Oxford Cambridge and RSA

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.

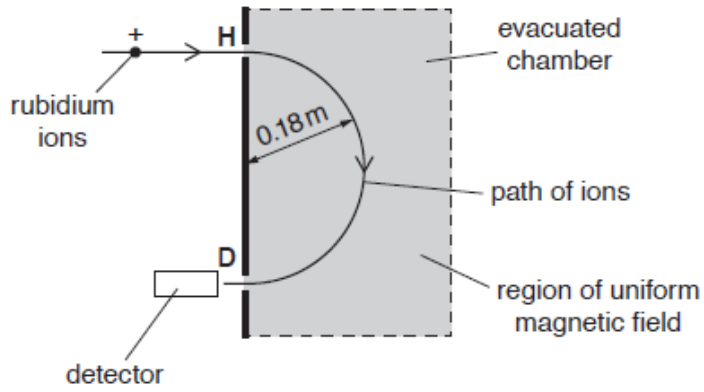

Fig. 20

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 $+1.6 \times 10^{-19}$ C and speed $4.8 \times 10^{4}\,m\,s^{-1}$.
The radius of the semi-circular path of the ions is 0.18 m.
The mass of a rubidium ion is 1.4×10^{-25} kg.

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

Centripetal force = magnetic force

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

$$\frac{mv}{r} = Bq \rightarrow B = \frac{mv}{rq} = \frac{1.4\times10^{-25} \times 4.8\times10^{4}}{1.6\times10^{-19} \times 0.18} = 0.23\ T$$

B = 0.23 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 ($^{87}_{37}Rb$) decay spontaneously into nuclei of strontium-87 ($^{87}_{38}Sr$).
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.

$$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{49} = 0.0141 \text{ billion yrs}^{-1}$$

$$\frac{N}{N_0} = e^{-\lambda t} \Rightarrow 0.95 = e^{-0.0141t}$$

$$\ln(0.95) = -0.0141t \Rightarrow t = \frac{\ln(0.95)}{-0.0141} = 3.63 \text{ billion yrs}$$

age = ... 3.6 ..... billion years **[3]**

Total Marks for Question Set 27: 7