Specific Heat of a Metal Lab

Objectives:

- Determine the specific heat of a metal.
- Calculate percent error of experimental results

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_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 = heat gained

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. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT) and knowing the specific heat of water (4.184 J/g °C) the heat gained by the water (lost by the metal) can be calculated as follows:

$$\mathbf{Q = (m)(\Delta T)(C)}$$

heat gained by the water	=	*mass of water (g)*	x	*change in temperature (ΔT)*	x	*specific heat of water (4 .184 J/g °C)*

The specific heat of the metal can now be calculated:

$$\textit{Specific heat, } \boldsymbol{C} = \frac{\textit{heat gained by the water, } \boldsymbol{Q}}{\textit{of metal mass of metal (g) } \boldsymbol{m} \quad x \quad \boldsymbol{\Delta T} \textit{ of metal (°C)}}$$

Procedure

1) Fill a large beaker approximately half full of water. Place the beaker of water on a hot plate. Begin heating the water to the boiling point.

2) Measure the mass of a metal sample. Record the letter engraved on metal sample and the mass in the data table. ⑤

3) Place the metal sample into the beaker of boiling water and allow it to heat until Step 7.

4) Obtain a calorimeter cup. Record the mass carefully to two decimal places. ①

5) Fill the inside compartment of the calorimeter approximately half full with water. (Make sure there is enough water to cover your mass sample.) Record the mass in the data table. ②

6) Measure the temperature of the water in the calorimeter cup. Record the temperature. ③

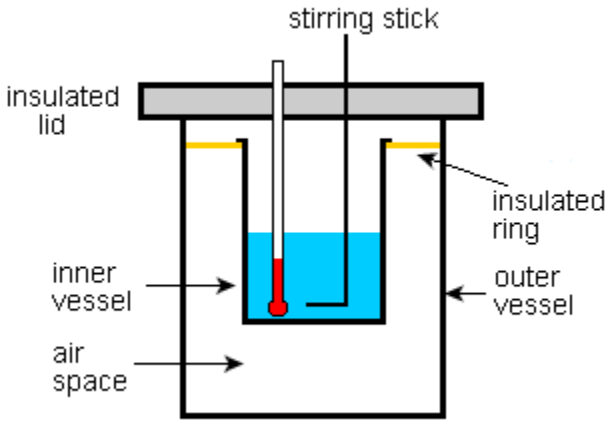
7) While the metal is still in the boiling water bath, measure the temperature of the water carefully with a thermometer and record in the data table. (It will be assumed that the temperature of the metal is the same as the boiling water.)④

8) CAREFULLY remove the metal from the boiling water and quickly transfer the metal to the water in the calorimeter.

9) Swirl the water in the cup to even out temperature differences. At the same time, observe the thermometer, the temperature should be rising, when the temperature has stopped rising the metal and the water are at equilibrium. Record the temperature in the data table. ⑥

10) Remove the calorimeter cover, retrieve and dry the metal. Return metal to its original place. Pour the water down the sink. Rinse and dry all equipment.

11) Repeat the **entire** procedure with a different metal if time permits.



Specific Heat of a Metal
Data Table

	Unknown Metal 1 ____ *(letter)*	**Unknown Metal 2** ____ *(letter)*
①Mass of empty calorimeter		
②Mass of calorimeter with water		
Mass of water only		
③Temperature of water (Initial)		
⑥Temperature of water at equilibrium (Final)		
Change in temperature, ΔT		
Specific heat of water, C	4.184 J/g°C	4.184 J/g°C
Heat gained by water, Q		
⑤Mass of metal		
④Temperature of metal (Initial-same as boiling water)		
⑥Temperature of metal (Final-after cooling in calorimeter)		
Change in temperature, ΔT		
Heat lost by metal, Q		
Experimental specific heat of unknown metal, C		
Theoretical specific heat of unknown metal (Check with me!)		
Percent Error		

Specific Heat of a Metal
Calculations

1. Calculate the mass of the water only.
mass of calorimeter with water minus the mass of empty calorimeter.

2. Calculate the temperature change for the water.
final temperature of water at equilibrium minus the initial temperature of water.

3. Calculate the heat water gained from the metal.
Q= (mass of water)(change in temperature)(specific heat of water)

4. Calculate the temperature change for the metal.
final temperature of metal at equilibrium minus the temperature of metal when it was hot.

5. Calculate the experimental specific heat of the unknown metal.

$$C = \frac{\textit{heat lost by metal}}{\textit{(mass of metal) (temperature change for the metal)}}$$

6. Calculate the percent error.

$$\%\ \text{error} = \frac{\text{experimental value of specific heat} - \text{theoretical value of specific heat}}{\text{theoretical value of specific heat}} \times 100$$

Follow Up Questions

1) What substance lost heat in this experiment?

2) What substance gained heat?

3) 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.