I. Objectives

1. Use a calorimeter to calculate the specific heat of two different metals.
2. Investigate the relationship between Centigrade degrees and Kelvins.

II. Introduction

This lab utilizes glassware and hot water. You must wear closed-toed shoes during this entire lab.

Energy can be neither created nor destroyed. As a result, consistent with the conservation of energy, objects at different temperatures come to equilibrium temperature when placed in contact. If there is no heat loss to the surroundings, the heat lost by the hotter part of the system equals the heat gained by the cooler part.

The specific heat of water is 1 *calorie/gram* C^0 = 4.186 *joule/gram* C^0 which is higher than any other common substance. Pay careful attention to the units! As a result, water plays a very important role in temperature regulation. The specific heat per gram for water is much higher than that of a metal.

The calorimeter is an insulated cup fitted with a top in which there is a hole for a thermometer. A mass can be suspended by a string.

III. Calculations

The specific heat is the amount of heat per unit mass required to raise the temperature of a substance by one degree Celsius. The relationship between heat and temperature change is usually expressed as:

$$\Delta Q = cm\Delta T$$

where ΔQ is the change in heat, c is the specific heat capacity, m is the mass of the substance, and ΔT is the change in temperature. The relationship does not apply if a phase change is encountered, because the heat added or removed during a phase change does not change the temperature.

In this lab, we will measure the specific heat of a metal in a closed system:

$$\Delta Q_{metal} = \Delta Q_{water}$$

$$c_{metal} m_{metal} \Delta T_{metal} = c_{water} m_{water} \Delta T_{water}$$

$$c_{metal} m_{metal} (T_{heated\ metal} - T_{equilibrium}) = c_{water} m_{water} (T_{equilibrium} - T_{water\ room\ temperature})$$

or more simply as:

$$c_m m_m (T_m - T_e) = c_w m_w (T_e - T_w)$$

$$c_m = \frac{c_w m_w (T_e - T_w)}{m_m (T_m - T_e)}$$

Finally calculate the percent error between the actual and experimental values of c_m:

$$\%\ error = \frac{experimental\ c_m - actual\ c_m}{actual\ c_m} x\, 100$$

IV. Equipment and Materials

Calorimeters with thermometers, water, hot plate, 1,000 mL beaker, thermometer, aluminum, brass, lead, and steel cubes, 600 gram balance, string, calculator

V. Procedure

1. Fill a 1,000 mL beaker with at least 600 mL of water and heat the beaker on the hot plate until it boils.

2. While the water is heating determine the masses, m_c, of two empty calorimeters with the lids and thermometers on. You will need to determine both masses, since they should be very similar, but not necessarily absolutely identical.

3. Partially fill both calorimeters with water and allow them to come to equilibrium room temperature. Use enough water so that when one of the metal cubes is immersed in the calorimeter that it will be completely covered, but not enough water that it will overflow. If you need to check, remove the metal cubes from the calorimeter before continuing.

4. Measure the mass of each calorimeter plus water and record the masses, m_{w+c}.

5. Calculate the mass m_w of water in each calorimeter by subtracting m_c from m_{w+c}.

6. Record the equilibrium room temperature T_w of the water in each calorimeter separately, since they may not be the same.

7. Select two of the metal cubes and obtain their masses. Be sure that you are able to identify which of the metal cubes you have selected.

8. Attach a length of string to each metal cube hook.

9. Be sure that strings are securely attached, hold the ends of the string, and place the metal samples carefully into the boiling water.

10. Carefully insert a thermometer into the beaker.

11. Allow the water to again come to a boil for at least 10 more minutes. The temperature of the metal cubes T_m should now be the same as the water.

12. Remove the two metal cubes, one at a time, from the boiling water and place one in each of the two calorimeters. **Put the lids on carefully. Do not break the thermometers!**

13. Put lids on the calorimeters, with thermometers in the corks of the lids. Watch the temperature change carefully, stirring the water occasionally by gently moving the calorimeter, not by moving the thermometers.

14. Once the system is at equilibrium and the temperature stops changing, record the equilibrium temperature T_e of the water in each of the calorimeters.

15. Complete Tables 1, 2, and 3 and see your text or search on the Internet for actual values for the specific heats of the metals you used.

VI. Data

Table 1 Mass

A	B	C	$D = C - B$	E
	Mass m_c of empty calorimeter in kg	Mass m_{w+c} of calorimeter plus water in kg	Mass m_w of water in kg	Metal mass m_m in kg
Metal #1				
Metal #2				

Table 2 Temperature

A	B	C	D	E	F
	Water room temperature T_w in ^{0}C	Metal temperature T_m in ^{0}C	Equilibrium temperature T_e in ^{0}C	$T_e - T_w$ in C^0	$T_m - T_e$ in C^0
Metal #1					
Metal #2					

Table 3 Specific Heat

A	B	C	D	E	F	G
	$c_w m_w (T_e - T_w)$ in joules	$m_m (T_m - T_e)$ in kg C^0	Experimental c_m in joules/kg C^0	Metal	Actual c_m in joules/kg C^0	Percent error
Metal #1						
Metal #2						

VII. Discussion Questions

1. Compare the experimental and actual values of the specific heats. How close are they?

2. What experimental procedures or processes could account for any differences?

3. What conversion did you need to perform on the number for the specific heat of water given in this lab in order to use it in the calculations needed for the values in Table 3? Show your work.

4. What is the relationship between the size of 1 Kelvin and 1 Centigrade degree?

5. Explain why it is unnecessary to convert any of the values in this lab to Kelvins and why 4.186 *joule/kg* C^0 = 4.186 *joule/kg K*