

# 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 and 300 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
Sample 1	90.5 g	20.5 °C	24.5 °C
Sample 2	64.1 g	20.9 °C	22.5 °C
Sample 3	203.0 g	20.8 °C	24.8 °C

Table 1: Experimental data

Material	Specific Heat Capacity
Water	4180 J/kg·°C
Aluminum	832 J/kg·°C
Zinc	453 J/kg·°C
Copper	387 J/kg·°C
Iron	452 J/kg·°C
Steel	452 J/kg·°C
Lead	128 J/kg·°C
Silver	230 J/kg·°C

Table 2: Known specific heat capacities

## 7 Example Calculations

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

$$C_{metal} = \frac{m_{water}}{m_{metal}} \frac{\Delta T_{water}}{\Delta T_{metal}} C_{water}$$
$$\Delta T_{water} = 24.8 - 20.8 = 4^{\circ}\text{C}$$
$$\Delta T_{metal} = 100 - 24.8 = 75.2^{\circ}\text{C}$$
$$C_{metal} = \frac{0.350\text{kg}}{0.203\text{kg}} * \frac{4^{\circ}\text{C}}{75.2^{\circ}\text{C}} * 4180 \text{ J/kg}\cdot^{\circ}\text{C} = 383.35 \text{ J/kg}\cdot^{\circ}\text{C}$$

The percent error is calculated as follows.

$$Error = \frac{387 - 383.35}{387} = 0.0094\%$$

## 8 Results

Material	Measured $C_p$	Percent Error
Aluminum	832 J/kg $\cdot^{\circ}\text{C}$	0.0489%
Zinc	453 J/kg $\cdot^{\circ}\text{C}$	-0.0629%
Copper	387 J/kg $\cdot^{\circ}\text{C}$	0.0094%

Table 3: Calculated specific heat capacities

## 9 Discussion of error

There is a very small percentage of an error. I think mostly is because of heat loss. It happens, because cups absorb some heat. Also after we put a sample into the water, our instructor was spinning cup and a little bit shake it to decrease time of the experiment.

## 10 Conclusion

We understood after this experiment, that metal can transit heat to the water and eventually both of the substances will be the same temperature. Although we measured everything as neat as we could, we still got some percentage of an error. Also during the experiment we faced some challenges. We could distinguish the material of sample 3 between copper and zinc only by color, because their heat capacities are very close: 380 and 387.

## References

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