Sec: 08 Group: 05 Date:

Experiment no: 08

Name of the Experiment: Determination of the mechanical equivalant of heat.

Questions on theory (all diagrams should be drawn by using a pencil and a scale)

*1) What is 1 calorie of heat? [0.5]

Ans: The amount of heat energy absorbed by 1 gram of water to increase it's temperature for 1 degree celcius at 1 atmosphere pressure is defined to be 1 calorie of heat.

*2) Define specific heat capacity of a material. [0.5]

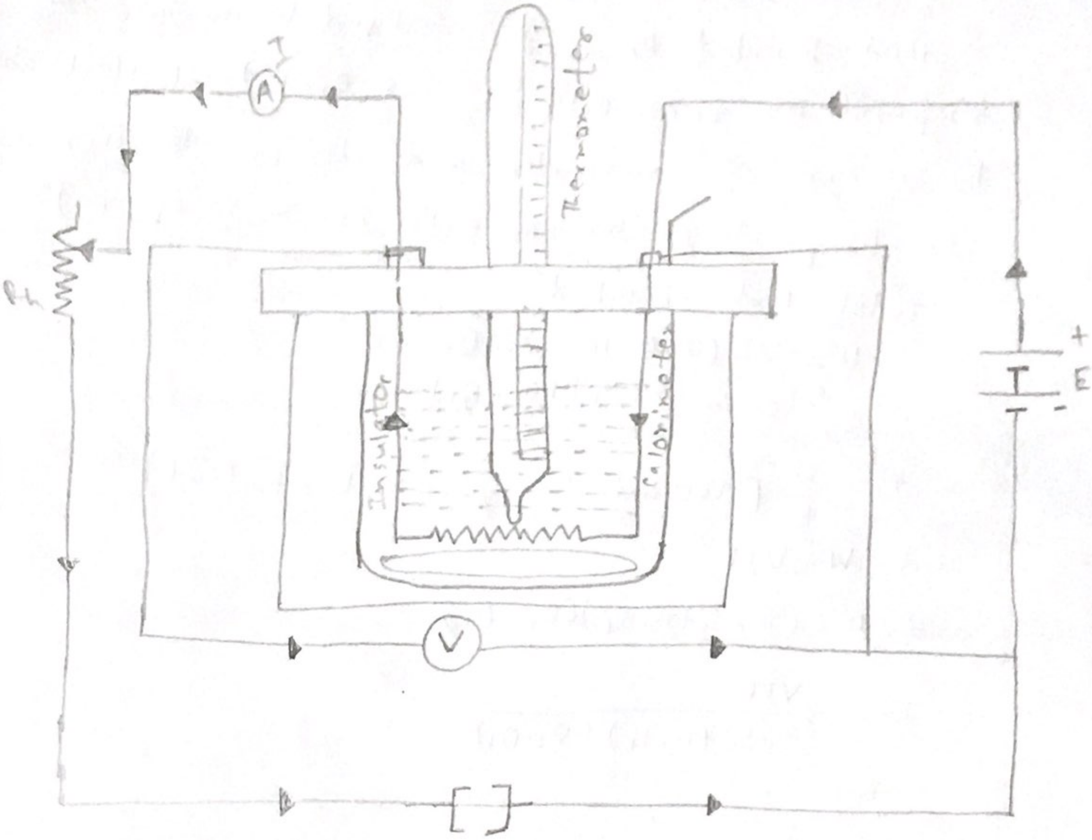
Ans: The amount of heat absorbed by one unit mass to increase its temperature by one unit (1°c) is called the specific heat capacity of that material.

*3) Define Mechanical Equivalent of Heat. [0.5]

Ans: The amount of mechanical work (in the unit Joule) which is required to be done to increase one unit of heat is called the Mechanical Equivalent of heat.

*4) Draw the arrangement of performing the experiment. [1]

Ans:



*5) Find out an expression of work done due to electrical energy when I A of current passes through a coil for t s time and the voltage across the coil is V Volts. [1]

Ans: $I = \frac{q}{t}$

$q = It$

If 1 coulomb charge passes through the coil then amount of work done is V joule.

If q coulomb charge passes through the coil then the amount of work done is Vq joule.

$\therefore$ total work done, $W = Vq$ joule

$\therefore W = Vq$

$W = VIt$

*6) Find out an expression of heat absorbed by the liquid, calorimeter and stirrer in terms of their masses, specific heat capacity and the rise of the temperature. [1]

Ans: Heat absorbed by m_1 gm of liquid to increase its temperature for $(\theta_2-\theta_1)^\circ c$ is $m_1 s_1 (\theta_2-\theta_1)$ cal Heat absorb by m_c gm of calorimeter and stinner to increase its temperature for $(\theta_2-\theta_1)^\circ c$ is $m_c s_c (\theta_2-\theta_1)^\circ c$

$\therefore$ Total heat absorbed

$$H = m_c s_c(\theta_2-\theta_1) + m_1 s_1(\theta_2-\theta_1)$$
$$= (m_c s_c + m_1 s_1)(\theta_2-\theta_1)$$

*7) Find out an expression for the Mechanical Equivalent of Heat. [0.5]

Ans: $J = \frac{W}{H}$ [Mechanical equivalent of heat]

and $W = VIt$

and $H = (m_c s_c + m_1 s_1)(\theta_2-\theta_1)$

$$J = \frac{VIt}{(m_c s_c + m_1 s_1)(\theta_2-\theta_1)}$$

- **Draw the data table(s) and write down the variables to be measured shown below (in the 'Data' section), using pencil and ruler BEFORE you go to the lab class.**

- **Write down your NAME and ID on the top of the page.**
- **This part should be separated from your Answers of "Questions on Theory" part.**
- **Keep it with yourself after coming to the lab.**

Data

Mass of the calorimeter & stirrer, m_c (in gm) = ~~59.8~~ 59.8

Mass of the calorimeter, stirrer & liquid, m_{total} (in gm) = 146

Mass of the liquid, m_l (in gm) = 146 - 59.8 = 86.2

Specific heat capacity of the liquid, s_l (in cal/gm/$^\circ C$) = 1

Specific heat capacity of the material of the calorimeter & stirrer, s_c (in cal/gm/$^\circ C$) = 0.073

Initial temperature of the liquid, calorimeter and stirrer, θ_1 (in $^\circ C$) = 29°

Table: Data for calculating J

Time t seconds	Voltage V Volts	Current I Amperes	Temperature $\theta\,^\circ C$
300 s	20	0.06	28.5
600 s	20	0.06	29.0
900 s	20	0.06	29.5
1200 s	20	0.06	30

The time when K is turned off, t (in second) = 1200

The maximum value of the temperature, $\theta_2\,^\circ$C = 30

The time required for the rise of temperature from $\theta_1\,^\circ$C to $\theta_2\,^\circ$C, Δt (in seconds) = 1200

The temperature after Δt s since the moment the system reached the maximum temperature of $\theta_2\,^\circ$C is $\theta_3\,^\circ$C = 29°C

Average value of the voltage across the coil, V (in Volts) = 20

Average value of the current passing through the coil, I (in Amperes) = 0.01

- **READ the PROCEDURE carefully and perform the experiment by YOURSELVES. If you need help to understand any specific point draw attention of the instructors.**
- **DO NOT PLAGIARIZE data from other group and/or DO NOT hand in your data to other group. It will bring ZERO mark in this experiment. Repetition of such activities will bring zero mark for the whole lab.**
- **Perform calculations by following the PROCEDURE . Show every step in the Calculations section.**
- **Write down the final result(s)**

Calculations

Radiation correction =

Corrected rise of the temperature, $\Delta\Theta$ (in degree Celsius) = $(\theta_2-\theta_1)+(\theta_2-\theta_3) = (30°-25°)+29° = 35°$

~~Work done by electric energy, W~~ H (in Joules) = $(m_c s_c + m_1 s_1)\times(\theta_2-\theta_1) = (59.8\times0.073+86.2\times1)(30°-25°) = 90.56\times6 = 543.39$

~~Heat produced out of electric energy, H (in calorie)~~ = $W = VIt = 20\times0.1\times1200 = 240J$

Mechanical equivalent of heat, J = $\dfrac{VIt}{(m_c s_c + m_1 s_1)(\theta_2-\theta_1)}$

$$= \frac{20\times0.1\times1200}{543.39} = 0.44$$

Results: Temperature = 35°, Work = ~~543.39~~ 240 J, Mechanical Heat = 0.44 J, Heat = 543.39J

- **TAKE printout of the 'Questions for Discussions' BEFORE you go to the lab class. Keep this printout with you during the experiment. ANSWER the questions in the specified space AFTER you have performed the experiment.**
- **Attach Data, Calculations, Results and the Answers of 'Questions for Discussions' parts to your previously submitted Answers of 'Questions on Theory' part to make the whole lab report.**
- **Finally, submit the lab report before you leave the lab.**

Questions for Discussion

1) See Fig 2. In the experiment you have performed, electrical energy is converted to heat.
On the other hand, the Fig 2 shows an experiment where mechanical energy is converted to heat. A turbine is immersed in the liquid. The axle of the turbine is wound by a rope of negligible mass. The rope passes over a smooth pulley. The bottom end of the load is connected with a load of mass M. When the load falls down for h distance, it rotates the turbine. Rotational kinetic energy of the turbine heats up the liquid. The temperature rise can be measured by the thermometer. Find out an expression for the mechanical equivalent of heat for this experiment. [1]

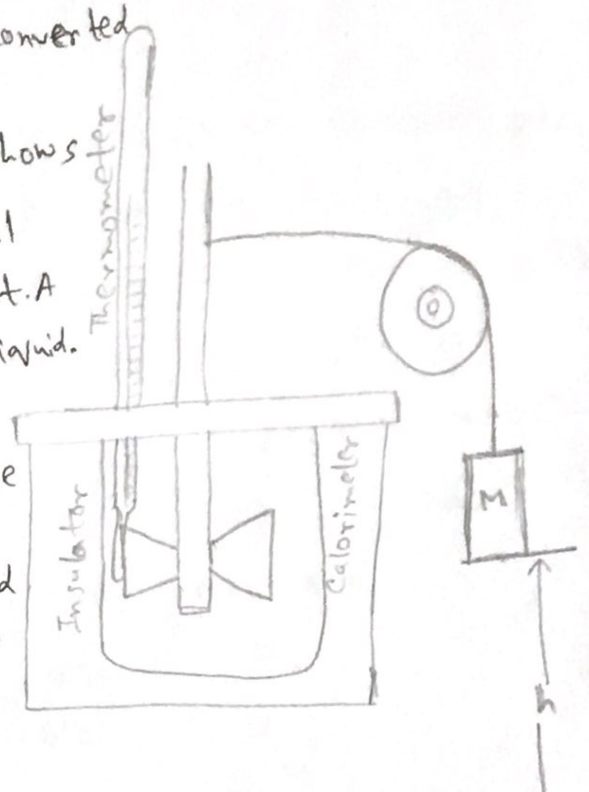


Fig-2

Ans: Here, W = rotational kinetic energy = potential energy of mass M at height h.

$W = mgh$

$\therefore H = (m_c s_c + m_l s_l)(\theta_2 - \theta_1)$

$\therefore J = \frac{W}{H}$

$= \frac{mgh}{(m_c s_c + m_l s_l)(\theta_2 - \theta_1)}$ $J\,cal^{-1}$

2) How did you approximate the radiation correction in the experiment which you have performed? Briefly discuss the theory. Why is it important to make radiation correction? [1]

Ans: We assumed that whole amount of electrical energy VIt joule is used to increase the temperature of that liquid, calorimeter and Stirrer. However, due to radiation of a portion of energy get lost and as a result, we get the value of θ_2 is lower than the actual value. In order to solve the problem we need to use cooling law of Newton for getting radiation correction.

Now, surface temperature $= \theta°C$

Surrounding temperature $= \theta_0°C$

$$\therefore \frac{d\theta}{dt} \propto (\theta - \theta_0)$$

$$\Rightarrow \frac{d\theta}{dt} = k(\theta - \theta_0) \text{ [k is a co-efficient]}$$