3 Fig. 3.1 shows the arrangement of a mass spectrometer, which is an instrument to measure the masses of ions. An ion of mass m and charge $+q$ from the ion source S is accelerated from rest through a potential difference V. The ion then passes through a slit into a region of uniform magnetic field of flux density B, which is directed perpendicularly out of the paper.

In the field, it moves in a semicircle, striking and producing a spot on a photographic plate at a distance x from the entry slit.

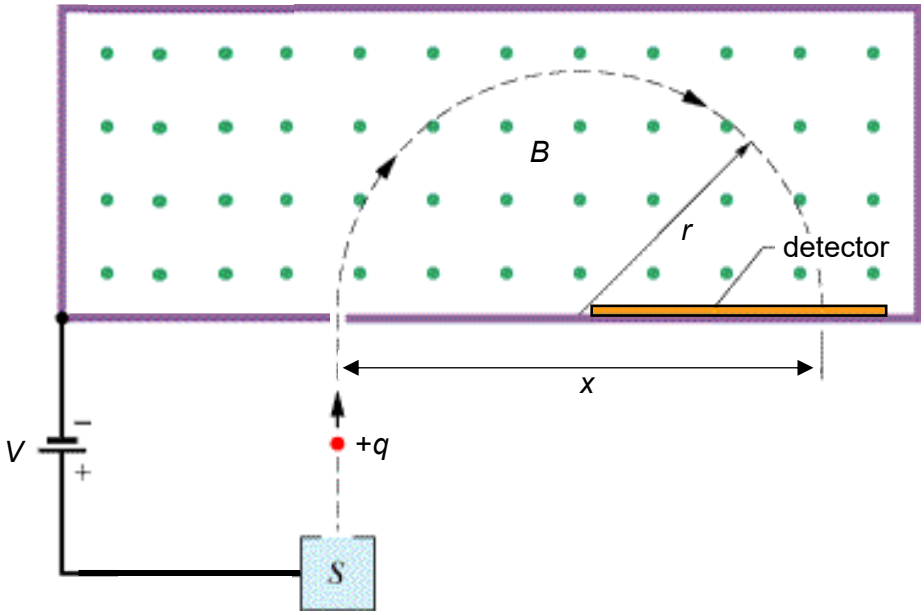

Fig. 3.1

(a) Show that the ion enters the magnetic field with a velocity, $v = \sqrt{\frac{2qV}{m}}$.

[1]

(b) Describe and explain the effects of the magnetic field on the velocity of the ion upon its entry into the magnetic field.

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.... [2]

(c) Two singly and positively charged ions are accelerated through a potential difference V of 4.0 kV and enter the magnetic field of flux density B of 0.50 T.

If the masses of the ions are $12u$ and $14u$, calculate the distance Δx between the two spots they make on the photographic plate.

Δx = ……..... m [3]

(d) If an electron were to be introduced into the mass spectrometer, briefly describe and explain, if any, changes to the path if the magnitude of the accelerating potential and the magnetic field remained unchanged.

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…… [2]