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.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.

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

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

4 Materials

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

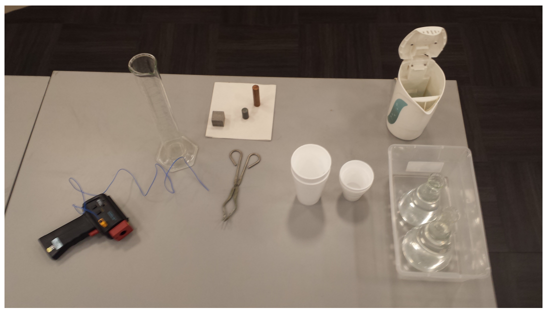

Figure 1: Experimental materials

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	Temp Water Initial	Temp Final
Aluminum	90.5 g	24.1 Celcius	28.0 Celcius
Zinc	64.1 g	24.4 Celcius	25.6 Celcius
Copper	203.0 g	24.7 Celcius	28.3 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 $^{J}/_{kg\cdot°C}$

Table 2: Known specific heat capacities

7 Example Calculations

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

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

$$\Delta T_{water} = 28.0 - 24.1 = 3.9\text{Celcius}$$

$$\Delta T_{metal} = 100 - 28.0 = 72\text{Celcius}$$

$$C_{metal} = \frac{0.350\text{kg}}{0.203\text{kg}} \frac{3.9\text{Celcius}}{72\text{Celcius}} 4180\ ^{J}/_{kg\cdot°C} = 875\ ^{J}/_{kg\cdot°C}$$

The percent error is calculated as follows.

$$Error = \frac{900 - 875}{900} = 2.8\%$$

8 Results

Material	Measured C_p	Percent Error
Aluminum	875 $^{J}/_{kg\cdot°C}$	2.8
Zinc	368 $^{J}/_{kg\cdot°C}$	3.1%
Copper	362 $^{J}/_{kg\cdot°C}$	6.5%

Table 3: Calculated specific heat capacities

9 Discussion of Error

As observed on the data above, the results of this experiment when calculated along with the specific heat of each metal differs from the value established by the NIST standards. (National Institute of Standards and Technology). The values extracted for specific heat capacity from this experience do not match the official value for a variety of reasons. First of, the rudimentary materials used to preform this experiment do not emulate the perfect an ideal environment that would given exact results. For example, the graduated cylinder may have absorb some amount of thermal energy which would lead to slight inaccuracies. During the transfer of the metal sample from the kettle to the sample cup of water leads to a slight cooling of the metal which again could have altered the dataThe slight inaccuracies of procedure since we preformed this experiment in a school environment lacking precise equipment did not allow us to produce exact answers. Nevertheless, we were subject to a maximum percentage of error relatively low of 6.5

Overall, this experiment was a success despite producing slightly inaccurate results when compared with the exact values of specific heat, since the methodology gave us a grasp of the concept of specific heat capacity and thermal equilibrium.

10 Conclusion

This lab enhanced my understanding of the specific heat concept. Through this experiment, we concluded that the specific heat of aluminum, zinc and copper are 875J/KgC, 368 J/kgC, 362 J/kgC respectively. Although the procedure and materials proved not to be as accurate as we desired, we obtained results with relatively low margins of error spanning from 2.8 percent to 6.5 percent. Through this observation, I am able to understand how the specific heat and mass of an object alter its capacity to change temperature. Moreover, I was able to directly observe how two different types of materials share the same exchange heat until the reach equilibrium when put together. Before this experiment, putting thermal equilibrium into perspective using the specific heat capacity of different materials proved challenging. But by applying the theory and conducting the experiment, and proving that the change in heat of water is equal to the change in heat of the metal was beneficial to my overall understanding of this concept.

References

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