

Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A student used a Geiger-Müller (GM) tube to determine a value for the background count. He recorded the count for 2 minutes, every 15 minutes, as shown in the table.

Time / min	Count for 2 min
0	34
15	39
30	28

The counts are not the same.

Which of the following is the reason for this?

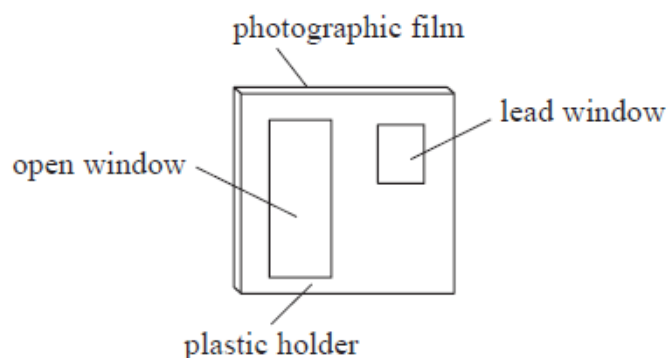
- ☒ **A** The background count rate is random.
- ☐ **B** The counter is incorrectly calibrated.
- ☐ **C** The temperature has not stayed constant.
- ☐ **D** There is a systematic error in the measurement.

(Total for question = 1 mark)

Q2.

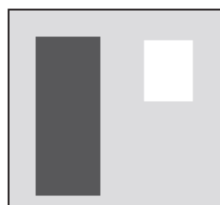
Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A radioactivity monitoring badge is worn by people who might be exposed to radiation. The badge is made from photographic film wrapped in thin paper and then held in a plastic holder that has an open window and a lead window, as shown.

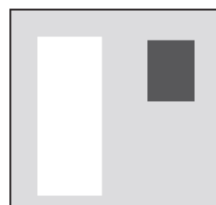


The film gets darker when exposed to ionising radiation.

Which of the following represents the film after the badge is exposed to beta radiation?



☐ **A**



☐ **B**



☐ **C**



☐ **D**

(Total for question = 1 mark)

Q3. When measuring the count rate from a radioactive source it is usual to also measure the background count rate.

The background count rate must be

- ☐ **A** as large as possible for an accurate experiment.
- ☐ **B** measured when the source is in place.
- ☐ **C** recorded for the same time as the count rate.
- ☐ **D** subtracted from the count rate measured from the source.

(Total for Question = 1 mark)

Q4.

The ionising properties of radiations determine their penetrating power.

Which of the following statements is correct?

- ☐ **A** α -particles are not very ionising so they are stopped by thin paper.
- ☐ **B** α -particles are very ionising so can only travel a few centimetres in air
- ☐ **C** γ -radiation is very penetrating because it is very ionising
- ☐ **D** γ -radiation is not very penetrating because it is very ionising

(Total for question = 1 marks)

Q5.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

A nucleus of protactinium, ${}_{91}^{231}\text{Pa}$, decays by emitting an α particle.

The nucleus formed is

- ☐ **A** ${}_{95}^{233}\text{Am}$
- ☐ **B** ${}_{93}^{235}\text{Np}$
- ☐ **C** ${}_{89}^{227}\text{Ac}$
- ☐ **D** ${}_{87}^{229}\text{Fr}$

(Total for question = 1 mark)

Q6.

A radioactive source is placed a few cm away from a detector. There is no change in the count rate when a thin aluminium foil is placed between the source and the detector, but the count rate is reduced to the background rate when a 0.5 cm aluminium plate is introduced.

These observations show that the source must be emitting

- ☐ **A** alpha and beta radiation.
- ☐ **B** beta and gamma radiation.
- ☐ **C** beta radiation only.
- ☐ **D** gamma radiation only.

(Total for Question = 1 mark)

Q7.

In an experiment to measure the activity of a radioactive source the measured activity should always be corrected by

- ☐ **A** adding the background count.
- ☐ **B** adding the background count rate.
- ☐ **C** subtracting the background count.
- ☐ **D** subtracting the background count rate.

(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

Select the row of the table that describes the relative ionisation and relative penetration of nuclear radiations.

	Most ionising	Most penetrating
☐ A	α	α
☐ B	α	γ
☐ C	γ	α
☐ D	γ	γ

(Total for question = 1 mark)

Q9.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

The isotope $^{221}_{87}\text{Fr}$ undergoes a series of alpha and beta decays before forming $^{205}_{81}\text{Tl}$.

Which row of the table shows the number of alpha and beta particles emitted during the decays?

	Alpha	Beta
☐ A	3	2
☐ B	3	6
☐ C	4	2
☐ D	4	6

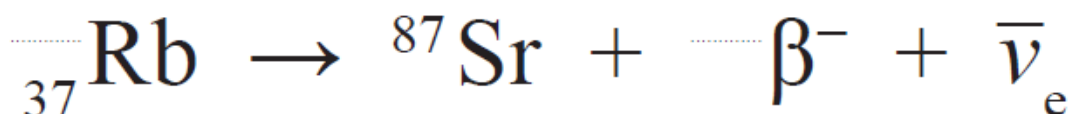
(Total for question = 1 mark)

Q10.

A hundred years ago, a method to determine the age of certain rocks was developed. An unstable isotope of rubidium is present in some rocks when they form. Over time the rubidium decays to a stable isotope of strontium.

Rubidium decays to strontium via β^- decay. Complete the nuclear equation representing the decay.

(2)

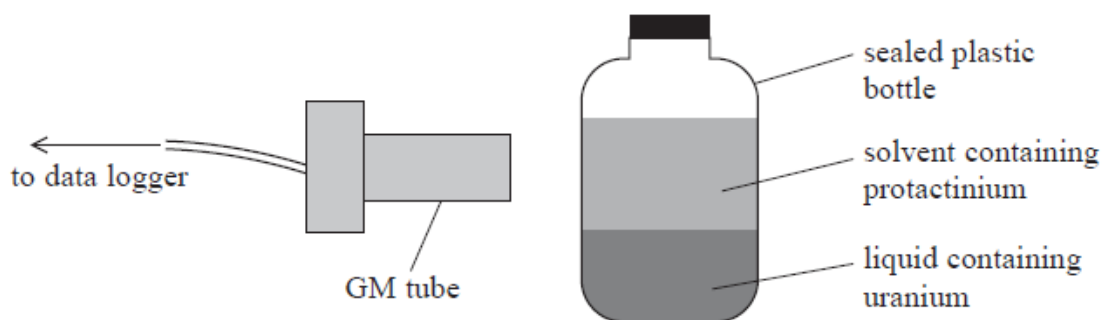


(Total for question = 2 marks)

Q11.

A teacher demonstrated the decay of protactinium using a Geiger-Müller (GM) tube connected to a data logger.

A sealed plastic bottle contains a solvent floating above a liquid containing a uranium salt. Protactinium is produced from the decay of uranium and is present in the solvent as shown.



Deduce whether alpha radiation or beta radiation from the inside of the bottle is detected by the GM tube.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q12.

An old type of camping lamp used a 'gas mantle'. The gas mantle is heated by the gas flame on the lamp and emits a bright white light. Gas mantles used to contain thorium-230.

Thorium-230 decays by alpha emission to form an isotope of radium. A student keeps a radioactive gas mantle in a sealed polythene bag. The student suggests that over a period of a year a significant volume of helium gas will be collected, since an alpha particle is a helium nucleus.

Give reasons why the sealed plastic bag is suitable for collecting the gas.

(2)

.....

.....

.....

(Total for question = 2 marks)

Q13.

A student investigated the way in which gamma radiation spreads out from a source. He placed a cobalt-60 source in a source holder and set up a Geiger-Müller (GM) tube a short distance d away. He connected the GM tube to a counter as shown.

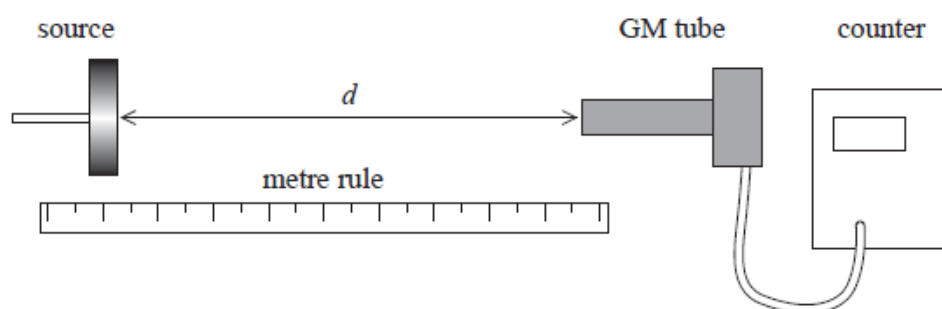


Figure 1

The student recorded the count for 2 minutes.

His teacher turned the GM tube through 90° so that the side of the tube faced the source as shown below.

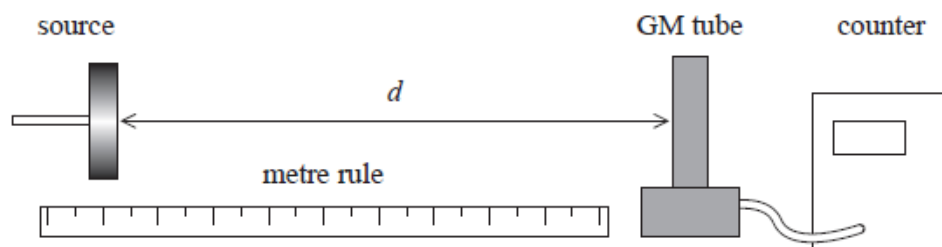


Figure 2

It is suggested that the investigation into the way in which gamma radiation spreads out from a source, using the apparatus as shown in **Figure 2**, could be carried out successfully using a radium-226 source.

Radium-226 emits α , β and γ radiation.

Justify this suggestion.

.....

.....

.....

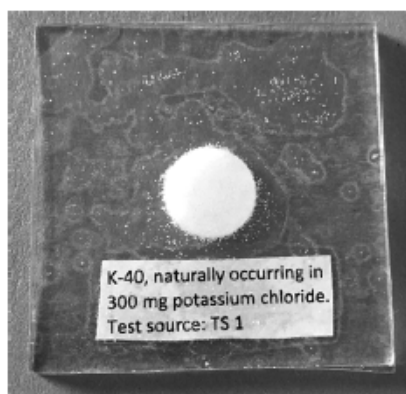
.....

.....

(Total for question = 2 marks)

Q14.

A school science department keeps a sample of potassium chloride to use as a test source for Geiger-Müller tubes.

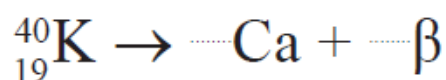


Potassium contains 0.012% of the unstable isotope potassium-40.

Potassium-40 undergoes β^- decay, producing a stable isotope of calcium.

Complete the nuclear equation for this decay.

(2)



(Total for question = 2 marks)

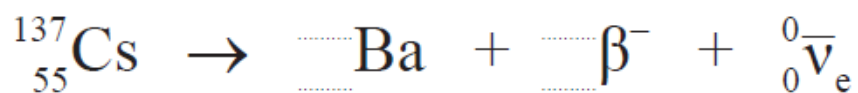
Q15.

Glaciers are massive bodies of slowly moving ice. Over time, a fine sediment forms on the surface of a glacier. The sediment contains radioactive isotopes.

Caesium-137, ^{137}Cs , is a common radioisotope found in the sediment.

Complete the following nuclear equation to represent the decay of caesium.

(2)



(Total for question = 2 marks)

Q16.

Radon is a radioactive gas. One isotope of radon, $^{220}_{86}\text{Rn}$, decays to polonium, Po, by emitting an alpha particle.

Complete the nuclear equation for the decay of radon.

(2)



(Total for question = 2 marks)

Q17.

Two students, A and B, used a cobalt-60 source to investigate the inverse square law for a gamma radiation source. Cobalt-60 is a pure gamma emitter.

Student A suggests that the investigation into the inverse square law for a gamma radiation

source could be carried out successfully using a radium-226 source.

Radium-226 emits alpha and beta radiation as well as gamma radiation.

Explain **one** modification that would be necessary if a radium-226 source were to be used.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q18.

Radon is a radioactive gas. One isotope of radon, $^{220}_{86}\text{Rn}$, decays to polonium, Po, by emitting an alpha particle.

Radon is produced in the ground and escapes into the atmosphere.

Explain why this is a safety hazard.

(2)

.....

.....

.....

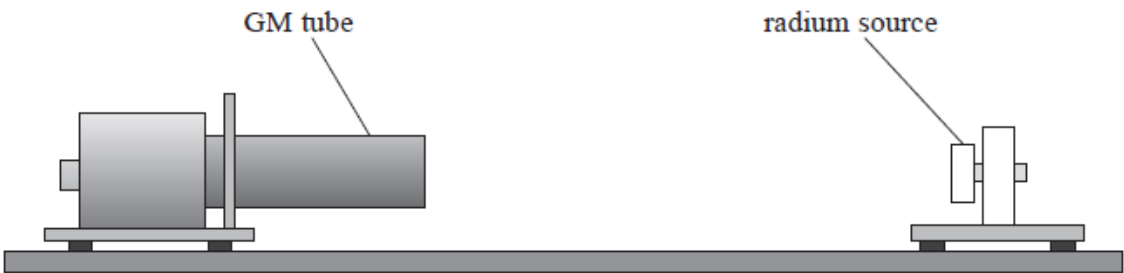
.....

(Total for question = 2 marks)

Q19.

A student used a Geiger-Müller (GM) tube to determine the activity of a radium source. Radium emits α , β , and γ radiation.

He positioned the source 20 cm from the GM tube, as shown, and recorded the count for 1 minute. He repeated the measurement and calculated a mean count.



The student recorded the following results.

Count 1	Count 2	Mean count
183	178	181

Criticise the student's method for determining the count at this position.

(3)

.....

.....

.....

.....

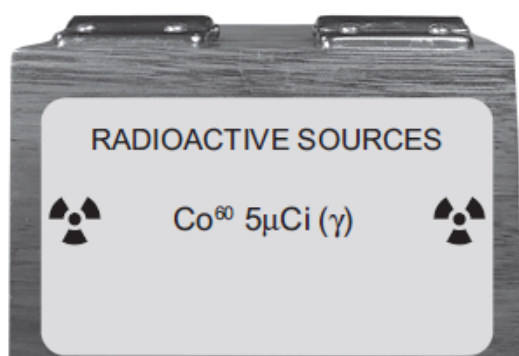
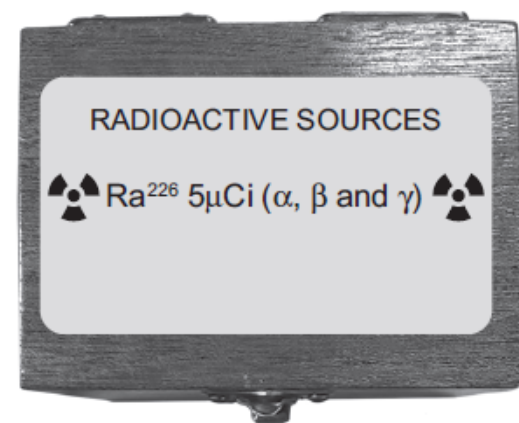
.....

.....

(Total for question = 3 marks)

Q20.

The photograph shows the containers of two radioactive sources kept in a school.



The isotope Ra 226 undergoes a series of decays until it produces the stable isotope Pb 206.

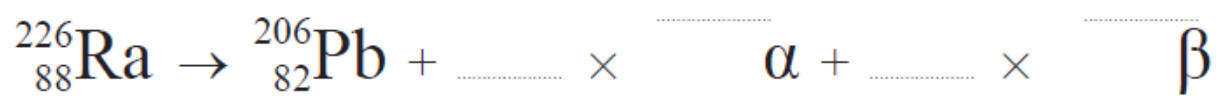
Determine the number of α particles and β particles emitted during this process to complete the nuclear equation.

(3)

.....

.....

.....



Q21.

Nuclear decay is described as being spontaneous and random.

A radioactive source used in a school laboratory emits alpha and beta radiation.

Describe how the percentage of the activity due to beta radiation may be determined using a Geiger-Müller tube and ratemeter.

(4)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q22.

The photograph shows the containers of two radioactive sources kept in a school.



The school is required to make a safety inspection of the sources every year.

(i) Explain how the sources can be tested to ensure that each source is in the correct container.

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Explain a safety precaution that must be applied during this procedure.

.....

.....

.....

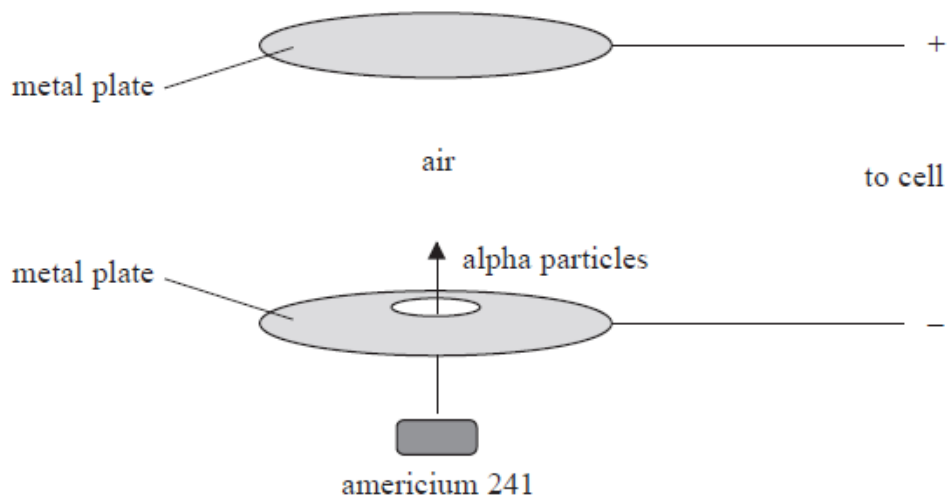
.....

Q23.

Some types of smoke detector contain a radioactive isotope of americium, ^{241}Am . The nuclei of ^{241}Am decay by emitting an alpha particle.

The diagram shows part of a smoke detector.

The detectors use a small amount of ^{241}Am to make the air between two metal plates conduct charge.



(a) (i) Explain why a stream of alpha particles will cause charge to flow between the metal plates.

(2)

.....

.....

.....

.....

(ii) Suggest how smoke particles entering the space between the plates will cause the current to decrease.

(1)

.....

.....

(b) (i) The decay of ^{241}Am is said to be random and spontaneous. State what is meant by random and spontaneous.

(2)

Random

.....

.....

Spontaneous

.....

.....

(ii) Complete the equation for the decay of ^{241}Am .

(2)



(Total for question = 7 marks)

Q24.

When a photographic film that is not exposed to light is placed near to a source of ionising radiation the film darkens.

(a) (i) State what is meant by ionising radiation.

(1)

.....

.....

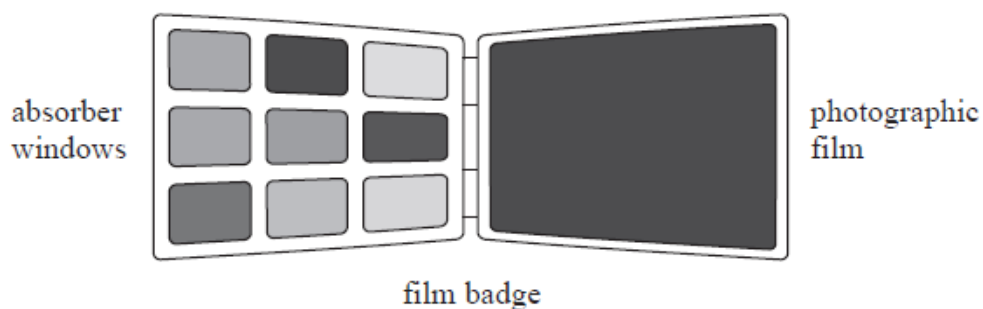
(ii) Complete the table to show α , β , and γ radiations in order of increasing ionising power.

(1)

Least ionising → Most ionising		

(b) In a physics lesson some students are learning about the use of a film badge to monitor exposure to ionising radiation.

Each absorber window is made from a different material and the type of radiation can be determined from the extent to which the film is darkened.



The students are asked to predict what would happen if α , β , and γ radiations were incident upon absorber windows made from paper, aluminium and lead.

(i) Complete the table to show the penetration of α , β , and γ radiations through each material.

Use the words "passes through" or "stopped".

	Paper	0.5 cm aluminium	0.5 cm lead
α radiation		stopped	
β radiation			stopped
γ radiation	passes through		

(ii) In a nuclear power plant there may be other radiation present which would **not** be detected by a film badge.

Suggest what type of radiation this is and why it would not be detected by a film badge.

(2)

.....

.....

.....

.....

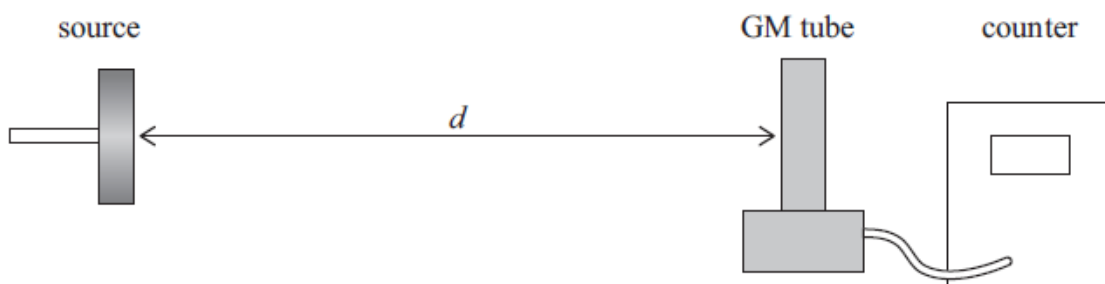
(Total for question = 7 marks)

Q25.

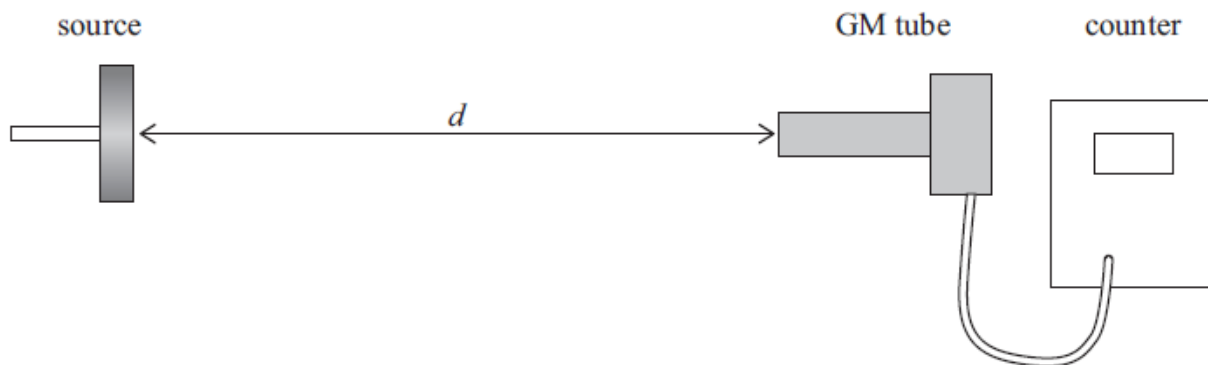
Two students, A and B, used a cobalt-60 source to investigate the inverse square law for a gamma radiation source. Cobalt-60 is a pure gamma emitter.

The cobalt-60 source was placed in a source holder. A Geiger-Müller (GM) tube was connected to a counter and placed a short distance d away.

(i) Student A set up the apparatus as shown.



Student B used the same distance d but rotated the GM tube by 90° , as shown below.



Both students recorded the count for 2 minutes.

Deduce which set-up will lead to a smaller percentage uncertainty in the count rate.

(3)

.....

.....

.....

.....

.....

.....

(ii) Explain two modifications to the experimental method which would improve the accuracy of the data.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

