[redacted]

[redacted]

Heat transfer or heat flow always occurs in one direction—from a region of higher temperature to a region of lower temperature—until some final equilibrium temperature is reached. In this experiment, heat is transferred from a hot metal sample to a colder water sample. Because each metal has a different specific heat, each metal will cause the temperature of the water to increase to a different extent. The transfer of energy can be detected by measuring the resulting temperature change, ΔT, calculated by taking the final temperature minus the initial temperature, according to *Equation 1*.

ΔT = final temperature – initial temperature = Tf – Ti : *Equation 1*

For the hotter object in this scenario (the metal), the amount of heat (q) delivered by the metal (*q* metal) is equal to the mass of the metal (m metal) multiplied by the specific heat of the metal (C metal) multiplied by the temperature change of the metal (ΔT metal). This relationship is given by *Equation 2*.

q metal = (m metal)(C metal)(ΔT metal) : *Equation 2*

For the cooler object in this scenario (the water), the amount of heat absorbed by the water (*q* water) is equal to the mass of the water (m water) multiplied by the specific heat of the water (C water) multiplied by the temperature change of the water (ΔT water). This relationship is given by *Equation 3*.

q water = (m water)(C water)(ΔT water) : *Equation 3*

By convention, the sign of *q* is a signal showing the direction of heat transfer. When heat is transferred out of a material, the sign of *q* is negative. Conversely, when heat is absorbed by a material, *q* is positive. The signs of *q*, along with the necessary associated temperature changes, are summarized below.

Direction of Heat Transfer	**Sign of q**	**Sign of ΔT**	**Change in Temperature of Material**
Heat is absorbed (transferred into material)	+	+	Temperature increases
Heat is delivered (transferred out of material)	-	-	Temperature decreases

According to the Law of Conservation of Energy, the heat delivered by the heated metal, *q* metal, must be equal to the heat absorbed by the water, *q* water, and its surroundings. Incorporating the sign convention given in Table 2 gives *Equations 4* & *5*:

- q metal = + q water : *Equation 4*

Equation 5: - (m metal)(C metal)(ΔT metal) = + (m water)(C water)(ΔT water)

In this lab, Equation 5 is used to calculate the specific heat of a heated metal added to a water sample. For calculation purposes, it is important to realize that when the metal is added to the water, the final temperature of both materials will be the same. The calculated specific heat value will then be compared to the known specific heat value given in *Table 1*.

To make accurate measurements of heat transfer and to prevent heat loss to the surroundings, an insulating device known as a calorimeter is used. A *calorimeter* is a device used to measure heat flow, where the heat given off by a material is absorbed by the calorimeter and its contents (often water or other material of known heat capacity). In this laboratory activity, a set of Styrofoam cups will be used as the calorimeter.

MATERIALS: Metal sinkers (old weights), electronic balance, paper towel, 250 mL beaker, hot plate, 100 mL graduated cylinder, tongs, Styrofoam cup calorimeters, thermometer attached to hot plate ring stand AND thermometer for calorimeter

PROCEDURE:

1. Weigh & record the mass of the metal to two decimal places.
2. Place a paper towel in a 250mL beaker (will act like a cushion so the glass doesn't break when water starts to boil), place the metal on top of the paper towel, and half-fill with tap water. The metal should be completely submerged. Heat the water to a boil on the hot plate. (Turn knob of hot plate all the way up.)
3. Mass the empty calorimeter (with top) and record its mass.
4. Pour 100.00 mL of tap water into the calorimeter. Record this mass. (Hint: 1.0 mL = 1.0 g)
5. Measure the temperature of the room temperature calorimeter water in degrees Celsius. Record this temperature to two decimal places.
6. Determine the temperature of the metal sample. To do this, measure the temperature of the boiling water bath after it has been boiling for about 2 minutes. (Assume the temperature of the metal is equal to the temperature of the water bath.) Record this as "T metal" in the Data Table to two decimal places.
7. Hold the thermometer in the calorimeter with the tap water.
8. Carefully lift the metal from the boiling water bath and quickly, yet carefully, place the metal cube into the calorimeter. Put the top on the calorimeter. Gently stir the water and metal cube in the calorimeter while observing the temperature change. *Caution:* Do not stir the mixture with the thermometer as it could break. Measure and record the highest temperature the mixture reaches. Record this temperature in the Data Table as temperature of mixture (Tmixture).
10. Turn off your hot plate.
11. Drain the water out of the calorimeter and pat the metal dry thoroughly. Dry the calorimeter.
12. Clean up and work on the calculations.

Data & Calculations Table - ***make all measurements to 2 decimal places!***

[redacted]	200.00g
[redacted]	9.42g
[redacted]	100.00
[redacted]	*4.18J/g°C*
[redacted]	23
[redacted]	95
[redacted]	35
[redacted]	12
[redacted]	60

[redacted]

Change in T = final temp - initial temp Change in T = 35-23 Change in T = 12	Change in T metal = final temp - initial temp Change in T metal= 35-95 Change in T metal= -60

[redacted]

(-m metal)(c metal)(Change in T Metal)= t(m water)(c water)(change in t water))

-(200g)(c metal)(-60) = t(100)(4.18)(12)

(1200)(c Metal) = 5016

5016/1200 = 0.42j/gc

C metal = 0.42j/gc

3. Experimental procedures will no doubt lead to some degree of difference from the published literature value. Determine the percent error for specific heat for the metal used. Specific heat of steel is 0.452 J/g °C.

$$\% \text{ error} = \frac{\text{Measured} - \text{accepted}}{\text{accepted}} \times 100$$

% of error = (0.42-0.452)/.452 x 100 %of error = 7.08

RESULTS/CONCLUSIONS: (must be written in bullet form)

A)● What was the purpose of today's lab?

B)● Explain the Law of Conservation of Energy and how it relates to your calculations. (Review the introduction of the lab)

C)● Compare your specific heat value for the metal and the literature specific heat value. How do they compare? Discuss your percent error.

D)● Suggest possible reasons for discrepancies between the experimental and literature values. Discuss any improvements that can be made for a future lab class.

A) To find specific heat of meal

B) The Law of conservation of energy states that energy cannot be created or destroyed

C) They are close