Q1.(a) Scattering experiments are used to investigate the nuclei of gold atoms.
In one experiment, alpha particles, all of the same energy (monoenergetic), are incident on a foil made from a single isotope of gold.

(i) State the main interaction when an alpha particle is scattered by a gold nucleus.

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(1)

(ii) The gold foil is replaced with another foil of the same size made from a mixture of isotopes of gold. Nothing else in the experiment is changed.

Explain whether or not the scattering distribution of the monoenergetic alpha particles remains the same.

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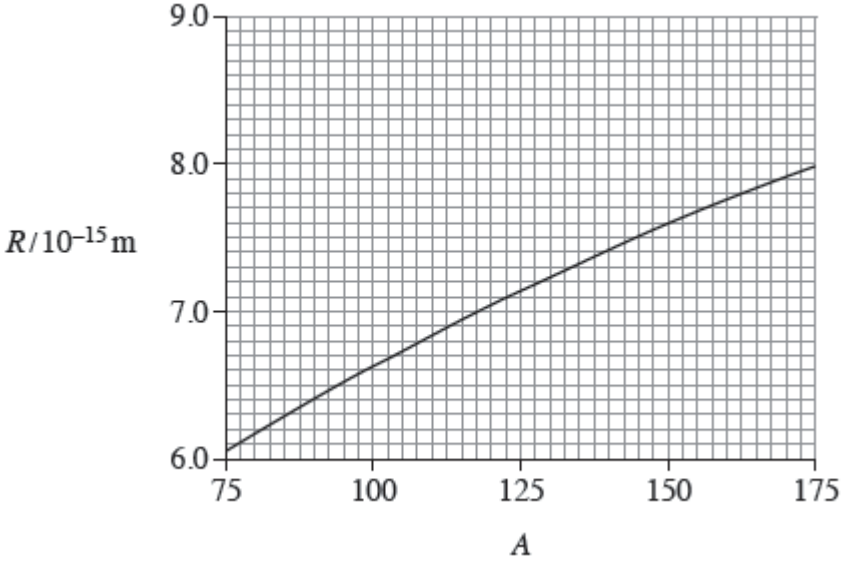
(1)

(b) Data from alpha−particle scattering experiments using elements other than gold allow scientists to relate the radius R, of a nucleus, to its nucleon number, A.
The graph shows the relationship obtained from the data in a graphical form, which obeys

the relationship $R = r_0 A^{\frac{1}{3}}$



(i) Use information from the graph to show that r_0 is about 1.4×10^{-15} m.

(1)

(ii) Show that the radius of a $^{51}_{23}\mathrm{V}$ nucleus is about 5×10^{-15} m.

(2)

(c) Calculate the density of a $^{51}_{23}\mathrm{V}$ nucleus.

State an appropriate unit for your answer.

density ..... unit .....

(3)
(Total 8 marks)

Q2. Which of the following is equal to $\frac{\text{radius of a nucleus of } {}^{125}_{51}\text{Sb}}{\text{radius of a nucleus of } {}^{64}_{30}\text{Zn}}$?

A 1.19

B 1.25 ⬭

C 1.33 ⬭

D 1.40 ⬭

(Total 1 mark)

Q3. The first artificially produced isotope, phosphorus $^{30}_{15}\mathrm{P}$, was formed by bombarding an aluminium isotope, $^{27}_{13}\mathrm{Al}$, with an *α* particle.

(a) Complete the following nuclear equation by identifying the missing particle.

$$^{27}_{13}\mathrm{Al} + \alpha \rightarrow {}^{30}_{15}\mathrm{P} + \ldots\ldots\ldots$$

(1)

(b) For the reaction to take place the α particle must come within a distance, *d*, from the centre of the aluminium nucleus. Calculate *d* if the nuclear reaction occurs when the α particle is given an initial kinetic energy of at least 2.18×10^{-12} J.

The electrostatic potential energy between two point charges Q_1 and Q_2 is equal to $\frac{Q_1 Q_2}{4\pi\varepsilon_0 r}$ where *r* is the separation of the charges and ε_0 is the permittivity of free space.

answer = ...m

(3)
(Total 4 marks)

Q4. (a) Calculate the radius of the $^{238}_{92}$U nucleus.

$r_0 = 1.3 \times 10^{-15}$ m

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(2)

(b) At a distance of 30 mm from a point source of γ rays the corrected count rate is *C*. Calculate the distance from the source at which the corrected count rate is 0.10 *C*, assuming that there is no absorption.

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(2)

(c) The activity of a source of β particles falls to 85% of its initial value in 52 s. Calculate the decay constant of the source.

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(3)

(d) Explain why the isotope of technetium, $^{99}Tc_{m}$, is often chosen as a suitable source of radiation for use in medical diagnosis.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3)
(Total 10 marks)

Q5. The radius of a nucleus, R, is related to its nucleon number, A, by

$R = r_0 A^{1/3}$, where r_0 is a constant.

The table lists values of nuclear radius for various isotopes.

Element	$R/10^{-15}$ m	A	
carbon	2.66	12	
silicon	3.43	28	
iron	4.35	56	

tin	5.49	120	
lead	6.66	208	

(a) Use the data to plot a straight line graph and use it to estimate the value of r_0.

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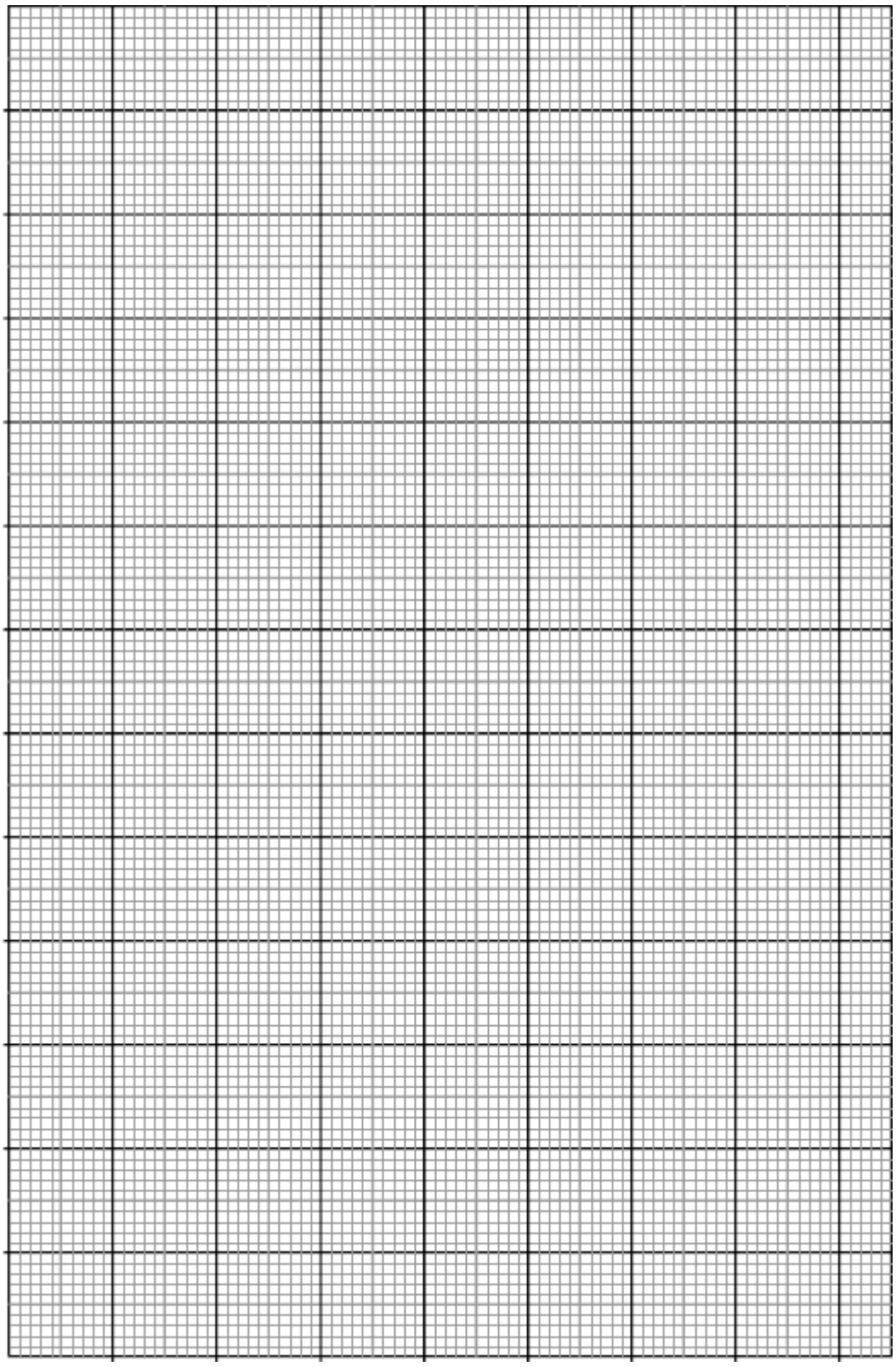

(8)

(b) Assuming that the mass of a nucleon is 1.67×10^{-27} kg, calculate the approximate density of nuclear matter, stating **one** assumption you have made.

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(4)
(Total 12 marks)