Specific Heat

Introduction

Heat is energy transferred to an object in such at way that no macroscopic work is done on the object. The energy is randomly distributed throughout the object so that the most notable change in the object is an increase in its temperature or a change in its phase, e.g. ice melting. The increase in temperature of an object is related to the heat transferred as follows:

$$Q = mc\Delta T \, , \tag{1}$$

where Q is the heat transferred to the object, m is the mass of the object, ΔT is the change in the temperature of the object, and c is the specific heat capacity of the material out of which the object is made [1]. The value of the specific heat capacity is approximately constant for a given material, but it does vary somewhat with temperature.

The purpose of this experiment is to measure values of the specific heat capacity of zinc and lead.

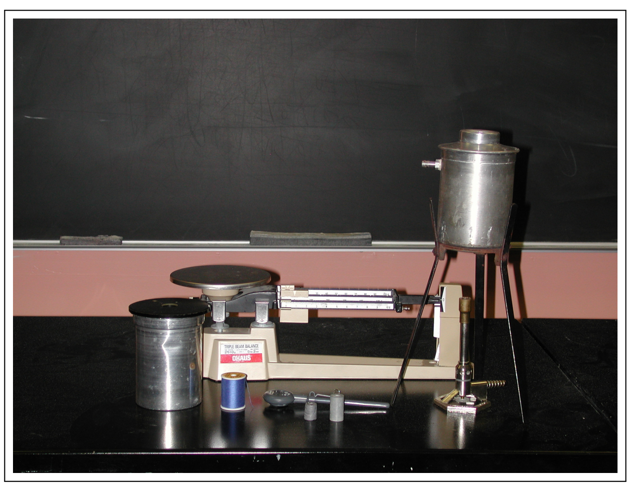

Figure 1: Equipment used in measuring specific heat capacity

Procedure

In order to measure the specific heat capacity, the object is heated to a temperature T_h. It is then immersed in an aluminum canister, i.e. calorimeter cup, containing water at temperature T_c. The entire system is allowed to come to equilibrium at temperature T_e. Using equation 1 and the principle of conservation of energy we can show that the specific heat capacity c of the material is given by

$$c = \frac{(m_{\text{water}}c_{\text{water}} + m_{\text{al}}c_{\text{al}})(T_e - T_c)}{m_{\text{o}}(T_h - T_e)} , \tag{2}$$

where m_{water}, c_{water} and m_{al}, c_{al} are the masses and values of the specific heat capacity of the water and aluminum canister, respectively. The quantity m_{o} is the mass of the object.

Apply the steps in the following procedure first to the zinc ingot and then to the lead ingot. [1] Report all data and the results of all computations, to the correct number of significant figures, in the appropriate table.

Experiment

1. The vessel for boiling the water should contain enough water so that when the ingot is immersed in the water it does not touch the bottom of the vessel. Bring the water to a boil.

2. Measure the mass of the ingot.

3. Measure the mass of the calorimeter cup.

4. Place the ingot in the calorimeter cup, and add a sufficient amount of water to cover the ingot by no more than approximately one centimeter. To improve the accuracy of the experiment the water should be approximately two or three degrees below room temperature. Remove the ingot. Measure the mass of the calorimeter cup and water.

5. Remove the cover from the calorimeter. Place the calorimeter cup into the calorimeter, and replace the cover.

6. Tie the ingot to a string. Attach the other end of the string to a wooden pencil or something comparable. Lower the ingot into the boiling water. Allow the ingot to come to equilibrium with the boiling water. At equilibrium the temperature of the ingot is $T_h = 100°\text{C}$. This should require approximately two minutes.

7. Just before removing the ingot from the boiling water measure the temperature of the water T_c in the calorimeter cup.

8. Remove the ingot from the boiling water. Blot it dry, quickly, with paper towels, and immerse it in the water in the calorimeter cup.

[1] Much of the procedure for this experiment has been adapted from that of an experiment authored by Russ Herman.

9. Stir the water in the calorimeter cup with the thermometer until the water reaches the equilibrium temperature T_e.

Analysis

1. Link to the website http://hypertextbook.com/physics/thermal/heat-sensible/, and obtain values of the specific heat capacity of aluminum, water, zinc, and lead. [2]

2. Using equation 2 calculate values of the specific heat capacity of zinc and lead.

3. Compare the experimental values (calculated values) of the specific heat capacity to those obtained from the website. Are the experimental values and values from the website in reasonable agreement? If not, comment on why they disagree, e.g. suggest some sources of systematic error inherent in the experiment.

References

[1] Wikipedia. Specific heat capacity. http://en.wikipedia.org/wiki/Specific_heat_capacity, 2007. [Online; accessed 10-June-2009].

[2] The values of specific heat capacity at constant pressure are listed at the website. These are the appropriate values since the experiment has been performed in a constant pressure environment, i.e. atmospheric pressure.

m_{al} (kg)	c_{al} (J/kg°C)	c_{water} (J/kg°C)

Table 1: Data I

	m_o (kg)	$m_{\text{water, al}}$ (kg)	m_{water} (kg)	T_h (°C)	T_c (°C)	T_e (°C)
Zn						
Pb						

Table 2: Data II

	c (J/kg°C) (experimental)	c (J/kg°C) (website)
Zn		
Pb		

Table 3: Calculations