Atomic and Nuclear Processes

Question Paper

Level	Pre U
Subject	Physics
Exam Board	Cambridge International Examinations
Topic	Atomic and Nuclear Processes
Booklet	Question Paper

Time Allowed: 33 minutes

**Score:**   /27

Percentage: /100

Grade Boundaries:

1 In an experiment to learn more about the structure of the atom, Geiger and Marsden fired α-particles at a thin sheet of gold foil. They found that most of the α-particles passed through the gold foil with no significant deviation, although a very tiny minority were deflected through large angles, and some were even back-scattered (deflected by more than 90°).

The experiment is repeated with a foil made from a heavier isotope of gold.

How would the results be different?

   A   A much greater proportion of the α-particles would be back-scattered.

   B   A much greater proportion of the α-particles would deflected through a large angle.

   C   A greater proportion of the α-particles would pass through with no significant deviation.

   D   There would be no significant change.

2 A nucleus of radium-226, $^{226}_{88}$Ra, decays by emitting an α-particle.

What is a product of this decay?

   A $^{224}_{84}$Po   B $^{222}_{86}$Rn   C $^{227}_{88}$Ra   D $^{226}_{89}$Ac
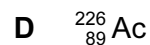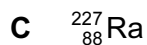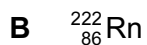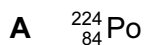
Space for working

3   A radioactive source is placed 5 cm from a Geiger-tube, and various absorbers are placed in between. For each absorber, a one-minute count is taken of the total number of decays, and this is repeated several times.

The table shows the results of the experiment. The background count was 5 Bq.

absorber	average number of decays detected in one minute
none	1043
0.1 mm paper	1038
1 mm aluminium	497
2 cm lead	301

What nuclear radiation does this suggest the source was emitting?

A   alpha and beta only

B   beta only

C   beta and gamma only

D   alpha, beta and gamma

4 Carbon-14 decays by the β⁻ emission.

Which statement about this process is correct?

A   The nucleon number decreases by one.

B   The nucleon number increases by one.

C   The number of neutrons increases by one.

D   The number of neutrons decreases by one.

Space for working

5   A fission reaction is shown.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr +$$
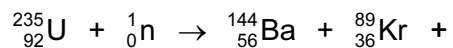
What does X represent?

A ${}^{1}_{0}n$ **B** ${}^{3}_{0}n$ **C** $2{}^{1}_{0}n$ **D** $3{}^{1}_{0}n$

6   Carbon-14 is a naturally occurring radioactive isotope of carbon. The proportion of it in living organisms is constant. Once the organism dies, the activity of the carbon decreases.

An 18 000-year-old sample of carbon is found to have roughly an eighth of the activity of a sample of modern-day carbon of the same mass.

What is the approximate half-life of carbon-14?

A   3000 years   **B**   6000 years   **C**   24 000 years   **D**   48 000 years

7   Nuclei of carbon-14 can be produced when neutrons interact with nuclei of nitrogen-14. The reaction equation is shown.

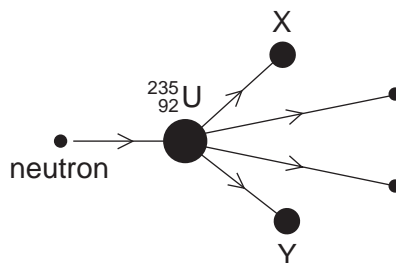$$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C +$$
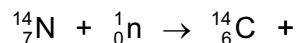
What is particle x?

A   an electron

B   a neutrino

C   a positron

D   a proton

Space for working

8 Which row correctly identifies the nuclear radiation with the greatest penetrating power and the nuclear radiation with the greatest ionising power?

	penetrating power	ionising power
A	α	α
B	α	γ
C	γ	α
D	γ	γ

9 The diagram represents the thermonuclear fission of a $^{235}_{92}U$ nucleus. The uranium nucleus absorbs a neutron and produces the nuclides X and Y and two neutrons.

Which row identifies what X and Y might be?

	X	Y
A	$^{92}_{36}Kr$	$^{141}_{56}Ba$
B	$^{92}_{36}Kr$	$^{142}_{56}Ba$
C	$^{93}_{36}Kr$	$^{142}_{56}Ba$
D	$^{93}_{36}Kr$	$^{143}_{56}Ba$

Space for working

10 A sample of a radioactive isotope with nucleon number 210 decays by alpha emission into a stable isotope with nucleon number 206. The process has a half-life of 140 days.

If all the emitted alpha-particles escape from the sample but none of the daughter product escapes, what will be the percentage fall in the mass of the source after 280 days?

A 0.48%   **B** 1.43%   **C** 25%   **D** 75%

Space for working

11 A stationary nucleus of the radioactive isotope radon-220 emits an alpha-particle.

The speed of the emitted particle is $1.60 \times 10^7 \, \text{m s}^{-1}$.

What is the speed of the daughter nucleus immediately after the decay?

A $3.44 \times 10^{-6} \, \text{m s}^{-1}$

B $1.46 \times 10^5 \, \text{m s}^{-1}$

C $2.96 \times 10^5 \, \text{m s}^{-1}$

D $1.60 \times 10^7 \, \text{m s}^{-1}$

12 An isotope of cobalt-60 is $^{60}_{27}\text{Co}$.

What are the proton and neutron numbers for this isotope?

|	protons	neutrons
A	27	33
B	27	60
C	33	27
D	60	27

13 A radioactive nucleus emits a negative beta-particle. The daughter nucleus formed then decays, emitting an alpha-particle. The daughter nucleus of this decay then emits a negative beta-particle.

How does the final nucleus compare with the original nucleus?

A   It is a nucleus of a different element of higher proton number.

B   It is a nucleus of a different element of lower proton number.

C   It is a nucleus of an isotope of the original element.

D   It is a nucleus identical to the original nucleus.

Space for working

14 A radioactive source emits α, β and γ radiation. It is placed on a laboratory bench with two absorbers about 5 cm away. One of the absorbers is paper of thickness 0.5 mm and the other is aluminium of thickness 0.5 mm.
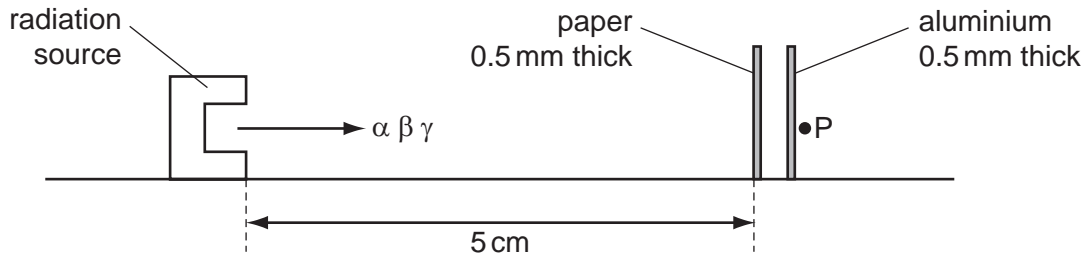
Which radiations will be detected at point P?

A α, β and γ **B** α and γ only   **C** β and γ only   **D** γ only

15 The induced nuclear fission of uranium-235 can create many different pairs of daughter nuclei.

Which nuclear transformation correctly represents such an induced fission?

A $^{235}_{92}U \rightarrow \,^{144}_{56}X + \,^{90}_{36}Y + 3\,^{1}_{0}n$

B $^{235}_{92}U \rightarrow \,^{1}_{0}n \rightarrow \,^{144}_{56}X + \,^{90}_{36}Y + 2\,^{1}_{0}n$

C $^{235}_{92}U + \,^{1}_{0}n \rightarrow \,^{144}_{56}X + \,^{90}_{36}Y + 2\,^{1}_{0}n$

D $^{235}_{92}U \rightarrow \,^{145}_{56}X + \,^{91}_{36}Y$

Space for working

16   Nuclide X is radioactive with a half-life of 300 million years. It decays to form the stable nuclide Y.

A sample of rock is thought to have contained none of nuclide Y when it was formed, but now contains 15 atoms of Y to every atom of X.

How old are the rocks in this sample?

A   much less than 300 million years

B   1200 million years

C   2400 million years

D   4500 million years

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If the experiment is repeated with a foil of a heavier isotope of gold, how would the results be different?

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18   A nucleus of radium-226, $^{226}_{88}$Ra, decays by emitting an α-particle.

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19   In a thermal reactor, induced fission occurs when a uranium-235 nucleus absorbs a neutron, splits and produces energy and more neutrons.

Which statement is correct?

A   Control rods are used to slow down the neutrons.

B   Slow neutrons are more likely to be absorbed by a uranium-235 nucleus than fast ones.

C   The moderator is used to moderate the power output.

D   To sustain the nuclear reaction a large number of neutrons is required per fission.

20   A radioactive source consists of a mixture of two isotopes P and Q.

P has a half-life of 60 minutes and Q has a half-life of 30 minutes. The initial activity recorded by a suitable counter is $800\,\text{min}^{-1}$. After 120 minutes the counter registers an activity of $80\,\text{min}^{-1}$.

What was the initial contribution of P to the count rate?

A $160\,\text{min}^{-1}$ **B** $240\,\text{min}^{-1}$ **C** $270\,\text{min}^{-1}$ **D** $480\,\text{min}^{-1}$

Space for working

21 When Rutherford fired α-particles at thin gold foil the results of his experiment helped us to understand more about the structure of the atom.

Which conclusion was drawn from the results?

A   Neutrons and protons are significantly more massive than electrons.

B   The atom contains a small positively charged nucleus.

C   The atom contains the same number of electrons and protons.

D   The nucleus contains protons and neutrons.

22    $^{232}_{90}$Th decays via a series of α, β¯ and γ decays to the stable isotope $^{208}_{82}$Pb .

Which row describes what can be deduced about the numbers of each decay type?

	number of α decays	number of β¯ decays	number of γ decays
A	6	4	cannot tell
B	6	cannot tell	4
C	cannot tell	6	6
D	cannot tell	cannot tell	cannot tell

Space for working

23   The activity of a radioactive source falls to $\frac{1}{16}$ of its original value in 32 minutes.

What is the half-life of the decay process?

A   2 minutes   **B**   4 minutes   **C**   8 minutes   **D**   16 minutes

24   Hydrogen bombs operate with tritium, a radioactive isotope of hydrogen with a half-life of 1.7×10^8 s.

It has been proposed that if the production of tritium were halted, countries storing hydrogen bombs would have to replenish supplies from existing bombs. Eventually there would not be enough tritium to make any bombs.

A country has a stockpile of 2000 hydrogen bombs.

After how many years would it be unable to make a single bomb?

A   54 years

**B**   59 years

C   10 800 years

D 1.7×10^9 years

25   In an alpha-particle scattering experiment, which factors could be increased so as to increase the number of alpha-particles scattered through large angles by a thin metal foil?

1   alpha-particle energy

2   thickness of foil

3   the atomic number of the metal of the foil

A   1 and 2   **B**   1 and 3   **C**   2 only   **D**   2 and 3

Space for working

26 From which nuclide is $^{216}_{84}Po$ the product of an alpha-particle emission?

A $^{214}_{80}Hg$ **B** $^{212}_{82}Pb$ **C** $^{220}_{86}Rn$ **D** $^{218}_{88}Ra$
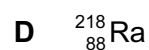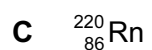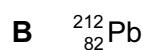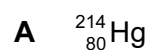
27 Which statement about radioactive nuclides is correct?

A The half-life is proportional to the probability of decay per unit time of each nucleus.

B The higher the temperature, the larger the probability of decay per unit time of each nucleus.

C The probability of decay per unit time of each nucleus decreases with time.

D The smaller the probability of decay per unit time, the longer the half-life.