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Experiment - 10
Hall Effect

Aim:- To study Hall effect in a semiconductor sample and determine the Hall coefficient and density of charge carriers. This experiment demonstrates the effect of ~~Lorentz~~ Lorentz force.

Apparatus:- Two solenoids, constant source of power to maintain magnetic field. Hall probe with semiconductor sample, constant current supply with ammeter and voltmeter, Gauss Meter.

Formula used:-

$$R_H = \frac{E_y}{IB} = \frac{V_H d}{IB} \quad -(1)$$

$$V_H = \frac{R_H B I}{d} \quad -(2)$$

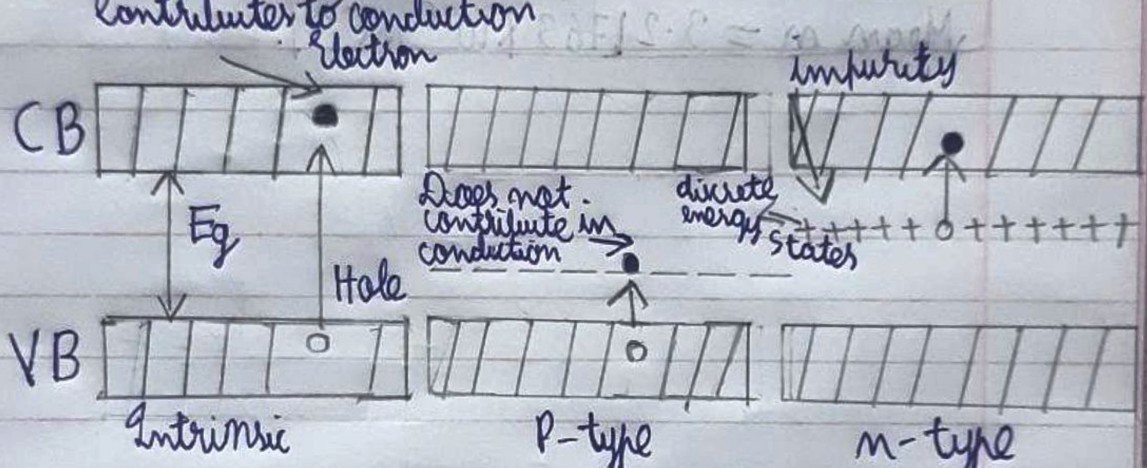
$$\boxed{\begin{matrix} m = R_H B/d \\ R_H = md/B \end{matrix}} \quad -(3)$$

$$\boxed{R_H = \frac{1}{qn}} \quad -(4)$$

n - carrier density in the semiconductor

$V_H \rightarrow$ Hall Voltage
$R_H \rightarrow$ Hall coefficient
$I \rightarrow$ Current
$E_y \rightarrow$ Electric field (transverse)
$q \rightarrow$ charge of the carrier
$m \rightarrow$ slope

MAHAVEER Teachers' Signature ›



Energy band diagram of a semiconductor

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Observations :-

Table 1 :-

* Data for calculating R_H and density of charge carrier for Germanium subjected to a fixed magnetic field.

* Parameters :-

a) Current through the solenoid = 1 A.
b) Resultant magnetic field (B) = 0.1482 T
c) Thickness of the material ~~field~~ (d) = 0.0001 m
d) Charge of the carrier (|q|) = 1.602×10^{-19} C

S.NO	Hall current I, (mA)	Hall Voltage V_H (mV)	Hall coefficient (R_H) ($\frac{\Omega m}{T}$ or $\frac{m^3}{C}$) (from slope Eq^n 3)	Density of charge carriers, n ($\frac{1}{m^3}$) from Eq^n 4
1.	1.0	28.756		
2.	1.5	43.133		
3.	2.0	57.511	0.0194	3.21763×10^{20}
4.	2.5	71.889		
5.	3.0	86.267		
6.	3.5	100.645		
7.	4.0	115.023		

Table 2:-

Current through the solenoid = 2.5A.
Resultant magnetic (B) = 0.3706T
Thickness of the material (d) = 0.0003 m
Charge of the carrier (|q|) = 1.602×10^{-19} C

S.NO	Hall current I (mA)	Hall Voltage V_H (mV)	Hall coefficient R_H ($\frac{\Omega m}{T}$ or $\frac{m^3}{C}$) (from slope Eq^n 3)	Density of charge carriers, n ($\frac{1}{m^3}$) from Eq^n 4
1.	1.0	23.963		
2.	1.5	35.945	0.0194	3.21763
3.	2.0	47.926		$\times 10^{20}$
4.	2.5	59.908		
5.	3.0	71.889		
6.	3.5	83.871		
7.	4.0	95.852		

Calculations :-

Table 1 :-

$x_1 = 1.0 \times 10^{-3} A$ $y_1 = 28.76 \times 10^{-3} V$

$x_2 = 2.0 \times 10^{-3} A$ $y_2 = 57.51 \times 10^{-3} V$

$$\text{Slope}(m) = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{(57.51 - 28.76) \times 10^{-3}}{(2.0 - 1.0) \times 10^{-3}}$$

$$\boxed{m = 28.75}$$

~~Hall coefficient~~ =>

Hall Coefficient (R_H) :-

$$R_H = \frac{md}{B}$$

$$= \frac{28.75 \times 0.0001}{0.1482}$$

$$\boxed{R_H = 0.0194 \, \Omega m / T}$$

Density of charge carrier (n):

$$n = \frac{1}{R_H q} = \frac{1}{0.0194 \times 1.602 \times 10^{-19}}$$

$$\boxed{n = 3.21763 \times 10^{20} m^{-3}}$$

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Calculations for Table 2:-

$x_1 = 1.0 \times 10^{-3} A$ $y_1 = 23.96 \times 10^{-3} V$

$x_2 = 2.0 \times 10^{-3} A$ $y_2 = 47.93 \times 10^{-3} V$

$$\text{Slope}(m) = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{47.93 - 23.96}{2.0 - 1.0}$$

$$\boxed{m = 23.97}$$

Hall coefficient (R_H):

$$R_H = \frac{md}{B} = \frac{23.97 \times 0.0003}{0.3706}$$

$$\boxed{R_H = 0.0194 \ \Omega m / T}$$

Density of charge carriers (n):-

$$n = \frac{1}{R_H q}$$

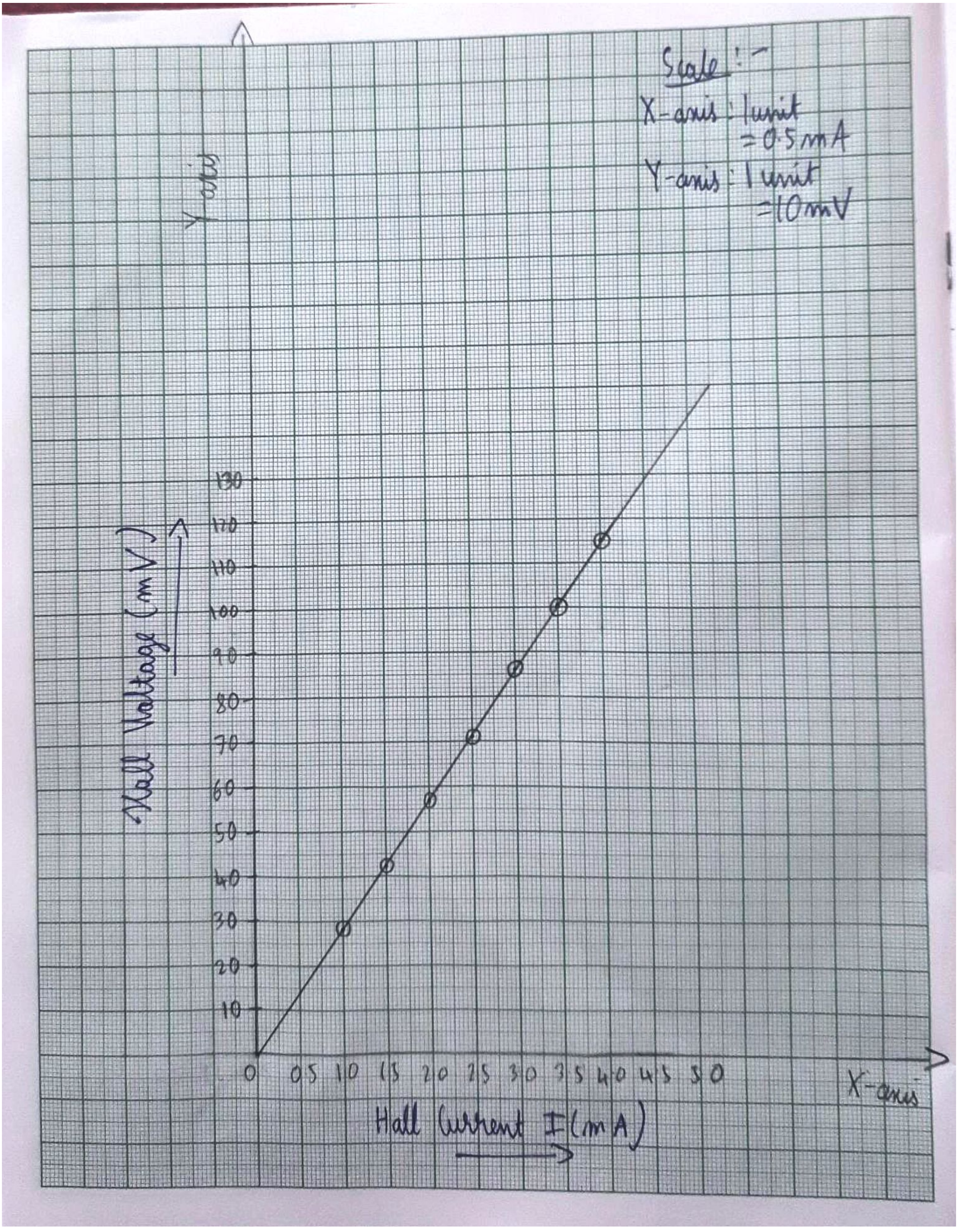
$$= \frac{1}{0.0194 \times 1.602 \times 10^{-19}}$$

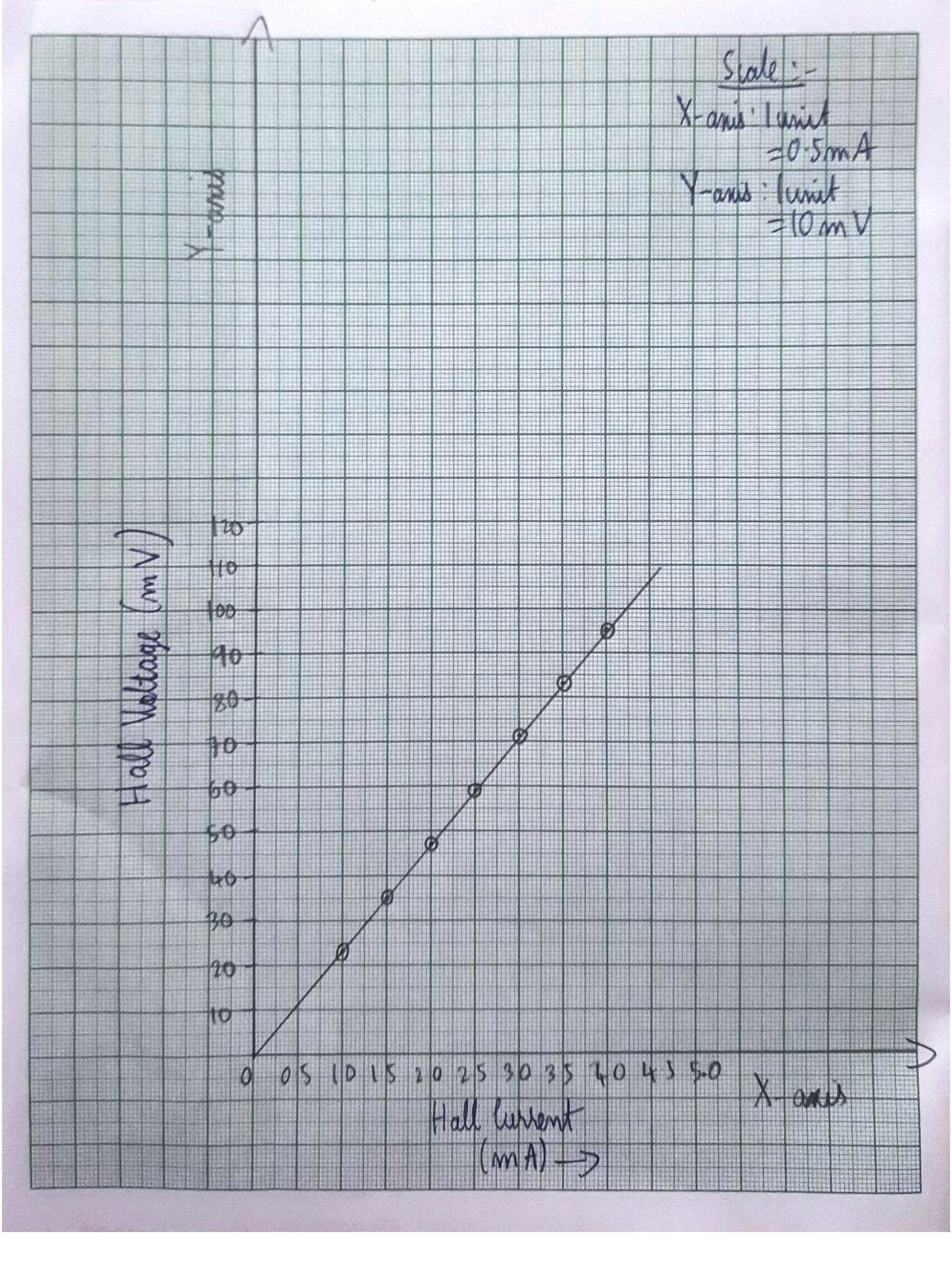
$$\boxed{n = 3.21763 \times 10^{20} \ m^{-3}}$$

Conclusions:-

$\boxed{\text{Mean } R_H = 0.0194\ \Omega\ m/T}$

$\boxed{\text{Mean } n = 3.21763 \times 10^{20}\ m^{-3}}$


Scale :-
X-axis : 1 unit = 0.5 mA
Y-axis : 1 unit = 10 mV
Y-axis
Hall Voltage (mV)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
X-axis
Hall Current I (mA)


Scale :-
X-axis : 1 unit = 0.5 mA
Y-axis : 1 unit = 10 mV
Y-axis
Hall Voltage (mV)
120
110
100
90
80
70
60
50
40
30
20
10
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
X-axis
Hall Current (mA)