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Specific Heat and Calorimetry

Experimental Objective

The objective of this experiment is to determine the specific heat of two metals using a calorimetric procedure called the method of mixtures.

Theory

Heat is energy that is transferred from one system to another because of a difference in temperature. The amount of heat, *Q*, required to raise the temperature of a solid body depends on a change of temperature, ΔT, the mass of the body, *m*, and its specific heat, *c*.

$$Q = cm\,\Delta T \qquad (1)$$

The specific heat, c, is the heat capacity per unit mass. The heat capacity, *C*, is the heat energy needed to raise the temperature of a solid body by 1 ^{o}C.

In this experiment you will measure the specific heat of two different metals by studying the heat interchange between a sample of each metal and a mass of water. This process is called calorimetry. When two bodies that are initially at different temperatures are placed in contact in time they will come to equilibrium at some intermediate temperature. Provided that no heat is lost to or gained from the surroundings, the quantity of heat lost by the hotter body is equal to that gained by the colder body. This is the process which occurs in the method of mixtures that you will use. You will heat the metal sample in boiling water, then quickly transfer it to an aluminum calorimeter cup which contains cold water of known temperature. When the metal sample and calorimeter cup come to equilibrium the temperature is measured using the thermistor. It is assumed that the transfer of heat between the thermistor and the system is small enough to be neglected. In arriving at this equilibrium temperature, the water and calorimeter must have gained the heat lost by the metal sample. This is expressed by the relation

$$Mc(t_1 - t_2) = (mc_w + m_1c_1)\,(t_2 - t_3) \qquad (2)$$

where M is the mass of the metal sample in grams, c is the specific heat of the metal, t_1 is the initial temperature of the metal sample, t_2 is the final equilibrium temperature, t_3 is the initial temperature of the water and calorimeter, m is the mass of the water, m_1 is the mass of the calorimeter cup, c_1 is the specific heat of the aluminum calorimeter cup, and c_w is the specific heat of water, which is 1 cal/g-^{o}C.

Equipment Needed

Calorimeter	Sample Cylinder #1
Steam Generator	Sample Cylinder #2
Balance	Thermistor Probe
Clamps and Rods	Thermistor Sensor
Three-legged Stand	500 cm^3 Beaker
BNC Adapter	Ice

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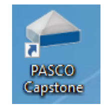
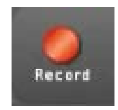
PART A: Computer and Equipment Setup

1. Plug the temperature sensor into port B of the “ANALOG INPUTS” in the 850 data collection box. Note that the 8 pin DIN connector must be inserted with the arrows on top.
2. Double click the PASCO Capstone icon to start the software.



3. Click on the “Hardware Setup” icon.

4. You should see an image of the 850 box. Click on the port B plug in “ANALOG INPUTS,” and choose “Temperature Sensor, Stainless Steel.” A few of the temperature sensors in the lab room are of a different type, so if your temperature reading seems incorrect, it might be necessary to try choosing another type during this step.
5. Click again on “Hardware Setup” to dismiss it.



6. The “Record” button should now be red, indicating that the sensor can collect data.
7. Double click on the graph icon (on the right-hand side of the window) to bring up graph in the main page.
8. Click <Select Measurement> on the vertical axis of the top graph and choose “Temperature.”
9. When the experiment is finished, you can kill the Capstone window. When you’re asked whether to save changes, click “Discard.”

PART B: Equipment Setup and Data Acquisition

4. Get about 800 cm^3 of water and pour it into the steam generator. Turn the steam generator on to a setting of 10. Note that it will take the steam generator 10 to 15 minutes to heat the water.

5. Weigh the empty calorimeter cup. Record the mass in grams in the Data Table.

6. Weigh sample cylinder #1. Record the mass in the Data Table and indicate metal used.

7. Tie a string to the hook on the cylinder and using the three-legged stand, rod and clamp suspend the sample cylinder above the steam generator. Lower the cylinder into the water making sure that the cylinder is completely immersed but not touching the bottom or sides of the steam generator.

8. Use the thermistor probe to measure the room temperature by pressing ‘Record’ in Capstone. Once the temperature reading stabilizes record the room temperature in the Data Table.

9. Pour cold water into the calorimeter cup until the cup is about half full. Add a small amount of chipped ice to adjust the temperature of the water to be about 3^o

below room temperature. Weigh the calorimeter cup with the water in it. Record the mass in the Data Table.

10. Replace the calorimeter in its insulating jacket and measure the temperature of the water with the thermistor probe. Record this temperature in the Data Table.
11. If the water in the steam generator has been boiling for a while, measure the temperature of the water. Record this temperature in the Data Table.
12. Quickly transfer the cylinder from the steam generator to the calorimeter. Stir the water with the thermistor probe and measure the equilibrium temperature. Record in the Data Table.
13. Repeat steps #5 - #12 for cylinder #2.

Lab Report

Mass of calorimeter cup ____________________

Specific heat of aluminum calorimeter cup ______________

Data Table

	Cylinder #1: ___________	Cylinder #2: __________
Mass of cylinder		
Mass of calorimeter and cold water		
Mass of cold water		
Room temperature		
Initial temperature of cold water		
Temperature of boiling water		
Equilibrium temperature		
Calculated specific heat		
Given value specific heat		
Percent error		

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Calculations:

1. Calculate the specific heat of cylinder #1 from the data of steps #5 – 12.

2. Calculate the specific heat of cylinder #1 from the data of steps #13.

3. Find the percent error by comparing your results with the given values for specific heat for each cylinder.

Questions:

1. What is the purpose of starting with the temperature of the water lower than room temperature and ending with it about the same amount above room temperature?

2. How would the computed value of the specific heat be affected if some boiling water were carried over with the metal?

3. How would your computed value of the specific heat be affected if some water originally in the calorimeter cup is splashed out during the sample transfer?

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4. What are possible sources of error in your experiment?