E-NOTE FOR WEEK 4 OF TERM 3 2020 SESSION

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TERM/ WEEK : **THREE / WEEK 4**

SUBJECT: **PHYSICS**

CLASS: **SS 1**

TOPIC: **HEAT CAPACITY /SPECIFIC HEAT CAPACITY**

HEAT ENERGY

MEASUREMENT OF HEAT ENERGY

Note that heat is a form of energy that flows from one body to the other due to temperature difference between the bodies

The heat content of a body depends on the following factors;

1 the mass of the body

2 the specific heat capacity

3 the temperature change

HEAT CAPACITY:

This is the quantity of heat required to raise the temperature of the entire body through one degree rise in temperature. (1K)

SPECIFIC HEAT CAPACITY:

This is the quantity of heat required to raise the temperature of unit mass (1kg) of a substance through a degree rise in temperature I.e 1^0 or 1K

The table below gives the values of the specific heat capacity of some substances

SUBSTANCES	c IN $JKg^{-1}K^{-1}$
Lead	130
Mercury	140
Brass	380
Zinc	380
Copper	400
Iron	450
Glass	670

Aluminum	**900**
Ice	**2100**
Methylated spirit	**2400**
Sea-water	**3900**
Water	**4200**

Heat capacity = mass X specific heat capacity

$$Q = mc\theta$$

Where

m = mass

c = specific heat capacity

θ = change in temperature

QUESTIONS:

(1) calculate the mass of iron with heat capacity of 900 $Jkg^{-1}K^{-1}$

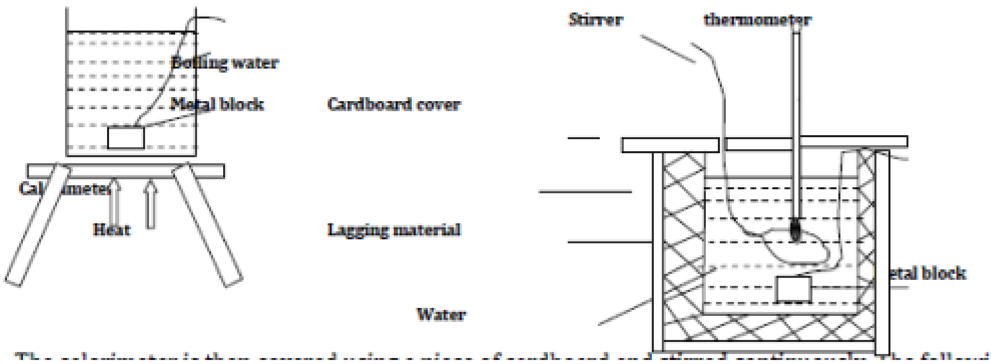
2 What quantity of heat is needed to raise the temperature of 20kg of aluminum through 10K

MEASUREMENT OF SPECIFIC HEAT CAPACITY

The following methods can be used;

1 Method of mixture 2 Electrical method

Experiment to determine the specific heat capacity by the method of mixtures.



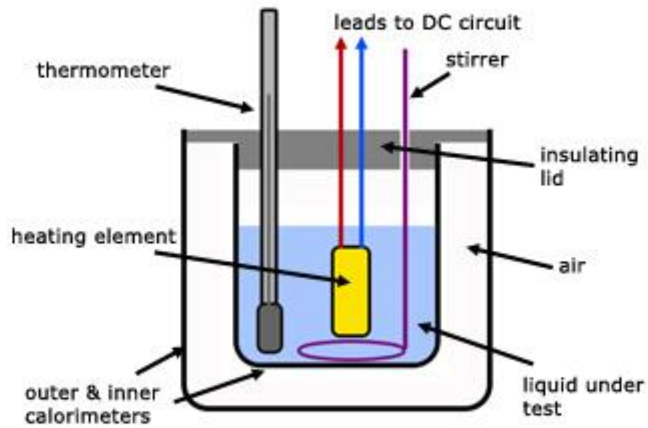
In this method, a known mass of a solid, e.g. a metal block is heated by dipping it in a bath of hot water. After some time, the solid is very fast transferred into cold water in a calorimeter and whose mass is known.

The calorimeter is then covered using a piece of cardboard and stirred continuously. The following measurements are then recorded:
- Mass of the solid metal block, M_s
- Mass of copper calorimeter with the stirrer, M_c
- Mass of the calorimeter and stirrer + water, M_1
- Temperature of the boiling water (initial temperature of the metal block), Θ_s
- Temperature of cold water in the calorimeter (initial temperature of calorimeter), Θw
- Final steady temperature of the mixture, Θ

Calculation
Mass of the water in the calorimeter = $M_1 – M_C = M_W$
Temperature change of the hot metal block = $\Theta s – \Theta$
Temperature change of the water in the calorimeter and the calorimeter = Θ- Θw
Assuming there is no heat loss to the surrounding when the metal block is being transferred into the cold water and thereafter;

mount of heat lost by the metal block = amount of heat gained by calorimeter with stirrer + amount of heat gained by water in the calorimeter.
i.e. $Ms\ Cs(\Theta s-\Theta) = McCc(\Theta-\Theta w) + MwCw(\Theta-\Theta w)$
wherecs – specific heat capacity of the metal block
Cc – specific heat capacity of the copper calorimeter
Cw – specific heat capacity of water.
Hence specific heat capacity of the metal block, $Cs=[McCc(\Theta-\Theta w) + MwCw(\Theta-\Theta w)] /Ms(\Theta s-\Theta)$

Specific Heat Capacity of a Liquid by Electrical Method



The heat energy supplied by the electrical element is given to the liquid and its container, producing a temperature rise **$\Delta\theta$**.

The heater current (I) and voltage (V) are monitored for a time (**t**).

energy supplied by heater = **VIt**

energy absorbed by liquid and container = $\mathbf{m_L c_L \Delta\theta + m_C c_C \Delta\theta}$

where,

$\mathbf{m_L}$ mass of liquid
$\mathbf{m_C}$ mass of container
$\mathbf{c_L}$ specific heat capacity of liquid
$\mathbf{c_C}$ specific heat capacity of container

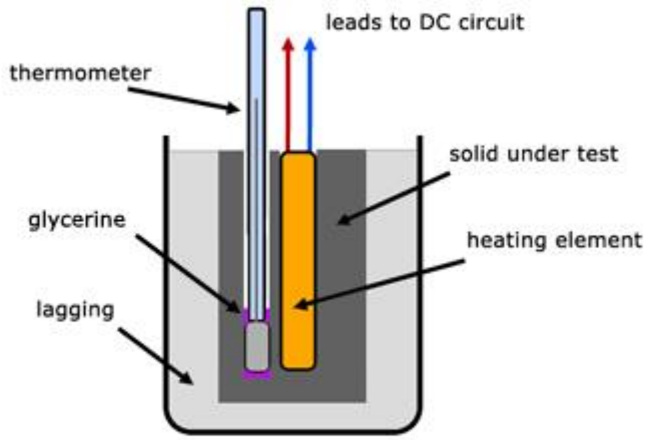
Equating the two quantities,

$$VIt = m_L c_L \Delta\theta + m_C c_C \Delta\theta$$

$\mathbf{m_L}$, $\mathbf{m_C}$, $\mathbf{c_C}$ are known and **V**, **I**, **t**, **$\Delta\theta$** are all measured.

So the specific heat capacity of the liquid ($\mathbf{c_L}$)can be calculated.

Specific Heat Capacity of a Solid by an Electrical Method



The method is very similar to that for a liquid except that there is **no container**.

The solid under test is a lagged cylinder with holes drilled for the thermometer and the heater element.

A little **glycerine** is added to the thermometer hole to improve thermal contact.

Heat energy supplied by the electrical element is given directly to the solid, producing a temperature rise **Δθ**.

$$VIt = m_s c_s \Delta\theta$$

where,

m_S - mass of solid
c_S - specific heat capacity of solid

m_S is known and **V**, **I**, **t**, **Δθ** are measured.

So the specific heat capacity of the solid (**c_S**)can be calculated.

NB More accurate results can be obtained by applying a '**cooling correction**'.
This is based on **Newton's Law of Cooling**, which states :
The rate of cooling is proportional to the excess temperature over the environment.

Example 1:

A piece of iron of specific heat capacity $0.04Jkg^{-1}k^{-1}$ and mass 400kg, is quickly dropped into 30kg of water at 10^0C contained in a calorimeter of 120kg mass and c of $0.1Jkg^{-1}K^{-1}$. If the temperature of the mixture is 30^0C, Calculate the initial temperature of the hot iron.

Example 2:

A liquid of specific heat capacity $3Jg^{-1}K^{-1}$ or $3000Jkg^{-1}K^{-1}$ rises from 15^0C to 65^0C in one minute when an electric heater is used. If the heater generates 63kJ per minutes, Calculate the mass of the liquid.

Example 3:

A certain metal of mass 1.5kg at initial temperature of 27^0C, absorbed heat from electric heater of 75W rating for 4 minutes. If the final temperature was 47^0C. Calculate the specific heat capacity of the metal, hence its heat capacity.

ASSIGNMENT

SPECIFIC HEAT CAPACITY QUESTIONS

1 How many Joules of heat are required to raise the temperature of 500g of copper from 16^0C to 116^0C ? (c of copper = 0.4J/g/K or 400J/Kg/K)

2 A liquid of specific heat capacity 3J/g/K or 300j/kg/K rises from a temperature of 15^0C to 65^0C in 1min when an electric heater is used . if the heater generates 63kJ per minute. Calculate the mass of the liquid.

3 An electric heater of 50Watts is used to heat a metal block of mass 5Kg in 10 minutes, a temperature rise of 12^0C is produced.

(a) how much heat is produced by the heater in 10 minutes?

(b) Calculate the specific heat capacity of the metal.

4 2kg of lead at 100^0C is dropped into a copper vessel containing 0.3kg of water at 0^0C and rapidly stirred. The final temperature attained by the vessel and its contents is 16^0C, taken the specific heat capacity of lead to be 130J/Kg/K. Calculate the heat capacity of the copper vessel.

THE QUESTIONS HERE ARE FOR PRACTICE, YOUR ASSIGNMENT IS IN THE ASSIGNMENT CORNER.

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