

Radioactivity

Question Paper

Level	O Level
Subject	Physics
Exam Board	Cambridge International Examinations
Unit	Atomic Physics
Topic	Radioactivity
Booklet	Question Paper

Time Allowed: 77 minutes

Score: /64

Percentage: /100

Grade Boundaries:

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- 1 Which type of radiation consists of electrons?
- A alpha-particles
 - B beta-particles
 - C gamma-rays
 - D X-rays
- 2 A sample of a radioactive isotope produces a count rate of 10 000 counts per minute. The half-life of the isotope is one day.
- What was the count rate of the sample two days ago?
- A 2500 counts per minute
 - B 5000 counts per minute
 - C 20 000 counts per minute
 - D 40 000 counts per minute
- 3 Which nucleus is produced when americium-241 (${}^{241}_{95}\text{Am}$) emits an alpha-particle?
- A ${}^{237}_{93}\text{Np}$
 - B ${}^{237}_{97}\text{Bk}$
 - C ${}^{245}_{93}\text{Np}$
 - D ${}^{245}_{97}\text{Bk}$
- 4 Which states the three types of radiation emitted by radioactive isotopes in order of their ionising effect from highest to lowest?
- A alpha-particles, beta-particles, gamma-rays
 - B alpha-particles, gamma-rays, beta-particles
 - C beta-particles, gamma-rays, alpha-particles
 - D gamma-rays, beta-particles, alpha-particles
- 5 Which statement about the half-life of a radioactive isotope is correct?
- A Half-life changes as the isotope decays.
 - B Half-life is the time it takes for the nucleon number of the isotope to halve.
 - C Half-life is half the time it takes for the number of nuclei of the isotope to decrease to zero.
 - D Half-life is the time it takes for the number of nuclei of the isotope to decrease by half.

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- 6 A factory continuously produces plastic sheets. A radioactive isotope and a detector are used to check the thickness of the sheets.

What is the most suitable source to use?

- A an alpha source with a half-life of a few minutes
- B an alpha source with a half-life of several years
- C a beta source with a half-life of a few minutes
- D a beta source with a half-life of several years

- 7 A source contains a radioactive material.

Without the radioactive source present, a detector records a background count rate of 20 counts per minute.

This source is placed in a fixed position near the detector. Initially a count rate of 520 per minute is recorded.

What count rate is recorded after a time of **two** half-lives of the radioactive source?

- A 125 counts per minute
- B 130 counts per minute
- C 135 counts per minute
- D 145 counts per minute

- 8 A nucleus of ${}_{84}^{215}\text{Po}$ decays by emitting an alpha-particle and the resulting nucleus then decays by emitting a beta-particle.

What is the nucleon number and proton number of the final nucleus?

	nucleon number	proton number
A	211	81
B	211	83
C	212	81
D	212	83

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- 9 The half-life of a radioactive isotope is 24 hours. A sample of this isotope produces an initial count rate of 720 counts per second.

How long does it take for the count rate to fall to 90 counts per second?

- A 3 hours
- B 72 hours
- C 96 hours
- D 192 hours

- 10 Which type of electromagnetic radiation is produced during radioactive decay?

- A alpha-particles
- B beta-particles
- C gamma-rays
- D X-rays

- 11 In the Geiger-Marsden experiment, a beam of alpha-particles is fired at a very thin sheet of gold foil, in a vacuum.

What is deduced from this experiment?

- A Alpha-particles are repelled by electrons.
- B Atoms contain air.
- C Electrons are found in atomic nuclei.
- D Nuclei are much smaller than atoms.

- 12 A radioactive isotope ^{14}C emits beta-particles.

A sample of this isotope is left for a period of time that is equal to its half-life.

Which two quantities decrease to **half** of their initial value during this time?

- A the decay rate and the number of protons
- B the mass of the sample and the number of ^{14}C nuclei
- C the number of ^{14}C nuclei and the decay rate
- D the number of protons and the mass of the sample

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- 13 Which row gives the range and electrical charge of an alpha-particle?

	range in air	electrical charge
A	a few centimetres	negative
B	a few centimetres	positive
C	a few metres	negative
D	a few metres	positive

- 14 Which row states the nature and range of beta-particles in air?

	nature	range in air
A	electromagnetic radiation	1-10 cm
B	electromagnetic radiation	10-100 cm
C	electron	1-10 cm
D	electron	10-100 cm

- 15 Three types of radiation emitted by unstable nuclei are electrons, helium nuclei and electromagnetic radiation.

What are these types of radiation?

	electrons	helium nuclei	electromagnetic radiation
A	alpha	beta	gamma
B	alpha	gamma	beta
C	beta	alpha	gamma
D	beta	gamma	alpha

- 16 A sample of wood contains 9.0×10^{16} nuclei of carbon-14. The nuclei undergo radioactive decay with a half-life of 5600 years.

How many carbon-14 nuclei remain in this sample after 16800 years?

- A** 1.1×10^2 **B** 1.1×10^{16} **C** 3.0×10^{16} **D** 4.5×10^{16}

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- 17 People working with radioactive materials use a photographic film badge covered in paper. The badge is used to monitor the level of their exposure to radiation.

Which radiation is detected?

- A alpha-particles only
- B beta-particles only
- C gamma-rays and beta-particles
- D gamma-rays only

- 18 When a radioactive atom decays by alpha-particle emission, its nucleus loses

- A 1 proton only.
- B 1 proton and 1 electron.
- C 2 protons and 2 electrons.
- D 2 protons and 2 neutrons.

- 19 A school keeps radioactive sources for use in radioactivity experiments in a laboratory.

The background radiation is measured at the start of an experiment.

Which statement is correct?

- A The background radiation is caused by the school's radioactive sources in the laboratory.
- B The background radiation is present when there are no radioactive sources in the laboratory.
- C The background radiation is radiation that is not detected in radioactivity experiments.
- D The background radiation is the same in laboratories in different countries.

- 20 The count rate from a radioactive source falls from 4000 counts per minute to 500 counts per minute in 72 minutes.

What is the half-life of the source?

- A 8 minutes
- B 9 minutes
- C 18 minutes
- D 24 minutes

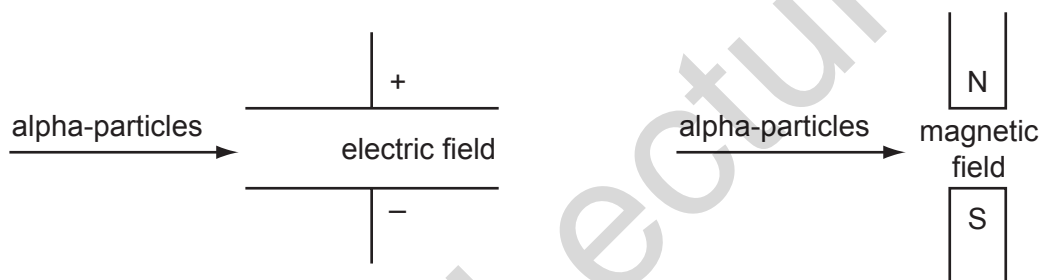
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21 What are the characteristics of an alpha-particle?

	charge	ionising effect
A	negative	strong
B	negative	weak
C	positive	strong
D	positive	weak

22 Alpha-particles pass through an electric field or a magnetic field.



How is the path of the particles affected by these fields?

	electric field	magnetic field
A	deflected	deflected
B	deflected	undeflected
C	undeflected	deflected
D	undeflected	undeflected

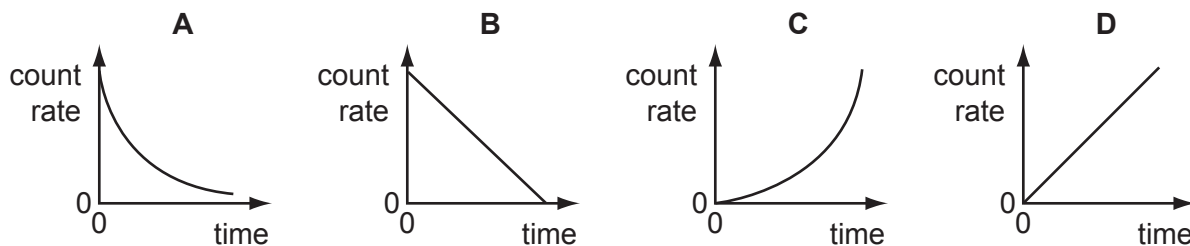
23 Which row is correct for nuclear fission and for nuclear fusion?

	fission	fusion
A	produces larger nuclei	is the energy source of a star
B	produces larger nuclei	releases energy in a power station
C	produces smaller nuclei	is the energy source of a star
D	produces smaller nuclei	releases energy in a power station

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24 Which graph shows how the count rate of a radioactive isotope varies with time?



25 For which purpose is the radioactive isotope carbon-14 used?

- A dating of ancient bones
- B fuel for a nuclear power station
- C killing cancerous cells
- D operating mobile telephones

26 When dealing with radioactive materials there are possible dangers.

Which statement is correct?

- A Beta-particles can pass through skin and damage body cells.
- B Materials that emit only alpha-particles must be kept in thick lead containers.
- C Radioactive materials are safe to handle after two half-lives.
- D Sources of gamma radiation are dangerous because they have long half-lives.

27 An isotope X is radioactive and has a half-life of 4 years. A sample initially contains 8000 atoms of X.

After how many years will the sample contain 1000 atoms of X?

- A 4 B 8 C 12 D 16

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28 What is the safest way to dispose of a large quantity of highly radioactive waste?

- A burning it on a fire
- B burying it in dry rock deep underground
- C pouring it down the drain
- D pumping it into a river

29 The count rate from a radioactive material falls from 400 counts per second to 50 counts per second in 12 minutes.

What is its half-life?

- A 8 minutes
- B 6 minutes
- C 4 minutes
- D 3 minutes

30 In nuclear1....., hydrogen nuclei2..... to form helium nuclei, releasing energy.

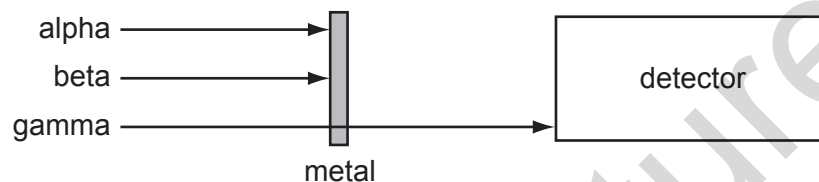
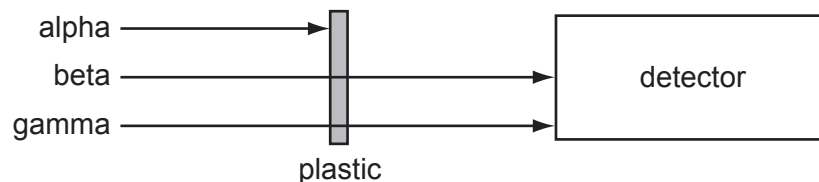
Which words correctly complete gaps 1 and 2?

	1	2
A	fission	join together
B	fission	split apart
C	fusion	join together
D	fusion	split apart

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- 31 The diagram shows the radioactive emissions that pass through a piece of plastic and a piece of metal of the same thickness.



Which types of radioactive emission can distinguish between the plastic and the metal?

- A alpha, beta and gamma
 - B alpha only
 - C beta only
 - D gamma only
- 32 The background count rate in a laboratory is 10 counts/min.
- The measured count rate from a radioactive source is 410 counts/min, which includes the background.
- The half-life of the source is 5 days.
- What is the measured count rate after 15 days?
- A 10 counts/min
 - B 50 counts/min
 - C 60 counts/min
 - D 110 counts/min

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33 Tritium is a radioactive isotope of hydrogen with a half-life of 12 years.

If a sample starts with 40 million atoms of tritium, how many atoms of tritium will be left after 12 years?

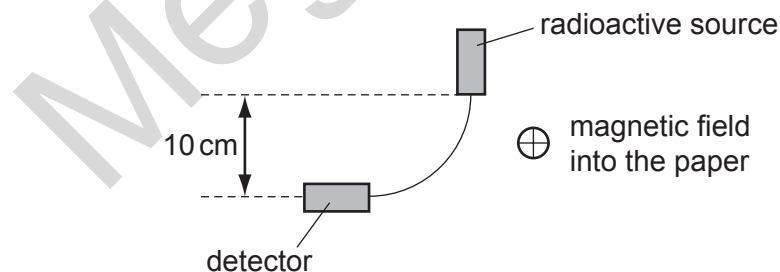
- A 40 million
- B 20 million
- C 10 million
- D 5 million

34 The isotope barium-140 has a half-life of 13 days. A sample of this isotope is kept for 13 days.

Which quantity halves during this time?

- A the number of atoms of barium-140 in the sample
- B the number of electrons in an atom of barium-140
- C the number of nucleons in an atom of barium-140
- D the number of protons in a nucleus of barium-140

35 In a laboratory experiment, particles from a radioactive source are deviated by a magnetic field and reach a detector.



Which particles are deviated and reach the detector?

- A alpha-particles and gamma-rays
- B alpha-particles only
- C beta-particles and gamma-rays
- D beta-particles only

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36 The isotope barium-140 has a half-life of 13 days. A sample of this isotope is kept for 13 days.

Which quantity halves during this time?

- A the number of atoms of barium-140 in the sample
- B the number of electrons in an atom of barium-140
- C the number of nucleons in an atom of barium-140
- D the number of protons in a nucleus of barium-140

37 When a sample of a radioactive nuclide decays, the count rate falls from 1200 to 150 in three minutes.

What is the half-life of the radioactive nuclide?

- A 0.75 minutes
- B 1.0 minutes
- C 3.0 minutes
- D 9.0 minutes

38 The table shows details of two samples of radioactive nuclides X and Y.

nuclide	number of radioactive atoms at time = 0	half-life
X	16 000	1 day
Y	2 000	2 days

After how many days will the number of atoms of nuclide X be equal to the number of atoms of nuclide Y?

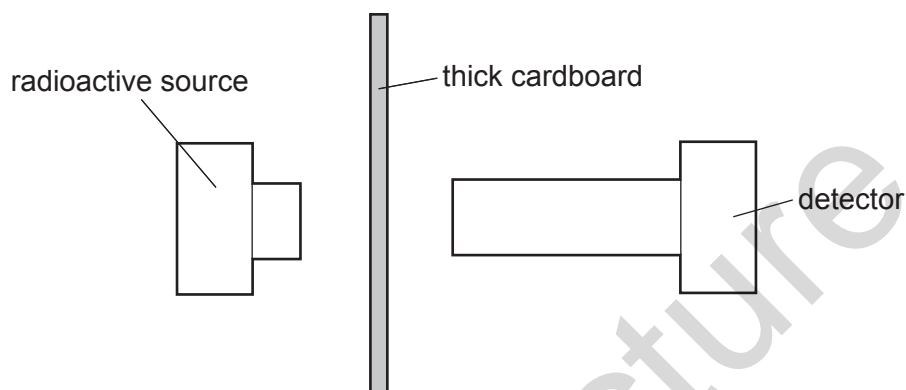
- A 2 days
- B 4 days
- C 6 days
- D 8 days

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- 39** A student investigates a radioactive source that emits only alpha-particles. Without any source nearby, the detector shows a low reading.

The source and thick cardboard are placed near the detector, as shown.



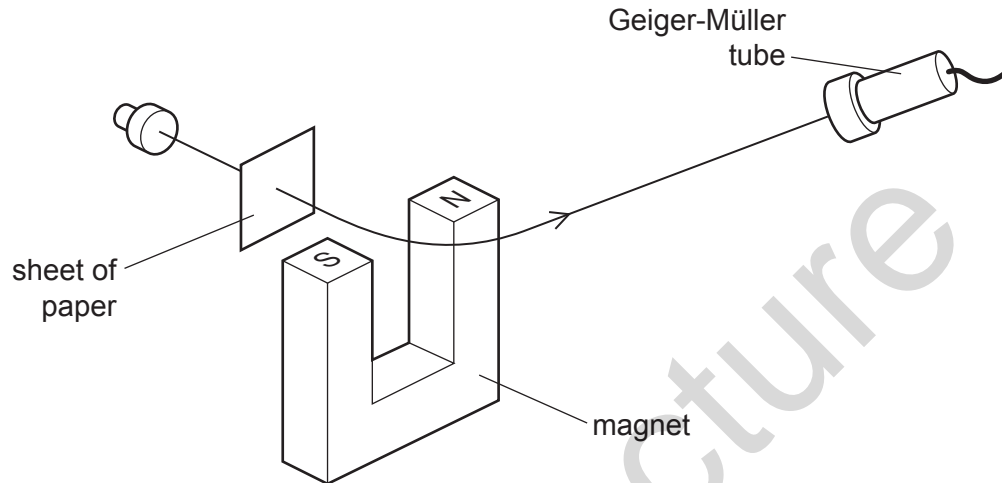
What is the reading on the detector now, and why?

	detector reading	reason
A	low	background radiation is detected
B	low	some alpha-particles pass through cardboard
C	zero	alpha-particles are all absorbed by the cardboard
D	zero	background radiation is all absorbed by the cardboard

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- 40 A radioactive source emits alpha-particles, beta-particles and gamma-rays. A Geiger-Müller tube and counter detect the emissions, which pass through a thin sheet of paper and a strong magnetic field.



What is detected by the Geiger-Müller tube?

- A alpha-particles and beta-particles
 - B alpha-particles only
 - C beta-particles and gamma-rays
 - D beta-particles only
- 41 The count-rate from a radioactive source falls from 400 to 50 in 3.0 minutes.

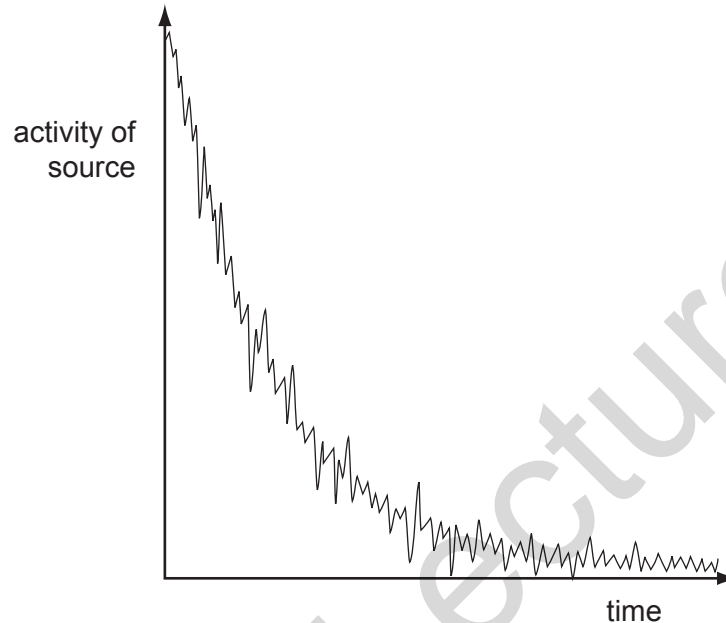
What is the half-life?

- A 0.75 minutes
- B 1.0 minutes
- C 2.7 minutes
- D 8.0 minutes

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- 42 The activity of a radioactive source is measured over a period of time. The graph shows the decay curve.



Why is the curve **not** smooth?

- A Background radiation has not been subtracted.
 - B Radioactive decay is a random process.
 - C The half-life is not constant.
 - D The temperature is changing.
- 43 A radioactive isotope has a half-life of 6000 years.
- How much time passes before the rate of emission from a sample of this isotope falls to $\frac{1}{16}$ of its original value?
- A 6000 years
 - B 18 000 yea
 - C 24 000 yea
 - D 96 000 yea

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44 Which travels in a straight line across a magnetic field?

- A alpha-particle
- B electron
- C gamma-ray
- D proton

45 In the treatment of brain cancer, a patient's head is enclosed in a helmet containing a number of radioactive sources. The radiation from each source is directed towards the cancer.

Which nuclide is the most suitable for these sources?

	nuclide	radiation	half-life
A	caesium-137	gamma	30 years
B	sodium-24	beta	15 hours
C	strontium-90	beta	29 years
D	californium-246	alpha	36 hours

46 What occurs in the decay of a radioactive nucleus?

- A The nucleus absorbs another nucleus.
- B The nucleus absorbs at least one form of radiation.
- C The nucleus always splits into two equal fragments.
- D The nucleus emits at least one form of radiation.

47 The radioactive nucleus $^{87}_{37}\text{Rb}$ decays with the emission of a beta-particle.

How many protons and neutrons are left in the nucleus?

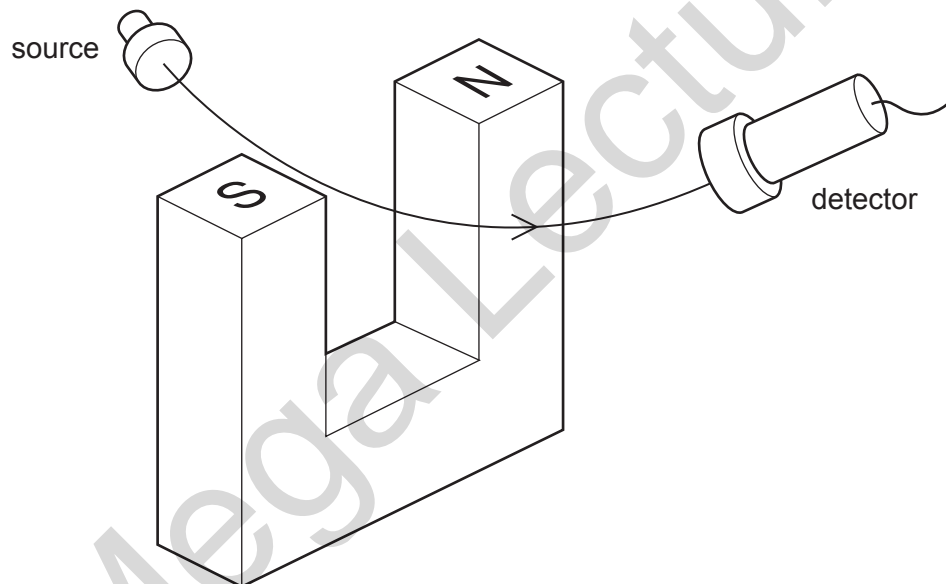
	protons	neutrons
A	37	49
B	37	50
C	38	49
D	38	87

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- 48 Which statement is true for all three types of radioactive emission (alpha-particles, beta-particles and gamma-rays)?
- A They are completely absorbed by a thin aluminium sheet.
 - B They are deflected by electric fields.
 - C They emit light.
 - D They ionise gases.

- 49 The diagram shows one type of radiation passing between the poles of a strong magnet and being detected.



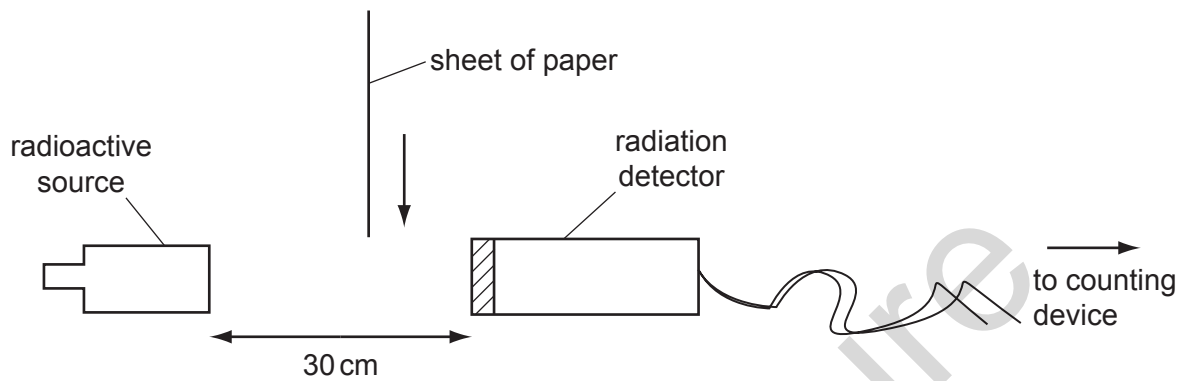
Which type of radiation is being detected?

- A alpha-particles only
- B beta-particles only
- C gamma-rays only
- D alpha-particles and beta-particles

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- 50 An experimenter sets up the following apparatus, in air, to discover whether a radioactive source is emitting alpha-particles.



The experimenter moves the paper between the source and the detector. There is no difference in the count-rate.

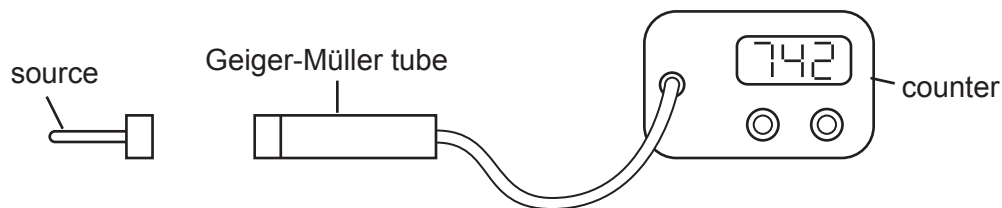
Why is this?

- A Paper does not absorb alpha-particles.
 - B The count-rate due to the background radiation is too high.
 - C The radioactive source is too far from the detector.
 - D The source emits beta-particles and alpha-particles.
- 51 The half-life of a radioisotope is 2400 years. The activity of a sample is 720 counts/s.
- How long will it take for the activity to fall to 90 counts/s?
- A 300 years B 2400 years C 7200 years D 19 200 years

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- 52 A radioactive source is placed 3 cm from a Geiger-Müller tube in air. The average count rate is 742 counts/minute.



Then, in three experiments, measurements are taken with sheets of different materials placed between the source and the tube. The results are recorded in the table.

material of sheet between source and tube	thin card	aluminium foil	thick lead
average count rate/counts per minute	273	275	68

Which types of radiation does the source emit?

- A alpha and beta only
 - B alpha and gamma only
 - C beta and gamma only
 - D alpha, beta and gamma
- 53 Which equation shows a nuclear fission reaction?

- A ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^4_2\text{He}$
- B ${}^{14}_7\text{N} + \text{neutron} \rightarrow {}^{15}_7\text{N}$
- C ${}^{46}_{21}\text{Sc} \rightarrow {}^{46}_{21}\text{Sc} + \text{gamma ray}$
- D ${}^{239}_{92}\text{U} \rightarrow {}^{95}_{38}\text{Sr} + {}^{141}_{54}\text{Xe} + 3 \text{ neutrons}$

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54 The half-life of a radioactive material is 24 years.

The activity of a sample falls to a fraction of its initial value after 72 years.

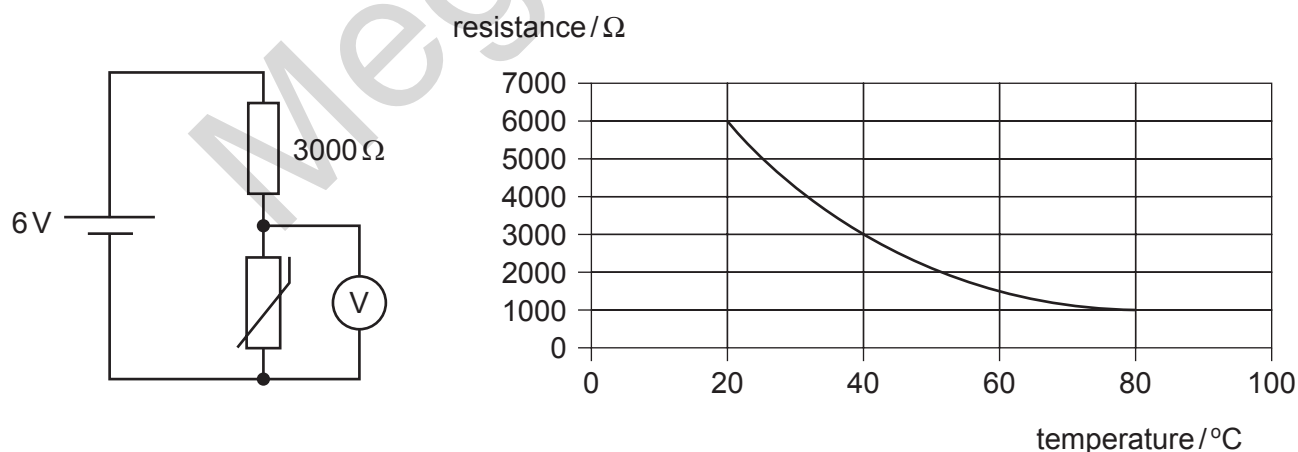
What is the fraction?

- A** 1/3 **B** 1/4 **C** 1/6 **D** 1/8

55 Which is the correct comparison of the penetrating power and ionising power of alpha-particles and gamma radiation?

	greater penetrating power	greater ionising power
A	alpha	alpha
B	alpha	gamma
C	gamma	alpha
D	gamma	gamma

56 A thermistor is connected in a circuit with a 6 V cell, a 3000 Ω resistor and a voltmeter, as shown. The graph shows how the resistance of the thermistor varies with temperature.



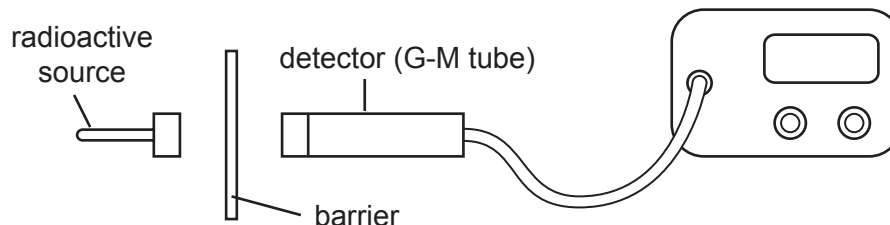
What is the temperature of the thermistor when the voltmeter reads 2V?

- A** 20°C **B** 40°C **C** 60°C **D** 80°C

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- 57 The diagram shows the apparatus used in an experiment in which barriers of various materials are placed in turn between different radioactive sources and a detector.



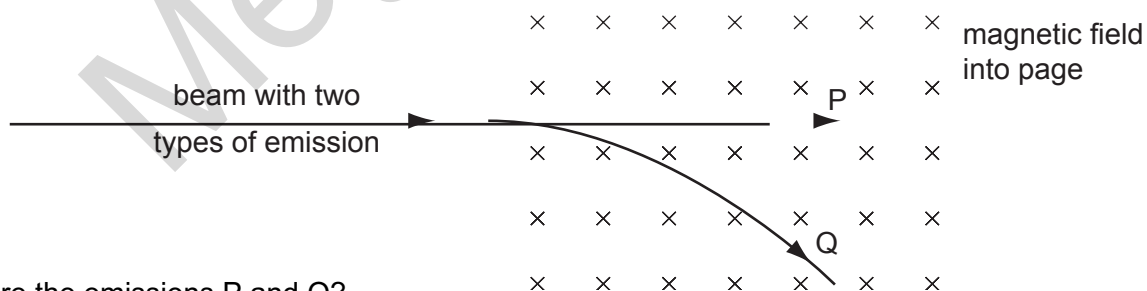
The table shows the count rates recorded by the detector for four sources.

Which source emits alpha-particles only?

source	count rate / counts per minute			
	no barrier	paper	thin aluminium	thick lead
A	200	200	200	30
B	200	30	30	30
C	1200	600	200	30
D	1200	1200	30	30

- 58 Two types of emission from a radioactive source are separated by passing them through a magnetic field.

The deflections are shown in the diagram.



What are the emissions P and Q?

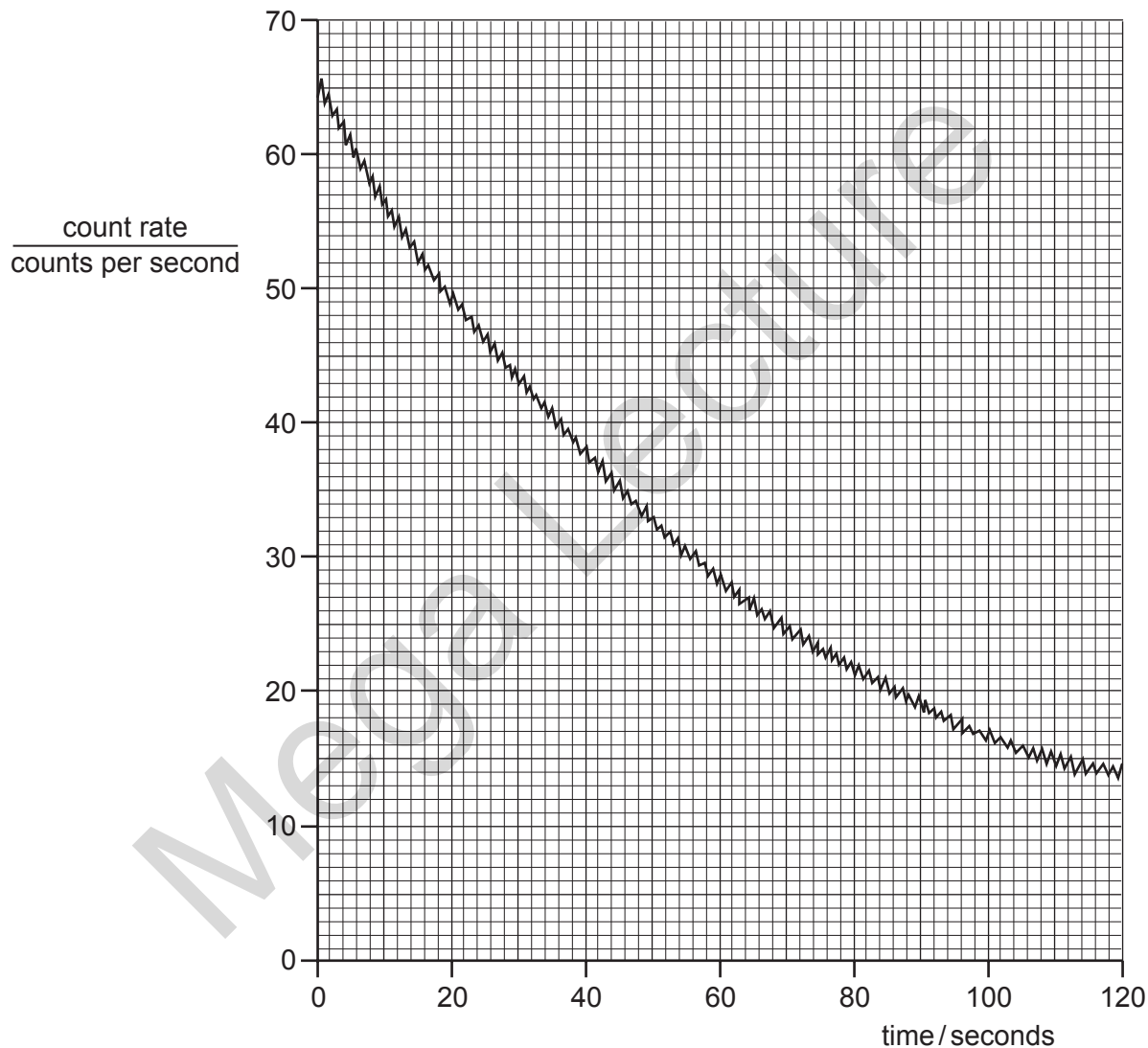
	emission P	emission Q
A	alpha-particles	gamma-rays
B	beta-particles	gamma-rays
C	gamma-rays	alpha-particles
D	gamma-rays	beta-particles

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- 59 Ra decays with a half-life of 1600 s.
- Rn decays with a half-life of 52 s.
- Po decays with a half-life of 9.1 s.
- Pb decays with a half-life of 10.6 h.

The changing count rate for one of these radioactive nuclides is shown in the graph.



From the half-life shown by the graph, which was the decaying radioactive nuclide?

- A** Ra
- B** Rn
- C** Po
- D** Pb

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60 When dealing with radioactive substances there are possible dangers.

Which statement is correct?

- A Beta-particles can pass through skin and damage body cells.
- B Gamma-radiation is more dangerous than alpha or beta because it has a longer half-life.
- C Materials that emit only alpha-particles must be kept in thick lead containers.
- D Radioactive materials are safe to handle after two half-lives.

61 In a fission reactor, which particle causes a Uranium-235 nucleus to split?

- A alpha-particle
- B gamma ray
- C neutron
- D proton

62 A radioactive isotope has a half-life of 2 minutes.

What can be deduced from this statement?

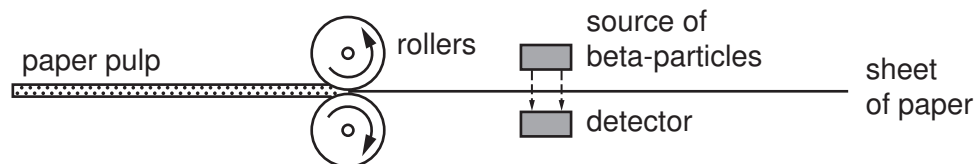
- A After $\frac{1}{2}$ minute, $\frac{1}{4}$ of the isotope remains.
- B After 1 minute, $\frac{1}{4}$ of the isotope remains.
- C After 4 minutes, $\frac{1}{4}$ of the isotope remains.
- D After 4 minutes, none of the isotope remains.

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63 The diagram shows how the thickness of paper is measured during manufacture.

If the sheet is too thick, fewer beta-particles can reach the detector.



A source of alpha-particles is **not** used for this purpose because alpha-particles

- A** are all stopped by the paper.
- B** are too dangerous to those working nearby.
- C** have a short half-life.
- D** make the paper radioactive.

64 **X**, **Y** and **Z** are three types of radiation.

X is almost completely absorbed by 5 cm lead but not by 5 mm aluminium.

Y is almost completely absorbed by 5 mm aluminium but not by thin card.

Z is absorbed by thin card.

What are **X**, **Y** and **Z**?

	X	Y	Z
A	alpha	beta	gamma
B	beta	alpha	gamma
C	gamma	alpha	beta
D	gamma	beta	alpha