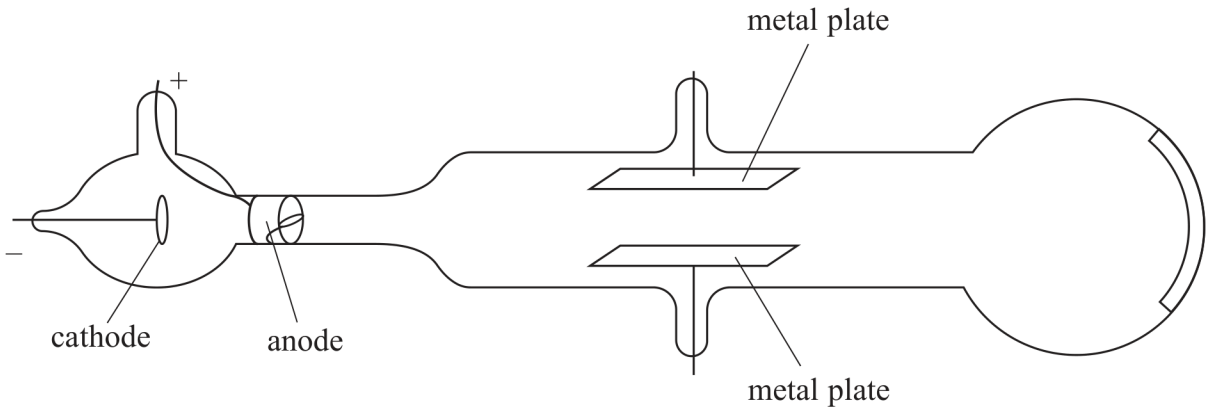
17 (a) In 1897 J J Thomson demonstrated that electrons are small negative particles.

The diagram shows the apparatus used by Thomson.



(Source: J.J. Thomson © Philosophical Magazine, 44, 293 (1897))

A potential difference V was applied across the metal plates, producing an electric field between them.

A magnetic field of flux density B was applied at right angles to the electric field.

Electrons were emitted from the cathode and accelerated towards the anode. The electrons moved between the metal plates with a speed v.

Thomson adjusted B until the electric and magnetic forces on the electrons were equal and opposite, so the electrons passed between the metal plates in a straight line.

(i) The plates are separated by a distance d.

Show that the speed v of the electrons is given by

$$v = \frac{V}{Bd}$$

(3)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) An experiment was carried out using similar apparatus.

Show that v was about $3 \times 10^{7}\,\text{m s}^{-1}$.

$d = 1.5\,\text{cm}$
$B = 5.5 \times 10^{-4}\,\text{T}$
$V = 231\,\text{V}$

(2)

(iii) When the electric field between the plates is switched off the electrons move in a circular path of radius 39 cm, due to the magnetic field.

The accepted value for the charge per unit mass of an electron is $1.8 \times 10^{11}\,\text{C kg}^{-1}$.

Deduce whether the charge per unit mass of an electron calculated using data from this experiment is consistent with the accepted value.

$B = 5.5 \times 10^{-4}\,\text{T}$

(3)

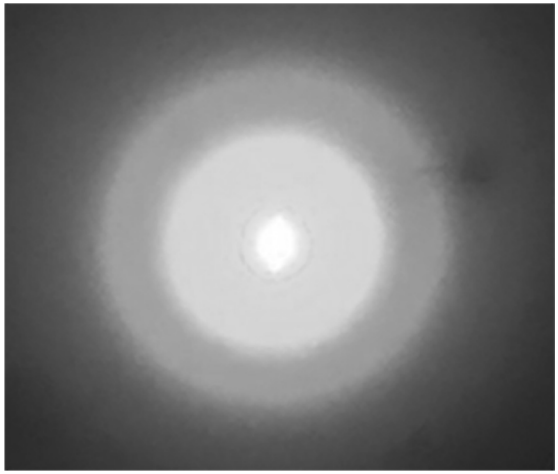
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) In 1927 J J Thomson's son directed beams of electrons at thin films of metal.

The photograph shows one of the patterns observed.



Explain how this pattern changed scientists' understanding about the nature of electrons.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 17 = 11 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA