Specific Heat Capacity of Metals
PHYS 442

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Partners:	Whole class
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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 three unknown metals.

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
- three unknown metals
- styrofoam cups
- graduated cylinder
- scale
- thermometer
- tongs
- flask of water

5 Method

a. Weigh the samples and record

b. Measure samples 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
Sample 1 (Cube)	90.6 g	350 ml	20.5 Celcius	24.5 Celcius
Sample 2 (Short bar)	64.1 g	300 ml	20.9 Celcius	22.5 Celcius
Sample 3 (Long bar)	203.0 g	350 ml	20.8 Celcius	24.8 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 Sample 1 (Cube).

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

$$\Delta T_{water} = 24.5 - 20.5 = 4.0\text{Celcius}$$

$$\Delta T_{metal} = 100 - 24.5 = 75.5\text{Celcius}$$

$$C_{metal} = \frac{0.350\text{kg}}{0.0905\text{kg}} \frac{4.0\text{Celcius}}{75.5\text{Celcius}} 4180 \text{ J/kg}\cdot^\circ\text{C} = 856 \text{ J/kg}\cdot^\circ\text{C}$$

The percent error is calculated as follows.

$$Error = \frac{900 - 856}{900} = 4.9\%$$

8 Results

Material	Measured C_p	Percent Error
Aluminum	856 J/kg·°C	4.9%
Zinc	403 J/kg·°C	6.1%
Copper	383 J/kg·°C	1.0%

Table 3: Calculated specific heat capacities

9 Discussion of Error

After we did the experiment, we are able to figure out what metal are we measuring, by looking at its specific heat. However, there are some percent errors between the material that we use and the correct concept. The reason is because the materials that we use are not pure, it mix with some other metals. So the result will be different with the concept of specific heat capacity.

10 Conclusion

Through this experiment, I learn the way to identify a metal by measuring its specific heat capacities. After we measure the specific heat of the sample, we can check the column to identify the metals. For example, in this experiment we identified three kinds of metal which are aluminum, zinc, and copper.

References

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