

Structured Questions

The Nuclear Atom

Alpha Particle Scattering Experiment / Atomic Structure / AZX Notation & Isotopes /
The Strong Nuclear Force / Nuclear Radius & Density

Medium (1 question)	/7
Hard (1 question)	/15
Total Marks	/22

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Medium Questions

1 (a) Describe the nature of the *strong nuclear force*.

[2]

(2 marks)

(b) i) Name a hadron found in the nucleus of an atom and state its quark combination.

name of hadron: quark combination: [1]

ii) Write a decay equation in terms of a quark model for beta-minus decay.

[2]

(3 marks)

(c) The radius of a nucleus is directly proportional to $A^{\frac{1}{3}}$, where A is the nucleon number. The mass of a proton and a neutron are similar. Explain why the mean density of all nuclei is about the same.

[2]

(2 marks)

Hard Questions

- 1 (a)** In the 1800s, the atom was considered to be a fundamental particle. It was an indivisible particle of matter. Modern physics shows that this idea is not correct.

Describe the fundamental particles within an atom of carbon-14 ($^{14}_6\text{C}$).

In your answer state the composition of the hadrons.

[4]

(4 marks)

- (b)** The half-life of the isotope carbon-14 is 5700 years (y).

i) Show that the decay constant λ for this isotope is about $1.2 \times 10^{-4} \text{ y}^{-1}$.

[1]

ii) Carbon-dating is a technique used to date an ancient wooden axe.

The ratio of carbon-14 to carbon-12 in the axe material is 78% of the current ratio of carbon-14 to carbon-12 in a living tree.

Calculate the age in years of the wooden axe.

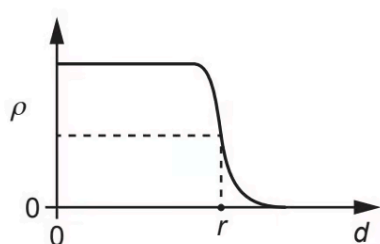
age = y [3]

iii) State **one** assumption made in the calculation in (ii).

[1]

(5 marks)

- (c) A graph of the density ρ of a nucleus against distance d from the centre of the nucleus is shown below.



The radius of the nucleus r is taken as the distance d where the density is half the maximum density.

Fig. 21.1 shows the density ρ variation for three different nuclei and **Table 21.1** shows the nucleon number A of each nucleus.

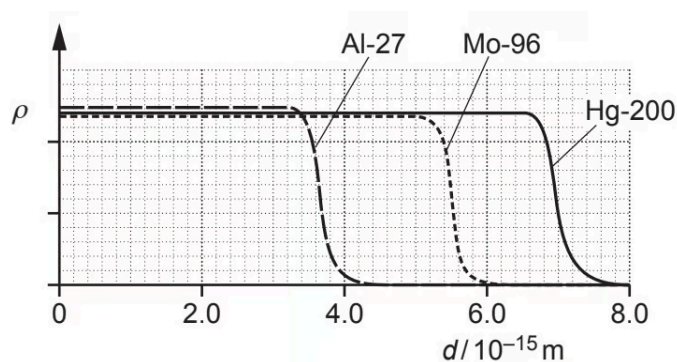


Fig. 21.1

Nucleus	Nucleon number A
Al-27	27
Mo-96	96
Hg-200	200

Table 21.1

Use the information provided opposite to

- describe how the density of a nucleus depends on its nucleon number A
- show numerically that $r \propto A^{\frac{1}{3}}$
- estimate the mean density of the nuclei.

[6]

(6 marks)