Heat Lost and Heat Gained
Determining the Specific Heat of a Metal

This lab is divided into two parts. In the first part you will examine the relationship between heat lost and heat gained when two liquids are mixed. In the second part of the lab you will use this relationship to determine the specific heat of a metal.

The specific heat of a substance is defined as the amount of energy needed to raise the temperature of one kilogram of the substance one degree on the Celsius scale.

The specific heat of water is: $4.186 \times 10^3 \ \frac{\text{J}}{\text{kg}^{\text{o}}\text{C}}$

You will have to research the specific heat of your assigned metal by looking in your textbook or the internet. You will also find the value in a reference book such as *The Handbook of Chemistry and Physics*.

In both parts you will use the following equations.

Equation 1 $$Q = mc\Delta T$$

Equation 2 $$|Q_{lost}| = |Q_{gained}|$$

Equation 3 $$m_{lost}c_{lost}|\Delta T_{lost}| = m_{gained}c_{gained}|\Delta T_{gained}|$$

The absolute value lines indicate that you want the magnitude of the value regardless of a gain or loss.

You will make two assumptions in this lab:

1) That the heat transfer to the room and the polystyrene cup is negligible.

2) That the temperature of the hot metal is the same as the temperature of boiling water at one atmosphere, 100^{o}C.

PURPOSE
In Part I, you will examine the relationship between the heat lost and the heat gained when two liquids are mixed. In Part II, you will use this relationship to determine the specific heat of a metal sample.

MATERIALS

2 polystyrene cups
balance
thermometer
metal sample
paper towels
tongs or forceps

> **Safety Alert**
> Prevent burns by using caution when handling the hot metal, boiling water, and hot plates.

PROCEDURE

PART I: WATER

1. Measure and record the mass of the two empty dry polystyrene cups. If the masses are different mark the cups to distinguish one from the other.
2. Fill one cup about 1/3 full with hot water from the faucet or other source provided by your teacher. Measure and record the mass and temperature of this cup. Record your values in Data Table 1 on your student answer page.
3. Fill the other cup about 1/3 full with cold water from the faucet. Measure and record the mass and temperature of this cup.
4. Pour the cold water into the hot water. Use the thermometer to stir the mixture then measure and record the temperature of the mixture to the nearest 1/10 degree Celsius. Do not wait too long. As soon as the thermometer stabilizes record the temperature.

PART II: METAL

1. Measure and record the mass of an empty dry polystyrene cup.
2. Fill the cup about 1/3 full with cold water from the faucet. Measure and record the mass and the temperature of this cup. Record your values in Data Table 2 on your student answer page.
3. Carry the cup and water to the hot water bath and carefully remove one of the metal samples from the bath. Quickly (but gently) transfer it to the cold water. Return to your lab station.
4. Gently stir the water with the thermometer and record the final stable temperature to the nearest 1/10 degree Celsius. Again, do this as quickly as possible after the transfer. The change in temperature will not be very large.
5. Completely dry the metal sample. Measure and record the mass of the metal.

Name _____

Period _____

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DATA AND OBSERVATIONS

PART I: WATER

Data Table 1: Water	
Mass of cup 1	kg
Mass of cup 2	kg
Mass of cup and warm water	kg
Mass of cup and cold water	kg
Initial temperature of warm water	^{o}C
Initial temperature of cold water	^{o}C
Final temperature of the mixture	^{o}C
Mass of warm water	kg
Mass of cold water	kg

PART II: METAL

Data Table 2: Metal	
Mass of empty cup	kg
Mass of cup and water	kg
Initial temperature of the water	^{o}C
Initial temperature of metal	^{o}C
Final temperature of the metal and water	^{o}C
Mass of the metal	kg
Mass of the water	kg
Type of metal	
Textbook value of the specific heat of the metal	$\frac{J}{kg^{o}C}$

ANALYSIS

PART I: WATER

1. Use Equation 1 to calculate the energy lost by the hot water.

2. Calculate the energy gained by the cold water.

3. Determine the percent difference between the heat lost by the hot water and the heat gained by the cold water.

PART II: METAL

1. Manipulate equation 3 to solve for the specific heat of the metal. Assume the left side of the equation is the metal side.

2. Use the equation you derived and substitute your data to calculate the specific heat of your metal sample.

3. Determine the percent error in the specific heat value.

CONCLUSION QUESTIONS

PART I: WATER

1. In Part I, what basic law of physics did you intend to confirm?

2. Did your experimental results demonstrate this law? What were possible sources of error in this section?

PART II: METAL

1. Why was the temperature change of the metal so much greater than the temperature change of the water?

2. In Part II you were instructed to assume that the initial temperature of the metal sample was 100^{o}C. Why were you able to make this assumption?

3. Why isn't it necessary to know the mass of the boiling water?

4. A student fails to work quickly when transferring his or her hot metal sample into the water. Will the student's reported specific heat value be too high, too low, or unaffected? Justify your answer.