B.SC. 6 SEM PHYSICS 2025-26

SKELETON PRACTICAL PAPER

QUESTION

I) Diagram

ii) Apparatus

iii) Theory

iv) Observation (min. 4)

v) Observation table

vi) Calculation

vii) Result

viii) Precautions (min. 2)

CHOOSE ANY ONE QUESTION IN PRE STUDENT

1 Determination of Planck's constant using solar cell.

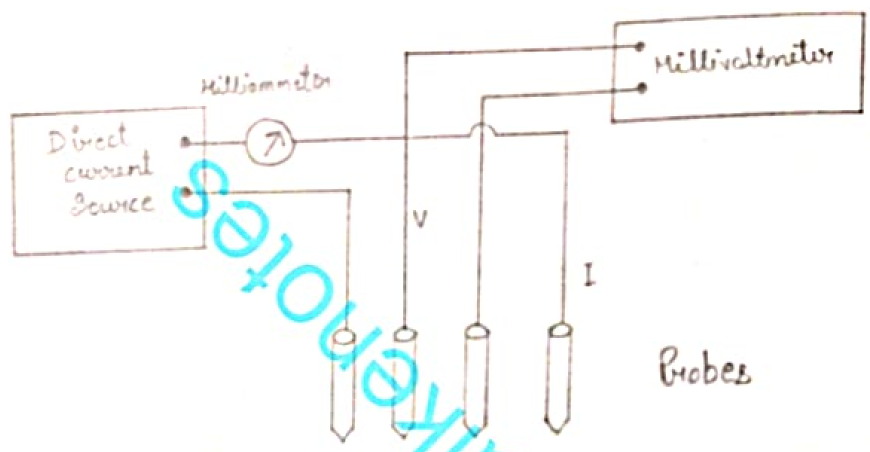
2 Determination of Stefan's constant (Black body method) .

3 Study of the temperature dependence of resistivity of a semiconductor using four probe-methods.

4 Study of characteristics of a GM counter and verification of inverse square law for the same strength of a radioactive source

5 Study of β-absorption in Al foil using GM Counter to find end point energy.

Full text: 661



Circuit used for Resistivity measurements

Object – Study of temperature dependence of resistance of a semiconductor using four probe method.

Apparatus – Probes arrangement, sample, oven, thermometer four probe setup, constant current generation.

Theory and formula –

Four sharp probes are placed on a flat surface of the material to be measured current is passed through the two outer electrodes and the floating potential is measured across the inner pair.

Four probes are spaced S_1, S_2 and S_3 apart current I is passed through the outer probes 1 and 4 and the floating potential v is measured across the inner pair of probes. (2 and 3).

When the points spacing equal

$$S_1 = S_2 = S_3 = S_4$$

We get resistivity (ρ_0)

$$\rho_0 = \frac{V}{I} \times 2\pi S$$

Here, v = floating potential difference between inner probe in V

I = Current through the outer pair of probes in the width of slice is ω

S = Spacing between the probes in meters

Resistivity –

$$\rho = \frac{\rho_0}{G_7(\omega/S)}$$

Calculation —

$$f_0 = \frac{V}{I} \times 2\pi S$$

$$f_0 = \frac{1.76}{2.6 \times 10^{-3}} \times 2\pi \times 2 \times 10^{-3} = \frac{1.76 \times 4\pi}{2.6} = 8.50$$

$$f_0 = \frac{1.70}{2.6} \times 4\pi = 8.21$$

$$f_0 = \frac{1.66}{2.6} \times 4\pi = 8.01$$

$$f_0 = \frac{1.63}{2.6} \times 4\pi = 7.87$$

$$f_0 = \frac{1.61}{2.6} \times 4\pi = 7.77$$

$$f_0 = \frac{1.60}{2.6} \times 4\pi = 7.72$$

$$f_0 = \frac{1.59}{2.6} \times 4\pi = 7.68$$

$$f_0 = \frac{1.58}{2.6} \times 4\pi = 7.63$$

$$f = \frac{f_0}{G_7(w/s)} = \qquad \left[w/s = \frac{0.5}{2} = 0.25 \right]$$

$$G_7(w/s) = 6.93$$

$$f_1 = \frac{8.50}{6.93} = 1.22$$

$$f_2 = \frac{8.21}{6.93} = 1.18$$

$$f_3 = \frac{8.01}{6.93} = 1.15$$

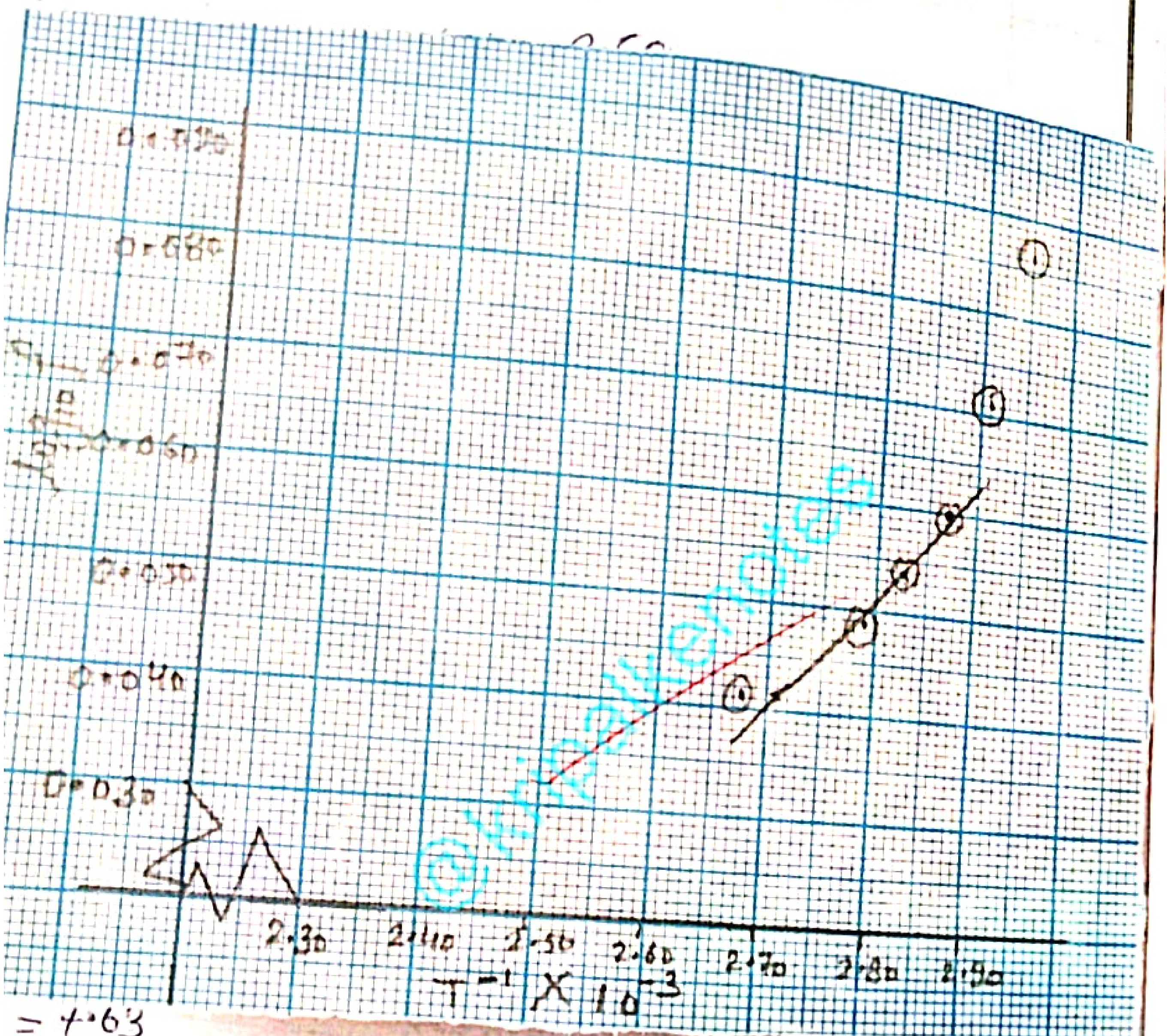
$$f_4 = \frac{7.87}{6.93} = 1.13$$

$$f_5 = \frac{7.77}{6.93} = 1.12$$

$$f_6 = \frac{7.72}{6.93} = 1.11$$

$$f_7 = \frac{7.68}{6.93} = 1.10$$

$$f_8 = \frac{7.63}{6.93} = 1.10$$



$= 7.63$

$$\left[\omega/s = \frac{0.5}{2} = 0.25 \right]$$

$$G_7(\omega/s) = 6.93$$

$$S_7 = \frac{7.63}{6.93} = 1.10$$

Observation -

Distance between probes $S = 2mm = 2 \times 10^{-3} m$.

Thickness of the crystal $w = 0.5mm = 5 \times 10^{-4} m$.

Observation table -

S.No.	Temperature(°c)	Volts(V)	Temp.(K)	ρ (Ω/cm)	$T^{-1} \times 10^{-3}$	$\log_{10} \rho$
1.	65	1.762	338	1.22	2.95	0.086
2.	70	1.704	343	1.18	2.91	0.071
3.	75	1.664	348	1.15	2.87	0.060
4.	80	1.638	353	1.13	2.83	0.053
5.	85	1.616	358	1.12	2.79	0.049
6.	90	1.601	363	1.11	2.75	0.045
7.	95	1.596	368	1.10	2.71	0.041
8.	100	1.584	373	1.10	2.68	0.041

Result -

We obtain the graph for this.

Precaution -

1. Wires should be tightly connected
2. Current should be constant.
3. Carefully notedown thermometer reading.

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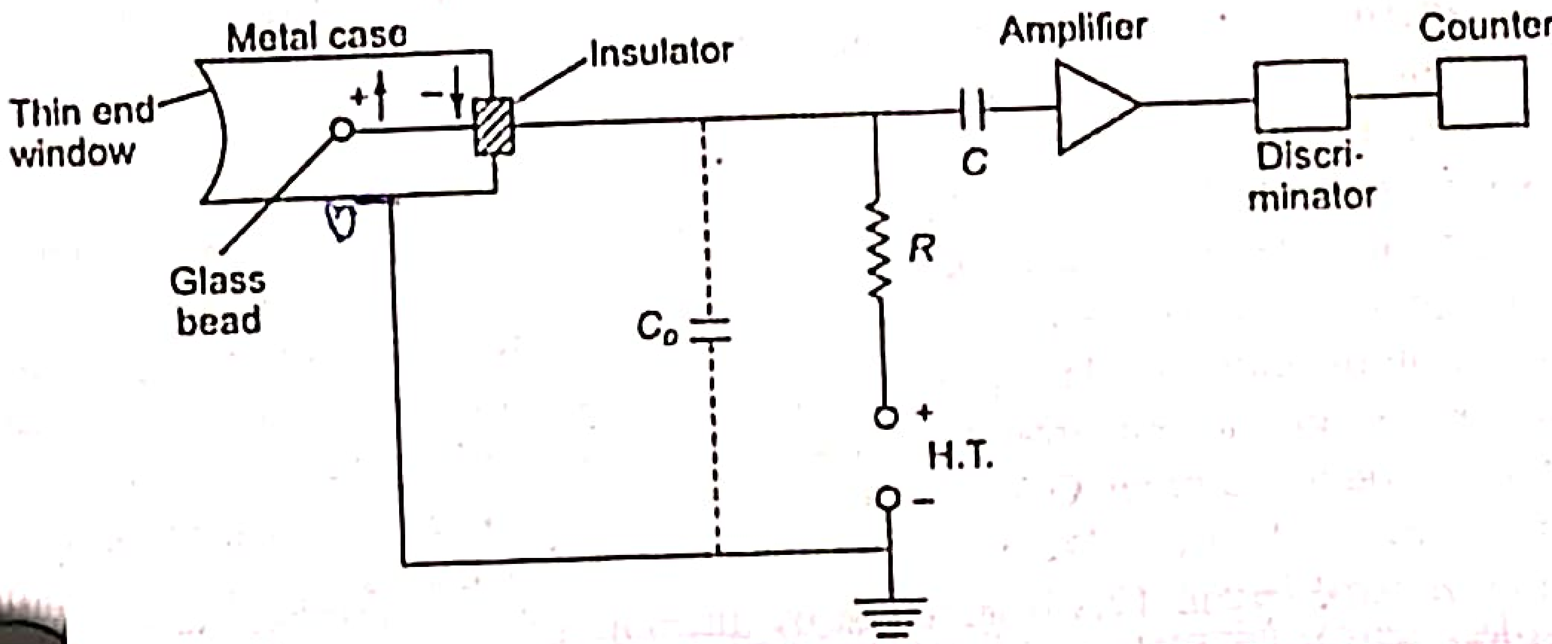


Fig.- GM COUNTER

Expt. No. 5.

Object :- To verify the inverse square relationship b/w the distance and radiation.

Apparatus :- GM Counter, GM deteater stand, GM deteater with conneating cable, A ~~gamma~~ (Beta) Source.

Theory :- The inverse square law says is that if we double the distance b/w source and deteater intensity goes down by a factor of four if we triple the distance intensity would decreares by foalr of nine and soon. As a result if we move to distance of a away from the deteator scale of the G.m counter then the intensity of radiation decreases by a facotor.
Product of $c = R \cdot d^2$ is constant

Observation :- operating voltage 463 V
Table

S.NO	distance in cm (d)	Counts N is 30 sec	Net count R (Rate)	in Product	$1/d^2$ (In $\frac{1}{m^2}$)
1	2	898	29.93	120	2500
2	3	665	22.57	200	1100
3	4	521	17.37	348	625
4	5	417	13.9	378	400
5	6	352	11.73	422	278
6	7	250	8.33	408	204

Teacher's Signature

Calculation

(i) at d = 2 cm

$$\frac{1}{d^2} = \frac{1}{4\times10^{-4}} = 2500 \quad (\text{in } \frac{1}{m^2})$$

(ii) at d = 3

$$\frac{1}{d^2} = \frac{1}{9\times10^{-4}} = 1100$$

(iii) at d = 4; $\frac{1}{16\times10^{-4}} = \frac{1}{d^2} = 625$

(iv) at d = 5

$$\frac{1}{d^2} = \frac{1}{25\times10^{-4}} = 400$$

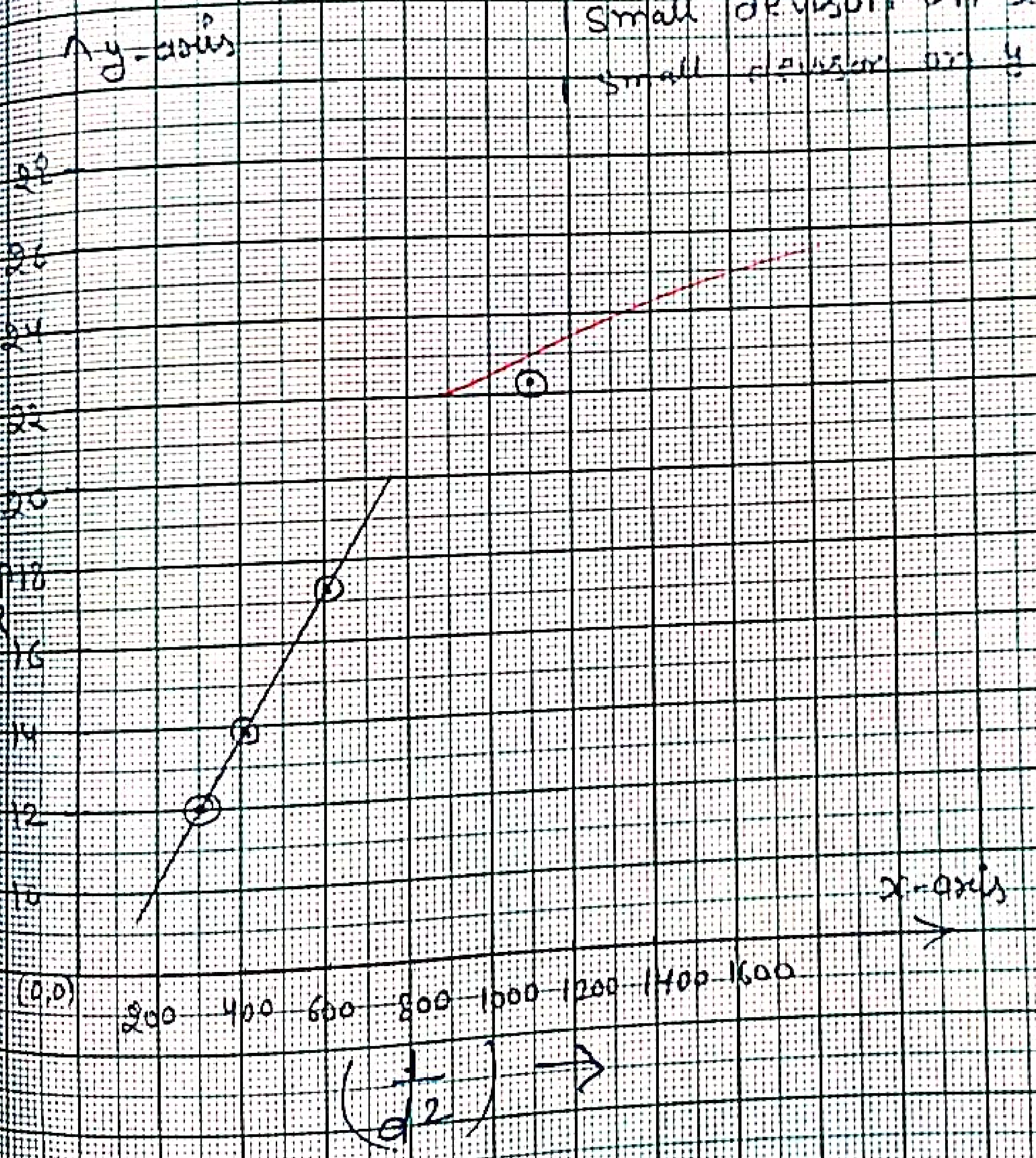
(v) at d = 6

$$\frac{1}{d^2} = \frac{1}{36\times10^{-4}} = 278$$

Scale :-

Small devision on x-axis = 20 1/m²

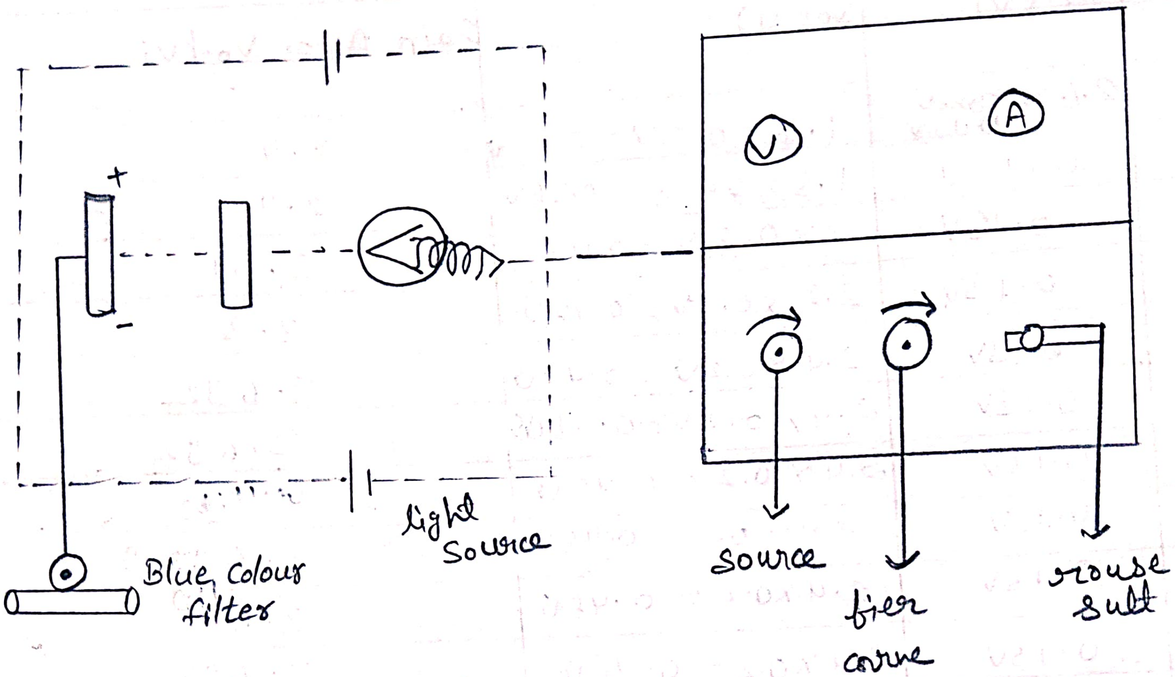
Small devision on y-axis = 0.2



Result :- plot a graph of net rate (R) as distance (d) and product of $(C = Rd^2)$ transformation $1/d^2$ shown in table.

Precaution :-

(i) Do not touch the detector wire of for power cuppel is one.



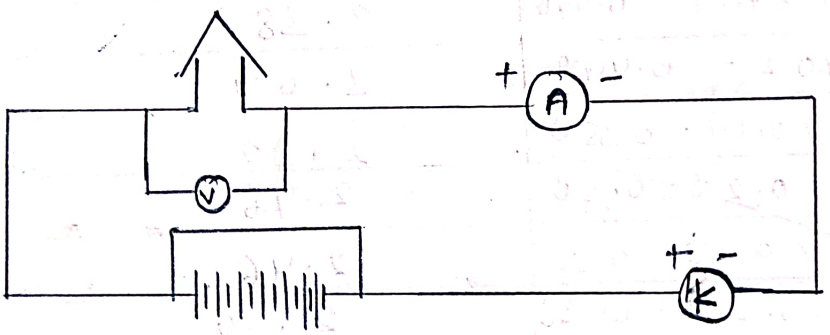


fig 1. circuit digram.

object :- Determine planck's constant using solar cell and optical fliter.

Apparatus :- The new tech type board Em 102 is constant. It compuises a DC micrometer, DC voltage three knob is course fine range one LED & ON, Blue, Red, green, fillter, &.

Theory :- For Black body energy dismbution is given

$$E_\lambda d\lambda = \frac{8\pi hc}{\lambda^5} \exp\left(-\frac{h\nu}{KT} - 1\right) d\lambda$$

when $E_\lambda d\lambda$ is total energy radiated by black body to $\lambda + d\lambda$ interval.

h :- plank constant
c :- Voloring of light
T → Absolute temp.
K → Boltzmann factor

According to weing's formula

$$E_\lambda = \frac{8\pi hc}{\lambda^5} e^{-hc/\lambda KT} \quad \text{---} (1)$$

Taking $\log_e$ of eq^n (1)

$$\ln E_\lambda = \ln A - \ln \frac{hc}{\lambda KT}$$

we know energy radiated directly proportional to photons $E_\lambda \propto \theta$

$$\ln E_\lambda = \ln A + \ln \theta \quad \text{---} (2)$$

By eq.^{n} (1.) and (2.)

$$\ln m + \ln \theta = \ln A - \frac{hc}{2.303} (\lambda K T)^{-1}$$

$$\ln \theta = \ln B - \frac{hc}{2.303} (\lambda K T)^{-1} \because \text{where } \ln B = \ln\left(\frac{A}{m}\right)$$

The graph plotted b/w $\ln \theta$ & $\frac{1}{T}$ is straight lines & it's slope is given by $\frac{hc}{2.303\lambda}$.

The planck constant $h = \frac{2.303 \lambda K}{c} \times$ slope of line

Temperature of filament of bulb
Let R_T be the resistance of the filament of bulb of temp. T and R_0 at room temp. Then

$$\frac{R_T}{R_0} = \left(\frac{T}{T_0}\right)^{1.2}$$

$$T = T_0 \left(\frac{R_T}{R_0}\right)^{0.833}$$

R_0 = measured at mV
R_T = measured resistance at Vo mode.

Observation table. :- Resistance of filament at room temp.

(in VA mode · the stopping potential for the ~~filltor~~ are :-

Calculation :-

(i) for first and second filter :-

$$h_1 = \frac{e(V_2 - V_1)\lambda_1\lambda_2}{c(\lambda_1 - \lambda_2)} \text{ J-sec.}$$

$$h_1 = \frac{1.6 \times 10^{-13} \times (V_2 - V_1) \times 61.43 \times 5645 \times 10^{-20}}{3 \times 10^8 \times 498 \times 10^{-10}}$$

$$h_1 = 37.14\ (V_2 - V_1) \times 10^{-34}$$

$$h_1 = 37.14 \times (2.20 - 1.98) \times 10^{-34} = 8.17 \times 10^{-34}$$

$$\boxed{h_1 = 8.17 \times 10^{-34} \text{ J sec.}}$$

(2.) for second and third filter :-

$$h_2 = \frac{e(V_3 - V_2)\lambda_2\lambda_3}{c(\lambda_2 - \lambda_3)} \text{ J-sec.}$$

$$h_2 = \frac{1.6 \times 10^{-19} (V_2 - V_3)\ 5645 \times 4865 \times 10^{-20}}{3 \times 10^8 \times 780 \times 10^{-10}}$$

$$h_2 = 18.78\ (V_3 - V_2) \times 10^{-34}$$

$$\boxed{h_2 = 15.02 \times 10^{34} \text{ Joule-sec.}}$$

(3.) for third and first filter :-

$$h_3 = \frac{e(V_3 - V_2)\lambda_1 \lambda_3}{e(\lambda_1 - \lambda_2)}$$

$$h_3 = \frac{1.6 \times 10^{-19} (V_3 - V_1) \cdot 6143 \times 4865 \times 10^{-34}}{3000 \times 1278}$$

$$h_3 = 12.47 (V_3 - V_1) \times 10^{-34} \text{ J sec}$$

$$h_3 = 12.47 (3 - 1.98) \times 10^{-34}$$

$$\boxed{h_3 = 12.71 \times 10^{-34} \text{ J-sec.}}$$

Mean value of planck constant :-

$$h = \frac{h_1 + h_2 + h_3}{3}$$

$$\boxed{h = 11.96 \times 10^{-34} \text{ J-sec.}}$$

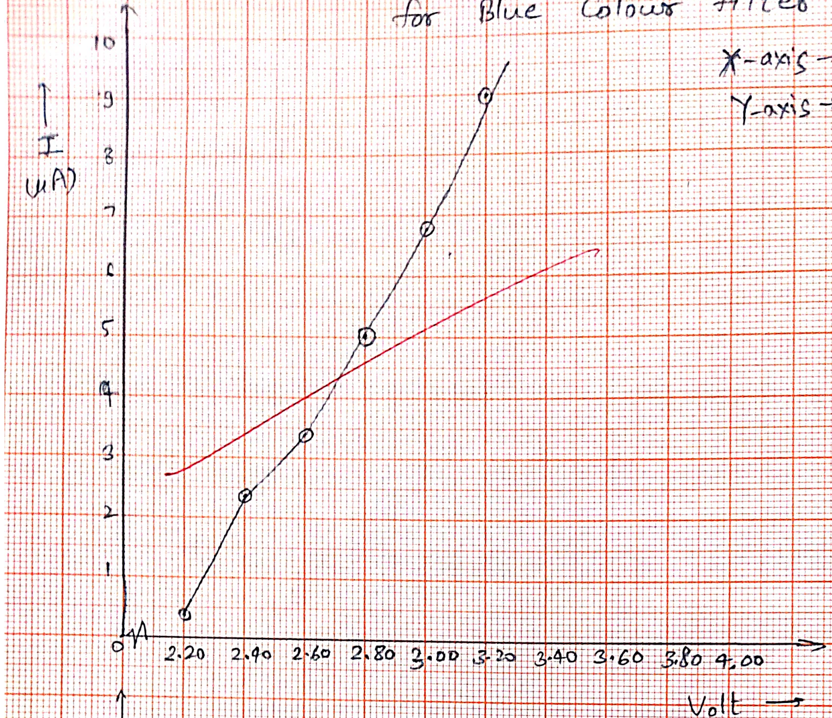
percentage error = $\frac{\text{Experimental value} - \text{standard value}}{\text{standard value.}}$

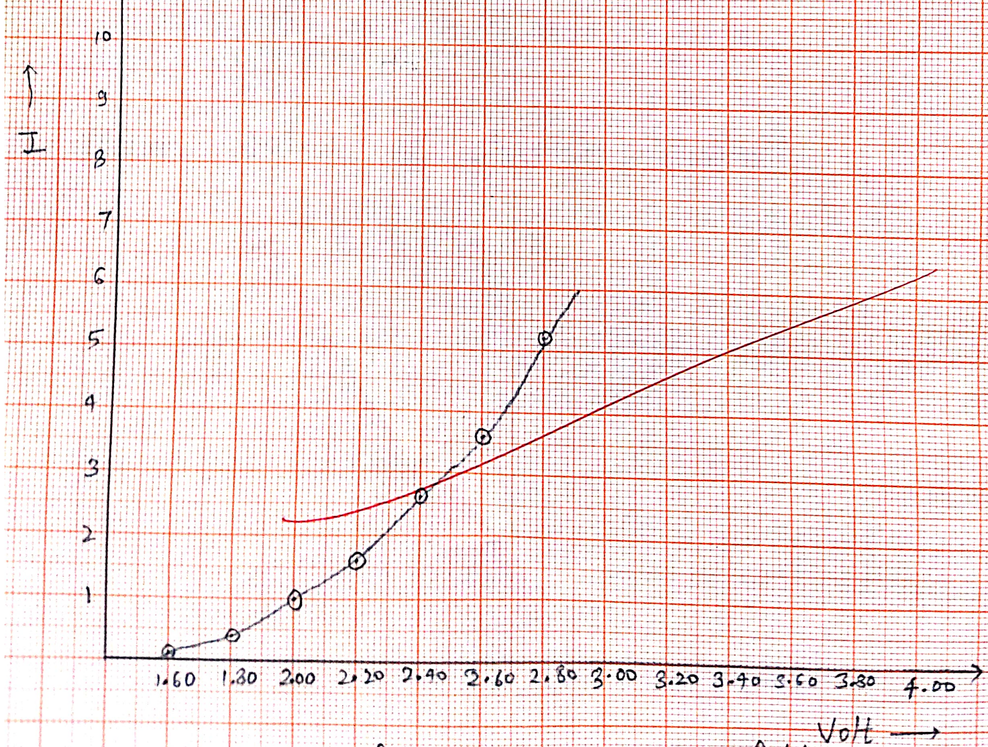
$= 44.69\%$

for Blue Colour filter

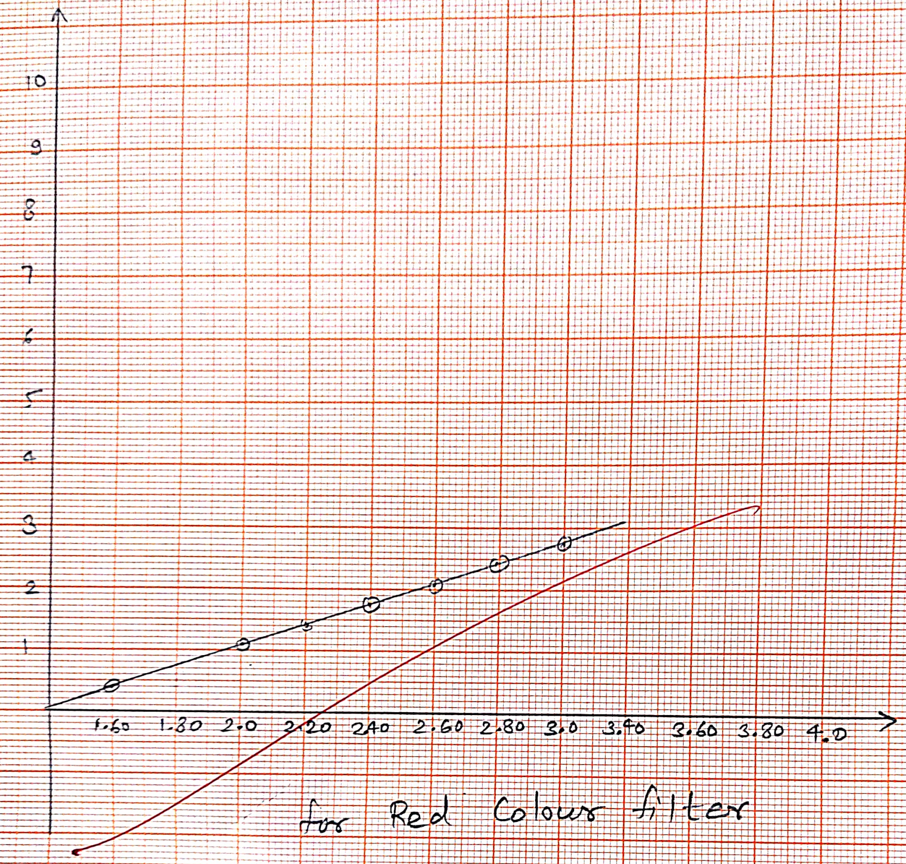
X-axis → 1cm = 0.2 V

Y-axis → 1cm = 1 μA





for Gree colour filter


10
9
8
7
6
5
4
3
2
1
1.60
1.80
2.0
2.20
2.40
2.60
2.80
3.0
3.40
3.60
3.80
4.0
for Red Colour filter

for red filter $V_3 = 3V$
green filter $V_2 = 2.20V$
Blue filter $V_1 = 1.98V$
electronic change $(e) = 1.6 \times 10^{-19} C$
speed of light $(c) = 3 \times 10^{8} m/sec.$
wavelength of Blue (1st) filter $\lambda_1 = 6148 \times 10^{-10} \pm 2\% m$
wavelenght of green (IInd) filter $\lambda_2 = 5645 \times 10^{-10} \pm 2\% m$
wavelenght of Red (3rd) filter $\lambda_3 = 486.5 \times 10^{-10} \pm 2\% m$

planck constant of first and second filter

$$h_1 = \frac{e(V_2 - V_1)\lambda_1 \lambda_2}{c(\lambda_1 - \lambda_2)}$$

similarly for h_2 & h_3

Observation Table :- for Blue colour :-

	Voltage (V)	Current (μA)
1.	2.20	0.4
2	2.40	2.4
3	2.60	3.4
4	2.80	5.0
5	3.00	6.8
6	3.20	9.0
7	3.40	11.0
8	3.60	13.6
9	3.80	16.6
10	4.00	20.6

for green colour :-

S.No.	voltage (V)	current (μA)	for Red filter. S.No.	V	I (μA)
1.	1.60	0.1	1.	1.60	0.4
2.	1.80	0.4	2	1.80	0.5
3.	2.00	1.0	3	2.0	1.1
4.	2.20	1.6	4	2.20	1.9
5.	2.40	2.6	5	2.40	2.4
6	2.60	3.6	6	2.60	3.6
7	2.80	5.2	7	2.80	4.6
8	3.00	6.8	8	3.00	7.4
9	3.20	9.2	9	3.20	8.6
10	3.40	10.8	10	3.40	11.2
11	3.60	14.0	11	3.60	13.6
12	3.80	16.6	12	3.80	16.3
13	4.00	20.0	13.	4.00	20.3

Result. :- Theoretical value of plank constant is $h\nu = 6.65 \times 10^{-34}$ J sec.

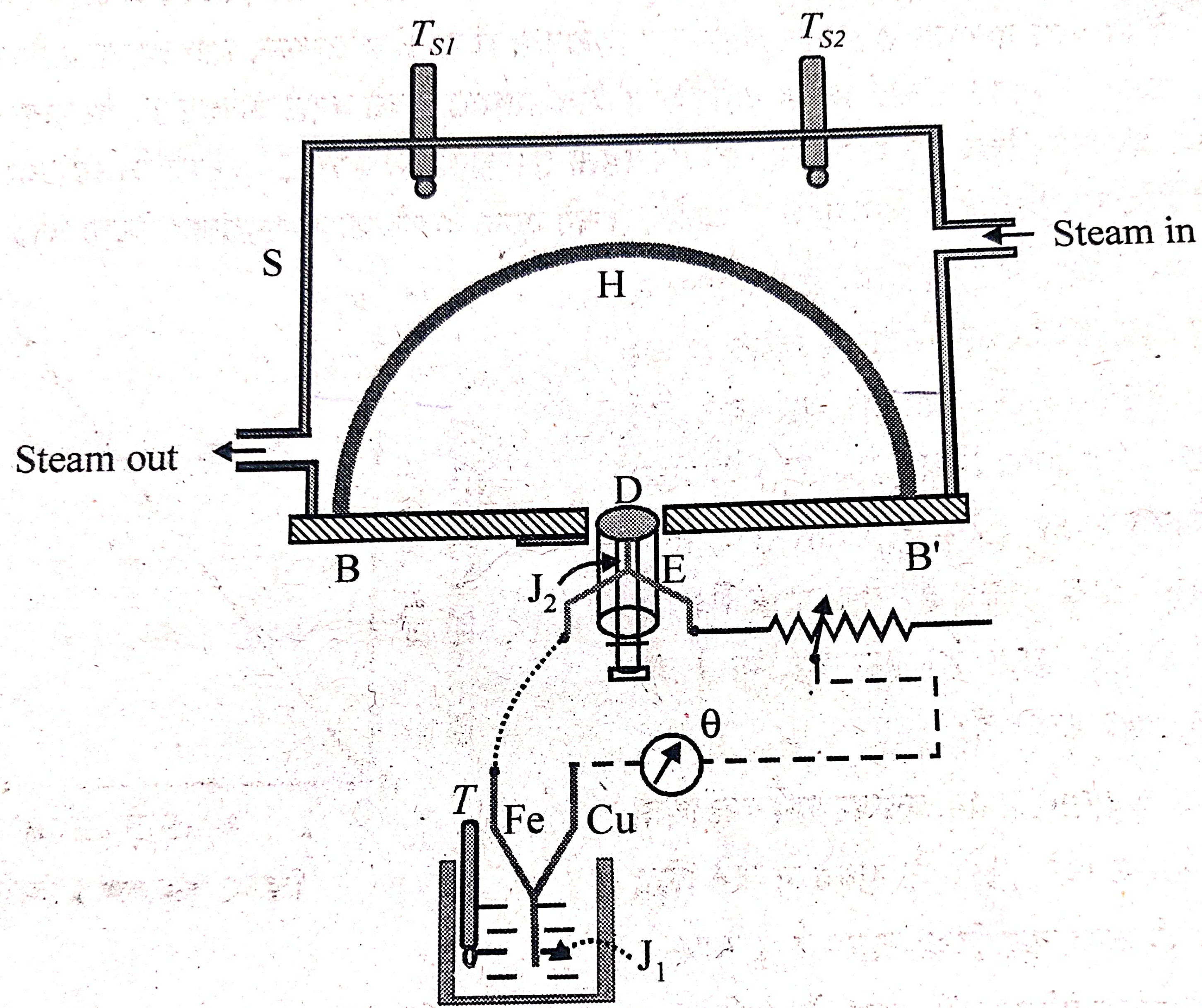
experimental value of planck's constant is $hc = 11.96 \times 10^{-34}$ J.sec.

percentage error in the value as given as

% error = 44.69 %

Teacher's Signature ____________

इस उपकरण में H, धातु का एक ...
ड़ी या ऐबोनाईट के आधार /प्लेटफार्म BB' पर रखी रहती है। इस प्लेटफार्म के मध्य में एक
ाकार छिद्र होता है जिसे एक ऊष्मीय कुचालक शटर का उपयोग कर बन्द या खुला रखा जा सकत
इस



.1 स्टेफॉन नियतांक के मापन के लिए उपयोग लिए जाने वाले उपकरण का व्यवस्थात्मक चि

Apparatus : Stefan's constant apparatus, thermometers, a copper-constantan thermocouple, metal beaker with stand, steam generator, resistance box, a test tube, stopwatch connecting wires, a spot galvanometer.

Theory:

The enclosure B is at a constant temperature T_1 K. The enclosure as well as the disc, behave like a black body. When the enclosure is at temperature T_1 K the disc is made to enter the enclosure. Let the temperature of the disc at any instant be T K. The disc absorbs the radiation from B and same time also emits radiation. Its rate of emission is different from its rate of absorption. In accordance with Stefan's law

rate of absorption of energy per unit area of the disc $= \sigma T_l^4$

rate of emission of energy per unit area of disc $= \sigma T^4$

net rate of gain of energy of the disc $= \sigma(T_l^4 - T^4) A$

$$= \frac{\sigma(T_l^4 - T^4) A}{J} \text{ cal/sec}$$

where A is upper area of disc and J is mechanical equivalent of heat.

Due to this gain in heat, the temperature of the disc rises.

Let m denote the mass of the disc, s its specific heat and dT/dt its rate of change of temperature.

For calibration

Temp (°c)	Deflection (mm)
85	89
80	84
75	77
70	71
65	64
60	57
55	49
50	42
45	35
40	26
35	19

Time (sec)	Deflection (mm)
0	26
10	26
20	27
30	29
40	30
50	31
60	32
70	33
80	35
90	37
100	37
110	38
120	39
130	40
140	40
150	41
160	42
17[illegible]	[illegible]2
18[illegible]	[illegible]3
19[illegible]	[illegible]3
200	44
210	45
220	45
230	45
240	45

Calculation :

from calibration curve

$$\frac{1}{\text{slope}} = \frac{dT}{dx} = 0.7132$$

from curve b/w t and x

$$\text{slope} = \frac{dx}{dt} = 0.1734$$

$$\frac{dT}{dt} = \frac{dT}{dx} \times \frac{dx}{dt} = 0.7132 \times 0.1734$$

$$= 0.123\ °C\ sec^{-1}$$

$T = 41°C = 314\,K$

$$\sigma = \frac{Jms}{A(T_1^4 - T^4)}\left(\frac{dT}{dt}\right)_T$$

$$= \frac{4.18 \times 3 \times 0.056 \times 0.123}{10^{-4} \times 1.7625 \times [(371)^4 - (314)^4]}$$

$\sigma = 5.318 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

Actual value $= 5.672 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

$$\%\ \text{error} = \left(\frac{5.672 - 5.318}{5.672}\right) \times 100$$

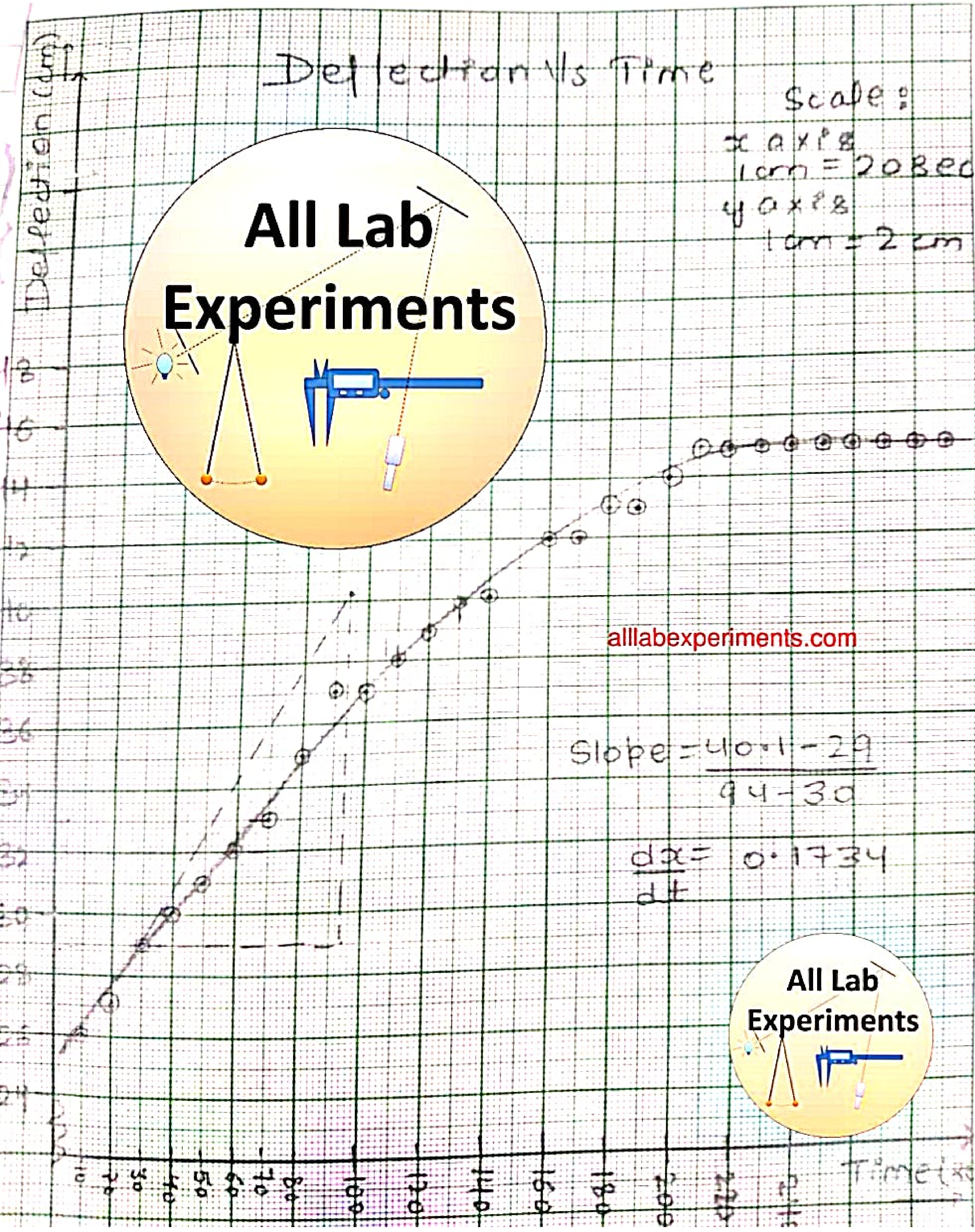
$= 6.2\%$

Result :

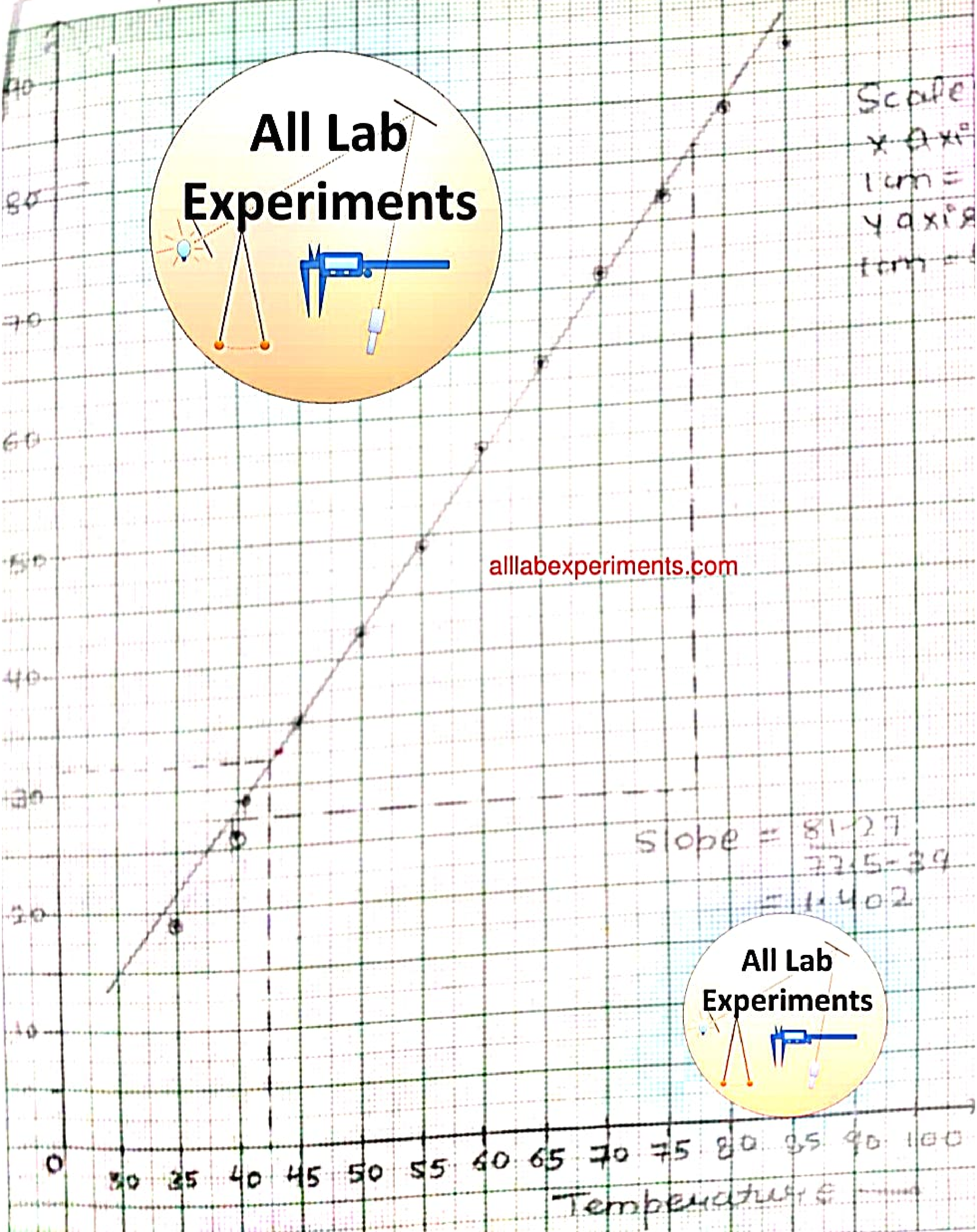
Value of Stefan's constant $= 5.318 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

Actual value $= 5.672 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

% error $= 6.2\%$


Deflection Vs Time
Scale:
x axis
1cm = 20 sec
y axis
1cm = 2 cm
Slope = 40.1 - 29 / 94 - 30
dx/dt = 0.1734
Deflection (cm)
Time

from the calibration curve



Heat gained by the disc per unit time $= ms\frac{dT}{dt}$

Equating the two expressions for gain of heat energy per unit time, we have

$$\frac{\sigma(T_0^4 - T^4)A}{J} = ms\frac{dT}{dt}$$

$$\sigma = \frac{Jms}{A(T_0^4 - T^4)} \cdot \frac{dT}{dt}$$

Here, the value of s is taken from tables, J=4.18 Joule/cal.

Result :

The value of Stefan's constant

$\sigma = 5.318 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

Actual Value $= 5.672 \times 10^{-8}\ J s^{-1} m^{-2} K^{-4}$

% Error = 6.2%

Precautions and Sources of Error

The junctions of thermocouple should be properly soldered.

Thermocouple wires should touch each other at junctions only.

The hot junction should be kept away from cold junction.

Exp:5. TO STUDY DETERMINATION OF BETA PARTICLE RANGE AND MAXIMUM ENERGY (BY HALF THICKNESS METHOD)

5.1 PURPOSE

To carry out the absorption studies on β-rays with the aid of a GM Counter and hence to determine the end point energy of β-rays emitted from a radioactive source.

5.2 EQUIPMENT/ACCESSORIES REQUIRED

- G.M Counting System 601A/602A with A.C main cord.
- G.M Detector (End window) stand (or) G.M Detector/source holder bench
- Radioactive source kit
- Aluminium absorber set

5.3 PROCEDURE

- Make standard connections and arrangement between G.M. Counting system, detector, absorber and source.
- Set the GM voltage at the operating voltage of the GM tube.
- Without source, make a few (about 5 readings) background measurements and take an average of them for a preset time of say 60 sec.
- Compute Average background counts in 60sec ($Ba = (b_1+b_2+b_3+b_4+b_5) / 5$).
- Compute Background rate = Ba/t (t = 60sec).
- Place a Beta source in the source tray at about 3 cm from the end window of the GM tube.
- Take the Aluminium absorber set.
- Place an aluminium absorber of zero thickness in the absorber holder at about 2 cm from the end window of the GM tube and record the counts.
- The absorber thickness is increased in steps of 0.05mm and every time counts are recorded.
- This process is repeated until the count rate becomes equal to or less than half the count rate with zero absorber thickness.
- Data is to be collected for the standard source and the second source.
- Here in this case the standard source is Tl - 204 and the second source is Sr - 90.
- Tabulate the data as shown in table.
- Density of Aluminium = 2.71g/cm_3 (g/cm. cube).
- The below data is taken with Thallium (Tl - 204)

Table : 1

Counting Time : 180 sec
Background : 146 counts

Absorber : Aluminium
Source : Tl-204 (4 KBq)

Absorber Thickness (in mm)	Absorber Thickness in mg/cm^2	Counts	Net counts (counts-BG)
0	0	2620	2474
0.05	13.55	2003	1857
0.10	27.10	1556	1410
0.15	40.65	1293	1147
0.20	54.20	1054	908
0.25	67.75	835	689
0.30	81.30	676	530
0.35	94.85	597	451
0.40	108.40	499	353
0.45	121.95	448	302

The below data is taken with Strontium (Sr^{90} - Y^{90})

Table : 2

Counting Time : 100 sec
Background : 79 counts

Absorber : Aluminium
Source : Sr-90

Absorber Thickness (in mm)	Absorber Thickness in mg/cm^2	Counts	Net counts (counts-BG)
0	0	5828	5749
0.05	13.55	5130	5051
0.10	27.10	4589	4510
0.15	40.65	4252	4173
0.20	54.20	3893	3814
0.25	67.75	3618	3539
0.30	81.30	3458	3379
0.35	94.85	3189	3110
0.40	108.40	3092	3013
0.45	121.95	2877	2798
0.50	135.50	2773	2694
0.55	149.05	2612	2533
0.60	162.60	2582	2503
0.65	176.15	2367	2288
0.70	189.70	2222	2143

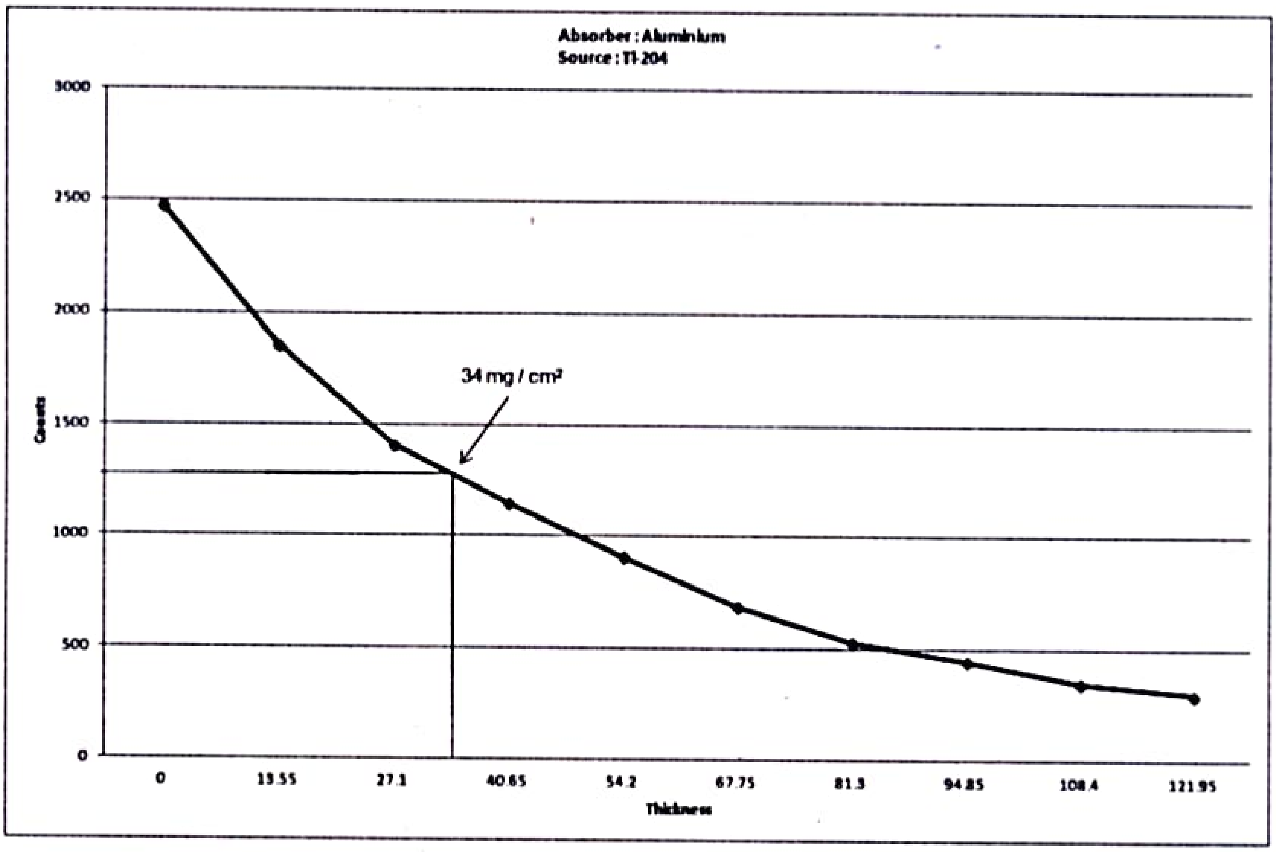


Figure : 16

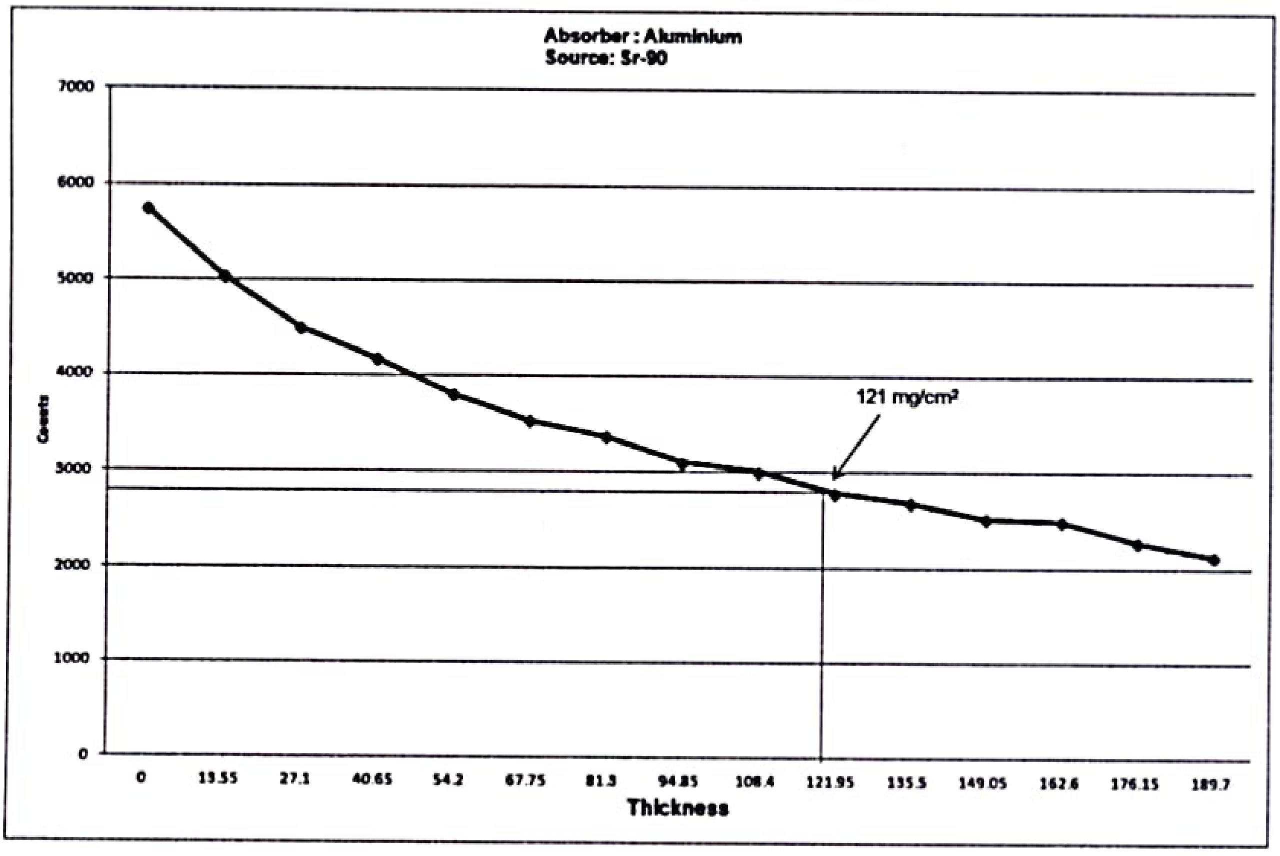


Figure : 17

5.4 ANALYSIS & COMPUTATIONS:

5.4.1 PRINCIPLE

The range of Beta particles is given by

$R_0 = (0.52\ E_0\ - 0.09)\ g/cm^2$ -- (1)

Where E_0 is the end point energy of of Beta rays from the radioactive source in MeV.

We have the ratio of thickness required to reduce the counts of Beta rays from one source to half to the thickness required for the other source is given by

$$\frac{t_1½}{t_2½} = \frac{\text{Range of Beta rays from first source}}{\text{Range of Beta rays from second source}}$$

$$\frac{t_1½}{t_2½} = \frac{R_1}{R_2} \qquad \text{-- (2)}$$

5.4.2 EXERCISE

- Subtract the background count rate from each measured count rate.
- Plot a graph of Net countrate (CPS) Vs absorber thickness (mg/cm^2) for both sources.
- Draw the curve through these points as shown in Figures 16 & 17.
- From the plotted graph extrapolate and obtain thickness of aluminium absorber required to reduce the countrate of Thallium and Strontium Beta rays by half ($t_1½$ and $t_2½$).
- Substitute $t_1½$ and $t_2½$ in the above equation (2) and calculate the range of βrays (R_2) from Sr90 source.
- Once we know the R_2, we can find out the energy (E_2) of Sr^{90} from equation-1

5.4.3 For Thallium-204

End point energy of Tl-204 = 0.764 MeV

$\therefore$ Range of ^{204}Tl $= R_1$ $= (0.52\,E_0 - 0.09)\ g/cm^2$

$= (0.52 \times 0.764\ Mev - 0.09)\ g/cm^2$

$= 0.30728\ g/cm^2$

- Thickness of Al absorber required to reduce the count rate of ^{204}Tl by half, $t_1½$ = 34mg/cm square
- Thickness of Al absorber required to reduce the count rate of Sr-90 by half $t_2½$ = 121mg/cm²

From Equation (2).

$$\frac{t_1½}{t_2½} = \frac{R_1}{R_2}$$

$$\Rightarrow \quad R_2 = R_1 \times \frac{t_2½}{t_1½} = \frac{0.30728 \times 121 \times 10^{-3}}{34 \times 10^{-3}}$$

$$R_2 = \frac{0.30728 \times 121}{34} = 1.09355\ gm/cm^2$$

$\therefore$ End point energy of $^{90}Sr/\,^{90}Y$

$$E_2 = \frac{R2 + 0.09}{0.52} = \frac{1.09355 + 0.09}{0.52}$$

$$E_2 = 2.276\ Mev$$

5.4.4 RESULT

End point energy of β-rays from ^{90}Sr = 2.28 MeV.