Specific Heat Capacity of Metals
PHYS 442

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Partners:	Whole class
Instructor:	Me

1 Objective

The objective of this experiment is to measure the specific heat capacity of three different samples of metal and to compare those with the accepted values. The samples consist of aluminum, zinc and copper.

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
- Aluminum, zinc and copper samples
- styrofoam cups
- graduated cylinder
- scale
- thermometer
- tongs
- flask of water

5 Method

a. Weigh the samples and record

b. Measure 350 ml of water 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
Aluminum	90.5 g	350 g	20.5 Celcius	24.5 Celcius
Zinc	64.1 g	350g	20.8 Celcius	24.8 Celcius
Copper	203.0 g	300g	20.9 Celcius	22.5 Celcius

Table 1: Experimental data

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

Table 2: Known specific heat capacities

7 Example Calculations

This is the calculation for the specific heat capacity of copper.

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

$$\Delta T_{water} = 26.2 - 22.5 = 3.7\text{Celcius}$$

$$\Delta T_{metal} = 100 - 26.2 = 73.8\text{Celcius}$$

$$C_{metal} = \frac{0.350\text{kg}}{0.203\text{kg}} \frac{3.7\text{Celcius}}{73.8\text{Celcius}} 4180 \text{ J/kg}\cdot^\circ\text{C} = 361 \text{ J/kg}\cdot^\circ\text{C}$$

The percent error is calculated as follows.

$$Error = \frac{387 - 361}{387} = 6.7\%$$

8 Results

Material	Measured C_p	Percent Error
Aluminum	832 J/kg·°C	7.5%
Zinc	453 J/kg·°C	18%
Copper	387 J/kg·°C	6.7%

Table 3: Calculated specific heat capacities

9 Discussion of Error

From Table 3 we can see that the percent error for aluminum, zinc and copper are 7.5%, 18% and 6.7% respectively. The percent error is minimal but present. It may have been caused by the physical limitations we encountered in the experiment: when the insulating containing metal was opened, some heat managed to have escaped and dissipated into the atmosphere.

10 Conclusion

From the entire experiment we can conclude that the metals given in the beginning were successfully identified via the findings of their respective specific heat capacities. There is slight inaccuracy in the results but essentially we must be able to ignore small deviations from the correct answer.

References

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