6

Two oppositely charged parallel metal plates P and Q are placed in vacuum. The electric field strength E is uniform in the region between the plates, and is zero outside this region. Uniform magnetic flux density B into the plane of the paper also exists in the region between the plates, as well as in the adjacent area, as shown in Fig. 6.1.

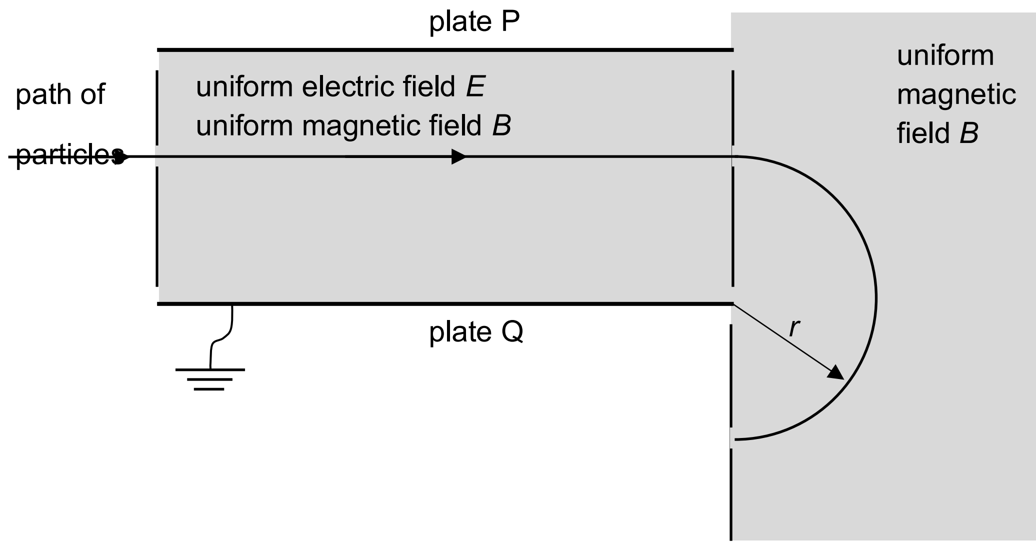

Fig. 6.1

A beam of negatively charged particles moving in the direction perpendicular to the electric field enters the region between the plates.

(a)

(i)

Some of the particles move in a straight line undeflected in the region between the plates.

State and explain the polarity, positive or negative, of plate P.

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(ii)

Show that the speed v of these particles satisfies

$$v = \frac{E}{B}$$

[1]

(iii)

Some of the particles move with an initial speed $v > \frac{E}{B}$.

On Fig. 6.1, sketch the path between the plates of these particles.

Explain your answer.

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(b)

After leaving the parallel plates, the undeflected particles enter a region with only the uniform magnetic flux density B, in which they follow a circular trajectory of radius r.

(i)

Explain why the speed of the particles remains constant along the circular trajectory.

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(ii)

Show that, for the particles that follow the circular path of radius r, the charge-to-mass ratio is given by

$$\frac{q}{m} = \frac{E}{B^2 r}.$$

[2]

[Total: 9]