AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICS

PHYSICS LAB 2

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Section: X , Group: 07

LAB REPORT ON

To determine the value of J, the mechanical equivalent of heat by electric method.

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4. S.M. Hosney Arafat Rizon	20-43019-1	Calculation, Result , References
5. Rad Shahmat Sabit	20-43610-1	Discussion and Reference parts

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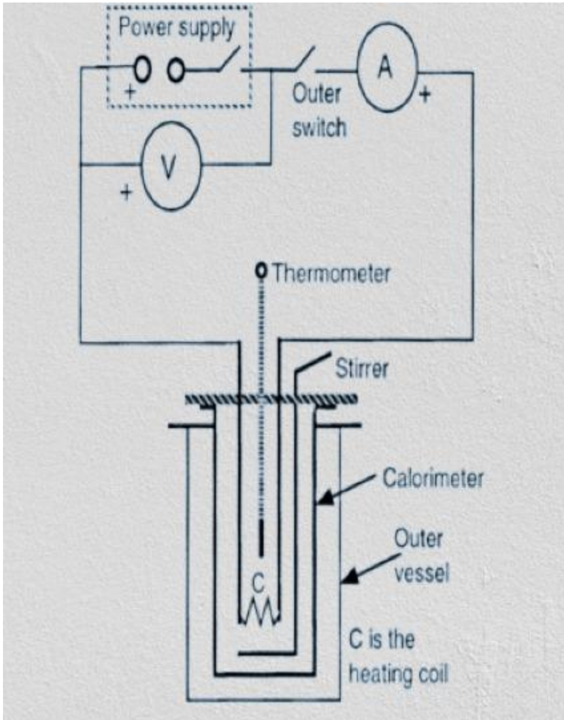
1. Introduction:



Schematic Diagram of Electrical Calorimeter

According to the first law of thermodynamics, the amount of work converted into heat (W) is directly proportional to the quality of heat generated (H).

Thus W = JH,

Where J is called the mechanical equivalent of heat or Joule's constant.

Therefore, J = W/H.

If W is measured in joules and H is measured in calories, the unit of J will be joule/calorie.

In this experiment, electrical energy (W) is converted into heat. If a voltage V (in volts) is applied across a resistor and thus a current I (in amperes) is maintained for a time t (in seconds), the electric power is given by

P = VI,

And the electrical energy converted into heat is given by

W = VIt.

The electrical energy supplied to the heating coil is converted into heat. This heat is taken up by the calorimeter (including the stirrer, heating coil, etc.) and the water in the calorimeter. If the temperature of the system rises from T_1 ºC to T_2 ºC, the heat generated is given by

$H = (m_1S_1+m_2S_2+m_3S_3)(T_2-T_1)$,

Where m_1 = mass of the calorimeter,

S_1 = specific heat capacity of the calorimeter,

m_2 = mass of water in the calorimeter,

m_3 = water equivalent of the heating coil, stirrer, etc.

(That is, the mass of water whose heat capacity is equal to the heat capacity of the heating coil, stirrer, etc.)

$$J = \frac{VIt}{(m_1S_{1+}m_2S_{2+}m_3S_3)\Delta\theta}$$

2.Apparatus:

i. An electrical calorimeter
ii. A thermometer
iii. A balance
iv. A power supply
v. An ammeter and
vi. A voltmeter

3. Procedure:

i. We have made the electrical connections as shown in the schematic diagram of the electrical calorimeter and also kept the outer switch open.

ii. Then we started to find the least counts of the voltmeter, ammeter and thermometer. We read the room temperature and recorded specific heat capacity [s = 0.22 calories /(gm ^oC)] of the calorimeter and the water equivalent of the heating coil, stirrer, etc. [m_3 = 2.5 gm].

iii. We have to weigh the empty dry calorimeter correct up to 0.1 gm.

iv. After mixing some hot and cold water such that the temperature in the calorimeter is about 3 ^oC below the room temperature we have to filled the calorimeter about 2/3 with water. We also have to wipe any drops of water sticking to the sides of the calorimeter.

v. Again, we have to weigh the calorimeter plus water correct up to 0.1 gm.

vi. For time measurement we have winded the timer and set it to zero and also keeping the outer switch off, switch on the power supply. After than by adjusting the voltage to a bit less than 6 volts. (We used the 6-volt range.)

vii. Again, we have to read the temperature of water in the calorimeter correct up to the least count of the thermometer. This is the temperature at time zero and it is also the initial temperature of the system (T_1) .

viii. After then, we have to close the outer switch and simultaneously start the timer. We read the voltmeter and ammeter and also we have entered these in the first row of the table on the data sheet.

ix. We also have taken the readings of the voltage, current and temperature at regular intervals of 2 (or 3) minutes and keep stirring the water in the calorimeter carefully.

x. Then we need to switch off the current at the end of N intervals of time. The number N should be chosen such that the final temperature is about as many degrees above the room temperature as the initial temperature T_1 = 23 ^oC, then the final temperature should be about 29 ^oC.

xi. We keep stirring and recording the highest temperature attained by the system. This is the final temperature T_2.

xii. Finally, we have performed the calculations and repeat the experiment if the result does not have the desired accuracy and also noted that, if the voltage V is in volts and current I is in amperes, then the power $P = VI$ will be in watts, and the energy $W = VIt$ will be in joules.

4. Experimental Data:

Mass of the calorimeter, m_1 = 71.03 gm

Mass of the calorimeter and water, m = 248.1 gm

Mass of water, m_2 = ($m-m_1$)= 177.07 gm

Mass of the stirrer, m_3 = 21gm

Specific heat of the material of the calorimeter, S_1= 0.0909 cal /gm –^{o} C

Specific heat of water, S_2= 1 cal/gm –^{o} C

Specific heat of the material of the stirrer, S_3= 0.089 cal / gm –^{o} C

Table1: Readings of current-voltage-temperature

No of Obs.	Time min	Curr-ent I amp	Volt-age V volts	Temp-erature ^{o}C
1	0	0.00	0.00	21
2	1	1.12	7.1	22
3	2	1.12	7.1	22
4	3	1.12	7.1	22
5	4	1.12	7.1	22
6	5	1.12	7.1	22
7	6	1.12	7.1	23
8	7	1.12	7.1	23
9	8	1.12	7.1	23
10	9	1.12	7.1	24

No of Obs.	Time min	Curr-ent I amp	Volt-age V volts	Tempe-rature ^{o}C
11	10	1.12	7.1	25
12	11	1.12	7.1	26
13	12	1.12	7.1	26
14	13	0	0	27
15	24	0	0	28
16	28	0	0	27.5

5. Analysis and Calculation:

Recordings of time and temperature with radiation correction:

Initial temperature of the calorimeter + contents, $\theta_1 = 21^o$ C
Final temperature, $\theta_2 = 28^o$ C
Time during which the current is passed, t = 12 Min = 720 sec
Mean current during the interval, I= 1.12 amp
Mean voltage during the interval, V = 7.1 volt
Rise of temperature, $\Delta\theta' = \theta_2 - \theta_1 = 7^o$ C
Radiation correction, $\theta_r = (\theta_2 - \theta_2')/2 = 0.25^o$ C
Corrected rise of temperature, $\Delta\theta = \Delta\theta' + \theta_r = 7.25^o$ C

Calculation:

The mechanical equivalent of heat,

$$J = \frac{VIt}{(m_1S_1+m_2S_2+m_3S_3)\Delta\theta}$$

$$J = \frac{7.1*1.12*720}{\{(71.03*0.0909)+(1.7*0.07*1)+(21*0.08)\}} \text{ J/cal}$$

J = 4.2596 J/cal

$$\text{Error of J} = \frac{Jth-Jex}{Jth} * 100\%$$

$= 0.0142*100\%$

$= 1.42\%$

6. Result:

From the experiment we have got the value of mechanical equivalent of heat as

J = 4.2596 J/cal

Error of J = 1.42%

7. Discussion:

i. In the experiment we have taken 24°c and 32°c reading of temperature 40 min.

ii. We tried our best to take the reading accurately.

iii. From the experiment, the result is 4.2596 J/cal and the error of J is 1.42%.

iv. But there have some problems in maintaining the time.

v. And sometimes we have the approximate value of temperature by assuming mediator of the thermometer.

vi. For this reason, we got some error on result.

vii. Other then everything is ok.

8. References:

i. Fundamentals of physics: Resnick & Halliday

ii.Practical physics : R.K.Shukla, Anchal Srivatasa, New age International (p) ltd,New Delhi

iii.Eric J.Irons, America Journal of Ohysics Vol, Issue 5,pp.426(1947)