9 **(a)** **(i)** Fig. 9.1 shows the path of an alpha particle as it scatters off a gold nucleus in the Rutherford's scattering experiment.

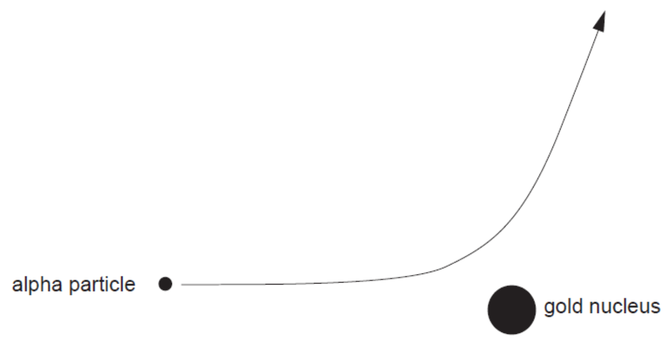

Fig. 9.1

1. Explain why the alpha particle follows the path as shown in Fig. 9.1

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……………………………………………………………………………………………..

…………………………………………………………………………………….....[2]

2. On Fig. 9.1, sketch the path of an alpha particle with the same initial path, but less kinetic energy. [2]

(ii) The alpha particles in this experiment originated from the decay of a radioactive nuclide. Suggest two reasons why beta particles from a radioactive source would be inappropriate for this type of scattering experiment.

....

....

....[2]

(b) (i) In Fig. 9.2, an alpha particle on path **Q** has a head-on collision with a lithium nucleus ${}^{7}_{3}Li$.

Fig. 9.2

This alpha particle gets to within a distance of 4.2 x10^{-15} m from the centre of the nucleus.

1. By discussing the energy changes of the alpha particle as it moves towards the centre of the nucleus, explain why it needs a **minimum** energy to get so close to the centre of the nucleus.

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………………………………………………………………………………………………[2]

2. Show that this minimum energy of the alpha particle 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.

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

Fig. 9.3 gives the masses of the particles involved in the nuclear reaction.

particle	mass / u

${}^{4}_{2}He$	4.0015
${}^{7}_{3}Li$	7.0144
${}^{10}_{5}B$	10.0011
${}^{1}_{0}n$	1.0087

Fig. 9.3

1. Show that there is a decrease of mass of about 1×10^{-29} kg as a result of this reaction.

[2]

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

maximum possible energy = ………………………….J[3]

(c) **(i)** Explain what is meant by the *binding energy* of a nucleus.

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…………………………………………………………………………………………..........[1]

(ii) Fig. 9.4 shows the variation with nucleon number (mass number) *A* of the binding energy per nucleon E_B of nuclei.

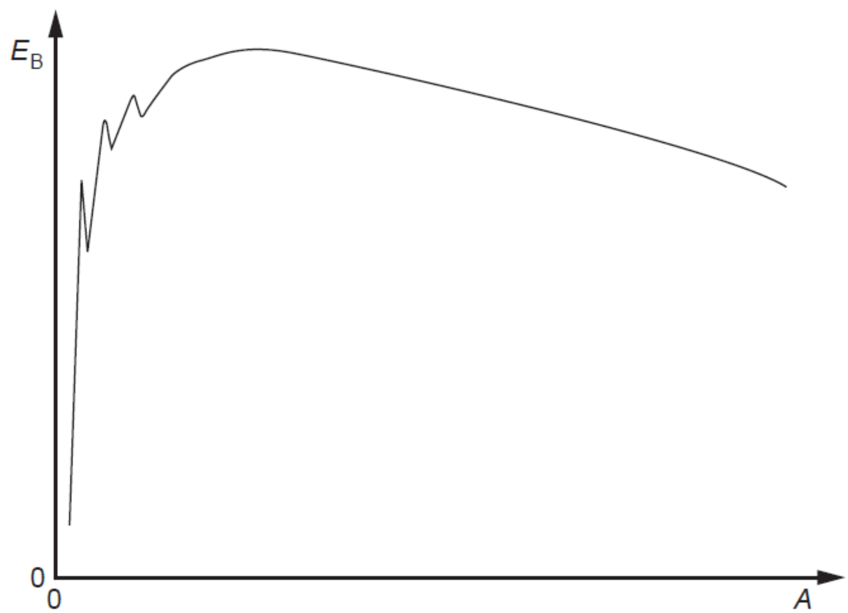

Fig. 9.4

One particular fission reaction may be represented by the nuclear equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n$$

On Fig. 9.4, label the approximate positions of

1. the uranium ($^{235}_{92}U$) nucleus with the symbol U,

2. the barium ($^{141}_{56}Ba$) nucleus with the symbol Ba,

3. the krypton ($^{92}_{36}Kr$) nucleus with the symbol Kr. [2]

(iii) The neutron that is absorbed by the uranium nucleus has very little kinetic energy. Explain why this fission reaction is energetically possible.

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[Total: 20]