9 **(a)** The Rutherford alpha particle scattering experiment involved firing alpha particles at a thin gold foil. The experiment changed the existing model of the atom at that time.

State and explain the evidence from this experiment that changed the model of the atom in terms of its charge distribution and its mass distribution.

charge
distribution

.....

.....

.....

.....

mass distribution

.....

.....

.....

[4]

.....

(b) Plutonium-239 decays by α-emission spontaneously to form the isotope uranium-235. The half-life of plutonium-239 is significantly shorter than the half-life of uranium-235.

(i) Explain what is meant by *spontaneous* decay.

.....

.....

[1]

.....

(ii) Define the term *half-life*.

.....

[1]

.....

(iii) The nuclear decay is given by

$$^{239}_{94}\text{Pu} \rightarrow {}^{235}_{92}\text{U} + {}^{4}_{2}\text{He}\,.$$

Data for the nuclei in the decay are given in Fig. 9.1.

nucleus	mass / u
plutonium $^{239}_{94}$Pu	239.052163
uranium $^{235}_{92}$U	235.043930
helium $^{4}_{2}$He	4.003860

Fig. 9.1

1. Show that the energy released in this decay is 4.08 MeV.

[2]

2. The plutonium-239 nucleus was at rest before the decay.

Calculate the speed of the uranium-235 nucleus.

speed = ... m s^{-1} [3]

(iv) Explain why an alpha radiation source poses little danger to humans unless it is ingested or inhaled.

.....

..... [1]

(c) A sample of pure plutonium-239 has *N* nuclei and an activity of *A* at time *t*. The variation with time *t* of ln *A* is shown in Fig. 9.2.

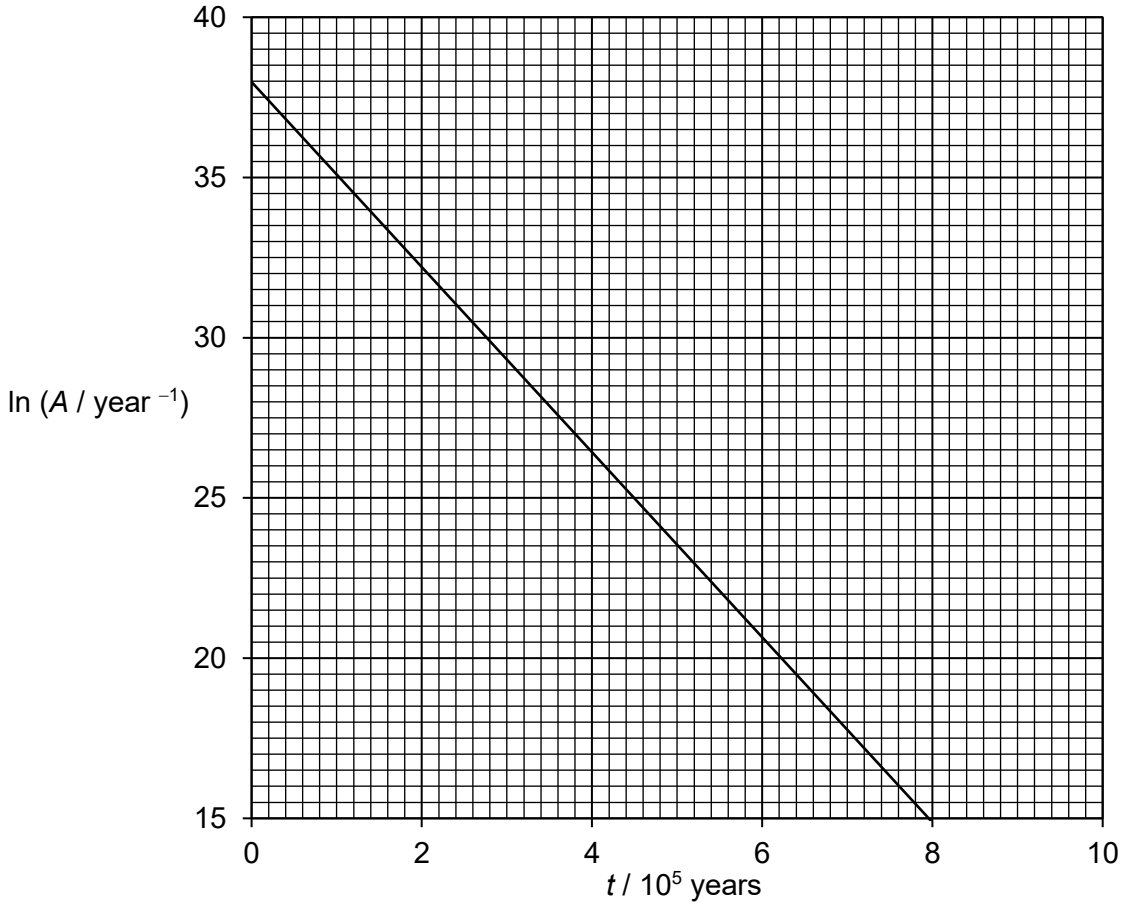

Fig. 9.2

(i) Explain why the activity decreases with time.

.....

.....

..... [1]

(ii) Determine the half-life of plutonium-239.

half-life = ... years [3]

(iii) Determine the initial number N_0 of plutonium-239 nuclei in the sample.

N_0 = ... [2]

(d) The activity of another pure sample of radioactive nuclei X is examined. The half-life of X is 0.5 times the half-life of plutonium-239.

At t = 0, the sample of X has the same number of nuclei N_0 as the sample of plutonium-239 in **(c)**.

On Fig. 9.2, draw the graph to show the variation with time t of ln A for this sample of X.

[2]

[Total: 20]