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 $2.39 \times 10^{-5}$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
- Aluminum, zinc and copper samples
- styrofoam cups
- graduated cylinder
- scale
- thermometer
- tongs
- flask of water

# 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 | 350g | 20.5 Celcius | 24.5 Celcius |
| Copper | 64.1 g | 350g | 20.8 Celcius | 24.8 Celcius |
| Zinc | 203.0 g | 300g | 20.9 Celcius | 22.5 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.

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

$$C_{metal} = \frac{0.35}{0.0905} \frac{4}{79.5} 4180$$

$$C_{metal} = 813 \ {}^{\mathrm{J}}\!/_{\mathrm{kg}\cdot{}^{\circ}\mathrm{C}}$$

The percent error is calculated as follows.

$$Error = \frac{900 - 813}{900} = 9.66\%$$

## 8 Results

| Material | Measured $C_p$ | Percent Error |
|---|---|---|
| Aluminum | 813 $^{\mathrm{J}}\!/_{\mathrm{kg}\cdot{}^{\circ}\mathrm{C}}$ | 9.6 |
| Zinc | 328 $^{\mathrm{J}}\!/_{\mathrm{kg}\cdot{}^{\circ}\mathrm{C}}$ | 13% |
| Copper | 461 $^{\mathrm{J}}\!/_{\mathrm{kg}\cdot{}^{\circ}\mathrm{C}}$ | 7.5% |

Table 3: Calculated specific heat capacities

## 9 Discussion of Error

Some of the might have gotten lost during the transfer of the metal samples from the kettle to the Styrofoam cup which could have caused the error in the calculation.

## 10 Conclusion

This lab enhanced my understanding of the specific heat concept. By comparing the calculated specific heat capacities of the sample metals to the accepted specific heat capacities of metal, we concluded that the specific heat of aluminium, zinc and copper are 813 J/KgC, 328 J/KgC and 461 J/KgC respectively.

## References

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