Name: ____

Lab 10. Specific Heat Capacity

Introduction

The property of matter that describes temperature's response to applied heat is called the *specific heat capacity*. In this experiment, you will determine the specific heat capacity of a metal sample.

When the hot metal contacts the cool water, heat flows from the hot metal to the cool water until they come to thermal equilibrium at the same temperature. We will make the approximation that there is no heat flow between the system (water + metal) and the surroundings (everything else). Thus, the energy lost from the metal as it cools is exactly the same as the energy gained by the water as it warms.

You will heat a metal piece to a known temperature (that of boiling water) and then measure how much its temperature drops when it is placed in a cup of cool water. The measured change in temperature will allow you to calculate the block's heat capacity.

The heat input q to the water raises its temperature an amount $\Delta T_{\mathrm{w}} = \frac{q}{c_{\mathrm{w}} M_{\mathrm{w}}}$, where c_{w} is the specific heat capacity of water and M_{w} is the water's mass. In the same way, the heat output q from the metal lowers its temperature an amount $\Delta T_{\mathrm{m}} = -\frac{q}{c_{\mathrm{m}} M_{\mathrm{m}}}$, where c_{m} and M_{m} are the metal's specific heat capacity and mass. These two equations contain two unknown quantities between them: q and c_{m}. Your job is to find c_{m}.

Materials

- tongs
- hot plate
- foam calorimeter with lid
- timer
- cool water
- cooking pan
- thermometer

Procedure

1. Measure the mass of your metal block. Record this and subsequent data in Table 1.
2. Measure the mass of the empty foam cup. Enter in the data table.
3. Place the metal block in the cup and add just enough water to cover the block.
4. Remove the block and transfer into the pan of boiling water. Record the temperature T_{m} of the boiling water. Record it in the data table.
5. Make sure that there is enough water in the pan that the block is completely covered. Heat the block in boiling water for at least three minutes. If the water stops boiling when you add the block, wait until it resumes boiling and start timing then.

6. Measure the mass of the calorimeter containing the cool water.
7. Subtract the mass of the empty cup to find the mass M_w of the water inside. Enter this value in the data table.
8. Just before removing the metal block from the boiling water, stir the cold water in the cup and measure its temperature T_1. Record this value in the data table.
9. Use tongs to remove the metal block from the boiling water and immediately place it in the cup. Swirl until the temperature of the water in the cup stops increasing. Record this value T_f in the Table.
10. Carry out the same measurements with a second metal sample.

Calculations

1. Calculate the temperature changes of the water and the metal block. The temperature change of each substance is its final temperature minus its initial temperature. Enter these values in the Calculations Table. Make sure you have the correct signs for the two ΔT's!
2. Calculate the heat q added to the water to raise its temperature. Enter into the Calculations Table.
3. (2 points) The heat added to the water came from the metal. In the formula for the heat transferred from the metal $q = M_m c_m \Delta T_m$, you now know q, M_m, and ΔT_m. You don't know c_m, the specific heat capacity of the metal. Rearrange the formula to solve for c_m.
4. Calculate the unknown specific heat capacity of the metal (c_m) using the formula you just derived. (Don't forget the units!) Enter into the Calculations Table.

Data Table (6 points)

	Block 1	**Block 2**
Description of block:		
Mass of block (M_m):		
Mass of empty cup		
Mass of cup with water		
Temperature of boiling water (T_m)		
Temperature of cool water before immersion of block (T_1):		
Final temperature of equilibrated calorimeter water + block (T_f):		

Calculations Table (10 points)

	Block 1	**Block 2**
Mass of water in cup (M_w)		
Temperature change of water $\Delta T_w = T_f - T_1$		
Temperature change of block $\Delta T_m = T_f - T_m$		
Heat transferred to water $q = M_w c_w \Delta T_w$		
Specific heat of metal c_m		

Questions

1. (2 points) In this analysis, we assumed that all the heat that went out from the metal block went into the water. Is that a reasonable assumption? Where else could the heat from the metal block have gone?

2. (2 points) In this analysis, we assumed that all the heat that went into the water came from the metal. Is that a reasonable assumption? Where else could the water have gotten heat from?

Report

Turn in this lab sheet with the data and calculations tables completed and questions answered.

Scoring

Points will be allocated as specified above in these instructions for your Data Table, Calculations Table, the questions, and for finding the formula for the heat capacity of the metal. In addition, 8 points are allocated for your skill, effort, and focus in lab. Keep your work station neat, use careful technique, work safely, and clean up after yourself.