

**1**

(a) (i) Describe the structure of alpha particles.

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.....  
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**(2)**

(ii) What are beta particles?

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.....  
.....

**(1)**

(b) Describe how beta radiation is produced by a radioactive isotope.

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.....

**(1)**

**(Total 4 marks)**

**2**

Atoms are very small and most of their mass is concentrated in the nucleus.

Electrons orbit at different distances from the nucleus.

(a) A nucleus is much smaller than an atom.

Approximately how many times smaller is a nucleus than an atom?

Tick **one** box.

100	<input type="checkbox"/>
1000	<input type="checkbox"/>
10 000	<input type="checkbox"/>
100 000	<input type="checkbox"/>

**(1)**

(b) The electrons in an atom can only orbit at specific distances from the nucleus.

State what causes an electron's distance from the nucleus to increase or decrease.

Increase .....

.....

Decrease .....

.....

**(2)**

(c) Atoms have different atomic numbers and mass numbers.

In terms of sub-atomic particles, describe the difference between an atom's atomic number and its mass number.

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**(2)**

(d) Transmutation is the name given to a process where one element changes into another.

Explain and compare how two different types of radioactive decay can cause transmutation.

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(4)  
(Total 9 marks)

**3**

The nuclei of some isotopes are radioactive.

(a) Which of the following statements could apply to a radioactive nucleus?

Tick **one** box.

The nucleus will emit an atom.

The nucleus will emit light.

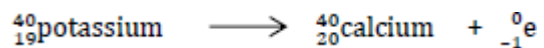
The nucleus will emit a neutron.

The nucleus will emit sound.

(1)

(b) Potassium-40 is a radioactive isotope present in food, such as bananas.

The following equation shows how potassium-40 will decay into calcium-40



Give one similarity and one difference between nuclei of potassium-40 and calcium-40

Similarity .....

Difference .....

(2)

(c) The activity of a sample of potassium-40 is measured 3 times.

The measurements are given below.

**4906 Bq**

**4956 Bq**

**4889 Bq**

Which of the following statements explains why the readings are different?

Tick **one** box.

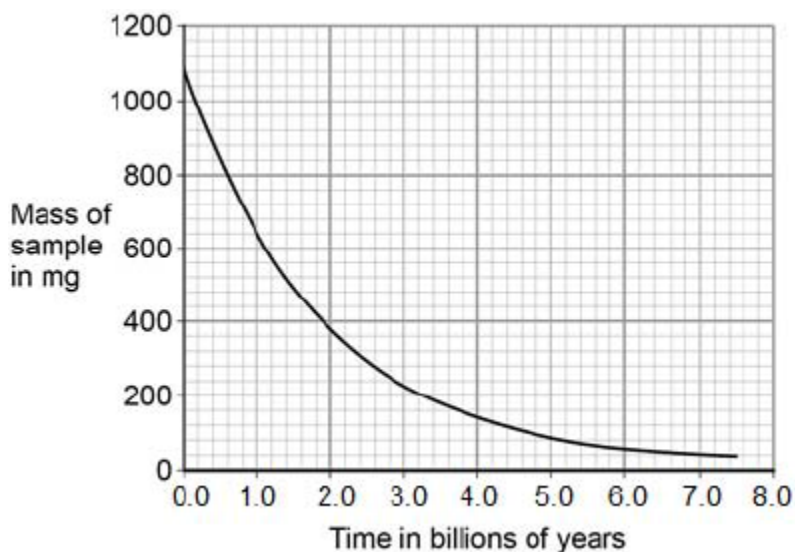
Radioactive decay is constant.

Radioactive decay is hazardous.

Radioactive decay is random.

(1)

(d) The figure below shows how the activity of a sample of potassium-40 changes over time.



Use the figure above to determine the half-life of potassium-40.

.....  
.....

Half-life = ..... billion years

(2)

(e) When food is eaten, some of the radiation the food emits is detectable outside the body.

Which type of radiation would not be detectable outside the body?

Tick **one** box.

alpha

beta

gamma

(1)  
(Total 7 marks)

4

Some small fractures do not show up on an X-ray image.

To see the fracture doctors inject the patient with a radioactive isotope.

The image is formed by detecting radiation as it leaves the body.

The figure below shows an image of a foot after the patient was injected with the radioactive isotope technetium-99.



© Ni Qin/ Getty Images

Technetium-99 emits gamma radiation.

(a) What is gamma radiation?

.....  
.....

(1)

(b) Explain why a gamma emitter is used.

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

(2)

(c) Technetium-99 has a **half-life** of 6 hours.

Give the meaning of the term **half-life**.

.....  
.....

(1)

(d) After treatment, hospital equipment may become contaminated.

Describe the level of the hazard associated with contamination with technetium-99.

You should include in your answer a description of how the level of hazard changes over time.

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.....  
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(3)

(e) Some of the hospital equipment may also be irradiated during treatment.

Describe how equipment becomes irradiated.

.....  
.....

(1)

(f) Why is irradiated equipment not hazardous?

.....  
.....

(1)

(Total 9 marks)

5

Some rocks inside the Earth contain a radioactive element, uranium-238. When an atom of uranium-238 decays, it gives out an alpha particle.

(a) The following statement about alpha particles was written by a student.  
The statement is **not** correct.

*Alpha particles can pass through a very thin sheet of lead.*

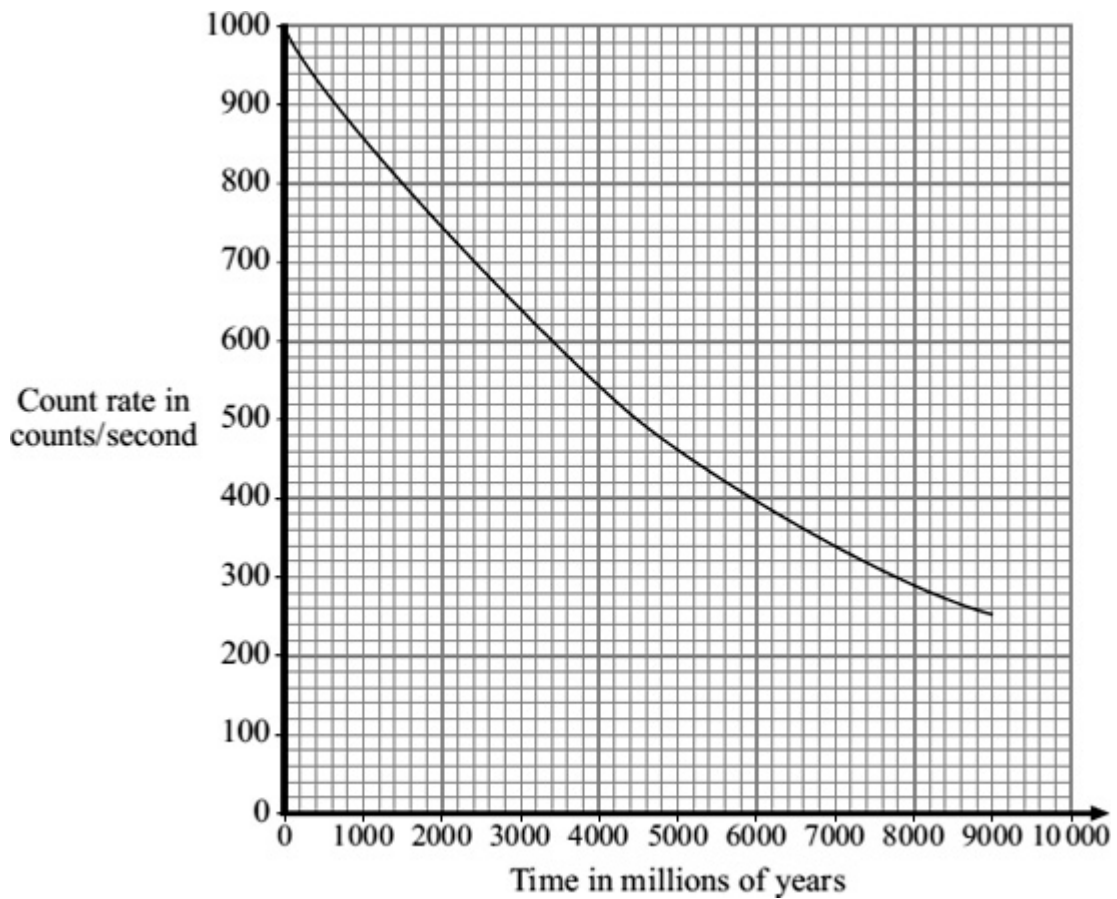
Change **one** word in the statement to make it correct.

Write down your **new** statement.

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.....

(1)

(b) The graph shows how the count rate from a sample of uranium-238 changes with time.



The graph can be used to find the half-life of uranium-238. The half-life is 4 500 million years.

(i) Draw on the graph to show how it can be used to find the half-life of uranium -238.

(1)

(ii) There is now half as much uranium-238 in the rocks as there was when the Earth was formed.

How old is the Earth?

Draw a ring around your answer.

**2250 million years**

**4500 million years**

**9000 million years**

(1)



- (iii) If a sample of uranium-238 were available, it would not be possible to measure the half-life in a school experiment.

Explain why.

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.....

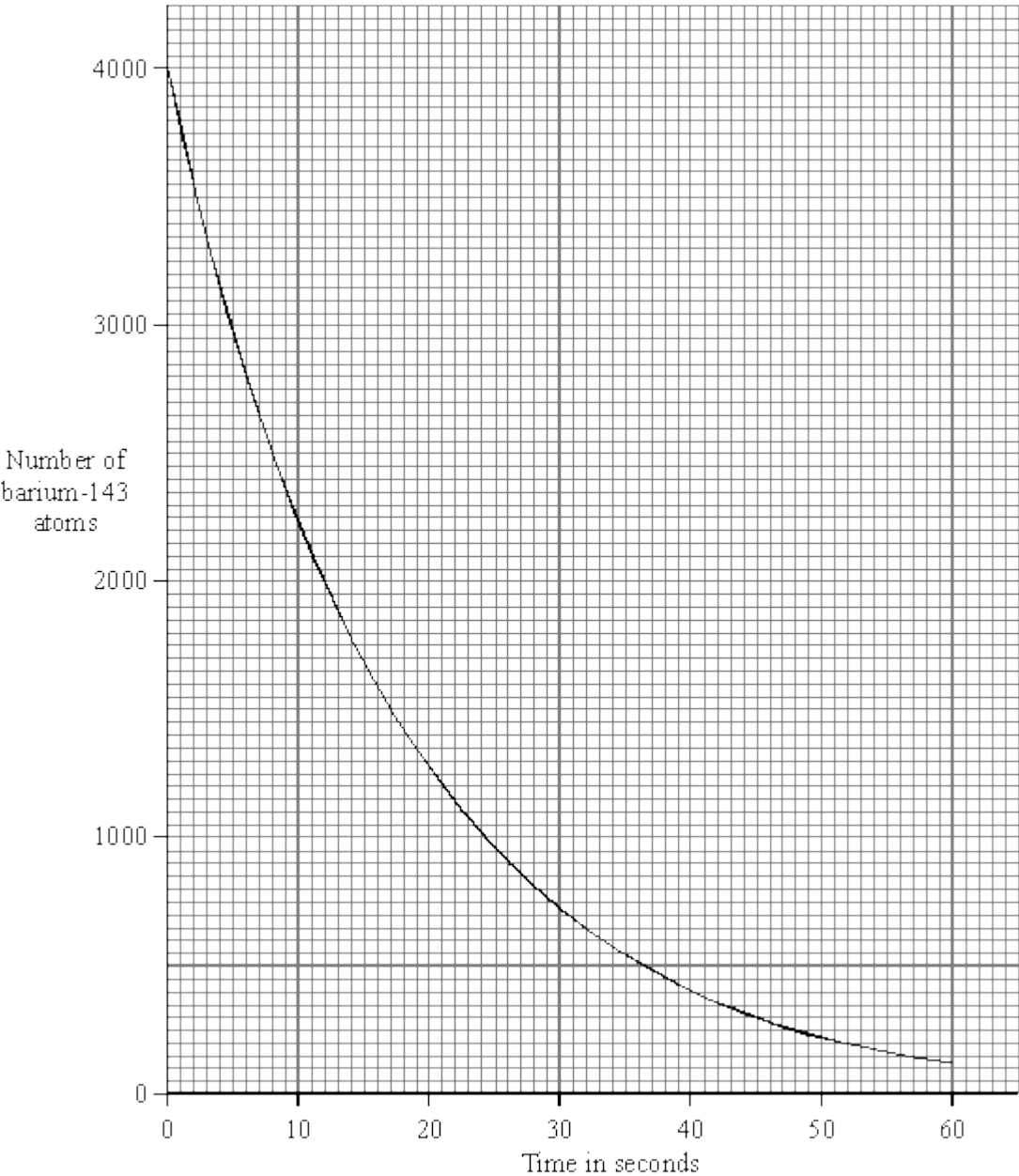
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**(2)**  
**(Total 5 marks)**

6

(a) The graph shows how a sample of barium-143, a radioactive *isotope* with a short *half-life*, decays with time.



(i) What is meant by the term *isotope*?

.....  
.....

(1)

(ii) What is meant by the term *half-life*?

.....  
.....

(1)

(iii) Use the graph to find the half-life of barium-143.

Half-life = ..... seconds

**(1)**

(b) Humans take in the radioactive isotope carbon-14 from their food. After their death, the proportion of carbon-14 in their bones can be used to tell how long it is since they died. Carbon-14 has a half-life of 5700 years.

(i) A bone in a living human contains 80 units of carbon-14. An identical bone taken from a skeleton found in an ancient burial ground contains 5 units of carbon-14. Calculate the age of the skeleton. Show clearly how you work out your answer.

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

Age of skeleton = ..... years

**(2)**

(ii) Why is carbon-14 unsuitable for dating a skeleton believed to be about 150 years old?

.....  
.....

**(1)**

- (c) The increased industrial use of radioactive materials is leading to increased amounts of radioactive waste. Some people suggest that radioactive liquid waste can be mixed with water and then safely dumped at sea. Do you agree with this suggestion? Explain the reason for your answer.

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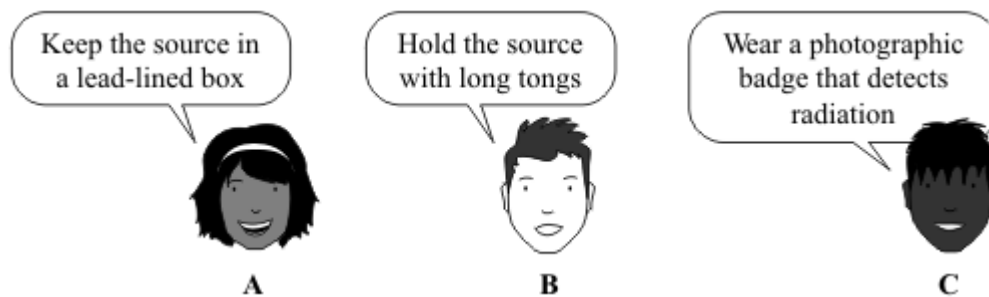
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(3)  
(Total 9 marks)

7

Before using a radioactive source, a teacher asked her students to suggest safety procedures that would reduce her exposure to the radiation. The students made the following

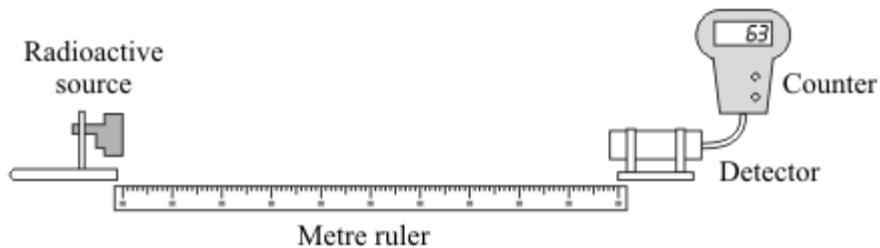


- (a) Which suggestion, **A**, **B** or **C**, would **not** reduce the exposure of the teacher to radiation?

.....

(1)

- (b) The diagram shows how the teacher measured the distance that the radiation traveled from the source. The count-rate at different distances from the source was measured and recorded in the table.



Distance from source to detector in cm	Count-rate in counts per minute
20	85
40	81
60	58
80	53
100	23

What type of radiation was the source emitting, alpha, beta or gamma?

.....

Explain the reasons for your choice.

.....

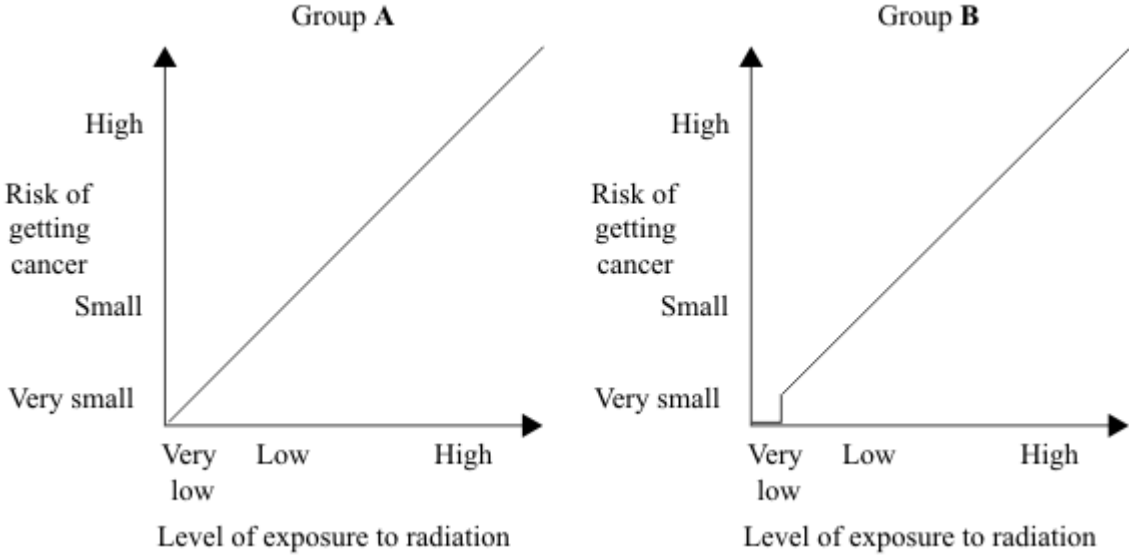
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(3)

(c) The graphs show how two groups of scientists, **A** and **B**, link exposure to radiation and the risk of getting cancer.



(i) Complete the following sentence using a word or phrase from the box.

**decreases      has no effect on      increases**

Both groups of scientists agree that a high level of exposure to radiation  
 ..... the risk of getting cancer.

**(1)**

(ii) Use the graphs to describe carefully how the two groups of scientists disagree when the level of exposure to radiation is very low.

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

**(2)**

**(Total 7 marks)**

8

In 2011 an earthquake caused severe damage to a nuclear power station in Japan.

The damage led to the release of large amounts of radioactive iodine-131 ( $^{131}_{53}\text{I}$ ) into the atmosphere.

(a) The table gives some information about an atom of iodine-131 ( $^{131}_{53}\text{I}$ ).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

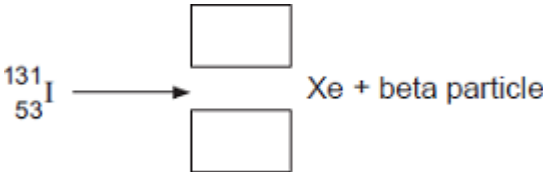
The number of protons in an atom is called the proton number or the ..... number.

(1)

(c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

(i) The decay of iodine-131 can be represented by the equation below.

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



(2)

(ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

.....  
.....

..... days

(2)

- (iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

.....

.....

.....

.....

(2)  
(Total 8 marks)

9

Certain types of atom emit alpha, beta or gamma radiation. The radiation is emitted from the centre of the atom.

- (a) What name is given to the centre of an atom?

.....

(1)

- (b) The sign below is used to warn people that a radiation source is being used in a laboratory.



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

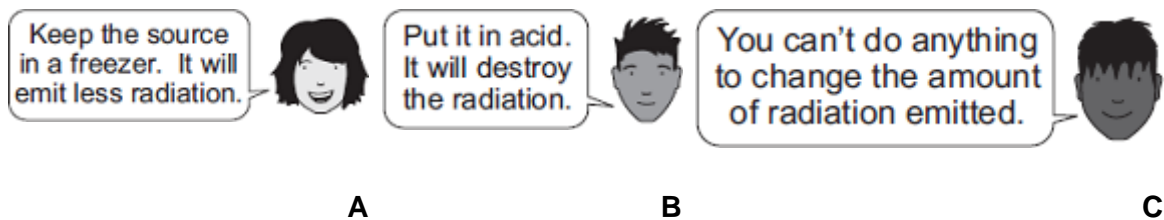
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(1)



- (c) Before using a radiation source, a teacher asked her class whether there was any way that she could reduce the amount of radiation that the source emitted. Three students each gave an answer to the teacher.

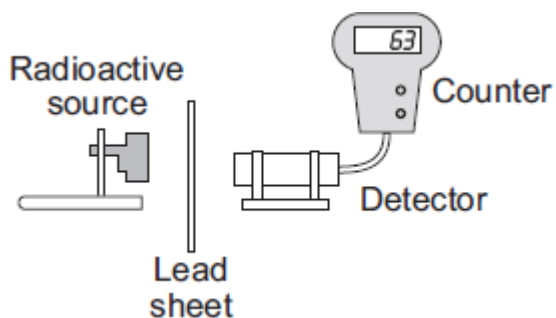


Which **one** of the students, **A**, **B** or **C**, is correct?

Write your answer in the box.

(1)

- (d) The diagram shows the apparatus used by the teacher to demonstrate how one type of radiation is able to pass through lead.



One lead sheet, 2 mm thick, was placed between the source and the detector and a count rate was taken. Extra lead sheets were added. For each extra lead sheet, a new count rate was taken and recorded in the table.

Number of lead sheets	Count rate in counts per minute
1	226
2	220
3	210
4	190
5	185

Which type of radiation was the source emitting: alpha, beta or gamma?

.....

Give the reason for your answer.

.....

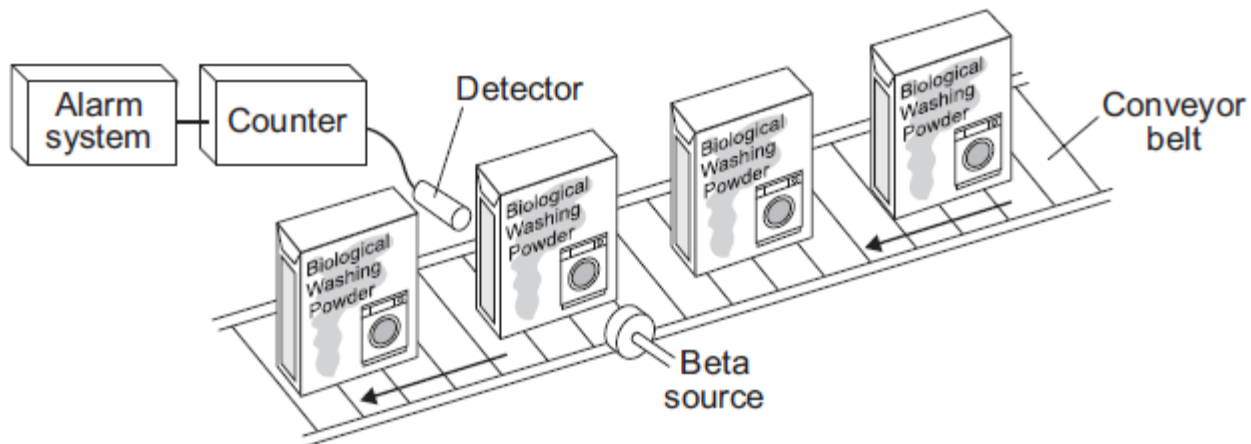
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(2)

(e) The diagram shows how a company detects any boxes left empty by an automatic filler.

When an empty box passes between the beta source and the detector, a buzzer sounds. A worker then removes the box from the conveyor belt.

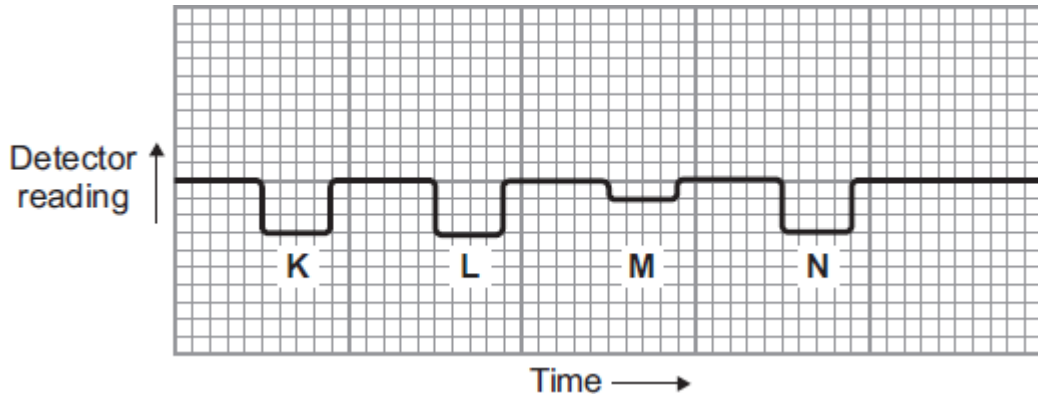


(i) Why would this system **not** work if an alpha source were used instead of the beta source?

.....  
.....

(1)

- (ii) The chart shows how the detector reading changes as boxes pass along the conveyor belt.



Which part of the chart, **K**, **L**, **M** or **N**, shows that an empty box is passing between the beta source and the detector?

.....

Give a reason for your answer.

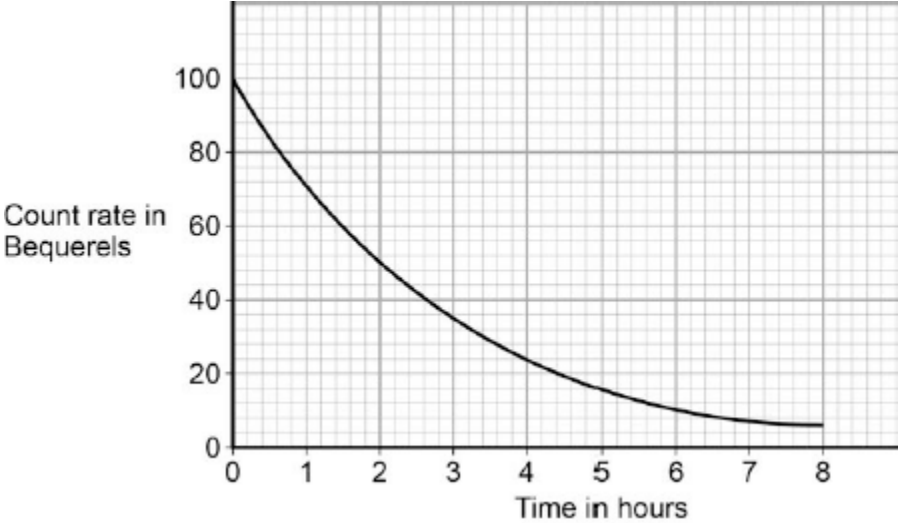
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(2)  
(Total 8 marks)

10

The figure below shows how the activity of a radioactive isotope changes over an 8 hour period of time.



(a) Predict how long it will take for the count rate to fall from 100 to 1.56 Bequerels.

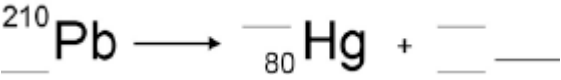
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Time = ..... hours

(2)

(b) Lead-210 is a radioactive isotope that decays to an isotope of mercury by alpha decay.

Complete the nuclear equation to show the alpha decay of lead-210.



(3)

(c) Explain how ionising radiation can have hazardous effects on the human body.

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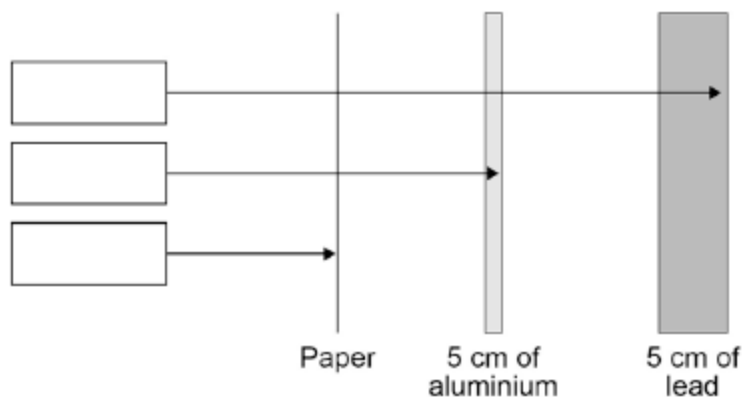
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(5)  
(Total 10 marks)

**11** Alpha, beta and gamma are types of nuclear radiation.

A teacher sets up a demonstration of the penetration properties of alpha, beta and gamma radiation.

The figure below shows the demonstration.



(a) Complete the figure above by writing the name of the radiation in each box.

(2)

(b) Give **two** safety precautions the teacher should take in the demonstration.

1 .....

.....

2 .....

.....

(2)

(c) The table below shows how the count rate of a radioactive source changes with time.

<b>Time in seconds</b>	0	40	80	120	160
<b>Count rate in counts / second</b>	600	463	300	221	150

Describe the relationship shown in the table above.

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.....

.....

(2)

(d) Use the table above to predict the count rate after 200 seconds.

.....

.....

.....

Count rate = ..... counts / second

(2)

(e) The half-life of the radioactive source is very short.

Give **one** reason why the source would be much less hazardous after 800 seconds.

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(1)

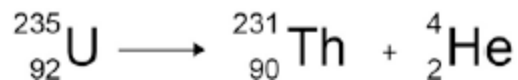
(Total 9 marks)

12

This question is about radioactive decay.

(a) **Figure 1** shows a nuclear equation for the decay of an atom of uranium.

**Figure 1**



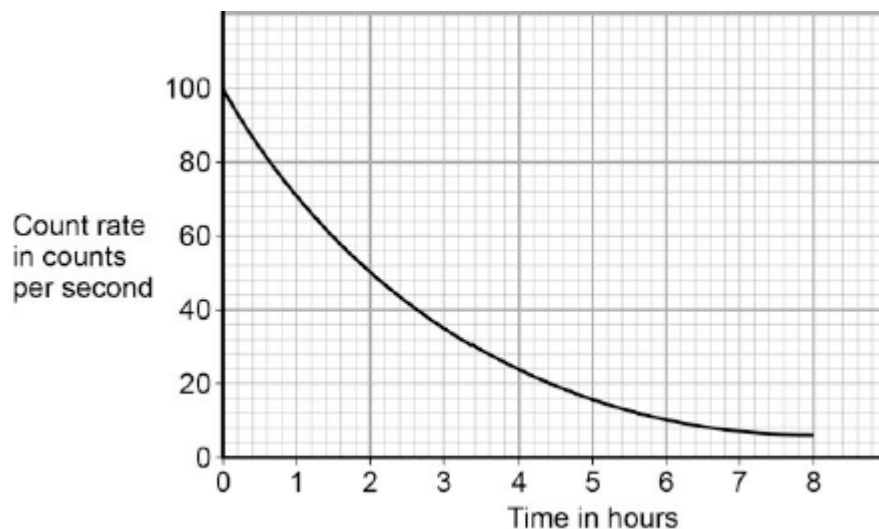
Use information from **Figure 1** to complete the table below.

	<b>U</b>	<b>Th</b>
Mass number	235	
Number of protons		90
Number of neutrons	143	

(3)

(b) **Figure 2** shows how the count rate from a radioactive isotope changes with time.

**Figure 2**



What is the half-life of the radioactive isotope?

Explain why you chose that value.

Half-life = ..... hours

Explanation .....

.....

(2)



(c) When a radioactive isotope decays it can produce beta particles.

What is a beta particle?

Tick **one** box.

A high-speed electron

A neutron and an electron

A neutron and a proton

A helium nucleus

(1)

(d) Beta particles can cause cancer.

Complete the sentences.

Use words from the box.

<b>benign</b>	<b>controlled</b>	<b>differentiated</b>	<b>malignant</b>	<b>slow</b>	<b>uncontrolled</b>
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Tumours form when cell division is .....

Tumours that do not invade other tissues are called .....

(2)

(Total 8 marks)