TO DETERMINE SPECIFIC CHARGE (e/m) OF AN ELECTRON USING THOMSON METHOD

Office phone: (033)23371539/9831450399
For Technical Assistance: 9830879969
Email: detechkolkata@yahoo.co.in

DE TECH
Manufacturers of Laboratory Instruments & Apparatus
CD 256, SALT LAKE, CALCUTTA 700064, WESTBENGAL

AIM:

To determination the value of Specific Charge (e/m) of an electron by using Thomson method

ACCESSORIES:

1. Cathode Ray Tube (CRT)
2. Power supply unit
3. Pair of bar magnets
4. Magnetometer
5. Compass box

Theory: The apparatus used to calculate (e/m) of electron is shown in figure 1. It consists of a cathode ray tube (CRT) which is highly evacuated to eliminate collisions of electrons with air molecules. C and A are the electrodes and A1 and A2 are the slits that collimate the electrons. A pair of deflecting plates M and N is placed symmetrically around the path of the electrons.

Uniform magnetic field is applied in the region where the electric field is produced by the deflecting

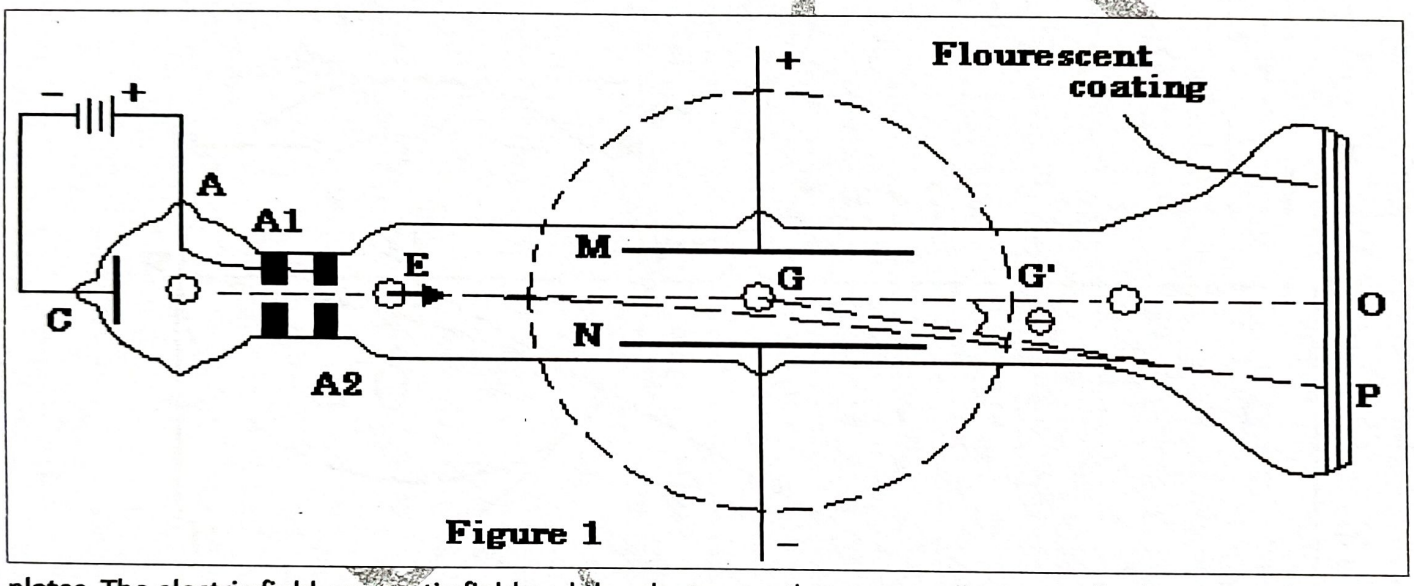

Figure 1

plates. The electric field, magnetic field and the electron path are mutually perpendicular.

The inner surface of the discharge tube at the right end is coated with a fluorescent material. The electrons stroke the screen and produce a glow at point O on the screen when the electric and magnetic fields are not switched on. Under the action of magnetic field alone, the electrons are deflected downward.

FORMULA USED:

The Specific Charge $$\frac{e}{m} = \frac{VD}{LlB^2d}$$

Where, V = Applied voltage
L = Distance of the screen from the edges of the plates
D = Total deflection of the spot on the screen
l = length of the deflecting plates
B = Applied magnetic field
d = Separation between the plates.

Initially the magnetic field B is turned on. The electron experiences a force which is equal to the centripetal force.

$evB = mv^2/R$ (R is the radius of circular arc)

$e/m = v/BR$ ..... (1)

Now, the electric field E is switched on. Then,

$eE = evB$

Therefore, $v = E/B$ ..... (2)

Therefore, $e/m = E/B^2R$ ..... (3)

In figure 2, the path of electrons is shown as in the circular are EP. CE and CF are radii of the circular arc.

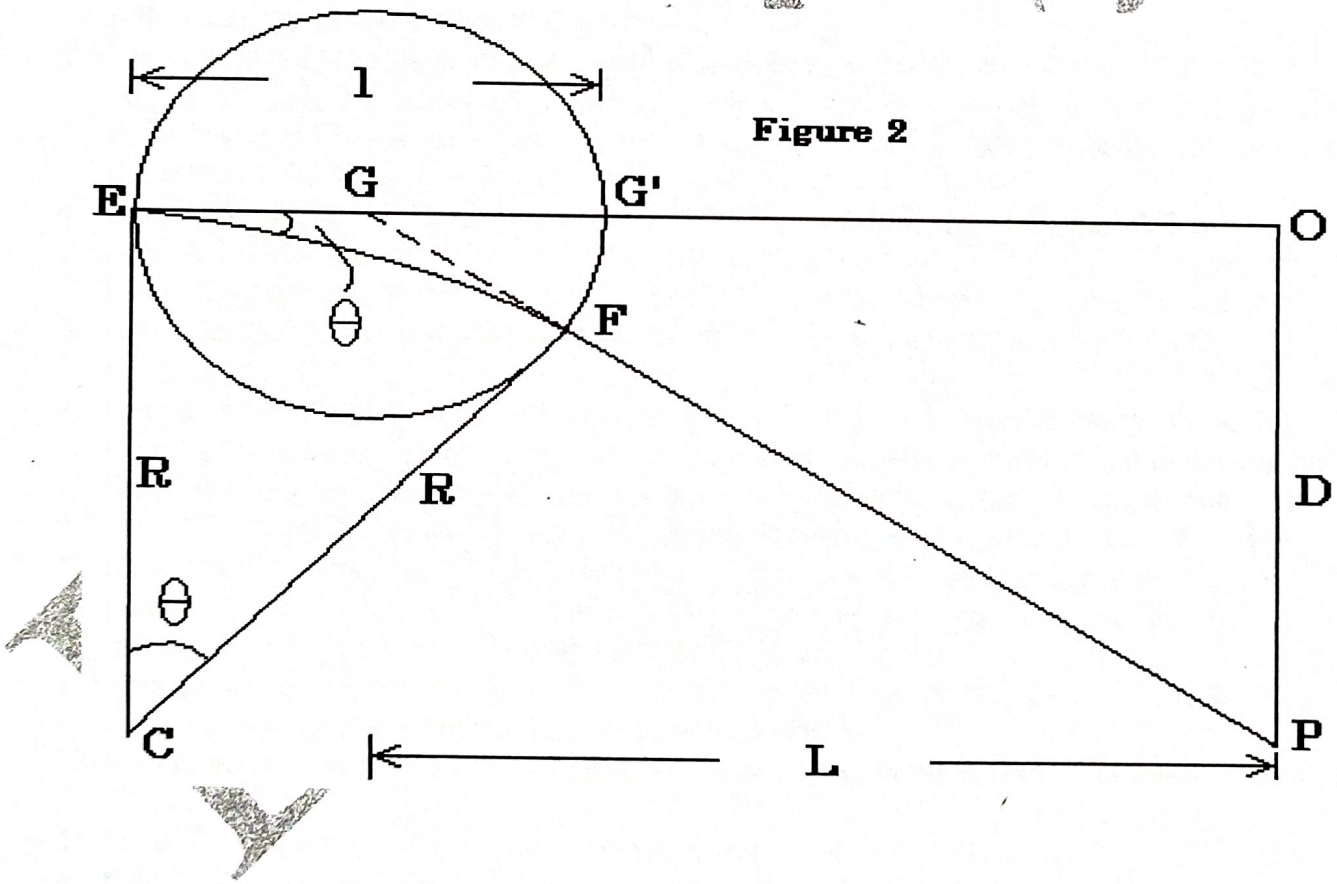

Figure 2

From the figure it is clear than ΔCEG' and OGP are similar

Therefore, $G'E/CE = PO/GO$

Therefore, $l/R = D/L$

Therefore, $R = lL/D$ ..... (4)

Put the value of 'R' in equation (3).

Therefore, $e/m = E/B^2 (IL/D)$

Therefore, $e/m = ED/LIB^2$

Using, $E = V/d$

$$\frac{e}{m} = \frac{VD}{LIB^2d}$$

PROCEDURE:

1. Place the magnetometer compass box in the wooden stand to trace the north-south direction such that it points at 0-0 degree. Now place the Cathode Ray Tube in such a way that it faces toward north and south direction. This is done because the magnetic field of the earth is in the north-south direction. So, when the CRT is placed along the same direction, the electron beam is not affected by the Earth's magnetic field.
2. Switch on the power supply for CR tube and after heating up, a spot will come on the screen. Adjust the intensity and focus of the spot.
3. Take the initial reading of the spot on the scale attached with screen, say it comes out to be +0.1. Now apply the deflecting voltage using the acceleration knob on power supply such that a deflection is in upward direction and the reading is +1.1 so that total deflection of the spot on the screen is (+1.1)-(+0.1) = +1.0.
4. Note down the applied deflecting voltage 'V' for the above deflection i.e. for +1.1cm.
5. Place the bar magnets symmetrically on each side such that the poles are perpendicular to the axis of C.R tube and the bar magnets have opposite pole (North-South) facing each other.
6. Now adjust the spacing and polarity of the magnets such that spot reaches back to the original position (+0.1).
7. Note down the spacing of the poles of the magnet from the C.R.T (say they are 'a' and 'b').
8. Remove the magnets and reverse the polarity of the voltage V applied to the deflecting plates. Now the initial deflection is +0.1 and final -0.9. Therefore total deflection is again one.
9. Place the bar magnets again on the wooden stand and repeat the procedure no. 7.
10. Note down the spacing of the poles of the magnet from C.R.T (say they are 'c' and 'd').
11. Remove the C.R.T and bar magnets and place the magnetometer compass box such that its center lies on the common axis of the magnets.
12. Now place the bar magnets in the position as placed in previous case i.e. to 'a' and 'b' distances. Note the reading of the pointer (say they are $\theta 1$ and $\theta 2$).
13. Now place the bar magnets in the position 'c' and 'd' as placed in (11). Note the deflection (say they are $\theta 3$ and $\theta 4$).
14. For deflecting voltage V calculate the mean deflection $\theta = (\theta 1+\theta 2+\theta 3+\theta 4)/4$.
15. Calculate the magnetic field $B = He.\tan\theta$ where **He is the earth's horizontal component of the field ≈ 0.35 Oersted.**
16. Take the different deflecting voltage V and repeat the whole procedure.

EXPERIMENTAL RESULT:

1. Separation between the plates d= 0.5cm
2. Length of the horizontal pair of the plates l = 2cm.
3. Distance of the screen from the edges of the plates L = 7cm.

DETERMINATION OF DEFLECTION FOR DIFFERENT DEFLECTING VOLTAGE (V)

Sl. No.	Voltage applied (V)	Initial position of the spot (cm)	Final position of the spot (cm)	Deflection D (cm)	Distance		
					'a' pole (cm)	'b' pole (cm)	Mean (cm)
1	V1 = 14	0.1	1.1	1	13.9(N)	13.9(S)	13.9
	V1'= -14	0.1	-0.9	-1	13.5(S)	13.5(N)	13.5
2	V2 = 27.8	0.1	2.1	2	9.7(N)	9.6(S)	9.65
	V2'= -27.9	0.1	-1.9	-2	9.6(S)	10(N)	9.8
3	V3 = 42.2	0.1	3.1	3	7.3(N)	7.9(S)	7.6
	V3'= -42	0.1	-2.9	-3	7.4(S)	7.4(N)	7.4

DETERMINATION OF MAGNETIC FIELD (B)

Voltage V	Reading of the pointer		Mean θ	tan θ	Magnetic Field B = He.tan θ	e/m ($x10^{11}$ C/kg)
	θ1	θ2				
V1 = 14	71	71	71	2.904	1.016	1.937
V1'= -14	72	72	72	3.077	1.076	1.727
V2 = 27.8	82	82	82	7.115	2.490	1.281
V2'= -27.9	82	81	81.5	6.691	2.341	1.454
V3 = 42.2	85	85	85	11.43	4.000	1.130
V3'= -42	84	84	84	9.51	3.328	1.625

N.B. : This is a sample table, readings may vary.

CALCULATION:

$e/m = VD/LlB^2d$

RESULT:

The value of e/m ratio of an electron is $1.76x10^{11}$ C/kg.

DISCUSSIONS:

1. The axis of the C.R.T is adjusted strictly along the magnetic meridian.
2. The spot on the screen must be small and intense.
3. C.R.T should be handled carefully.
4. There should be parallel error while taking the reading of the magnetometer.