

Radioactivity

Question Paper

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|------------|--------------------------------------|
| 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:

CHEMISTRY ONLINE
— TUITION —

- 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.

- 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 $^{215}_{84}\text{Po}$ 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 |

- 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

- 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}

- 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.

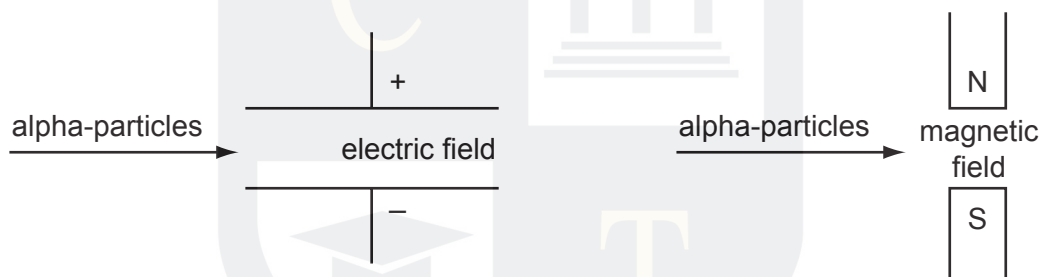
What is the half-life of the source?

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

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.



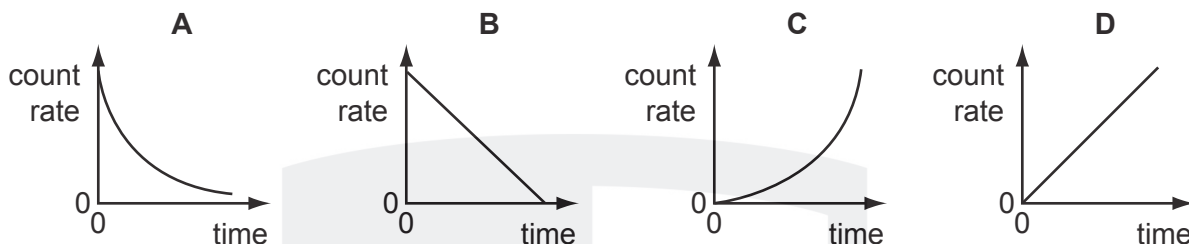
How is the path of the particles affected by these fields?

| | 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 |

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

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?

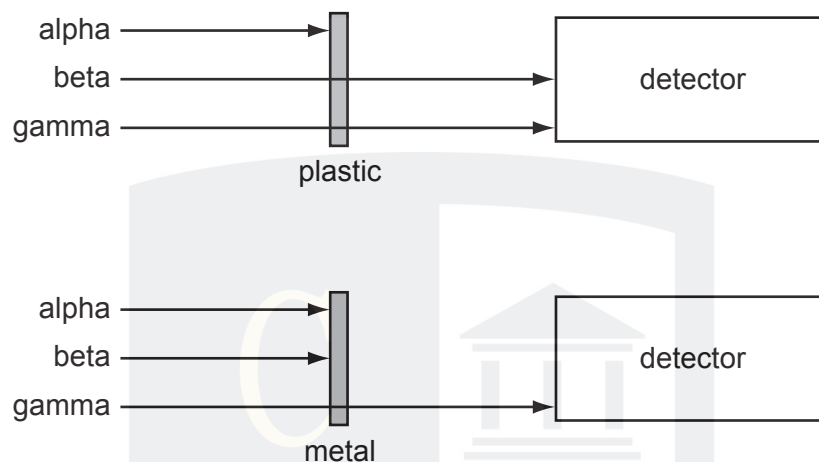
- A 8 minutes
- B 6 minutes
- C 4 minutes
- D 3 minutes

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 |

- 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

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?

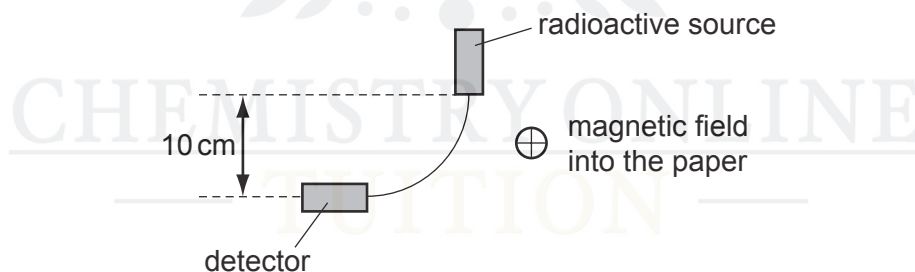
- A 40 million
- B 20 million
- C 10 million
- D 5 million

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

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.

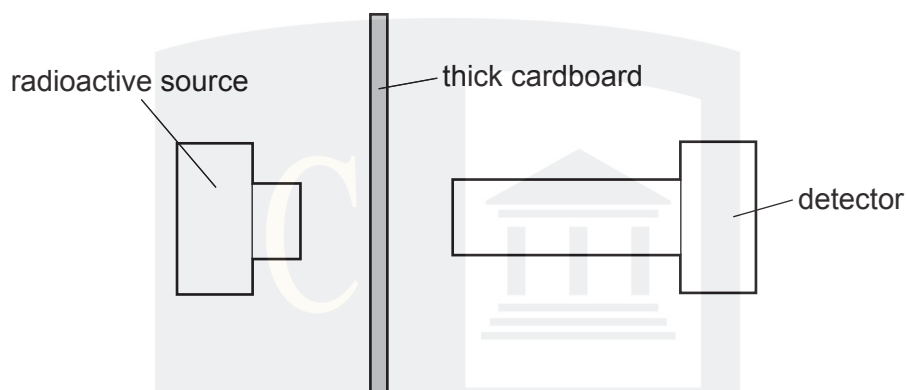
| nuclide | number of radioactive atoms at time = 0 | half-life |
|---------|---|-----------|
| X | 16 000 | 1 day |
| Y | 2 000 | 2 days |

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

- 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.

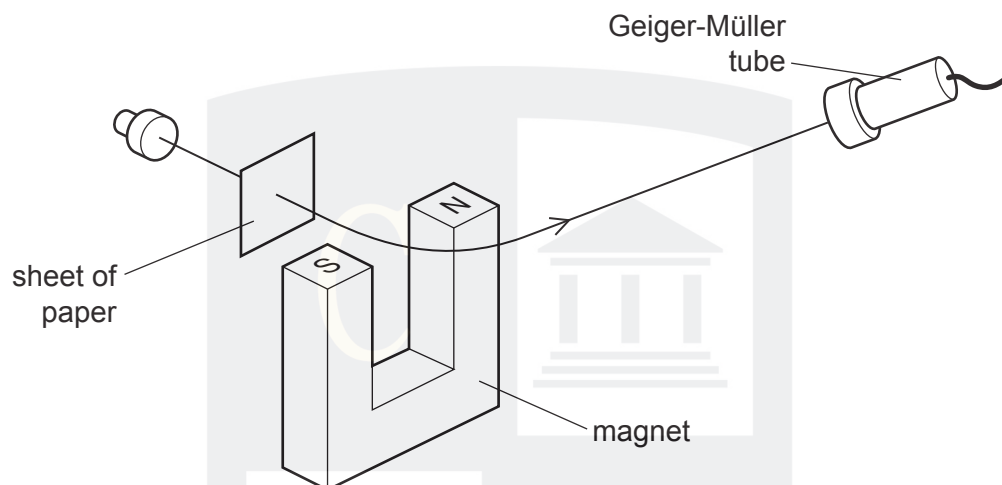


What is the reading on the detector now, and why?

| | 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.



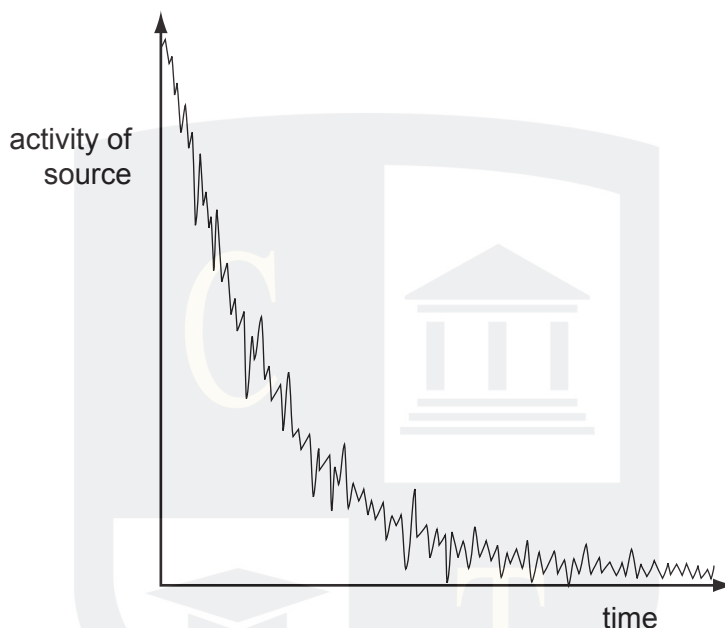
What is detected by the Geiger-Müller tube?

- 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

- 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

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?

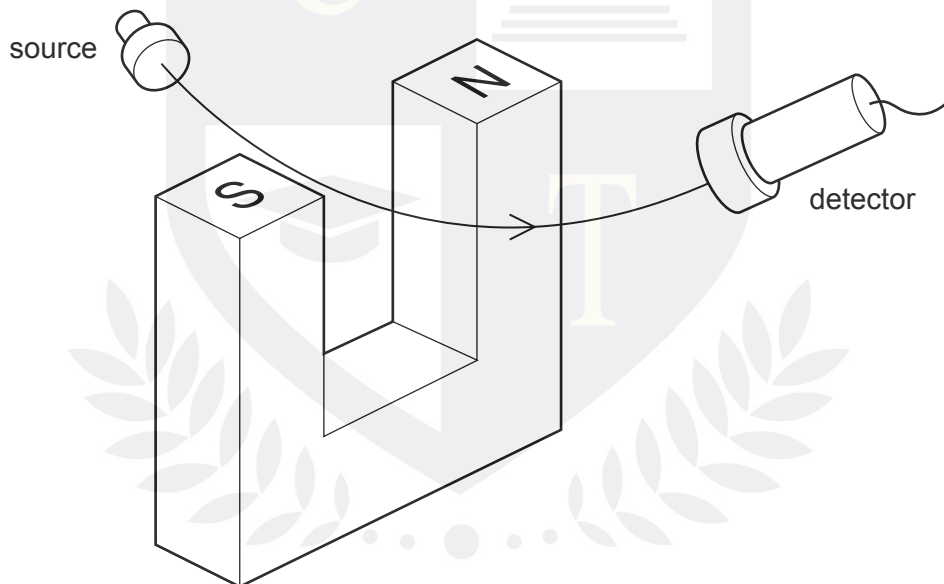
- A The nucleus absorbs another nucleus.
- B The nucleus absorbs at least one form of radiation.
- C The nucleus always splits into two equal fragments.
- D The nucleus emits at least one form of radiation.

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 |

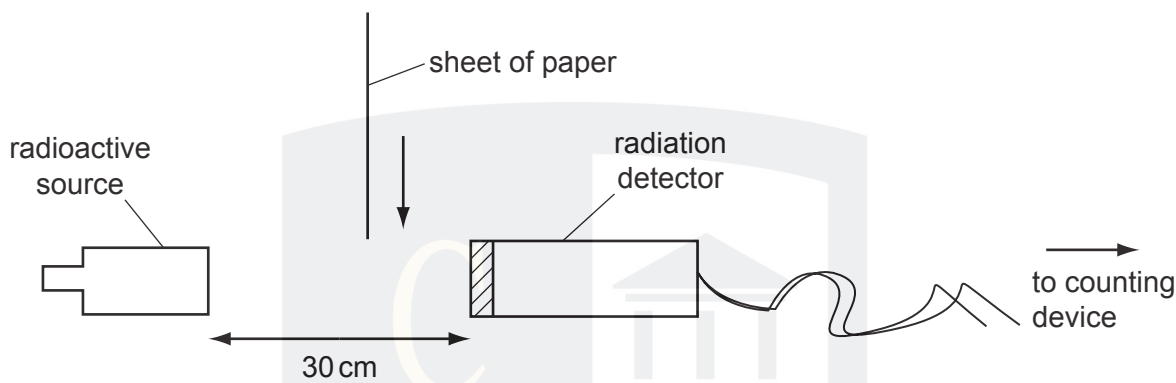
- 48 Which statement is true for all three types of radioactive emission (alpha-particles, beta-particles and gamma-rays)?
- A They are completely absorbed by a thin aluminium sheet.
 - B They are deflected by electric fields.
 - C They emit light.
 - D They ionise gases.
- 49 The diagram shows one type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

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



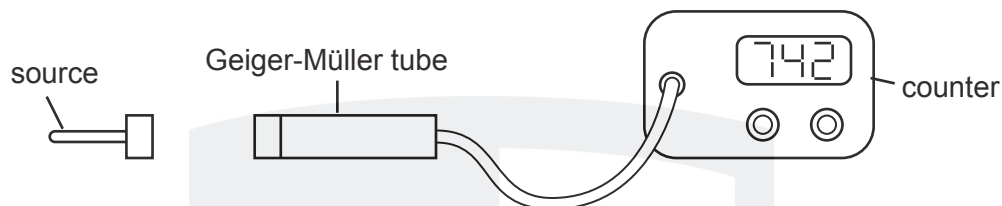
The experimenter moves the paper between the source and the detector. There is no difference in the count-rate.

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

- 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 ${}^{239}_{92}\text{U} \rightarrow {}^{95}_{38}\text{Sr} + {}^{141}_{54}\text{Xe} + 3 \text{ neutrons}$

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.

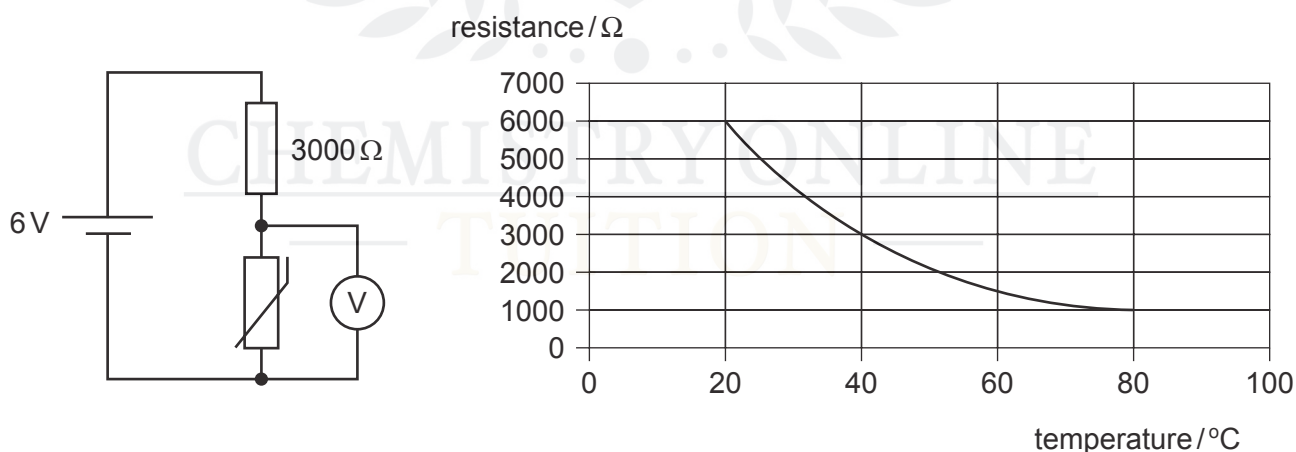
What is the fraction?

- A** $\frac{1}{3}$ **B** $\frac{1}{4}$ **C** $\frac{1}{6}$ **D** $\frac{1}{8}$

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 |

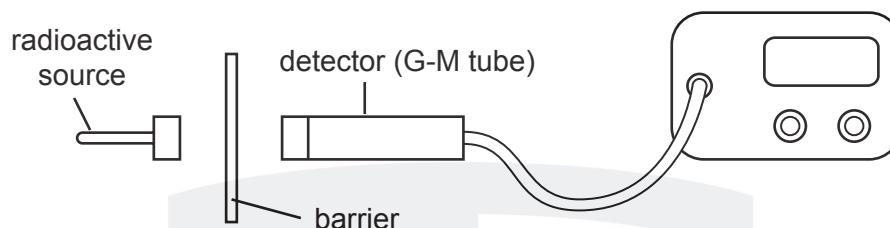
56 A thermistor is connected in a circuit with a 6 V cell, a $3000\ \Omega$ resistor and a voltmeter, as shown. The graph shows how the resistance of the thermistor varies with temperature.



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

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

- 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.



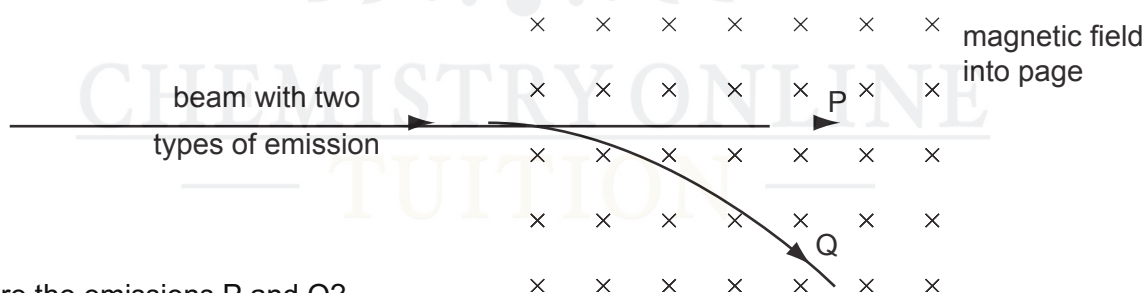
The table shows the count rates recorded by the detector for four sources.

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.

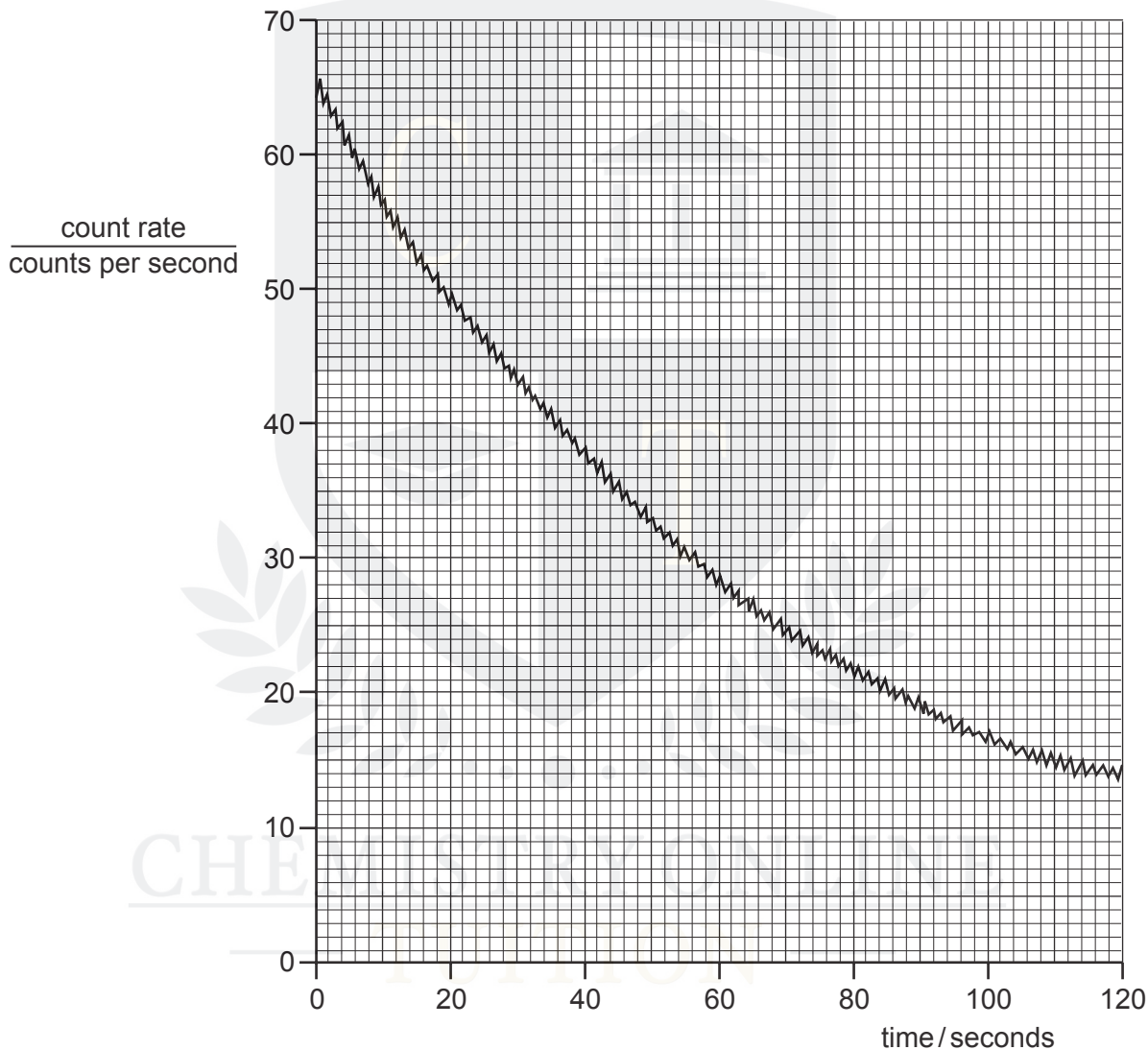


What are the emissions P and Q?

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

- 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

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

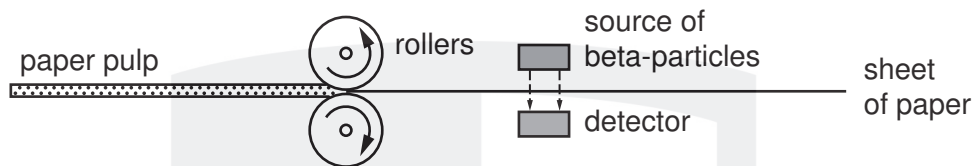
62 A radioactive isotope has a half-life of 2 minutes.

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.

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 |