[1]

8 **(a)** In an α-particle scattering experiment, an α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 8.1.

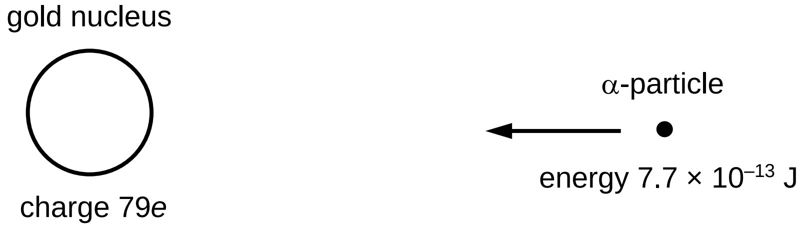

Fig. 8.1

The gold nucleus has a charge 79e. At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(i) The α-particle does not collide with the gold nucleus.

Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m.

[2]

(ii) Fig. 8.2 shows three α-particles, all with the same kinetic energy and travelling in the same initial direction, as they approach a stationary gold nucleus.
The path followed by one of the α-particles is shown.

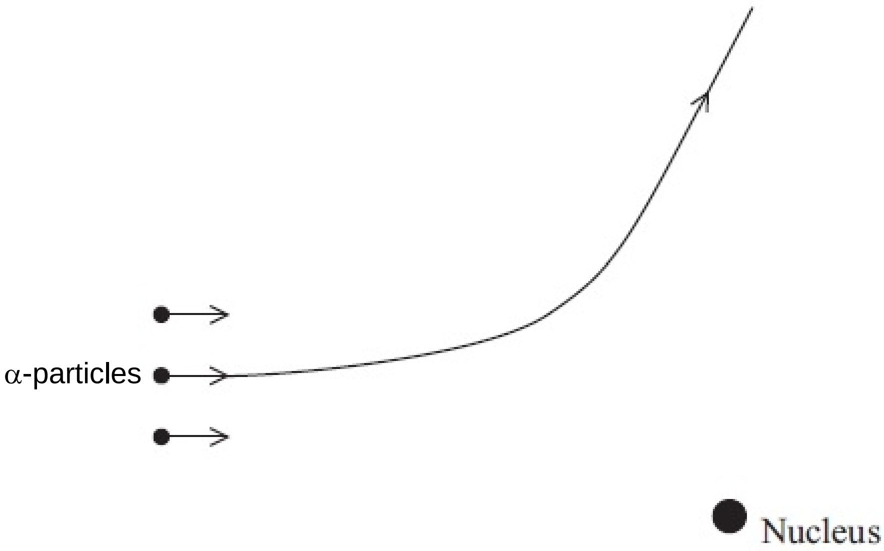

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Fig. 8.2 (not to scale)

On Fig. 8.2, complete the paths of the other two α-particles as they approach and pass by the nucleus. [2]

(b) Some data for nuclei are given in Fig. 8.3.

Particle/ Nuclide	**Name**	**Mass / u**	**Binding energy per nucleon / MeV**
$^{1}_{1}H$	Proton	1.00728	-
$^{1}_{0}n$	Neutron	1.00866	-
$^{4}_{2}He$	Helium		7.07470
$^{14}_{7}N$	Nitrogen		7.47724
$^{17}_{8}O$	Oxygen		7.75224

Fig. 8.3

(i) Explain what is meant by *binding energy per nucleon* for the helium nucleus.

....

....

.... [2]

(ii) Use data from Fig. 8.3 to determine the mass of helium nucleus.

mass = ... u [2]

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(iii) In a particular nuclear reaction, a slow moving alpha particle bombards a stationary nitrogen nucleus ${}^{14}_{7}\mathrm{N}$, transmuting it to an oxygen nucleus ${}^{17}_{8}\mathrm{O}$ and a proton.

The nuclear reaction is shown below.

$${}^{14}_{7}\mathrm{N} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}\mathrm{H}$$

Use data from Fig. 8.3 to determine whether the reaction can occur spontaneously.
Explain your working.

[3]

(c) A radiation detector is placed close to a radioactive source.

The variation with time t of the measured count rate is shown in Fig. 8.4.

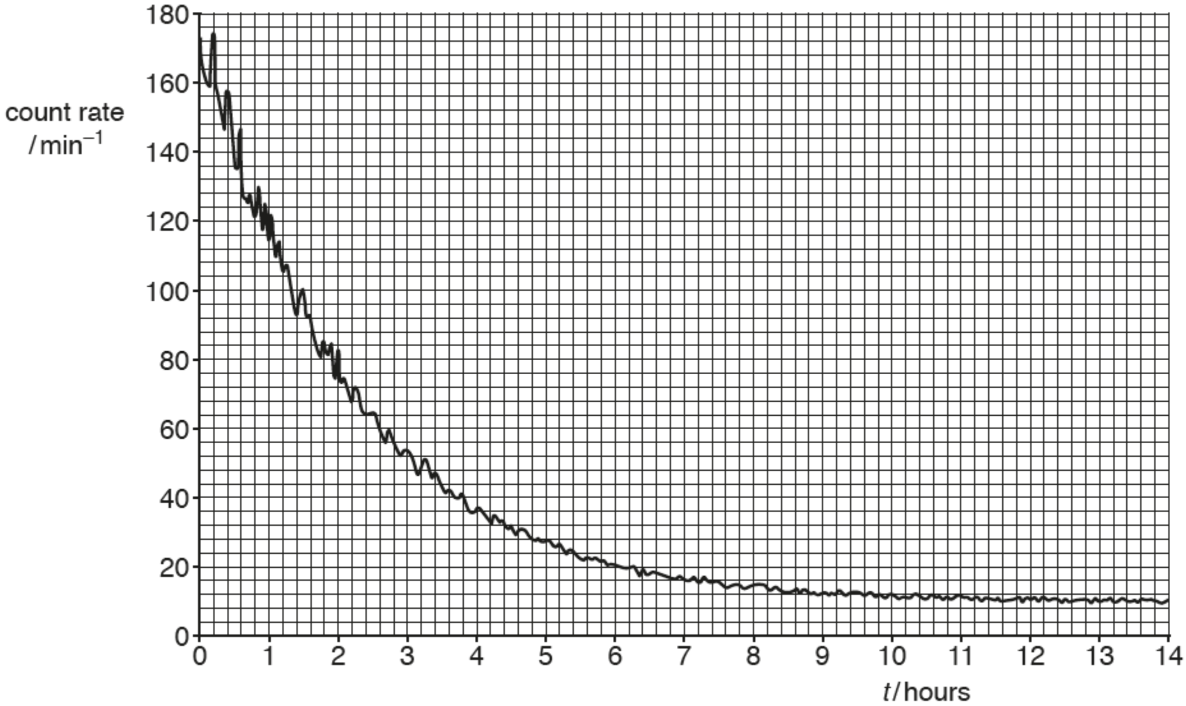

Fig. 8.4

The graph is used to determine the half-life of the radioactive source.

(i) With reference to the graph, explain how we can deal with the problem of the random nature of count rate.

....

.... [1]

(ii) With reference to the graph, explain how we can deal with the problem of background radiation.

....

.... [1]

(iii) Hence use Fig. 8.4 to determine the half-life of the radioactive source.

half-life = ... hours [2]

(iv) The readings in Fig. 8.4 were obtained at room temperature.

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A second sample of this radioactive source is heated to a temperature of 500 °C.
The initial count rate at time $t = 0$ *is* the same as that in Fig. 8.4.
The variation with time t of the measured count rate from the heated source is determined.

State and explain if there are any differences for the 2 samples in

1. the half-life,

....

.... [1]

2. the measured count rate at any time *t.*

....

.... [1]

(d) A small volume of solution containing the radioactive isotope sodium-24 ($^{24}_{11}Na$) has an initial activity of 3.8×10^4 Bq.

Sodium-24 has a half-life of 15 hours and decays to form a stable daughter isotope.

All of the solution is poured into a container of water. After 36 hours, a sample of water of volume 5.0 cm^3, taken from the container, is found to have an activity of 1.2 Bq.

Assuming that the solution of the radioactive isotope is distributed uniformly throughout the container of water, calculate the volume of water in the container initially.

volume = ... cm^3 [3]

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