Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_\_\_\_

**LAB: Specific Heat (Calorimetry)**

**Background**

How much heat energy is needed to warm up a pot of water to boiling? How do utility companies know how much heat energy was used to heat a home in the winter? The amount of energy transferred as heat cannot be measured directly, but can be determined by measuring changes in temperature. Today we will calculate this heat transfer using a calorimeter.

**Calorimeter**



A calorimeter is a device that measures the specific heat of a substance. The polystyrene cup, used as a calorimeter, insulates the water-metal system from the environment. Since energy always flows from a hotter object to a cooler one and the total energy of the closed, isolated system always remains constant, the heat energy (Q) lost by one part of the system is gained by the other:

Q lost by the metal = Q gained by the water

In this lab, you will determine the specific heat of at least 2 different metals. You will heat a metal to a known temperature and put it in the calorimeter containing a known mass of water at a measured temperature. You will measure the final temperature of the water and metal in the calorimeter. Given the specific heat of water and the temperature change of water you can calculate the heat gained by the water which is also the heat lost by the metal. You will need the following formula:

Qgained by the water = mwater \* ΔTwater \* Cwater

 Q lost by metal

 Cmetal =

 mmetal \* ΔTmetal

**Materials**

* 2 Styrofoam cups
* Lid for a Styrofoam cup
* 400mL, 600mL Beaker
* Thermometer
* Graduated Cylinder
* Cold Water
* Hot Water
* Unknown Metal
* String

**Data Table #1: Unknown Cube #1**

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial 1** | **Volume** | **Initial Temp.** | **Final Temp.** |
| **Cold water** |  |  |  |
|   | **Mass** | **Initial Temp.** | **Final Temp.** |
| **Cube**  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial 2** | **Volume** | **Initial Temp.** | **Final Temp.** |
| **Cold water** |  |  |  |
|   | **Mass** | **Initial Temp.** | **Final Temp.** |
| **Cube** |  |  |  |

**Data Table #2: Unknown Cube #2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial 1** | **Volume** | **Initial Temp.** | **Final Temp.** |
| **Cold water** |  |  |  |
|   | **Mass** | **Initial Temp.** | **Final Temp.** |
| **Cube** |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial 2** | **Volume** | **Initial Temp.** | **Final Temp.** |
| **Cold water** |  |  |  |
|   | **Mass** | **Initial Temp.** | **Final Temp.** |
| **Cube** |  |  |  |

**Procedure**

**Figure 1: Constructing a Calorimeter**

**Part 1: Setting up the Lab** *(Some of this may be already done for you)*

1. Turn on the hot plate to a setting between 8-9.
2. Carefully place a **600 mL** beaker that is two thirds full with DI water on the hot plate.
3. Attach a string tightly to an unknown cube (metal, then plastic) and place the metal in the beaker of boiling water.
4. One lab member hold the string away from the hot plate for 5 minutes while the group continues.
5. Construct a calorimeter from two Styrofoam cups:
	1. Place the whole Styrofoam cup into the **400mL beaker** so it doesn’t fall over**.**
	2. Nestle the cut Styrofoam cup inside of the whole Styrofoam cup.
	3. Using a thermometer, carefully make a small hole in the center of the base of the small cup. (Refer to the picture as a model.)

**Part 2: Analysis of an Unknown Cube**

1. Use a graduated cylinder to measure 75mL of cold water. **Record the exact volume to the nearest 0.1mL in Table 1.**
2. Pour the cold water into your calorimeter. Record the temperature of the cold water. Measure the temperature every minute until the temperature stays constant for 1-2 minutes. This constant temperature will be used as the initial temperature for the cold water.

**DO NOT USE THE THERMOMETER TO STIR ANYTHING.**

1. After the cube has been soaking in the boiling water for 5 minutes, take the temperature of the water in the 600 mL beaker on the hot plate. *You can assume the metal and the water are now the same temperature so record this temperature for the initial temperature of the metal in table 1.*
2. Carefully pick up the cube in the beaker using the string. **BE CAREFUL: the cube will be very HOT.** Immediately transfer the cube into the calorimeter with the cool water. Put on the lid and gently swirl the beaker for 15 seconds. Record the highest temperature attained by the mixture (but make sure the thermometer is NOT touching the metal) as the final temperature for the cube and cool water.
3. Discard the water in the calorimeter down a working sink.
4. Repeat steps 1-10 for the 2nd trial using the same cube. Be sure to record all data in the data table.
5. Repeat steps 1-10 for the second unknown cube (plastic). Make sure to do two trials.
6. Once you are finished, TURN OFF THE HOT PLATE and start cleaning up your lab stations.
7. Return to your seats and start working on the lab report.

**LAB REPORT TO BE COMPLETED ON A SEPARATE SHEET OF PAPER**

 **WORTH 49 POINTS: DUE FRIDAY 10/17/2014**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lab Report Title: Specific Heat Lab (1 point)****Procedure:**  Write two paragraphs summarizing what you did. The first paragraph should summarize the set up of the lab, and the second paragraph should summarize the process for collecting data on the cubes. Remember the procedure must be written in paragraph form, past tense, and non-person voice. This means NO PERSONAL PRONOUNS (I, me, you, we, they, he/she, etc.) and do NOT refer to a person (“the scientist”, “the students”…) **(4 points for each part, 8 points total)****Data Table:** Construct an organized data table for the unknown cubes. Include volume and temperature of water and mass and temperature of the unknown metal. Don’t forget UNITS! **(1 point for each trial, 12 points total)****Calculations:** Show all work and make sure to include UNITS with the final answer. **(7 points for each cube [.5 point for each trial], 16 points total)*****Note: Show Calculations for Trial 1 AND Trial 2 to receive full credit.***1. Assuming that 1.00g/mL is the density of cool water, calculate the mass of cool water used in the calorimeter.
2. Calculate ΔT of **(a)** the cool water and **(b)** the cube.
3. Calculate the heat absorbed by the cool water (use proper sign and units).
4. Calculate the heat released by the cube. (HINT: qmetal+ qcold = 0)
5. Calculate the specific heat of the cube using the equation found in the Background.
6. What is the identity of the cubes given the following information? **Support your claim with evidence. Write in COMPLETE sentences.**

|  |  |
| --- | --- |
| **Metal** | **Specific Heat (J/g ·°C)** |
| Brass | 0.380 |
| Copper | 0.386 |
| Zinc | 0.390 |
| Steel | 0.420 |
| Iron | 0.449 |
| Aluminum | 0.897 |
| Acrylic | 1.433 |
| Glass | 0.843 |
| Chalk | 0.906 |
| Polypropylene | 1.939 |
| Nylon | 1.700 |

1. Calculate the % error of the calculated specific heat and the theoretical specific heat.

$$Percent error = \frac{experimental value – theoretical value}{theoretical value} × 100\%$$**Final Data Presentation:** Attach the final data presentation found on the last page of this handout to your lab report. Include all answers with UNITS in the data presentation. (**6 points per cube, 12 points total**) | Lab **Owner** Name:**Title**: \_\_\_\_\_/1**Procedure, Part 1**: (setting up)In past tense: \_\_\_\_\_\_/1In paragraph form: \_\_\_\_\_\_\_/1Summary of what was done: \_\_\_\_\_/1Non-person voice \_\_\_\_\_\_\_/1**Procedure, Part** **2**: (cubes)In past tense: \_\_\_\_\_\_/1In paragraph form: \_\_\_\_\_\_\_/1Summary of what was done\_\_\_\_\_/1Non-person voice \_\_\_\_\_\_\_/1**Data Tables**: **(1 point/trial)****Table 1**: (Unknown cube 1)All boxes complete: \_\_\_\_\_\_/2Values make sense: \_\_\_\_\_\_/2Neat/Readable: \_\_\_\_\_\_\_/2**Table 2**: (Unknown cube 2)All boxes complete: \_\_\_\_\_\_/2Values make sense: \_\_\_\_\_\_/2Neat/Readable: \_\_\_\_\_\_\_/2**Calculations:** **Trials 1 & 2 (.5 point each)****Cube 1:** Question 1: \_\_\_\_\_/1 Question 2a: \_\_\_\_\_/1 Question 2b: \_\_\_\_\_/1 Question 3: \_\_\_\_\_/1 Question 4: \_\_\_\_\_/1 Question 5: \_\_\_\_\_/1 Question 6: \_\_\_\_\_/1 Question 7: \_\_\_\_\_/1 **Cube 2:**Question 1: \_\_\_\_\_/1 Question 2a: \_\_\_\_\_/1 Question 2b: \_\_\_\_\_/1 Question 3: \_\_\_\_\_/1 Question 4: \_\_\_\_\_/1 Question 5: \_\_\_\_\_/1 Question 6: \_\_\_\_\_/1 Question 7: \_\_\_\_\_/1 **Final Data Presentation:**Cube #1 is completely filled in with correct units \_\_\_\_\_\_/6Cube #2 is completed filled in with correct units \_\_\_\_\_/6**TOTAL POINTS EARNED:** \_\_\_\_\_\_/49Lab **Grader** Name: |

**Final Data Presentation:**

Cube #1:

|  |  |  |  |
| --- | --- | --- | --- |
| Calculation # |  | **Trial 1** | **Trial 2** |
| **From Lab****Data Table** | **Mass of Cube** |  |  |
| **From Lab Data Table** | **Volume of Water** |  |  |
| **1** | **Mass of Cool Water** |  |  |
| **From Lab Data Table** | **Ti of Water** |  |  |
| **From Lab Data Table** | **Ti of Hot Cube** |  |  |
| **From Lab Data Table** | **Tf of Water and Cube** |  |  |
| **2a** | **ΔT of Cube** |  |  |
| **2b** | **ΔT of Water** |  |  |
| **3** | **ΔQ of Water** |  |  |
| **4** | **ΔQ of Cube** |  |  |
| **5** | **Specific Heat of Cube** |  |  |
| **6** | **Identity of Cube** |  |
| **7** | **% Error** |  |  |

Cube #2:

|  |  |  |  |
| --- | --- | --- | --- |
| Calculation # |  | **Trial 1** | **Trial 2** |
| **Data TablePart 2** | **Mass of Cube** |  |  |
| **Data TablePart 2** | **Volume of Water** |  |  |
| **6** | **Mass of Cool Water** |  |  |
| **Data TablePart 2** | **Ti of Water** |  |  |
| **Data TablePart 2** | **Ti of Hot Cube** |  |  |
| **Data TablePart 2** | **Tf of Water and Cube** |  |  |
| **7a** | **ΔT of Cube** |  |  |
| **7b** | **ΔT of Water** |  |  |
| **8** | **ΔQ of Water** |  |  |
| **9** | **ΔQ of Cube** |  |  |
| **10** | **Specific Heat of Cube** |  |  |
| **11** | **Identity of Cube** |  |
| **12** | **% Error** |  |  |