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.

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

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

4 Materials

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

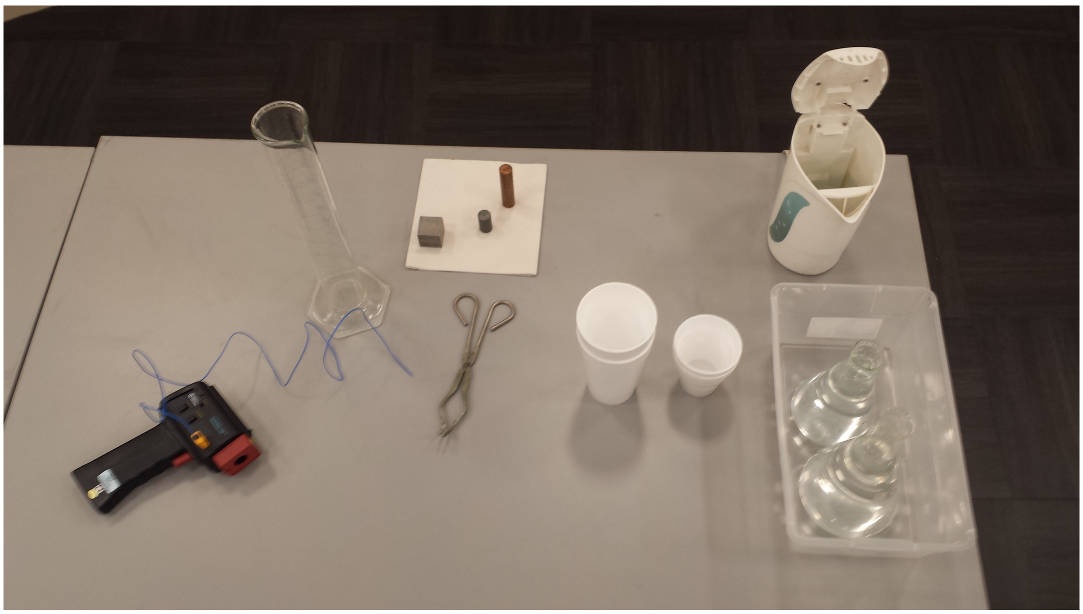

Figure 1: Experimental materials

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 Example Calculations

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

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

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

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

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

The percent error is calculated as follows.

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

8 Results

Material	Measured C_p	Percent Error
Aluminum	832 $^{\text{J}}/_{\text{kg}\cdot°\text{C}}$	7.5
Zinc	453 $^{\text{J}}/_{\text{kg}\cdot°\text{C}}$	18%
Copper	387 $^{\text{J}}/_{\text{kg}\cdot°\text{C}}$	6.7%

Table 3: Calculated specific heat capacities

9 Discussion of Error

There are some sources of errors because a certain amount of heat has certainly lost as well as emitted away from the cup which might potentially caused a false result in the end when you were pouring the water inside the cup. Moreover, heat may have been transformed from the metal to the tong when it was in contact with each other. Another thing that might lead the experiment's result into error is the Styrofoam cup was not totally isolated from the surface and heat was released, in which makes metal could not perfectly reach to a 100 degree Celsius when being heated. Overall, these are two reasons why I think might lead to the error of the experiment.

10 Conclusion

As a result, the experiment helps us to come up with the calculation of the specific heat of each metal. However, as mention above, there might be some elements that can lead to error during the process but it's still a reasonable result after all.

References

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