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**SPECIFIC HEAT OF METALS LAB**

**Background**

On a sunny day, the water in a swimming pool might only warm up a degree or two while the concrete around the pool may become too hot to walk on with your bare feet. This may seem strange because both the concrete and the water are being heated by the same source – the sun. Considering this evidence, one might assume that it takes more heat to raise the temperature of some substances than others. This is, in fact, true. The amount of heat needed to raise the temperature of 1 gram of a substance by 1°C is called the *specific heat capacity*, or simply the *specific heat*, of that substance. Water has a specific heat value that is significantly higher in comparison with the specific heats for other materials, such as concrete or various metals. That is why it takes more heat to cause a temperature increase in water when compared to other substances, and, that is why water can maintain a nearly constant temperature when the temperature of the air around it varies. Water has a specific heat of 4.18 J/g°C where J represents joules, a unit of heat, g is mass in grams, and C is temperature in Celsius. Many metals have a specific heat that is less than 1 J/g°C.

The following equation shows how the heat gained or lost is related to the specific heat capacity of a substance, as well as the mass of the substance and the temperature change of the substance.

**q (J) = Cp(J/g°C) x mass (g) x ΔT(°C) q = heat gained or lost Cp = specific heat capacity**

When objects at different temperatures are put together, a temperature change in both objects occurs due to the heat flowing from the warmer object to the cooler object. When a metal sample at a high initial temperature (such as the temp of boiling water) is placed into a calorimeter containing a known quantity of water at a lower temperature, the metal sample and the water in the calorimeter will come to thermal equilibrium, meaning both materials will be at the same final temperature. If you know the specific heat of one object as well as the mass and change in temperature, the specific heat of the second object can be determined. Because the heat lost by one object is absorbed by the other, the heat value is the same but the sign is opposite.

**q(object A) = -q(object B) or, in this lab, q(water) = -q(metal)**

In this experiment you will identify 2 metals by determining the specific heat of each one. The specific heat you determine will be based on the temperature change for both the water and the piece of metal, as well as measurements of mass.

**Pre-Lab Questions:**

1. List three factors that determine the amount of heat involved in changing the temperature of a substance.
2. Explain what happens (on a molecular level) when a hot metal is placed into a sample of cool water? Include the temperature change for the metal and the water and kinetic energy.
3. Determine how much heat is required to raise the temperature of 175 g of water from 23.0°C to 88.0°C. Use the equations and the specific heat of water in the background information.
4. Determine the specific heat of a metal if a 15.0g sample loses the heat calculated above when it goes from 95.0 to 34.0.

**Problem Statement:** Write a problem statement, according to the EDR.

**Design**

**Materials:**

metal sample thermometer calorimeter (Styrofoam cup) hot plate

400 or 250 mL beaker tongs 100 mL graduated cylinder

**Safety:** Be careful using hot plates. Do not drop the metal into the glass beaker.

**Procedure:**

1. Make a data table to record the metal, mass of the metal, mass of the water, initial temperature of metal, final temp of metal, initial temp of water in calorimeter, and final temp of water in the calorimeter. Allow for 2 metals. Write metals and water in the left column and mass and temperature across the top.
2. Prepare a boiling water bath using about 250 mL of tap water in a 400 mL beaker
3. Measure the mass ofthe firstmetal sample and record in the data table.
4. To determine the mass of the water in the calorimeter (Styrofoam cup), you may carefully measure the volume of 150 mL of water and pour it into the calorimeter. Or, you can measure the mass of the empty, dry calorimeter and then measure the mass of the calorimeter with water.
5. Measure and record the temperature of the water in the calorimeter.
6. Use tongs to place the metal sample in the boiling water and **BOIL** the metal for at least five minutes.
7. Measure and record the temperature of the boiling water*(this is the initial temperature of the metal)*. Do not hold the thermometer against the glass.
8. Use tongs to quickly transfer the metal sample from the boiling water bath to the calorimeter, being careful not to splash any of the water out of the calorimeter. DO NOT DROP the metal sample into the water bath!
9. Gently stir the water in the calorimeter with the thermometer being careful not to touch the metal with the thermometer. When the temperature of the water in the calorimeter has stabilized, record the temperature**.** *(This is the final temperature for both the water and the metal).*
10. Repeat steps 3-9 for a second metal sample.

**Calculations**. Present the following calculations, according to the EDR, on your own paper. You may want to make 2 columns, one for each metal sample so that you are only writing each label and word equation once. **Look back at the background information and pre-lab questions for useful equations.**

1. temperature change of water (ΔT)
2. temperature change of metal sample (ΔT)
3. heat change of water, q(water)
4. heat change of metal sample, q(metal)
5. specific heat of metal (J/g oC)
6. identity of each metal based on specific heats given below
7. percent error

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Metal** | **Specific Heat (J/g °C)** |  | **Metal** | **Specific Heat (J/g °C)** |
| Aluminum | 0.902 |  | iron | 0.466 |
| Copper | 0.387 |  | Brass | 0.380 |
| Zinc | 0.385 |  | lead | 0.128 |

**Analysis.** Answer the following questions thoroughly. When possible support with numbers.

1. State your results (include labels) as they relate to the purpose of the lab.
2. Explain how the heat lost by the metal was the same as the heat gained by the water, even though their temperature changes were very different.
3. You assumed that the initial temperature of the metal was the same as that of the boiling water.  If the metal lost heat as it was transferred from the boiling water to the calorimeter, so it was actually at a lower temperature than the boiling water, how would your value for the specific heat be affected?  Explain why referring to data and calculations.
4. Was your experimental value for the specific heat of your metal (choose the first metal or the second metal) higher or lower than the accepted value?  Identify a source of error that would cause this difference and explain how it affected the specific heat by referring to data AND calculations. Do *not* use the error given in question (3).

1. Describe the specific heat capacity of water relative to metals or other substances and explain why water’s specific heat is critical for aquatic life.