5 **(a)** Fig. 5.1 shows the path of an alpha particle as it scatters off a gold nucleus from a thin gold foil in the Rutherford's scattering experiment.

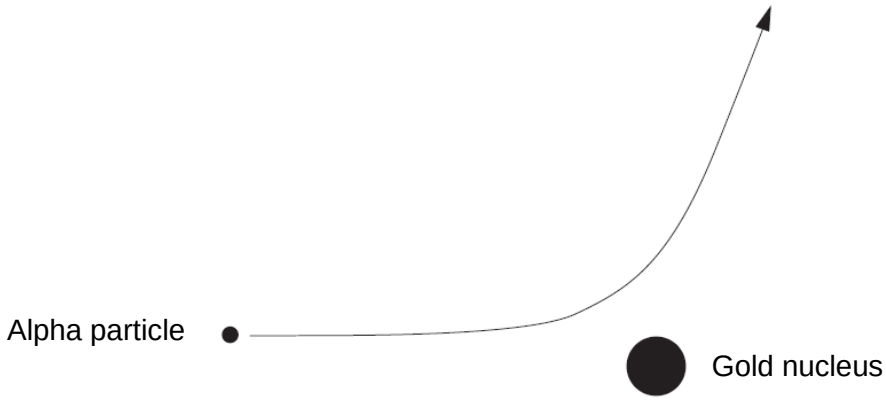

Fig. 5.1

(i) Explain why the alpha particle follows the path as shown in Fig. 5.1.

.....

.....

..... [1]

(ii) On Fig. 5.1, sketch the path of an alpha particle with the same initial path, but less kinetic energy and label it **(ii)**. [1]

(iii) Explain why a thin gold foil is required for this experiment.

.....

.....

..... [1]

(iv) On Fig 5.1, sketch the path of an alpha particle if the gold nucleus is now changed to an iron nucleus and label it **(iv)**.
Atomic number of gold is 79 and atomic number of iron is 26. [1]

(b) In **Fig. 5.2**, an alpha particle on path Q has a head-on collision with a lithium nucleus $^{7}_{3}\text{Li}$.

Fig. 5.2

The energy of alpha particle changes as it moves towards the centre of the nucleus. This alpha particle gets to within a distance of 4.2 x10^{-15} m from the centre of the nucleus.

(i) Show that the *minimum* energy needed by the alpha particle to get to within 4.2×10^{-15} m from the centre of the nucleus is 3.3×10^{-13} J.

[2]

(ii) When the alpha particle gets to within 4.2×10^{-15} m of the centre of the nucleus, the following nuclear reaction takes place.

$$^{4}_{2}\mathrm{He} + {}^{7}_{3}\mathrm{Li} \rightarrow {}^{10}_{5}\mathrm{B} + {}^{1}_{0}\mathrm{n}$$

The masses of the particles involved in the nuclear reaction are as follows:

Particle	mass / u
$^{4}_{2}\mathrm{He}$	4.0015
$^{7}_{3}\mathrm{Li}$	7.0144
$^{10}_{5}\mathrm{B}$	10.0011
$^{1}_{0}\mathrm{n}$	1.0087

Calculate the maximum possible energy of a neutron ejected from the target when the alpha particles in the beam have energy of 3.3×10^{-13} J.

maximum possible energy = ...J [3]

(c) **(i)** Compare the properties of a photoelectron and a β-particle by making reference to their origin.

.....

.....

.....

.....

..... [2]

(ii) Write down the equation which relates the rate of decay – d*N*/d*t* in a sample of *N* radioactive nuclei to their decay constant *λ.*

..... [1]

(iii) State the units of *λ.*

..... [1]

(iv) A certain medical treatment requires a radioactive source with an activity of 2.8×10^3 Bq at the start of the treatment. The nuclide selected has a half-life of 4.2×10^4 s and happens to be prepared 20 hours before the treatment commences. Determine the activity of the source at the time of preparation.

activity of the source = ...Bq [2]

[Total: 15]