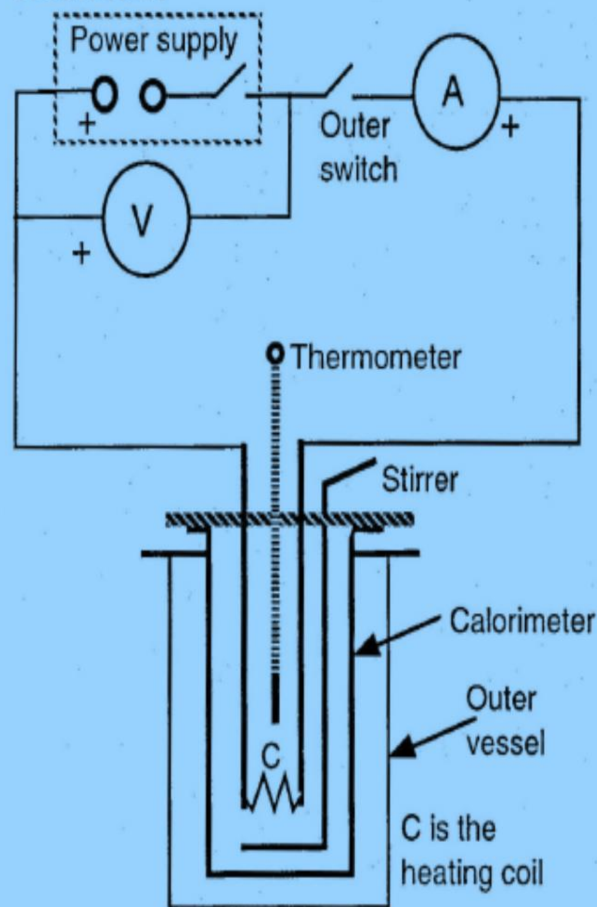
Experiment Name: To determine the value of J, the mechanical equivalent of heat by electric method.

Objective:

To determine Joule's constant (J) or the mechanical equivalent of heat by electrical method.

Apparatus:

An electrical calorimeter, a thermometer, a balance, a power supply, an ammeter and a voltmeter.



Schematic Diagram of Electrical Calorimeter

Theory:

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

Thus $W = J H$,

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

$P = V I$,

and the electrical energy converted into heat is given by

$W = V I t$.

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

$H = (m_1 s_1 + m_2 s_2 + m_3 s_3)(T_2 - T_1)$,

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.)

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

Procedure:

1. Make the electrical connections as shown in the schematic diagram of the electrical calorimeter. Keep the outer switch open.
2. Find the least counts of the voltmeter, ammeter and thermometer. Read the room temperature. Record specific heat capacity [s = 0.22 calories/(gm C^{o})] of the calorimeter and the water equivalent of the heating coil, stirrer, etc. [m_3 = 2.5 gm].
3. Weigh the empty dry calorimeter correct up to 0.1 gm.
4. Mix some hot and cold water such that the temperature in the calorimeter is about 3 ^{o}C below the room temperature. Fill the calorimeter about 2/3 with water. Wipe any drops of water sticking to the sides of the calorimeter.
5. Weigh the calorimeter plus water correct up to 0.1 gm.
6. Wind the timer and set it to zero. Keeping the outer switch off, switch on the power supply. Adjust the voltage to a bit less than 6 volts. (Use the 6-volt range.)

7. 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).
8. Close the outer switch and simultaneously start the timer. Read the voltmeter and ammeter. Enter these in the first row of the table on the data sheet.
9. Take the readings of the voltage, current and temperature at regular intervals of 2 (or 3) minutes. Keep stirring the water in the calorimeter carefully.
10. 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 was below. For example, if the room temperature was 26 ^oC and the initial temperature $T_1 = 23\ ^oC$, then the final temperature should be about 29 ^oC.
11. Keep stirring and record the highest temperature attained by the system. This is the final temperature T_2.
12. Perform the calculations and repeat the experiment if the result does not have the desired accuracy.

Note that if the voltage V is in volts and current I is in amperes, then the power P (=V I) will be in watts, and the energy W (= V I t) will be in joules.

Experimental Data:

Mass of the calorimeter, m_1 = ………………gm

Mass of the calorimeter and water, m = ………………gm

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

Mass of the stirrer, m_3 = …………………….. gm

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

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

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

Table1: Readings of current-voltage-temperature

No. of Obs.	Time Min.	Current I amp.	Voltage V volts	Temp-erature °C
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

No. of Obs	Time Min.	Current I amp.	Voltage **V** volts	Temp-erature ° C
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Recordings of time and temperature with radiation correction: Initial temperature of the calorimeter + contents, θ_1= ------------ ^{o}C

Final temperature, θ_2= ------------------ ^{o}C

Time during which the current is passed, t = ------------------Min = ------------------ sec

Mean current during the interval, I = ----------------- amp

Mean voltage during the interval, V = ------------ volt

Rise of temperature, $\Delta\theta' = \theta_2 - \theta_1$ = ------------------ ^{o}C

Radiation correction, $\theta_r = (\theta_2 - \theta_2')/2$ =----------------- ^{o}C

Corrected rise of temperature, $\Delta\theta = \Delta\theta' + \theta_r$ = --------------- ^{o}C

CALCULATION:

The mechanical equivalent of heat,

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

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

J = ...