Name ______________________
Lab Partner(s) ______________________
Section ______________________
Date ______________________

Specific Heat of a Metal

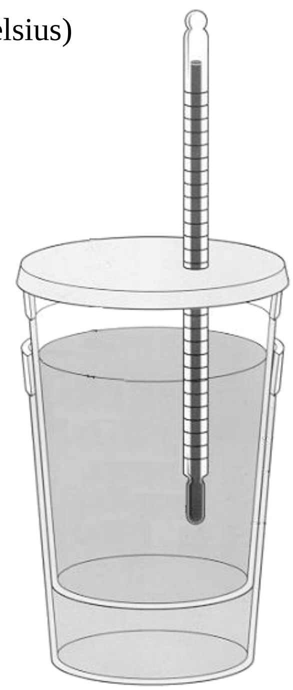
Objective

In this experiment you will use calorimetry to determine the specific heat of a metal.

Introduction

When a substance is heated, the motion of its individual particles increases, resulting in an increase in temperature. The more heat that is added per gram of substance, the greater the temperature change. The relationship between the heat added, the mass of a substance, and the temperature change it undergoes is known as *specific heat*.

$$\text{Specific Heat} = \frac{\text{Energy change in calories}}{(\text{Mass in grams} \times \text{Temperature change in Celsius})}$$



Specific heat is defined as the amount of energy necessary to produce a temperature change of 1°C per gram of substance. The specific heats of different substances vary, and therefore this quantity may be useful in identifying an unknown.

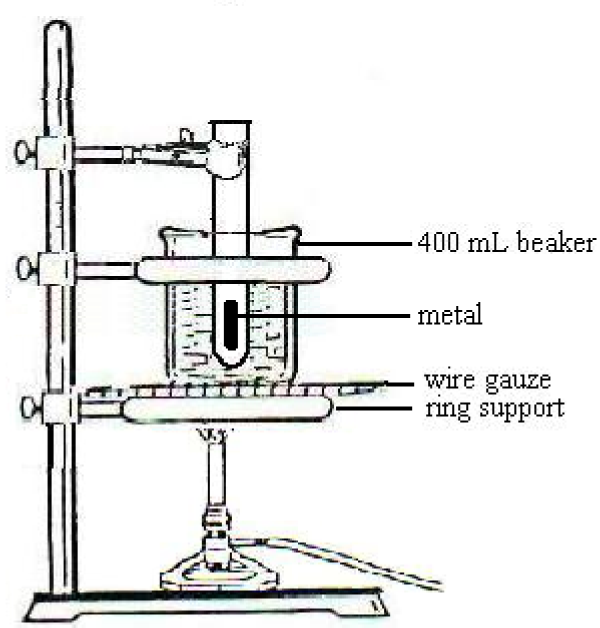
The measurement of heat changes is called *calorimetry*. In this lab, calorimetry will be used to determine the specific heat of an unknown metal. This will be done using a coffee cup calorimeter containing water.

A calorimeter is insulated so as to minimize any loss of energy to the surroundings. Therefore, when a heated piece of metal is placed into the calorimeter, all of the energy should be accounted for. In other words, the energy released from the metal should be gained by the water, with no loss to the surroundings. This is based on the Law of Conservation of Energy, which states that energy is neither created nor destroyed. We will assume no heat loss to the calorimeter.

$$\text{Energy released by metal} = \text{Energy gained by water}$$

There are five measurements that must be made to determine the specific heat of the unknown metal:

1. Determine the mass of the piece of metal.
2. Heat the metal piece to a known temperature and measure this temperature precisely. This is the initial temperature of the metal.
3. Determine the mass of the water in a calorimeter.
4. Measure the temperature of the water in the calorimeter. This is the initial temperature of the water.
5. Place the metal piece into the water of the calorimeter and measure the highest temperature reached by the water. This is the final temperature of both the metal and the water.



The energy change of water is calculated by rearranging the specific heat equation. The specific heat of water is 1.00 calorie/gram°C.

$$\text{Energy Change} = \text{Mass of water} \times \text{Specific heat of water} \times \text{Temperature change of water}$$

Since the energy gained by the water equals the energy released by the metal, the specific heat of the metal is calculated as follows:

$$\text{Specific heat of the metal} = \frac{\text{Energy released by the metal}}{(\text{Mass of metal} \times \text{Temperature change of metal})}$$

Pre Lab Question (answer on separate paper)

If a heated piece of metal is placed into a Styrofoam cup containing water at room temperature, where does the metal's heat go?

Equipment

Unknown metal	Bunsen burner
18 mm x 150 mm test tube	400 mL beaker
Ring stand and supports	Thermometer
Calorimeter (Styrofoam cup)	Boileezers
Test tube holder	Wire gauze

Procedure

1. Obtain a calorimeter. Weigh it as precisely as possible. Fill the calorimeter with about 40 mL (or enough to cover the metal) of distilled water at room temperature. Reweigh the calorimeter.
2. Weigh the unknown metal as precisely as possible (should be at least 25 g). Place the unknown metal into a 18 mm x 150 mm test tube.
3. Set up a water bath using a 400 mL beaker. Fill the beaker halfway with water and add several Boileezers. Place the test tube into the water bath (see figure, right). Heat with a Bunsen burner until the water is boiling. Continue heating for 10 minutes.
4. Measure the temperature of the boiling water. This is assumed to be the initial temperature of the metal piece. It may be necessary to replenish the water in the beaker, as it should not be allowed to boil to dryness. Be sure that the level of the water in the beaker remains higher than the metal piece in the test tube.
5. Measure the temperature of the water in the calorimeter. Immediately remove the test tube from the water bath, using a test-tube holder. Carefully transfer the metal piece into the calorimeter by sliding it out. Use a glass rod to guide it, if necessary. Be careful not to allow any water from the test tube to enter the calorimeter. Do not allow any water from the calorimeter to spatter out.
6. Perform the calculations on the next page. Once you have determined the identity of your metal based on your calculations, see your Lab Assistant. You must bring your metal and your lab to the Lab Assistant in order to have your answer checked and your lab initialed.
7. Cleanup

   Clean your lab area and glassware before being signed out.

Calculations (attach detailed calculations to your data sheet)

1. Determine the change in temperature for both the metal and the water in the calorimeter. Calculate the specific heat of the metal.
2. Calculate the density of your unknown metal by determining its volume and using the mass you have already determined. If your piece of metal will fit into a small 10 mL graduated cylinder, you can use water displacement to find the volume. Add about 2 mL of water to the dry graduated cylinder and find the volume to the proper number of sfs. Then gently slide the metal down the side, being careful not to splash the water out of the cylinder. Then read the new volume of water; the difference is the volume of your metal. Or, you can measure the length and the diameter and calculate the volume. The first is the preferred method.
3. Determine the identity of your unknown metal by comparing its specific heat and density with those in the Table 1 below.

Table 1
Specific Heat and Density of Selected Metals

Element	Specific Heat (cal/g °C)	Density (g/mL)
Aluminum	0.215	2.7
Copper	0.092	8.9
Iron	0.106	7.9
Lead	0.038	11.4
Magnesium	0.243	1.7
Tin	0.052	7.3
Zinc	0.093	7.1
Brass	0.09	8.5

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Report: Specific Heat of a Metal

Data

	Trial 1	Trial 2
Mass of calorimeter	____________	____________
Mass of calorimeter and water	____________	____________
Mass of water	____________	____________
Mass of metal	____________	
Temperature of boiling water bath (initial temperature of metal)	____________	____________
Initial temperature of water in calorimeter	____________	____________
Highest temperature of water in calorimeter	____________	____________

Calculations

Temperature change of metal	____________	____________
Temperature change of water	____________	____________
Specific heat of unknown metal	____________	____________
Average specific heat	____________	
Volume of metal	____________	
Density of metal	____________	

	1st guess	2nd guess
Identity of unknown metal	____________	____________
Instructor's or Lab Assistant's Initials	____________	

Post Lab Questions

1. Explain how you were able to identify the unknown metal. What evidence do you have to support your claim?
2. Which metal would cause the greatest increase in the temperature of the water in the calorimeter: the one with the higher specific heat, or the one with the lower specific heat? Explain.
3. Relative to metals, how does the specific heat of water compare: higher, or lower?
4. If equal masses of two metals are heated to a temperature of 100 °C, which would cause a more severe burn – the one with the higher specific heat or the one with the lower specific heat? Explain.