LABORATORY REPORT SAMPLE

Experiment 1. Charge-to-mass ratio e/m of electron

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Q1. Derive the expression 7 for e/m ratio.

The Lorentz force acting on the electron of charge e moving with speed v in a magnetic field of strength B is

$$F_{Lorentz} = evB \tag{1}$$

For a close orbit, this force is equal to the centripetal force of the moving electron,

$$F_{centripetal} = \frac{mv^2}{r} \tag{2}$$

where m is the mass of the electron and r is the radius of the circular orbit. Therefore,

$$\frac{e}{m} = \frac{v}{Br} \tag{3}$$

In this experiment, the electron is accelerated by an electric field with potential V_0 from rest to a speed of v. By conservation of energy, the speed can be expressed:

$$\frac{1}{2}mv^2 = eV_0 \Rightarrow v = \sqrt{\frac{2eV_0}{m}} \tag{4}$$

Using (3) and (4), we can get:

$$\frac{e}{m} = \frac{2V_0}{B^2r^2} \tag{5}$$

The magnetic induction B generated by a set of Helmholtz coils is given by

$$B = \frac{(N\mu_0)I}{\left(\frac{5}{4}\right)^{3/2} R} \tag{6}$$

where N is the number of turns of wire, R is the radius of the coils and I is the current. Using this expression for the magnetic field in (5), we get the expression 7 for the e/m ratio:

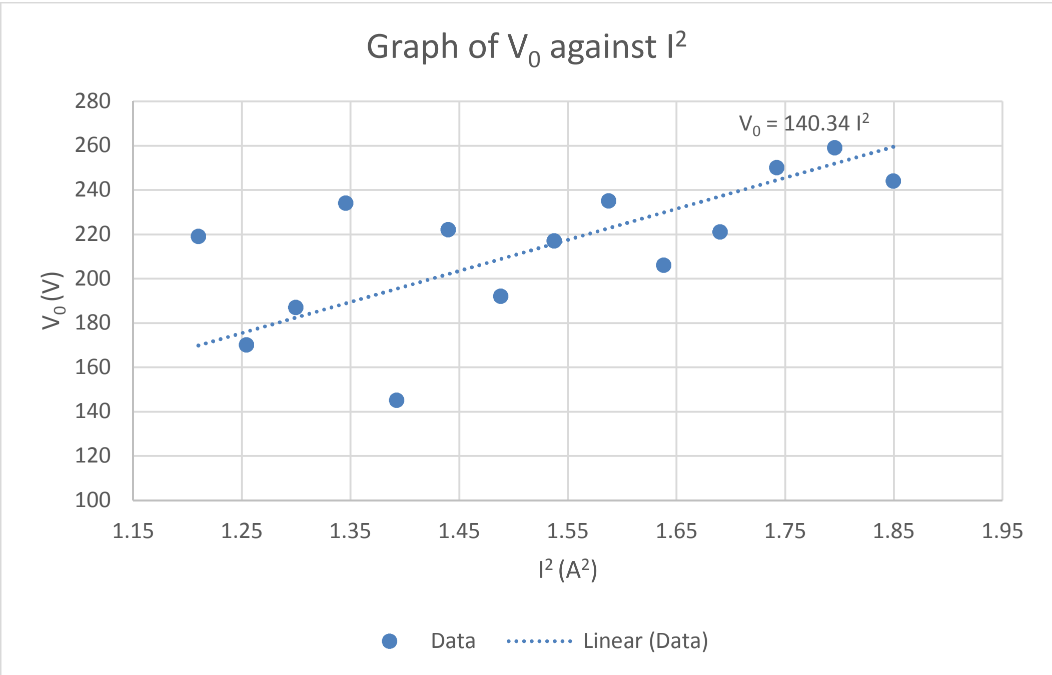
$$\frac{e}{m} = \frac{2V_0(5/4)^3R^2}{(N\mu_0 Ir)^2} \tag{7}$$

Q2. Complete the table and plot a graph of V_o against I^2. Measure the gradient of your graph. Deduce the specific charge, e/m of an electron.

Electron Beam Radius, r = 0.05 (m)

V_0 (V)	I^2 (A^2)
219	1.10
170	1.12
187	1.14
234	1.16
145	1.18
222	1.20
192	1.22
217	1.24
235	1.26
206	1.28
221	1.30
250	1.32
259	1.34
244	1.36

The graph of V_0^2 against I^2 is plotted:



From the graph, the slope is 140.34. Since the slope is equal to $\frac{e}{m}\left(\frac{N\mu_0 r}{R}\right)^2 \frac{1}{2(5/4)^3}$, the charge to mass ratio is obtained:

e/m = 1.84×10^{11} C kg^{-1}

Q3. What is the error of the measured charge-to-mass ratio? How is the value compared to the accepted value (1.758×10^{11} C kg^{-1})?

By regression analysis, the error of the slope is 4.60, corresponding to an error of 6.06×10^{9} C kg^{-1} in the charge-to-mass ratio. Thus, the measured e/m is $(1.84 \pm 0.06) \times 10^{11}$ C kg^{-1}.

This value is 5% greater than the accepted value.

Q4. What are the purposes of the 6.3V supplies? Why is the tube evacuated?

The 6.3 V supply is used to heat up the cathode so that the atoms on it are ionized. The electrons are knocked out to form a cathode ray.

The tube has to be evacuated because the ions in the air would be attracted to the positive and negative terminals of the applied electrical potential. This would neutralize the terminals.