

# Nuclear Radius

## Question Paper 1

<b>Level</b>	A LEVEL
<b>Subject</b>	Physics
<b>Exam Board</b>	AQA
<b>Topic</b>	3.8 Nuclear Physics
<b>Sub-Topic</b>	Radioactivity – Nuclear Radius
<b>Booklet</b>	Question Paper 1

**Time Allowed:** 46 minutes

**Score:** / 35

**Percentage:** /100

**Grade Boundaries:**

**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.

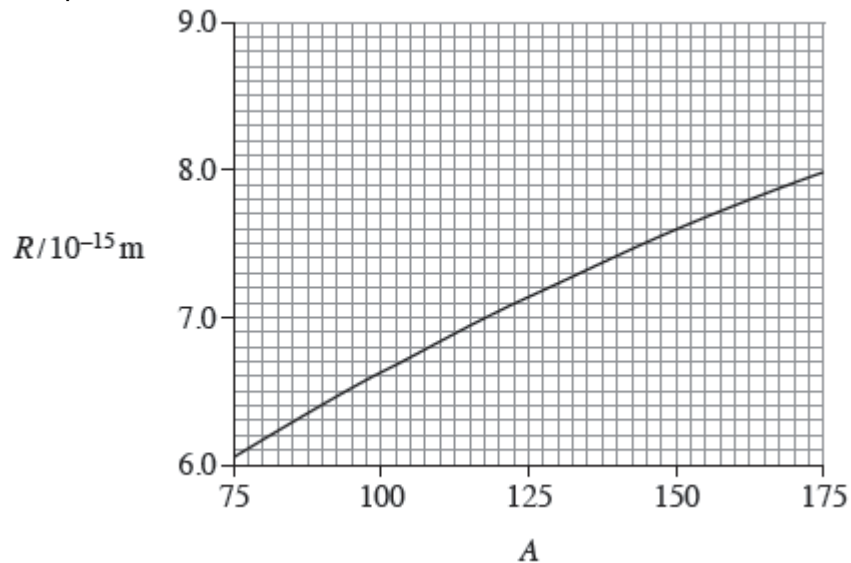
Explain whether or not the scattering distribution of the monoenergetic alpha particles remains the same.

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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  $1.4 \times 10^{-15}$  m.

(1)

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

(2)

(c) Calculate the density of a  $^{51}_{23}\text{V}$  nucleus.  
State an appropriate unit for your answer.

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

(3)  
(Total 8 marks)

Q2. Which of the following is equal to  $\frac{\text{radius of a nucleus of } ^{125}_{51}\text{Sb}}{\text{radius of a nucleus of } ^{64}_{20}\text{Zn}}$  ?

A 1.19

B 1.25

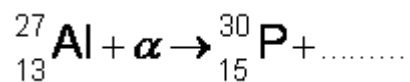
C 1.33

D 1.40

(Total 1 mark)

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

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



(1)

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

The electrostatic potential energy between two point charges  $Q_1$  and  $Q_2$  is equal

to  $\frac{Q_1 Q_2}{4\pi\epsilon_0 r}$  where  $r$  is the separation of the charges and  $\epsilon_0$  is the permittivity of free space.

answer = .....m

(3)  
(Total 4 marks)

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

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

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(2)

(b) At a distance of 30 mm from a point source of  $\gamma$  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  $\beta$  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,  $^{99}\text{Tc}_m$ , 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

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

The table lists values of nuclear radius for various isotopes.

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

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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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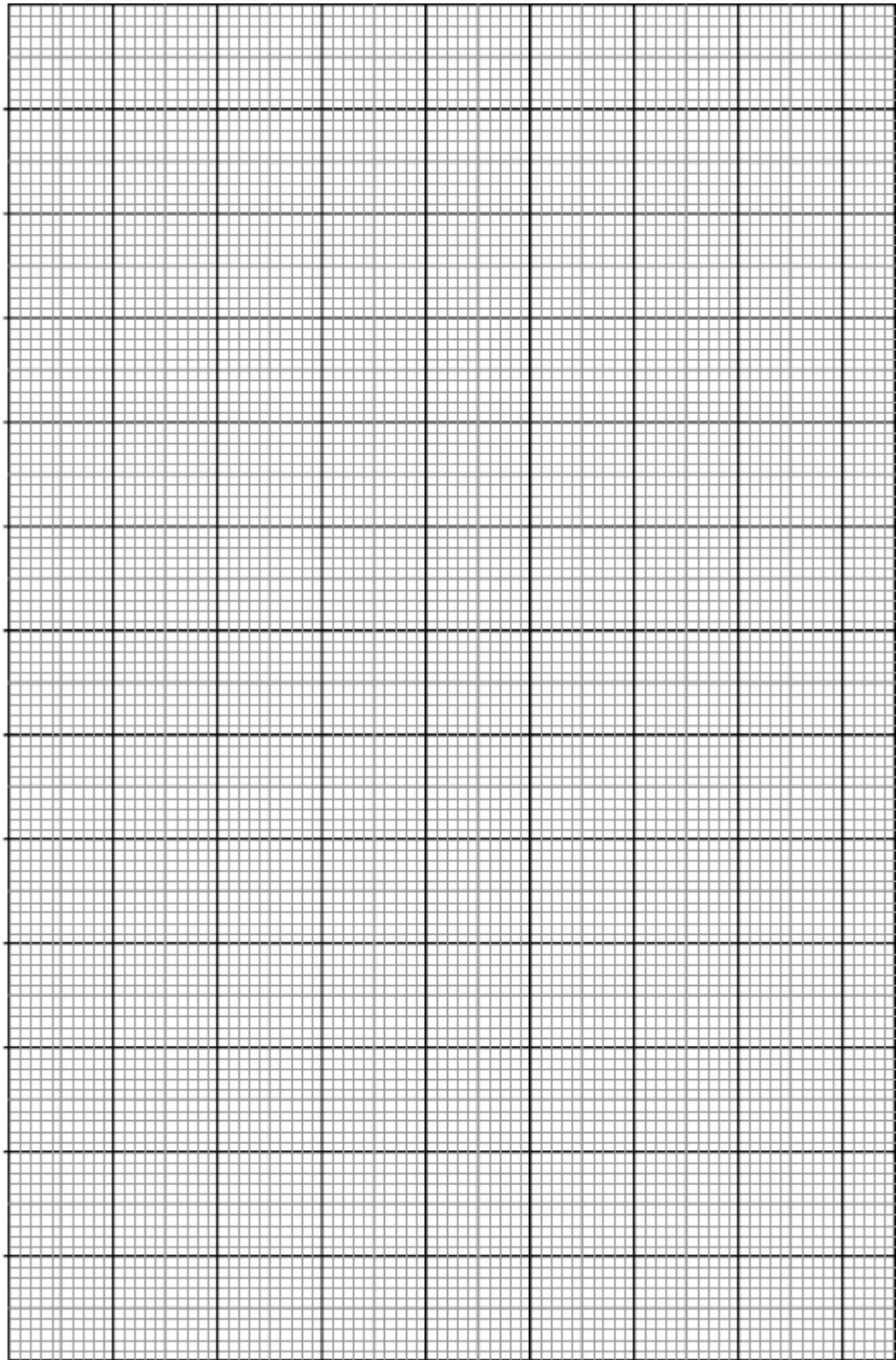
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(8)

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



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(4)  
**(Total 12 marks)**