The Second Experiment

MEASURING SPECIFIC HEAT CAPACITY BY MIXING METHOD & USING A CALORIMETER

The Objective of the experiment:

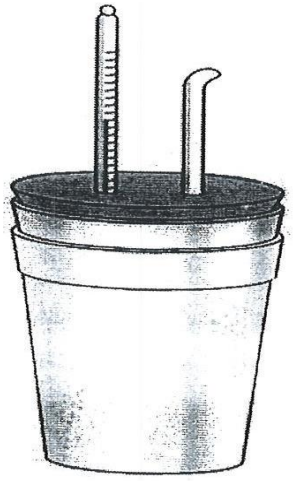
To calculate the specific heat of a solid body.

The Used Equipments:

- Copper calorimeter with its outer cover.
- Thermometer
- Water boiler.
- A solid body in which its specific heat capacity is to be measured.

What is the calorimeter?

It is a metal container made of copper or aluminum, its specific heat capacity is known, and it has a preservative, which is another container that is wider and it contains an insulating material such as felt or sawdust on which the calorimeter is based when placing it inside the case. The case after placing the calorimeter is covered with a lid made of a heat-insulating material that has two holes, one for inserting a thermometer and the other for inserting a hooked wire that moves the liquid in the calorimeter. Copper is used because its specific heat is very low. The absorption and liberation of heat will be less during heat transfer.



The Theoretical Part:

When two bodies of different temperatures come into contact, the heat energy is transferred from the hot body to the cold body until it reaches a state of equilibrium.
Specific heat is defined as the amount of heat required to change the temperature of a unit mass of a body by one degree.
The specific heat of an object can be measured using mixing method. For this method, a calorimeter is used, and here are the details:

If a hot solid object is put in the water in a calorimeter, heat exchange between the hot object and the water and calorimeter starts. This continues till the temperatures of the solid object, water and the calorimeter become equal.
Therefore, Heat lost by solid object= Heat gained by water in calorimeter+ Heat gained by the calorimeter.
Here, heat lost by the solid object (Q) = mass of the solid object * its specific heat * decrease in its temperature.
Similarly, heat gained by the water (Q1)= mass of the water * its specific heat x increase in its temperature as, Heat gained by the calorimeter (Q2)= mass of the calorimeter * its specific heat * increase in its temperature.
Heat lost by hot object= Heat gained by calorimeter+ Heat gained by water. Q=Q2+Q1
Using these equations, if the specific heat of water and the calorimeter are known, the specific heat of the solid object can be calculated.

The amount of heat ΔQ that a body of mass (m) and specific heat (C) gains or losses and its temperature changes by the amount (ΔT) is given by the following relationship:

$$\Delta Q = c\ m\ \Delta T \quad \ldots \quad (1)$$

By applying the law of **thermal equilibrium** to calculate the value of the specific heat capacity of a solid body, **the amount of heat lost by the hot body** is **equal to the amount of heat absorbed by the water and calorimeter**.

$$m\ c_1(T-T_2)=[m_0-c_0+(m_1-m_0)c]\ (T_2-T_1)\ldots\ldots\ldots(2)$$

Where:
c_1 Specific heat of the substance to be determined
c_0 Specific heat of the calorimeter and it is equal to 0.22 cal/g.C^0
c= specific heat of water and it is equal to 1 cal/g.C^0

The Procedure:

1. Put a quantity of water in the water boiler and then start heating.

2. Find the mass of the body whose specific heat capacity is to be calculated, let it be (m) in grams and tie this body with a thread and place it with a thermometer in boiling water for an appropriate period of time so that its temperature is equal to the temperature of the boiling water which is 100 °C, then record that temperature and let it be (T) in °C.

3. Find the mass of the empty, dry calorimeter let it be (m_0) in grams.

4. Fill the calorimeter with water to its half, then determine its mass, let it be (m_1) in grams.

5. Put the calorimeter in its case and set the initial calorimeter and water temperature with the thermometer and let it be (T_1) in °C.

6. Move the metal piece from the boiling water by the thread quickly to the water in the calorimeter. Close the cover of the case and stir the water with the stirring wire while observing the thermometer carefully, you will notice the rising in temperature of the calorimeter, set the final temperature of the calorimeter and let it be (T_2) in °C which is the highest temperature recorded by the thermometer.

7. Calculate the specific heat of a solid body by applying the heat equilibrium law through equation (2).

Some notes:

1. This method is applied when the specific heat capacity of the liquid which exchange heat with the solid body is known without any loss of heat energy.
2. Any liquid with a known specific heat capacity can be used other than water, provided that the solid body does not dissolve in that liquid and does not interact with it.
3. There might be heat loss while transferring solid into the calorimeter, and this may causes some errors .

Example (1):

If you have a solid copper body with a mass of 101 g, where the temperature of the calorimeter with water before placing the body was 22 °C, and the mass of the calorimeter when empty was 76 g, and the mass of the calorimeter with water was 319 g, and the temperature of the calorimeter with water after placing the body was 25°C, and the boiling water temperature was 100°C, knowing that the specific heat capacity of the calorimeter is 0.22 cal/g.°C and the specific heat capacity of water is 1 cal/g.°C. Find the specific heat capacity of the body?

Solution:

$mc_1(T-T_2)=[m_0-c_0+(m_1-m_0)c](T_2-T_1)$
$101*c_1(100-25)=[76*0.22+(319-76)*1)]*(25-22)$
$7575*c_1 = 770.16 / 7575$

$c_1 = 0.09$ cal/g.C^0 which is the specific heat capacity for Copper

Assignment:

1. If you have a solid copper body with a mass of 102 g, where the temperature of the calorimeter with water before placing the body was 23°C, and the mass of the calorimeter when empty was 76 g, and the mass of the calorimeter with water was 257 g, and the temperature of the calorimeter with water after placing the body was 25°C, as the boiling water temperature was 100°C, knowing that the specific heat capacity of the calorimeter is 0.22 cal/g.C^0 , and the specific heat capacity of water is 1 cal/g.C^0 , find the specific heat capacity of the body?

2. Answer the following questions:
   a) What is the heat?
   b) Define the specific heat of the substance.
   c) State the principle of Calorimeter.
   d) Why is calorimeter made of copper is used in the experiment?
   e) Is heat gained always equal to the heat lost?