Exercises for Midterm exam - Magnetism

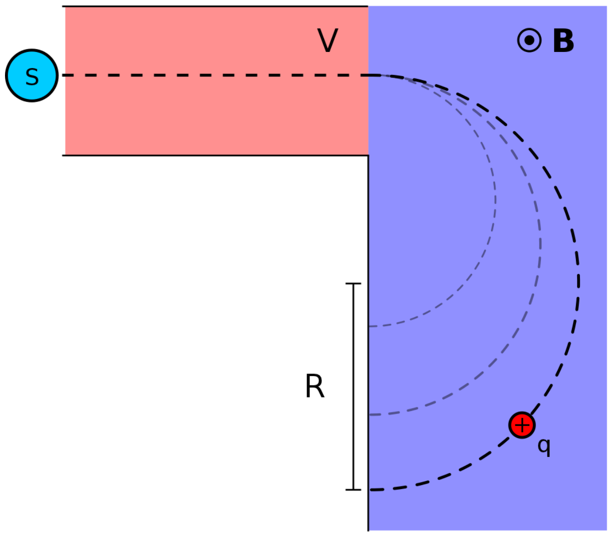

Figure 1

Exercise 0.1: Mass Spectrograph

A mass spectrograph is used to measure the masses of ions, or to separate ions of different masses. In one design for such an instrument, ions with mass m and charge q are accelerated trough a potential difference V. They then enter a uniform magnetic field that is perpendicular to their velocity, and they are deflected in a semicicular path of radius R. A detector measures where the ions complete the semicircle and from this it is easy to cacluate R. The situation where a source S is emitting ions is shown in figure 1. In the red region there is a potential difference, while in the blue region there is a uniform magnetic field.

a) Derive the equation for calculating the mass of the ion from measurements of B, V, R and q.

Answer:

$$m = \frac{qB^2R^2}{2V}. \tag{1}$$

b) What potential difference V is needed so that singly ionized ^{12}C atoms will have $R = 50.0\,\text{cm}$ in a $0.150\,\text{T}$ magnetic field?

Answer:

$$V = 22.5904\,\text{kV}. \tag{2}$$

c) Suppose the beam consists of a mixture of ^{12}C and ^{14}C ions. If V and B have the same values as in part (b), calculate the separation of these two isotopes at the detector. Do you think that this beam separation is sufficient for the two ions to be distinguished?

Answer:

$$\Delta R = 4\,\mathrm{cm} \tag{3}$$

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Exercise 0.2: Force on a Semicircular Wire

Figure 2 shows a conducting wire which enters a region of a uniform magnetic field **B** pointing out of the page. In this region the wire takes the form of a semicirle. The direction of the current running trough it is shown by the arrows. Find the net force on the conducting wire.

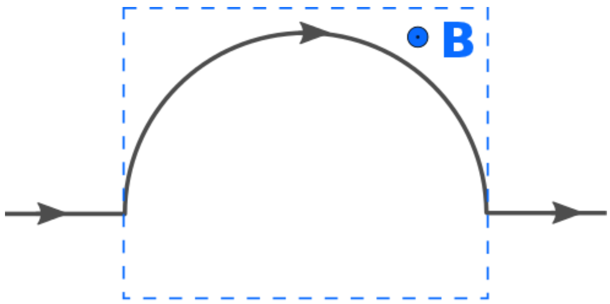

Figure 2

Answer:

$$\mathbf{F} = -2IBR\hat{\mathbf{j}}. \tag{4}$$