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

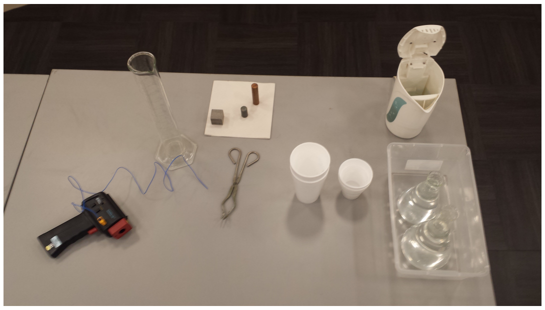

Figure 1: Experimental materials

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 $^{J}/_{kg\cdot ^\circ C}$
Aluminum	900 $^{J}/_{kg\cdot ^\circ C}$
Zinc	380 $^{J}/_{kg\cdot ^\circ C}$
Copper	387 $^{J}/_{kg\cdot ^\circ C}$

Table 2: Known specific heat capacities

7 Example Calculations

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

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

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

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

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

The percent error is calculated as follows.

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

8 Results

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

Table 3: Calculated specific heat capacities

9 Discussion of Error

As it is possible to see, the specific heat of each metal, when calculated with the results obtained in the experiment, differs from the value established by the National Institute of Standards and Technology (NIST). The value does not match perfectly with the accepted one for some reasons. First, the conditions in which our experiment took place are different than the conditions NIST experiment had. Furthermore, our materials, when compared to the ones from a international institute, are precarious. Because of that, the values we obtain are not as accurate as they could be. This inaccuracy leads to a specific capacity value that does not match exactly to the one determined by the NIST. However, we were able to do an experiment in which our highest percentage of error is 6.5%. Summing up, the errors we obtained were due to the lack of professional materials and the conditions encountered in the experiment, such as possible minimum lost of heat.

10 Conclusion

It is possible to say that after this lab my understanding of specific heat is greater. I now have the knowledge that a gas is able to do work. Moreover, I know not only the definitions and the formulas we need to apply, but also how this concepts would function in real life. After the lab I am able to understand how the mass and the specific heat of an object interfere in the change in temperature. Furthermore, it is now clear that the change in internal energy of two materials, when they are put together, is the same as they exchange heat until they reach equilibrium. All in all, with this lab my knowledge of specific heat and internal energy changed. I know totally understand the formulas and definitions and I am able to picture in my mind how the change of heat would work.

References

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