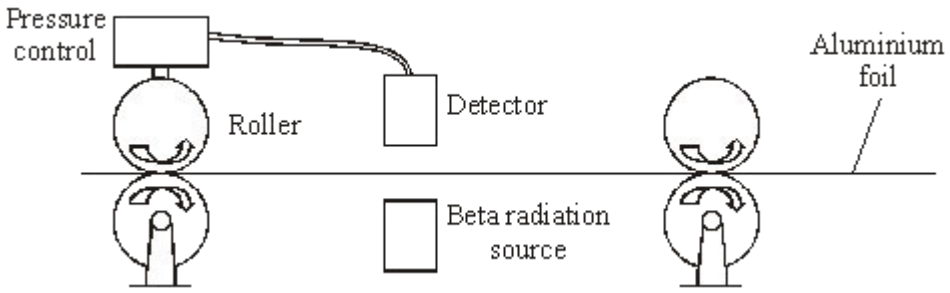
Q1. The diagram shows how the thickness of aluminium foil is controlled. The thicker the aluminium foil, the more radiation it absorbs.



(a) The designers used a beta radiation source for this control system.

(i) Why would an alpha radiation source be unsuitable in this control system?

.....

.....

(1)

(ii) Why would a gamma radiation source be unsuitable in this control system?

.....

.....

(1)

(b) The substance used in the beta radiation source is radioactive.

(i) Why are some atoms radioactive?

.....

.....

(1)

(ii) Explain why radiation is dangerous to humans.

.....

.....

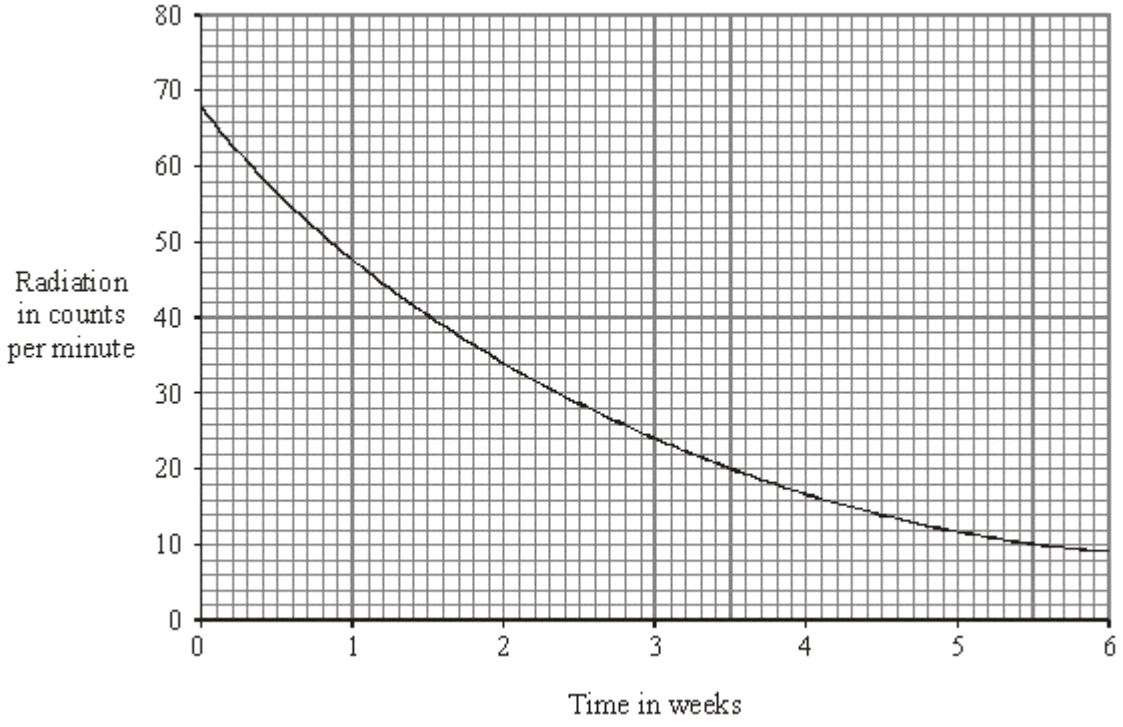
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(2)
(Total 5 marks)

Q2. A teacher measured the amount of radiation from a radioactive source, during the same lesson each week, over a period of six weeks.

The results are shown on the graph.



How long does it take for the radiation to fall from 68 counts per minute to half that value?

Show clearly how you work out your answer.

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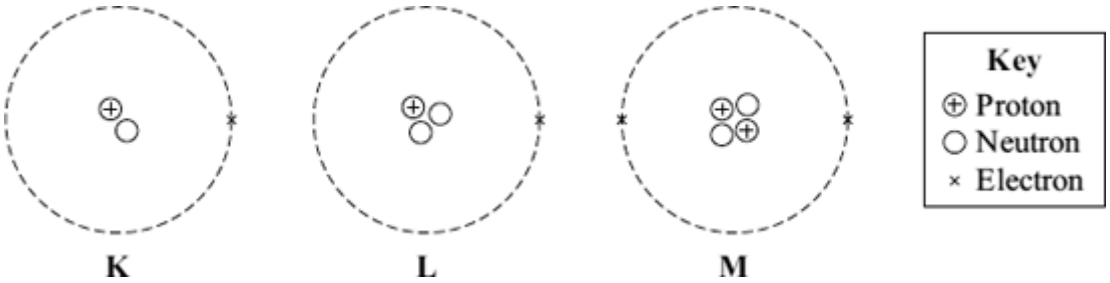
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Time taken for radiation to halve .....

(Total 3 marks)

Q3. (a) The diagram represents 3 atoms, **K**, **L** and **M**.



(i) Which **two** of the atoms are isotopes of the same element?

..... and .....

(1)

(ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element .....

.....

(2) different isotopes of the same element. .....

.....

.....

(2)

(b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

(i) How many electrons are there in an atom of thorium-230?

.....

(1)

(ii) How many neutrons are there in an atom of thorium-230?

.....

(1)

(c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.

$$^{230}_{90}\text{Th} \longrightarrow {}^{226}_{88}\text{Ra} + \boxed{\text{Radiation}}$$

What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

.....

Explain the reason for your answer.

.....

.....

.....

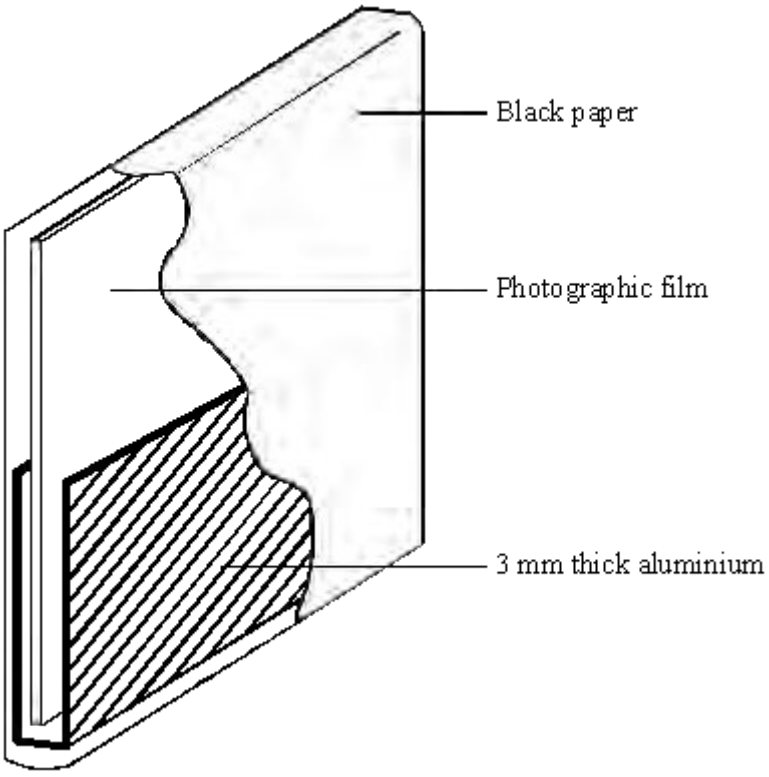
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.....

(3)
(Total 8 marks)

Q4. The diagram shows a badge worn by a worker at a nuclear power station.

Part of the outer black paper has been removed so that you can see the inside of the badge.



Scientists examined the worker's badge at the end of a day's work.

They found that the top part of the badge had been affected by radiation, but the bottom half had not.

What type of radiation had the worker been exposed to? Explain the reasons for your answer.

.....

.....

.....

.....

(Total 2 marks)

Q5. (a) A radioactive isotope has a half-life of 10 minutes.
At the start of an experiment, the activity of a sample of this isotope was 800 counts per second after allowing for background radiation.

Calculate how long it would be before the activity fell from 800 counts per second to 200 counts per second.

.....

.....

Time ..... min.

(2)

(b) A physicist investigates a solid radioactive material. It emits alpha particles, beta particles and gamma rays.
The physicist does not touch the material.

Explain why the alpha particles are less dangerous than the beta particles and gamma rays.

.....

.....

.....

.....

(2)
(Total 4 marks)

Q6. (a) Two sources of radiation look identical. One source emits only alpha radiation, the other only beta radiation. Describe **one** way to find out which source emits the alpha radiation. You can assume a radiation detector and counter are available. You may wish to draw a diagram to help with your answer.

.....

.....

.....

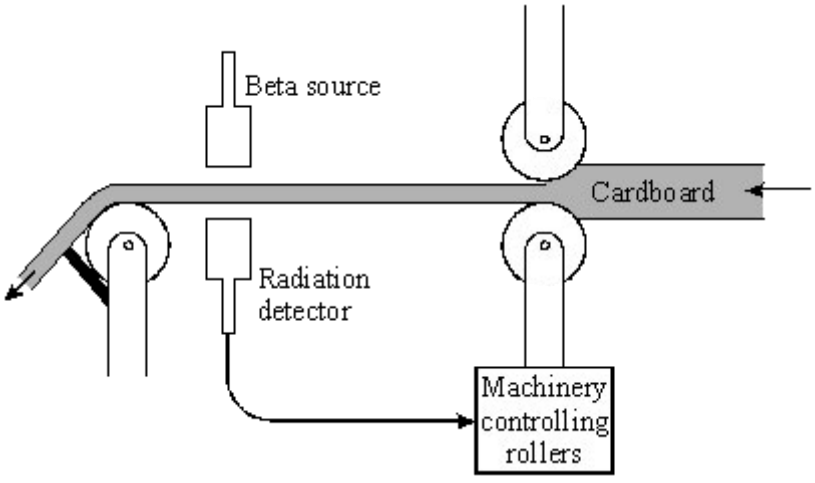
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(3)

(b) The diagram shows a beta radiation source and detector used to measure the thickness of cardboard as it is made. The table gives the detected count rate at different times.



Time	Count rate in counts/minute
09:00	120
09:30	122

10:00	119
10:30	165
11:00	118

(i) Between 09:00 and 10:00 the cardboard is produced at the correct constant thickness. Give a reason for the small variation in count rate.

.....

.....

(1)

(ii) What can you say about the thickness of the cardboard being made at 10:30?

.....

Explain the reason for your answer.

.....

.....

.....

(3)

(iii) Explain why gamma radiation is not suitable for detecting changes to the thickness of the cardboard.

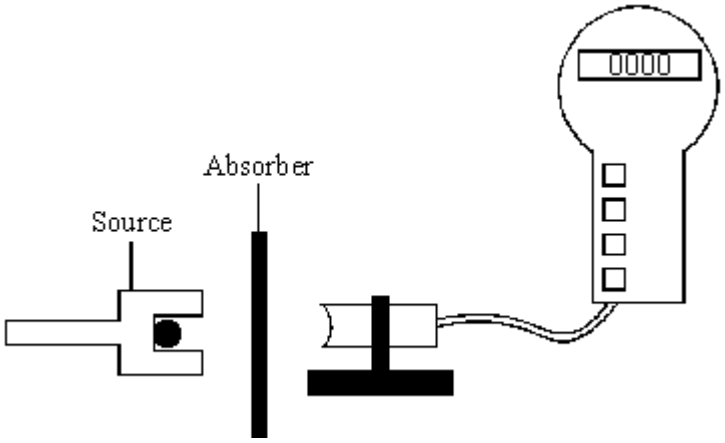
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(1)

(Total 8 marks)

Q7. The detector and counter are used in an experiment to show that a radioactive source gives out alpha and beta radiation only.



Two different types of absorber are placed one at a time between the detector and the source. For each absorber, a count is taken over ten minutes and the average number of counts per second worked out. The results are shown in the table.

Absorber used	Average counts per second
No absorber	33
Card 1 mm thick	20
Metal 3 mm thick	2

Explain how these results show that alpha and beta radiation is being given out, but gamma radiation is **not** being given out.

.....

.....

.....

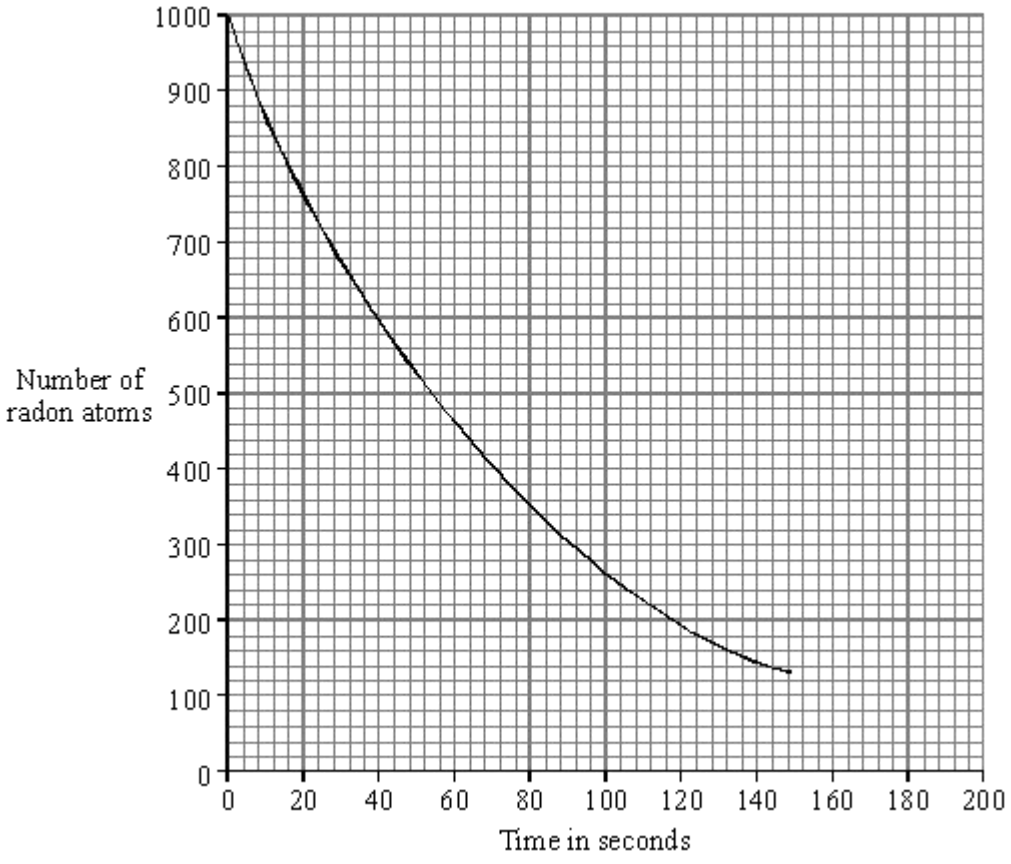
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(Total 3 marks)

Q8. Radon is a radioactive element. The graph shows how the number of radon atoms in a sample of air changes with time.



(i) How long did it take the number of radon atoms in the sample of air to fall from 1000 to 500?

Time = ... seconds

(1)

(ii) How long is the half-life of radon?

Half-life = ... seconds

(1)

(iii) Complete this sentence by crossing out the **two** lines in the box that are wrong.

As a radioactive material gets older, it emits

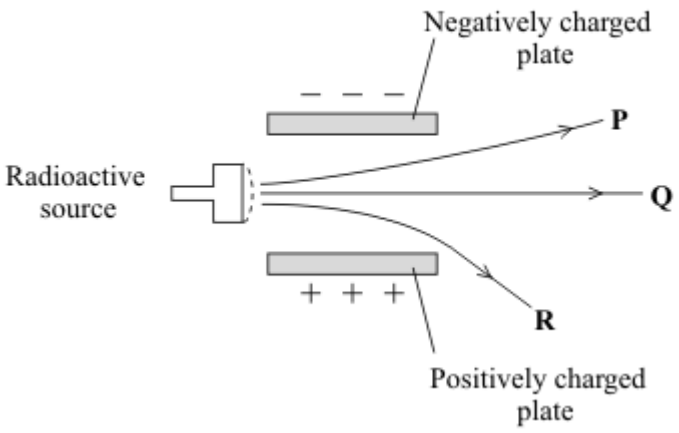
less
a constant level of
more

radiation per second.

(1)
(Total 3 marks)

Q9. 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:

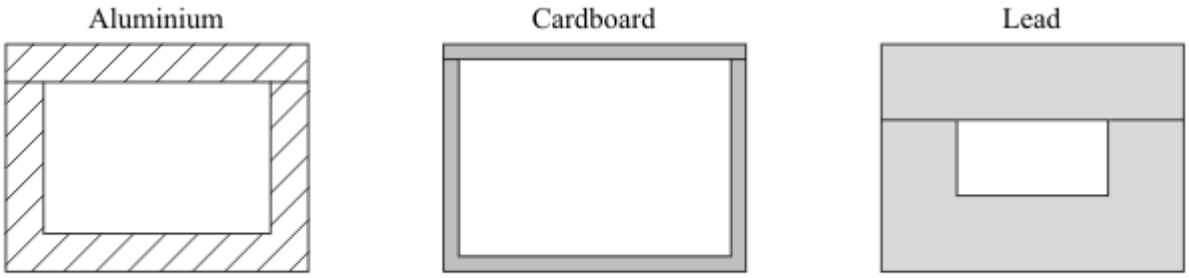
(i) alpha radiation .....

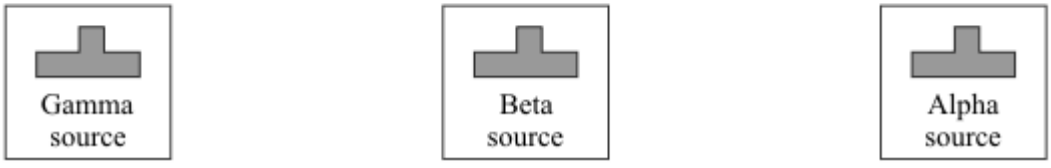
(1)

(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.

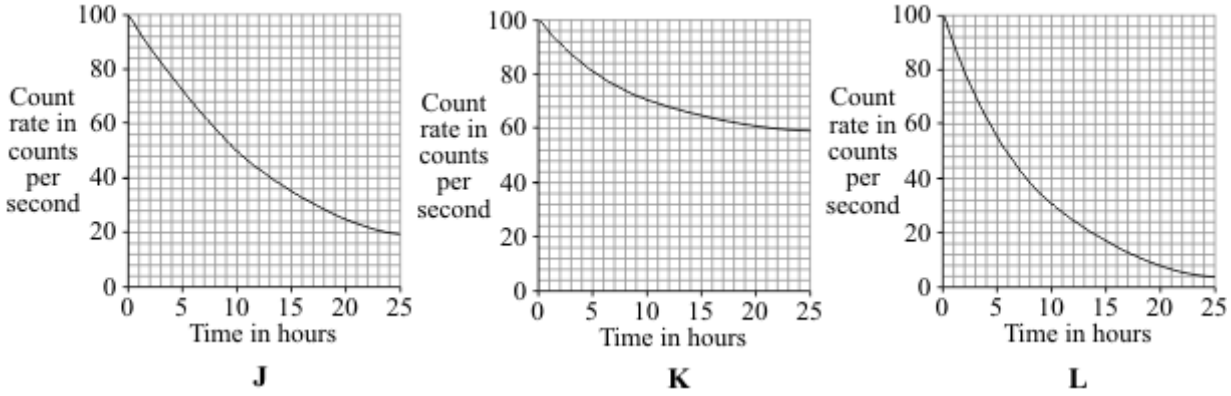




Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.

(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)

Q10. 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)

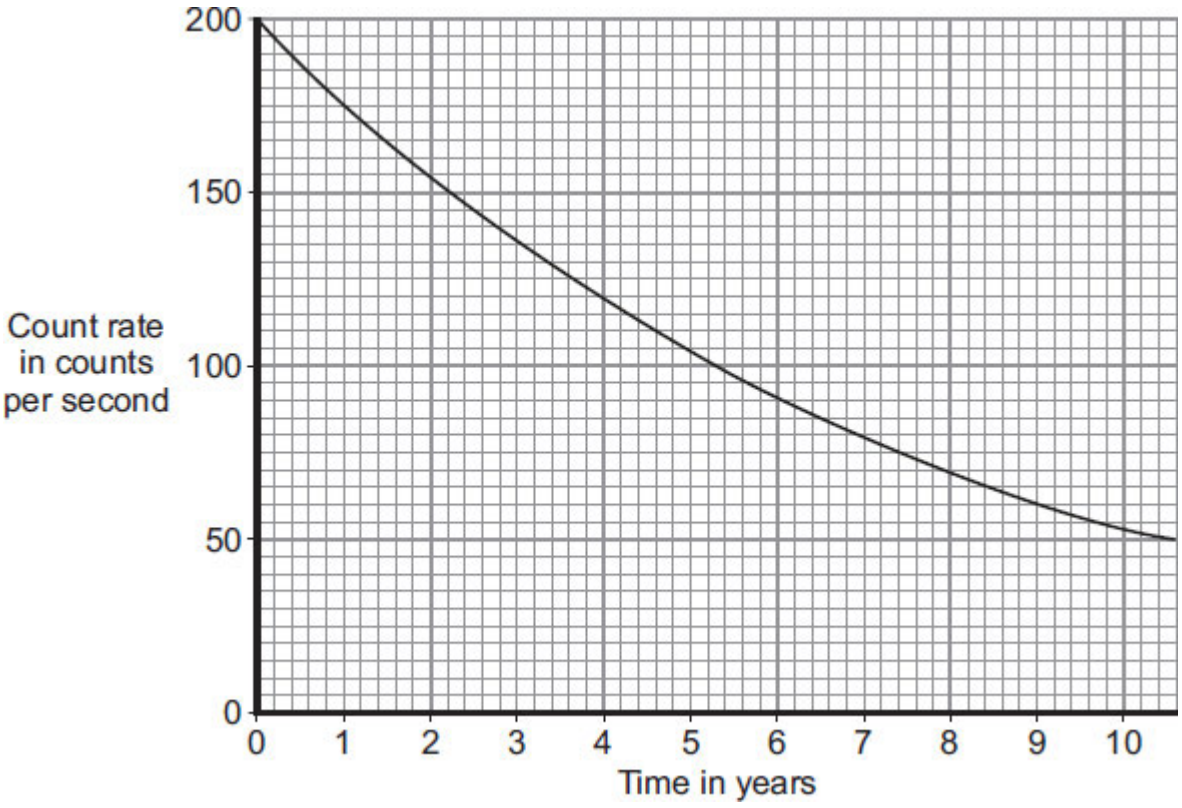
(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

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

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

(3)
(Total 10 marks)

Q11. (a) The graph shows how the count rate from a sample containing the radioactive substance cobalt-60 changes with time.



(i) What is the range of the count rate shown on the graph?

From ..... counts per second to ..... counts per second.

(1)

(ii) How many years does it take for the count rate to fall from 200 counts per second to 100 counts per second?

Time = ... years

(1)

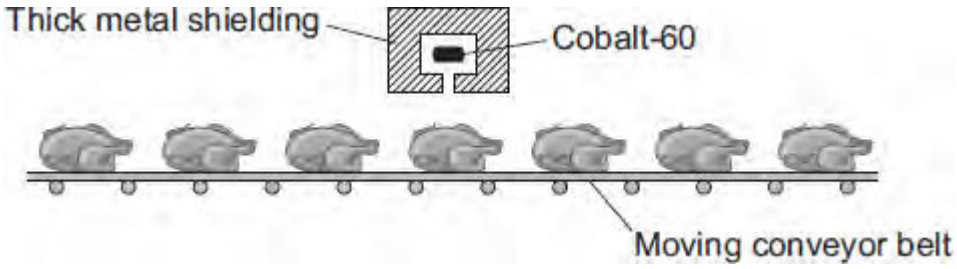
(iii) What is the half-life of cobalt-60?

Half-life = ... years

(1)

(b) The gamma radiation emitted from a source of cobalt-60 can be used to kill the bacteria on fresh, cooked and frozen foods. Killing the bacteria reduces the risk of food poisoning.

The diagram shows how a conveyor belt can be used to move food past a cobalt-60 source.



(i) Which **one** of the following gives a way of increasing the amount of gamma radiation the food receives?

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

Increase the temperature of the cobalt-60 source. ☐

Make the conveyor belt move more slowly. ☐

Move the cobalt-60 source away from the conveyor belt. ☐

(1)

(ii) To protect people from the harmful effects of the gamma radiation, the cobalt-60 source has thick metal shielding.

Which **one** of the following metals should be used?

Draw a ring around your answer.

aluminium **copper** **lead**

(1)

(c) A scientist has compared the vitamin content of food exposed to gamma radiation with food that has not been exposed.

The table gives the data the scientist obtained when she tested 1 kg of cooked

chicken.

Vitamin	Food not exposed to gamma radiation	Food exposed to gamma radiation
	Mass in milligrams	Mass 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 this data, which **one** of the following is a correct conclusion?

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

Vitamin content is not affected by gamma radiation. ☐

Gamma radiation completely destroys some types of vitamin. ☐

Exposure increased the content of some types of vitamin. ☐

(1)
(Total 6 marks)