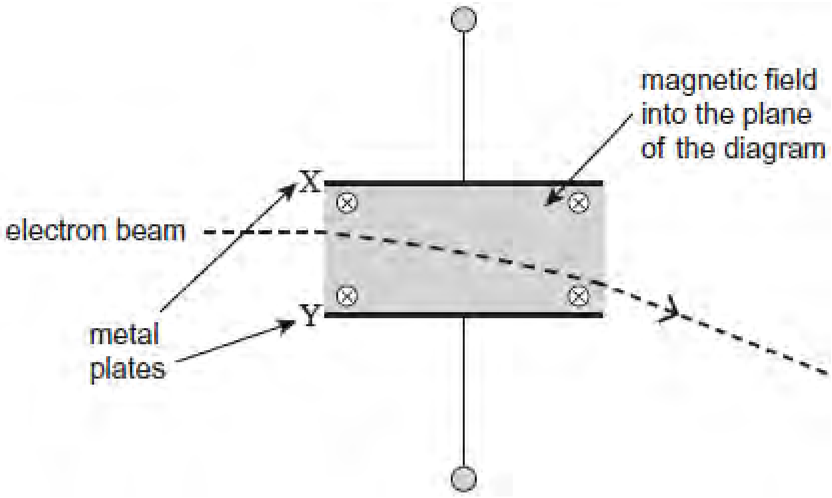
Q1. The diagram below shows part of an evacuated tube that is used to determine the specific charge (e / m) for an electron. An electron beam is directed between the two parallel metal plates, X and Y. In the region between the plates, a magnetic field is applied perpendicularly into the plane of the diagram. An electric field can be applied in this region by applying a potential difference (pd) between the plates.



(a) The diagram shows the path of the electron beam when the magnetic field is applied and the pd between X and Y is zero.

(i) Explain why the path followed by the electron beam in the magnetic field is a circular arc.

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(2)

(ii) Show that the speed v of the electrons is given by $v = \frac{Ber}{m}$

where r is the radius of the path of an electron in the magnetic field and B is the flux density of the magnetic field.

(1)

(iii) A pd V is now applied between X and Y without changing the flux density of the magnetic field. V is adjusted until the electron beam is not deflected as it travels in the region between the plates.

Determine an expression for the speed v of the electrons in terms of V, B and the separation d of the metal plates.

(1)

(b) Use the equation given in part (ii) and your answer to part (iii) to show that the specific charge for the electron = $\frac{V}{B^2 r d}$

(1)

(c) If the charge on an electron is known then its mass can be determined from the specific charge. Describe how Millikan's experiment with charged oil droplets enables the electronic charge to be determined.

Include in your answer:

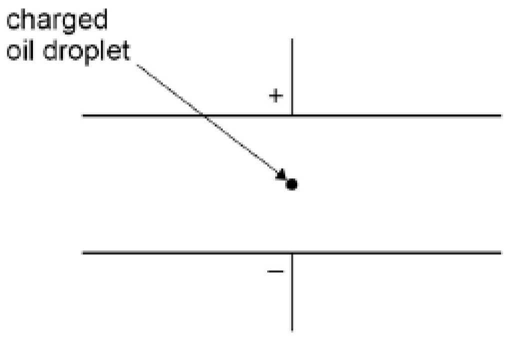
- the procedures used to determine the radius of a droplet and the charge on a droplet

- how the measurements made are used
- how the electronic charge can be deduced.

The quality of your written communication will be assessed in your answer.

(6)
(Total 11 marks)

Q2. In an experiment to measure the charge of the electron, a spherical charged oil droplet of unknown mass is observed between two horizontal parallel metal plates, as shown in the figure below.



(a) The droplet falls vertically at its terminal speed when the potential difference (pd) between the plates is zero.

A droplet of radius g falls at its terminal velocity, v.

Derive an expression for g in terms of v, η , ρ and g, where η is the viscosity of air and ρ is the density of the oil droplet.

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(2)

(b) Explain how the mass of the oil droplet can be calculated from its radius and other relevant data.

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(1)

(c) A potential difference (pd) is applied across the plates and is adjusted until the droplet is held stationary. The two horizontal parallel metal plates are 15.0 mm apart. The mass of the droplet is 3.4×10^{-15} kg.

The droplet is held stationary when the pd across the plates is 1560 V.

Calculate the charge of the oil droplet.

charge = ... C

(2)

(d) A student carries out Millikan's oil drop experiment and obtains the following results for the charges on the oil drops that were investigated.

-9.6×10^{-19} C -12.8×10^{-19} C -6.4×10^{-19} C

Discuss the extent to which the student's results support Millikan's conclusion and how the student's conclusion should be different.

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(3)
(Total 8 marks)