24.1 Composition of a nucleus

MCQs

[2015.p1.40] **[Nuclear Physics]**
A nucleus contains 94 protons and 240 nucleons. It emits an alpha–particle.

How many protons and how many neutrons are in the nucleus produced?

	number of protons	number of neutrons
A	90	144
B	90	236
C	92	144
D	92	236

Ans: D

☺ **Teachers' Comments**

In this question, answer **D** was chosen almost as frequently as the correct answer **C**. Perhaps these candidates read the second heading as nucleons rather than reading it correctly as neutrons. Alternatively, these candidates might have simply performed the more usual alpha–decay calculation without noticing what was being requested.

1. A nucleus is represented by the symbol $^{81}_{37}X$.

What does the nucleus contain?

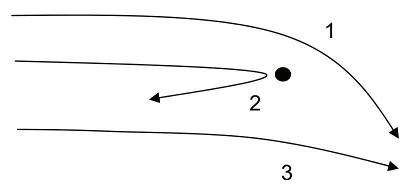
(A) 37 electrons and 44 neutrons

(B) 37 neutrons and 81 protons

(C) 37 protons and 44 neutrons

(D) 37 protons and 81 neutrons

2. Which path or paths are possible for an α –particle moving near a nucleus *N*?



(A) 2 only

(B) 2 & 3 only

(C) 1 & 3 only

(D) 1, 2 & 3

Questions – 24.1

[2015.p2.11] [Nuclear Physics]

(a) A student makes a model of an atom. The model contains 24 electrons, 25 protons and 26 neutrons. Some of these particles are inside a nucleus at the centre of the model.

(i) Determine the nucleon number (mass number) of the atom. **[1]**

(ii) Explain why the model represents a charged atom. **[2]**

(iii) The student makes a new model of a different isotope of the same element.

Describe the nucleus of this new model. **[2]**

(b) Americium–241 is radioactive. Its nuclide notation is $^{241}_{94}\text{Am}$.

(i) Determine the number of neutrons in a nucleus of americium–241. **[1]**

(ii) A nucleus of americium–241 emits an α–particle and decays to uranium–237.

Complete the nuclear equation for the decay of americium–241. **[3]**

(c) Geiger and Marsden studied the structure of gold atoms. Figure 1 below shows a version of their apparatus. Alpha–particles strike a thin gold foil.

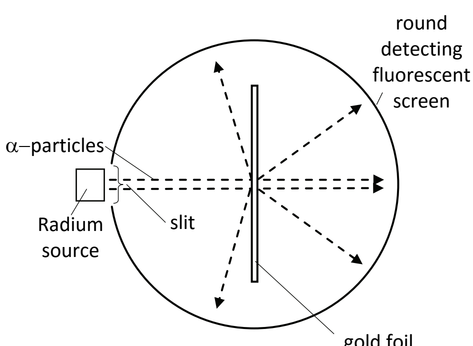


Figure 1

The apparatus shown is in a container from which all the air is removed.

(i) Suggest why it is necessary to remove all the air from the container. **[1]**

(ii) The alpha–particles are emitted from the source at random.

Explain why most of the alpha particles from the source do not reach the gold foil. **[1]**

(iii) Figure 2 shows a model of an atom of the gold foil, with its nucleus at the centre.

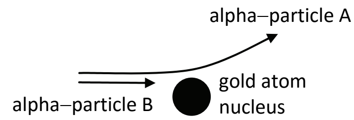


Figure 2 (not to scale)

The alpha–particle labelled A is deflected by the nucleus, as shown.

On Figure 2, complete the path of the alpha–particle labelled B. **[1]**

(iv) Explain how the alpha–particle scattering experiment provides evidence for the existence of a small nucleus inside the atom. **[3]**

Ans: (a) (i) 51 **(b) (i)** 147 (ii) $^{4}_{2}\alpha$, 92

☺ **Teachers' Comments**

(a) The majority of candidates gave the correct answer in **(i)**. The best answers in **(ii)**, as well as stating that neutrons are neutral, suggested that there are an equal number of protons and electrons, with a charge of +1 and –1 respectively, and so the charge cancels. The best answers in **(iii)** gave some suggested values for the number of protons and electrons, although general statements about isotopes were accepted. The most common error was for candidates to include electrons as though they were in the nucleus.

(b) The majority of candidates were successful with both parts of this question.

(c) The best answers in **(i)** included technical details about the alpha particle, such as its small range or that it ionises the air. Candidates should avoid vague answers such as the air interferes with or obstructs the electrons and try to use ideas from the course. In **(ii)**, only a few candidates stated that the emission of particles from the source is in random directions and so few particles will travel towards the slit. Less than half of candidates successfully drew the path of alpha–particle B. Most often the path drawn was less deviated than that of alpha–particle A, even though particle B passes closer to the nucleus and should be deviated more. The most successful answers in **(iv)** suggested that only a few particles are deflected significantly and that as most particles pass straight through the foil, the nucleus must be small. Many candidates explained why the particles are defected by the nucleus, in terms of the charges involved and did not answer the question itself.

☺ **Publisher's Note**

This is definitely *advanced level* syllabus, *i.e.*, the subject matter is only taught at a higher level than the current examination syllabus.

[2014.p2.8] [Nuclear Physics]
A hospital laboratory uses a small sample of a radioactive isotope of iodine, $^{131}_{53}I$.

(a) **(i)** Describe the structure of the nucleus of an atom of this isotope. **[2]**

(ii) The sample is radioactive. Describe what happens in radioactive decay. **[2]**

(b) The count in one minute from the source is measured several times. The table below shows the readings obtained.

2686	2759	2847	2799

(i) Suggest why the readings are different. **[1]**

(ii) The half-life of $^{131}_{53}I$ is 8.0 days. Estimate the count in one minute obtained from the sample after 24 days. **[2]**

Ans: **(a) (i)** 53 protons & 78 neutrons **(b) (ii)** values between 330 and 360

☺ **Teachers' Comments**

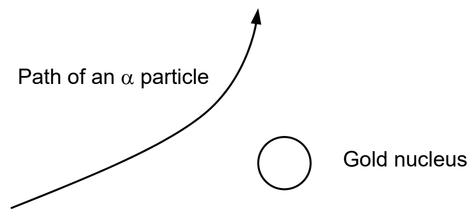
(a) Many candidates gave a correct description of the particles and their numbers within the nucleus. A number of candidates incorrectly stated that there were also 53 electrons in the nucleus. Where it was clear that these electrons were circulating the nucleus there was no penalty. When describing what happens in radioactive decay, many answers defined half-life, which was not required, and did not describe the important properties, such as the emission of alpha, beta and gamma from the nucleus.

(b) The idea of randomness in radioactive decay was not always suggested, and the calculation in **(ii)** was a challenge to many candidates. Candidates needed to calculate an average initial count and then divide it by two for each of the three half-lives. Some candidates attempted to use the exponential function and decay constant. These were almost always unsuccessful because of errors in the mathematics. Marks were available for calculating the average and showing the principle of halving. Many candidates incorrectly halved the nucleon or proton number rather than any value of the count.

1. In Geiger and Marsden's experiment, α -particles were fired at a thin gold foil which contained atoms of the nuclide $^{197}_{79}Au$.

(a) Describe the structure of an atom of this nuclide of gold.

(b) The figure below shows the path of an α -particle near the nucleus of a gold atom.



(i) Explain why the α -particle was deflected as in the figure shown.

(ii) In Geiger and Marsden's experiment, only a few of the α -particles were deflected by more than 90°. Explain what this tells us about the structure of the atom.

2. Compare the relative size of the atom and the atomic nucleus.