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 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.**?**

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.

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

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

4 Materials

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

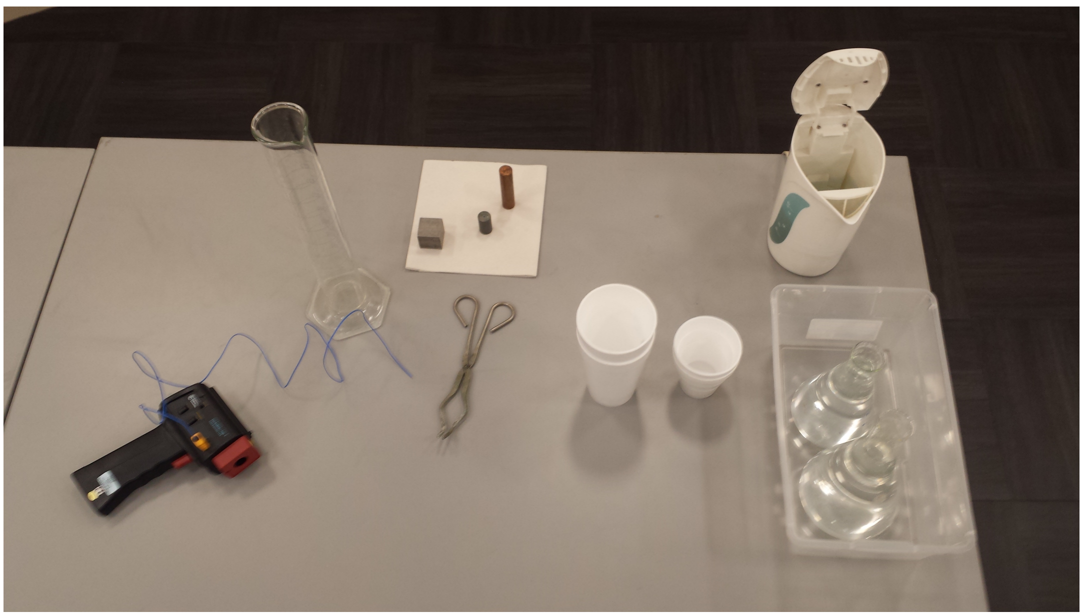

Figure 1: Experimental materials

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	90.6 g	350 g	22.5 Celcius	26.3 Celcius
Zinc	64.1 g	350 g	22.9 Celcius	24.4 Celcius
Copper	203.0 g	300 g	22.5 Celcius	26.2 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 Calculations

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

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

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

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

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

The percent error is calculated as follows.

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

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

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

$$\Delta T_{water} = 26.3 - 22.5 = 3.8°\text{C}$$

$$\Delta T_{metal} = 100 - 26.3 = 73.7°\text{C}$$

$$C_{metal} = \frac{0.350\text{kg}}{0.0906\text{kg}} \frac{3.8°\text{C}}{73.7°\text{C}} 4180 \ {}^{\text{J}}\!/_{\text{kg}°\text{C}} = 833 \ {}^{\text{J}}\!/_{\text{kg}\cdot°\text{C}}$$

The percent error is calculated as follows.

$$Error = \frac{900 - 833}{900} = 7.4\%$$

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

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

$$\Delta T_{water} = 24.4 - 22.9 = 1.5°\text{C}$$

$$\Delta T_{metal} = 100 - 24.4 = 75.6°\text{C}$$

$$C_{metal} = \frac{0.350\text{kg}}{0.0641\text{kg}} \frac{1.5°\text{C}}{75.6°\text{C}} 4180 \ {}^{\text{J}}\!/_{\text{kg}°\text{C}} = 453 \ {}^{\text{J}}\!/_{\text{kg}\cdot°\text{C}}$$

The percent error is calculated as follows.

$$Error = \frac{453 - 390}{390} = 16.1\%$$

8 Results

Material	Measured C_p	Percent Error
Aluminum	833 ${}^{\text{J}}\!/_{\text{kg}\cdot°\text{C}}$	7.4
Zinc	453 ${}^{\text{J}}\!/_{\text{kg}\cdot°\text{C}}$	16.1%
Copper	361 ${}^{\text{J}}\!/_{\text{kg}\cdot°\text{C}}$	6.7%

Table 3: Calculated specific heat capacities

9 Discussion of Error

Overall, the amount of error in finding specific heat capacity is relatively low. However, the percentage of error such as Zinc kind of high. I believe the reason behind this is the the mistake when we was doing. The object may had cooled down when we moved it. The water's temperature changed over time when it was in a different room temperature.

10 Conclusion

I know how we can figure out the specific heat capacity of an object and why it is important especially when we use that number to calculate the heat and the changing time of heat. I have better idea about the theory of specific heat capacity of metals.