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.

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

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

4 Materials

- Kettle
- Long bar, short bar and cube samples
- styrofoam cups
- graduated cylinder
- scale
- thermometer
- tongs
- flask of water

5 Method

a. Weigh the samples and record

b. Measure sample 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	Water volume	Temp Water Initial	Temp Final
Cube	90.6 g	350ml	20.5 Celcius	22.5 Celcius
Short bar	64.1g	300ml	20.9 Celcius	22.9 Celcius
Long bar	203.0 g	350ml	20.8 Celcius	24.8 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 short bar.

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

$$\Delta T_{water} = 20.9 - 22.5 = 1.6\text{Celcius}$$

$$\Delta T_{metal} = 100 - 22.5 = 77.5\text{Celcius}$$

$$C_{metal} = \frac{0.300\text{kg}}{0.0641\text{kg}} \frac{1.6\text{Celcius}}{77.5\text{Celcius}} 4180 \text{ J/kg}\cdot^\circ\text{C} = 403.89 \text{ J/kg}\cdot^\circ\text{C}$$

The percent error is calculated as follows.

$$Error = \frac{387 - 403.89}{387} = 4.36\%$$

8 Results

Material	Measured C_p	Percent Error
Cube(Aluminum)	856.46 J/kg.°C	4.83%
Short bar(Copper)	403.89 J/kg.°C	4.36%
Long bar(Zinc)	383.35 J/kg.°C	1.8%

Table 3: Calculated specific heat capacities

9 Discussion of Error

Firstly even though the cup won't absorb heat in experiment, but the air in the cup will conduct the heat. Thus it can cause heat escaping. On the other hand teacher pull the water firstly and then put the metal into the water. Air will absorb heat from metal wile it was taken from the boiling water. Because the metal's heat capacity is very low, and metal has very strong heat conductivity. Therefore it will lose a lot of heat while it was taken from boiling water.

10 Conclusion

This experiment want to search the heat capacity of different shape of metals in order to know what type of metal they are. Because of purity of metals and the escaping of heat. It is kind of hard to find the which type of metal is. For example long bar's heat capacity is 383.35, it is very close to zinc and copper. If we cannot know the color metal bar is, we won't know what type of metal exactly is. The all of percent of error for each metal are not more than 5. Therefore the this is a successful experiment.

References

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