

APOLLO

Radioactive decay

HL

Physics

First assessment 2025

9 questions | questions

36. Three products of radioactive decay are:

- I. alpha particles
- II. beta particles
- III. gamma photons.

Which products can be deflected by both magnetic and electric fields?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

37. A nucleus of nuclide X decays.

Which series of emissions will produce an isotope of X?

- A. One α and two β^-
- B. One α and two β^+
- C. Two α and two β^-
- D. Two α and two β^+

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Turn over
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37. Three statements about gamma radiation are:

- I. It travels faster than beta radiation in a vacuum.
- II. It has a greater penetration ability than beta radiation.
- III. It has a greater ionizing ability than beta radiation.

Which statements are correct?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

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2225-0713

- 38.** A pure sample of 4.4 g of Radon-222 has an activity of 2.5×10^{16} Bq.

What is the decay constant of Radon-222?

- A. $2.1 \times 10^{-10} \text{ s}^{-1}$
- B. $8.3 \times 10^{-10} \text{ s}^{-1}$
- C. $2.1 \times 10^{-6} \text{ s}^{-1}$
- D. $8.3 \times 10^{-6} \text{ s}^{-1}$

35. Thorium-232 ($^{232}_{90}\text{Th}$) is an unstable nuclide. It decays by emitting an alpha particle followed by a beta minus (β^-) particle.

What is the number of protons and neutrons in the final nuclide?

	Number of protons	Number of neutrons
A.	87	139
B.	87	141
C.	89	139
D.	89	141

- 36.** A pure sample of radon-222 decays into polonium with a half-life of 4 days. A measurement is made of its radioactivity. The initial count rate is 420 counts per second. The measured background count is 20 counts per second.

What is the measured count rate after 8 days?

- A. 85
- B. 100
- C. 105
- D. 120

37. The table shows how the count rate from a sample of a radioactive nuclide varies with time t . The nuclide has a half-life of 50 s. The average background count rate is constant.

t/s	Count rate/ s^{-1}
0	72
50	40

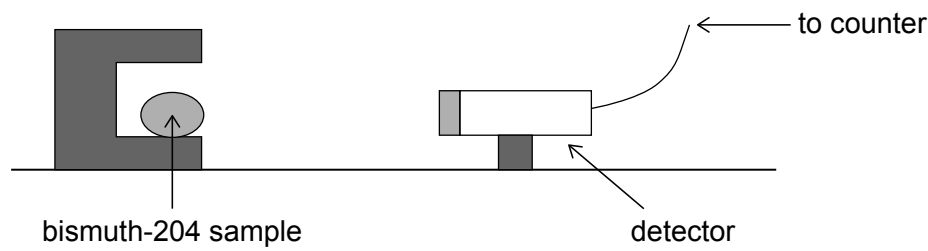
What count rate will the detector measure when $t = 150\text{ s}$?

- A. 8 s^{-1}
- B. 16 s^{-1}
- C. 24 s^{-1}
- D. 32 s^{-1}

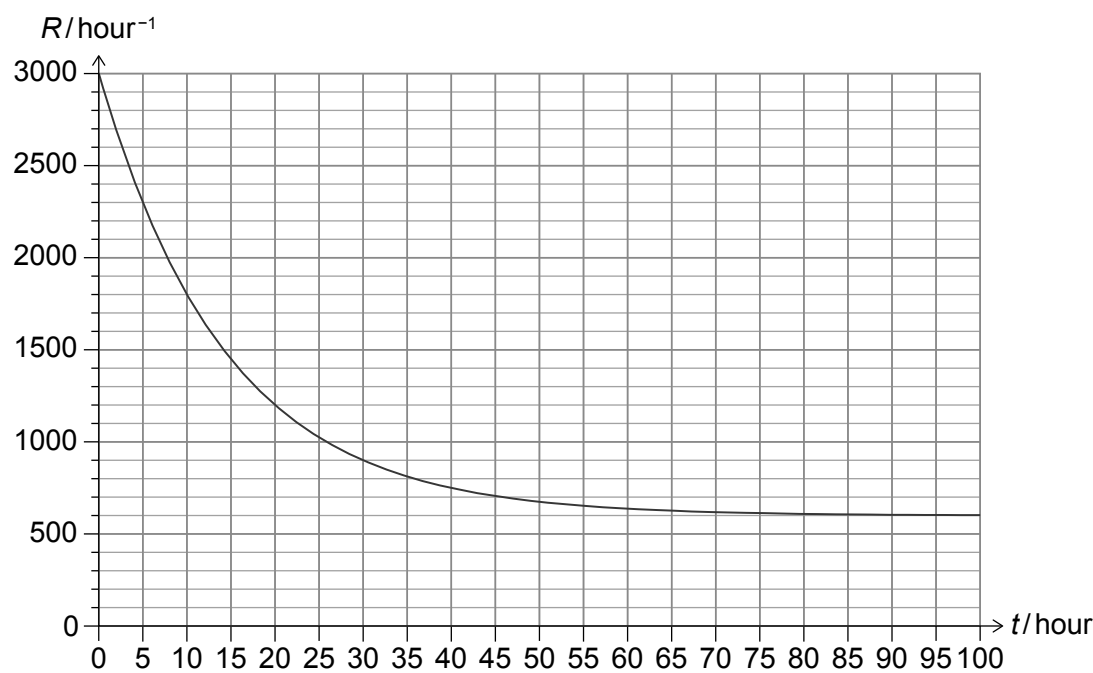
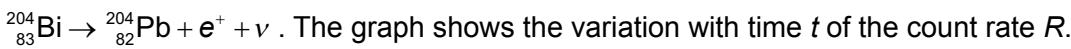
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0025-0107

4. (a) A pure radioactive sample of bismuth-204 ($^{204}_{83}\text{Bi}$) is placed near a detector, which is connected to a counter.



Bismuth-204 decays into lead ($^{204}_{82}\text{Pb}$) by beta-plus decay according to the equation



- (i) State the background count rate. [1]

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(Question 4 continued)

(ii) Estimate the half-life of $^{204}_{83}\text{Bi}$. [3]

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(iii) State and explain how the binding energy per nucleon of $^{204}_{83}\text{Bi}$ compares with that of $^{204}_{82}\text{Pb}$. [2]

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(iv) The distance between the sample and the detector is 20 cm. State why this would be an inappropriate distance for a sample that decayed by alpha decay. [1]

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(b) The following data are available for **nuclear** masses:

bismuth = 203.932254 u
 lead = 203.928034 u

Calculate the energy released in the decay of one nucleus of bismuth-204. [2]

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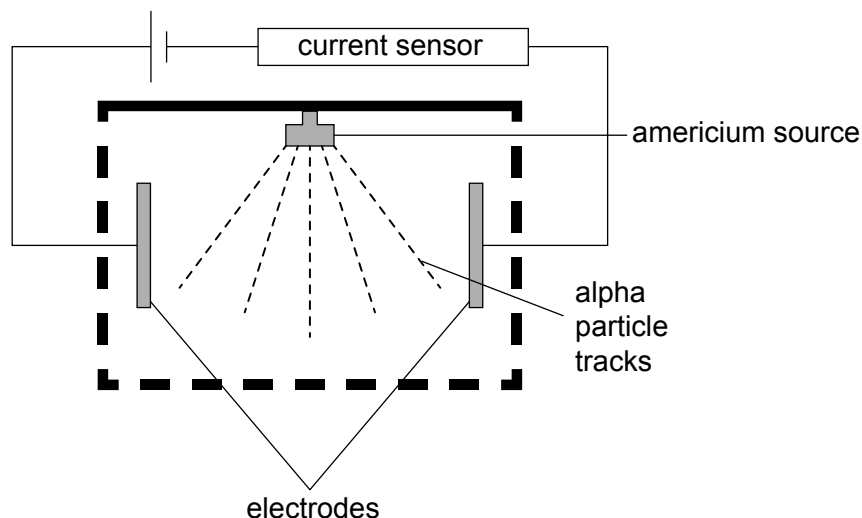
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0020-0121

6. A smoke detector uses the radioactive nuclide americium-241.

The americium is contained in a chamber that is open to the air. There are two electrodes in the chamber that are connected to a power supply and a current sensor.



Americium-241 emits alpha particles that ionize the air in the chamber. Each ionization forms one positive ion and one electron; these are called an ion pair. The electrons and the positive ions move towards the electrodes and the sensor detects a current in the air.

When smoke enters the chamber, fewer ion pairs are formed and the current in the sensor decreases, sounding an alarm.

The decay constant of americium-241 is $5.08 \times 10^{-11} \text{ s}^{-1}$.

The chamber is 0.10 m in each dimension.

- (a) A nucleus of americium-241 has 146 neutrons. This nuclide decays to neptunium through alpha emission.

Complete the nuclear equation for this decay.

[2]



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(Question 6 continued)

(b) Outline why the radioactive source is safe for use in a house. [1]

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(c) Deduce whether the radioactive source will need to be replaced during the life of the detector. [3]

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The initial activity of the source is 42 kBq. 33% of the alpha particles emitted by this source enter the chamber and form an ion pair.
Each alpha particle has an initial kinetic energy of 5.5 MeV.
The energy required to form one ion pair is 15 eV.

(d) Calculate the maximum current in the chamber due to the electrons when there is no smoke in the chamber. [3]

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