

A Level Physics A

H556/02 Exploring physics

Question Set 27

1 Fig. 20 illustrates a device used to determine the relative abundance of charged rubidium ions.

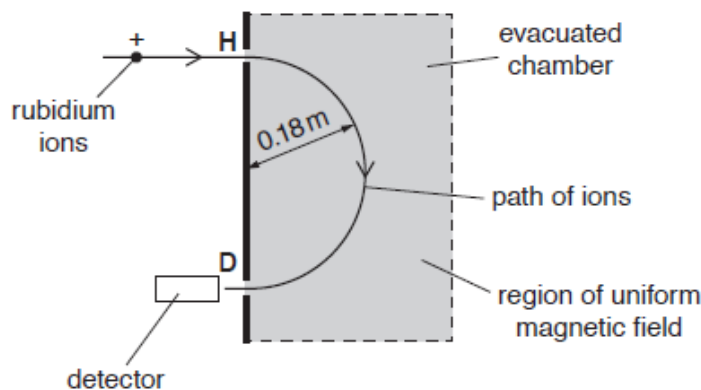


Fig. 20

A uniform magnetic field is applied to an evacuated chamber. The direction of the magnetic field is perpendicular to the plane of the paper.

A beam of positive rubidium ions enters the chamber through a hole at H. The ions travel in a semi-circular path in the magnetic field. The ions are detected at point D.

- (a) Each rubidium ion has charge $+1.6 \times 10^{-19} \text{ C}$ and speed $4.8 \times 10^4 \text{ ms}^{-1}$.
 The radius of the semi-circular path of the ions is 0.18 m.
 The mass of a rubidium ion is $1.4 \times 10^{-25} \text{ kg}$.

Calculate the magnitude of the magnetic flux density B of the magnetic field.

Centripetal force = magnetic force

$$\frac{mv^2}{r} = Bqv$$

$$\frac{mv}{r} = Bq \rightarrow B = \frac{mv}{rq} = \frac{1.4 \times 10^{-25} \times 4.8 \times 10^4}{1.6 \times 10^{-19} \times 0.18} = 0.23 \text{ T}$$

$$B = \dots\dots\dots 0.23 \dots\dots\dots \text{ T [3]}$$

(b)

The chemical composition of ancient rocks found on the Earth can be used to estimate the age of the Earth.

Nuclei of rubidium-87 ($^{87}_{37}\text{Rb}$) decay spontaneously into nuclei of strontium-87 ($^{87}_{38}\text{Sr}$).
 The half-life of rubidium-87 is 49 billion years.

(i) Name the two leptons emitted in the decay of a rubidium-87 nucleus.

1. *electron*
2. *anti-neutrino*

[1]

(ii) The percentage of rubidium **left** in a sample of an ancient rock is 95%.

Estimate the age of the Earth in billion years.

$$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{4.9} = 0.141 \text{ billion yrs}^{-1}$$

$$\frac{N}{N_0} = e^{-\lambda t} \Rightarrow 0.95 = e^{-0.141 t}$$

$$\ln(0.95) = -0.141 t \Rightarrow t = \frac{\ln(0.95)}{-0.141} = 3.63 \text{ billion yrs}$$

age = 3.6 billion years [3]

Total Marks for Question Set 27: 7

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