184 J/g°C. We can calculate the specific heat of the unknown metal ($c_m$) using the following equation. Since we are solving for $c_m$ and not the final temperature, we can use absolute value for the left side of the equation.

$$[(m_m)\,(c_m)\,(T_{final,\,m} - T_{initial,\,m})] = [(m_w)\,(c_w)\,(T_{final,\,w} - T_{initial,\,w})]$$

Solving for $c_m$:

$$c_m = \frac{[(m_w)\,(c_w)\,(T_{final,\,w} - T_{initial,\,w})]}{[(m_m)\,(T_{final,\,m} - T_{initial,\,m})]}$$

## Procedure

1) Fill a large beaker approximately half full of water. Place the beaker of water on a hot plate. Turn the hot plate on high. Begin heating the water to the boiling point.
2) Obtain a sample of metal. Determine the mass of the metal to 0.01 g.
3) Obtain a calorimeter cup. You may use the insert of the cup only for measurement. Record the mass to two decimal places.
4) Fill the calorimeter approximately half to two-thirds with distilled water at room temperature and record the mass to two decimal places.
5) Carefully grasp the metal with crucible tongs and transfer it into the water bath. Boil at least 10 minutes.
6) While the metal is still in the boiling water bath, measure the temperature of the water with a thermometer and record to tenths. It will be assumed that the temperature of the metal is the same as the boiling water.
7) Measure the temperature of the water IN THE CUP and record to tenths.
8) After the metal has been heating 10 minutes, remove the water bath from the heat with the beaker tongs. Turn off the hotplate unless instructed otherwise.

9) Remove the metal with crucible tongs, shake off excess water, and quickly place it into the calorimeter cup so that the metal is covered by the water. Immediately cover the calorimeter with its cover.
10) Carefully insert the thermometer through the small hole in the cover. Observe and record the highest temperature reached by the water, to tenths.
11) Remove the calorimeter cover, retrieve and dry the metal. Return metal to its original place. Pour the water down the sink. Rinse and dry the calorimeter cup.
12) Repeat the entire procedure with a different metal.

**Calculations**: show all units

1) Experimental specific heat of metal ($C_m$)
2) Percent error = $\frac{|\text{ACTUAL} - \text{THEORETICAL}|}{\text{THEORETICAL}} \times 100$

**Questions**

1) What is the purpose of this lab?
2) What physical properties, other than specific heat, could you use to help you identify the metal samples?
3) Why is water an excellent material to use in the calorimeter?
4) What substance lost heat in this experiment?
5) What substance gained heat in this experiment?
6) Metals have a lower specific heat than that of water. Was this true in what you observed? Explain.
7) Explain what a "low specific heat" means in terms of heat retention and heat requirements.

**DATA TABLES ON THE NEXT PAGE…**

**DATA TABLE 1: MASS DATA**

| MATERIAL | MASS (g), trial 1 | MASS (g), trial 2 |
|---|---|---|
| Metal | _____ | _____ |
| Calorimeter | _____ | _____ |
| Calorimeter + water | _____ | _____ |
| Water | _____ | _____ |

**DATA TABLE 2: TEMPERATURE DATA**

| MATERIAL | TEMP. (°C), trial 1 | TEMP. (°C), trial 2 |
|---|---|---|
| Boiling water | _____ | _____ |
| Water in calorimeter | _____ | _____ |
| Water in calorimeter after metal was added and temperature stabilized | _____ | _____ |
| $\Delta T$ for the water | _____ | _____ |
| $\Delta T$ for the metal | _____ | _____ |

**DATA TABLE 3: SPECIFIC HEAT DATA**

| | TRIAL 1 | TRIAL 2 |
|---|---|---|
| Experimental specific heat (J/g °C) | _____ | _____ |
| Standard specific heat (J/g °C) | _____ | _____ |
| Percent error | _____ | _____ |