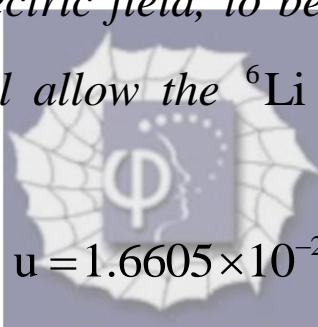


429.

Problem 29.13P (HRW)

An ion source is producing ${}^6\text{Li}$ (mass = 6.0 u), each with a charge of $+e$. The ions are accelerated by a potential difference of 10 kV and pass horizontally in a region in which there is uniform magnetic field of magnitude $B = 1.2$ T. We have to calculate the strength of the smallest electric field, to be set up over the same region, which will allow the ${}^6\text{Li}$ ions to pass through undeflected.


$$1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg.}$$

Solution:

We will first determine the velocity that a ${}^6\text{Li}$ ion have after being accelerated by a 10 kV potential difference. Let us assume that the speed acquired is non-relativistic. That is

$$\frac{v}{c} = 1.$$

Mass of a ${}^6\text{Li}$ ion will be

$$m_{\text{Li}} = 6 \text{ u} = 6 \times 1.6605 \times 10^{-27} \text{ kg} = 9.963 \times 10^{-27} \text{ kg}.$$

Kinetic energy of a ${}^6\text{Li}$ ion of charge $+e$ after falling across a potential difference of 10 kV will be

$$KE_{\text{Li}} = 10^4 \times 1.6 \times 10^{-19} \text{ J} = 1.6 \times 10^{-15} \text{ J}.$$

Velocity of ${}^6\text{Li}$ ion, when it enters the region where uniform electric and magnetic fields perpendicular to the velocity vector of the charged ion and orthogonal to each other, will be

$$v = \sqrt{\frac{2KE_{\text{Li}}}{m_{\text{Li}}}} = \sqrt{\frac{2 \times 1.6 \times 10^{-15}}{9.963 \times 10^{-27}}} \text{ m s}^{-1} = 0.5667 \times 10^6 \text{ m s}^{-1}.$$

For ${}^6\text{Li}$ ions to go through undeflected in the region of uniform electric and magnetic fields the condition to be fulfilled is

$$eE = evB,$$

or

$$E = vB.$$

Magnetic field through which the ${}^6\text{Li}$ ions move is

$$B = 1.2 \text{ T}.$$

Therefore, the electric field has to be

$$E = vB = 0.5667 \times 10^6 \times 1.2 \text{ V m}^{-1} = 680 \text{ kV m}^{-1}.$$

