Kevin Zhang

Lab Report 1

Introduction

The goal of this lab was to measure the specific heat of a known substance, in this case copper and glass beads. This was done by heating up the beads in boiling water, and then cooling down the beads in cool water, and measuring the energy transferred to the cooled water.

Chemical Responsibility

The chemicals used in this lab are not inherently dangerous, but caution is advised with the glass beads that can shatter and boiling water that can burn. The copper and glass beads must be disposed of in their proper containers after finishing the experiment as copper is expensive, and glass beads are a safety hazard.

Report Sheet

Part 1: Copper

Measurement	Personal	Neighbor 1	Neighbor 2
Weight of copper (g)	25.606	25.458	25.109
Weight of water (g)	49.7	50.0	50.0
Heated Copper Temp ($^\circ C$)	99.4	105	102.8
Cool Water Temp ($^\circ C$)	19.0	22.5	14.1
Final Temp Reached ($^\circ C$)	22.1	28	17.8
Heat Gained By Water (J)	644	1150.6	773.3
Heat Lost By Copper (J)	644	1150.6	773.3
Copper Specific Heat (J/g$^\circ C$)	0.325	0.585	0.363
Average Specific Heat (J/g$^\circ C$)		0.424	

Part 2: Glass

Measurement	Personal	Neighbor 1	Neighbor 2
Weight of glass (g)	25.592	25.206	25.109
Weight of water (g)	49.7	50.0	50.0
Heated Glass Temp ($^\circ C$)	19.6	101.9	104.2
Cool Water Temp ($^\circ C$)	25.8	14.3	22.2
Final Temp Reached ($^\circ C$)	101.3	21.1	28.2
Heat Gained By Water (J)	1289	1421.2	1254.0
Heat Lost By Glass (J)	1289	1421.2	1254.0
Glass Specific Heat (J/g$^\circ C$)	0.667	0.698	0.658

Measurement	Personal	Neighbor 1	Neighbor 2
Average Specific Heat (J/g°C)		0.674	

Sample Calculations

$$q_{\text{copper}} = q_{\text{water}} = mc_{\text{water}}\Delta T = (25.606g)(4.184J/g^\circ C)(22.1^\circ C - 19.0^\circ C) = 0.644J$$
$$c_{\text{copper}} = \frac{q_{\text{copper}}}{m_{\text{copper}}\Delta T} = \frac{0.644J}{(25.606g)(99.4^\circ C - 22.1^\circ C)} = 0.325J/g^\circ C$$

Discussion of Results

The average specific heat of copper found in our lab was 0.424 J/g°C. According to an online reference, the expected specific heat would be 0.385 J/g°C, leaving us with a margin of error of 10.1%. Possible sources of this error include the outlier data point that Neighbor 1 provided us with at 0.585 J/g°C. Other sources of error may include inaccurate measurement of the thermometer as the water absorbed the heat from the copper beads, and/or the time taken to transfer the copper from the hot water to the cool water.

The average specific heat of glass found in our lab was 0.674 J/g°C. According to an online reference, the expected specific heat would be 0.670 J/g°C, leaving us with a margin of error of 0.6%. This is an extremely good result, either meaning that all three of our experiments had few sources of error, or the results of our experiments balanced each other out. Looking at the data, the latter is a bit more likely.

Post-Lab Questions

1. A solar panel is used to heat water in a tank. How much heat energy is needed to raise the temperature of 1000 L of water from an initial temperature of 23.0°C to a final temperature of 65°C?

$$q_{\text{water}} = mc_{\text{water}}\Delta T = (1000L)(\frac{1000g}{1L})(4.184J/g^\circ C)(65.0^\circ C - 23.0^\circ C) = 1.76 \times 10^8 J = 1.76 \times 10^5 kJ$$

2. Determine the specific heat of an unknown metal when 25.0 g of the metal, initially at 80.0°C is added to 100.0 mL of water initially at 20.0°C. The final temperature of the mixture is 21.6°C.

$$q_{\text{unknown}} = q_{\text{water}} = mc_{\text{water}}\Delta T = (100.0\text{mL})(\frac{1g}{1\text{mL}})(4.194J/g^\circ C)(21.6^\circ C - 20.0^\circ C) = 671.04J$$
$$c_{\text{unknown}} = \frac{q_{\text{unknown}}}{m_{\text{unknown}}\Delta T} = \frac{(671.04J)}{(25.0g)(80.0^\circ C - 21.6^\circ C)} = 0.460J/g^\circ C$$

3. Thirty grams of silicon at 80.0°C is added to 70.0 mL of water at 20.0°C. Calculate the final temperature after the two substances are mixed together. The specific heat of water is 4.184 J/g°C and the specific heat of silicon is 0.7121 J/g°C.

$$q_{\text{silicon}} = m_{\text{silicon}}c_{\text{silicon}}\Delta T = m_{\text{silicon}}c_{\text{silicon}}(T_{\text{initial-silicon}} - T_{\text{final}})$$
$$q_{\text{water}} = m_{\text{water}}c_{\text{water}}\Delta T = m_{\text{water}}c_{\text{water}}(T_{\text{final}} - T_{\text{initial-water}})$$
$$q_{\text{silicon}} = q_{\text{water}} \Rightarrow \frac{m_{\text{silicon}}c_{\text{silicon}}}{m_{\text{water}}c_{\text{water}}} = \frac{T_{\text{final}} - T_{\text{initial-water}}}{T_{\text{initial-silicon}} - T_{\text{final}}} \Rightarrow \text{Let } k = \frac{m_{\text{silicon}}c_{\text{silicon}}}{m_{\text{water}}c_{\text{water}}}$$
$$kT_{\text{initial-silicon}} - kT_{\text{final}} = T_{\text{final}} - T_{\text{initial-water}} \Rightarrow T_{\text{final}} = \frac{kT_{\text{initial-silicon}} + T_{\text{initial-water}}}{k+1}$$
$$k = \frac{(30.0g)(0.7121J/g^\circ C)}{(70.0g)(4.184J/g^\circ C)} = 0.0729 \Rightarrow T_{\text{final}} = \frac{(0.0729)(80.0^\circ C) + (20.0^\circ C)}{(0.0729) + 1} = 24.08^\circ C$$

4. A cube of brass, 2 cm on a side, is heated until the temperature of the brass is 75°C. The cube is quickly added to 100 mL of water at 23°C. What is the final temperature of the mixture? The specific heat of brass is 0.385 J/g°C. The density of brass is 8.45 g/cm^3.

$$\text{Using same derivation as above:}$$
$$k = \frac{m_{\text{brass}} c_{\text{brass}}}{m_{\text{water}} c_{\text{water}}}$$
$$T_{\text{final}} = \frac{kT_{\text{initial-brass}} + T_{\text{initial-water}}}{k+1}$$
$$m_{\text{brass}} = (2cm)(2cm)(2cm)(8.45g/cm^3) = 67.6g$$
$$k = \frac{(67.6g)(0.385J/g^\circ C)}{(100g)(4.184J/g^\circ C)} = 0.0622 \Rightarrow T_{\text{final}} = \frac{(0.0622)(75.0^\circ C) + (23.0^\circ C)}{(0.0622)+1} = 26.04^\circ C$$

Conclusion

In conclusion, the experimental values for the specific heat of copper and glass are 0.474 J/g°C and 0.670 J/g°C, respectively. This was done by heating up copper and glass elements, and then cooling them down in water, whose specific heat is known. The temperature differential and energy exchange was then used to compute the specific heat of copper and glass.