

Specific Heat Capacity of Metals

PHYS 442

TRI DAO

November 16, 2015

Date Performed: November 13, 2015
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.

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

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

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 | Temp Water Initial | Temp Final |
|----------|------------|--------------------|--------------|
| Aluminum | 90.5 g | 24.1 Celcius | 28.0 Celcius |
| Zinc | 64.1 g | 24.2 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. $^{\circ}$ C |
| Aluminum | 900 J/kg. $^{\circ}$ C |
| Zinc | 380 J/kg. $^{\circ}$ C |
| Copper | 387 J/kg. $^{\circ}$ C |

Table 2: Known specific heat capacities

7 Example Calculations

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

$$C_{metal} = \frac{m_{water}}{m_{metal}} \frac{\Delta T_{water}}{\Delta T_{metal}} C_{water}$$
$$\Delta T_{water} = 28.3 - 24.7 = 3.6 \text{ Celcius}$$
$$\Delta T_{metal} = 100 - 28.3 = 71.7 \text{ Celcius}$$
$$C_{metal} = \frac{350 \text{ g}}{203 \text{ g}} \frac{3.6 \text{ Celcius}}{71.7 \text{ Celcius}} 4180 \text{ J/kg} \cdot ^\circ \text{C} = 361.9 \text{ J/kg} \cdot ^\circ \text{C}$$

The percent error is calculated as follows.

$$Error = \frac{387 - 361.9}{387} = 6.5\%$$

8 Results

| Material | Measured C_p | Percent Error |
|----------|------------------------|---------------|
| Aluminum | 875 J/kg. $^\circ$ C | 2.8 |
| Zinc | 368.1 J/kg. $^\circ$ C | 3.13% |
| Copper | 361.9 J/kg. $^\circ$ C | 6.5% |

Table 3: Calculated specific heat capacities

9 Discussion of Error

There are various factors that contributed to the error:

- + The metal may have cooled down when we moved it from the kettle to the cup.
- + The water's temperature changed over time when it is in a different room temperature.
- + The tongs temperature may have also transferred to the water when it was dipped in the cup.

10 Conclusion

I know how to measure the specific heat capacity of some metal with the biggest percentage error is 6.5% from its value.

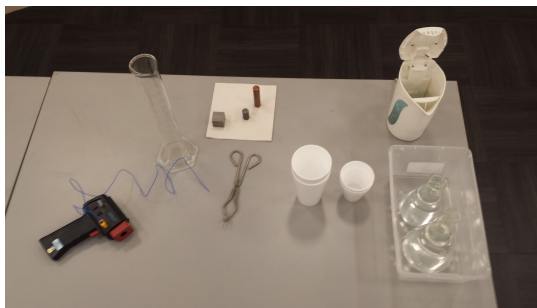


Figure 1: Experimental materials

References

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