Hazards + Uses Of Emissions

These practice questions can be used by students and teachers and is

Suitable for GCSE AQA Physics Topic Question 8463

Level: GSCE AQA 8463

Subject: Physics

Exam Board: GCSE AQA

Topic: Hazards + Uses Of Emissions

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.

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)

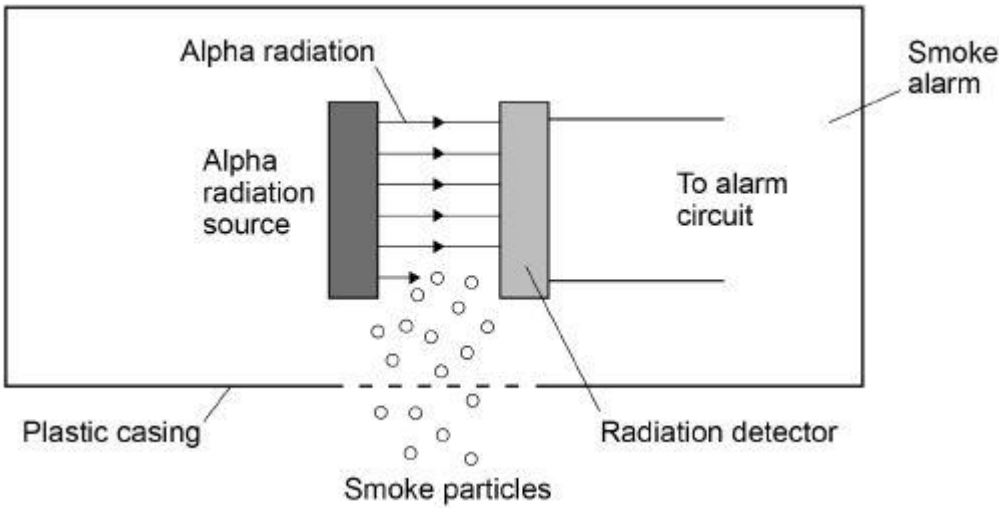
(Total 8 marks)

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?

_____

_____

_____

(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.

_____

_____

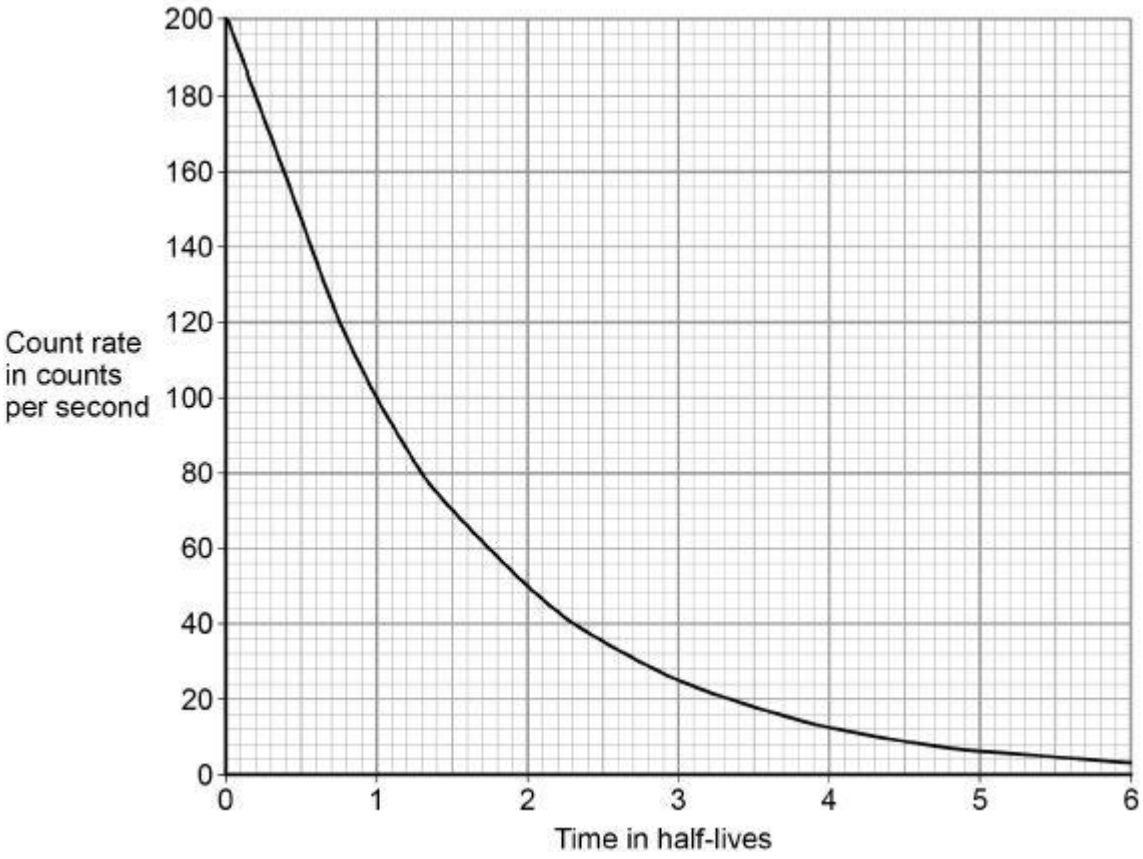
_____

_____

(2)

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

Figure 2



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

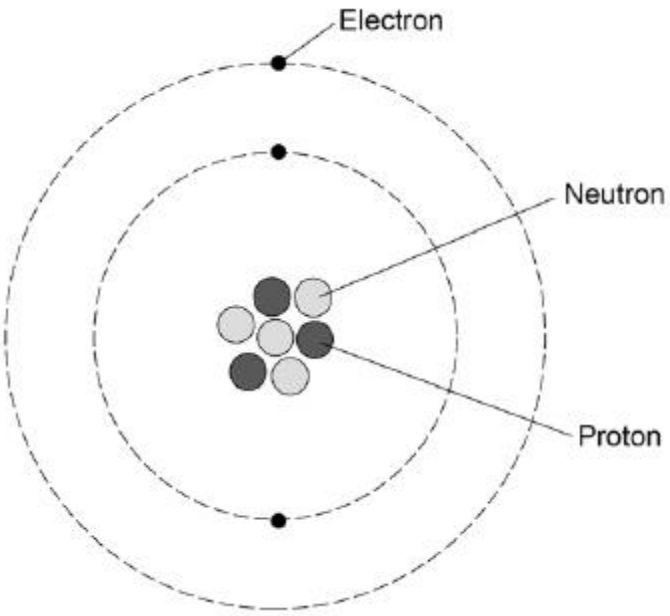
Explain the ideal properties of a radioactive source for use in medical diagnosis.

(4)

(Total 10 marks)

Q3.

The diagram shows a lithium atom.



(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 _____ .

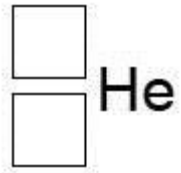
(1)

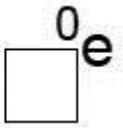
(d) Some atomic nuclei are unstable and decay by emitting an alpha particle or a beta particle.

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.

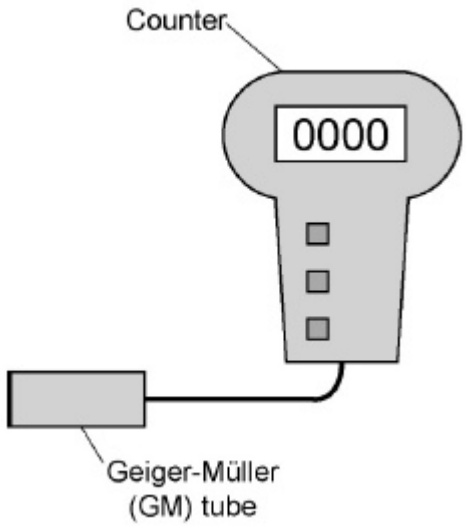
Cosmic rays	☐
Medical X-rays	☐
Nuclear power stations	☐
Nuclear weapons testing	☐
Radon gas	☐

(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

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

Tick **one** box.

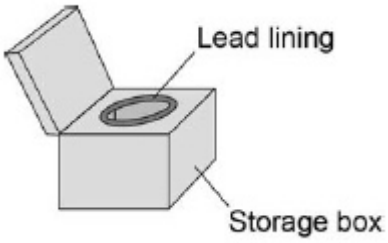
- Radioactive decay is a random process. ☐
- The air pressure in the laboratory increased. ☐
- The background radiation increased during the day. ☐
- The temperature in the laboratory decreased. ☐

(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. ☐

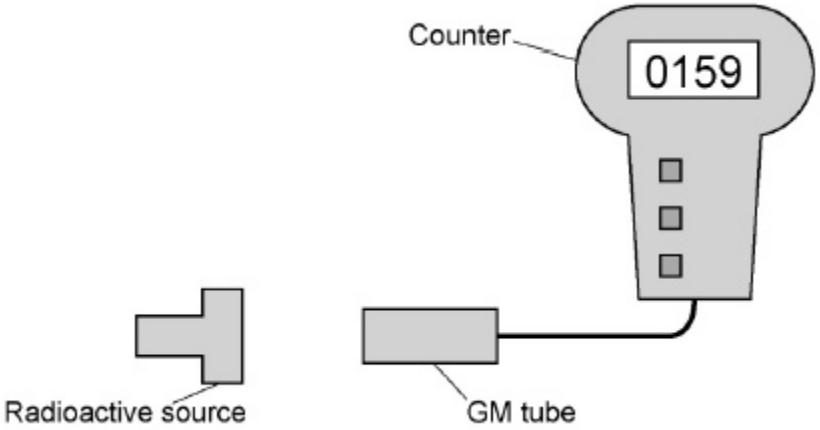
(1)

(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



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 ☐

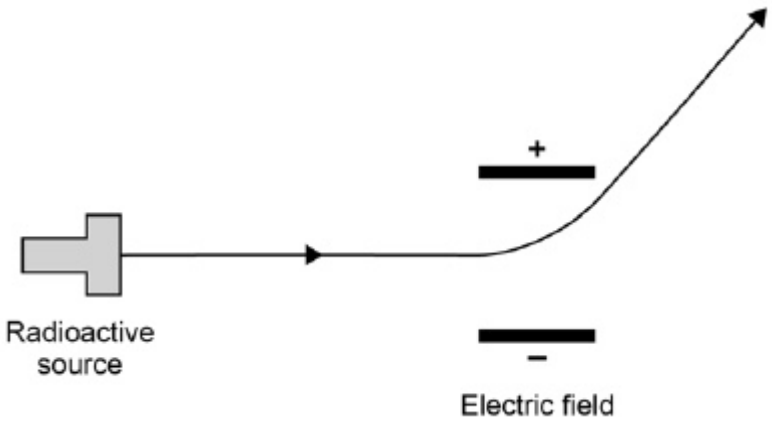
Subtract the background count from 159 ☐

(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.

Alpha ☐ Beta ☐ Gamma ☐ Neutron ☐

Explain the reason for your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 8 marks)

Q5.

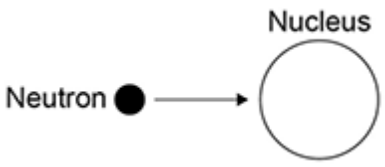
Electricity is generated in a nuclear power station.

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.

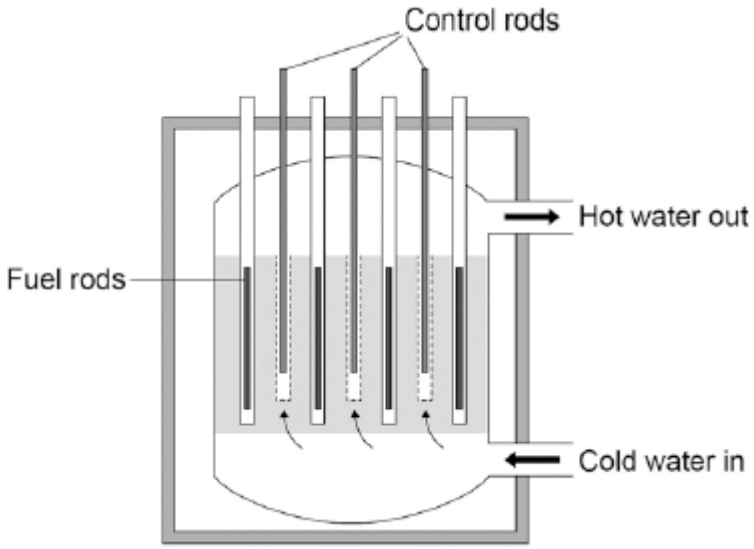
Figure 1



(3)

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

Figure 2



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.

_____

_____

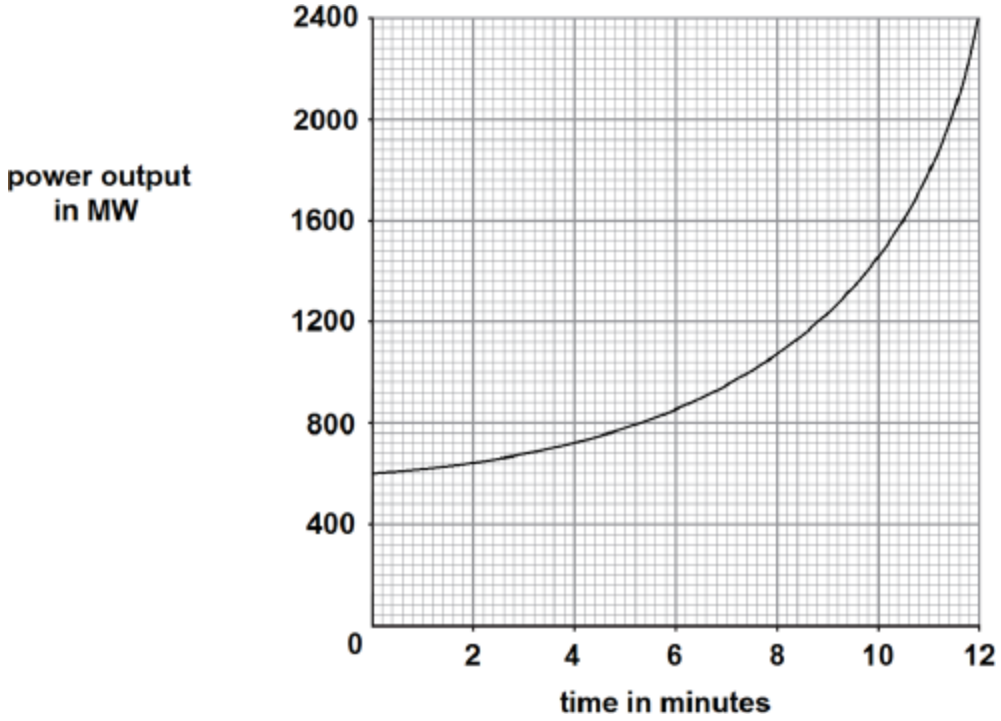
_____

_____

(2)

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

Figure 3



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 ☐

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?

_____

_____

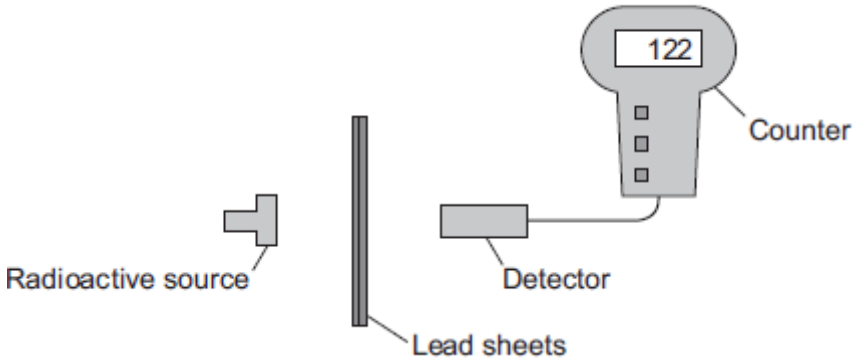
(1)

(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**.

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.

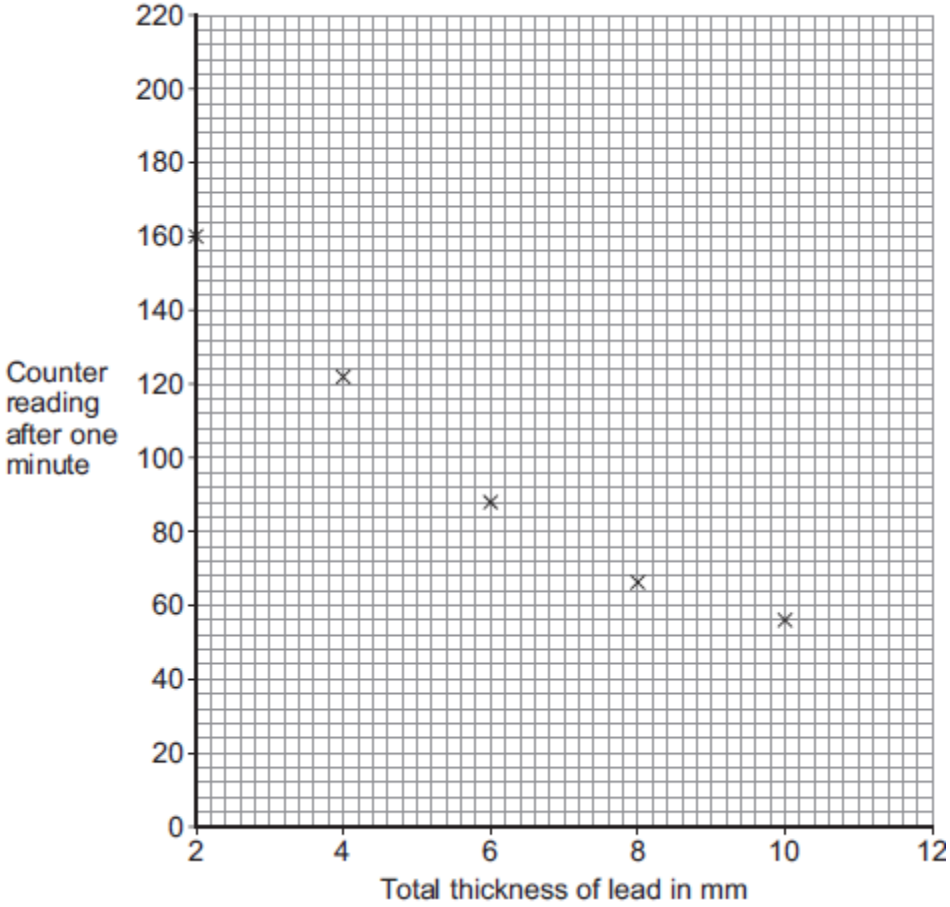
Complete the following word equation.

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**.

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.

_____

_____

(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?

_____

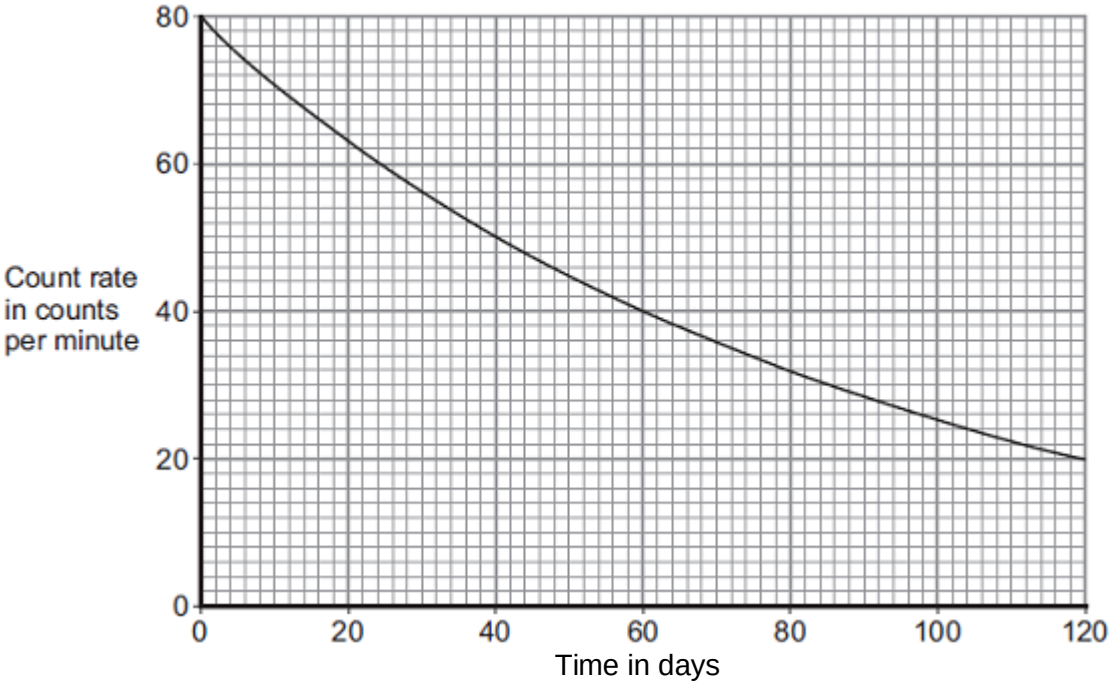
_____

_____

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

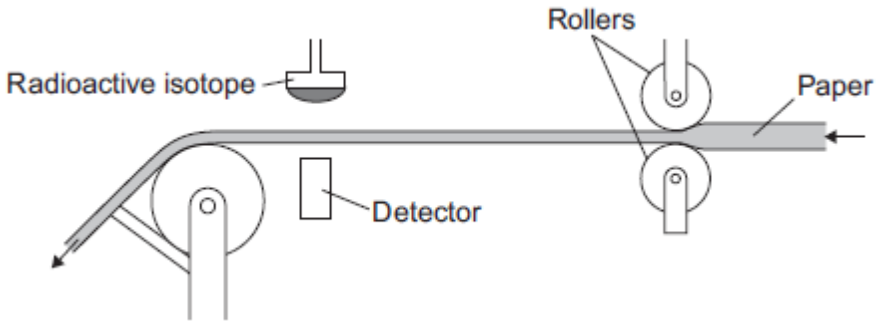
(i) State which radioactive isotope in the table above emits only radiation that is **not** deflected by a magnetic field.

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.

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

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

Explain your answer.

_____

_____

_____

_____

_____

_____

(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)

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

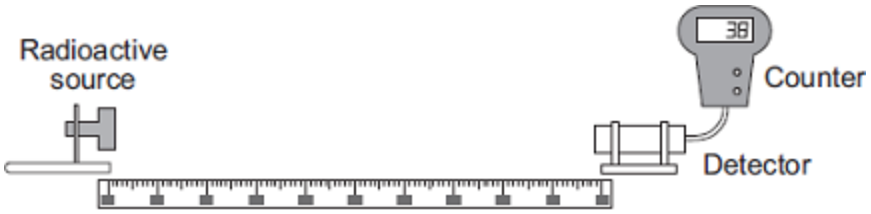
Complete the nuclear equation that represents the decay of Ba-139 to La-139.

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

(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)

(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?

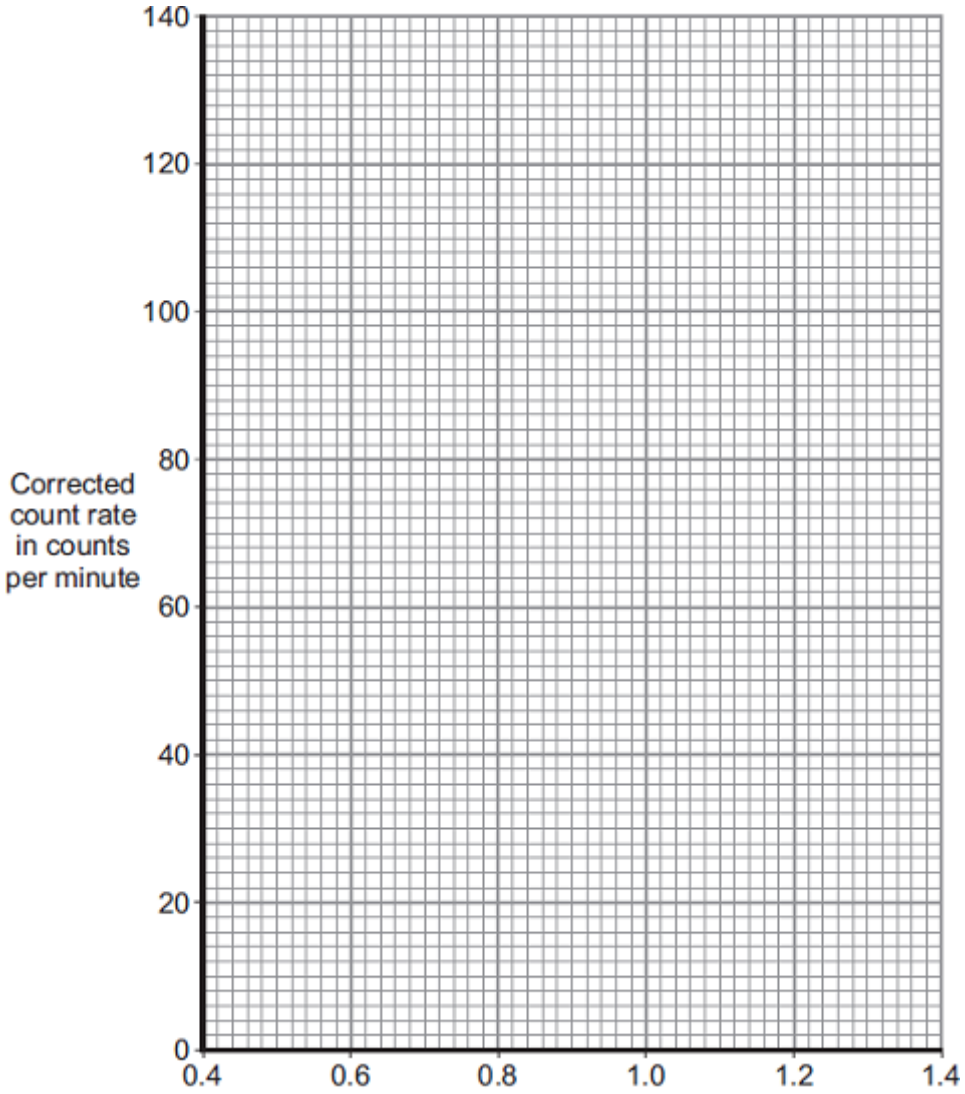
_____

_____

(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.



(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

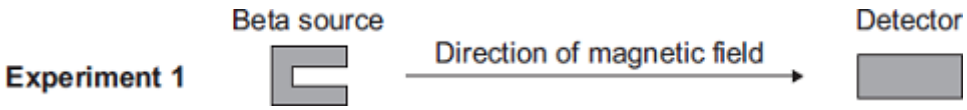
Use **Table 1** to determine if the hypothesis is correct for this radioactive source.

You should use calculations in your answer.

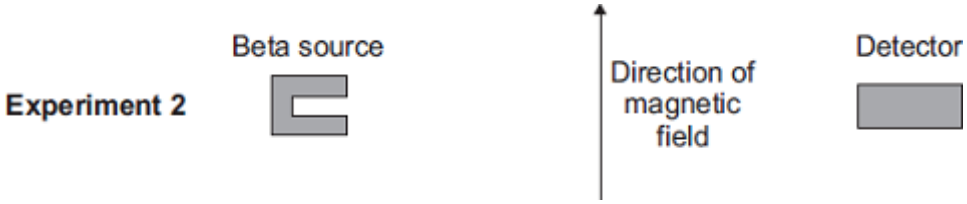
(3)

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

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 field	Count rate in counts per minute in Experiment 1	Count rate in counts per minute in Experiment 2
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?

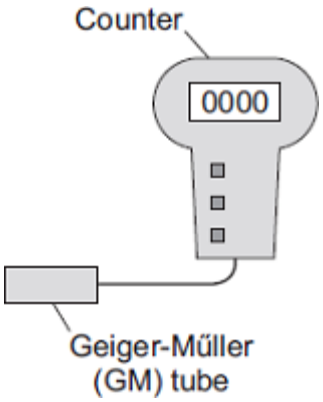
Draw a ring around each of your answers.

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?

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.

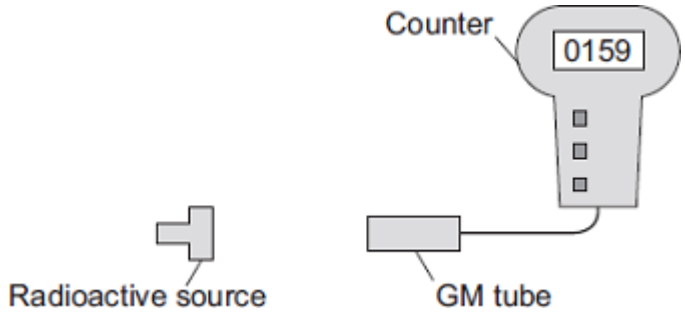
_____

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.

_____

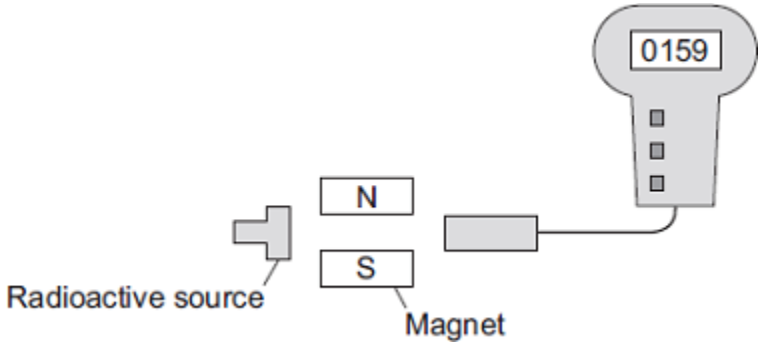
_____

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.



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.

_____

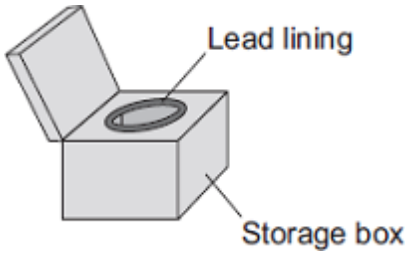
_____

_____

_____

(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? ☐

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

Should radioactive waste be dumped in the oceans? ☐

(1)

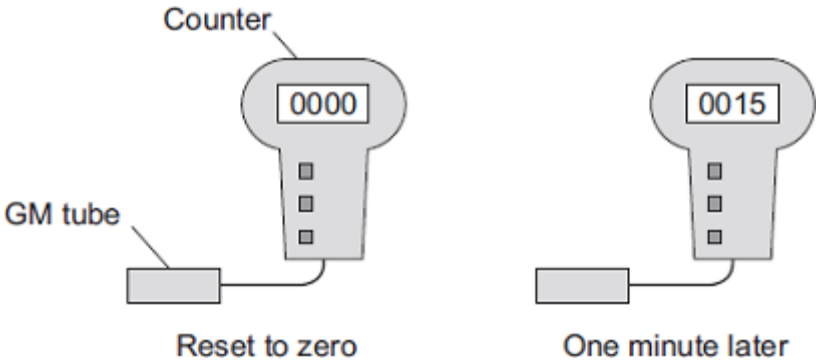
(Total 10 marks)

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?

_____

_____

(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)

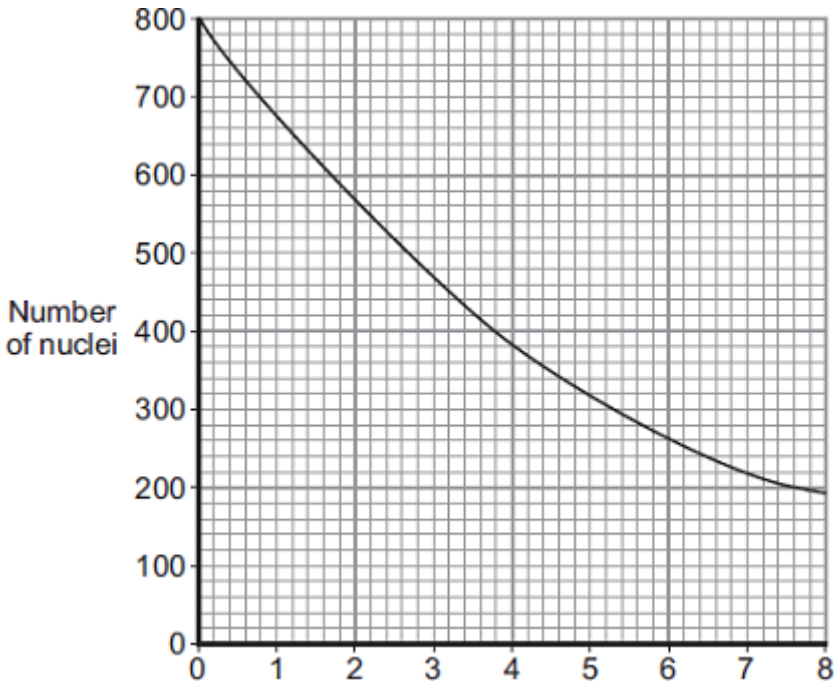
(ii) The decay of radon-222 can be represented by the equation below.

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.



Time in days

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.

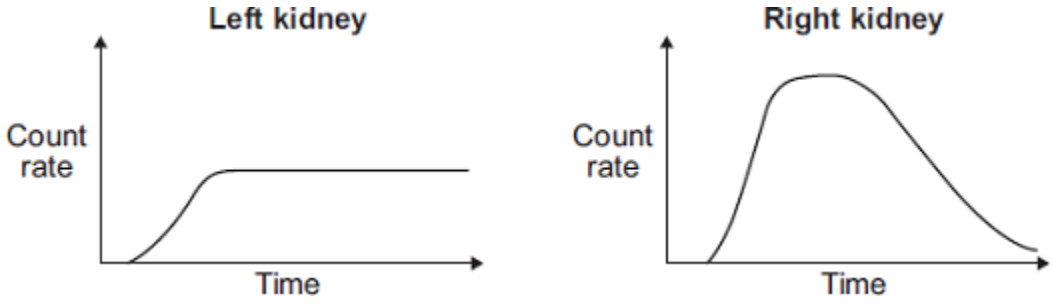
A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.

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.

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.

_____

_____

_____

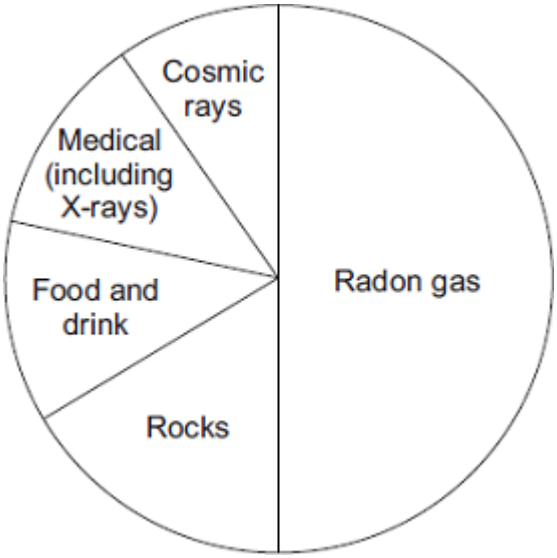
_____

(3)

(Total 4 marks)

Q14.

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



(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**.

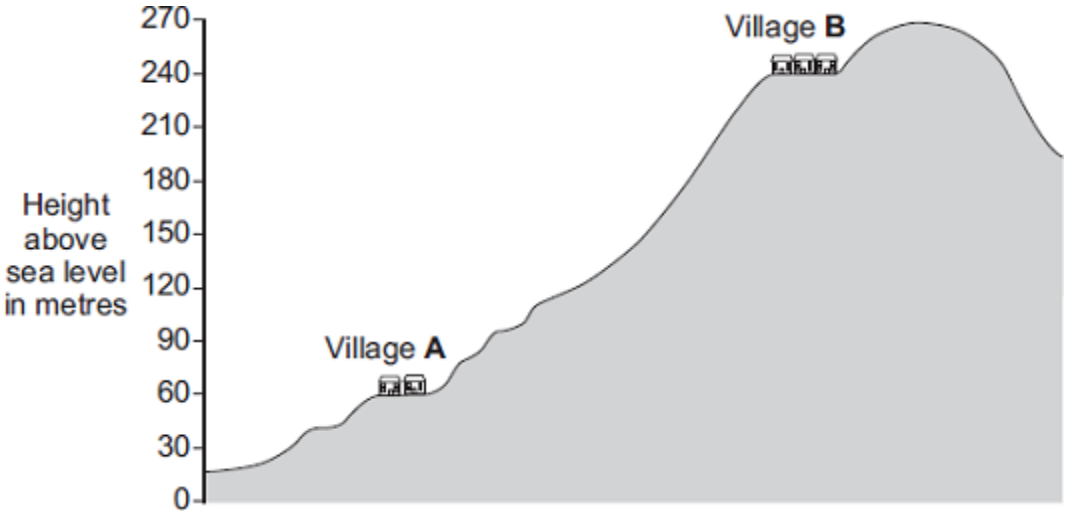
Draw only **three** lines.

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.



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

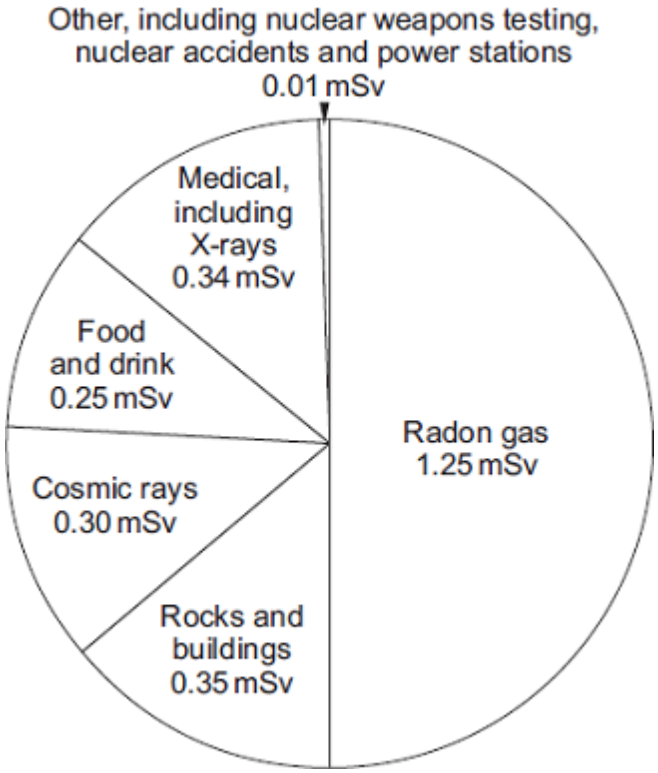
To obtain full marks, you must include a calculation in your answer.

(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).



(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.

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.

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?

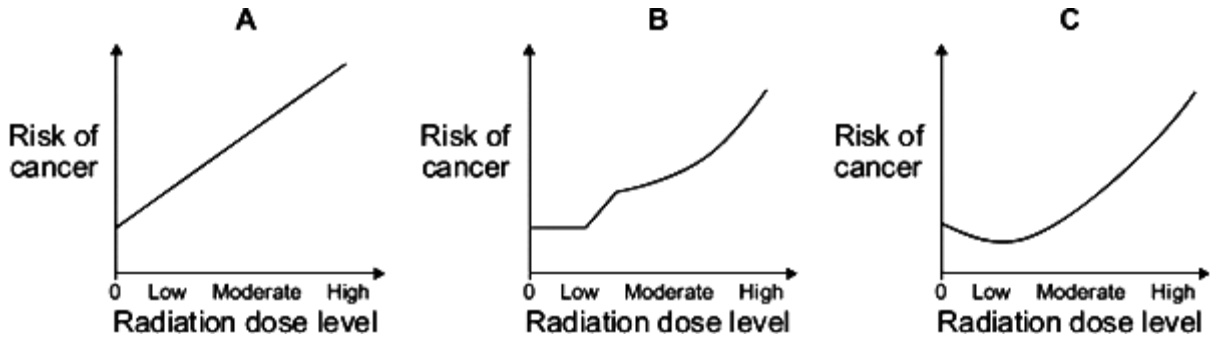
_____

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'.

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
social

issues.

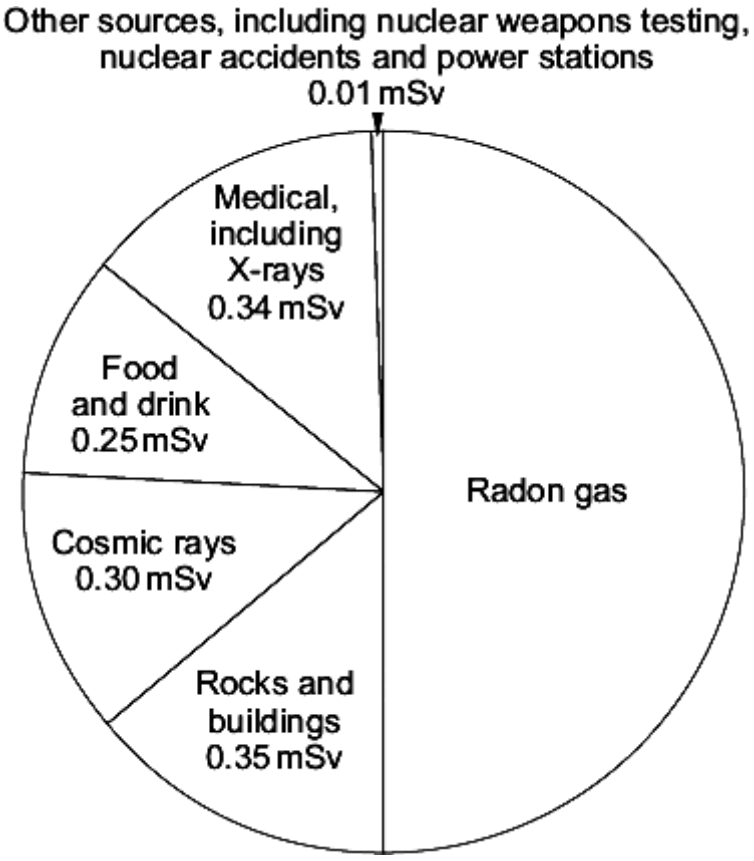
(1)

(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. _____

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?

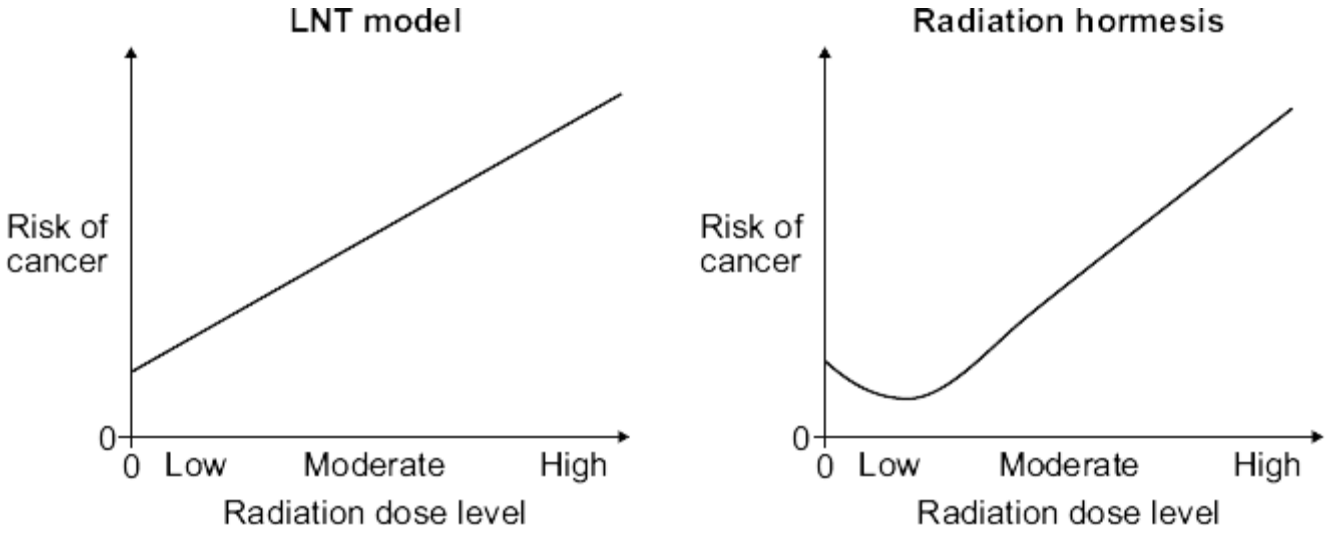
(1)

(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.



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.

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)

(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?

_____

_____

(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.

_____

_____

_____

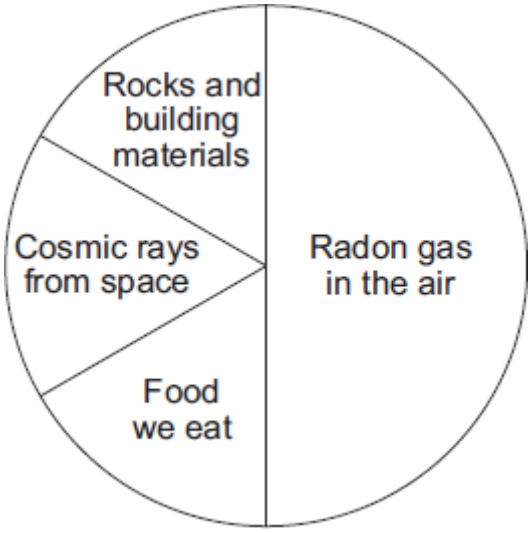
Time taken = _____ years

(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
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.

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

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?

_____

_____

(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.

_____

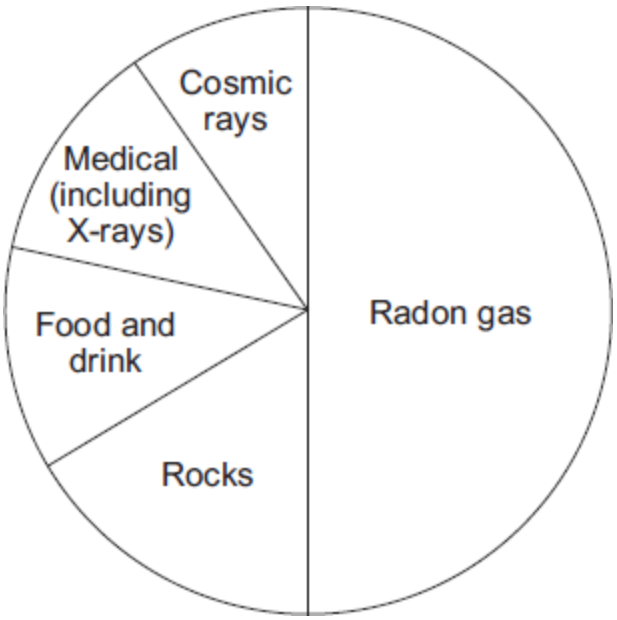
_____

(1)

(Total 9 marks)

Q21.

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



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.

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. _____

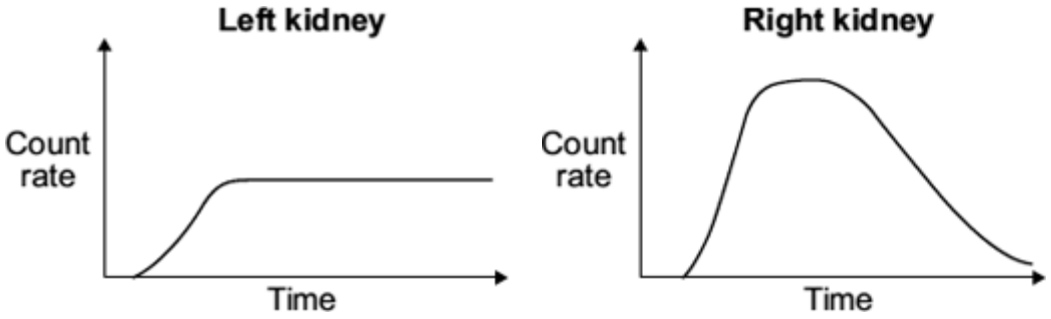
_____

(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)

(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.

_____

_____

_____

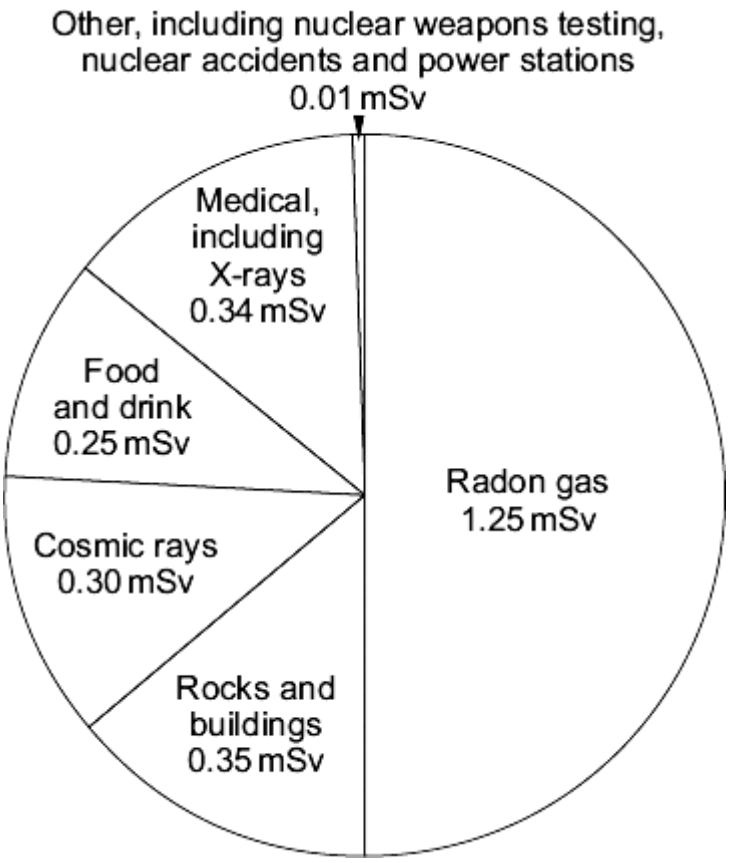
_____

(2)

(Total 9 marks)

Q23.

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

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**.

_____

_____

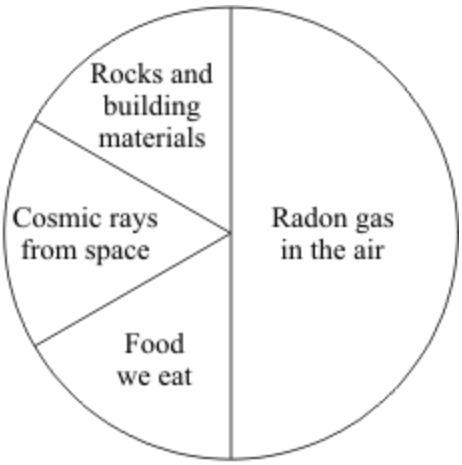
_____

(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.

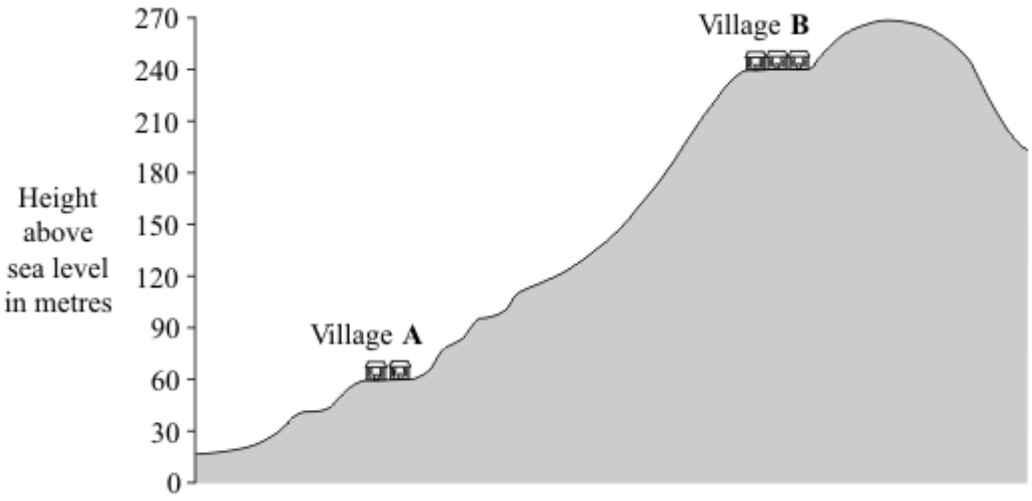
_____

_____

(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.



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.

_____

_____

_____

_____

_____

_____

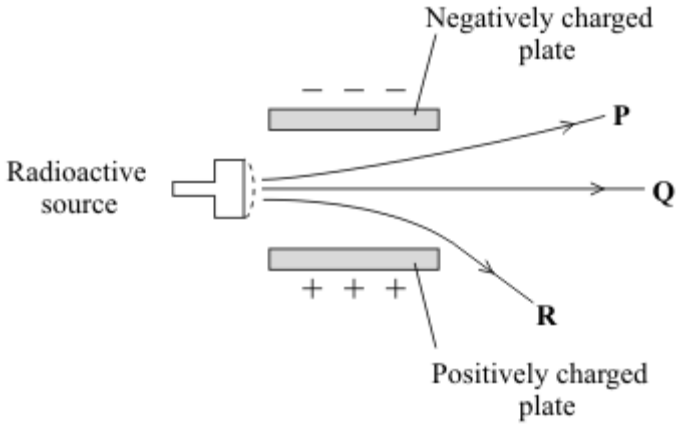
(3)

(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:

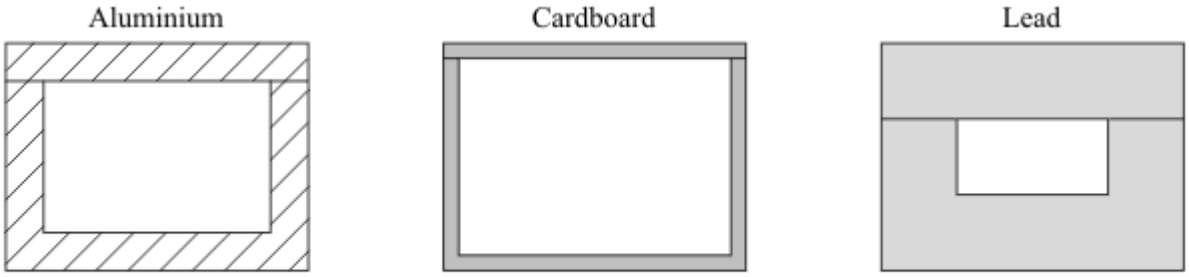
(i) alpha radiation _____

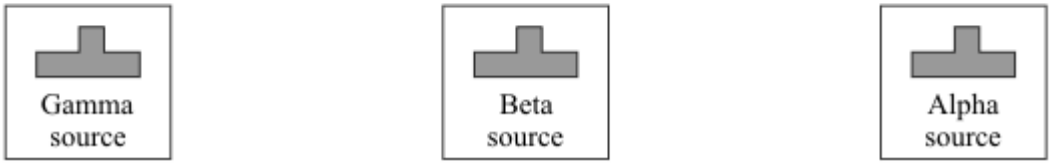
(1)

(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.

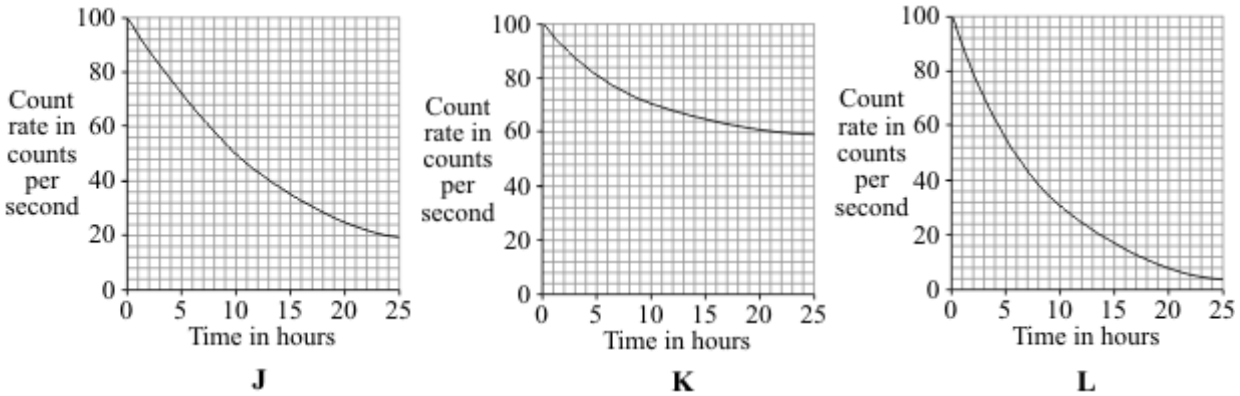




Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.

(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)

(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)

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

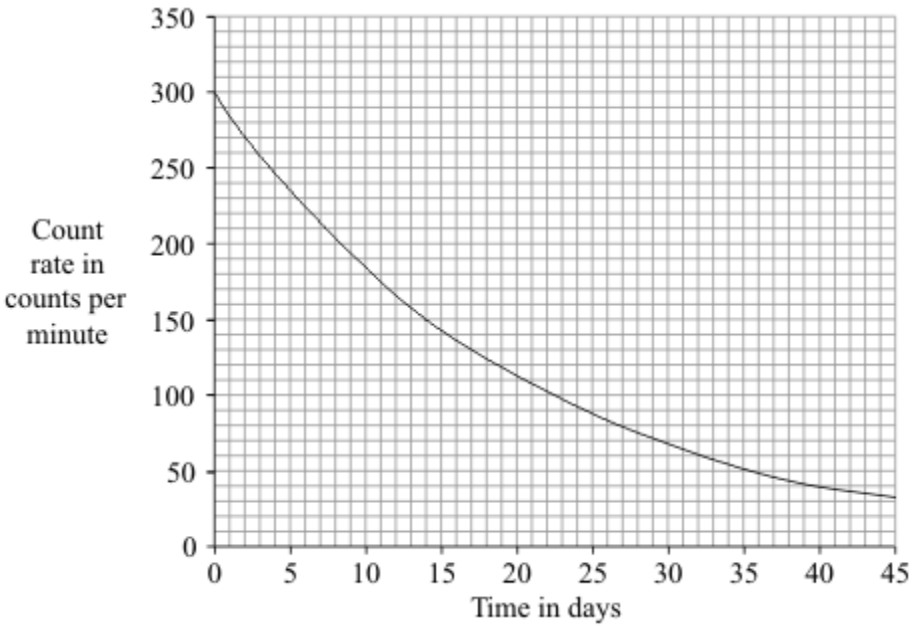
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

_____

_____

(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.

_____

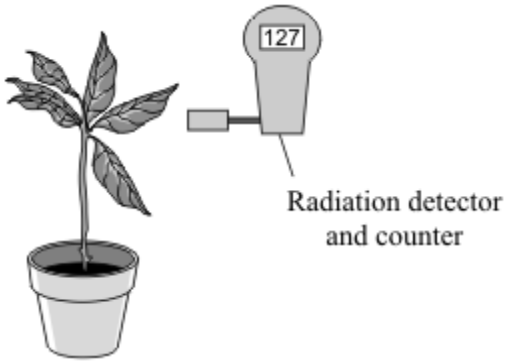
_____

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.



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. ☐

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 Type of nuclear radiation	**List B** Property of radiation

alpha	not deflected by an electric field
beta	stopped by thin metal but not paper
gamma	the most strongly ionising
	will not harm living cells

(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
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.

_____

_____

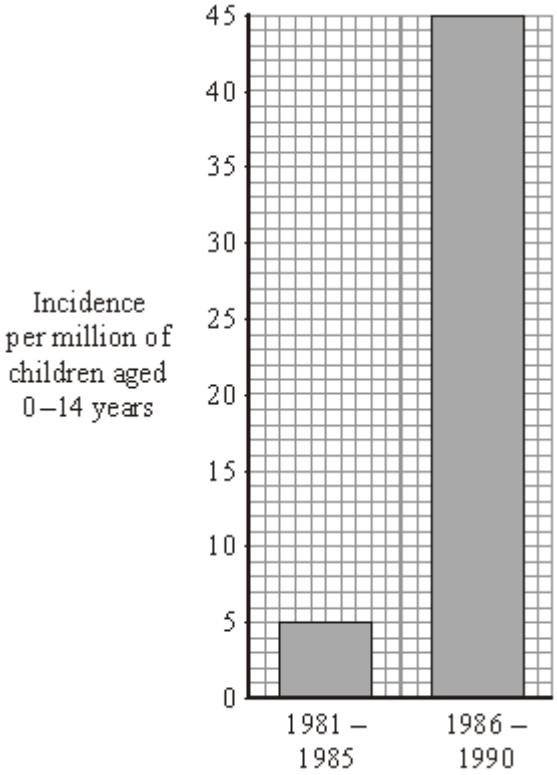
_____

_____

_____

(2)

(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. _____

_____

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.

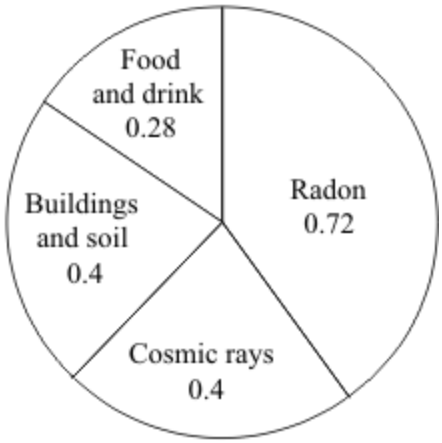
How is the structure of the nucleus of a polonium-218 atom different from the structure of the nucleus of a radon-222 atom?

_____

(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).



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

_____

_____

Proportion of radon = _____

(2)

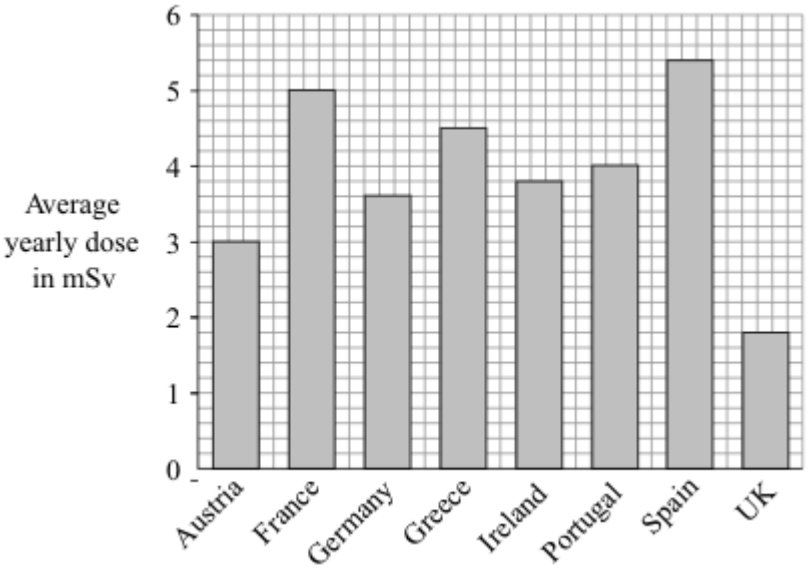
(ii) Not all background radiation is from natural sources.

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)

(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.

List A Type of radiation	List B Property of radiation
	not dangerous
alpha (α)	
	stopped by paper
beta (β)	
	travels at 300 000 000 m/s
gamma (γ)	
	travels up to 1 metre in air

(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.

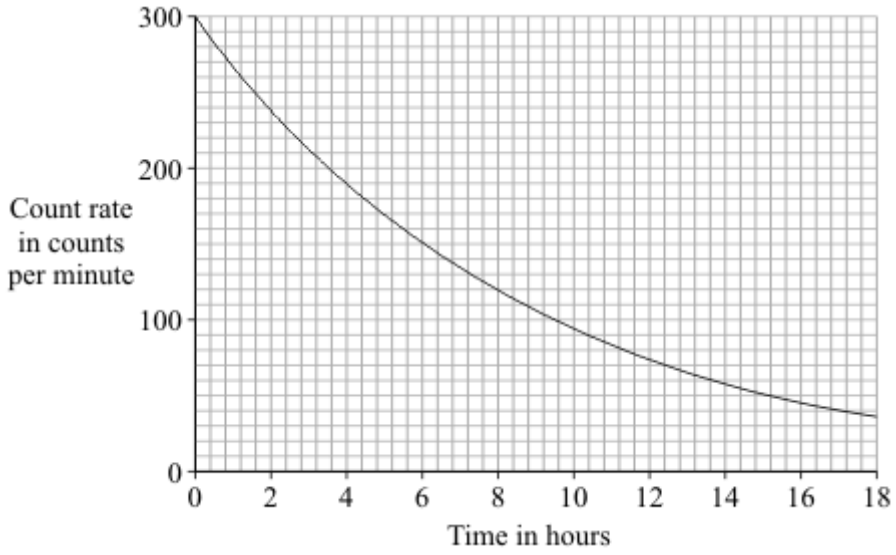
It can travel through a vacuum. ☐

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?

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?

_____

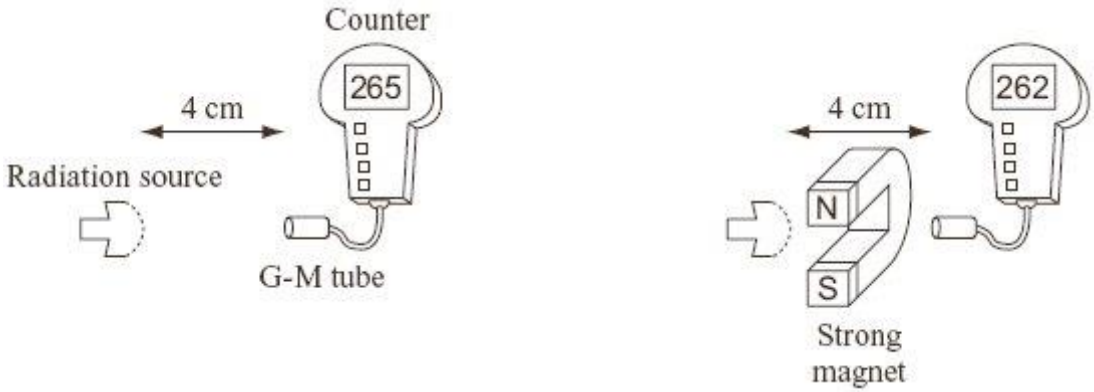
(1)

(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
Half-life: 6 hours
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.

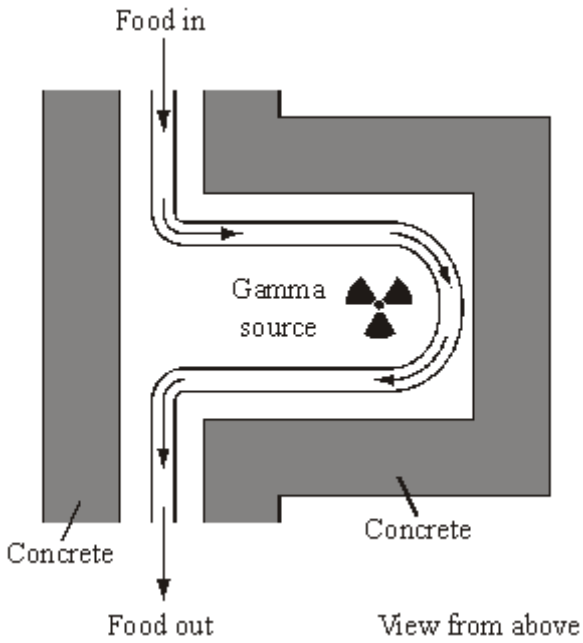
Complete the following sentence by choosing the correct word from the box.

electrons	**neutrons**	**protons**

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)

(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?

_____

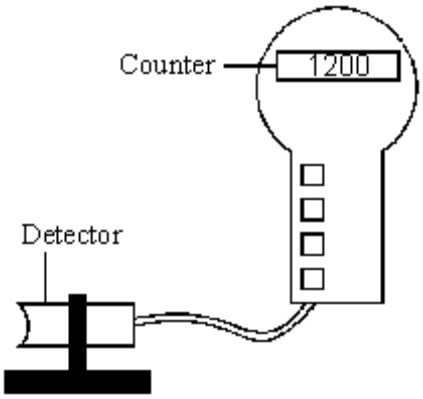
_____

(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.

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.

_____

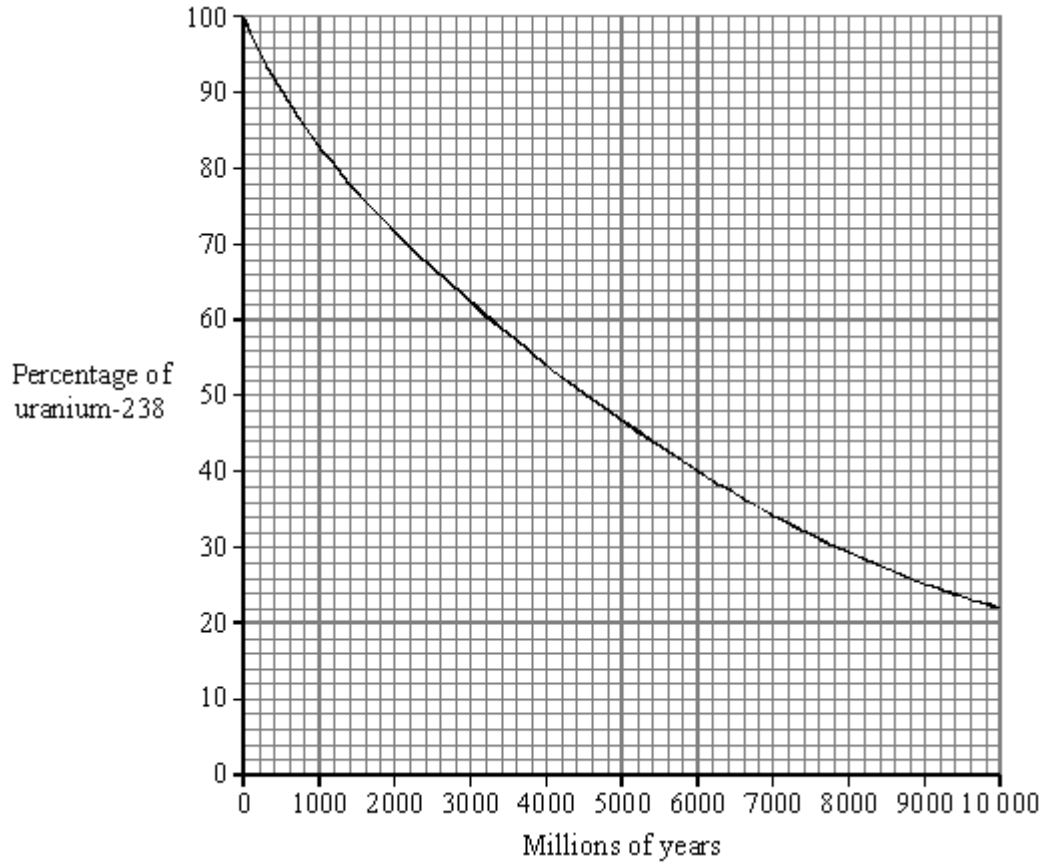
_____

_____

_____

(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.



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)

Mark schemes

Q1.

(a) $\text{count rate} = \frac{819}{60}$

1

count rate = 13.65

1

corrected count rate = 13.35 (per second)

allow an answer of
background = 0.30 × 60
= 18 (per minute)
corrected count rate
= 819 – 18
corrected count rate
= 801 per minute

1

*an answer of 13.35 (per second) scores **3** marks*
*an answer of 13.95 (per second) scores **2** marks*
*an answer of 801 (per second) scores **2** marks*

(b) activity = 1250 × 180

1

activity = 225 000 (Bq)

1

*an answer of 225 000 (Bq) scores **2** marks*

(c) yearly dose = 0.003 × 365

allow yearly dose = 1.095 (mSv)

1

which is << 100 (mSv)
or
(well) below the lowest dose with evidence of causing cancer / harm

1

(d) people are able to compare a radiation risk / dose / hazard to the radiation dose from (eating) bananas

1

[8]

Q2.

(a) smoke absorbs / stops alpha radiation

allow alpha particles for alpha radiation
alpha radiation does not reach the detector is insufficient

1

(b) alpha radiation is not very penetrating

allow alpha particles for alpha radiation

or

alpha radiation does not penetrate skin

allow alpha radiation does not travel very far (in air)

1

(c) beta and gamma radiation will penetrate smoke

allow beta and gamma radiation will not be stopped by smoke

1

no change (in the count rate) would be detected

allow the change detected (in the count rate) would be too small

1

(d) (a long half-life means) the count rate is (approximately) constant

allow activity of source is (approximately) constant

or

a short half-life means the count rate decreases quickly

1

until 1.3 half-lives the count rate is above 80 per second

allow after 1.3 half-lives the count rate is below 80 per second

or

until 1.3 half-lives the count rate is above the threshold for the smoke alarm to be activated

or

after 1.3 half-lives the smoke alarm will be activated all the time

so don't have to replace source or smoke detector is insufficient

1

(e) **Level 2:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

3–4

Level 1: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

1–2

No relevant content

0

Indicative content

- short half-life or half-life of a few hours
- (short half-life means) less damage to cells / tissues / organs / body
- low ionising power
- (low ionising power means) less damage to cells / tissues / organs / body
- highly penetrating
- (highly penetrating means) it can be detected outside the body
- emits gamma radiation

[10]

Q3.

(a) 7

1

(b) 3

1

number of <u>protons</u>

reason only scores if 3 chosen

1

(c) levels

1

(d) $^{4}_{2}He$

correct order only

1
1

$^{0}_{-1}e$

1

(e) shorter half-life (than the other sources)

1

exposure time to radiation is shorter

1

[9]

Q4.

(a) cosmic rays

1

radon gas

1

(b) radioactive decay is a random process

1

(c) the lead lining absorbs the emitted radiation

1

(d) subtract the background count from 159

1

(e) beta

1

beta is negatively charged

1

(so is) attracted to positive plate

or
(so is) repelled by negative plate

1

[8]

Q5.

(a) Nucleus splitting into two fragments and releasing two or three neutrons

1

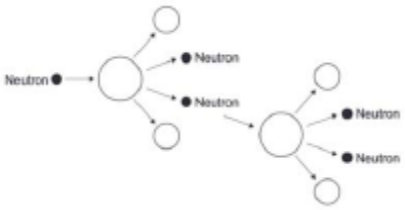
(at least one) fission neutron shown to be absorbed by additional large nucleus and causing fission

1

two or three additional neutrons released from fission reaction

1

*This diagram would gain all **3** marks:*



(b) lowering the control rods increases the number of neutrons absorbed

accept converse description

1

(so) energy released decreases

1

*allow changing the position of the control rods affects the number of neutrons absorbed for **1** mark*

(c) rate of increase between 240 and 276 (MW / min)

2

*allow **1** mark for attempt to calculate gradient of line at 10 minutes*

[7]

Q6.

(a) 2 protons and 2 neutrons

accept 2p and 2n
accept (the same as a) helium <u>nucleus</u>
symbol is insufficient
do not accept 2 protons and neutrons

1

(b) (i) gamma rays

1

(ii) loses/gains (one or more) <u>electron(s)</u>

1

(c) any **one** from:

- wear protective clothing
- work behind lead/concrete/glass shielding
- limit time of exposure
- use remote handling

accept wear mask/gloves
wear goggles is insufficient
wear protective equipment/gear is insufficient
accept wear a film badge
accept handle with (long) tongs
accept maintain a safe distance
accept avoid direct contact

1

[4]

Q7.

(a) cell damage or cancer

accept kills / mutates cells
radiation poisoning is insufficient
ionising is insufficient

1

(b) (i) any **one** from:

- use tongs to pick up source
- wear gloves
- use (lead) shielding
- minimise time (of exposure)
- maximise distance (between source and teacher).

accept any other sensible and practical suggestion
ignore reference to increasing / decreasing the number / thickness of lead sheets

1

(ii) <u>background</u>

1

(c) (i) curve drawn *from point 2,160*

*do **not** accept straight lines drawn from dot to dot*

1

(ii) (also) increases

less radiation passes through is insufficient

1

(iii) 50

accept any value from 40 to 56 inclusive

1

(d) gamma

1

only gamma (radiation) can pass through lead

*accept alpha **and** beta cannot pass through lead*
a general property of gamma radiation is insufficient

1

[8]

Q8.

(a) (average) time taken for the amount / number of nuclei / atoms (of the isotope in a sample) to halve
or
time taken for the count rate (from a sample containing the isotope) to fall to half

accept (radio)activity for count rate

1

(b) *60 ±3* (days)

1

indication on graph how value was obtained

1

(c) (i) cobalt(-60)

1

gamma not deflected by a magnetic field
or
gamma have no charge

dependent on first marking point
accept (only) emits gamma
gamma has no mass is insufficient
*do **not** accept any reference to half-life*

1

(ii) strontium(-90)

1

any **two** from:

- *only* has beta
- alpha would be absorbed
- gamma unaffected
- *beta penetration / absorption depends on thickness of paper*

*if thorium(-232) or radium(-226) given, max **2** marks can be awarded*

2

(iii) cobalt(-60)

1

shortest half-life

accept half-life is 5 years

dependent on first marking point

1

so activity / count rate will decrease quickest

1

(iv) *americium(-241) / cobalt(-60) / radium(-226)*

1

gamma emitter

1

(only gamma) can penetrate lead *(of this box)*

do not allow lead fully absorbs gamma

1

[14]

Q9.

(a) (i) nuclear reactor

1

star

1

(ii) nuclei are joined (not split)

accept converse in reference to nuclear fission

*do **not** accept atoms are joined*

1

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)

  ignore atom
  *do **not** accept reacts*
  *do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) <u>nuclei</u> / into Ba and Kr
- releasing <u>three</u> neutrons and energy

  accept fast-moving for energy

4

(ii) 56 (Ba)

1

57 (La)

*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*

1

$^{0}_{-1}\beta$

accept e for β

$^{139}_{56}Ba \longrightarrow {}^{139}_{57}La + {}^{0}_{-1}\beta$

*scores **3** marks*

1

[10]

Q10.

(a) (i) 18

1

(ii) the count rate for the source

1

(iii) the alpha radiation would not cover such a distance

1

(iv) plots correct to within ½ small square

*allow **1** mark for 4 correct points plotted*

2

correct curve through points as judged by eye

1

(v) two attempts at finding 'half-distance' using the table

20 to 10 cpm d = 0.4 m
125 to 56 cpm d = 0.2 m
31 to 14 cpm d = 0.4 m

*allow **1** mark for one attempted comparison*

2

obeyed or not obeyed

dependent on previous two marks

1

(b) (i) there is no effect on the count rate in experiment 1 because the field is parallel **or** beta particles are not deflected **or** there is no force

1

count rate is reduced in experiment 2 because field is perpendicular **or** beta particles are deflected **or** there is a force

1

(ii) only background radiation (as beta do not travel as far)

1

slightly different values show the random nature of radioactive decay

1

[13]

Q11.

(a) cosmic rays

1

radon gas

1

(b) (i) Radioactive decay is a random process

1

(ii) 19

1

(iii) 140

accept 159 – their (b)(i) correctly calculated

1

(iv) gamma

1

the count stayed the same

1

or

gamma does not have a charge

accept gamma is an electromagnetic wave

(so) gamma is not deflected / affected by the magnetic field

accept magnet for magnetic field

*do **not** accept is not attracted to the magnet*

last two marks may be scored for an answer in terms of why it cannot be alpha or beta

only answer simply in terms of general properties of gamma are insufficient

1

(c) lead absorbs (some of the) radiation

accept radiation cannot pass through (the lead)

or

less radiation emitted into the (storage) room

1

(d) Should radioactive waste be dumped in the oceans

1

[10]

Q12.

(a) (i) any **one** from:

- nuclear power (stations)

accept nuclear waste
accept coal power stations

- nuclear weapons (testing)
  accept nuclear bombs / fallout

- nuclear accidents
  accept named accident, eg Chernobyl or Fukushima
  accept named medical procedure which involves a radioactive source
  accept radiotherapy
  accept X-rays
  accept specific industrial examples that involve a radioactive source
  nuclear activity / radiation is insufficient
  smoke detectors is insufficient

1

(ii) (radioactive decay) is a random process
accept an answer in terms of background / radiation varies (from one point in time to another)

1

(b) any **one** from:

- (maybe) other factors involved
  accept a named 'sensible' factor, eg smoking

- evidence may not be valid
  accept not enough data

- may not have (a complete) understanding of the process (involved)

1

(c) (i) 2

1

2

1

(ii) 218
correct order only

1

84

1

(d) 3.8 (days)
*allow **1** mark for showing correct method using the graph provided no subsequent steps*
*correct answers obtained using numbers other than 800 and 400 gain **2** marks provided the method is shown*

2

[9]

Q13.

(a) (both graphs show an initial) increase in count rate

accept both show an increase

1

(b) only the right kidney is working correctly

1

any **two** from:

*if incorrect box chosen maximum of **1** mark can be awarded*
reference to named kidney can be inferred from the tick box

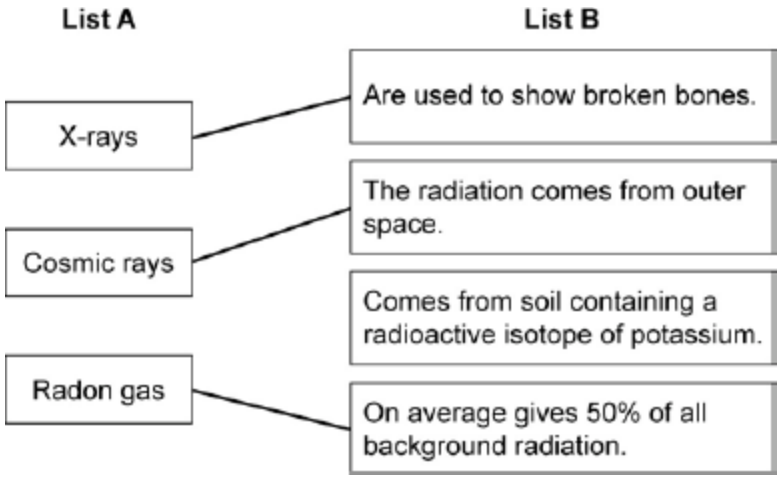
- count-rate / level / line for right kidney decreases (rapidly)
  it decreases is insufficient
- count-rate / level / line for left kidney does not change
  it does not change is insufficient
- radiation is being passed out into urine – if referring to right kidney
- radiation is not being passed out – if referring to the left kidney
- left kidney does not initially absorb as much technetium-99

2

[4]

Q14.

(a) 1 mark for each correct line



*if more than 1 line has been drawn from a box in **List A** then all those lines are marked incorrect*

3

(b) higher in village B

1

by 6 units

*allow **1** mark for correctly obtaining a height difference of 180 (m) / 4 times higher – this refers to height not radiation levels*

*accept for **3** marks in village A it is 2 units (extra) and in village B it is 8 units (extra) allow **1** mark for a correct radiation calculation based on incorrect height readings*

2

[6]

Q15.

(a) (i) 2.5

1

(ii) The radiation dose from natural sources is much greater than from artificial sources

1

(b) (i) any **one** from:

- different concentrations in different rooms
- to average out daily fluctuations
  accept to find an average
  accept to make the result (more) reliable / valid
  *do **not** accept to make more accurate on its own*

1

(ii) average level (much) higher (in **C** and **D**)
accept converse

1

some homes have very high level (in **C** and **D**)
*accept maximum level in **A** and **B** is low*

1

or

maximum level in some homes (in **C** and **D**) is very high
*accept higher radiation levels (in **C** and **D**) for **1** mark*

[5]

Q16.

(a) (i) on average, cosmic rays produce less background radiation than rocks.

1

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

1

(ii) 4
*allow **1** mark for 350 / 4*
*allow **1** mark for an answer 3.5*

2

(b) (i) (risk) increases

1

(ii) C

*reason only scores if **C** chosen*

1

shows a lower risk for low doses (than for zero exposure)

accept risk reduces when you go from low to moderate (doses)

1

(c) (i) *no mark for YES or NO, marks are for the explanation*

YES

fewer mice exposed first to a low dose

1

get cancer (than those only exposed to a high dose)

only scores if first marking point scores

NO

the results are for mice (1)

and may not be applicable to people (1)

1

(ii) ethical

1

[10]

Q17.

(a) (i) 1.25 (mSv)

1

(ii) any **two** from:

- (frequent) flying
  accept stated occupation that involves flying
- living at altitude
- living in areas with high radon concentrations
  accept a specific area, eg Cornwall
- living in a building made from granite (blocks)
- having more than the average number of X-rays
  or
  having a CT scan
  accept more medical treatments
- working in a nuclear power station
  accept any suggestion that could reasonably increase the

level from a specific source

2

(b) (i) to be able to see the effect of exposure (to radon gas)
or
as a control
accept to compare (the effect of) exposure (with no exposure)

1

(ii) increased levels of exposure increases the risk (of developing cancer)
accept exposure (to radon gas) increases the risk

1

smoking increases the (harmful) effect of radon
answers that simply reproduce statistics are insufficient

1

(c) LNT model – risk increases with increasing radiation (dose) level
accept in (direct) proportion
accept low doses increase the risk

1

Radiation hormesis - low radiation (dose) levels reduce the risk

1

(d) two valid points made – examples:

- animals have no choice and so should not be used
- should not make animals suffer
- better to experiment on animals than humans
- experiments lead to a better understanding / new knowledge
- experiments may lead to health improvement / cures for humans

results for animals may not apply to humans is insufficient

2

[10]

Q18.

(a) cobalt-(60)

1

gamma (radiation) will pass through food / packaging
this can score if technetium chosen

1

long half-life so level of radiation (fairly) constant for (a number) of years
this can score if strontium / caesium is chosen
accept long half-life so source does not need frequent replacement
accept answers in terms of why alpha and beta cannot be

used
gamma kills bacteria is insufficient

1

(b) (i) people may link the use of radiation with illness / cancer
accept (they think) food becomes radioactive
accept (they think) it is harmful to them
'it' refers to irradiated food

1

(ii) not biased / influenced (by government views)

1

(iii) any **two** from:

- data refers only to (cooked) chicken
- data may not generalise to other foods
- the content of some vitamins increases when food / chicken is irradiated
- no vitamins are (completely) destroyed
- (only) two vitamins decrease (but not significantly)
accept irradiated chicken / food contains a higher level of vitamins
marks are for the explanation only

2

(iv) so can choose to eat / not eat that (particular) food
accept irradiated food may cause health problems (for some people)
accept people may have ethical issues (over eating irradiated food)

1

(c) (i) electron
from nucleus / neutron
***both** parts required*

1

(ii) 90 years
*allow **1** mark for showing 3 half-lives*

2

[11]

Q19.

(a) (i) half / 50 %

1

(ii) Measure the radon gas level in more homes in this area

1

(b) (i) 86

1

(ii) 222

1

[4]

Q20.

(a) (i) any **one** from:

- food / drink
- rocks / building materials
- cosmic rays / rays from space
  accept correctly named example

1

(ii) any **one** from:

- nuclear power / coal power (stations)
  accept nuclear waste
- nuclear accidents
  accept named accident eg Chernobyl
- nuclear weapons testing
  accept named medical procedure which involves a radioactive source
  accept radiotherapy
  nuclear activity / radiation is insufficient
  *do **not** accept CT scans*

1

(iii) different number of / fewer protons
accept does not have 86 protons
accept only has 84 protons
or
different atomic number
*do **not** accept bottom number different*
reference to mass number negates this mark

1

(b) 168

accept 169 if clear, correct method is shown
*allow **1** mark for a correct dose ratio involving the spine*
eg 2:140 etc
***or** ratio of days to dose is 1.2*
***or** ratio of dose to days is 0.83*

2

(c) (i)

Group A	Group B
J M O	K L N

all correct
any order within each group

1

(ii) similar (number) / same (number) / large (number)
accept the same specific number in each group eg three
reference to other factors such as age is neutral

1

(iii) how many people in each group developed cancer
a clear comparison is required

1

(iv) *there are no marks for **Yes** or **No** the mark is for the reason*

Yes
the benefit of having the scan is greater than the risk
or
the risk is (very) small (compared to the chance from natural causes)
accept the risk is much greater from natural causes

No
no additional risk is acceptable

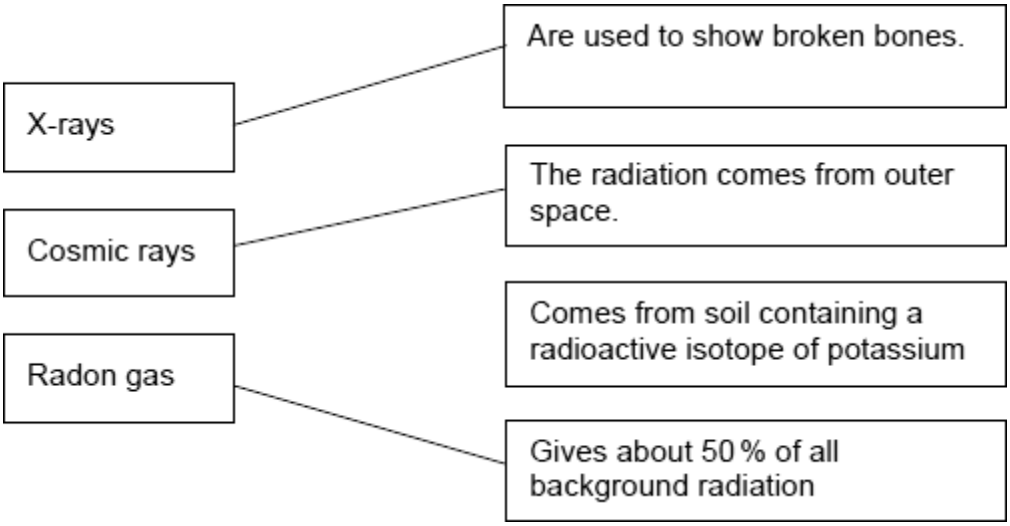
1

[9]

Q21.

1 mark for each correct line

*If more than 1 line has been drawn from a box in **List A** then all those lines are marked incorrect.*



[3]

Q22.

(a) gamma will pass through the body

it refers to gamma

or

alpha will not pass through the body

answers must relate to the body

accept skin for body

1

gamma is only slightly ionising

accept gamma causes less damage to cells / tissue

or

alpha is heavily ionising

*do **not** accept gamma causes no damage to cells*

less harmful is insufficient

1

(b) (i) (both graphs show an initial) increase in count-rate

accept both show an increase

1

(ii) only the right kidney is working correctly

1

any **two** from:

*if incorrect box chosen maximum of **1** mark can be awarded*

reference to named kidney can be inferred from the tick box

- count-rate / level / line for right kidney decreases (rapidly)
  it decreases is insufficient
- count-rate / level / line for left kidney does not change
  it does not change is insufficient

- radiation is being passed out / into urine - if referring to right kidney
- radiation is not being passed out - if referring to the left kidney

2

(c) (i) time taken for number of nuclei to halve
or
time taken for the count-rate to halve

1

(ii) short half-life – the level of radiation (in the body) decreases rapidly
it refers to short life isotope

1

to a safe / very small level
or
a long half-life – the radiation remains in the body / for a long time

level of radiation remains high
answers in terms of damage eg cancer are insufficient

1

[9]

Q23.

(a) (i) 2.5

1

(ii) The radiation dose from natural sources is much greater than from artificial sources.

1

(b) (i) other factors may be involved
accept a specific suggestion
eg they may be exposed to other types of radiation
accept cannot be sure (in many cases) that the cause of death is radon (poisoning)

1

(ii) any **one** from:

- different concentrations in different rooms
- to average out daily fluctuations
accept to find an average
accept to make the result (more) reliable / valid
*do **not** accept to make more accurate on its own*

1

(iii) average level (much) higher (in **C** and **D**)
accept converse

1

some homes have very high level (in **C** and **D**)

*accept maximum level in **A** and **B** is low*

or

maximum level in some homes (in **C** and **D**) is very high

*accept higher radiation levels (in **C** and **D**) for **1** mark*

1

[6]

Q24.

(a) (i) half / ½ / 50%

accept 1 (part) in 2 (parts) 1

1

(ii) (the) food (we eat) is radioactive

accept because of the food (we eat)

accept we breathe in radon

radon in the air is neutral

1

(b) higher in village B

1

by 6 units

allow 1 mark for correctly obtaining a height difference of 180(m)/ 4 times higher – this refers to height and not radiation levels

accept for 3 marks in village A it is 2 units (extra) and in village be it is 8 units (extra)

allow 1 mark for a correct radiation calculation based on incorrect height readings

2

[5]

Q25.

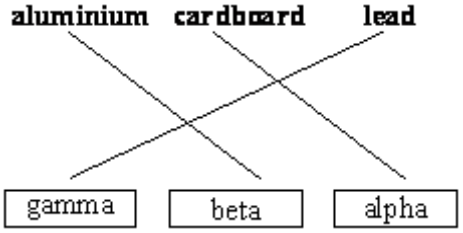
(a) (i) **P**

1

(ii) **Q**

1

(b) 3 lines correct



*allow **1** mark for 1 correct line*

two lines drawn from any source or box – both incorrect

2

(c) (i) **K**

1

(ii) 56

accept 50 – 60 inclusive

1

(iii) **K**

1

(iv) to inject... tracer

1

[8]

Q26.

(a) (i) beta and gamma

both answers required

accept correct symbols

1

(ii) alpha and beta

both answers required

accept correct symbols

1

(iii) gamma

accept correct symbol

1

(b) nothing *(*you do to a radioactive substance / source*)* changes the count rate / activity / rate of decay / radiation (emitted)

accept it = radiation emitted

or *(*reducing*)* the temperature does not change the activity / count rate / rate of decay / radiation (emitted)

1

(c) (i) has <u>one</u> more neutron

correct answer only

1

(ii) 14 days

no tolerance

*allow **1** mark for showing a correct method on the graph*

2

(iii) any **two** from:

- beta particles / radiation can be detected externally
- beta particles / radiation can pass out of / through the plant
- long half-life gives time for phosphorus to move through

the plant / be detected / get results

- phosphorus-32 is chemically identical to phosphorus-31
- phosphorus-32 is used in the same way by a plant as phosphorus-31

2

[9]

Q27.

(a) top and bottom boxes identified

1

(b) Medical (treatment)

or X-rays

answer must be in table
accept treatment for medical treatment

1

(c) 15

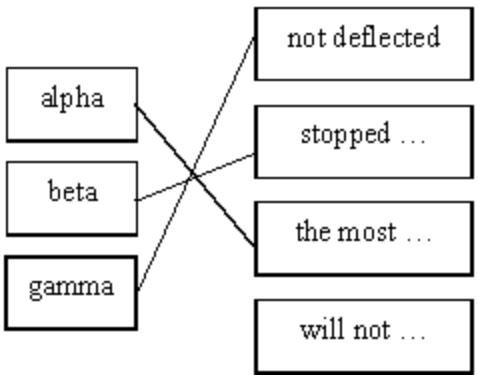
*allow **1** mark for correctly identifying 300 as the average dose*

2

[4]

Q28.

(a) 3 lines correctly drawn



***1** mark for each correct line if more than one line is drawn from a box in List **A** all lines from that box are wrong*

3

(b) nucleus

accept nuclei
*do **not** accept nuclear*

1

(c) **Y**

*do **not** accept gamma*

any **two** from:

*do **not** accept other properties of gamma*

- least dangerous (inside the body)
  *do **not** accept not dangerous*
  accept not as harmful as alpha
  (inside the body)
- least ionising
- penetrates through the body
  *do **not** accept can be detected externally*

1

- is a gas / can be breathed in
  accept it is not a solid
  *(cannot score if **Z** chosen)*
  *if **X** chosen can score this gas mark*
  *if **Z** chosen can score **both** gamma marks*

2

(d) any **one** from:

*do **not** accept kills bacteria*

- longer shelf life
  accept stays fresh longer / stops it going bad / mouldy
- food can be supplied from around the world
- wider market for farmers
- cost to consumers (may be) lower
- less likely to / will not get food poisoning
  accept infection / disease / ill for food poisoning

1

[8]

Q29.

(a) (i) 3 fewer neutrons

accept fewer neutrons

accept different number of neutrons
*do **not** accept different number of electrons*

1

(ii) electron from the nucleus

both points needed

1

(iii) 32 (days)

*allow **1** mark for clearly obtaining 4 half-lives*

2

(iv) has a **much** longer half-life

accept converse answers in terms of iodine-131

accept it has not reached one half-life yet

1

little decay happened / still in the atmosphere

accept it is still decaying

1

(b) any **two** from:

marks are for reasons

- some children developed TC before 1986
- some children (after 1986) that developed TC did not live in highly contaminated areas
- the (large) increase can (only) be explained by (a large increase in) radiation as caused by Chernobyl
- all areas would be contaminated (and raise the risk of TC)
- no evidence (of effect) of other variables

2

(c) People not exposed (to the radiation but who were otherwise similar)

accept people not affected (by the radiation)

1

(d) any **two** from:

*answers should be in terms of nuclear power and **not** why we should not use other fuels*

- produce no pollutant / harmful gases

  accept named gas or greenhouse gases
  *do **not** accept no pollution*

- produces a lot of energy for a small mass (of fuel) **or** is a concentrated energy source

  accept amount for mass

  accept high energy density

- it is reliable **or** it can generate all of the time
- produces only a small volume of (solid) waste

  accept amount for volume

2

[11]

Q30.

(a) (i) protons

1

neutrons

answers may be in either order

1

(ii) 86

1

(iii) two **fewer** protons and two **fewer** neutrons

*do **not** accept two fewer protons and neutrons*

or 84 protons 134 neutrons

*do **not** accept 218 protons and neutrons*

1

(b) (i) 0.4

accept $\frac{2}{5}$ */ accept 40 % for 2 marks*

*allow **1** mark for correct totalling = 1.8*

*allow **1** mark for a clearly correct method with a clearly incorrect total*

2

(ii) any **one** from:

- nuclear weapon testing

  *do **not** accept nuclear*

- nuclear power (stations)

  accept nuclear/ radioactive waste

- nuclear accidents

- medical

  accept X-rays

1

(c) (i) 2

accept 2:1

accept twice as big

ignore units

1

(ii) No with a reasonable reason explained

only going for two weeks so

or even staying for a year

total exposure well under lowest limit for causing cancer

1 *mark is for a time frame*
1 *mark is for correctly relating to a dose*

1

or Yes with a reasonable reason explained

all levels of radiation are (potentially) hazardous (1)

accept low doses could still cause cancer
accept all levels affect you
*do **not** accept radiation dose is high(er)*
*do **not** accept level of background radiation is higher in Germany*

harm caused by lower doses may not have been recorded (1)

or evidence may not be complete

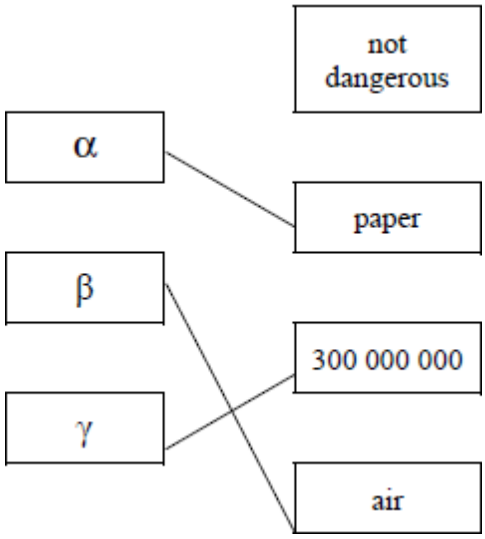
or insufficient research into effect of small doses

1

[10]

Q31.

(a) 3 correct lines drawn



any box in list A with 2 or more lines,
all lines for that box do not score

3

(b) radiation damages our cells

accept radiation can cause cancer
accept kills cells
accept changes DNA / causes mutations
accept dangerous / poisonous / harmful / toxic
accept so precautions can be taken

1

(c) it can pass through the human body

1

(d) (i) 6 (hours)

no tolerance

1

(ii) 6 (hours)

accept their (d)(i)

1

[7]

Q32.

(a) (i) alpha

1

(ii) damages them / changes DNA

accept kills them / destroys

accept causes cancer

accept causes cell mutations

*do **not** accept they ionise cells on its own*

1

(b) count is (roughly) the same

1

gamma is not affected by magnetic field

accept magnet for magnetic field

1

or

alpha and beta are deflected by a magnetic field (1)
count would go down significantly (1)

(c) time taken for number of nuclei to halve

*do **not** accept time for radioactivity to halve*

or

time taken for count rate to fall to half
(its initial value)

*do **not** accept time for nuclei to halve*

1

(d) not enough time to take measurements / make observations

1

before level of radiation became insignificant

1

[7]

Q33.

(a) (i) electromagnetic (wave / radiation)

accept em (wave / radiation)

ignore reference to frequency

1

(ii) gamma can penetrate the crate / box / packaging

accept converse (but must relate to both alpha and beta)

ignore just gamma radiation kills bacteria

accept can get through to food

1

(iii) neutrons

1

(b) (i) absorb gamma / radiation

accept it stops / reduces the radiation

1

(ii) any **one** from:

- slow down the conveyor belt
- food does more than one circuit
- stay on the conveyor belt longer
- food closer to the source / radiation

ignore larger doses / use more of the source

ignore thinner packaging

1

(c) (i) idea of testing food on humans / animals

1

no (measured) ill effects **or** monitor their health

accept monitor people that have eaten the food

*accept a measurement / comparison for **1** mark*

eg measure the amount of radiation in treated food

*comparison plus a reason for the comparison would get **2** marks*

*eg idea of measuring level of radiation in treated food **with** no measurable increase in level = **2** marks **or** comparing it to untreated food = **2** marks*

1

(ii) so can make own decision about eating or not eating treated food

accept may be against their religious / moral views

accept some people prefer food that hasn't been tampered with

ignore in case they don't like the idea of eating treated food

accept don't want to eat treated food

ignore might be allergic to the food

*eg think it will give them cancer = **0** marks*
*think it will give you cancer so I need to know so that I can choose = **1** mark1*

1

[8]

Q34.

(i) any **one** from:

the ground
the air
radon (gas)
building materials
buildings
rocks / granite
food
cosmic rays or solar rays

*do **not** accept mobile phones*

X-rays
nuclear weapons testing
nuclear power stations / accidents

accept from outer space
*accept sun but **not** sunlight*
accept medical uses

1

(ii) 2

allow $\frac{1200}{60 \times 10}$ **or** $\frac{120}{600}$ **or** 120

2

[3]

Q35.

(a) (i) two protons and two neutrons **or** the nucleus of a helium atom

1

(ii) different numbers of neutrons **or** one has (3) more or less neutrons than the other

accept different mass (numbers)

if give a number as a difference it must be 3

1

(iii)

*if polonium or hydrogen chosen gets **0** marks*

technetium (99) or none

1

any **two** from:

*do **not** accept gamma rays are less dangerous*

gamma rays less dangerous inside the body

gamma radiation less likely to be absorbed by cells **or** gamma rays do not ionise cells

gamma rays can penetrate the body (to be detected externally)

first 3 points valid if either technetium or iridium or none is given

2

short half-life so safe levels inside body soon reached

half-life long enough to obtain measurements

half-life short enough not to cause long term damage

last 3 points valid if either technetium or uranium or none is given

(b) 2200 ± 200

*allow **1** mark for attempted use of 70% on the graph*

2

[7]