5. Nuclear physics

5.2 Radioactivity

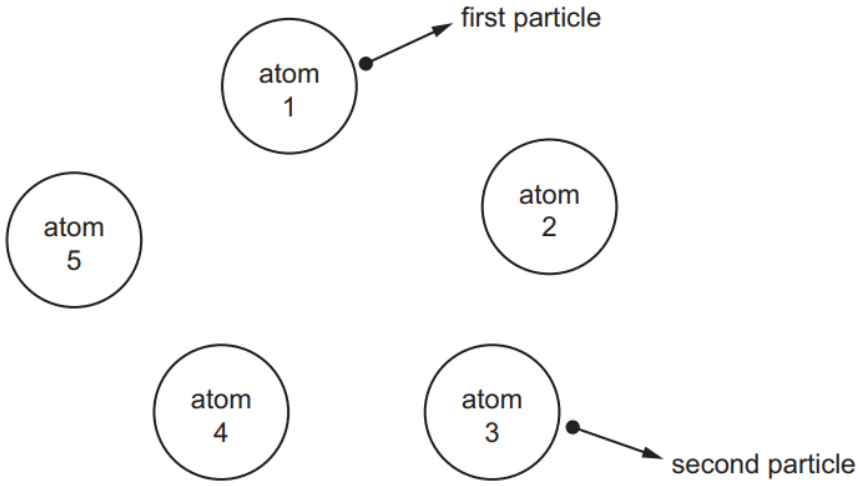
Paper 1 and 2

Question Paper

Paper 1

Questions are applicable for both core and extended candidates

1 The diagram shows five atoms in a radioactive substance. The atoms each give out an α-particle.



Atom 1 is the first to give out a particle. Atom 3 is the second to give out a particle.

Which atom will give out the next particle?

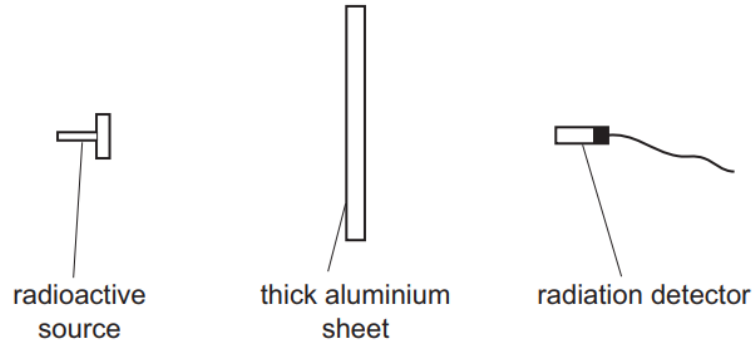
A atom 2

B atom 4

C atom 5

D impossible to tell

2 The diagram shows a radioactive source, a thick aluminium sheet and a radiation detector.



The radiation detector shows a reading greater than the background reading.

Which type of radiation is being emitted by the source and detected by the detector?

A α-radiation

B β-radiation

C γ-radiation

D infrared radiation

3 A student suggests three sources of naturally occurring background radiation.

1 cosmic rays

2 medical X-rays

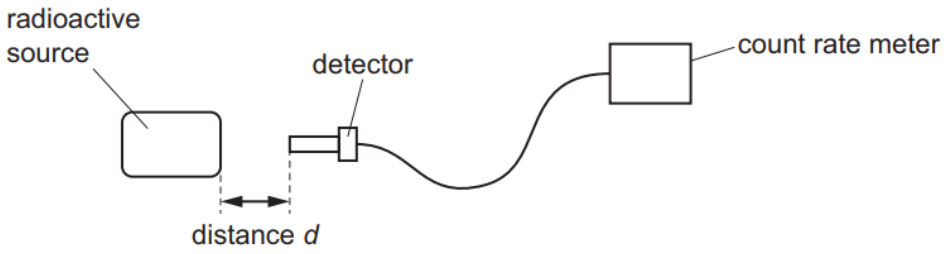
3 radioactive emissions from radon gas from the ground

Which suggestions are correct?

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

4 A student measures the rate at which ionising radiation is emitted from a radioactive substance.

He places a detector at different distances from the radioactive source.



The table shows how the count rate from the source varies with distance *d*.

distance *d* / cm	0	2	4	6
count rate / counts per minute	1250	115	0	0

Which type of ionising radiation is being emitted by the substance?

A α-particles

B β-particles

C γ-rays

D X-rays

5 Radioactive decay results in the emission of α-particles, β-particles and γ-radiation.

Which types of emission result in a nucleus changing to that of a different element?

A α-particle emission and β-particle emission

B α-particle emission and γ-radiation emission

C β-particle emission and γ-radiation emission

D γ-radiation emission only

6 A radioactive isotope has a half-life of 120 minutes.

It emits radiation at a rate of 100 particles per second.

How long does it take for the rate of emission to fall to 25 particles per second?

A 30 minutes **B** 45 minutes **C** 90 minutes **D** 240 minutes

7 An isotope of radon is radioactive. It decays by emitting an α-particle.

What happens to the nucleus of a radon atom during the emission of the α-particle?

A It becomes the nucleus of a different isotope of radon with fewer neutrons.

B It becomes the nucleus of a different isotope of radon with more neutrons.

C It becomes the nucleus of an element with a higher proton number.

D It becomes the nucleus of an element with a lower proton number.

8 The nuclide notation of the isotope strontium-90 is $^{90}_{38}\text{Sr}$.

Which statement is correct?

A A nucleus of strontium-90 has 38 neutrons.

B A nucleus of strontium-90 has 52 neutrons.

C A nucleus of strontium-90 has 90 electrons.

D A nucleus of strontium-90 has 90 neutrons.

9 A box is used for storing radioactive sources.

What is the best material to use for lining the box to prevent radiation from escaping?

A aluminium

B lead

C paper

D plastic

10 Four statements about isotopes of a certain element are listed.

Which statement about the isotopes **must** be correct?

A They are radioactive.

B They are unstable.

C They have the same number of neutrons.

D They have the same number of protons.

11 What makes a contribution to a person's annual dose of ionising radiation?

A food and drink

B greenhouse gases

C mobile phone masts

D radio and TV transmissions

12 The emissions from a radioactive source pass through a sheet of lead that is 10 mm thick.

Which type of radiation is emitted from the source and how is the radiation affected by an electric field?

	type of radiation	effect of electric field on radiation
A	α	radiation deflected
B	α	radiation **not** deflected
C	γ	radiation deflected
D	γ	radiation **not** deflected

13 Radioactive waste is often mixed with liquid glass. This mixture solidifies and is stored in steel drums.

Why is this process used to store radioactive waste?

A It reduces the decay rate.

B It reduces the half-life of the waste.

C The waste is contained in a solid block so it cannot leak out.

D The glass is transparent so the waste can be seen.

14 α-particles, β-particles and γ-rays are emitted by radioactive nuclei when they decay.

Which emissions can be deflected by an electric field?

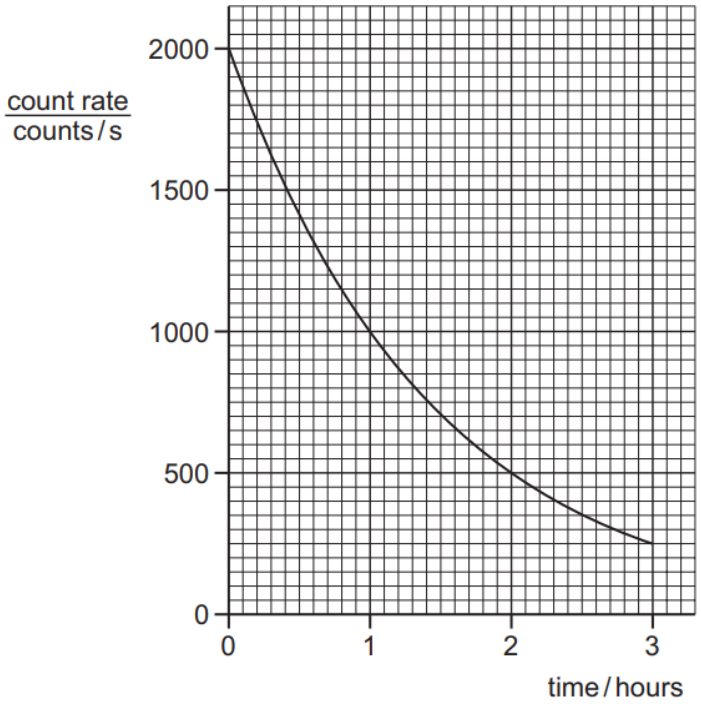
A α-particles, β-particles and γ-rays

B α-particles and β-particles only

C β-particles and γ-rays only

D γ-rays and α-particles only

15 The graph shows the count rate from a radioactive source over a period of time.



What is the half-life of the source?

A 0.5 hour **B** 1.0 hour **C** 1.5 hours **D** 3.0 hours

16 A scientist carries out an experiment using a sealed source which emits β-particles. The range of the β-particles in the air is about 30 cm.

Which precaution is the most effective to protect the scientist from the radiation?

A handling the source with long tongs

B keeping the temperature of the source low

C opening all windows in the laboratory

D washing his hands before leaving the laboratory

17 Which row correctly describes an example of radioactive decay?

	original nucleus	emission	change or no change of element
A	stable	γ	change of element
B	unstable	α	change of element
C	unstable	α	no change of element
D	unstable	β	no change of element

18 A detector is used to monitor the emissions from a radioactive source over several days.

The table shows the count rate from the source at different times.

time / days	count rate / counts / s
0	250
1	215
2	180
3	148
4	120
5	100

What is the half-life of the source?

A between 1 and 2 days

B between 2 and 3 days

C between 3 and 4 days

D between 4 and 5 days

19 What is the most effective precaution to reduce the risk when handling, storing or using a radioactive source that emits γ-rays?

A Handle the source for the least possible time.

B Have a fire extinguisher nearby when using the source.

C Store the source at a low temperature.

D Wear plastic safety goggles when handling the source.

20 Which statement about the random decay of the nuclei in a sample of uranium-238 is correct?

A The probabilities of an alpha-particle, a beta-particle or a gamma ray being emitted from a nucleus in the sample are equal.

B The probability of a nucleus in the sample decaying decreases as time passes.

C The probability of a nucleus decaying in any ten minute interval is the same for all the nuclei in the sample.

D The probability of a nucleus in the sample decaying increases as time passes.

21 The count rate due to a sample of a radioactive isotope is measured for 80 minutes.

time / minutes	count rate / counts / second
0	480
20	380
40	300
60	240
80	190

What is the half-life of the isotope?

A 20 minutes **B** 40 minutes **C** 60 minutes **D** 80 minutes

22 The table shows the composition of three different nuclei.

nucleus	number of protons	number of neutrons
X	3	3
Y	3	4
Z	4	3

Which nuclei are isotopes of the same element?

A X, Y and Z **B** X and Y only **C** X and Z only **D** Y and Z only

23 A sample of a radioactive isotope emits 9600 α-particles per second.

After 40 hours the rate of emission has fallen to 600 α-particles per second.

What is the half-life of this isotope?

A 4.0 hours **B** 8.0 hours **C** 10 hours **D** 20 hours

24 Which row states a harmful effect and a beneficial effect of ionising radiation on living things?

	harmful effect	beneficial effect
A	kills cancer cells	kills cancer cells
B	kills cancer cells	mutates living cells
C	mutates living cells	kills cancer cells
D	mutates living cells	mutates living cells

25 A radioactive material is emitting α-particles. The radioactive material is used in a demonstration in a school laboratory experiment.

Which safety precaution must be taken by the person carrying out the experiment?

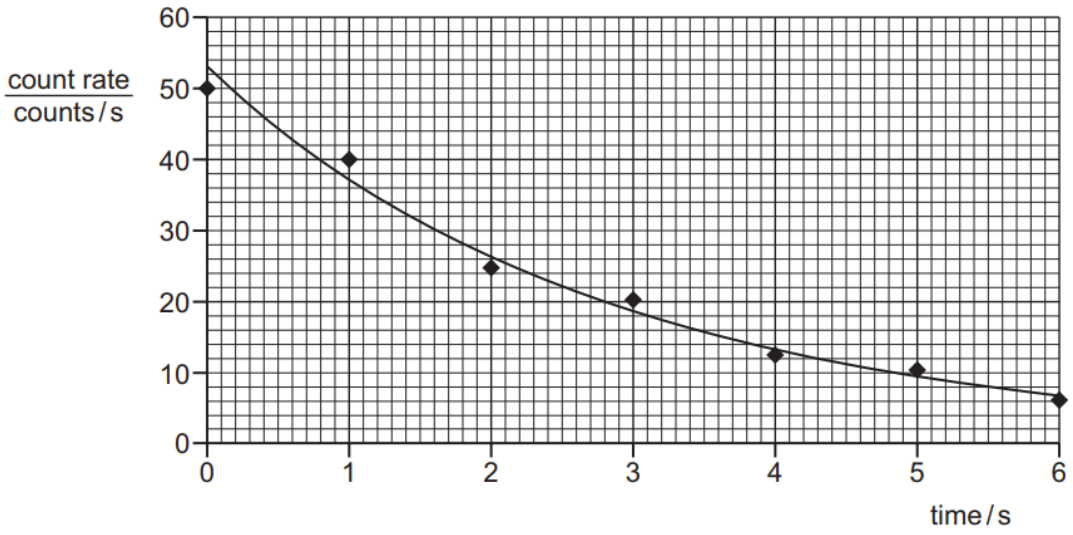
A Handle the source with tongs.

B Place the source on a heat-proof mat.

C Surround the experiment with a lead screen.

D Wear goggles.

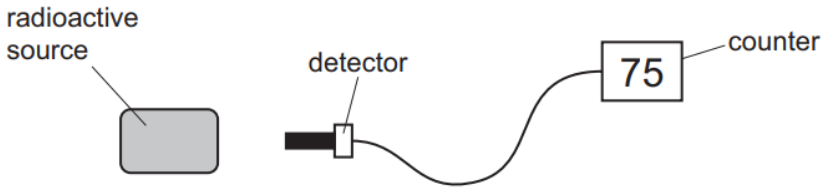
26 The graph shows how the count rate from a radioactive isotope changes with time.



What is the half-life of this isotope?

A 2.0 s **B** 6.0 s **C** 12 s **D** 53 s

27 A student measures the count rate near a radioactive source using a detector of ionising radiation. The diagram shows the arrangement.



The counter reads 75 counts per minute.

When the source is taken away, the reading on the counter decreases to 5 counts per minute.

What was the rate of emission from the radioactive source when the counter reading is corrected for background radiation?

A 5 counts per minute

B 15 counts per minute

C 70 counts per minute

D 80 counts per minute

28 Everyone is exposed to background radiation.

What are sources of background radiation?

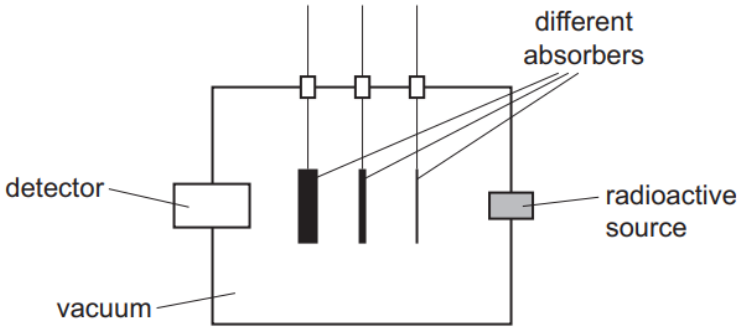
A food and drink only

B rocks only

C cosmic rays only

D food and drink, rocks and cosmic rays

29 The diagram shows a piece of apparatus used to determine the nature of the emissions from a radioactive source. The absorbers can be raised out of or lowered into the path of the radiation from the source to the detector. The apparatus is evacuated.



The table gives a set of results for a particular radioactive source.

absorber in use	count rate on detector (counts per second)
none	350
thin paper	350
1.0 mm aluminium	180
1.0 cm lead	23

Which types of radiation are being emitted by the radioactive source?

A α-particles and β-particles

B α-particles only

C β-particles and γ-rays

D β-particles only

30 The half-life of a sample of radioactive material is 400 years.

How long will it take until only $\frac{1}{4}$ of this sample remains undecayed?

A 100 years

B 400 years

C 800 years

D 1600 years

31 A radioactive source has a half-life of 0.5 hours.

A detector near the source shows a reading of 6000 counts per second.

Background radiation can be ignored.

What is the reading on the detector 1.5 hours later?

A 750 counts per second

B 1500 counts per second

C 2000 counts per second

D 3000 counts per second

32 Which statement about the radioactive decay of a substance is correct?

A It cannot be predicted when a particular nucleus will decay.

B Placing a radioactive substance inside a lead-lined box prevents it from decaying.

C The decay always produces poisonous gases.

D The rate of decay increases if the substance is dissolved in water.

33 Some nuclei are unstable. They emit radiation and change into nuclei of a different element.

What is this process called?

A convection

B electromagnetic induction

C radioactive decay

D the motor effect

34 A radioactive material is placed near a detector.

The detector shows a count rate of 28 000 counts / min.

When a piece of card is put between the material and the counter, the reading decreases to 25 000 counts / min.

When an aluminium sheet is put between the material and the counter, the reading remains at 25 000 counts / min.

When a sheet of lead is put between the material and the counter, the reading decreases to 19 000 counts / min.

What is being emitted by the radioactive material?

A α, β and γ-radiation

B α and β-radiation only

C α and γ-radiation only

D β and γ-radiation only

35 A radioactive isotope has a half-life of 3 years.

A sample gives a count rate of 100 counts / min on a detector.

Which calculation is used to predict the count rate after 12 years?

A $100 \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$

B $100 \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$

C $100 \times \frac{3}{12}$

D $100 \times \frac{12}{3} \times \frac{1}{2}$

36 Some sources of background radiation are natural and others are due to human activity.

Which source is natural?

A medical X-rays

B nuclear weapons testing

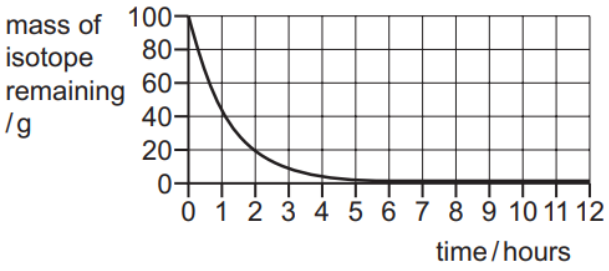
C radioactive waste from power stations

D radon gas from rocks

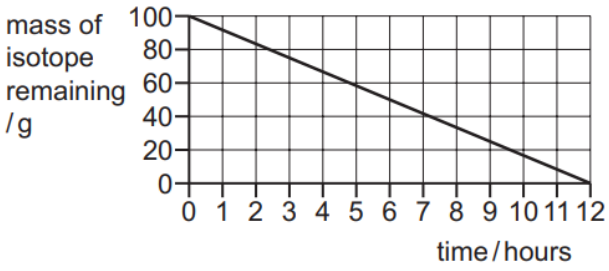
37 A sample of a radioactive isotope has a mass of 100 g. The half-life of the radioactive isotope is 6.0 hours.

Which graph shows the decay for this isotope?

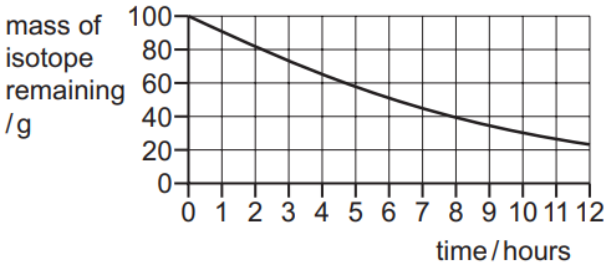
A



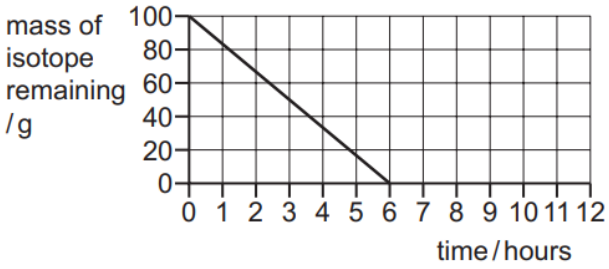
B



C



D



38 Which statement best describes background radiation?

A any harmful level of radiation

B radiation that is only found in space

C radiation from natural sources

D radiation that is absorbed by rocks

39 A radioactive atom decays by emission of a β-particle.

Which row is correct?

	what decays	what happens to the atom
A	the nucleus of the atom	it becomes a different element
B	the nucleus of the atom	it becomes a lighter version of the same element
C	the outer layers of the atom	it becomes a different element
D	the outer layers of the atom	it becomes a lighter version of the same element

40 Which statement about α-particles and γ-rays is correct?

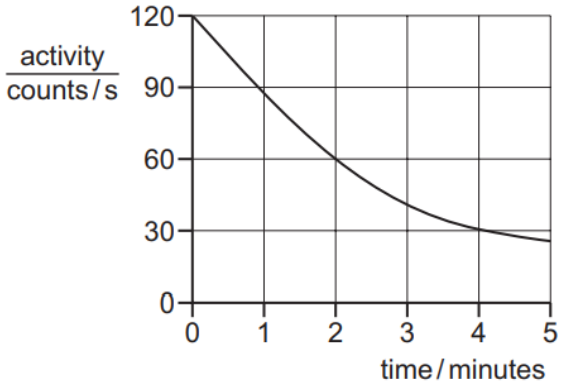
A α-particles are a form of electromagnetic radiation.

B α-particles penetrate materials more easily than γ-rays.

C The emission of an α-particle produces a nucleus of a different element.

D γ-rays are more ionising than α-particles.

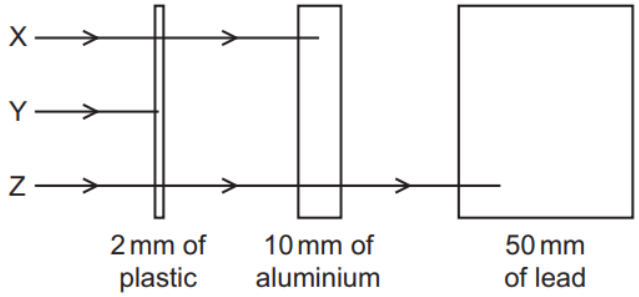
41 The graph shows the activity of a radioactive source over a period of time.



What is the half-life of the source?

A 1.0 minute **B** 2.0 minutes **C** 2.5 minutes **D** 4.0 minutes

42 The diagram shows the paths of three different types of radiation X, Y and Z.



Which row correctly identifies X, Y and Z?

	X	Y	Z
A	α-particles	β-particles	γ-rays
B	β-particles	α-particles	γ-rays
C	β-particles	γ-rays	α-particles
D	γ-rays	α-particles	β-particles

43 A radiation detector records a low reading even when no radioactive source is close. This is due to background radiation.

What does **not** contribute to this background radiation?

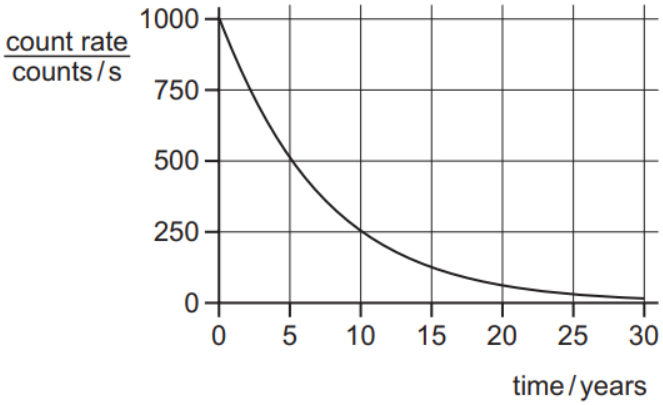
A rocks on Earth

B cosmic rays from the Sun

C satellite TV signals

D waste from nuclear power stations

44 The graph shows the radioactive decay curve of a substance.



What is the half-life of this substance?

A 0.5 years **B** 5 years **C** 15 years **D** 30 years

45 Three types of radiation are α-radiation, β-radiation and γ-radiation.

Which statement is correct?

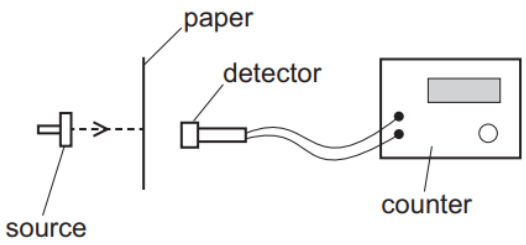
A α-radiation is less ionising than β-radiation.

B α-radiation is less ionising than γ-radiation.

C γ-radiation produces no ionisation.

D β-radiation is more ionising than γ-radiation.

46 A thin sheet of paper is placed between a radioactive source and a radiation detector. The count rate falls to a very low reading.



From this result, which type of radiation is the source emitting?

A α-particles

B β-particles

C γ-rays

D X-rays

47 In 1986 the Chernobyl nuclear power station in Ukraine suffered a meltdown.

This caused background radiation in many countries, thousands of kilometres from Chernobyl, to increase.

What was transported in the atmosphere to these countries to cause this rise in background radiation?

A α-particles

B β-particles

C γ-rays

D radioactive isotopes

48 An isotope of radon is radioactive. It decays by emitting an α-particle.

What happens to the nucleus of a radon atom during the emission of the α-particle?

A It becomes the nucleus of a different isotope of radon with fewer neutrons.

B It becomes the nucleus of a different isotope of radon with more neutrons.

C It becomes the nucleus of an element with a higher proton number.

D It becomes the nucleus of an element with a lower proton number.

49 Why are some radioactive sources stored in boxes made from lead?

A Lead absorbs emissions from the radioactive sources.

B Lead decreases the half-life of radioactive sources.

C Lead increases the half-life of radioactive sources.

D Lead repels emissions from the radioactive sources.

50 Which type of radiation can be stopped by a sheet of paper?

A α-particles

B β-particles

C γ-rays

D X-rays

51 Which statement about α-particles and β-particles is correct?

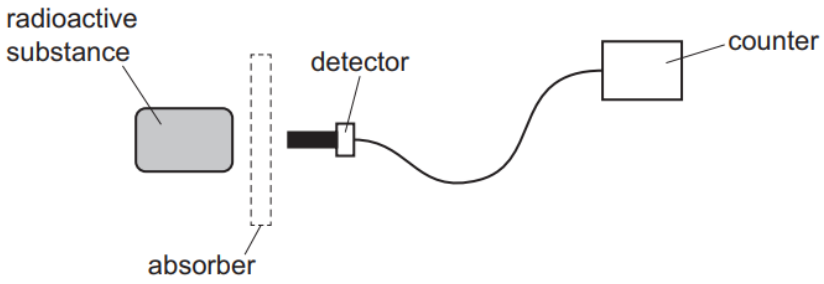
A α-particles are less ionising than β-particles.

B α-particles are more penetrating than β-particles.

C α-particles have greater mass than β-particles.

D α-particles have the same charge as β-particles.

52 A student measures the level of radiation emitted from a radioactive substance. He places a detector very close to the substance. He puts different absorbers between the radioactive substance and the detector.



The student's results are shown. These results are corrected for background radiation.

absorber	counter reading / counts per minute
none	95
thin paper	52
few mm of aluminium	52
several cm of lead	12

Which types of radiation are being emitted by the substance?

A α-particles and β-particles only

B α-particles and γ-rays only

C β-particles and γ-rays only

D α-particles, β-particles and γ-rays

53 The nuclei of the atoms in a substance are changing randomly and emitting radiation.

What is happening to the substance?

A It is undergoing electromagnetic induction.

B It is undergoing magnetisation.

C It is undergoing solidification.

D It is undergoing radioactive decay.

54 Which statement explains the meaning of the half-life of a radioactive isotope?

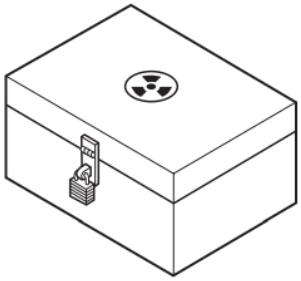
A half the time taken for one nucleus of the isotope to decay

B half the time taken for the isotope to decay completely

C the time taken for half of the nuclei of the isotope to decay

D the time taken for one nucleus of the isotope to split in half

55 The diagram shows a lead-lined box used for storing radioactive sources.



Why is the inside of the box lined with lead?

A It helps the sources to stay radioactive for longer.

B It makes the box heavier.

C It makes the radioactive sources more stable.

D It reduces the amount of radiation that can escape from the box.

56 An explosion in a nuclear reactor spread the isotope caesium-137 across a large area.

Ninety years after the explosion, the quantity of caesium-137 present will be 12.5% of its original level.

What is the half-life of caesium-137?

A 11.25 years **B** 22.5 years **C** 30.0 years **D** 45.0 years

57 The table compares the penetrating abilities and ionising effects of α-radiation and of γ-radiation.

Which row is correct?

	least penetrating	most ionising
A	α	α
B	α	γ
C	γ	α
D	γ	γ

58 Radioactive materials must be handled in a safe way.

What is **not** a safety procedure?

A Monitor exposure time to radioactive materials.

B Store radioactive materials in cardboard boxes.

C Use tongs to pick up the radioactive source.

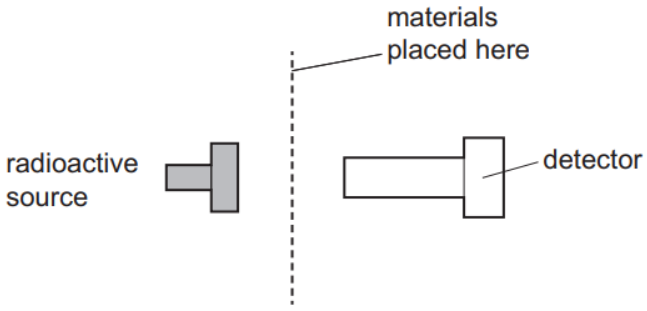
D Wear protective clothing.

Paper 2

Questions are applicable for both core and extended candidates unless indicated in the question

59 A radioactive source is placed near a detector.

The radiation arriving at the detector from the source is measured for 10 minutes with different materials placed between the source and the detector.



material between source and detector	radiation detected / counts
none	5626
sheet of paper	5629
thick sheet of aluminium	2226
thick sheet of lead	255

Which types of radiation are emitted by the source?

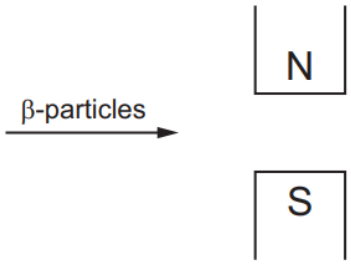
A α-particles and γ-rays

B α-particles only

C β-particles and γ-rays

D β-particles only

60 The diagram shows β-particles being directed between the poles of a magnet. **(extended only)**



In which direction will the particles be deflected?

A into the page

B out of the page

C towards the bottom of the page

D towards the top of the page

61 An α-particle and a β-particle have the same kinetic energy. **(extended only)**

Why does the α-particle have a larger ionising effect than the β-particle as it passes through air?

A The α-particle has a larger charge and a larger velocity so is closer to an air particle for a shorter time.

B The α-particle has a larger charge and a smaller velocity so is closer to an air particle for a longer time.

C The α-particle has a smaller charge and a larger velocity so is closer to an air particle for a shorter time.

D The α-particle has a smaller charge and a smaller velocity so is closer to an air particle for a longer time.

62 Which statement correctly compares the properties of alpha-particles and beta-particles?

A Alpha-particles are less penetrating than beta-particles because alpha-particles are less ionising.

B Alpha-particles are less penetrating than beta-particles because alpha-particles are more ionising.

C Alpha-particles are more penetrating than beta-particles because alpha-particles are less ionising.

D Alpha-particles are more penetrating than beta-particles because alpha-particles are more ionising.

63 A student is carrying out an experiment to measure the radiation from a radioactive source.

He uses a radiation detector and records the total counts in 5-minute intervals. He does this three times with the source present and three times with the source absent. Here are his results.

(extended only)

total counts in 5 minutes with source present	total counts in 5 minutes with source absent
68	25
73	28
69	22

What is the average corrected count rate for the source?

A 5 counts / minute

B 9 counts / minute

C 25 counts / minute

D 45 counts / minute

64 The count rate measured near a radioactive source drops from 542 counts per minute to 94 counts per minute in 12 hours. The background count remains constant at 30 counts per minute.

What is the half-life of the source? **(extended only)**

A 2 hours **B** 3 hours **C** 4 hours **D** 8 hours

65 Which statement about alpha decay is correct?

A The nucleus loses electrons.

B The nucleus changes to that of a different element.

C The nucleus does not decay until after one half-life.

D After two half-lives, alpha decay always stops.

66 The reading on a detector placed near a radioactive material is 536 counts per second.

The background count rate is 44 counts per second. **(extended only)**

The half-life of the radioactive material is 34 hours.

What is the reading on the detector after 68 hours?

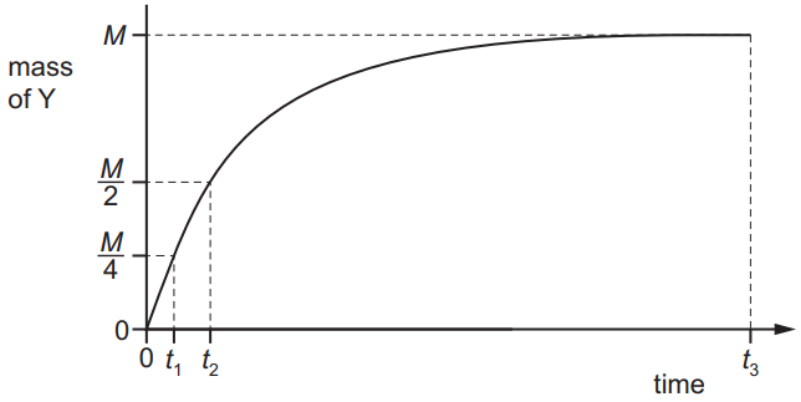
A 44 counts per second

B 123 counts per second

C 134 counts per second

D 167 counts per second

67 Radioisotope X decays to the stable isotope Y. The graph shows how the mass of Y present in a sample varies with time.

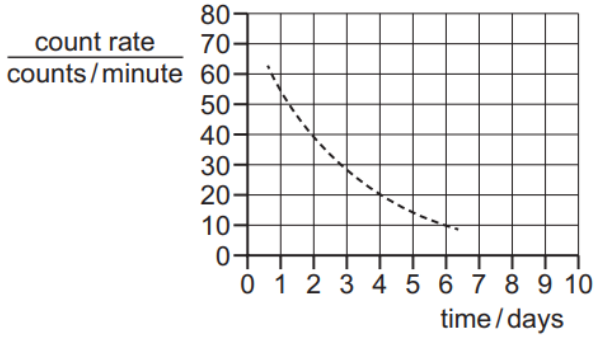


Which time interval gives the half-life of X?

A $t_2 - t_1$ **B** $t_3 - t_2$ **C** t_2 **D** $\frac{1}{2} t_3$

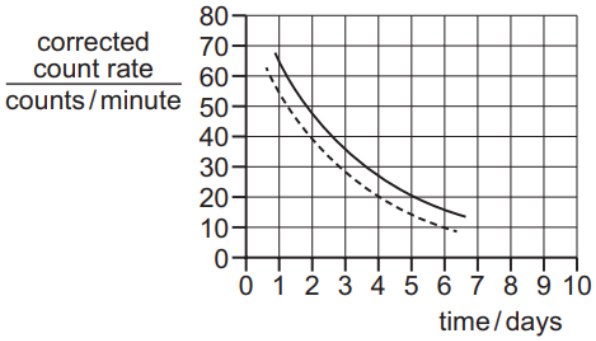
68 The dashed line on the graph shows the decay curve recorded from a sample of a particular radioactive isotope. The count rate includes background radiation.

(extended only)

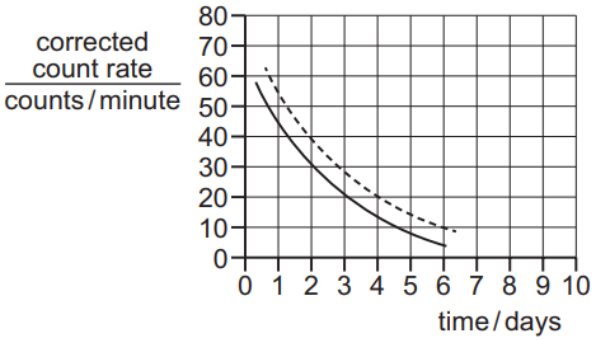


Which curve shows the corrected count rate for the decay?

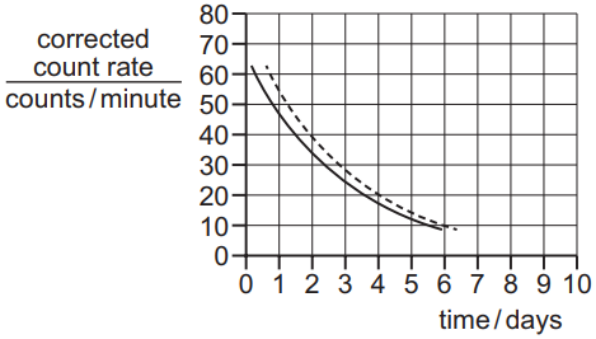
A



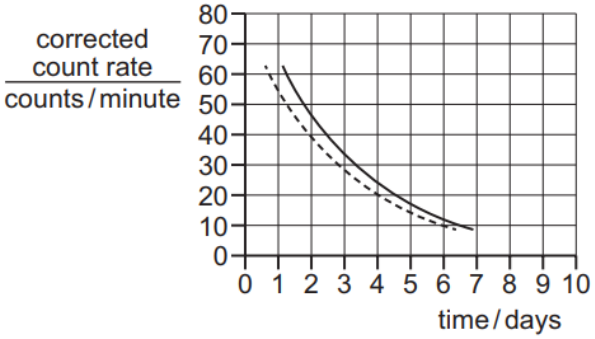
B



C



D



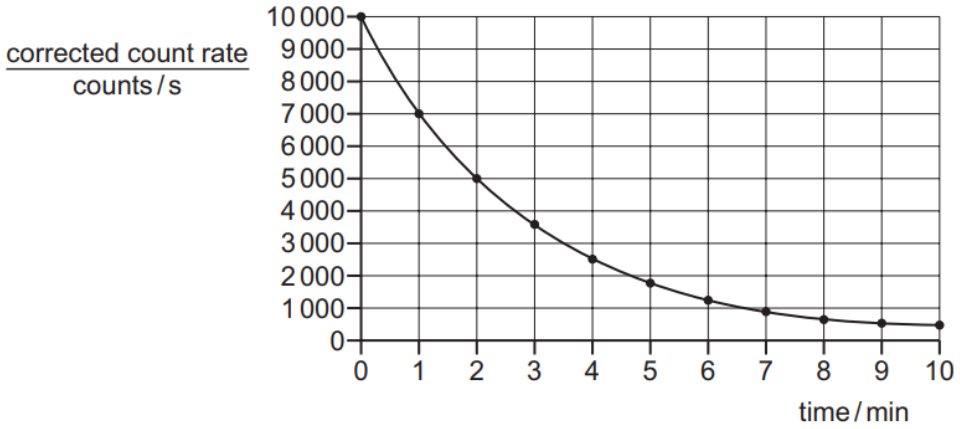
69 Which type of radioactive source is suitable for use in measuring and controlling the thickness of paper in a paper-manufacturing factory?

(extended only)

	type of emission	half-life
A	alpha	long
B	alpha	short
C	beta	long
D	beta	short

70 A medical tracer is used to investigate a tumour in a patient.

The graph shows the corrected count rate from the tracer against time.



What is the half-life of the source?

A 2 minutes

B 10 minutes

C 5 000 minutes

D 10 000 minutes

71 A radioactive source is placed near a detector connected to a counter. **(extended only)**

210 counts are recorded by the counter in 3 minutes.

The background count rate is 20 counts per minute (cpm).

What is the corrected count rate for the radioactive source?

A 50 cpm **B** 70 cpm **C** 190 cpm **D** 270 cpm

72 The background count rate measured by a radiation counter is 40 counts per minute (cpm).

With the counter close to a radioactive source, the counter reading is 960 cpm.

The half-life of the source is 20 minutes.

What is the counter reading one hour later? **(extended only)**

A 115 cpm **B** 120 cpm **C** 155 cpm **D** 160 cpm

73 A radioactive isotope of sodium has a half-life of 15 h. **(extended only)**

The table gives data from an experiment to show how the rate of decay of the isotope varies with time.

The background count rate has not been subtracted from these data.

time / h	0	10	20	30
count rate / counts / s	400	260	170	115

What is the background radiation count rate?

A 12 counts / s

B 15 counts / s

C 20 counts / s

D 30 counts / s

74 Which change occurs in the nucleus of a radioactive atom during β-emission? **(extended only)**

A A neutron transforms into a proton and an electron.

B A neutron transforms into a proton only.

C A proton transforms into a neutron and an electron.

D A proton transforms into a neutron only.

75 A radioactive isotope has a half-life of 8 days. **(extended only)**

A detector close to a sample of this isotope gives a count rate of 200 counts per minute.

Without the source, the background count is 20 counts per minute.

What is the count rate due to the source after 8 days?

A 80 counts per minute

B 90 counts per minute

C 100 counts per minute

D 110 counts per minute

76 Polonium, Po, has a proton number equal to 84 and a nucleon number equal to 218.

Polonium changes into astatine, At, by emitting a β-particle. **(extended only)**

Which equation represents this decay?

A $^{84}_{218}\text{Po} \rightarrow {}^{85}_{218}\text{At} + {}^{-1}_{0}\beta$

B $^{84}_{218}\text{Po} + {}^{-1}_{0}\beta \rightarrow {}^{85}_{218}\text{At}$

C $^{218}_{84}\text{Po} \rightarrow {}^{218}_{85}\text{At} + {}^{0}_{-1}\beta$

D $^{218}_{84}\text{Po} + {}^{0}_{-1}\beta \rightarrow {}^{218}_{85}\text{At}$

77 What is the nature of α-emission?

A electromagnetic waves

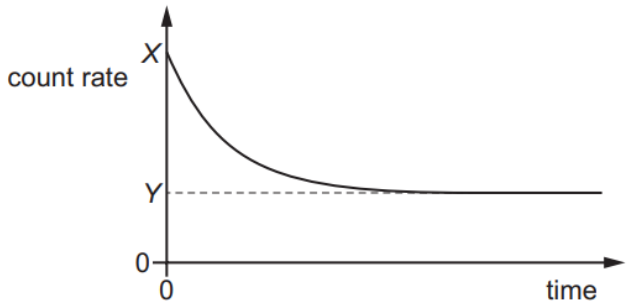
B negatively charged particles

C positively charged particles

D uncharged particles

78 The graph shows the measured count rate of radiation from a source containing a radioactive isotope. The detector is in a laboratory, with no shielding from background radiation.

(extended only)



What is the measured count rate after a time of one half-life?

A $\frac{X}{2}$ **B** $\frac{Y}{2}$ **C** $\frac{(X-Y)}{2}$ **D** $\frac{(X+Y)}{2}$

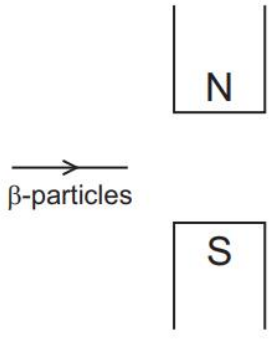
79 Thorium-230 is represented by the symbol $^{230}_{90}Th$. This isotope is radioactive and decays to radium by emitting α-particles.

Which nuclide is produced by this decay? **(extended only)**

A $^{226}_{88}Ra$ **B** $^{230}_{89}Ra$ **C** $^{230}_{91}Ra$ **D** $^{234}_{92}Ra$

80 The diagram shows a stream of β-particles travelling in a line that passes between the poles of a magnet.

(extended only)



In which direction will the β-particles be deflected by the magnet?

A towards the N pole

B towards the S pole

C into the page

D out of the page

81 Which radioactive source is used in a smoke alarm system and what is the reason for this?

(extended only)

	source	reason
A	α	causes least ionisation of air
B	α	causes most ionisation of air
C	γ	causes least ionisation of air
D	γ	causes most ionisation of air

82 A beam of α-particles and β-particles is incident at right angles to an electric field.

Which statement about the deflection of the particles in the field is correct? **(extended only)**

A α-particles deflect, but β-particles do not deflect.

B α-particles deflect in the opposite direction to β-particles.

C β-particles deflect, but α-particles do not deflect.

D Both α-particles and β-particles deflect in the same direction.

83 The nucleus of an americium atom contains 146 neutrons and 95 protons. It decays by emitting an α-particle.

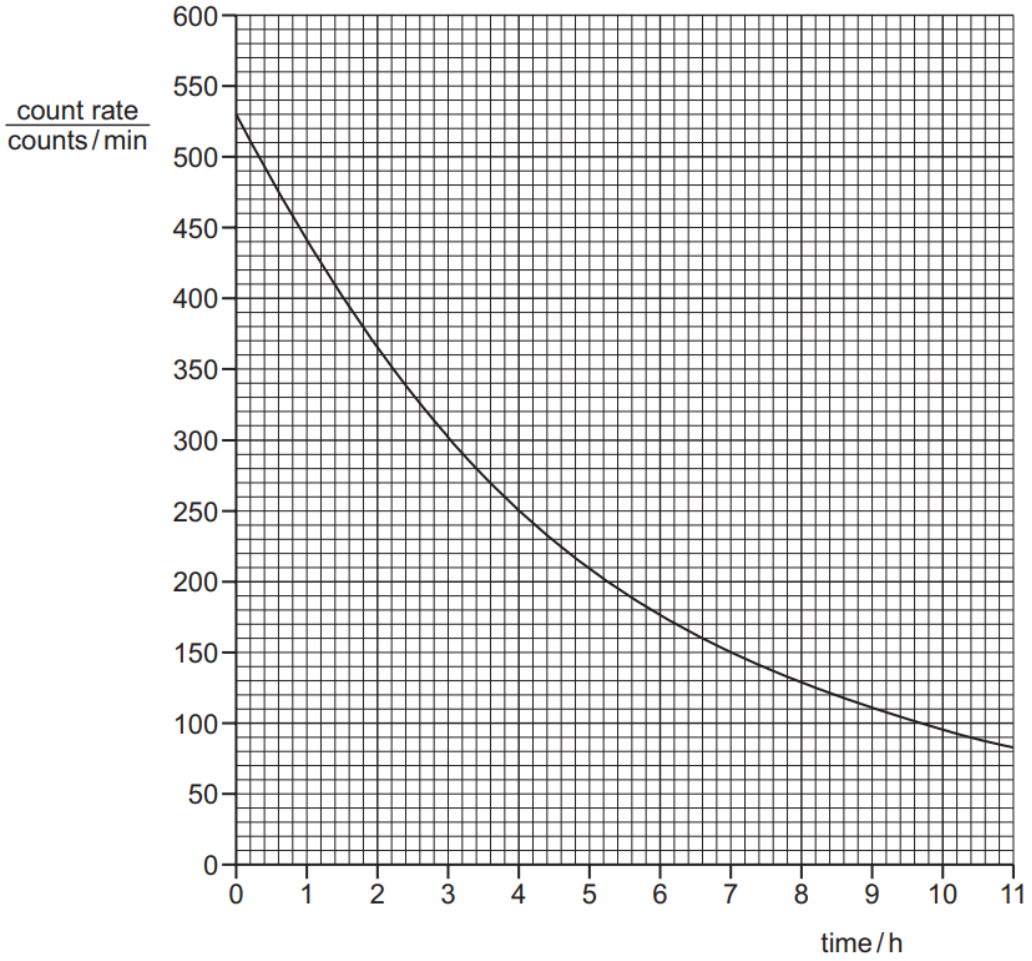
(extended only)

How many neutrons and how many protons remain in the nucleus when this form of americium decays?

	number of neutrons remaining	number of protons remaining
A	142	93
B	142	95
C	144	93
D	144	95

84 The graph shows how the count rate measured by a radioactivity detector placed near a radioactive sample changed with time.

(extended only)



Given that the background count rate is 30 counts / min, what is the half-life of this sample?

A 3.4 h **B** 3.6 h **C** 4.0 h **D** 5.5 h

85 A teacher holds a radioactive source near a detector. **(extended only)**

The reading on the detector is 320 counts / min.

The detector is switched on again after the source has been removed and it shows a reading of 20 counts / min.

What is the counts / min solely due to the source and why is there a reading on the detector when there is no radioactive source present?

	counts / min due to the source	reason for reading with no source
A	300	zero error on detector
B	300	background radiation
C	340	zero error on detector
D	340	background radiation

86 Which statement is **not** correct?

A α-particles are used to detect cracks in metallic structures.

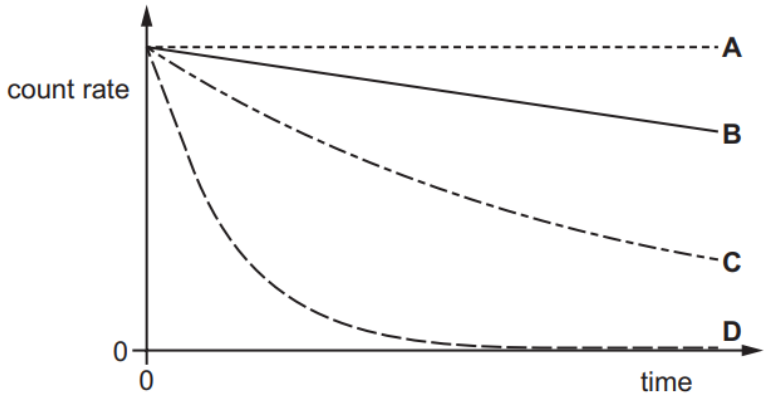
B β-particles are used in the measurement of the thickness of paper.

C γ-rays may be used to treat cancer patients.

D Smoke alarms contain a weak source of α-particles.

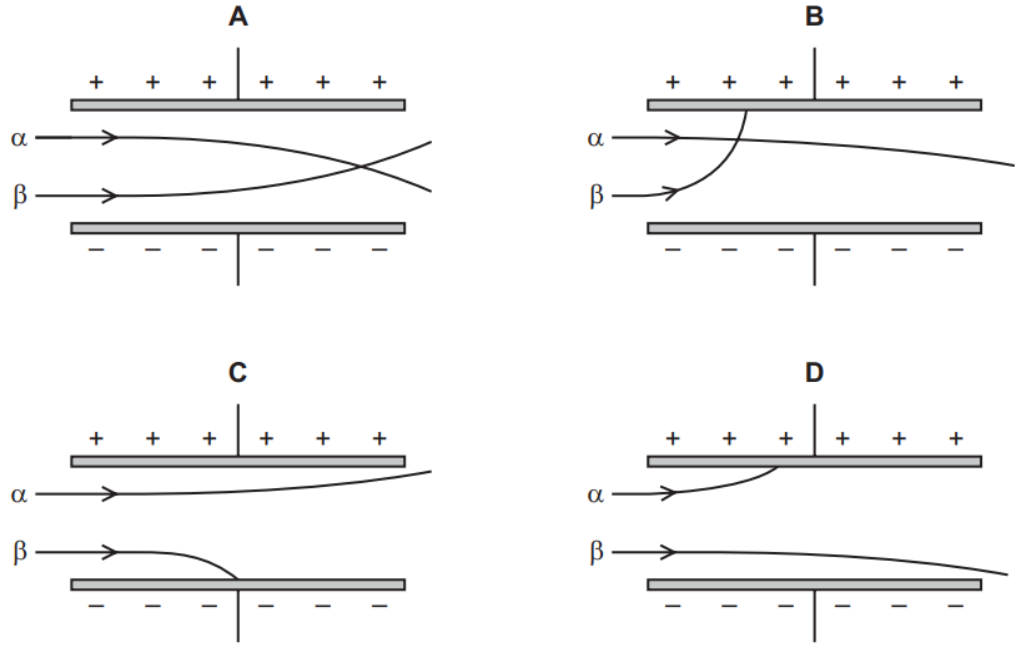
87 The graph shows the decay curves of four different radioactive isotopes.

Which isotope has the largest half-life?



88 The diagrams show α-particles and β-particles passing through an electric field.

Which diagram shows the correct paths of the α-particles and β-particles? **(extended only)**



89 A sample of americium decays and changes into neptunium. The half-life of americium is 432 years.

Which fraction of the americium will remain after 1728 years?

A 0 **B** $\frac{1}{16}$ **C** $\frac{1}{8}$ **D** $\frac{1}{4}$

90 Radon $^{219}_{86}Rn$ decays by emitting an α-particle. **(extended only)**

Which nuclide is formed in this decay?

A $^{215}_{84}Po$ **B** $^{223}_{88}Ra$ **C** $^{219}_{87}Fr$ **D** $^{219}_{85}At$

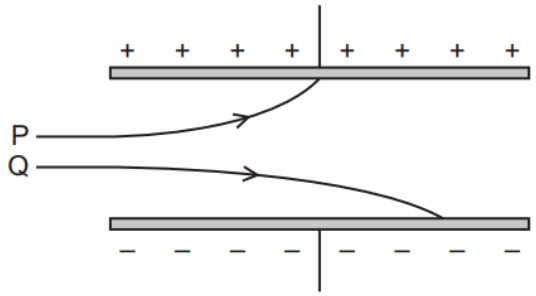
91 Some radioactive nuclei decay to give new nuclei which are also radioactive. Part of a series of decays is shown. **(extended only)**

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa \rightarrow {}^{234}_{92}U \rightarrow {}^{230}_{90}Th \rightarrow {}^{226}_{88}Ra$$

How many decays involve the emission of a β-particle?

A 1 **B** 2 **C** 3 **D** 5

92 Two beams of radiation, P and Q, enter an electric field as shown. **(extended only)**



Which type of radiations are P and Q?

	P	Q
A	beta (β)	alpha (α)
B	beta (β)	gamma (γ)
C	gamma (γ)	alpha (α)
D	gamma (γ)	gamma (γ)

93 Which equation represents the β-decay of lead-209? **(extended only)**

A $^{209}_{82}Pb + {}^{0}_{-1}e \rightarrow {}^{209}_{83}Bi$

B $^{209}_{82}Pb + {}^{0}_{-1}e \rightarrow {}^{209}_{81}Tl$

C $^{209}_{82}Pb \rightarrow {}^{209}_{83}Bi + {}^{0}_{-1}e$

D $^{209}_{82}Pb \rightarrow {}^{209}_{81}Tl + {}^{0}_{-1}e$

94 A beam of particles moves through a magnetic field. **(extended only)**

In which situation do the particles experience a magnetic force?

A a beam of α-particles moving parallel to the magnetic field lines

B a beam of electrons moving parallel to the magnetic field lines

C a beam of β-particles moving perpendicularly across the magnetic field lines

D a beam of neutrons moving perpendicularly across the magnetic field lines

95 Uranium-235 is a radioactive isotope. It undergoes a chain of decays and eventually forms the stable isotope lead-207. These two isotopes are represented as shown.

$^{235}_{92}U$ $^{207}_{82}Pb$

During this chain of decay, how many protons and how many neutrons are lost from a single nucleus of uranium-235 to form a single nucleus of lead-207?

	protons	neutrons
A	10	18
B	10	28
C	18	10
D	28	10

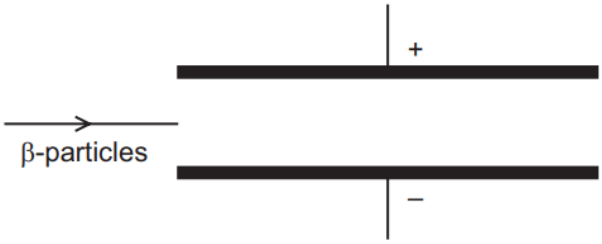
96 A radioactive material has a half-life of 20 days.

A sample of the material contains 8.0×10^{10} atoms.

How many atomic nuclei have decayed after 60 days?

A 1.0×10^{10} **B** 4.0×10^{10} **C** 6.0×10^{10} **D** 7.0×10^{10}

97 The diagram shows a beam of β-particles passing through a strong electric field. **(extended only)**



In which direction will the β-particles be deflected?

A upwards towards the top of the page

B downwards towards the bottom of the page

C into the plane of the page

D out of the plane of the page

98 Plutonium-238 decays by the emission of an α-particle. **(extended only)**

Which equation represents the decay of a plutonium-238 nucleus?

A $^{238}_{94}Pu \rightarrow {}^{238}_{95}U + {}^{0}_{-1}\alpha$

B $^{238}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{4}_{2}\alpha$

C $^{238}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{2}_{4}\alpha$

D $^{238}_{94}Pu \rightarrow {}^{242}_{96}U + {}^{4}_{2}\alpha$

99 The chemical symbol for sodium is Na. The equation represents the radioactive decay of sodium-24. **(extended only)**

$$^{24}_{11}Na \rightarrow {}^{24}_{x}Mg + {}^{y}_{-1}e$$

What are the numbers x and y?

	x	y
A	10	0
B	10	1
C	12	0
D	12	1

100 The chemical symbol for uranium is U. The equation represents the radioactive decay of uranium-235. **(extended only)**

$$^{235}_{92}U \rightarrow {}^{x}_{y}Th + {}^{4}_{2}He$$

What are the numbers x and y?

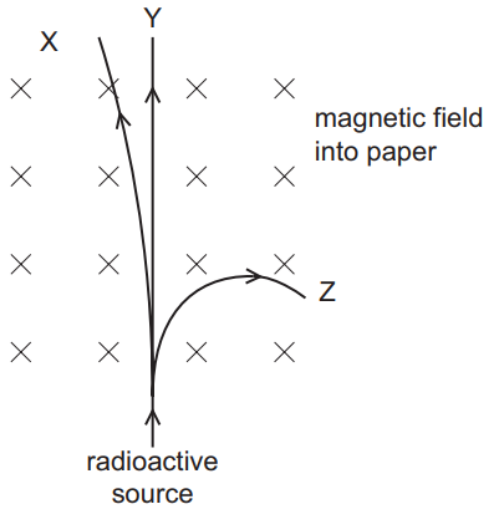
	x	y
A	231	94
B	231	90
C	239	94
D	239	90

101 A radioactive source emits α-particles, β-particles and γ-rays into a vacuum where there is a magnetic field.

(extended only)

The magnetic field acts perpendicularly into the plane of the paper.

The paths X, Y and Z of the three types of radiation through the magnetic field are shown.

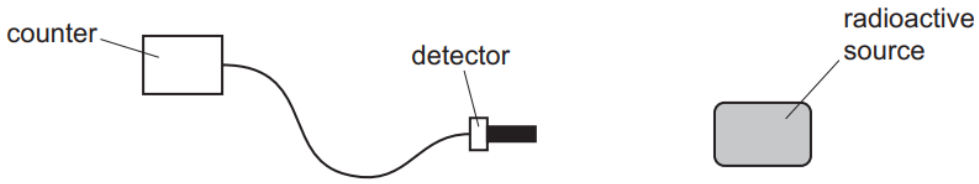


Which radiation follows path X, path Y and path Z?

	X	Y	Z
A	α-particles	β-particles	γ-rays
B	α-particles	γ-rays	β-particles
C	β-particles	α-particles	γ-rays
D	β-particles	γ-rays	α-particles

102 An experiment is done to measure the radiation from a radioactive source that has a half-life of 10 minutes. **(extended only)**

The source is placed close to a detector that is connected to a counter, as shown.



The average background count-rate is 20 counts / minute.

At the start of the experiment, the count-rate recorded by the counter is 1000 counts / minute.

What is the count-rate 10 minutes later?

A 490 counts / minute

B 500 counts / minute

C 510 counts / minute

D 530 counts / minute

103 An isotope of polonium has the nuclide notation $^{218}_{84}\text{Po}$. **(extended only)**

A nucleus of this isotope decays by emitting an α-particle. A β-particle is then emitted to form nuclide X.

What is the notation for nuclide X?

A $^{214}_{81}\text{X}$ **B** $^{213}_{82}\text{X}$ **C** $^{213}_{83}\text{X}$ **D** $^{214}_{83}\text{X}$

104 A scientist measures the count rate of a radioactive sample in a laboratory over a period of 12 weeks.

The background radiation count rate in the laboratory remains constant at 20 counts per minute.

The table shows the scientist's results before the background radiation count rate is taken into account.

(extended only)

time / weeks	count rate / counts per minute
0	100
2	80
4	65
6	54
8	45
10	39
12	34

In which range does the half-life of the radioactive isotope lie?

A between 4 and 6 weeks

B between 6 and 8 weeks

C between 8 and 10 weeks

D more than 12 weeks

105 A radioactive nucleus $^{220}_{86}Rn$ decays in two stages to produce $^{212}_{82}Pb$. **(extended only)**

Which two particles are emitted in this process?

A an α-particle and a β-particle

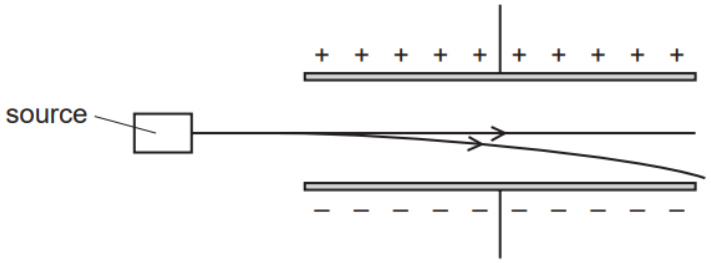
B an α-particle and a proton

C two α-particles

D two β-particles

106 The diagram shows emissions from a source passing into the electric field between two charged plates.

(extended only)



What is emitted by this source?

A neutrons and γ-rays only

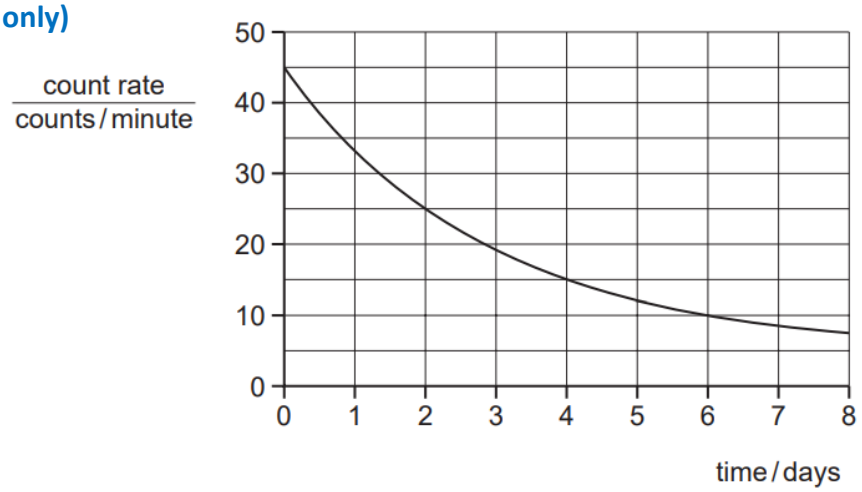
B α-particles and β-particles only

C α-particles and γ-rays only

D β-particles and γ-rays only

107 The graph shows how the count rate registered by a counter near to a sample of a radioactive isotope changes over a period of a few days. The background count rate is 5 counts per minute.

(extended only)



What is the half-life of the isotope?

A 2.0 days **B** 2.5 days **C** 3.0 days **D** 4.0 days