Specific Heat Capacity of Metals
PHYSICS 442

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1 Objective

The objective of this experiment is to measure the specific heat capacity of three different samples of unknown metals and to compare those with the accepted values.

2 Definitions

Heat Heat is the measure of the internal kinetic energy of a substance.

Temperature Temperature is a measure of the kinetic energy of a particle. It is the degree or intensity of heat in a substance. Celcius is a unit of temperature. One degree Celcius represents the temperature change of one gram of water when 2.39×10^{-5}Joules of heat is added to it.

Specific Heat Capacity The specific heat capacity is the energy transferred to one kilogram of substance causing its temperature to increase by one degree Celcius.Homer (2014)

Thermal Equilibrium Thermal equilibrium is a condition where two substances in physical contact with each other exchange no net heat energy. Substances in thermal equilibrium are at the same temperature.

3 Theory

The change in the internal energy of an object or substance is equal to the product of the mass and the specific heat capacity and the change in temperature.
$$\Delta U = mC_p \Delta T$$

When water and the metal samples are in thermal equilibrium the change in heat of the water is equal in magnitude to the change in heat of the metal.
$$\Delta U_{metal} = \Delta U_{water}$$

From this relationship we may derive a formula for the specific heat capacity of the metal sample given the mass of metal, mass of water, change in temperature of the water, change in temperature of the metal and the specific heat capacity of water.
$$m_{metal} C_{metal} \Delta T_{metal} = m_{water} C_{water} \Delta T_{water}$$

$$C_{metal} = \frac{m_{water}}{m_{metal}} \frac{\Delta T_{water}}{\Delta T_{metal}} C_{water}$$

4 Materials

- Kettle

- Samples of Three Unknown Metals

- Styrofoam Cups

- Graduated Cylinder

- Scale

- Thermometer

- Tongs

- Flask of Water

5 Method

a. Weigh the samples and record

b. Measure 350 ml of water for Samples 1 and 2, and 300 ml of water for Sample 3 in graduated cylinder and transfer to Styrofoam cup

c. Measure the initial temperature of the water

d. Boil water and add metal samples to kettle

e. Use tongs to transfer a sample to the cup with water

f. Place thermometer in cup, cover it, stir and record equilibrium temperature

g. Repeat steps b-f for each sample

6 Data

Metal	Mass Metal	Mass Water	Temp Water Initial	Temp Final
Sample 1	90.5 g	350g	20.5 Celcius	24.5 Celcius
Sample 2	64.1 g	350g	20.8 Celcius	24.8 Celcius
Sample 3	203.0 g	300g	20.9 Celcius	22.5 Celcius

Table 1: Experimental data

Material	Specific Heat Capacity
Water	4180 $J/_{kg\cdot°C}$
Aluminum	900 $J/_{kg\cdot°C}$
Zinc	380 $J/_{kg\cdot°C}$
Copper	387 $J/_{kg\cdot°C}$
Iron	452 $J/_{kg\cdot°C}$
Steel	452 $J/_{kg\cdot°C}$
Lead	128 $J/_{kg\cdot°C}$
Silver	230 $J/_{kg\cdot°C}$

Table 2: Known specific heat capacities

7   Example Calculations

This is the calculation for the specific heat capacity of Sample 1.

$$C_{metal} = \frac{m_{water}}{m_{metal}} \frac{\Delta T_{water}}{\Delta T_{metal}} C_{water}$$

$$C_{metal} = \frac{0.35}{0.0905} \frac{4}{79.5} 4180$$

$$C_{metal} = 813.4 \text{J/}_{\text{kg·°C}}$$

The percent error is calculated as follows.

$$Error = \frac{900 - 813}{900} = 9.66\%$$

8   Results

Material	Measured C_p	Percent Error
Sample 1/Aluminum	813 J/$_{\text{kg·°C}}$	9.6%
Sample 2/Copper	461 J/$_{\text{kg·°C}}$	7.5%
Sample 3/Zinc	328 J/$_{\text{kg·°C}}$	13%

Table 3: Calculated specific heat capacities

9   Discussion of Error

Some of the heat might have gotten lost during the transfer of the metal samples from the kettle to the Styrofoam cup which could have caused the error in the calculation.

10   Conclusion

By comparing the calculated specific heat capacities of the sample metals to the accepted specific heat capacities of metals, we could determine that Samples 1, 2, and 3 were Aluminium, Copper, and Zinc, respectively. Another way of determining what the metals were was by analysing their colours. For example, it could be determined that Sample 2 was copper by its colour.

References

Homer, J. (2014). *Physics*. Oxford, 3rd edition.