Physics

B. Sc. IV – Semester

Practical Mannual

(As per the syllabus of Adikavi Nannaya University, Rajamahendravaram)

Prepared by

P.S. Brahmachary M.Sc., M.Phil.

Lecturer in Physics

D.R.G. Government Degree College

Tadepalligudem

West Godavari

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Thermistor

Aim :- To determine the temperature coefficient of resistance of a thermistor from resistance - temperature graph, after determining the resistances of the thermistor at different temperatures.

Apparatus :- Post office box, thermistor, galvanometer, battery, plug- key, a hot water bath, thermometer and connecting terminals.

Formulae :- 1. Wheat- Stones bridge principle $\frac{P}{Q} = \frac{R}{S}$ (OR) $S = \frac{Q}{P}.R$ $\boldsymbol{\Omega}$

Here P, Q and R are the known resistances in the post office box ($\boldsymbol{\Omega}$)

S = Unknown resistance of the thermistor ($\boldsymbol{\Omega}$)

2. Temperature coefficient of resistance of thermistor $\boxed{\alpha = \frac{S_2 - S_1}{S_1 t_2 - S_2 t_1}}$ / ^{O}C

Here S_1 , S_2 are the resistances of the thermistor at temperatures t_1 , t_2 (^{o}C)

Theory :- The effect of temperature is more on thermistors. The change in resistance of thermistor is large when its temperature changes. Thermistor is made with semi-conductor material. These thermistors have positive and negative temperature coefficient of resistances. They are often used in devices that control temperatures and that measure temperatures , as their resistance is temperature dependant. Specifically, they are used mostly in temperature measuring devices from -100oC to + 350oC. They are made with a mixture of metal (such as manganese, cobalt, and copper) oxides. The resistance ranges from 0.5Ω to 100 MΩ. These are chemically fragile. These are interconnected in series or in parallel in the circuit as per the need. Their voltage - current characteristic curves are not straight lines. This means that they are non-Ohmic resistors. If the current through the load is increased, the voltage will increases gradually and then gradually decreases.

Description: - The Wheat-Stone's bridge circuit is the circuit of this experiment. P, Q and R are three resistance boxes connected with in one box called post office box. In place of the fourth resistance 'S' a thermistor is connected. As shown in the figure, a galvanometer is connected to a pair of opposite terminals and a battery in series with a plug-key is connected to another pair of terminals in the bridge.

Procedure : - After connecting the circuit, it is necessary to first keep fixed resistances P and Q blocks. Keep zero resistance in R in one case and keep infinite resistant in R in another case and hold the key in the plug and send the electric current through the circuit. In both cases the galvanometer deflection should be in opposite directions. Then the connections in the circuit are correct. Other wise the connections must be checked.

Now the thermistor is placed in a hot water bath and the thermometer placed in the same hot water. This can measure the temperature of the water in the vessel. Send the electric

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current through the circuit and change the resistance R value upto the galvanometer shows zero deflection. Doing this is called bridge balancing. This R value is noted in the table.

$\frac{P}{Q} = \frac{R}{S}$ formula is applicable when the bridge is balanced.

The resistance of the thermistor 'S' is calculated using the formula $S = \frac{Q}{P}.R$

Now gradually increase the temperature of water in the vessel in steps of $2^{o}C$, change the resistance R value and balance the bridge and note the R value in the table. The experiment is repeated by increasing the temperature in equal steps of $2^{o}C$ upto $30^{o}C$ or $40^{o}C$. This experiment should also be done by decreasing the temperature. These t and R values should be included in the table.

Graph : - Draw a graph by taking temperature t on the X - axis and resistance of the thermistor S on the Y - axis. It gives a curve. Draw two straight perpendicular lines at two different temperatures which are very close to each other. These two straight lines intercept the curve at two points. Two perpendicular lines on to the Y - axis are drawn from these two points of interception. These two feet of perpendiculars on the Y - axis give S_1 and S_2 which are the resistances of thermistor at temperatures t_1 and t_2.

Temperature coefficient of resistance α value of the thermistor can be calculated by substituting the t_1, t_2 and S_1, S_2 values in the equation $\alpha = \frac{S_2 - S_1}{S_1 t_2 - S_2 t_1}$

Precautions: -

1. P and Q resistance values must be kept constant through out the experinet.
2. Do not send too much current through the thermistor.
3. In the two cases, when R = 0 and R = ∞, the deflections of the galvanometer should be in the opposite directions, then only the experiment can be continued, other wise check the connections once again.
4. Use a sensitive thermometer to measure temperature.

Result: - Temperature coefficient of resistance of thermistor α value = ____________ / oC

Graph

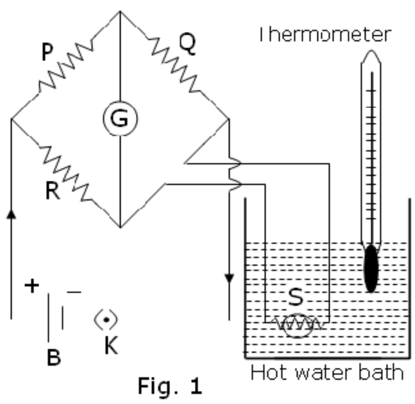

Fig. 1

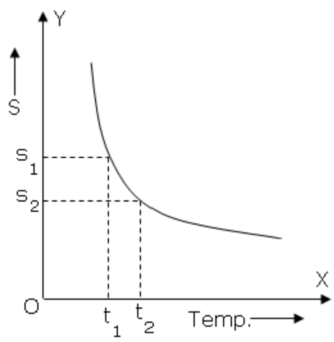

Fig. 2

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Table

S. No.	Temp. t °C	Resistance when the bridge is balanced (R) Ω			Thermistor resistance $S = \frac{Q}{P}.R$ Ω
		While increasing temperature R_1	While decreasing temperature R_2	Average $R = \frac{R_1 + R_2}{2}$	
1. 2. 3. 4. . . . . 18. 19. 20.					

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Specific heat of liquid – Newton's law of cooling

Aim : - To determine the specific heat of the given liquid by using Newton's law of cooling method.

Apparatus: - Calorimeter with black coating on the outer surface + stirrer, wooden box, sensitive thermometer with low minimum measurement (0.2°C), stop - clock, Physical balance, weight box, water and liquid whose specific heat is to be determined.

Formula :-

$$\boxed{\frac{[W_1 S_1 + (W_2 - W_1)S_2]}{t_w} = \frac{[W_1 S_1 + (W_3 - W_1)S]}{t_l}}$$

W_1 = Mass of Empty calorimeter + stirrer (gms)
W_2 = Mass of Empty calorimeter + stirrer + water (gms)
$(W_2 - W_1)$ = Mass of water (gms)
W_3 = Mass of Empty calorimeter + stirrer + liquid (gms)
$(W_3 - W_1)$ = Mass of liquid (gms)
S_1 = Specific heat of the material of the calorimeter (0.1 Cal/gm/°C)
S_2 = Specific heat of water (1.0 Cal/gm//°C)
S = Specific heat of liquid (Cal/gm//°C)
t_w & t_l are the times (in seconds) taken by (calorie meter + square + water) and (calorie meter + starter + liquid), to cool from temperature θ_2 to temperature θ_1. These values are taken from the graph.

Theory : - According to the Newton's law of cooling, the rate of heat loss of a body is directly proportional to the difference of its temperature and the temperature of the surroundings.

$$\frac{dQ}{dt} \propto (\theta_B - \theta_S)$$

$\frac{dQ}{dt}$ = Rate of cooling of the body or rate of loss of heat
θ_B = Temperature of the body
θ_S = Temperature of the surroundings

If the temperatures of two bodies are equal then their rates of cooling are also equal.

Temperatures of two bodies $\theta_{B1} = \theta_{B2}$ then $\boxed{\frac{dQ_1}{dt_1} = \frac{dQ_2}{dt_2}}$

As per this equation, the rates of cooling of water and liquid are equal if their masses taken in the calorimeter are equal.

Rate of cooling of (calorimeter + water) = Rate of cooling of (calorimeter + liquid)

As per the formula $Q = mSt$

$$\frac{[W_1 S_1 + (W_2 - W_1)S_2]\,(\theta_2 - \theta_1)}{t_w} = \frac{[W_1 S_1 + (W_3 - W_1)S]\,(\theta_2 - \theta_1)}{t_l}$$

(OR)

$$\boxed{\frac{[W_1 S_1 + (W_2 - W_1)S_2]}{t_w} = \frac{[W_1 S_1 + (W_3 - W_1)S]}{t_l}}$$

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Procedure : - Take a calorimeter with black coating on the outer surface with the stirrer. Its mass W_1 grams is found with the help of a physical balance. Water whose temperature is around 80°C to 90°C, is taken in to calorimeter upto 2/3 of its volume. The calorimeter is placed in a wooden box and cotton or wool is placed around it. The Ebonite lid is placed on the wooden box. This avoids heat loss due to forced convection. The thermometer is placed in the hole of the Ebonite lid. The temperature of hot water is recorded for each minute, with the help of the stop clock, thermometer and the values are noted in the table. Thus time-temperature values should be noted up to 60°C. Then the calorimeter is removed from the wooden box and allow it to cool upto room temperature. Its mass W_2 grams is found with the help of a physical balance. Remove the water from the calorimeter and make it dry.

The liquid whose specific heat is to be calculated is heated up to 80°C to 90°C in another vessel. This hot liquid is taken in to the same calorimeter up to the water level taken prior. Keep this calorie meter in a wooden box. The Ebonite lid is placed on a wooden box and place the thermometer in the hole.

The temperature of hot liquid is also recorded for each minute, with the help of the stop clock, thermometer and the values are noted in the table. Thus time-temperature values should be noted up to 60°C. Then the calorimeter is removed from the wooden box and allow it to cool upto room temperature. Its mass W_3 grams is found with the help of a physical balance.

Graph: - Draw two graphs (two cooling curves) on the same graph sheet, one graph for (calorie meter + water) and another graph for (calorimeter + liquid) by taking time on X-axis and temperature on Y-axis.

Draw two parallel lines in parallel to the time axis at temperatures θ_2 and θ_1. The two horizontal lines intercept each cooling curve at two points. From these two pairs of intercepting points draw four perpendicular lines on to the X- axis. From these four perpendicular lines, the time (t_w) taken by the calorimeter + water to cool from θ_2 to θ_1 and the time (t_l) taken by the calorimeter + liquid to cool from θ_2 to θ_1 are determined.

The specific heat (S) of the given liquid is found by substituting the values of W_1, W_2, W_3, S_1, S_2, t_w and t_l in the above equation.

Precautions : -

1. Liquid and water should be taken up to the same level in the calorimeter.
2. Temperatures should be measured with a sensitive thermometer which is having minimum measurement.
3. Liquid and water temperatures should be around 40 °C above the temperature of surroundings.
4. Measure the time and temperature with out error.

Result: - Specific heat of given liquid, S = _______ calorie / gram / °C

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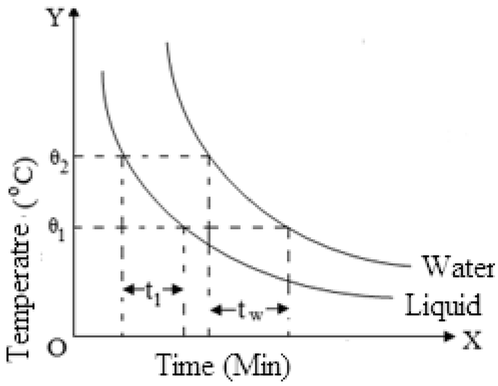
Table

S.No.	Time (Minutes)	Temperature (^oC)	
		Calorimeter + Water	Calorimeter + Liquid
1.			
2.			
3.			
4.			
18.			
19.			
20.			

Graph



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Electric Kettle - Efficiency

Aim : - To find the change in the efficiency of electric kettle by heating it by changing voltage.

Apparatus : - AC power source, step-down transformer, AC voltmeter, AC ammeter, rheostat, plug-key, thermometer, stop - clock and connecting wires.

Formula :- Percent of efficiency of electric Kettle $\eta = \frac{[W_1 S_1 + (W_2 - W_1)S_2](\theta_2 - \theta_1)}{VIt/J} X\ 100$

W_1 = Mass of empty Kettle (gms)
W_2 = Mass of empty Kettle + water (gms)
$(W_2 - W_1)$ = Mass of water (gms)
S_1 = Specific heat of the material of the Kettle (0.1 cal/gm/^{o}C)
S_2 = Specific heat of water (1.0 cal/gm/^{o}C)
θ_1 & θ_2 = Initial and final temperatures of (Kettle + water) (^{o}C)
V = Applied voltage (volts)
I = Current (amp)
t = Time of flow of current (Sec)
J = Mechanical equivalent of heat = 4.18 J / cal

Description and theory : - The primary coil of the step-down transformer is connected to the AC power source. Plug-key, rheostat, AC ammeter and resistance coil in the Kettle are connected in series to the secondary coil of the transformer. AC voltmeter is connected in parallel to the resistance coil in the Kettle. When the electric current is sent for a period of time through the electric circuit, the resistance converts the electric energy into heat. The Kettle and water absorb this thermal energy and their temperature increases.

The electric energy delivered to the kettle and water by the circuit is the in put energy. The increase in the internal energy of kettle and water when their temperatures increase is the out put energy. The ratio of the out put energy to the input energy is the Kettle's thermal efficiency.

Procedure : - First, the electrical circuit should be connected. Then take a clean, dry, empty kettle, and find its mass W_1 with the help of physical balance. Now take water in to the Kettle such that the resistance coil in the Kettle should immerse completely in that water. Then the mass W_2 of (Kettle + water) should be taken with the help of balance.

Now keep the resistant coil in the kettle water and close the circuit and adjust the rheostat jockey until the voltmeter (V) shows150V. Then note voltmeter reading (V) and ammeter reading (I). Now remove the key in the plug to open the circuit. Keep the thermometer in the water in the kettle and note the initial temperature θ_1. Now hold the key in the plug to close the circuit and start the stop-clock at the same time. Now the kettle and water gradually warm up. After current is sent for 5 minutes, the electric current will be

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discontinued and the final temperature θ_2 and the time of flow of the current (t) should be noted.

Remove the water in the Kettle and repeat the experiment with different voltages by taking clean water again. W_2, V, I, θ_1, θ_2 and t are noted in the table below each time and find the Kettle thermal(heat) efficiency(η).

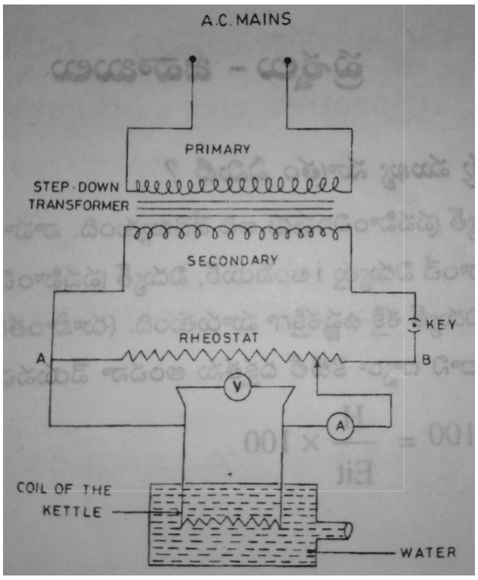
Table

Mass of empty Kettle W_1 = _______ gms

S.No.	Mass of Kettle + Water (W_2) gms	Voltage (V) Volts	Current (I) amps	Time of flow of current (t) Min	Initial temp. (θ_1) °C	Final temp. (θ_2) °C	Efficiency of Kettle (η)
1.							
2.							
3.							
4.							
5.							

Precautions: -

1. Scratch the tips or edges of the connecting wires with the blade.
2. Electric current should be sent through the circuit, only after the resistance is completely submerged in the water.
3. Thermometer minimum measurement should be less than 0.2°C.
4. The voltmeter and ammeter readings should be noted without parallax error.



Result :- Heat efficiency of electric Kettle = ______

____

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Thermal conductivity of bad conductor – Lee's method

Aim : - To determine the thermal conductivity of a bad conductor using Lee's method.

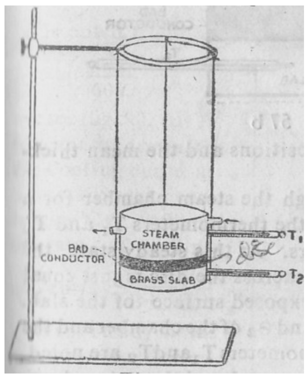
Apparatus : - Lee's apparatus, steam generator, bad conductor disc, two thermometers, spring balance, stop - clock, Vernier calipers and screw guage.

Formula: - Thermal conductivity of bad conductor

$$K = \frac{mSta\,(r+2d)}{2\pi r^2\,(r+d)\,(\theta_1-\theta_2)} \quad \text{cal / sec / cm /}^oC$$

m = mass of brass disc (gms)
d = Thickness of brass disc (cm)
r = Radius of the bad conductor disc (cm)
t = Thickness of the bad conductor disc (cm)
S = Specific heat of brass (disc) (0.1 cal/gm/^{o}C)
θ_1 = Steady temperature of the steam (^{o}C)
θ_2 = Steady temperature of brass disc (^{o}C)
a = $\frac{d\theta}{dt}$ = Rate of cooling of the brass disc (^{o}C/sec)

Description : - In the Lee's device, there is a brass disc well-polished with nickel. A circular metal ring is arranged horizontally to a retort stand. Three chains having the same lengths are hanged to the ring. A brass disc is hanged horizontally from the three chains. There is a hole at one place on the side of the brass disc. It holds the thermometer T_2 and this thermometer measures the temperature of brass disc.



There is a brass hallow steam chamber that has also diameter equal to that of the brass disc. This steam chamber has three holes on the curved side. Steam is passed through one hole and steamed out by the second hole. In the third hole, the thermometer, T_1, is inserted to measure the temperature of steam.

The bad conductor material whose thermal conductivity is to be measured must also be taken in the form of circular disc. Steam chamber, bad conductor and brass disc, all these three should have equal radii. Also, top and bottom sides of all these three must be flat. When they are placed on one another those surfaces need to touch completely.

The bad conductor is placed on the brass disc and the steam chamber is placed on the bad conductor. When they are observed, they should look like a single cylinder.

Procedure : - First, the mass of the brass disc (m) is obtained by using the spring balance. Later with the help of the Vernier calipers, the thickness (d) of the brass disc and the radius (r) of the bad conductor are found. The thickness (t) of the bad conductor is found with the help of a screw gauge.

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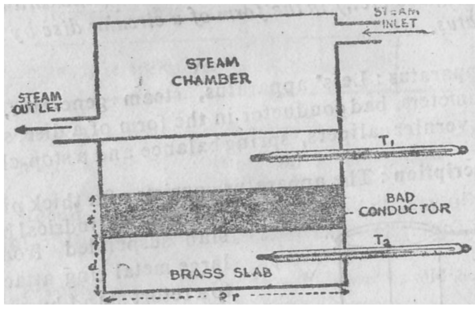
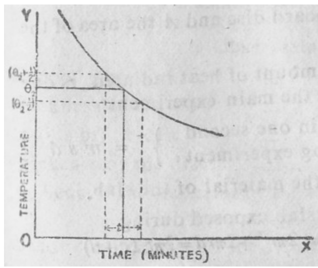


Place the bad conductor disc on the brass disc and place the steam chamber on it. Now water taken in the steam generator is heated. The water vapor coming from the steam generator is passed through the steam chamber until the temperature of the brass disc attains a steady temperature. Now the steam temperature θ_1 in the steam chamber and the brass disc temperature θ_2 are measured. Then remove the bad conductor disc. Now brass disc is put in contact directly with the steam chamber. Hence, the brass disc temperature still increases. The brass disc temperature should be increased by 10^oC above θ_2 and then remove the steam chamber above the brass disc.

Now the brass disc is allowed to cool, temperature of the brass disc is noted for every minute, with the help of the stop - clock and the thermometer T_2 . These values should be taken into the table.

Graph : - A graph is drawn by taking the temperature of the brass disc on the Y-axis and time on the X-axis. It gives a curve. Draw two parallel lines, parallel to the X-axis at two close temperatures on Y-axis, they intercept the curve at two points. Then draw to perpendicular lines from the two points of intercept on to the X-axis. From this the temperature fall dθ in time dt can be known. From this the rate of cooling $\boxed{a = \frac{d\theta}{dt}}$ can be determined.



The values of m, s, t, r, d, a, θ_1, and θ_2 are substituted in the above equation and the value of thermal conductivity (K) of bad conductor can be found.

Precautions: -

1. The brass disc, bad conductor and the steam chamber should have equal radii.
2. The top and bottom faces the brass disc, bad conductor and the steam chamber should be flat. They must touch each other completely.
3. Temperatures θ_1 and θ_2 should be noted after the brass disc attaining steady temperature (Constant temperature).
4. The steam coming from the steam chamber is converted in to water and this water should not fall on the brass disc.

Result : - Thermal conductivity of the given bad conductor K = ________ cal / sec / cm /^oC

Mass of the brass disc = ______ gms

Vernier calipers

Least count of vernier calipers $L.C. = \frac{1\ \text{MSD}}{\text{No.of VSD}}$

Table - 1

To determine the thickness of the brass disc :-

S. No.	MSR (a) cm	VSR (n)	n x L.C. (b) cm	Total reading (a +b) cm
1.				
2.				
3.				
4.				

Average thickness of the brass disc (d) = _________ cm

Table - 2

To determine the radius of the bad conductor disc:-

S. No.	MSR (a) cm	VSR (n)	n x L.C. (b) cm	Total reading (a +b) cm
1.				
2.				
3.				
4.				

Average diameter of the bad conductor disc (d) = _________ cm

Average radius of the bad conductor disc (r) = (d/2) = _________ cm

Screw guage

Zero error = ______

Zero correction = ______

$$\text{Pitch of the screw} = \frac{\text{Distance advanced}}{\text{No. of rotations}}$$

Least count of Screw guage $L.C. = \frac{\text{Pitch of the screw}}{\text{No.of head scale divisions}}$

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Table - 3

To determine thethickness of the bad conductor disc :-

S. No.	PSR (a) mm	HSR		n x L.C. (b) mm	Total reading (a +b) mm
		Before correction	After correction (n)		
1.					
2.					
3.					
4.					

Average thickness of the bad conductor disc (t) = _________ mm = _________ cm

Table - 4

S. No.	Time (Min)	Temperature (^oC)
1.		
2.		
3.		
4.		
5.		
17.		
18.		
19.		
20.		

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Rubber – Thermal conductivity

Aim : - To find the thermal conductivity of the rubber.

Apparatus : - Calorie meter (large size) + stirrer, wooden box, thermometer, rubber tube, steam generator, stopwatch, Physical balance, weighing box and traveling microscope.

Formula : - Thermal conductivity of the rubber

$$K = \frac{2.303\ \log_{10}(\frac{r_2}{r_1})}{2\pi l\ (\theta_1 - \theta_2)t}\ x\ [W_1S_1 + (W_2 - W_1)S_2]\ (\theta_4 - \theta_3)$$ Calorie / sec / cm / ^OC

W_1 = Mass of empty calorie meter + stirrer (grams)

W_2 = Mass of empty calorie meter + stirrer + water (grams)

(W_2 - W_1) = Mass of water (grams)

S_1 = Specific heat of the material of the calorie meter (0.1 Calorie / gm / ^OC)

S_2 = Specific heat of water (1.0 calories / gm / ^OC)

r_1= Inner radius of the rubber tube (cm)

r_2 = Outer radius of the rubber tube (cm)

l = Submerged Pipe Length in water (cm)

t = Time of flow of steam (seconds)

θ_1 = Temperature of steam in the rubber tube (^OC)

θ_2 = Average temperature of water outside the rubber tube in the Calorie meter (^OC)

θ_3 = Initial temperature of calorie meter + water (^OC)

θ_4 = Final temperature of calorie meter + water (^OC)

$$\theta_2 = \frac{(\theta_3 + \theta_4)}{2}$$

Description: - A large length of rubber tubing is coiled and immersed in the water contained in the calorimeter but allowing its both ends to project a little out side the calorimeter. Two cotton threads are tied round the rubber tubing, where the tubing enters and leaves the water level in the calorimeter. One end of the rubber tubing is connected to the steam generator G.

One hole rubber cork is placed as lid to the steam generator and insert a thermometer through the hole. The steam generator is heated on a heater and the water in it is evaporated and the steam is pumped through the tubing. Water vapour flows out of the second end of the tube.

Theory: - Suppose the submerged length tube is l, the inner radius of the tube is r_1, the outer radius of the tube is r_2. Suppose the inside and outside temperatures of the rubber tube are θ_1 and θ_2 respectively. When the steam is sent through the rubber tube for a time t, let the Q_1 be the heat transferred from the steam into the water. Then

$$Q_1 = \frac{2\pi l K(\theta_1 - \theta_2)t}{2.303\ \log_{10}(\frac{r_2}{r_1})} \longrightarrow (1)$$

Here, K is the thermal conductivity of rubber. The calorimeter + water absorbs the heat transferred through the rubber tube into the calorie meter. If their temperature rises from θ_3 to θ_4. If Q_2 is the heat absorbed by the calorimeter and water.

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Then

$$Q_2 = W_1S_1(\theta_4 - \theta_3) + (W_2 - W_1)S_2\,(\theta_4 - \theta_3)$$

(OR) $$Q_2 = [W_1S_1 + (W_2 - W_1)S_2]\,(\theta_4 - \theta_3) \longrightarrow (2)$$

Heat transferred through the rubber tubing in to calorimeter Q_1 = Heat absorbed by calorimeter + water Q_2

From equns. (1) & (2)

$$\frac{2\pi l K(\theta_1 - \theta_2)t}{2.303\ \log_{10}(\frac{r_2}{r_1})} = [W_1S_1 + (W_2 - W_1)S_2]\,(\theta_4 - \theta_3)$$

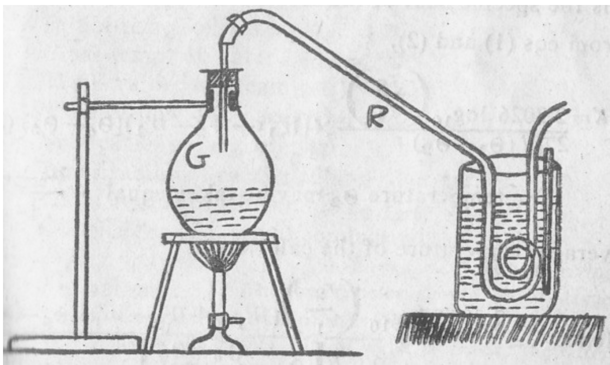
(OR) $$K = \frac{2.303\ \log_{10}(\frac{r_2}{r_1})}{2\pi l\,(\theta_1 - \theta_2)t}\ x\ [W_1S_1 + (W_2 - W_1)S_2]\,(\theta_4 - \theta_3)$$

The outer temperature of the rubber tube θ_2, is the average of the initial temperature θ_3 and final temperature θ_4 of calorimeter + water in it.

i.e. $$\theta_2 = \frac{(\theta_3 + \theta_4)}{2}$$

From the above equation, the thermal conductivity of the rubber tubing material is found.

Procedure: - A clean, dry calorimeter is taken with a stirrer. Its mass W_1 grams is found with the help of a balance. Now take about 2 / 3rd of water in the large calorimeter and find the mass W_2. The amount of water in the calorimeter is (W_2 - W_1). The calorimeter + water must be placed in a wooden box and cotton or wool is placed around it. Their initial temperature is θ_3 is measured with a thermometer.



The steam-carrying rubber tube, of length ‘l’ is submerged in the calorimeter water and the steam is dropped from the second end. When the tube is immersed in water, the stop watch should be started. The steam is pumped through the tube for a period of time , stop the clock and remove the steam pipe from the calorimeter water, and determine the time t and the final temperature θ_4. Disconnect the tube from the steam generator. The inner radius r_1 and outer radius r_2 of rubber tube are determined with the help of a travelling microscope,.

Precautions : -

1. The calorimeter should be large enough to keep the rubber tube in the water.
2. Measure the temperature of the calorimeter + water, after mixing well with the stirrer.
3. The tube should be kept in the calorimeter only when the vapor passes through the rubber tube.
4. Vapor must be sent through the tube until the water temperature in the calorimeter rises to at least 10 ^{O}C.

Determination of the inner and outer radii of the rubber tube

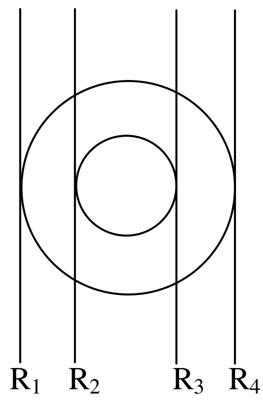
$$Least\ count\ of\ travelling\ microscope\ \mathrm{L.C} = \frac{1\ M.S.D.}{No.of\ vernier\ scale\ divisions}$$

S.No.	Position of vertical wire	M.S.R (a) (cm)	Vernier coincedence (n)	n xL.C. (b) (cm)	Total reading (a+b) (cm)	Diameter (cm)
1.	Left outer edge				R_1	Inner diameter ($R_2 \sim R_3$)
2.	Left inner edge				R_2	
3.	Right inner edge				R_3	Outer diameter ($R_1 \sim R_4$)
4.	Right outer edge				R_4	

$r_1 = (R_2 \sim R_3)/2$ = ____________ cm

$r_2 = (R_1 \sim R_4)/2$ = _____________ cm

Result :- Thermal conductivity of rubber $K =$ ___________ Calorie / sec / cm / ^{O}C



P. S. Brahmachary M.Sc., M.Phil. Ph. No.: 9492512250

Specific heat of liquid – Joule's calorimeter
Barton's radiation correction

Aim : - To find the specific heat of the given liquid, by means of Barton's radiation correction, using the Joule's calorimeter.

Apparatus : - Joule calorimeter, sensitive thermometer (0.1 ^{O}C), ammeter, voltmeter, plug-key, rheostat, 6 volt battery, stop clock and connecting wires.

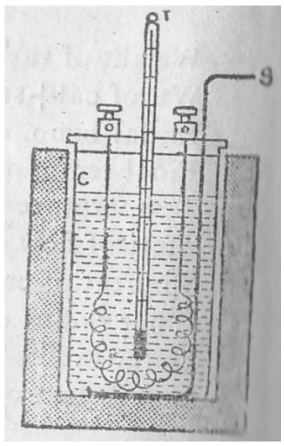
Formula :- $$\frac{VIt}{J} = [W_1S + (W_2 - W_1)x]\,(\theta_2 - \theta_1)$$

V = Applied average Voltage (Volts)
I = Average current (amperes)
t = Time of current flow (Sec)
J = Mechanical equivalent of heat = 4.18 Joules / Calorie
W_1 = Mass of empty calorimeter + stirrer (grams)
W_2 = Mass of empty calorimeter + stirrer + liquid (grams)
(W_2 - W_1) = Mass of liquid (grams)
S = Specific heat of the material of the calorimeter (0.1 Calorie / gm / ^{O}C)
x = Specific heat of liquid (Calorie / gm / ^{O}C)
θ_1 = Initial temperature of calorimeter + liquid (^{O}C)
θ_2 = Final temperature of calormeter + liquid, after correction (^{O}C)

$$\theta_2 = \theta_2' + C$$

θ_2' = Final temperature of calormeter + liquid, before correction (^{O}C)
C = Correction (^{o}C)

Description: - The Joule's calorimeter is also a regular calorimeter, including a stirrer. It has an ebonite lid. The lid has three holes. Two copper bars are inserted into the calorimeter through the two holes. The upper edges of copper rods are outside of the ebonite lid and screws are arranged to these edges. The lower two edges are soldered to the two ends of a resistance coil. Care should be taken that the resistance coil is almost close to the bottom of the calorimeter. The thermometer is inserted through the third hole. With this the temperature of the ingredients in the calorimeter is measured.



The outer layer of the calorimeter is well polished. By this way, the calorimeter does not lose any heat by radiation. The entire arrangement of this calorimeter is placed in a wooden box and the bad conductor such as cotton or wool are placed around the calorimeter. This means that the calorimeter does not lose heat through convection.

Theory : - Let a electric potential difference V is applied between the two ends of the resistance coil in the joule calorimeter for t seconds. i be the current in the coil. The coil generates a heat H.

$$H = VIt \text{ joules} = \frac{VIt}{J} \text{ cal} \longrightarrow (1)$$

Here J is mechanical equivalent of heat. Its value J = 4.18 joules / cal

P. S. Brahmachary M.Sc., M.Phil. Ph. No.: 9492512250

By dividing by (J), the energy in the joules is converted into calories.
The heat H generated by resistance wire is absorbed by the calorimeter + liquid and their temperature raised from θ_1 to θ_2.

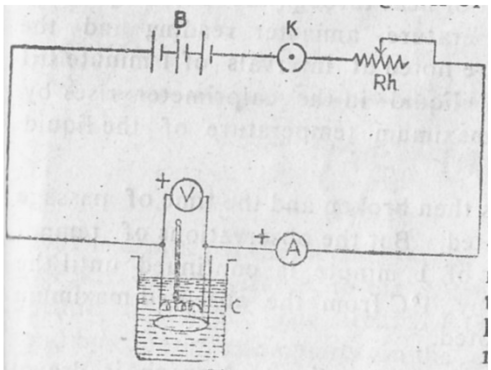
$$H = [W_1S + (W_2 - W_1)x](\theta_2 - \theta_1) \longrightarrow (2)$$

W_1 = Mass of empty calorimeter
W_2 = Mass of empty calorimeter + liquid
S = Specific heat of the material of the calorimeter
x = Specific heat of liquid

The above equations (1) & (2) are equal. So, $\frac{VIt}{J} = [W_1S + (W_2 - W_1)x](\theta_2 - \theta_1)$

Using this equation, we can find the specific heat x of liquid.

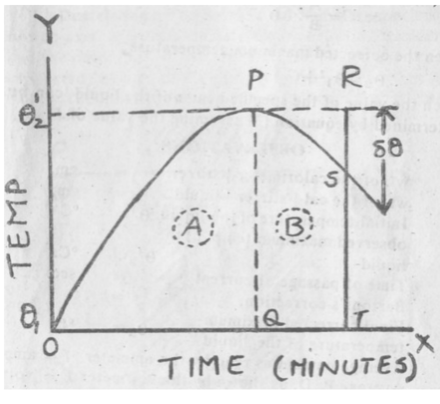
Procedure: - A battery B, a plug-key K, a rheostat Rh and an ammeter A are connected in series to the upper ends of the copper rods, arranged to ebonite lid. A volt meter V is connected in parallel to the same two ends of copper rods. First take the empty calorimeter, including the stirrer and find its mass W_1 with the help of balance. Take the liquid whose specific heat x is tobe determined upto 2/3rd of the calorimeter and again its mass W_2 is found.



Now the ebonite lid is placed on the calorimeter such that the resistance coil is immersed in the liquid. Now keep the calorimeter in the wooden box. Insert the key into the plug, to close the circuit. Adjust the jockey position in the rheostat such that 1 ampere current flows in the circuit. Now remove the key from the plug and insert the thermometer through middle hole of the ebonite lid and determine the initial temperature θ_1 of calorimeters + liquid.

Now hold the key in the plug again and start the clock simultaneously and note the temperature θ, voltage V and current I for every minute. Send the current in the circuit until the temperature of calorimeter + liquid raises through 10^oC. Note the final temperature θ_2' before correction and time t of the current sent. Then the key is removed from the plug. Even after removing the key from the plug, you must note the temperature and time, until the temperature drops to 1^oC without stopping the clock.

Barton Radiation Correction : - Take time on the X - axis, the temperature on the Y - axis and draw a graph for increasing and decreasing of temperatures. It is as shown in the figure. Draw a horizontal line PR at P i.e. at the maximum temperature θ_2' . Draw a perpendicular line PQ at P. Draw another perpendicular line RST after 1^oC fall of temperature.



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According to the Barton Radiation correction

$$\frac{\text{Correction } C}{Area\ OPQ} = \frac{Fall\ of\ temperature\ \delta\theta}{Area\ PSTQ}$$

$\delta\theta$ = RS = Temperature fall

Find the correction C using this equation and add this value to θ_2' to get the final temperature θ_2.

$$\therefore\ \theta_2 = \theta_2' + C$$

Precautions: -

1. The liquid in the calorimeter should be stirred well with the stirrer through out the experiment.
2. If the resistance wire is in the air, current should not be sent through it.
3. The initial temperature θ_1 should be noted, only after the resistance wire is placed in the liquid and adjusted to the voltage V and current I values to the desired values & key is removed from plug.
4. After noting the initial temperature θ_1, again keeping the key in the plug to send current and starting the stop clock, both must be done simultaneously.
5. The specific heat should be calculated by taking the average voltage and average current.
6. After noting the maximum temperature θ_2', remove the key from the plug to turn off the current, note time and temperature, without stopping the stop clock, until the temperature drops to 1°C.

Result :- Specific heat of liquid given x = __________ (Cal/gm/°C)

Table

S.No.	Time (Min)	Temperature θ (°C)	Voltage V (Volts)	Current I (amperes)
1.				
2.				
3.				
4.				
.				
.				
.				
.				
18.				
19.				
20.				

____

P. S. Brahmachary M.Sc., M.Phil. Ph. No.: 9492512250