AQA GCSE PHYSICS (HIGHER) · 8463

# PHYSICS



## EXAM QUESTION PACK

4.4.3 HAZARDS AND USES OF RADIOACTIVE EMISSIONS AND OF BACKGROUND RADIATION (PACK 1)

| SCORE | PERCENTAGE |
| --- | --- |
| /274 | % |

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## Q1.

A teacher used a Geiger-Muller tube and counter to measure the number of counts in 60 seconds for a radioactive rock.

(a) The counter recorded 819 counts in 60 seconds. The background radiation count rate was 0.30 counts per second.

Calculate the count rate for the rock.

_____

_____

_____

_____

Count rate = _____ per second

**(3)**

(b) A householder is worried about the radiation emitted by the granite worktop in his kitchen.

1 kg of granite has an activity of 1250 Bq. The kitchen worktop has a mass of 180 kg.

Calculate the activity of the kitchen worktop in Bq.

_____

_____

_____

_____

Activity = _____ Bq

**(2)**

(c) The average total radiation dose per year in the UK is 2.0 millisieverts.

The table below shows the effects of radiation dose on the human body.

| **Radiation dose in millisieverts** | **Effects** |
|---|---|
| 10 000 | Immediate illness; death within a few weeks |
| 1000 | Radiation sickness; unlikely to cause death |
| 100 | Lowest dose with evidence of causing cancer |

The average radiation dose from the granite worktop is 0.003 millisieverts per day.



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Explain why the householder should **not** be concerned about his yearly radiation dose from the granite worktop.

One year is 365 days.

_____

_____

_____

_____

**(2)**

(d) Bananas are a source of background radiation. Some people think that the unit of radiation dose should be changed from sieverts to Banana Equivalent Dose.

Suggest **one** reason why the Banana Equivalent Dose may help the public be more aware of radiation risks.

_____

_____

_____

_____

**(1)**

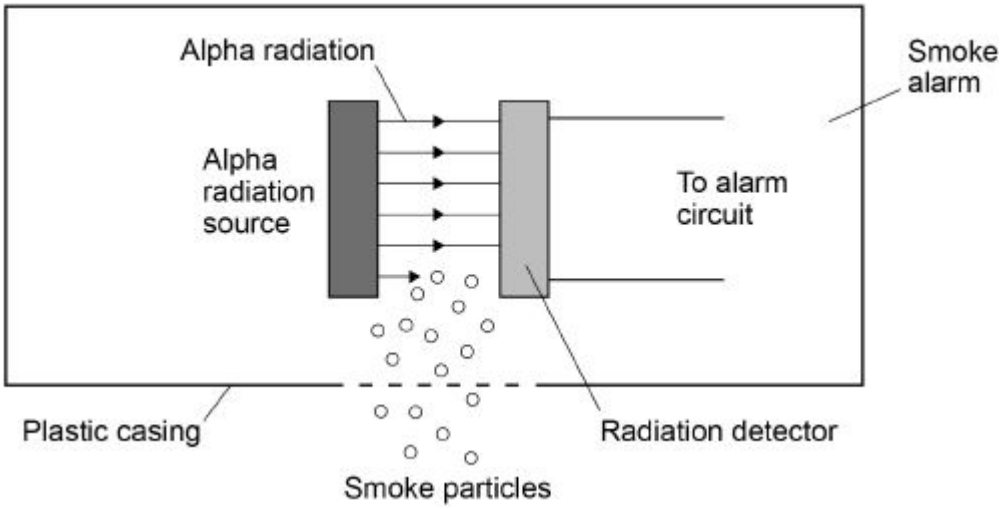
**(Total 8 marks)**

## Q2.

Smoke alarms contain an alpha radiation source and a radiation detector.

**Figure 1** shows part of the inside of a smoke alarm.

**Figure 1**




(a) The smoke alarm stays off while alpha radiation reaches the detector.

Why does the alarm switch on when smoke particles enter the plastic casing?



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_____

_____

_____

**(1)**

(b) Why is it safe to use a source of alpha radiation in a house?

_____

_____

_____

**(1)**

(c) The smoke alarm would not work with a radiation source that emits beta or gamma radiation.

Explain why.

_____

_____

_____

_____

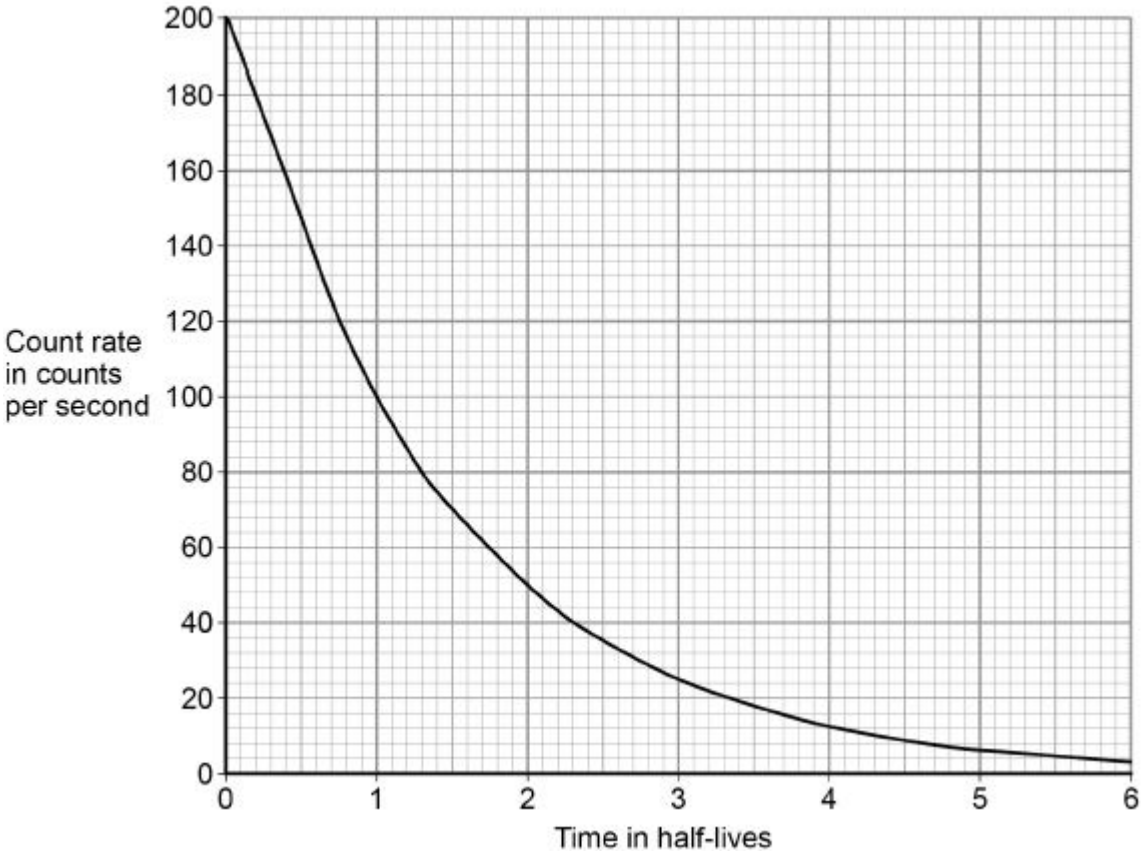
**(2)**

(d) **Figure 2** shows how the count rate detected from the radiation source in the smoke alarm changes with time.

**Figure 2**



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The smoke alarm switches on when the count rate falls to 80 counts per second.

Explain why the radiation source inside the smoke alarm should have a long half-life.

_____

_____

_____

_____

**(2)**

(e) **Figure 3** shows a patient who has been injected with a radioactive source for medical diagnosis.

**Figure 3**



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Explain the ideal properties of a radioactive source for use in medical diagnosis.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

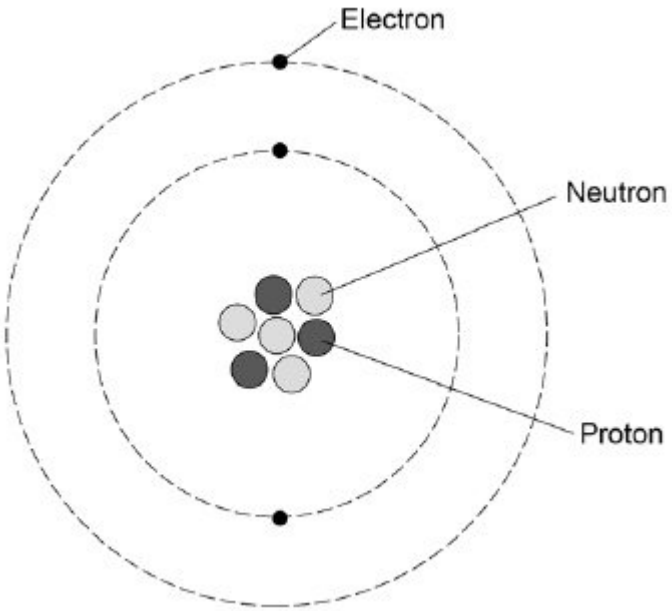
**(Total 10 marks)**

## Q3.

The diagram shows a lithium atom.



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(a) What is the mass number of this lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

**(1)**

(b) What is the atomic number of a lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

Give a reason for your answer.

_____

_____

**(2)**

(c) Complete the sentence.

Choose the answer from the box.

| **circles** | **levels** | **rings** |
|---|---|---|

The electrons in an atom orbit in different energy _____ .

**(1)**

(d) Some atomic nuclei are unstable and decay by emitting an alpha particle or a beta particle.

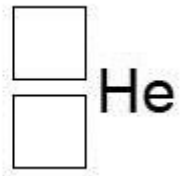


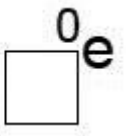
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Complete the symbols for an alpha particle and a beta particle.

Use answers from the box.

| –1 | 0 | 1 | 2 | 4 |
|---|---|---|---|---|

Alpha 

Beta 

**(3)**

(e) Doctors may use nuclear radiation to diagnose certain types of illness.

The table below gives data about three radiation sources used.

Each source emits beta radiation.

| Radiation source | Half-life in minutes |
|---|---|
| Carbon-11 | 20 |
| Nitrogen-13 | 10 |
| Oxygen-15 | 2 |

Explain why oxygen-15 is likely to pose the least risk to a patient.

_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

## Q4.

Sources of background radiation are either natural or man-made.

(a) Which **two** of the sources listed in the table are natural sources of background radiation?

Tick **two** boxes.



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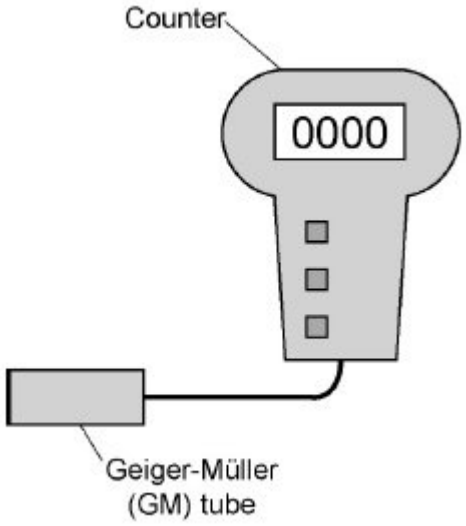
| | |
|---|---|
| Cosmic rays | ☐ |
| Medical X-rays | ☐ |
| Nuclear power stations | ☐ |
| Nuclear weapons testing | ☐ |
| Radon gas | ☐ |

**(2)**

A teacher used a Geiger-Müller (GM) tube and counter to measure the background radiation in his laboratory.

**Figure 1** shows the GM tube and counter.

**Figure 1**




(b) The table gives three readings taken by the teacher at three different times on the same day.

| Counts in 1 minute |
|---|
| 16 |
| 21 |
| 18 |

What is the most likely reason for the readings being different?

Tick **one** box.



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Radioactive decay is a random process. ☐

The air pressure in the laboratory increased. ☐

The background radiation increased during the day. ☐

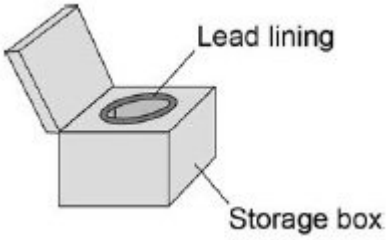
The temperature in the laboratory decreased. ☐

**(1)**

(c) The teacher takes a radioactive source from a storage box.

**Figure 2** shows the box.

**Figure 2**




Why does storing the radioactive source in the box reduce the risk of radiation exposure to the teacher?

Tick **one** box.

The lead lining absorbs the emitted radiation. ☐

The lead lining reflects the emitted radiation. ☐

The lead lining transmits the emitted radiation. ☐

**(1)**

(d) **Figure 3** shows how the teacher used the GM tube and counter to measure the radiation emitted from the radioactive source.

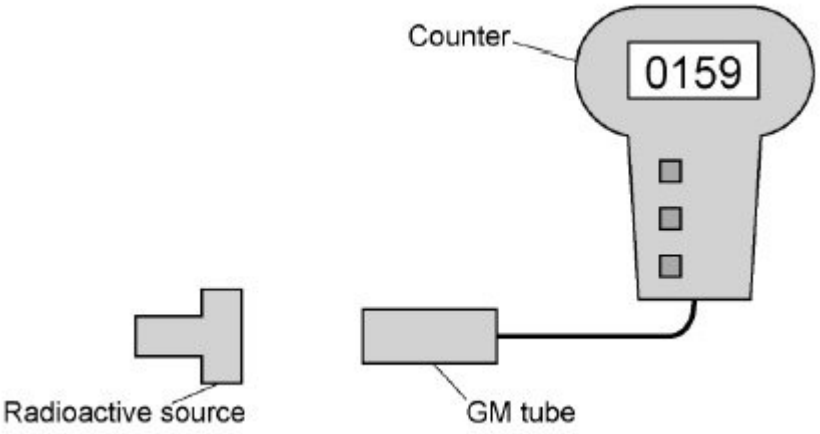
The counter was reset to zero.

The count after one minute was 159.

**Figure 3**



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How should the teacher calculate the counts from the radioactive source?

Tick **one** box.

Add the background count to 159 ☐

Divide the background count by 159 ☐

Multiply the background count by 159 ☐

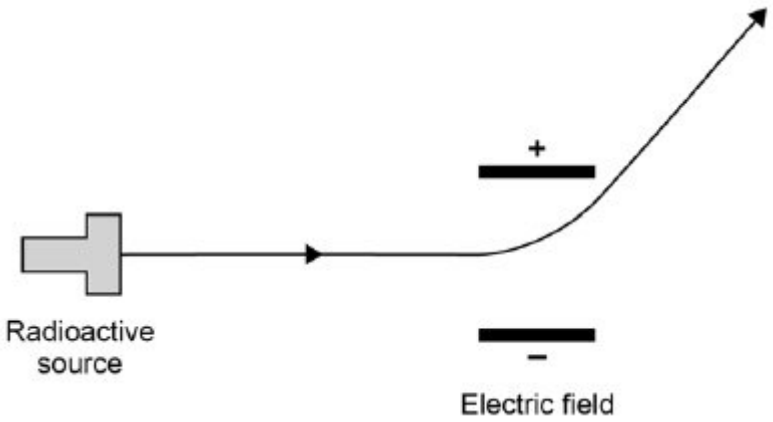
Subtract the background count from 159 ☐

**(1)**

(e) The teacher passed the radiation through an electric field.

**Figure 4** shows the path that the radiation took through the electric field.

**Figure 4**




What type of radiation was being emitted by the radioactive source?

Tick **one** box.



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Alpha ☐ Beta ☐ Gamma ☐ Neutron ☐

Explain the reason for your answer.

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 8 marks)**

## Q5.

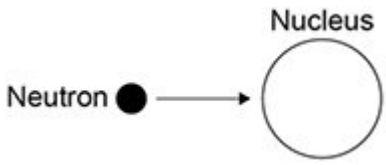
Electricity is generated in a nuclear power station.

Fission is the process by which energy is released in the nuclear reactor.

(a) **Figure 1** shows the first part of the nuclear fission reaction.

Complete **Figure 1** to show how the fission process starts a chain reaction.

**Figure 1**



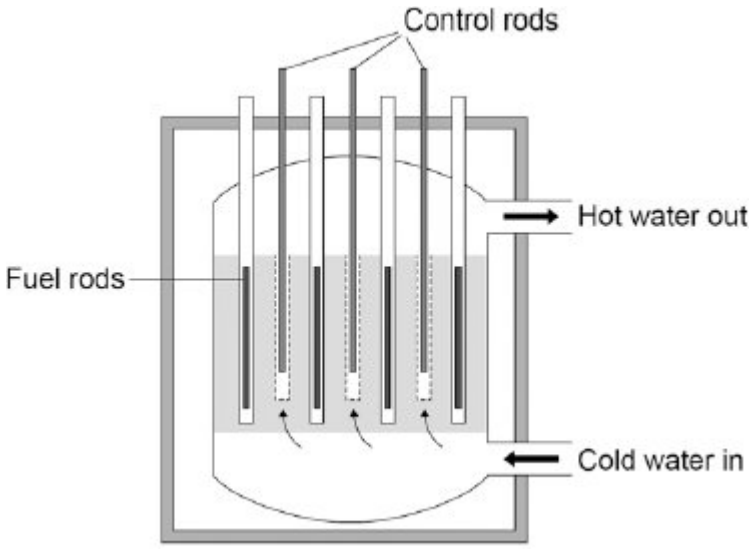

**(3)**

(b) **Figure 2** shows the inside of a nuclear reactor in a nuclear power station.

**Figure 2**



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In a nuclear reactor a chain reaction occurs, which causes neutrons to be released.

The control rods absorb neutrons.

The control rods can be moved up and down.

Explain how the energy released by the chain reaction is affected by moving the control rods.

_____

_____

_____

_____

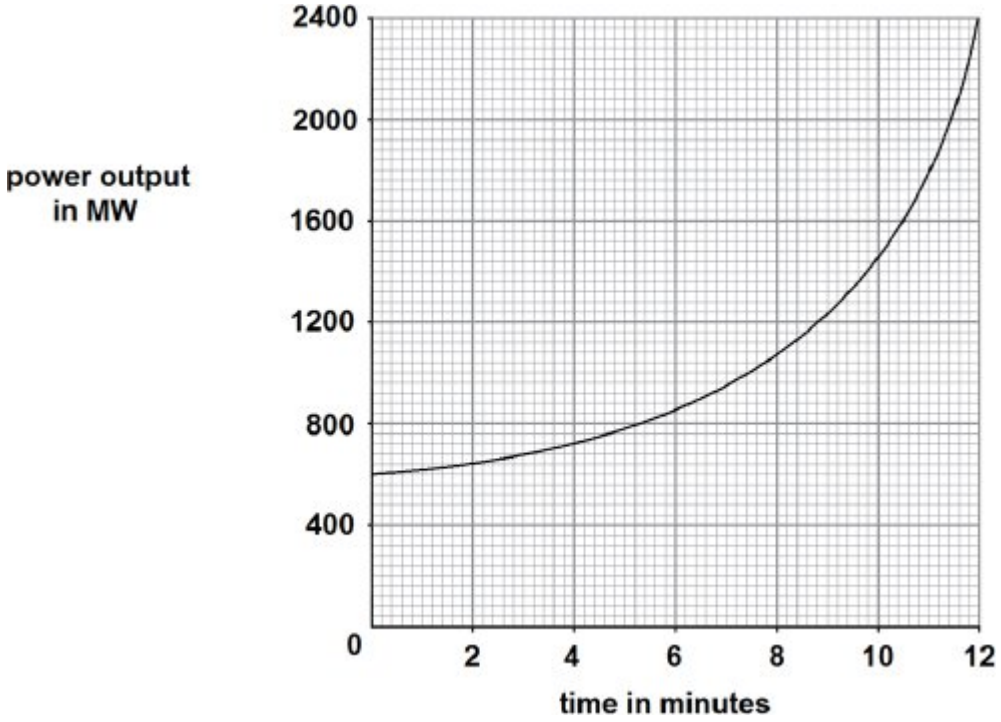
**(2)**

(c) **Figure 3** shows how the power output of the nuclear reactor would change if the control rods were removed.

**Figure 3**



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Calculate the rate of increase of power output at 10 minutes.

_____

_____

_____

_____

Rate of increase of power output = _____ MW / minute

**(2)**

**(Total 7 marks)**

## Q6.

Alpha particles, beta particles and gamma rays are types of nuclear radiation.

(a) Describe the structure of an alpha particle.

_____

_____

**(1)**

(b) Nuclear radiation can change atoms into ions by the process of ionisation.

(i) Which type of nuclear radiation is the least ionising?

Tick (✔) **one** box.

alpha particles ☐



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beta particles ☐

gamma rays ☐

**(1)**

(ii) What happens to the structure of an atom when the atom is ionised?

_____

_____

**(1)**

(c) People working with sources of nuclear radiation risk damaging their health.

State **one** precaution these people should take to reduce the risk to their health.

_____

_____

**(1)**

**(Total 4 marks)**

## Q7.

(a) Radioactive sources that emit alpha, beta or gamma radiation can be dangerous.

What is a possible risk to health caused by using a radioactive source?

_____

_____

**(1)**

(b) In an experiment, a teacher put a 2 mm thick lead sheet in front of a radioactive source.
She used a detector and counter to measure the radiation passing through the lead sheet in one minute.

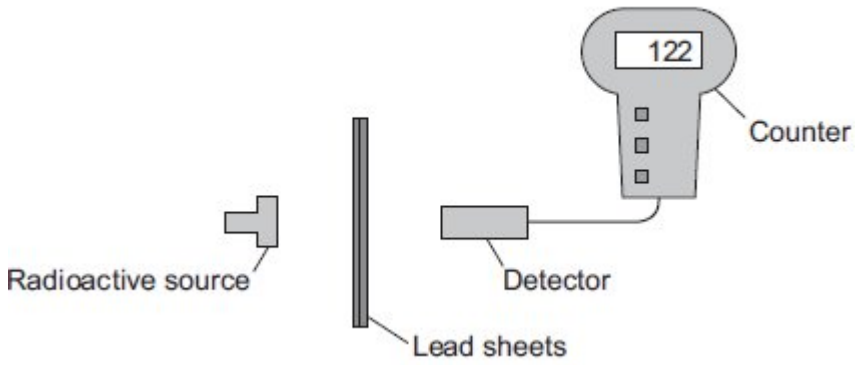
She then put different numbers of lead sheets, each 2 mm thick, in front of the radioactive source and measured the radiation passing through in one minute.

The apparatus the teacher used is shown in **Figure 1**.



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**Figure 1**




(i) When using a radioactive source in an experiment, how could the teacher reduce the risk to her health?

Suggest **one** way.

_____

_____

**(1)**

(ii) The number recorded on the counter is actually higher than the amount of radiation detected from the source.

Complete the following word equation.

| | | | | |
|---|---|---|---|---|
| The number recorded on the counter | = | The amount of radiation detected from the source | + | _____ radiation |

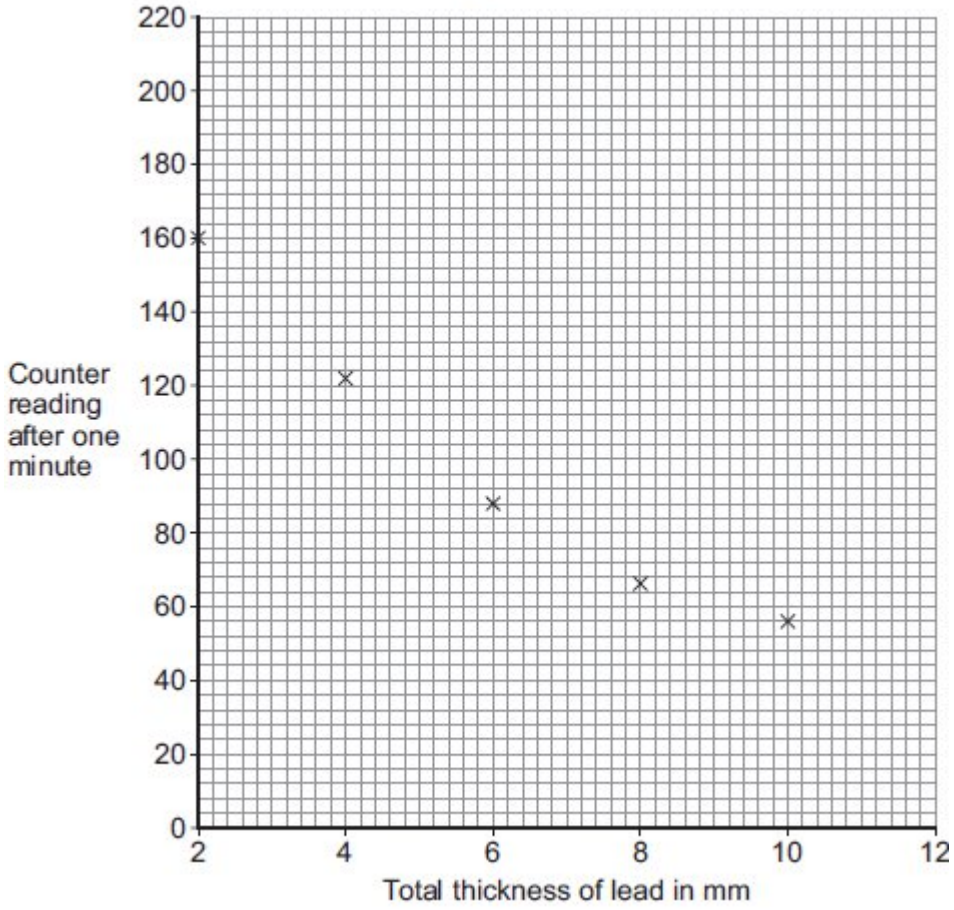
**(1)**

(c) The readings taken by the teacher are plotted in **Figure 2**.



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**Figure 2**




(i) Draw a line of best fit to complete **Figure 2**.

**(1)**

(ii) How does the amount of radiation **absorbed** by the lead change as the total thickness of the lead is increased?

_____

_____

**(1)**

(iii) Use **Figure 2** to estimate the reading on the counter when the total thickness of the lead is increased to 12 mm.

Estimated counter reading = _____

**(1)**

(d) What type of radiation was emitted from the radioactive source?

Draw a ring around the correct answer.

**alpha** **beta** **gamma**

Give a reason for your answer.

_____



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_____

**(2)**

**(Total 8 marks)**

## Q8.

Different radioactive isotopes have different values of half-life.

(a) What is meant by the 'half-life' of a radioactive isotope?

_____

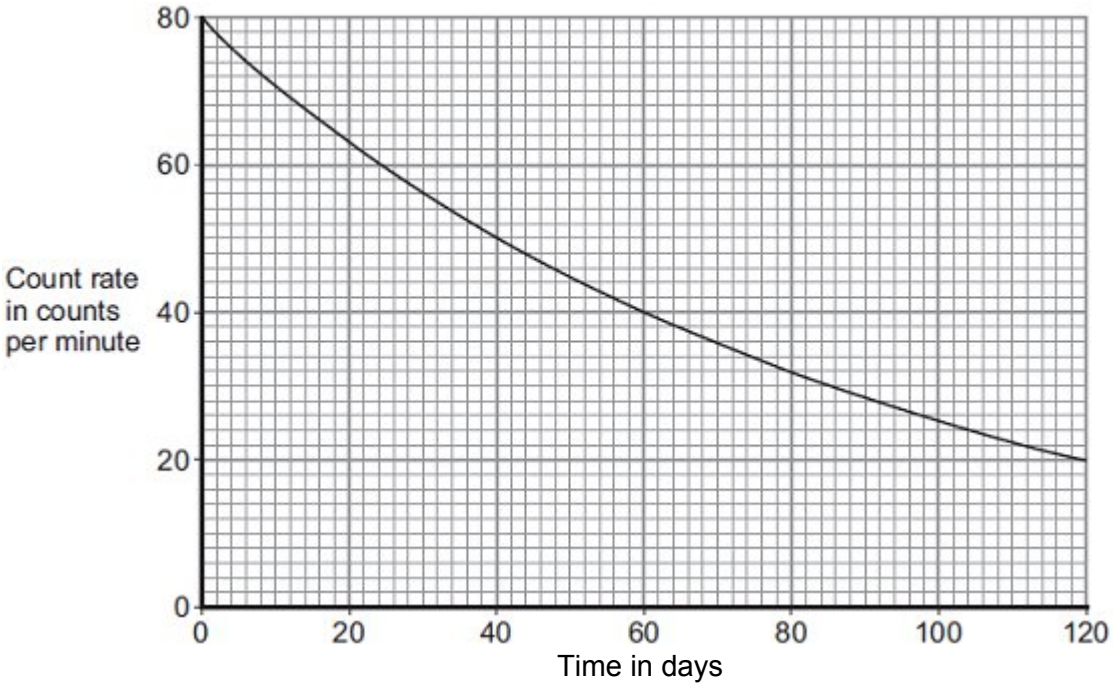
_____

_____

**(1)**

(b) **Figure 1** shows how the count rate from a sample of a radioactive isotope varies with time.

**Figure 1**




Use information from **Figure 1** to calculate the half-life of the radioactive isotope.

Show clearly on **Figure 1** how you obtain your answer.

Half-life = _____ days

**(2)**

(c) The table below shows data for some radioactive isotopes that are used in schools.

| Radioactive isotope | Type of radiation emitted | Half-life in years |
|---|---|---|
| Americium-241 | Alpha and gamma | 460 |



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| | | |
|---|---|---|
| Cobalt-60 | Gamma | 5 |
| Radium-226 | Alpha, beta and gamma | 1600 |
| Strontium-90 | Beta | 28 |
| Thorium-232 | Alpha and beta | $1.4 \times 10^{10}$ |

(i) State which radioactive isotope in the table above emits only radiation that is **not** deflected by a magnetic field.

Give a reason for your choice.

_____

_____

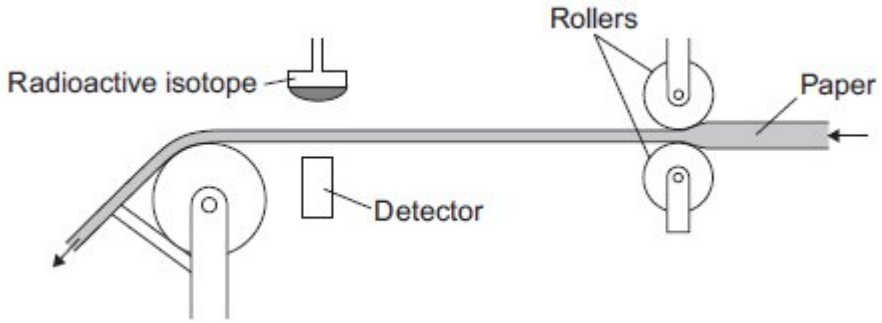
_____

_____

**(2)**

(ii) **Figure 2** shows a radioactive isotope being used to monitor the thickness of paper during production.

**Figure 2**




State which radioactive isotope in the table should be used to monitor the thickness of the paper.

Explain your choice.

_____

_____

_____

_____

_____

**(3)**

All the radioactive isotopes in the table have practical uses.



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State which source in the table would need replacing most often.

Explain your choice.

_____

_____

_____

_____

_____

**(3)**

(iii) When the radioactive isotopes are not in use, they are stored in lead-lined wooden boxes.

The boxes reduce the level of radiation that reaches the surroundings.

**Figure 3** shows two of these boxes.

**Figure 3**




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State **one** source from the table which emits radiation that could penetrate the box.

Explain your answer.

_____

_____

_____

_____

_____



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_____

**(3)**

**(Total 14 marks)**

## Q9.

Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

| **Geiger counter** | **nuclear reactor** | **star** |
|---|---|---|

Nuclear fission takes place within a _____ .

Nuclear fusion takes place within a _____ .

**(2)**

(ii) State **one** way in which the process of nuclear fusion differs from the process of nuclear fission.

_____

_____

**(1)**

(b) The following nuclear equation represents the fission of uranium-235 (U-235).

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}$$

Chemical symbols:

Ba - barium

Kr - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**



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(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

Complete the nuclear equation that represents the decay of Ba-139 to La-139.

$$^{139}Ba \longrightarrow {}^{139}La + \text{.....}$$

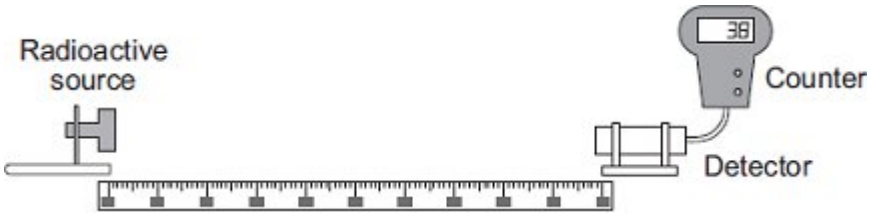
.....  .....  .....

**(3)**

**(Total 10 marks)**

## Q10.

A teacher used the equipment shown in the diagram to measure the count rate at different distances from a radioactive source.




Metre rule

(a) Her results are shown in **Table 1**.

**Table 1**

| Distance in metres | Count rate in counts per minute | Corrected count rate in counts per minute |
|---|---|---|
| 0.4 | 143 | 125 |
| 0.6 | 74 | 56 |
| 0.8 | 49 | 31 |
| 1.0 | 38 | 20 |
| 1.2 | 32 | 14 |
| 1.4 | 28 | 10 |
| 1.6 | 18 | 0 |
| 1.8 | 18 | 0 |
| 2.0 | 18 | 0 |

The background count rate has been used to calculate the corrected count rate.

(i) What is the value of the background count rate?

Background count rate = _____ counts per minute

**(1)**



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(ii) What information does the corrected count rate give?

_____

_____

**(1)**

(iii) The radioactive source used in the demonstration emits only one type of radiation.

The radioactive source is **not** an alpha emitter.

How can you tell from the data in the table?

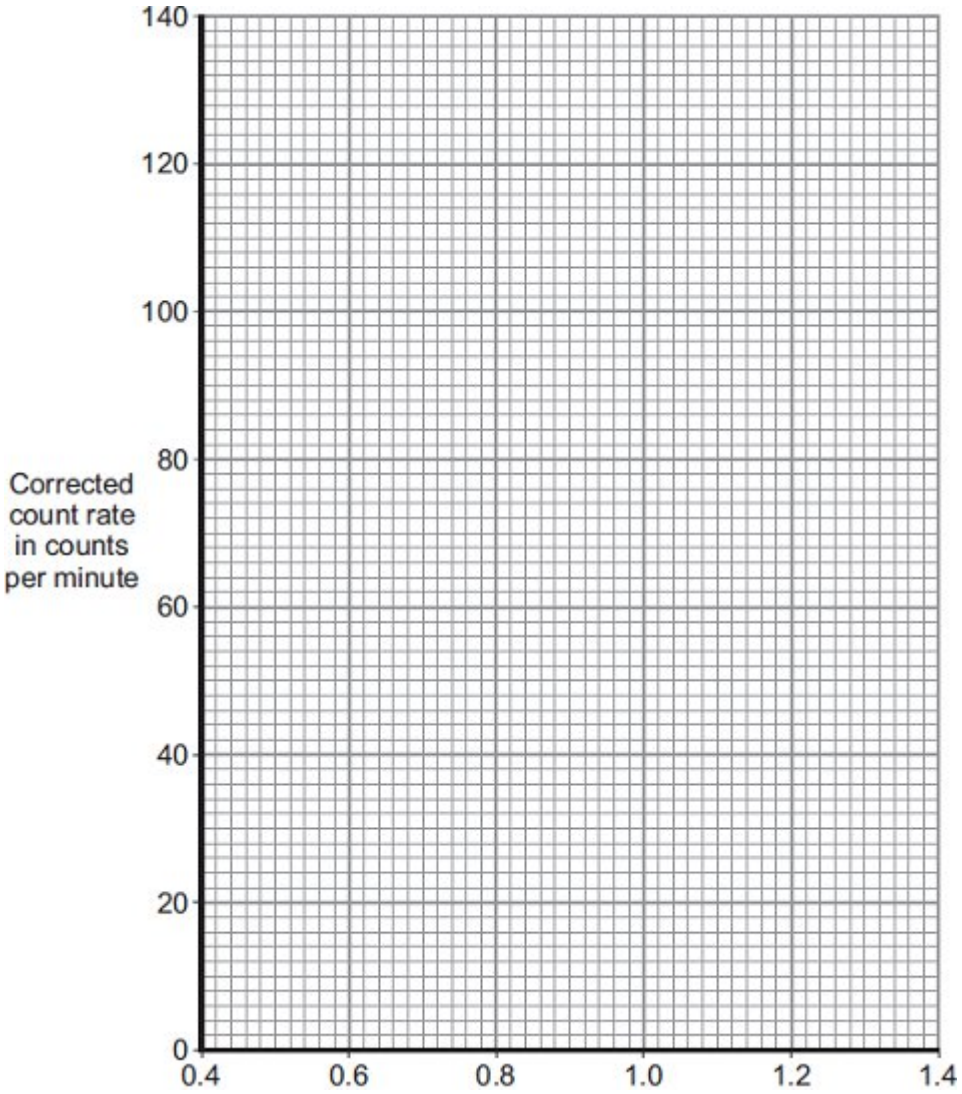
_____

_____

**(1)**

(iv) Plot a graph of corrected count rate against distance for distances between 0.4 m and 1.4 m.

Draw a line of best fit to complete the graph.






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Distance in metres

**(3)**

(v) The ‘half-distance’ is the distance a detector has to be moved away from a radioactive source for the corrected count rate to halve.

A student has the hypothesis:
A radioactive source has a constant ‘half-distance’.

**Table 1** has been repeated for your information.

**Table 1**

| Distance in metres | Count rate in counts per minute | Corrected count rate in counts per minute |
|---|---|---|
| 0.4 | 143 | 125 |
| 0.6 | 74 | 56 |
| 0.8 | 49 | 31 |
| 1.0 | 38 | 20 |
| 1.2 | 32 | 14 |
| 1.4 | 28 | 10 |
| 1.6 | 18 | 0 |
| 1.8 | 18 | 0 |
| 2.0 | 18 | 0 |

Use **Table 1** to determine if the hypothesis is correct for this radioactive source.

You should use calculations in your answer.

_____

_____

_____

_____

_____

_____

_____

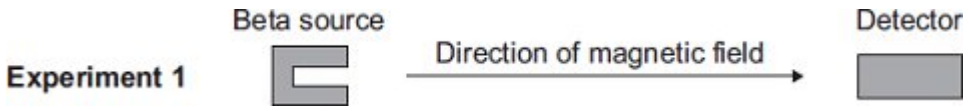
**(3)**

(b) A teacher places a beta source and a detector in a magnetic field.



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The arrangement of the magnetic field is shown.




The teacher repeated the experiment with the magnetic field in a different direction.




A set of results is shown in **Table 2**.

**Table 2**

| Distance between source and detector in metres | Count rate in counts per minute without magnetic field | Count rate in counts per minute in Experiment 1 | Count rate in counts per minute in Experiment 2 |
|---|---|---|---|
| 0.8 | 48 | 48 | 32 |

(i) Describe **and** explain the effect of the magnetic field on the count rate detected by the detector.

_____

_____

_____

_____

_____

_____

**(2)**

(ii) The experiment is repeated with a different distance between the source and the detector.

**Table 3** shows the repeated results.

**Table 3**

| Distance between source and detector in metres | Count rate in counts per minute without magnetic | Count rate in counts per minute in Experiment 1 | Count rate in counts per minute in Experiment 2 |
|---|---|---|---|



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| | field | | |
|---|---|---|---|
| 1.8 | 19 | 18 | 20 |

Explain these results.

_____

_____

_____

_____

_____

_____

**(2)**

**(Total 13 marks)**

## Q11.

(a) Sources of background radiation are either natural or man-made.

Which **two** of the sources listed in the box are *natural* sources of background radiation?

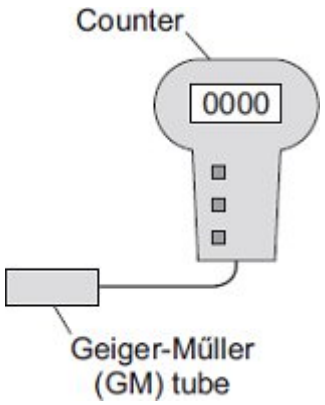
Draw a ring around each of your answers.

| | | | |
|---|---|---|---|
| **cosmic rays** | **nuclear accidents** | **X-rays** | **radon gas** |

**(2)**

(b) A teacher used a Geiger-Műller (GM) tube and counter to measure the background radiation in her laboratory. The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated this two more times.

The three readings taken by the teacher are given in the table.




| Count |
|---|
| 17 |
| 21 |
| 19 |

(i) The three readings are different.

What is the most likely reason for this?



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Tick ( ✓ ) **one** box.

The teacher did not reset the counter to zero. ☐

Radioactive decay is a random process. ☐

The temperature in the laboratory changed. ☐

**(1)**

(ii) Calculate the mean (average) value of the three readings given in the table.

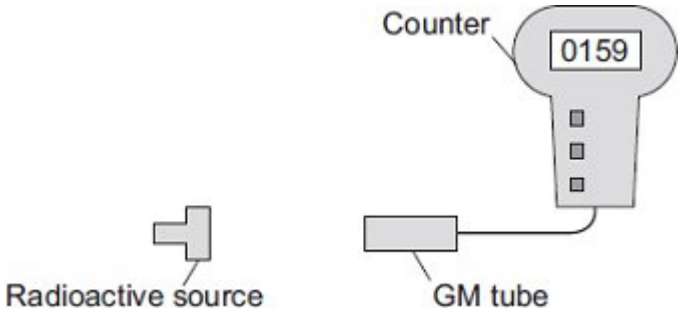
_____

Mean (average) value = _____ counts

**(1)**

(iii) The diagram shows how the teacher used the GM tube and counter to measure the radiation emitted from a radioactive source.

The counter was reset to zero. The count after one minute was 159.




Calculate how many counts were due to the radiation from the radioactive source.

_____

_____

Counts due to the radiation from the radioactive source = _____

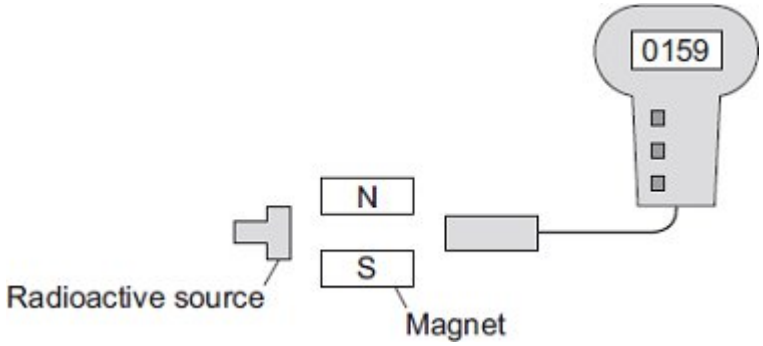
**(1)**

(iv) The teacher then put a powerful magnet between the radioactive source and the GM tube.

The counter was reset to zero. The number on the counter shows the count after one minute.



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What type of radiation was being emitted from the radioactive source?

Draw a ring around your answer.

**alpha** **beta** **gamma**

Explain the reason for your answer.

_____

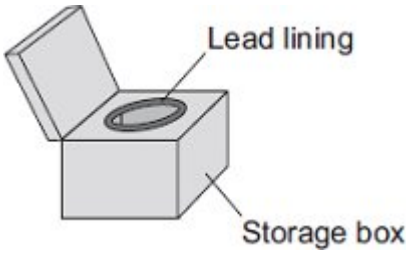
_____

_____

_____

**(3)**

(c) At the end of the lesson the teacher put the radioactive source back inside its storage box.




Why is the inside of the box lined with lead?

_____

_____

**(1)**

(d) Which **one** of the following questions **cannot** be answered by scientific study?

Tick ( ✓ ) **one** box.

Where does background radiation come from? ☐



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What is meant by the half-life of a radioactive source? ☐

Should radioactive waste be dumped in the oceans? ☐

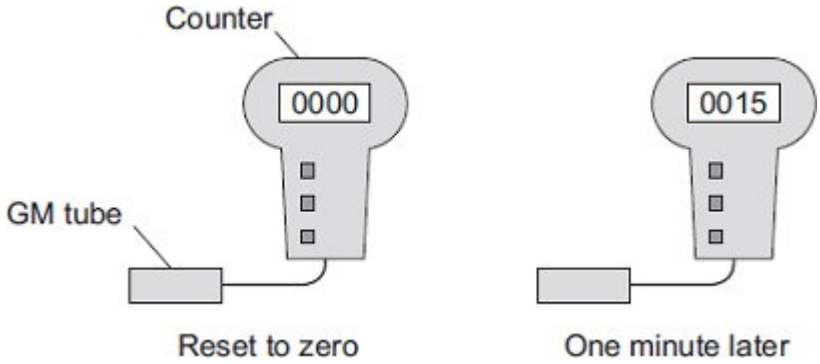
**(1)**

**(Total 10 marks)**

## Q12.

(a) A teacher used a Geiger-Műller (GM) tube and counter to measure the *background radiation* in her laboratory.

The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated the procedure two more times.




(i) Background radiation can be either from natural sources or from man-made sources.

Name **one man-made** source of background radiation.

_____

**(1)**

(ii) The three readings taken by the teacher are given in the table.

| **Count after one minute** |
|---|
| **15** |
| **24** |
| **18** |

The readings given in the table are correct.

Why are the readings different?

_____

_____



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**(1)**

(b) Some scientists say they have found evidence to show that people living in areas of high natural background radiation are less likely to develop cancer than people living in similar areas with lower background radiation.

The evidence these scientists found does not definitely mean that the level of background radiation determines whether a person will develop cancer.

Suggest a reason why.

_____

_____

**(1)**

(c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

$$^{4}_{2}\text{He}$$

(i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = _____

Number of neutrons = _____

**(2)**

(ii) The decay of radon-222 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.

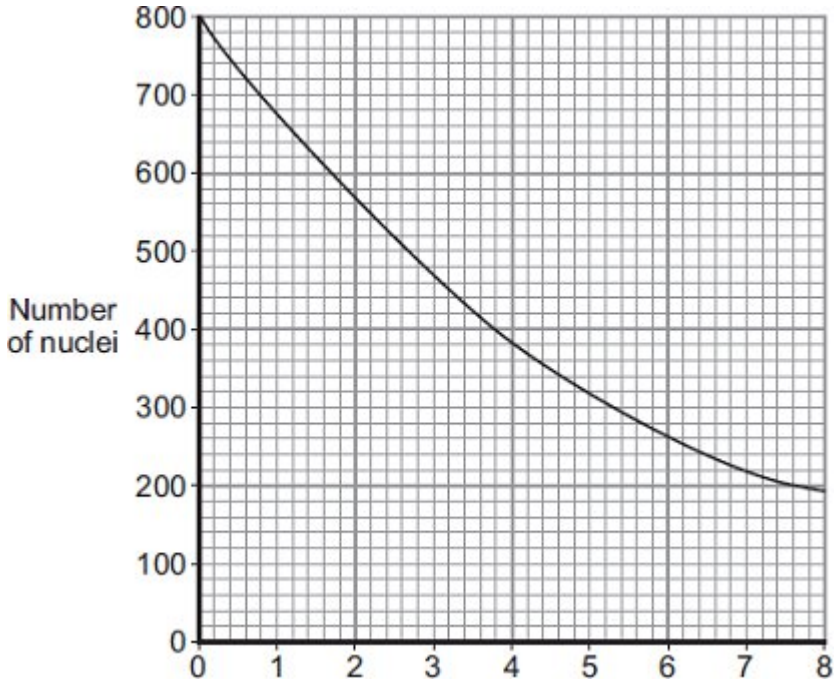
$$^{222}_{86}\text{Rn} \longrightarrow \square \quad \square \quad + \text{ Po + alpha particle}$$

**(2)**

(d) The graph shows how, in a sample of air, the number of radon-222 nuclei changes with time.



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Use the graph to find the half-life of radon-222.

Show clearly on the graph how you obtain your answer.

Half-life = _____ days

**(2)**

**(Total 9 marks)**

## Q13.

A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.




The doctor injects a small amount of technetium-99 into the patient's bloodstream. Technetium-99 emits gamma radiation.

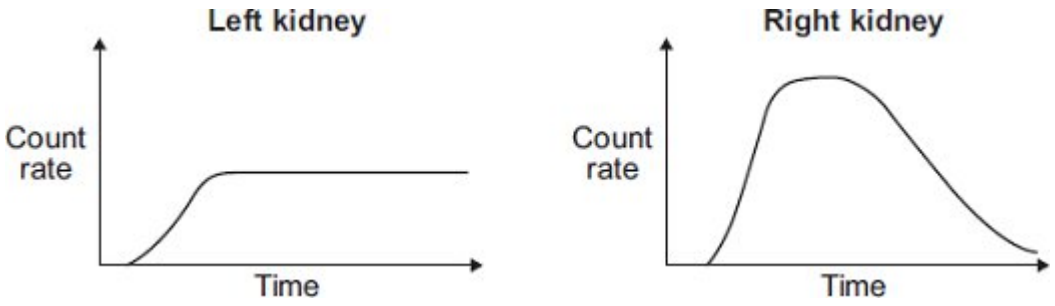
If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.



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The level of radiation emitted from each kidney is recorded on a graph.




(a) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

_____

_____

**(1)**

(b) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

Put a tick (✓) in the box next to your answer.

| | |
|---|---|
| Only the right kidney is working correctly. | ☐ |
| Only the left kidney is working correctly. | ☐ |
| Both kidneys are working correctly. | ☐ |

Explain the reason for your answer.

_____

_____

_____

_____

**(3)**

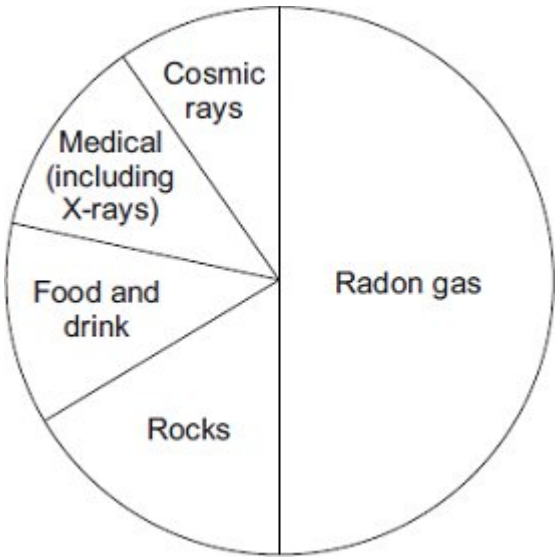
**(Total 4 marks)**

## Q14.

The pie chart shows the average proportions of background radiation from various sources in the UK.



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(a) Three sources of background radiation are given in **List A**.
Statements about sources of background radiation are given in **List B**.

Draw **one** line to link each source of background radiation in **List A** to the statement about that source given in **List B**.

Draw only **three** lines.

| List A | List B |
|---|---|
| | Are used to show broken bones. |
| X-rays | |
| | The radiation comes from outer space. |
| Cosmic rays | |
| | Comes from soil containing a radioactive isotope of potassium. |
| Radon gas | |
| | On average gives 50% of all background radiation. |

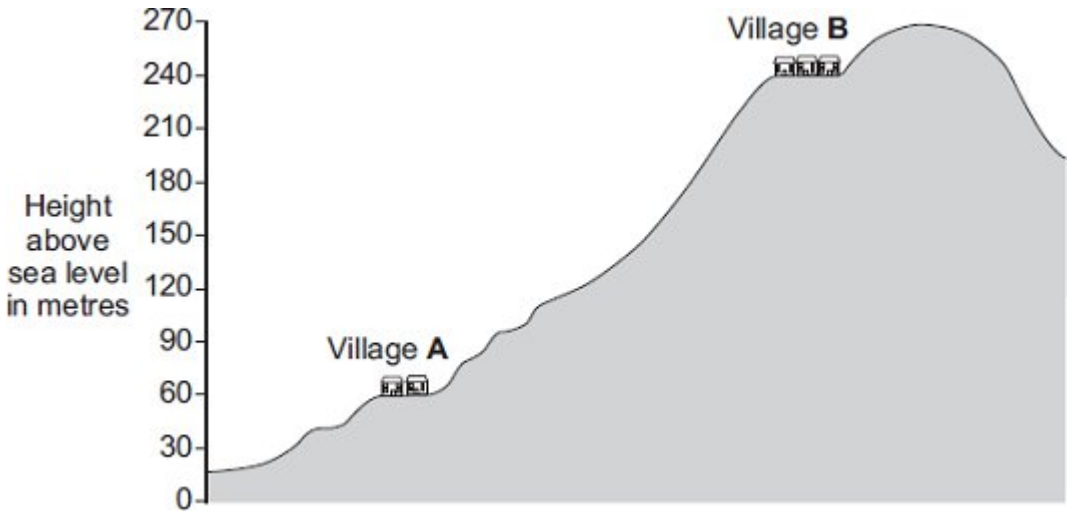
**(3)**

(b) The level of background radiation from cosmic rays is not the same everywhere. For every 30 metres above sea level, the amount of background radiation increases by one unit.

The diagram shows the position of two villages, **A** and **B**, built on a hill.



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How is the amount of background radiation from cosmic rays different in village **A** compared to village **B**?

To obtain full marks, you must include a calculation in your answer.

_____

_____

_____

_____

_____

_____

**(3)**

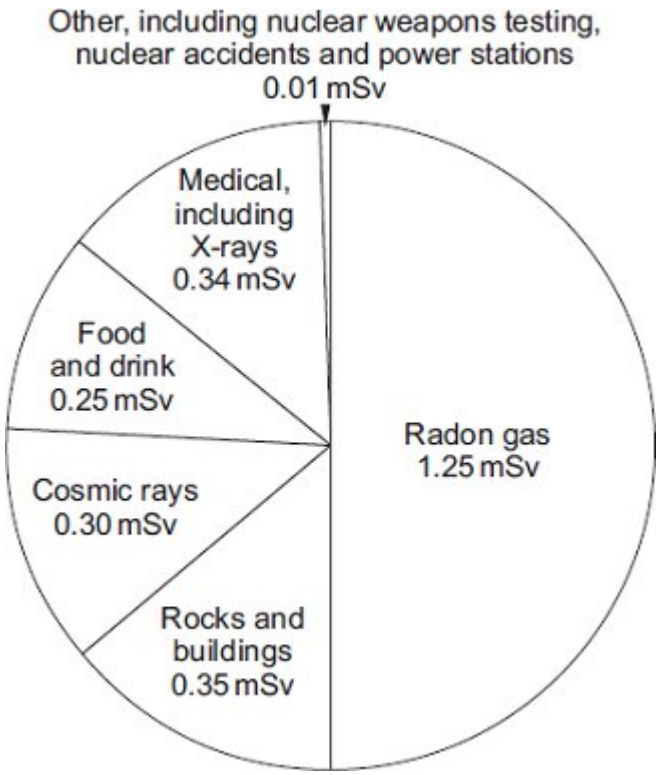
**(Total 6 marks)**

## Q15.

The pie chart shows the sources of the background radiation and the radiation doses that the average person in the UK is exposed to in one year.
Radiation dose is measured in millisieverts (mSv).



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(a) (i) What is the total radiation dose that the average person in the UK receives?

_____

_____

Total radiation dose = _____ mSv

**(1)**

(ii) A student looked at the pie chart and then wrote down three statements.

Which **one** of the following statements is a correct conclusion from this data?

Put a tick ( ✓ ) in the box next to your answer.

In the future, more people will be exposed to a greater proportion of radon gas. ☐

People that have never had an X-ray get 50 % of their radiation dose from radon gas. ☐

The radiation dose from natural sources is much greater than from artificial sources. ☐

**(1)**

(b) The concentration of radon gas inside a home can vary from day to day.

The table gives data for the radiation measured in homes in four different parts of the UK. The radiation was measured using two detectors, one in the living room and one in the bedroom. The measurements were taken over 3 months.



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| Area of the UK | Number of homes in the area | Number of homes in the sample | Average radiation in Bq/m$^3$ | Maximum radiation in Bq/m$^3$ |
|---|---|---|---|---|
| **A** | 590 000 | 160 | 15 | 81 |
| **B** | 484 000 | 130 | 18 | 92 |
| **C** | 221 000 | 68 000 | 162 | 10 000 |
| **D** | 318 000 | 35 300 | 95 | 6 900 |

(i) Give **one** reason why the measurements were taken over 3 months using detectors in different rooms.

_____

_____

**(1)**

(ii) Use information from the table to suggest why a much higher proportion of homes were sampled in areas **C** and **D** than in areas **A** and **B**.

_____

_____

_____

**(2)**

**(Total 5 marks)**

## Q16.

The table shows the average background radiation dose from various sources that a person living in the UK receives in one year.

| Source of background radiation | Average radiation dose received each year in dose units |
|---|---|
| Cosmic rays (from space) | 300 |
| Food and drink | 250 |
| Medical treatments (including X-rays) | 350 |
| Radon gas | 1250 |
| Rocks | 350 |
| TOTAL | 2500 |

(a) (i) A student looked at the data in the table and then wrote down four statements.



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Only **two** of the statements are true.

Put a tick (✓) in the boxes next to the **two** true statements.

More than half of the average radiation dose comes from radon gas. ☐

On average, cosmic rays produce less background radiation than rocks. ☐

Everyone living in the UK receives the same background radiation dose. ☐

Having no X-rays reduces a person's radiation dose. ☐

**(2)**

(ii) Each time a chest X-ray is taken, the patient receives about 100 units of radiation.

How many chest X-rays would just exceed the yearly average dose for medical treatments?

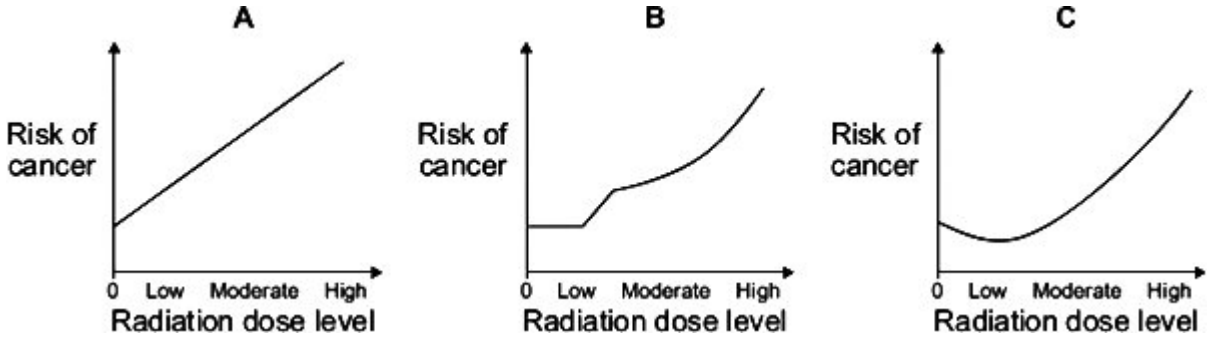
_____

Number of chest X-rays = _____

**(2)**

(b) Exposure to radiation can cause cancer.

The graphs, **A**, **B** and **C**, show three different ways that the exposure to radiation and the risk of getting cancer could be linked.




(i) What do all three of these graphs suggest happens to the risk of getting cancer when the radiation dose goes from moderate to high?

_____

_____

**(1)**

(ii) Some scientists believe that exposure to **low** radiation doses reduces the chance that a person will get cancer. This effect is called 'radiation hormesis'.



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Which one of the graphs, **A**, **B** or **C**, shows 'radiation hormesis'?

Write your answer in the box. ☐

Give a reason for your answer.

_____

_____

_____

**(2)**

(c) Scientists did an experiment in which mice were exposed to different doses of radiation.

The results from the experiment are given in the table.

| **Description of exposure** | **Percentage of mice getting cancer** |
|---|---|
| Mice exposed to a low dose of radiation and then a high dose of radiation. | 16% |
| Mice exposed to a high dose of radiation only. | 46% |

(i) Do the results from this experiment provide evidence to support 'radiation hormesis'?

Draw a ring around your answer. NO YES

Explain the reason for your answer.

_____

_____

_____

_____

_____

**(2)**

(ii) Complete the following sentence by drawing a ring around the correct word in the box.

Using animals in scientific experiments raises | environmental / ethical | issues.



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social

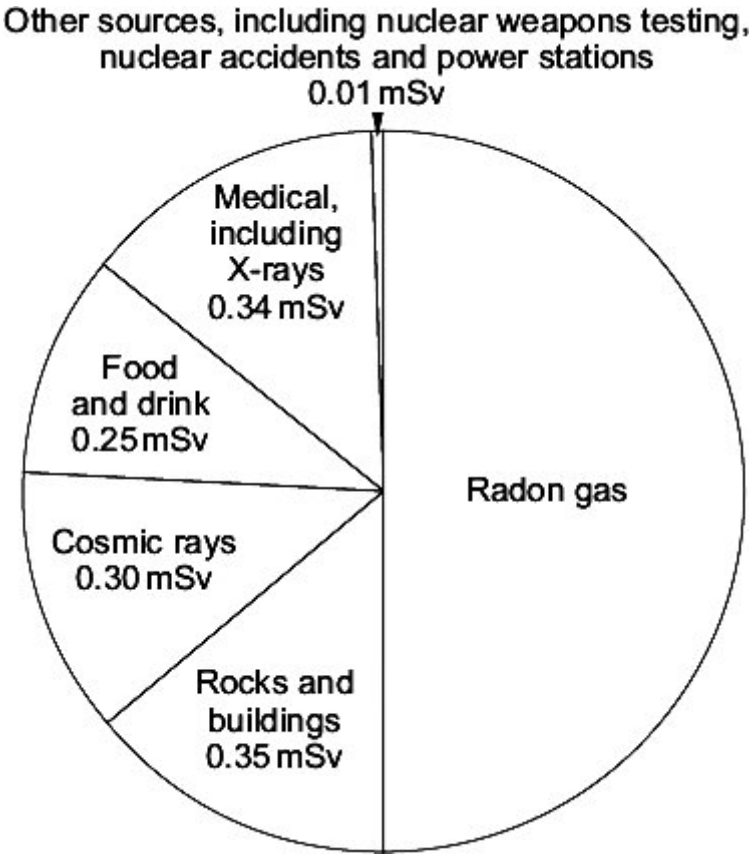
**(1)**

**(Total 10 marks)**

## Q17.

The pie chart shows the sources of the background radiation and the radiation doses that the average person in the UK is exposed to in one year.

Radiation dose is measured in millisieverts (mSv).




(a) (i) What is the radiation dose that the average person in the UK receives from radon gas?

_____

_____

Radiation dose from radon gas = _____ mSv

**(1)**

(ii) A person may receive a higher than average dose of radiation from background sources.

Suggest **two** reasons why.

1. _____

_____



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2. _____

_____

**(2)**

(b) Exposure to radon gas can cause lung cancer.
A recent study has compared the risk of getting lung cancer, by the age of 75 years, for cigarette smokers and non-smokers.
The people in the study had been exposed throughout their lives to different levels of radon gas.
A summary of the data produced from the study is given in the table.

| **Exposure to radon gas** | **Risk of lung cancer by age of 75** | |
|---|---|---|
| | **Non-smoker** | **Smoker** |
| No exposure | 0.4 % | 10 % |
| Moderate exposure | 1.0 % | 14 % |
| Very high exposure | 1.5 % | 32 % |

(i) Why were people that have had **no exposure** to radon gas included in the study?

_____

_____

**(1)**

(ii) Using information from the table, what conclusions can be made about exposure to radon gas and the risk of getting lung cancer?

_____

_____

_____

_____

_____

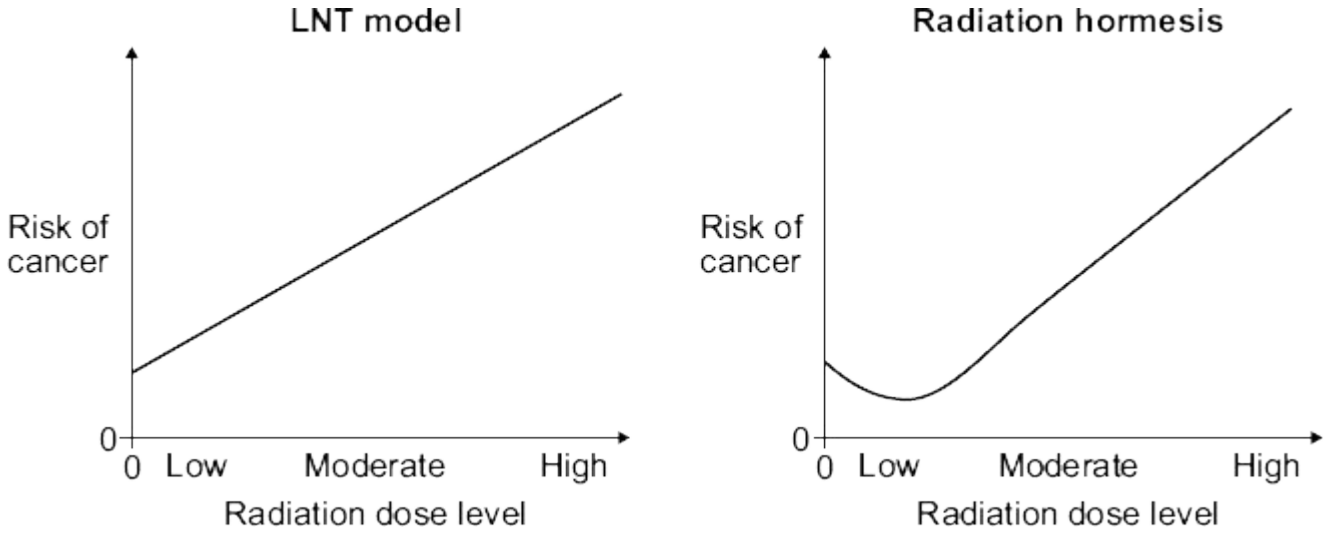
**(2)**

(c) At the moment, the regulations designed to protect people from over-exposure to radiation are based on a model called the ‘linear no-threshold□ (LNT) model.
Some scientists believe that the LNT model is too simple.These scientists believe that at low radiation levels a process called ‘radiation hormesis□ happens.

The graphs show that each model suggests a link between the risk of developing a cancer and exposure to low levels of radiation.



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The link between the risk of developing cancer and exposure to low levels of radiation suggested by each of the models is different.

Describe how.

_____

_____

_____

_____

_____

**(2)**

(d) Scientists have conducted experiments in which mice have been exposed to different levels of radiation. The number of mice developing a cancer has then been measured.

Discuss whether it is ethical to use animals in scientific experiments.

_____

_____

_____

_____

_____

**(2)**

**(Total 10 marks)**

## Q18.

Food irradiation is a process that exposes food to radiation. Irradiation can be used to kill the bacteria that cause food poisoning or to slow down the ripening of fresh fruit and vegetables. Frozen foods and food inside packaging can also be irradiated.

(a) The table gives information about five radioactive isotopes.



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| Isotope | Half-life | Radiation emitted |
|---|---|---|
| Caesium-134 | 2.1 years | beta |
| Cobalt-60 | 5.3 years | gamma |
| Curium-242 | 160 days | alpha |
| Strontium-90 | 28 years | beta |
| Technetium-99 | 6 hours | gamma |

Which of these radioactive isotopes would be most suitable for irradiating food?

_____

Explain the reasons for your choice.

_____

_____

_____

_____

_____

**(3)**

(b) Many people think that food should not be irradiated. Consumer groups have said that they are worried about the nutritional value and safety of eating irradiated foods.

(i) Suggest **one** reason why some people may be concerned about the safety of eating irradiated food.

_____

_____

**(1)**

(ii) Independent scientific committees in several countries, including Sweden, Canada and the UK, have concluded that it is safe to eat irradiated food.

These scientific committees need to be independent from government influence.

Suggest why.

_____

_____

**(1)**



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(iii) One group of scientists has compared the vitamin content of non-irradiated foods with irradiated foods.

The table below gives the data obtained for 1 kg of cooked chicken.

| Vitamin | Non-irradiated food in milligrams | Irradiated food in milligrams |
|---|---|---|
| B6 | 1.22 | 1.35 |
| B12 | 21.00 | 28.00 |
| E | 3.30 | 2.15 |
| Niacin | 58.00 | 55.50 |
| Riboflavin | 2.10 | 2.25 |

Considering only the data in the table, is it valid to conclude that irradiated food is less nutritional than non-irradiated food?

Explain your answer.

_____

_____

_____

_____

_____

**(2)**

(iv) In a restaurant, meals with ingredients that have been irradiated must be clearly identified on the menu.

It is important that people eating in a restaurant are given this information.

Suggest why.

_____

_____

**(1)**

(c) The isotope caesium-137 decays by emitting beta radiation.
Caesium-137 has a half-life of 30 years.

(i) What is a beta particle, and from which part of an atom is a beta particle emitted?

_____



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_____

**(1)**

(ii) A sample containing caesium-137 has a count rate of 600 counts per minute.

Calculate how long it would take for the count rate from the sample to fall to 75 counts per minute.

Show clearly how you work out your answer.

_____

_____

_____

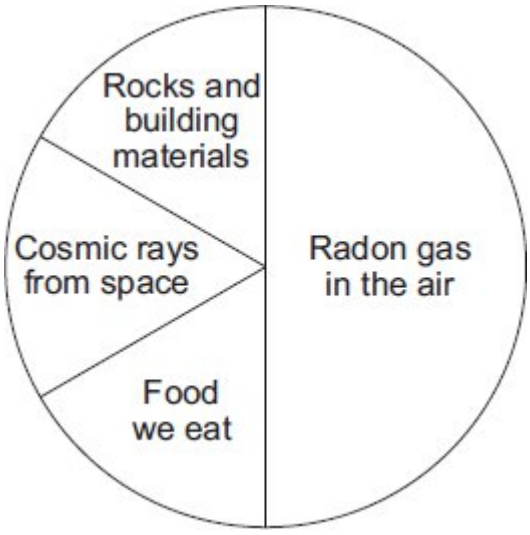
Time taken = _____ years

**(2)**

**(Total 11 marks)**

## Q19.

The pie chart shows the average proportions of natural background radiation from various sources in the UK.




(a) (i) Complete the following sentence.

On average, _____ of the natural background radiation in the UK comes from radon gas.

**(1)**

(ii) Radon gas is found inside homes.

The table shows the results from measuring the level of radon gas inside four homes in one area of the UK.

| Home | Level of radon gas in Bq per $m^3$ of air |
|---|---|



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| | |
|---|---|
| 1 | 25 |
| 2 | 75 |
| 3 | 210 |
| 4 | 46 |
| Mean | 89 |

One of the homes has a much higher level of radon gas than the other three homes.

What should be done to give a more reliable mean for the homes in this area of the UK?

Put a tick (✓) in the box next to your answer.

ignore the data for home number 3 ☐

measure the radon gas level in more homes in this area ☐

include data for homes from different areas of the UK ☐

**(1)**

(b) Each atom of radon has 86 protons and 136 neutrons.

(i) How many electrons does each atom of radon have?

Draw a ring around your answer.

**50** **86** **136** **222**

**(1)**

(ii) How many particles are there in the nucleus of a radon atom?

Draw a ring around your answer.

**50** **86** **136** **222**

**(1)**

**(Total 4 marks)**

## Q20.

(a) Background radiation is all around us all the time.

(i) Radon is a natural source of background radiation.



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Name another natural source of background radiation.

_____

**(1)**

(ii) X-rays are an artificial source of background radiation.

Name another artificial source of background radiation.

_____

**(1)**

(iii) An atom of radon-222 decays by emitting an alpha particle.
The equation representing the decay is shown below.

$$^{222}_{86}Rn \longrightarrow {}^{218}_{84}X + \text{alpha particle}$$

How can you tell from the equation that 'X' is not an atom of radon?

_____

_____

**(1)**

(b) Having an X-ray taken increases your exposure to radiation.

The table gives:

- the radiation doses received for 6 different medical X-rays;
- the number of days' of exposure to natural background radiation each dose is equivalent to.

| **Medical X-ray** | **Radiation dose received (in arbitrary units)** | **Equivalent number of days of exposure to natural background radiation** |
|---|---|---|
| **Chest** | 2 | 2.4 |
| **Skull** | 7 | 8.4 |
| **Pelvis** | 22 | 26.4 |
| **Hip** | 44 | 52.8 |
| **Spine** | 140 | |
| **CT head scan** | 200 | 240 |



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A hospital patient has an X-ray of the spine taken.
Calculate the number of days of exposure to natural background radiation that an X-ray of the spine is equivalent to.

Show how you work out your answer.

_____

_____

_____

Equivalent number of days = _____

**(2)**

(c) Scientists have shown that X-rays increase the risk of developing cancer.
The scientists came to this conclusion by studying the medical history of people placed in one of two groups, **A** or **B**.
The group into which people were put depended on their X-ray record.

(i) Person **J** has been placed into group **A**.
Place each of the people, **K**, **L**, **M**, **N** and **O**, into the appropriate group, **A** or **B**.

| **Person** | **J** | **K** | **L** | **M** | **N** | **O** |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| **Medical X-ray record** | 3 arm | None | None | 2 skull | None | 4 leg |

| **Group A** | **Group B** |
|---|---|
| **J** | |

**(1)**

(ii) To be able to make a fair comparison, what is important about the number of people in each of the two groups studied by the scientists?



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_____

_____

**(1)**

(iii) What data would the scientists have compared in order to come to the conclusion that X-rays increase the risk of developing cancer?

_____

_____

**(1)**

(iv) The chance of developing cancer due to a CT head scan is about 1 in 10 000. The chance of developing cancer naturally is about 1 in 4.

A hospital patient is advised by a doctor that she needs to have a CT head scan.
The doctor explains to the patient the risks involved.

Do you think that the patient should give her permission for the CT scan to be taken?

Draw a ring around your answer.

**Yes** **No**

Give a reason for your answer.

_____

_____

**(1)**

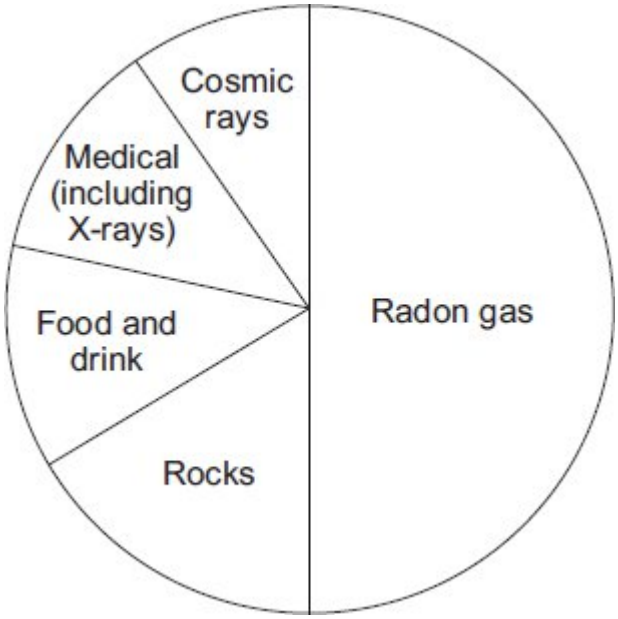
**(Total 9 marks)**

## Q21.

The pie chart shows the average proportions of background radiation from various sources in the UK.



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Three sources of background radiation are given in **List A**.
Statements about sources of background radiation are given in **List B**.

Draw **one** line to link each source of background radiation in **List A** to the statement about that source given in **List B**.

Draw only **three** lines.

| List A | List B |
|---|---|
| | Are used to show broken bones. |
| X-rays | |
| | The radiation comes from outer space. |
| Cosmic rays | |
| | Comes from soil containing a radioactive isotope of potassium. |
| Radon gas | |
| | Gives about 50 % of all background radiation. |

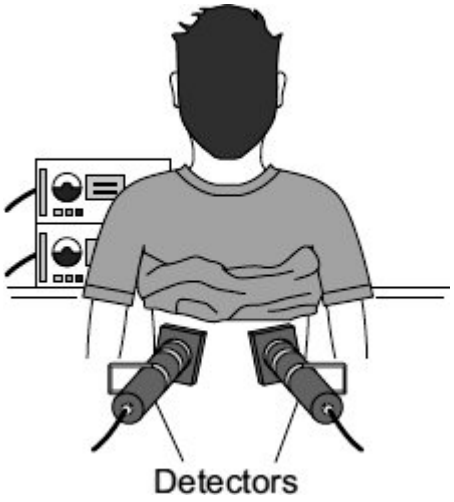
**(Total 3 marks)**

## Q22.

(a) A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.



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The doctor injects a small amount of technetium-99 into the patient's bloodstream.

Technetium-99 emits *gamma radiation.*

Give **two** reasons why an isotope that emits gamma radiation is injected into the patient rather than an isotope that emits alpha radiation.

1. _____

_____

2. _____

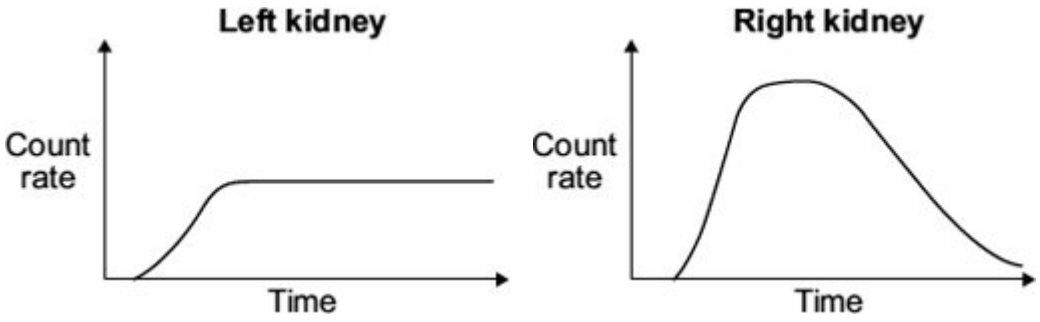
_____

**(2)**

(b) If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.

The level of radiation emitted from each kidney is recorded on a graph.




(i) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

_____

_____

**(1)**



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(ii) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

Put a tick (✓) in the box next to your answer.

Only the right kidney is working correctly. ☐

Only the left kidney is working correctly. ☐

Both kidneys are working correctly. ☐

Explain the reason for your answer.

_____

_____

_____

_____

**(3)**

(c) The patient was worried about having a radioactive isotope injected into their body. The doctor explained that the risk to the patient's health was very small as technetium-99 has a short *half-life.*

(i) What does the term *half-life* mean?

_____

_____

**(1)**

(ii) Explain why it is important that the doctor uses an isotope with a short half-life rather than an isotope with a long half-life.

_____

_____

_____

_____

**(2)**

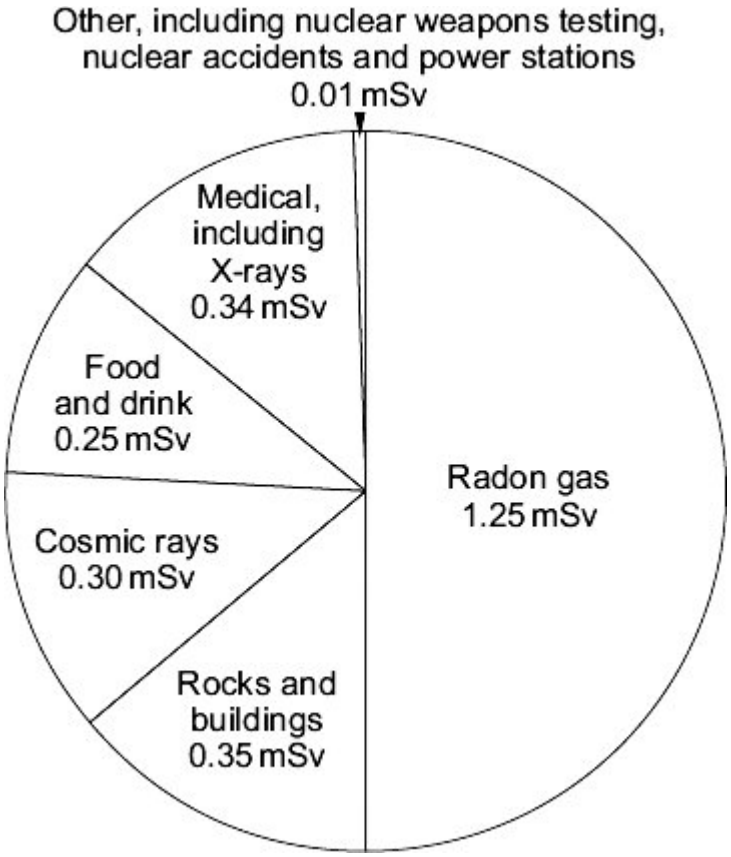
**(Total 9 marks)**

## Q23.



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The pie chart shows the sources of the background radiation and the radiation doses that the average person in the UK is exposed to in one year.
Radiation dose is measured in millisieverts (mSv).




(a) (i) What is the total radiation dose that the average person in the UK receives?

_____

_____

Total radiation dose = _____ mSv

**(1)**

(ii) A student looked at the pie chart and then wrote down three statements.

Which **one** of the following statements is a correct conclusion from this data?

Put a tick (✓) in the box next to your answer.

In the future, more people will be exposed to a greater proportion of

radon gas. ☐

People that have never had an X-ray get 50% of their radiation dose from



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radon gas. ☐

The radiation dose from natural sources is much greater than from artificial sources. ☐

**(1)**

(b) The concentration of radon gas inside a home can vary from day to day. In some homes, the level can build up to produce a significant health risk. It is estimated that each year 1000 to 2000 people die because of the effects of radiation from radon gas.

(i) It is not possible to give an exact figure for the number of deaths caused by the effects of radiation from radon gas. Why?

_____

_____

**(1)**

The table gives data for the radiation levels measured in homes in 4 different parts of the UK. The radiation levels were measured using two detectors, one in the living room and one in the bedroom. The measurements were taken over 3 months.

| Area of the UK | Number of homes in the area | Number of homes in the sample | Average radiation level in Bq/m$^3$ | Maximum radiation level in Bq/m$^3$ |
|---|---|---|---|---|
| **A** | 590 000 | 160 | 15 | 81 |
| **B** | 484 000 | 130 | 18 | 92 |
| **C** | 221 000 | 68 000 | 162 | 10 000 |
| **D** | 318 000 | 35 300 | 95 | 6 900 |

(ii) Give **one** reason why the measurements were taken over 3 months using detectors in different rooms.

_____

_____

**(1)**

(iii) Use information from the table to suggest why a much higher proportion of homes were sampled in areas **C** and **D** than in areas **A** and **B**.



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_____

_____

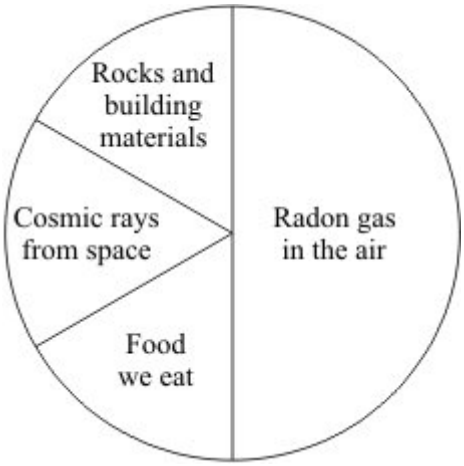
_____

**(2)**

**(Total 6 marks)**

## Q24.

(a) The pie chart shows the average proportions of natural background radiation from various sources in one part of the UK.




(i) What proportion of the background radiation comes from radon gas?

_____

**(1)**

(ii) Suggest why our bodies are slightly radioactive.

_____

_____

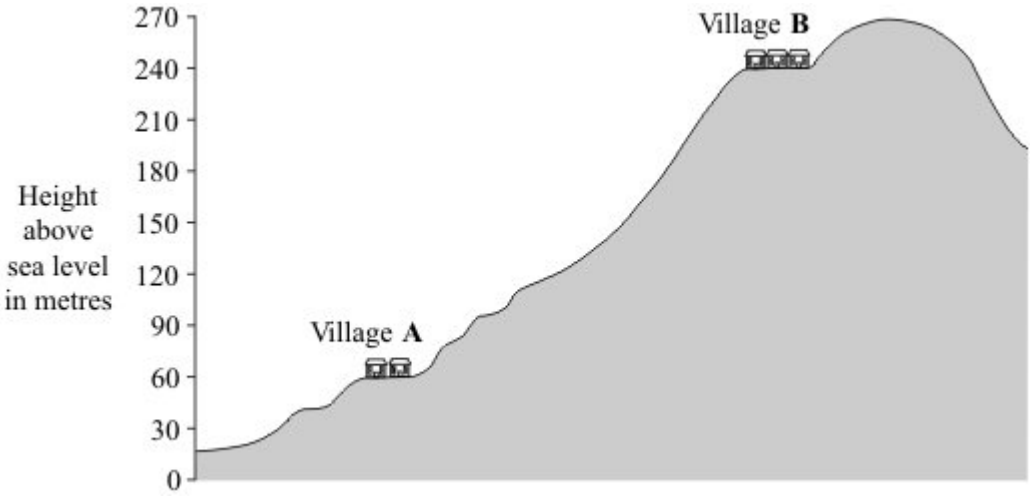
**(1)**

(b) The level of background radiation from cosmic rays is not the same everywhere. For every 30 metres above sea level, the amount of background radiation increases by one unit.

The diagram shows the position of two villages, **A** and **B**, built on a hill.



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How is the amount of background radiation from cosmic rays different in village **A** compared to village **B**?

To obtain full marks you must include a calculation in your answer.

_____

_____

_____

_____

_____

_____

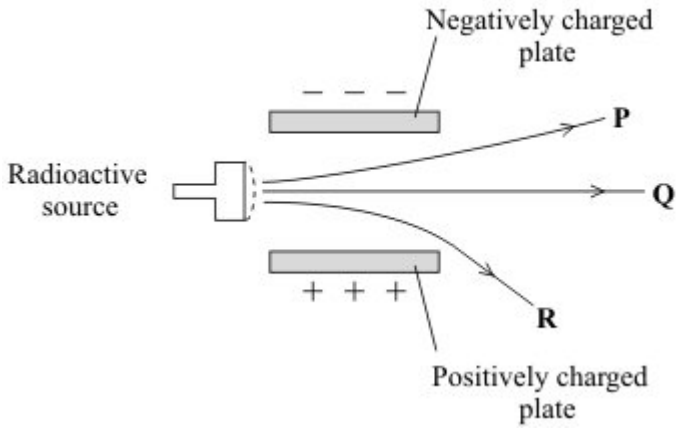
**(3)**

**(Total 5 marks)**

## Q25.

A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation. The diagram shows what happens to the radiation as it passes between two charged metal plates.

**Diagram 1**




(a) Which line **P**, **Q** or **R** shows the path taken by:



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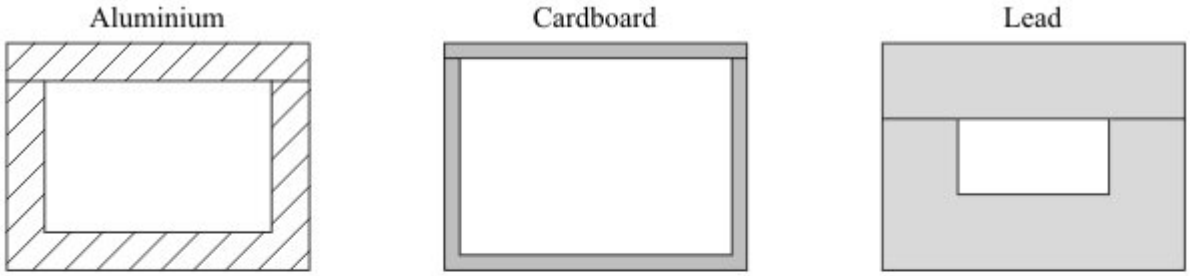
(i) alpha radiation _____

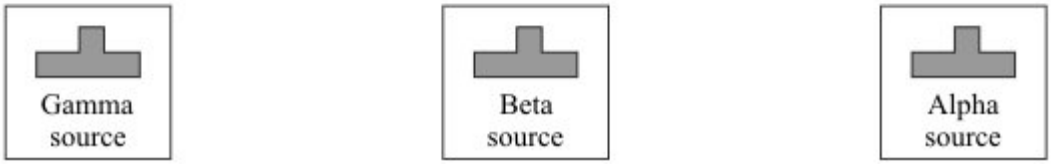
**(1)**

(ii) gamma radiation? _____

**(1)**

(b) The diagram shows three different boxes and three radioactive sources. Each source emits only one type of radiation and is stored in a different box. The box reduces the amount of radiation getting into the air.

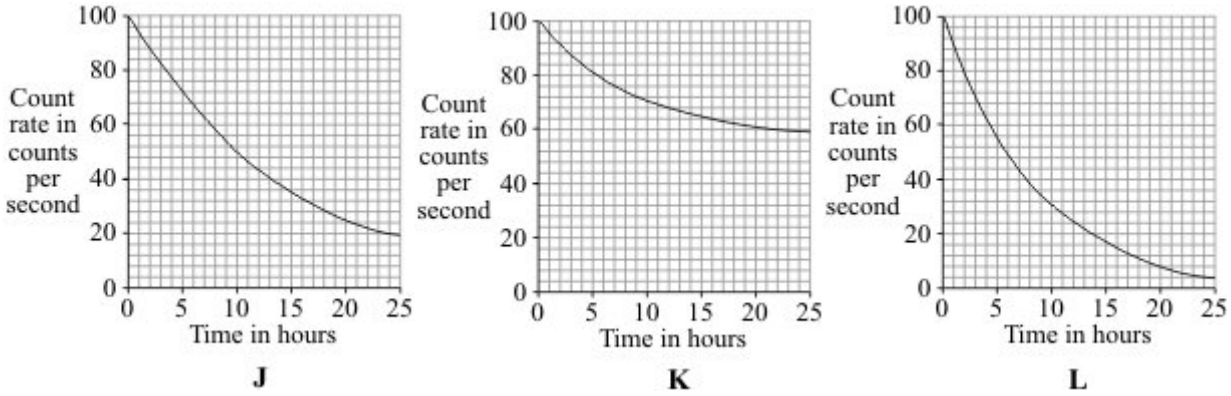



Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.

**(2)**

(c) The graphs show how the count rates from three different radioactive sources, **J**, **K**, and **L**, change with time.




(i) Which source, **J, K**, or **L**, has the highest count rate after 24 hours?

_____

**(1)**



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(ii) For source **L**, what is the count rate after 5 hours?

_____ counts per second

**(1)**

(iii) Which source, **J, K,** or **L**, has the longest half-life?

_____

**(1)**

(iv) A radioactive source has a half-life of 6 hours.

What might this source be used for?

Put a tick (✓) in the box next to your choice.

To monitor the thickness of paper as it is made in a factory ☐

To inject into a person as a medical tracer ☐

To make a smoke alarm work ☐

**(1)**

**(Total 8 marks)**

## Q26.

(a) A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation.

(i) Which **two** types of radiation will pass through a sheet of card?

_____

**(1)**

(ii) Which **two** types of radiation would be deflected by an electric field?

_____

**(1)**

(iii) Which type of radiation has the greatest range in air?

_____

**(1)**

(b) A student suggests that the radioactive source should be stored in a freezer at –20 °C. The student thinks that this would reduce the radiation emitted from the source.

Suggest why the student is wrong.

_____

_____

**(1)**



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(c) Phosphorus-32 is a radioactive isotope that emits beta radiation.

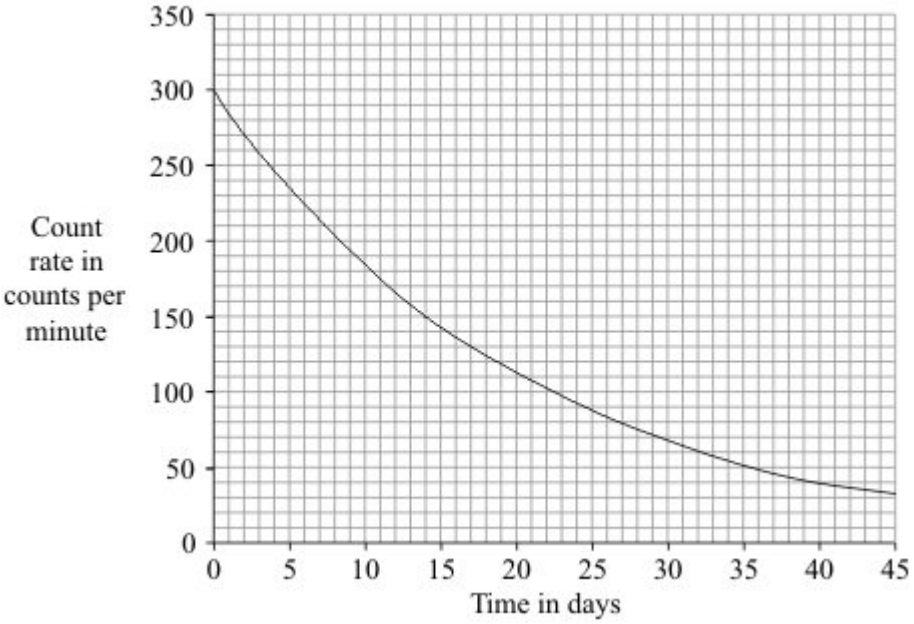
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

_____

_____

**(1)**

(ii) The graph shows how the count rate of a sample of phosphorus-32 changes with time.




Use the graph to calculate the half-life of phosphorus-32.

Show clearly how you used the graph to obtain your answer.

_____

_____

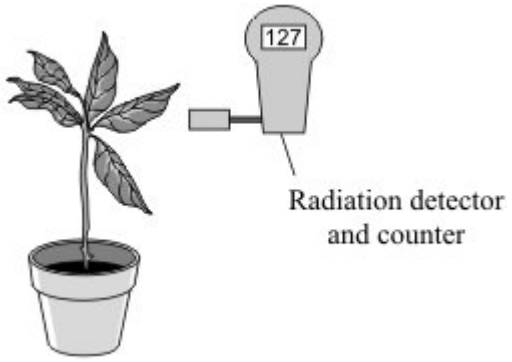
Half-life = _____ days

**(2)**

(iii) Plants use phosphorus compounds to grow. Watering the root system of a plant with a solution containing a phosphorus-32 compound can help scientists to understand the growth process.



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Explain why phosphorus-32 is suitable for use as a tracer in this situation.

_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

## Q27.

The table shows the average background radiation dose from various sources that a person living in Britain receives in one year.

| Source of background radiation | Average amount each year in dose units |
|---|---|
| Buildings | 50 |
| Food anddrink | 300 |
| Medicaltreatments (including X-rays) | 300 |
| Radon gas | 1250 |
| Rocks | 360 |
| Space(cosmic rays) | 240 |
| TOTAL | 2500 |

(a) Only **two** of the following statements are true.

Tick (✓) the boxes next to the true statements.

Half the average background radiation dose comes from radon gas. ☐

Everyone receives the same background radiation dose. ☐



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Cosmic rays produce less background radiation than food and drink. ☐

**(1)**

(b) Most sources of background radiation are natural but some are artificial (man-made).

Which source of background radiation given in the table is artificial?

_____

**(1)**

(c) Each time a dental X-ray is taken, the patient receives about 20 units of radiation.

How many dental X-rays would give the yearly average dose for medical treatments?

_____

_____

Number of X-rays = _____

**(2)**

**(Total 4 marks)**

## Q28.

(a) The names of three types of nuclear radiation are given in **List A**. Some properties of these three types of radiation are given in **List B**.

Draw a straight line to link each type of radiation in **List A** to its correct property in **List B**. Draw only three lines.

| **List A**<br>Type of nuclear radiation | **List B**<br>Property of radiation |
|---|---|
| | not deflected by an electric field |
| alpha | |
| | stopped by thin metal but not paper |
| beta | |
| | the most strongly ionising |
| gamma | |
| | will not harm living cells |



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**(3)**

(b) Nuclear radiation is given out from the centre of some types of atom.

What name is given to the centre of an atom? _____

**(1)**

(c) One of the substances in the table is used as a radioactive tracer. A hospital patient breathes in air containing the tracer. The radiation given out is measured by a doctor using a detector outside the patient's body.

| Substance | Radiation given out | Solid, liquid or gas |
|---|---|---|
| **X** | alpha | gas |
| **Y** | gamma | gas |
| **Z** | gamma | solid |

Which **one** of the substances, **X**, **Y** or **Z**, should be used as the tracer? _____

Give **two** reasons for your answer.

1. _____

_____

2. _____

_____

**(3)**

(d) Radiation can also be used to kill the bacteria on fresh food.

Give **one** reason why farmers, shop owners or consumers may want food to be treated with radiation.

_____

_____

**(1)**

**(Total 8 marks)**

## Q29.

In 1986, a nuclear reactor exploded in a power station at Chernobyl in the Ukraine.

(a) The table gives information about some of the radioactive substances released into the air by the explosion.

| Radioactive substance | Half-life | Type of radiation emitted |
|---|---|---|



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| | | |
|---|---|---|
| Iodine-131 | 8 days | beta and gamma |
| Caesium-134 | 2 years | beta |
| Caesium-137 | 30 years | beta |

(i) How is the structure of a caesium-134 atom different from the structure of a caesium-137 atom?

_____

**(1)**

(ii) What is a beta particle and from which part of an atom is a beta particle emitted?

_____

_____

**(1)**

(iii) Once a radioactive substance is dissolved in rainwater, it can enter the food chain.

Following the Chernobyl explosion, some milk supplies were found to be radioactive.

If one litre of milk contaminated with iodine-131 gives a count rate of 400 counts/second, how long will it take for the count rate to fall to 25 counts/second?

Show clearly how you work out your answer.

_____

_____

_____

Time taken = _____ days

**(2)**

(iv) After 20 years, the caesium-137 emitted into the atmosphere is a more serious problem than the iodine-131.

Explain why.

_____

_____

_____

_____

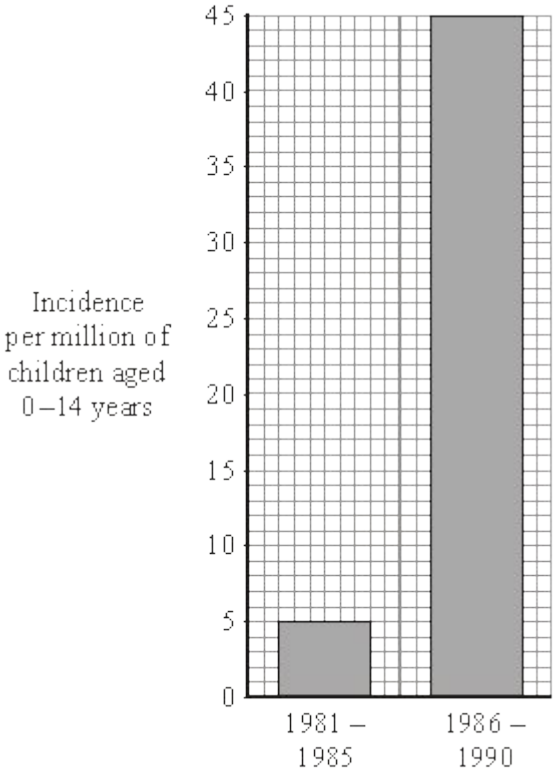
_____

**(2)**



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(b) The bar chart compares the incidence of thyroid cancer in Ukrainian children, aged 0–14 years, before and after the Chernobyl explosion.




Of the children that developed thyroid cancer, 64% lived in the areas most contaminated by the radiation.

Considering this data, can you be certain that a child who developed thyroid cancer between 1986 and 1990 did so because of the Chernobyl explosion?

Explain the reason for your answer.

_____

_____

_____

_____

**(2)**

(c) In 1991, some scientists compared the health of two groups of people: a *control* group and a group that had been exposed to the radiation from Chernobyl.

What people would have been in the *control* group?

_____

**(1)**

(d) Although there are some risks associated with nuclear power stations, it is likely that new ones will be built.

Give **two** reasons to justify the use of nuclear power.

1. _____



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_____

2. _____

_____

**(2)**

**(Total 11 marks)**

## Q30.

(a) The table gives information about the radioactive isotope, radon-222.

| | |
|---|---|
| mass number | 222 |
| atomic number | 86 |
| radiation emitted | alpha particle |

(i) Complete the following sentence.

The mass number is the total number of _____ and

_____ inside an atom.

**(2)**

(ii) Radon-222 is an isotope of radon.

How many protons are there in an atom of radon-222?

_____

**(1)**

(iii) When an atom of radon-222 emits an alpha particle, the radon-222 changes into an atom of polonium-218.

An alpha particle consists of 2 protons and 2 neutrons.

How is the structure of the nucleus of a polonium-218 atom different from the structure of the nucleus of a radon-222 atom?

_____

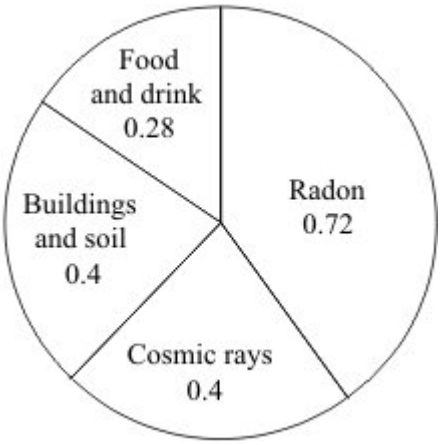
**(1)**

(b) The pie chart shows the average radiation dose that a person in the UK receives each year from natural background radiation.

The doses are measured in millisieverts (mSv).



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(i) Calculate the proportion of natural background radiation that comes from radon. Show clearly how you work out your answer.

_____

_____

Proportion of radon = _____

**(2)**

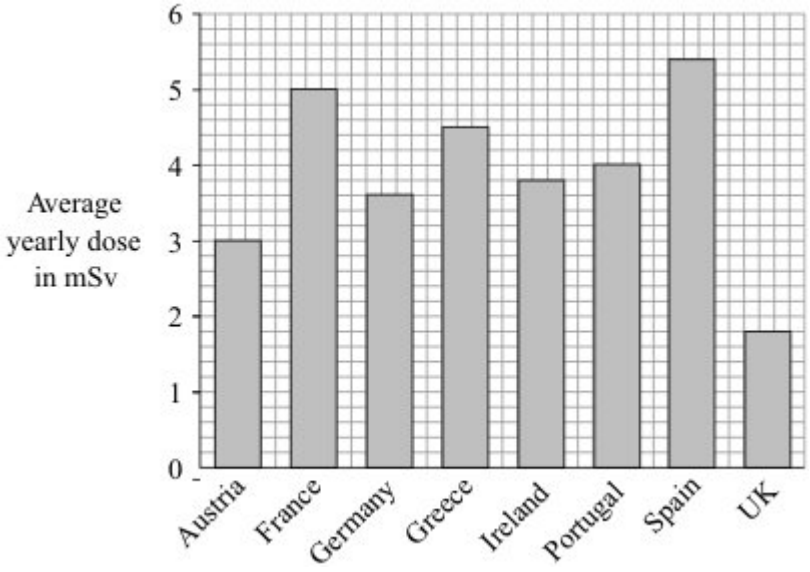
(ii) Not all background radiation is from natural sources.

Name **one** source of background radiation that is not natural.

_____

**(1)**

(c) The bar chart shows the average yearly dose from natural background radiation in different European countries.




(i) How many times bigger is the average annual background dose in Germany compared to the UK?

_____

**(1)**



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(ii) The following table gives the effects of different radiation doses on the human body.

| Radiation dose in mSv | Effects |
|---|---|
| 10 000 | Immediate illness; death within a few weeks |
| 1 000 | Radiation sickness; unlikely to cause death |
| 50 | Lowest dose with evidence of causing cancer |

A family goes to Germany for a two-week holiday. Should they be concerned about the higher level of background radiation in Germany?

Draw a ring around your answer.

**Yes** **No**

Explain your answer.

_____

_____

_____

_____

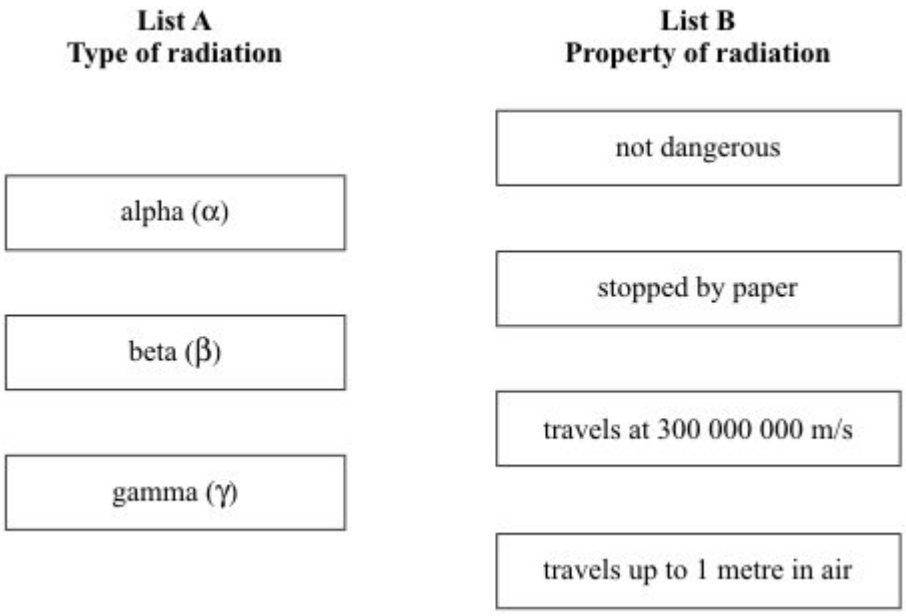
**(2)**

**(Total 10 marks)**

## Q31.

(a) The names of three types of radiation are given in **List A**. Various properties of these three types of radiation are given in **List B**.

Draw a line to link each type of radiation in **List A** to its correct property in **List B**. Draw only **three** lines.






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**(3)**

(b) This sign warns people that a radioactive source is being used in a laboratory.



Why is it important to warn people that a radioactive source is being used?

_____

_____

**(1)**

(c) To study the blood flow in a patient's lungs, a doctor injects some technetium-99 compound into the patient. The gamma radiation given out by the technetium-99 atoms is detected using a gamma camera outside the patient's body.

Which statement gives the reason why gamma radiation is used? Put a tick (✓) in the box next to your choice.

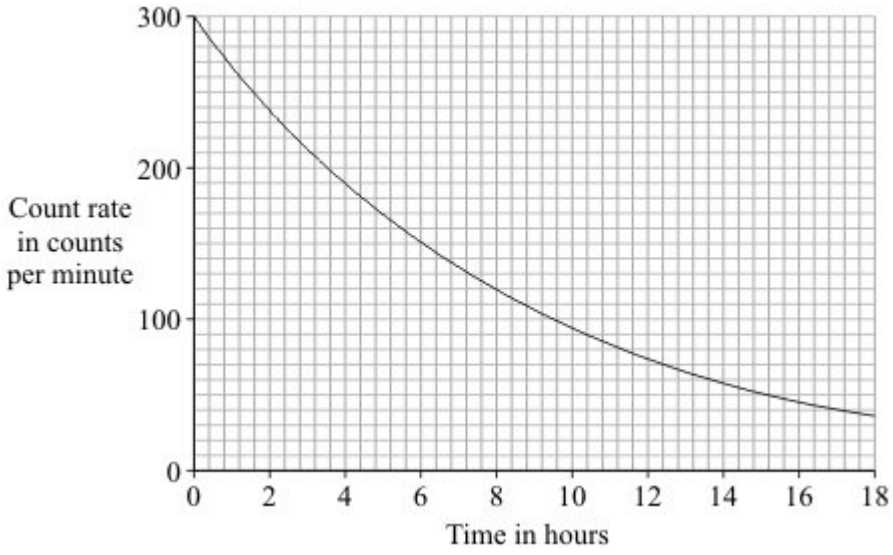
It can travel through a vacuum. ☐

It is not affected by a magnet. ☐

It can pass through the human body. ☐

**(1)**

(d) The graph shows how the count rate from a sample of technetium-99 changes with time.




(i) How many hours does it take for the count rate to fall from 300 counts per minute to 150 counts per minute?



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Time = _____ hours

**(1)**

(ii) What is the half-life of technetium-99?

Half-life = _____ hours

**(1)**

**(Total 7 marks)**

## Q32.

(a) Alpha particles (α), beta particles (β) and gamma rays (γ) are types of nuclear radiation.

(i) Which of the three types of radiation is the most strongly ionising?

_____

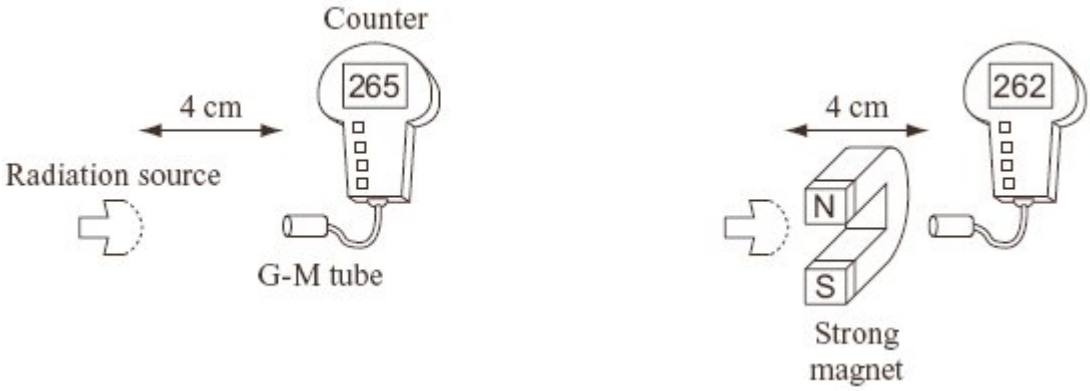
**(1)**

(ii) What effect does nuclear radiation have on living cells?

_____

**(1)**

(b) The diagrams show a G-M tube and counter used to measure the radiation emitted from a source. Both diagrams show the reading on the counter one minute after it was switched on.




Explain why the counter readings show that the source is giving out only gamma radiation.

_____

_____

_____

_____

**(2)**

(c) The box gives information about the radioactive isotope technetium-99.

| Type of radiation emitted: gamma |
|---|



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| |
|---|
| *Half-life*: 6 hours<br><br>Used as a medical tracer |

What is meant by the term *half-life*?

_____

_____

**(1)**

(d) To study the blood flow in a patient's lungs, a doctor injects a small quantity of a technetium-99 compound into the patient. The radiation emitted by the technetium-99 atoms is detected outside the patient's body.

Explain why a doctor would not use a radioactive isotope with a very short half-life, such as 2 seconds, as a medical tracer.

_____

_____

_____

_____

**(2)**

**(Total 7 marks)**

## Q33.

Some types of food are treated with *gamma* radiation. Low doses of radiation slow down the ripening of fresh fruit and vegetables while higher doses of radiation kill the bacteria that make the food go off.

(a) (i) What is *gamma* radiation?

_____

**(1)**

(ii) Food packed in crates or boxes can be treated using this method.

Why must a source that emits *gamma* radiation be used?

_____

_____

**(1)**

(iii) A suitable source of gamma radiation is the isotope caesium 137.

Complete the following sentence by choosing the correct word from the box.

| | | |
|---|---|---|
| **electrons** | **neutrons** | **protons** |

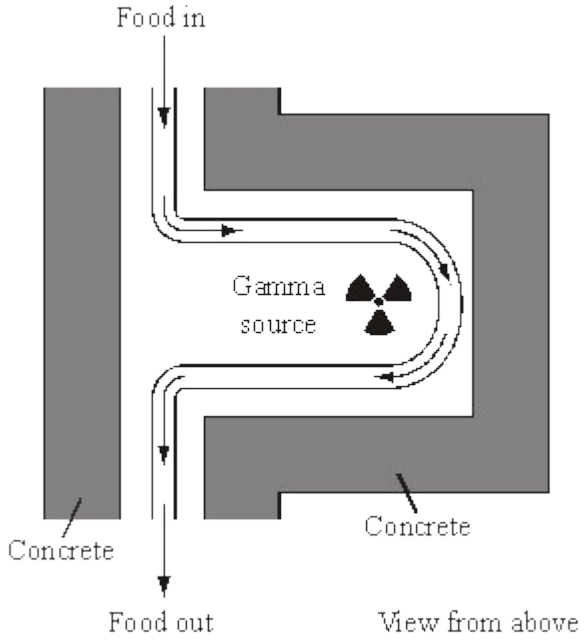


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An atom of caesium 137 has two more _____ than an atom of caesium 135.

**(1)**

(b) The diagram shows how a conveyor belt can be used to move food past the radioactive source.




(i) How do the concrete walls reduce the radiation hazard to workers outside the food treatment area?

_____

_____

**(1)**

(ii) Suggest **one** way that the dose of radiation received by the food could be increased other than by changing the radioactive source.

_____

_____

**(1)**

(c) Some people may not like the idea of eating food treated with radiation.

(i) What evidence could a food scientist produce to show that food treated with radiation is safe to eat?

_____

_____

_____

_____

**(2)**



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(ii) The diagram shows the sign displayed on food treated with radiation.



Why is it important for people to know which foods have been treated with radiation?

_____

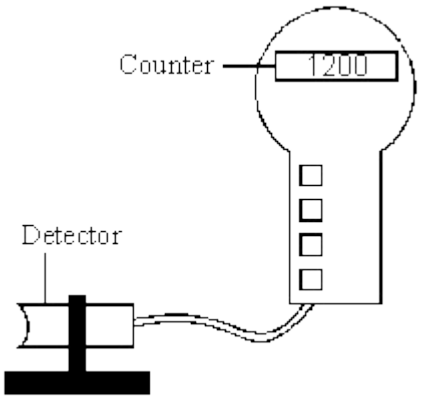
_____

**(1)**

**(Total 8 marks)**

## Q34.

The diagram shows a radiation detector and counter being used to measure background radiation. The number shows the count ten minutes after the counter was reset to zero.




(i) Name **one** source of background radiation.

_____

**(1)**

(ii) Calculate the average background radiation level, in counts per second. Show clearly how you work out your answer.

_____

_____

Background radiation level = _____ counts per second

**(2)**

**(Total 3 marks)**

## Q35.

(a) The table gives information about six radioactive isotopes.



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| Isotope | Type of radiation emitted | Half-life |
|---|---|---|
| hydrogen-3 | beta particle | 12 years |
| iridium-192 | gamma ray | 74 days |
| polonium-210 | alpha particle | 138 days |
| polonium-213 | alpha particle | less than 1 second |
| technetium-99 | gamma ray | 6 days |
| uranium-239 | beta particle | 24 minutes |

(i) What is an alpha particle?

_____

**(1)**

(ii) Two isotopes of polonium are given in the table. How do the nuclei of these two isotopes differ?

_____

**(1)**

(iii) A doctor needs to monitor the blood flow through a patient's heart. The doctor injects a radioactive isotope into the patient's bloodstream. The radiation emitted by the isotope is then detected outside the body.

Which **one** of the isotopes in the table would the doctor inject into the bloodstream?

_____

Explain the reasons for your choice.

_____

_____

_____

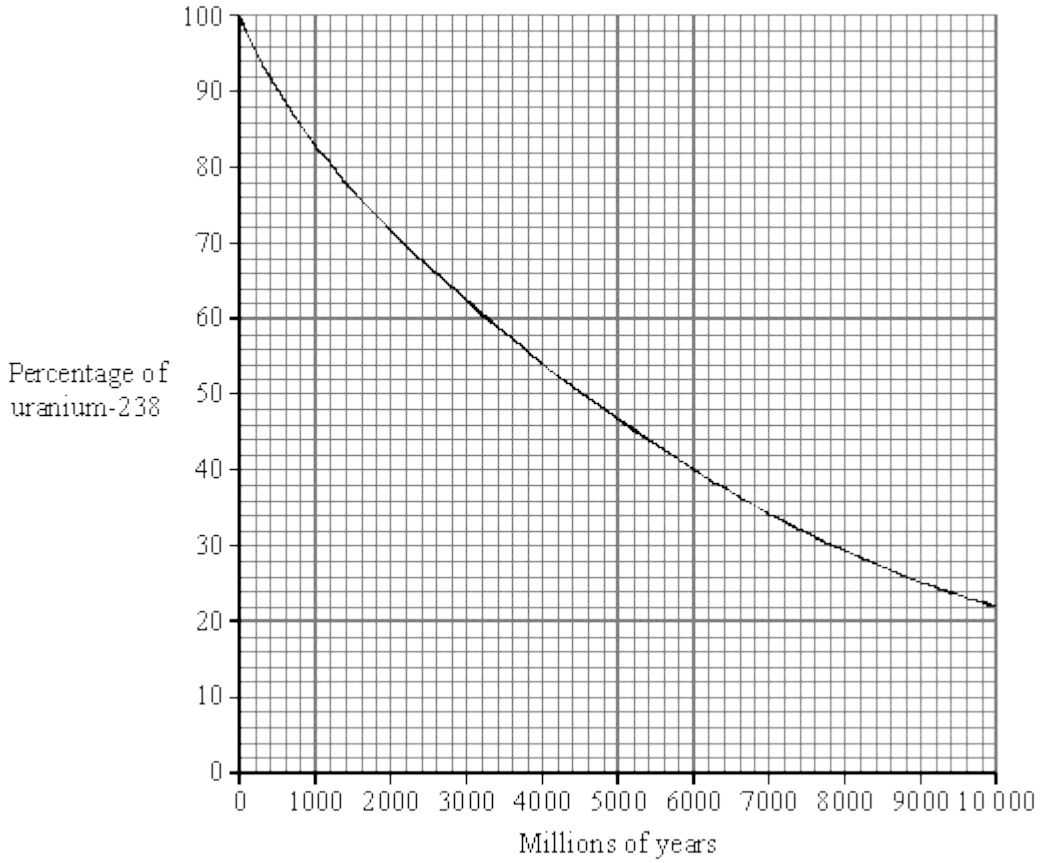
_____

**(3)**

(b) Igneous rock contains uranium-238 which eventually changes to the stable isotope lead-206. The graph shows how the percentage of uranium-238 nuclei present in an igneous rock changes with time.



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A rock sample is found to have seven atoms of uranium-238 for every three atoms of lead-206. Use the graph to estimate the age of the rock. Show clearly how you obtain your answer.

_____

_____

Age of rock = _____ million years

**(2)**

**(Total 7 marks)**



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