#7 Specific Heat of Metals and Heat of Fusion of Ice

Pre-Lab Report

Lab section:

Name & Surname:

Table #:

***Before the Lab** complete this page YOURSELF! Hand it in in the first 5 min. of the session PERSONALLY!*

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. The calorimeter used in this experiment does not have perfect insulation and some heat is lost to the surroundings. Estimate the effect of 10% heat loss (10% of the total heat exchanged) on the specific heat value you determine for the specimen. Consult to the introduction part of your Lab Book or you may search for "Error propagation". **Show your calculations below explicitly or no credits!**

(2nd Question is on the next page!)

Q2. Show the dimensional analysis for the specific heat. **Show your formulae / derivation below explicitly or no credits!**

Q3. In the heat exchange equations, the thermal effect of the thermometer is neglected; discuss the possible thermal effect of the thermometer or the thermal sensor in the results of the experiment. **Justify your answers, show calculations if needed or no credits!**

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Lab Report

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Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest! **Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To measure the specific heat of a metal and to determine the unknown mass of an ice block, through the method of mixtures.

THEORY : It is experimentally shown that the heat absorbed by an object is directly proportional to the change in the temperature and the mass of the object. Proportionality constant is the specific heat of the material that the object is made of:

$$Q = mc\Delta T$$

If you use the SI unit system, the specific heat is defined as the amount of heat absorbed to increase the temperature by one centigrade for a 1 kg object. Unit for the heat is the same as Joule but in these calculations mostly calories are used (1 cal = 4.187 Joules).

When you place two objects at different temperatures in close contact, they will exchange heat until the temperatures are equal. The heat gained by one object is equal to the heat given by the other object since the energy is conserved. For example, if you have a calorimeter with a known mass $\boldsymbol{m_c}$ and specific heat $\boldsymbol{c_c}$ filled with water with mass $\boldsymbol{m_w}$ at a known temperature $\boldsymbol{T_1}$. When you place a specimen into the water inside the calorimeter at a higher temperature $\boldsymbol{T_2}$, assuming that there is no heat lost to the surroundings, we can write the following heat exchange equation:

$$m_s c_s (T_2 - T_3) = m_c c_c (T_3 - T_1) + m_w c_w (T_3 - T_1)$$

where T_3 is the final temperature of the mixture when it comes into equilibrium.

These expressions are valid unless there is no phase change. If there is a phase change involved, then the corresponding heat necessary for the phase change should be added into the appropriate side of the equation. For example, if we add a block of ice with a mass $\boldsymbol{m_i}$ at a temperature of $\boldsymbol{T_i}$ into the calorimeter mentioned in the previous paragraph, we should write the heat exchange as follows:

$$m_i c_i (0 - T_i) + m_i L_f + m_i c_w (T_4 - 0) = m_c c_c (T_3 - T_4) + m_w c_w (T_3 - T_4) + m_s c_s (T_3 - T_4)$$

since the heat of fusion, L_f, depends only on the mass. Temperature is constant during the phase change and the final temperature is T_4.

vAPPARATUS: Calorimeter, stirrer, thermometer, heater, water, specimen, ice, temperature sensor, data logger.

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PROCEDURE :

Calorimeter = Inner vessel of calorimeter + stirrer

Part 1: Determine the mass of the calorimeter (*inner vessel of the calorimeter and the stirrer*), and the mass of the specimen and its container.

Put your sample in its container into a water boiler one-third full and heat it until the temperature is 95°C.

Add 80 g of water at room temperature to the calorimeter. Measure the initial temperature of calorimeter and water, $t_{i\text{-}cal}$ and $t_{i\text{-}w}$. Quickly pour the hot sample into the calorimeter and observe the temperature rise of the water and calorimeter combination. Note the highest temperature as equilibrium temperature, t_{1e}. Before calculating the specific heat of given metal, continue with Part 2.

Part 2: Get an ice block and drop it into the calorimeter immediately and keep the system closed and well mixed. The temperature will first drop, then it will stay stationary as the ice melts, and finally, it will decrease to the equilibrium temperature t_{2e}. Record this temperature.

Calculate the specific heat of metal and the mass of ice block.

DATA:

Description / Symbol			Value & Unit
Specific Heat of Water	c_w	=	.....
Specific Heat of the Calorimeter	c_{cal}	=	.....
Specific Heat of Ice	c_{ice}	=	.....
Heat of Fusion of Ice	L_f	=	.....

PART 1 – SPECIFIC HEAT OF METALS

Description / Symbol			Value & Unit
Mass of the Calorimeter	m_{cal}	=	.....
Mass of Water	m_w	=	.....
Mass of the Specimen + container	m_{s+con}	=	.....
Mass of the			

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Specimen m_s = ...

Initial Temperature of the

Calorimeter $t_{i\text{-}cal}$ = ...

Initial Temperature

of Water $t_{i\text{-}w}$ = ...

Initial Temperature of the

Specimen $t_{i\text{-}s}$ = ...

Equilibrium

Temperature t_{1e} = ...

PART 2 – HEAT OF FUSION OF ICE

Description / Symbol	**Value & Unit**

Initial Temperature

of Ice $t_{i\text{-}ice}$ = ...

Initial Temperature of the

Calorimeter, Water and the

Specimen $t_{i\text{-}cal + contents}$ = ...

Equilibrium

Temperature t_{2e} = ...

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CALCULATIONS:

For PART-1: **(NO NUMERICAL EVALUATION)**

Heat Lost: . . . . . .

. . . . . .

Heat Gained: . . . . . .

. . . . . .

Specific Heat of the Specimen: c_s = ...

For PART-2: **(NO NUMERICAL EVALUATION)**

Heat Lost: . . . . . .

. . . . . .

Heat Gained: . . . . . .

. . . . . .

Mass of Ice: $m_{\text{ice-EV}}$ = ...

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RESULTS:

Description	Calculations (show each step)	Result

Specific Heat

of the Specimen c_s =. . . . . .

. . . . . .

Total Mass m_{total} = ...

Experimental Value of the Mass of Ice $m_{ice\text{-}EV}$=. . . . .

. . . . . .

Measured Value of the Mass of Ice $m_{ice\text{-}MV}$=. . . . . .

. . . . . .

% Error for the Mass of Ice:. . . . . .

Dimensional analysis for the Specific Heat:. . . . . .

Consult to the resources for this experiment from PHYS LAB Website:

PHYL102 Intro

Presentation #7

PHYL102 Lab Book