Minilab [20 pts]
Specific Heat of a Metal

Name ____________________________
Lab Partner ______________________
Period _____ Date ________________

Purpose: To use calorimetry to measure the change in temperature experienced by a metal and by water and to use this data to determine the specific heat of the metal.

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*). 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. Because of conservation of energy, the heat gained by the cooler substance (positive) equals the heat lost by the warmer substance (negative), if we assume no loss of heat to the surrounding environment, so if we can determine one, we know the other.

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 water will increase in T as it gains energy from the metal, which will decrease in T. With the mass of the water in the calorimeter, the specific heat of water (C = 4.184 J/g·°C), and the temperature change of the water (ΔT), the heat gained by the water (q_{water}) can be calculated from Equation 1:

$$q = m \times C \times \Delta T \qquad \text{(Eqn. 1)}$$

Because of the Law of Conservation of Energy, the amount of heat lost by the metal must be equal to the amount of heat gained by the water:

$$q_{metal} = q_{water} \qquad \text{(Eqn. 2)}$$

With the mass of the metal and the temperature change of the metal, Equation 1 can now be used to calculate the specific heat of the metal, C_{metal}.

Procedure

1) Fill a 400-mL beaker approximately ¾-full of water. Place the beaker of water on a hot plate set on high. Place one boiling chip in the beaker to prevent "bumping." Begin heating the water to boiling.
2) Obtain a metal sample. Record the identity of your metal in the data table on page 2.
3) Place a weighing boat on a balance, zero it, and place your metal sample into the boat. Record the mass of your sample in the data table to two decimal places.
4) CAREFULLY transfer the metal to a large test tube. Clamp the test tube, suspending it in the beaker of water, ensuring that the metal is all below the surface of the water. Boil at least 5 minutes.
5) Obtain a double-cup styrofoam calorimeter. Record the mass carefully to two decimal places.
6) Fill the calorimeter approximately half full with distilled water at room temperature and record the mass to two decimal places.
7) Place calorimeter into an empty 250 or 400-mL beaker for support.
8) While the metal is still in the boiling water, measure the **temperature of the hot water** carefully with a thermometer. Record this to one decimal place as the **Initial Temperature of the Metal**.
9) Measure the temperature of the water in the calorimeter. Record to one decimal point as the **Initial Temperature of the Water**.
10) After the metal has been in boiling water for 5 minutes, remove the test tube from the bath (hold it by its clamp). *Immediately* pour the metal into the calorimeter so that the metal is covered by the water.
11) With the thermometer in the water, stir very slowly. Record the **highest temperature** reached by the water to one decimal place as the **Final Temperature** for both the **metal** and the **water**.

12) Remove the metal from the calorimeter and put it in a beaker (labeled with its name) in the oven to dry.
13) Return the vial to the lab bench. Pour the water down the sink. Rinse the calorimeter and return it to the lab bench (do not throw it out!).
14) Determine the experimental value of the specific heat for your metal. Find its actual value below:

metal	specific heat (J/g·˚C)	metal	specific heat (J/g·˚C)	metal	specific heat (J/g·˚C)
aluminum	0.903	chromium	0.469	lead	0.128
bismuth	0.122	copper	0.385	nickel	0.444
cadmium	0.231	iron	0.449	tin	0.218
				zinc	0.388

Data and Calculations

TABLE #1: DATA [5 pts]

Metal Data			Water Data		
Identity of Metal	______________		Mass of Calorimeter	______________	g
			Mass of Calorimeter + Water	______________	g
Mass of Metal	______________	g	Mass of Water	______________	g
Initial Temperature of Metal	______________	°C	Initial Temperature of Water	______________	°C
Final Temperature of Metal	______________	°C	Final Temperature of Water	______________	°C
ΔT of Metal	______________	°C	ΔT of Water	______________	°C

TABLE #2: Calculations [4 pts]

Heat gained by the water*	______________	J
Experimental specific heat of metal*	______________	J/g·°C
Accepted specific heat of metal (record from table above)	______________	J/g·°C
Percent error*	______________	%

*Show calculations for these values

Questions (Answer on separate sheet and attach to lab sheet)

1) [1 pt] What is heat?
2) [1 pt] In what direction does heat always flow?
3) [1 pt] Why is water a good liquid to use in a calorimeter?
4) [2 pts] How much heat is released when 25.0 g of water is cooled from 85.0ºC to 40.0ºC?
5) [2 pts] Calculate the specific heat of a metallic element if 314 joules of energy are needed to raise the temperature of a 50.0 g sample from 25.0˚C to 50.0˚C.
6) [2 pts] Chloroform is a liquid that can be used in place of water for measuring the specific heat of materials that react with water. If a sample of chloroform is initially at 25°C, what is its final temperature if 150.0 g of chloroform absorbs 1.00×10^3 joules of heat, and the specific heat of chloroform is 0.96 J/g·°C?
7) [2 pts] What is the final temperature of a 50.0 g piece of glass if it absorbs 5275 joules of heat and its specific heat capacity is 0.50 J/g·°C? The initial temperature of the glass is 20.0°C. [Think: what direction does the temperature go?]