2: DETERMINATION OF SPECIFIC HEAT OF METALS

Marmara University - Department of Physics
Physics 3 Laboratory
Experiment Report

1 Objective

The purpose of this experiment is to determine the specific heat capacity of iron using a calorimeter based on the principle of conservation of energy.

2 Theoretical Background

Heat is energy transferred due to temperature difference while temperature is a measure of average kinetic energy.

Specific heat (c) is the heat required to raise 1 kg of a substance by 1°C $Q = mc\Delta T$.

According to the law of conservation of energy, total heat is conserved: $Q_{\text{received}} = Q_{\text{given}}$, so $Q_{\text{Fe}} + Q_{\text{aqua}} + Q_{\text{Cu}} = 0$.

Initially, water and copper are at equal temperature T_1. When hot iron is added, iron's temperature decreases from 100°C to T_2, while water and copper increase to T_2, with heat lost by iron equaling heat gained by water and copper.

The formula is:

$$m_{\text{Fe}}c_{\text{Fe}}(100 - T_2) = m_{\text{aqua}}c_{\text{aqua}}(T_2 - T_1) + m_{\text{Cu}}c_{\text{Cu}}(T_2 - T_1)$$

Solving for c_{Fe}:

$$c_{\text{Fe}} = \frac{(m_{\text{aqua}}c_{\text{aqua}} + m_{\text{Cu}}c_{\text{Cu}})(T_2 - T_1)}{-m_{\text{Fe}}(T_2 - 100)}$$

3 Apparatus and Method

The experiment utilized an iron sample, calorimeter with a copper inner container, thermometer, stirrer, triple beam balance and beaker for boiling water. The procedure involved measuring the masses of the iron, water and copper container using the triple beam balance, heating the iron in boiling water to approximately 100 °C, filling the copper container with water and measuring its mass, placing the calorimeter in an isolated environment to prevent contact between the inner and outer containers, recording the initial temperature T_1 with the thermometer submerged only in water, quickly transferring the heated iron into the calorimeter and stirring until thermal equilibrium was reached then recording the final temperature T_2. It was noted that the irons small mass relative to the water resulted in a minimal temperature change.

4 Measurements and Data

Constants: Specific heat of water: $c_{\text{aqua}} = 4200\,\text{J/kg°C}$ Specific heat of copper: $c_{\text{Cu}} = 386\,\text{J/kg°C}$ Theoretical specific heat of iron: $c_{\text{Fe, theoretical}} = 452\,\text{J/kg°C}$

Measurement	Symbol	Value
Iron mass	m_{Fe}	157.9 g
Water mass	m_{aqua}	406.6 g
Copper container mass	m_{Cu}	106.5 g
Initial temperature	T_1	24.1 °C
Final temperature	T_2	27.2 °C

Table 1: Experimental Data

5 Calculations and Graphs

Calculations: Experimental specific heat of iron:

$$c_{\text{Fe, exp}} = \frac{(0.4066\,\text{kg} \times 4200\,\text{J/kg°C} + 0.1065\,\text{kg} \times 386\,\text{J/kg°C}) \times 3.1\,\text{°C}}{-0.1579\,\text{kg} \times (27.2\,\text{°C} - 100\,\text{°C})} = 471.6\,\text{J/kg°C}$$

Percentage error:

$$\text{Error} = \left|\frac{c_{\text{Fe, exp}} - c_{\text{Fe, theoretical}}}{c_{\text{Fe, theoretical}}}\right| \times 100 = \left|\frac{471.6\,\text{J/kg°C} - 452\,\text{J/kg°C}}{452\,\text{J/kg°C}}\right| \times 100 = 4.33\%$$

Graph:

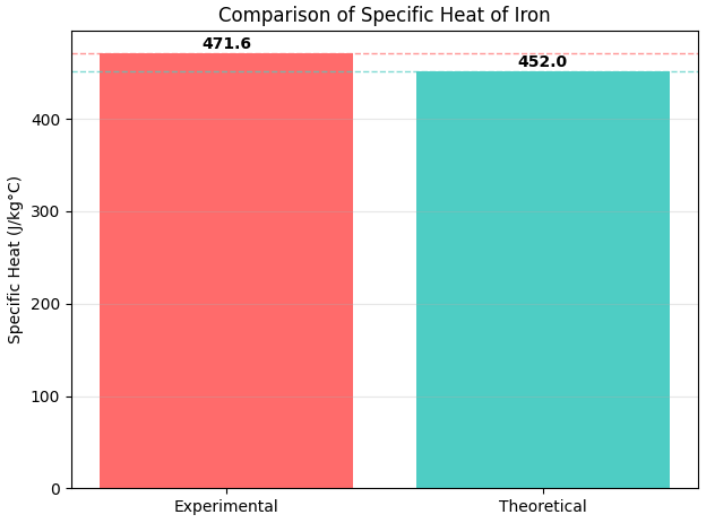

Figure 1: Comparison of Specific Heat of Iron

6 Results and Discussion

The results earned from the experiment show the experimental specific heat of iron at 471.6 J/kg°C compared to the theoretical 452 J/kg°C with a 4.33% error indicating reasonable alignment with the objective. Possible sources of error include heat loss during

transfer, imperfect calorimeter insulation and thermometer contact with non-water surfaces. Suggestions for improvement involve using better insulation and a larger iron mass to enhance accuracy. The purpose of the experiment is thus compared with the achieved results, showing a good outcome despite the identified differences.

Notes: Law of conservation of energy Total ($Q_{\text{received}} = Q_{\text{given}}$) = 0, $Q_{\text{Fe}} + Q_{\text{aqua}} + Q_{\text{Cu}} = 0$. Initially water and copper temperatures are equal. When iron is added its temperature decreases while water and copper temperatures increase with heat lost equaling heat gained. Masses measured with triple beam balance. Boiled water, heated iron to 100°C. Transferred iron quickly to calorimeter to minimize heat loss. Isolated copper container avoided outer container contact. Irons small mass caused minimal water temperature change. Kept thermometer in water only for accuracy. **Specific heat:** The amount of heat energy required to raise the temperature of a unit mass of a substance by one degree Celsius, measured in J/(kg·°C). **Difference between heat and temperature:** Heat is a form of energy transfer between bodies, while temperature is a physical property that quantifies the average kinetic energy of molecules in a substance.

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