AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



EXAM QUESTION PACK

4.4.2 ATOMS AND NUCLEAR RADIATION (PACK 1)

SCORE	PERCENTAGE
/249	%

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Q1.

Americium-241 ($^{241}_{95}Am$) is an isotope of americium.

(a) Which of the isotopes given in the table below is **not** an isotope of americium?

Isotope	Mass number	Atomic number
A	243	95
B	243	94
C	242	95

Isotope _____

Give a reason for your answer.

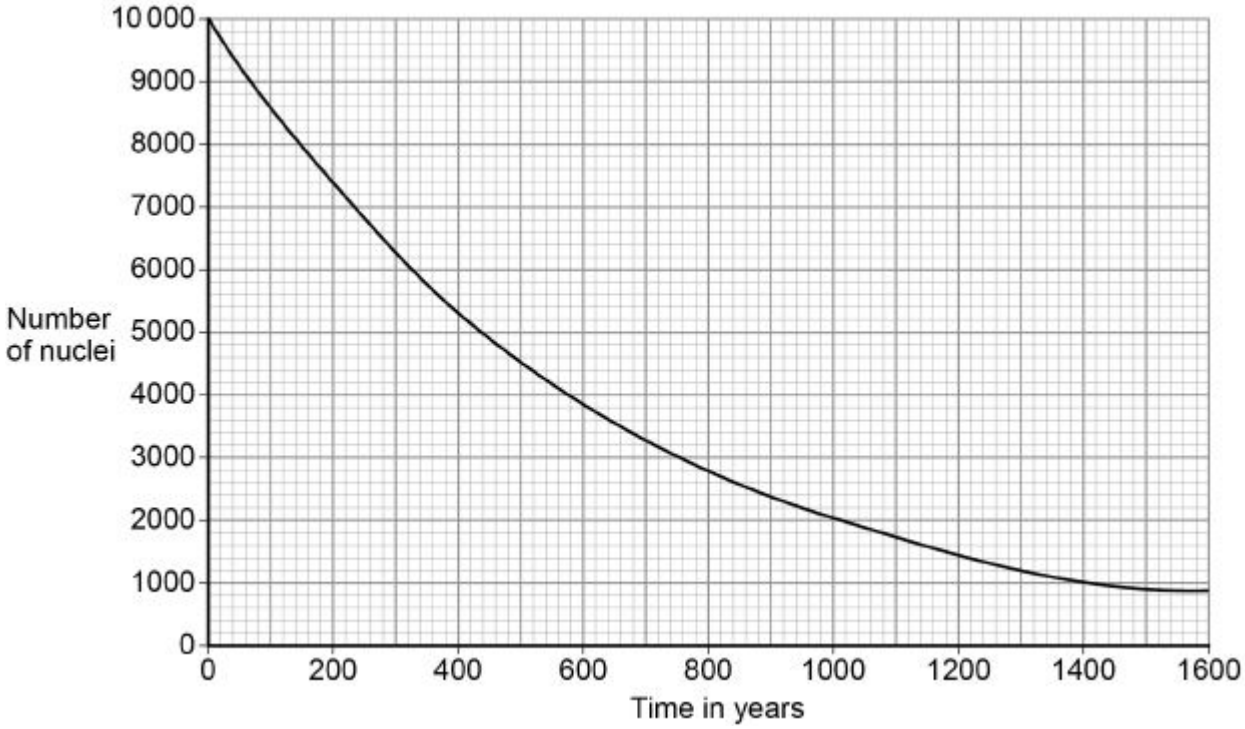
_____

_____

_____

(2)

The graph below shows how the number of americium-241 nuclei in a sample changes with time.



(b) How many years does it take for the number of americium-241 nuclei to decrease from 10 000 to 5000?

Time = _____ years

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(1)

(c) What is the half-life of americium-241?

Half-life = _____ years

(1)

(Total 4 marks)

Q2.

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

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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)

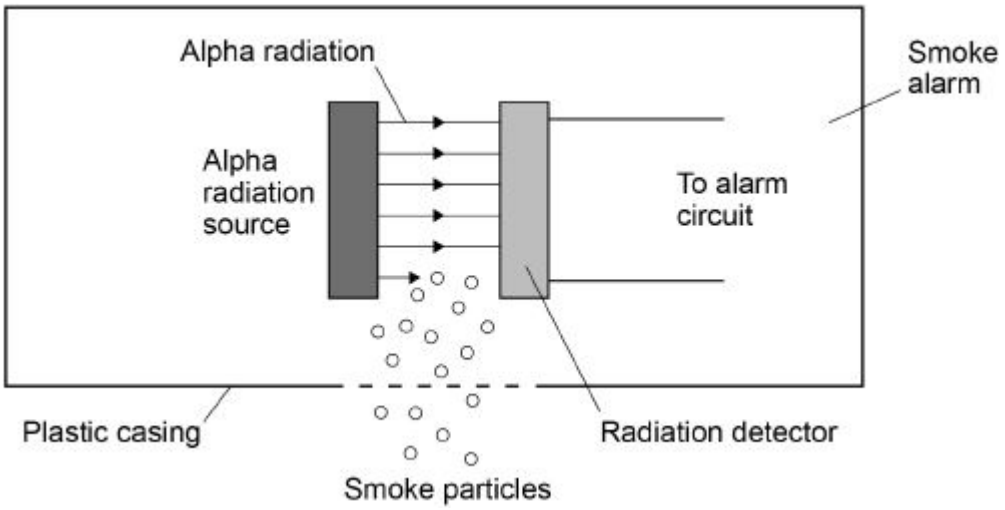
Q3.

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

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

Figure 1

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(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.

_____

_____

_____

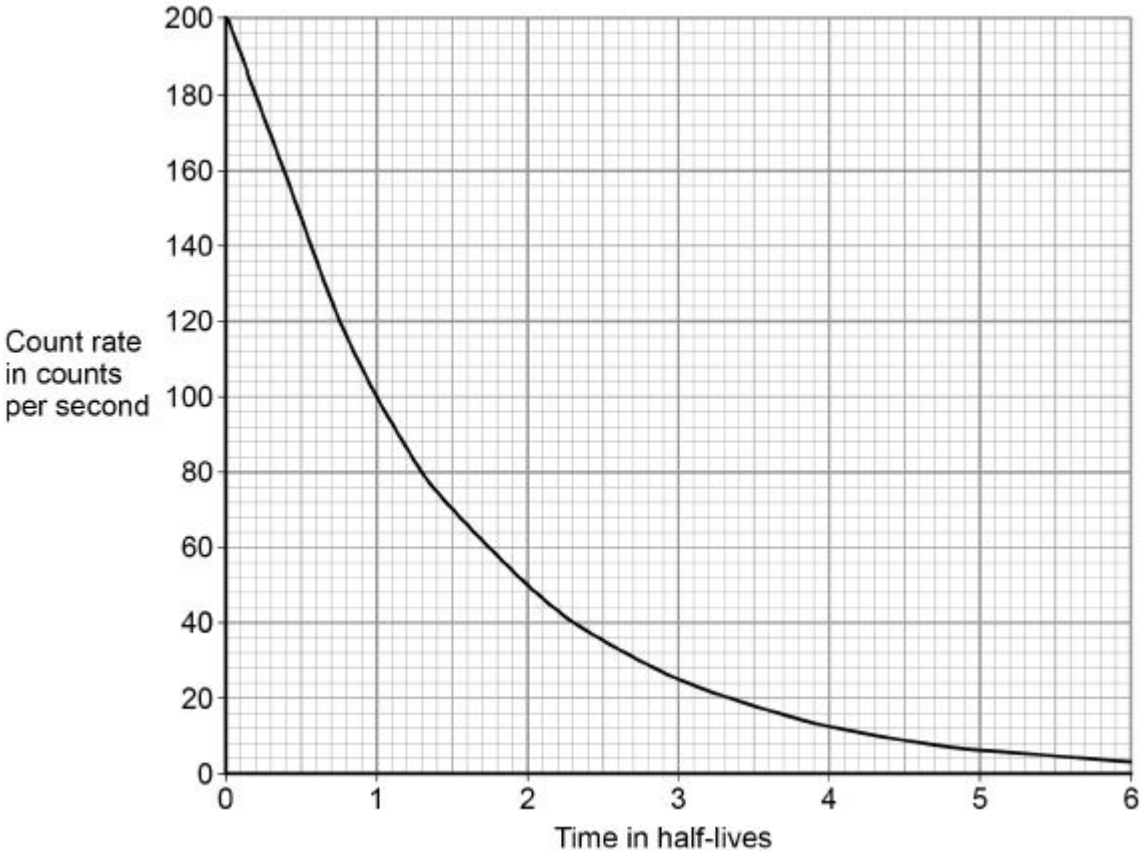
_____

(2)

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

Figure 2

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

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

_____

_____

_____

_____

(2)

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

Figure 3

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

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 10 marks)

Q4.

Alpha, beta and gamma are types of nuclear radiation.

(a) Draw **one** line from each type of radiation to what the radiation consists of.

Type of radiation	**What radiation consists of**
Alpha	Electron from the nucleus

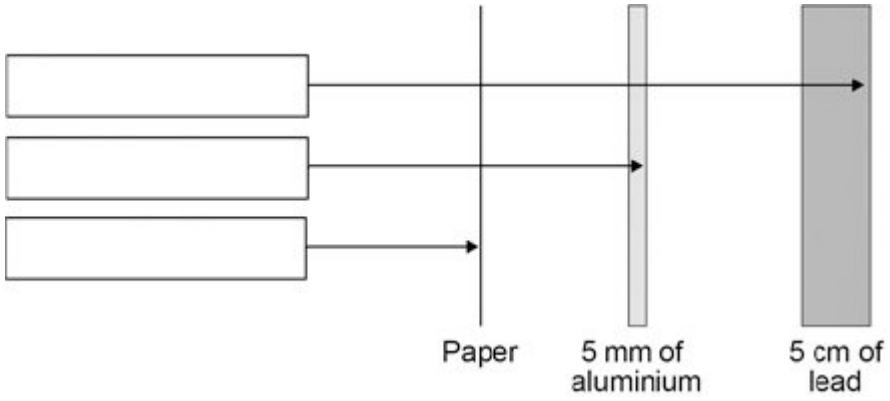
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	Two protons and two neutrons
Beta	
	Electromagnetic radiation
Gamma	
	Neutron from the nucleus

(3)

(b) A teacher demonstrates the penetration of alpha, beta and gamma radiation through different materials.

The demonstration is shown in the figure below.



Complete the figure above by writing the name of the correct radiation in each box.

(2)

(c) Give **two** safety precautions the teacher should have taken in the demonstration.

1. _____

_____

2. _____

_____

(2)

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

Time in seconds	0	40	80	120	160
Count rate in counts/second	400	283	200	141	100

Use the table to calculate the count rate after 200 seconds.

_____

_____

(2)

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

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

_____

_____

(1)

(Total 10 marks)

Q5.

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)

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Q6.

(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?

_____

_____

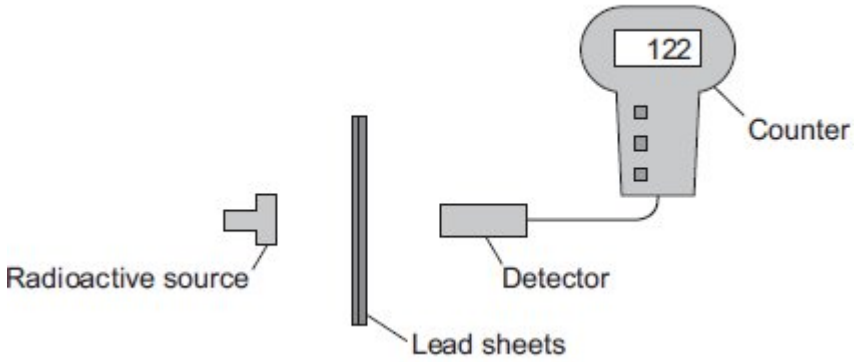
(1)

(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.

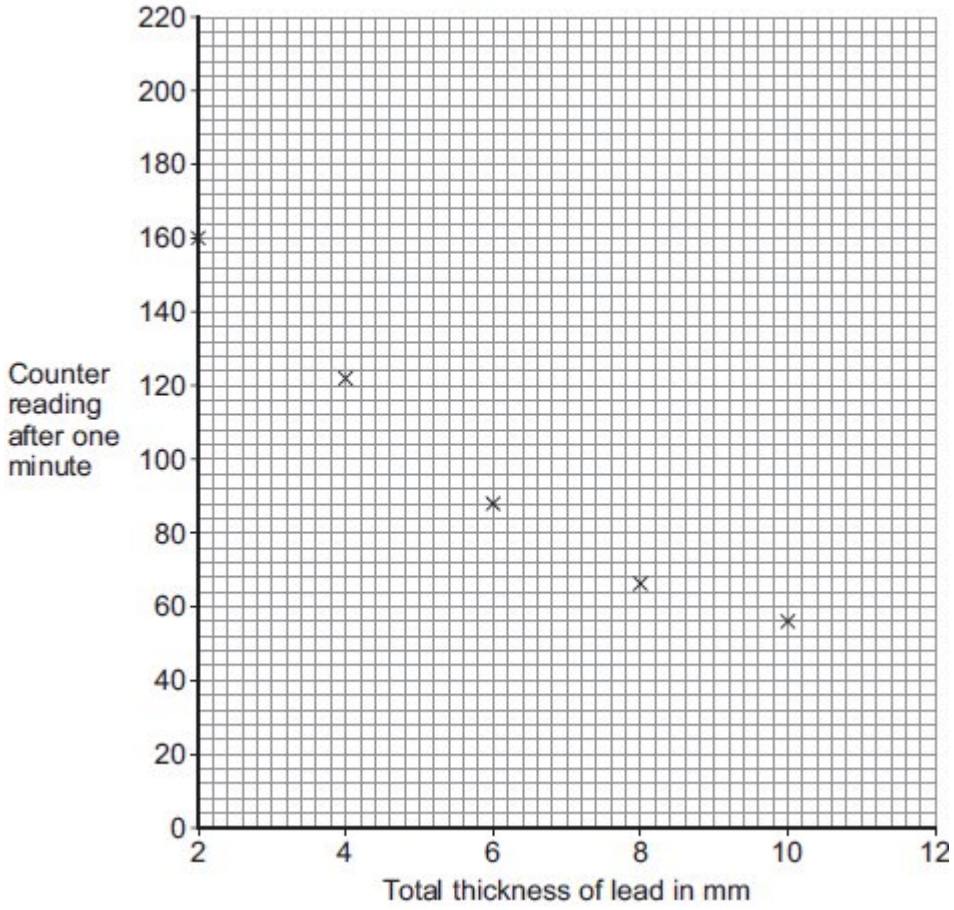
The number recorded on the counter	=	The amount of radiation detected from the source	+	_____ radiation

(1)

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

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Figure 2



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

(1)

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

_____

_____

(1)

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

Estimated counter reading = _____

(1)

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

Draw a ring around the correct answer.

alpha **beta** **gamma**

Give a reason for your answer.

_____

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_____

(2)

(Total 8 marks)

Q7.

Many countries use nuclear power stations to generate electricity.
Nuclear power stations use the process of nuclear fission to release energy.

(a) (i) What is nuclear fission?

_____

_____

(1)

(ii) Plutonium-239 is one substance used as a fuel in a nuclear reactor. For nuclear fission to happen, the nucleus must absorb a particle.

What type of particle must be absorbed?

_____

(1)

(b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

(i) Why is there a repulsion force between the nuclei of atoms?

_____

_____

(1)

(ii) Where does nuclear fusion happen naturally?

_____

(1)

(c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

The table gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

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(i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

1. _____

_____

_____

2. _____

_____

_____

(2)

(ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

_____

_____

_____

(1)

(d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

_____

_____

Half-life = _____ years

(2)

(Total 9 marks)

Q8.

Atoms contain three types of particle.

(a) Draw a ring around the correct answer to complete the sentence.

The particles in the nucleus of the atom are

electrons and neutrons.
electrons and protons.
neutrons and protons.

(1)

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(b) Complete the table to show the relative charges of the atomic particles.

Particle	Relative charge
Electron	–1
Neutron	
Proton	

(2)

(c) (i) A neutral atom has no overall charge.

Explain this in terms of its particles.

_____

_____

_____

_____

(2)

(ii) Complete the sentence.

An atom that loses an electron is called an _____

and has an overall _____ charge.

(2)

(Total 7 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).

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

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.

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

....

(3)

(Total 10 marks)

Q10.

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

Draw **one** line from each type of radiation in **List A** to its correct property in **List B**.

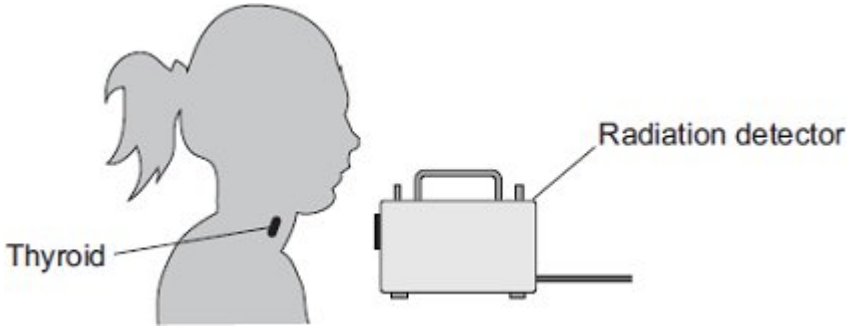
List A Type of radiation	**List B Property of radiation**
	will pass through paper but is stopped by thin metal
alpha	
	has the shortest range in air

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beta	will not harm human cells
gamma	is very weakly ionising

(3)

(b) The radioactive isotope iodine-123 can be used by a doctor to examine the thyroid gland of a patient. The iodine, taken as a tablet, is absorbed by the thyroid gland. The gamma radiation emitted as the iodine atoms decay is detected outside the body.



The doctor uses an isotope emitting gamma radiation to examine the thyroid gland rather than an isotope emitting alpha or beta radiation.

Which **one** of the following gives a reason why gamma radiation is used?

Tick (✓) **one** box.

Gamma radiation will pass through the body. ☐

Gamma radiation is not deflected by a magnet. ☐

Gamma radiation has a long range in air. ☐

(1)

(c) Iodine-123 has a half-life of 13 hours.

Use a word from the box to complete the sentence.

all	**half**	**most**

After 13 hours _____ of the iodine-123 atoms the thyroid absorbed have decayed.

(1)

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(d) Iodine-123 and iodine-131 are two of the isotopes of iodine.

Draw a ring around the correct answer to complete the sentence.

The nucleus of an iodine-123 atom has the same number of

electrons
neutrons
protons

as the nucleus of an iodine-131 atom.

(1)

(Total 6 marks)

Q11.

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 $(^{131}_{53}\mathrm{I})$ into the atmosphere.

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

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

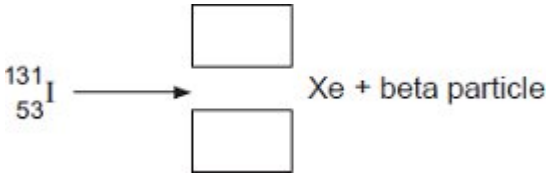
the _____ number.

(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)

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(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.

_____

_____

_____

_____

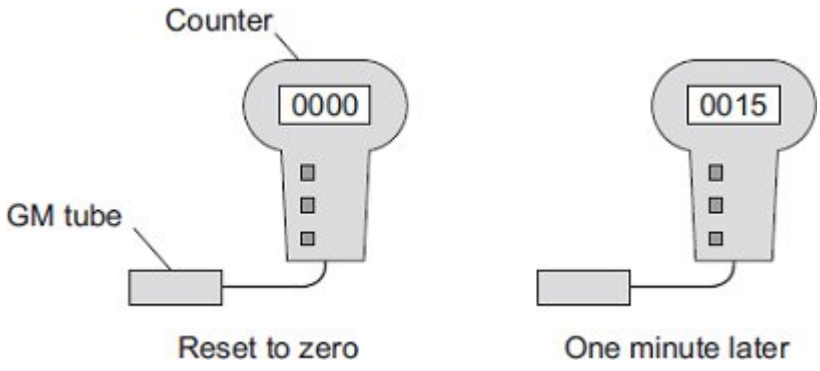
(2)

(Total 8 marks)

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.



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(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.

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

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

Number of protons = _____

Number of neutrons = _____

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(2)

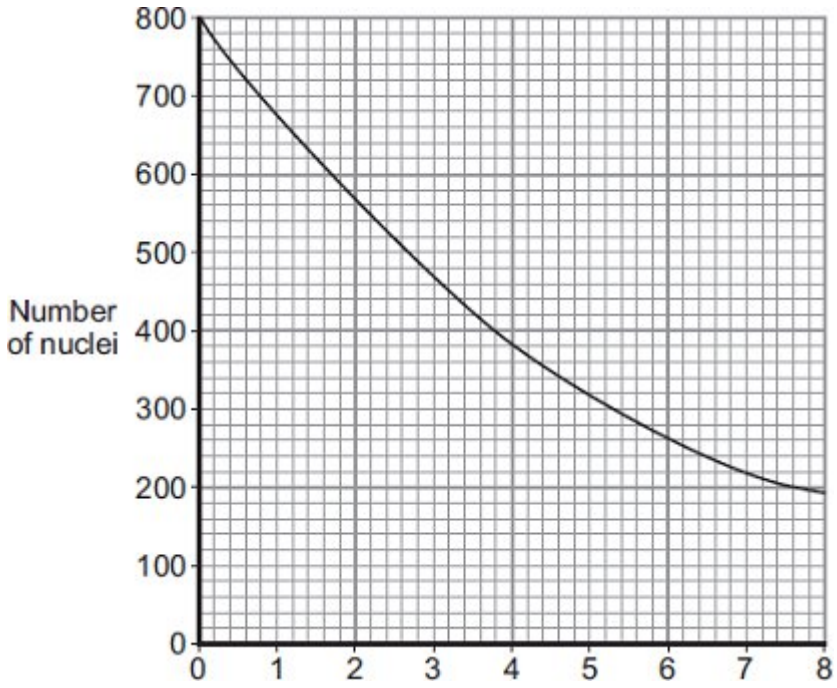
(ii) The decay of radon-222 can be represented by the equation below.

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

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

(2)

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



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.

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.

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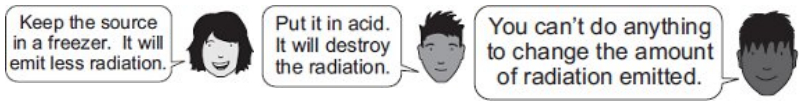
Why is it important to warn people that a radiation source is being used?

_____

_____

(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.



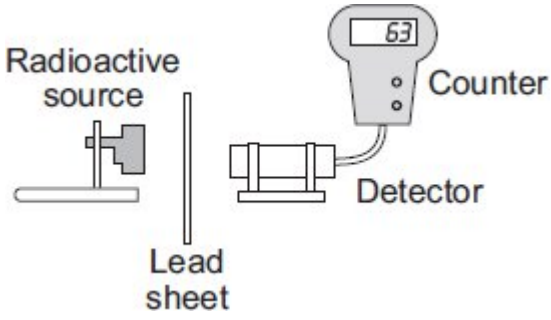
A **B** **C**

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

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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.

_____

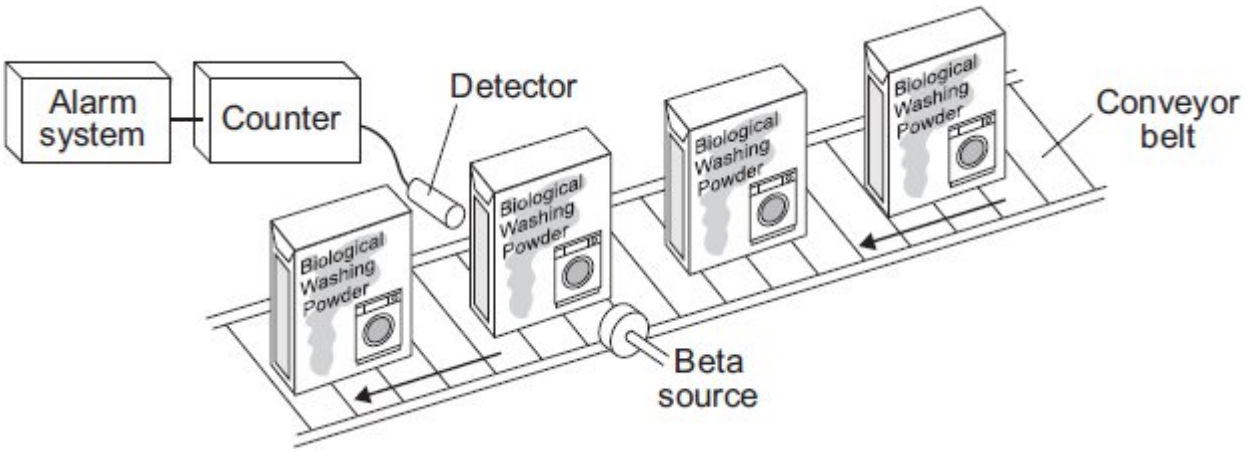
_____

_____

(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?

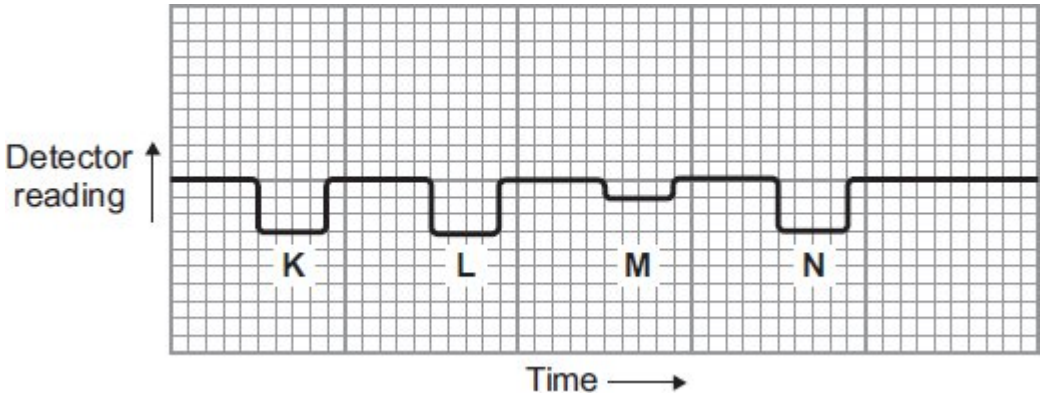
_____

_____

(1)

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

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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.

_____

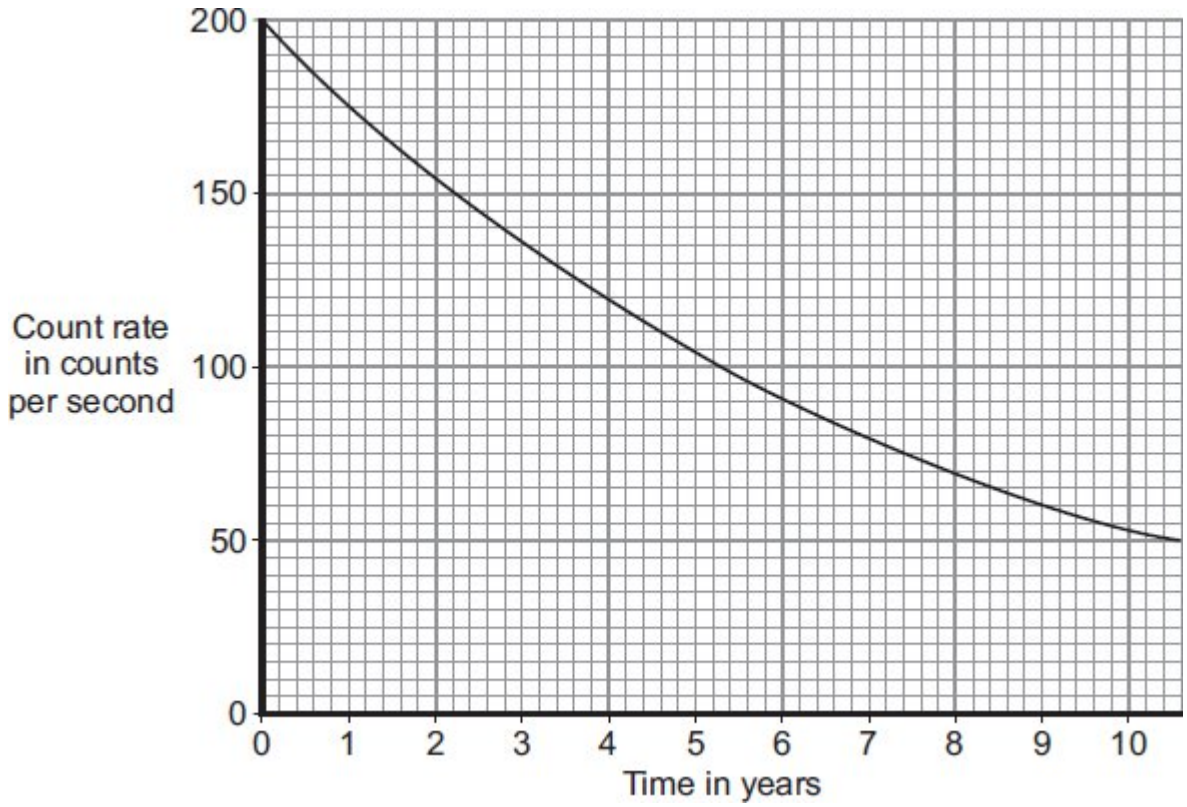
_____

(2)

(Total 8 marks)

Q14.

(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?

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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)

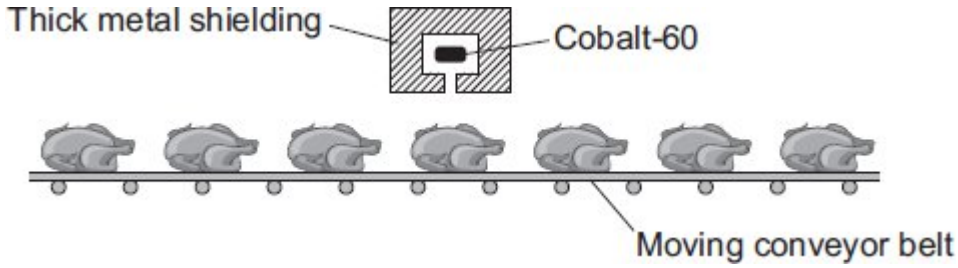
(iii) What is the half-life of cobalt-60?

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.

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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)

Q15.

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

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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.

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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.

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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)

Q16.

(a) Atoms of the isotope bismuth-212 decay by emitting either an alpha particle or a beta particle.
The equation represents what happens when an atom of bismuth-212 decays by beta emission into an atom of polonium-212.

$$^{212}_{83}\text{Bi} \longrightarrow {}^{212}_{84}\text{Po} + \text{beta particle}$$

(i) The bismuth atom and the polonium atom have the same mass number (212).

What is the *mass number* of an atom?

_____

(1)

(ii) Beta decay does **not** cause the mass number of an atom to change.

Explain why not.

_____

_____

_____

_____

(2)

(b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

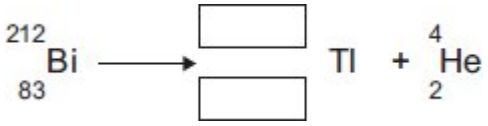
An alpha particle is the same as a helium nucleus.
The symbol below represents an alpha particle.

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

(i) The equation below represents the alpha decay of bismuth-212.

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



(2)

(ii) It is impossible for the alpha decay of bismuth-212 to produce the same element as the beta decay of bismuth-212.

Explain why.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q17.

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

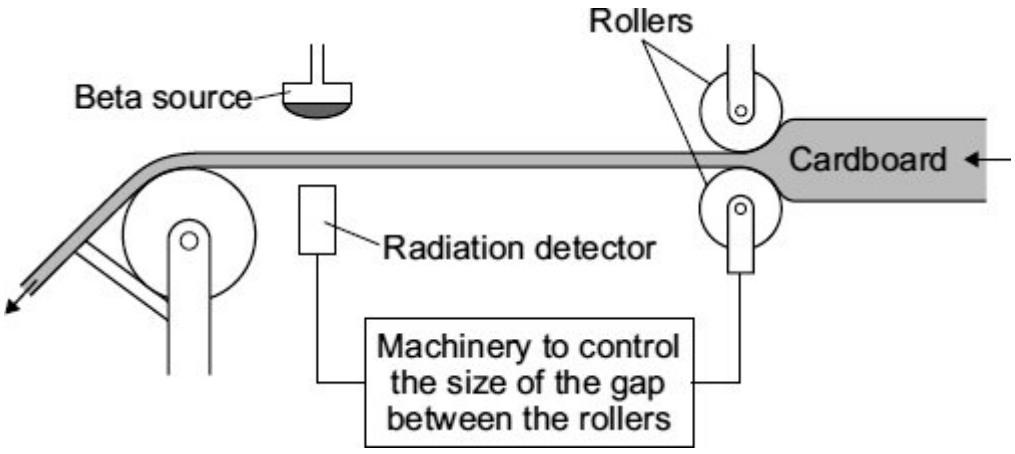
Draw only **three** lines.

List A **Type of nuclear radiation**	**List B** **Property of radiation**
	Has the same mass as an electron
Alpha	
	Very strongly ionising
Beta	
	Passes through 10 cm of aluminium
Gamma	
	Deflected by a magnetic field but not deflected by an electric field

(3)

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(b) The diagram shows a system used to control the thickness of cardboard as it is made.



The cardboard passes through a narrow gap between a beta radiation source and a radiation detector.

The table gives the detector readings over 1 hour.

Time	Detector reading
08:00	150
08:15	148
08:30	151
08:45	101
09:00	149

(i) Between 08:00 and 08:30, the cardboard is produced at the usual, correct thickness.

Explain how you can tell from the detector readings that the cardboard produced at 08:45 is thicker than usual.

_____

_____

_____

_____

(2)

(ii) Which would be the most suitable half-life for the beta source?

Draw a ring around your answer.

six days **six months** **six years**

(1)

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(iii) This control system would **not** work if the beta radiation source was replaced by an alpha radiation source.

Why not?

_____

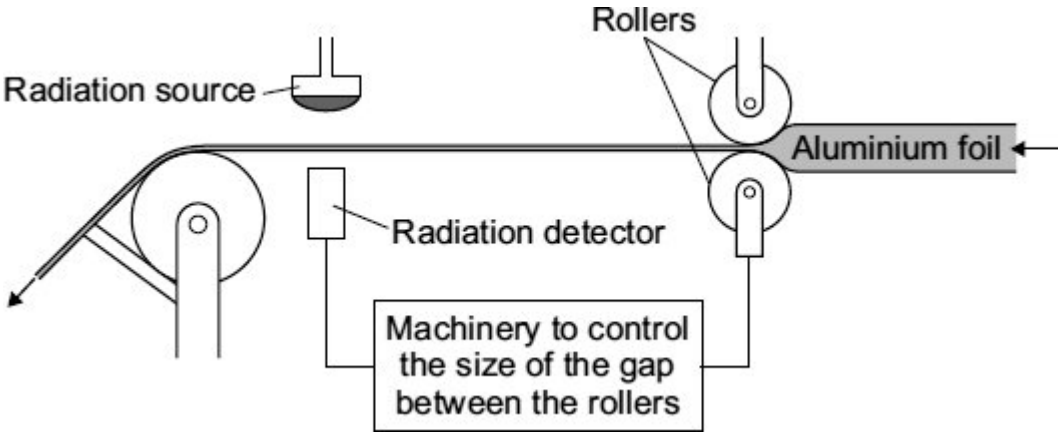
_____

(1)

(Total 7 marks)

Q18.

The diagram shows a system used to control the thickness of aluminium foil as it is being rolled. A radiation source and detector are used to monitor the thickness of the foil.



(a) Which type of source, alpha, beta or gamma, should be used in this control system?

_____

Explain why each of the other two types of source would **not** be suitable.

_____

_____

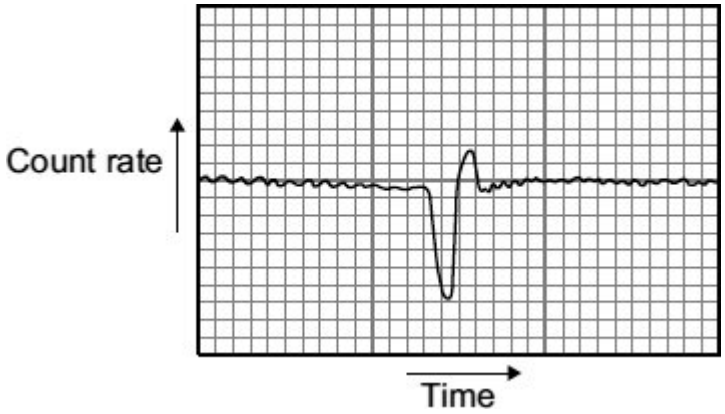
_____

_____

(3)

(b) The chart shows how the count rate recorded by the detector varies over a short period of time.

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Use the graph to explain how the thickness of the foil changes, and how the control system responds to this change.

_____

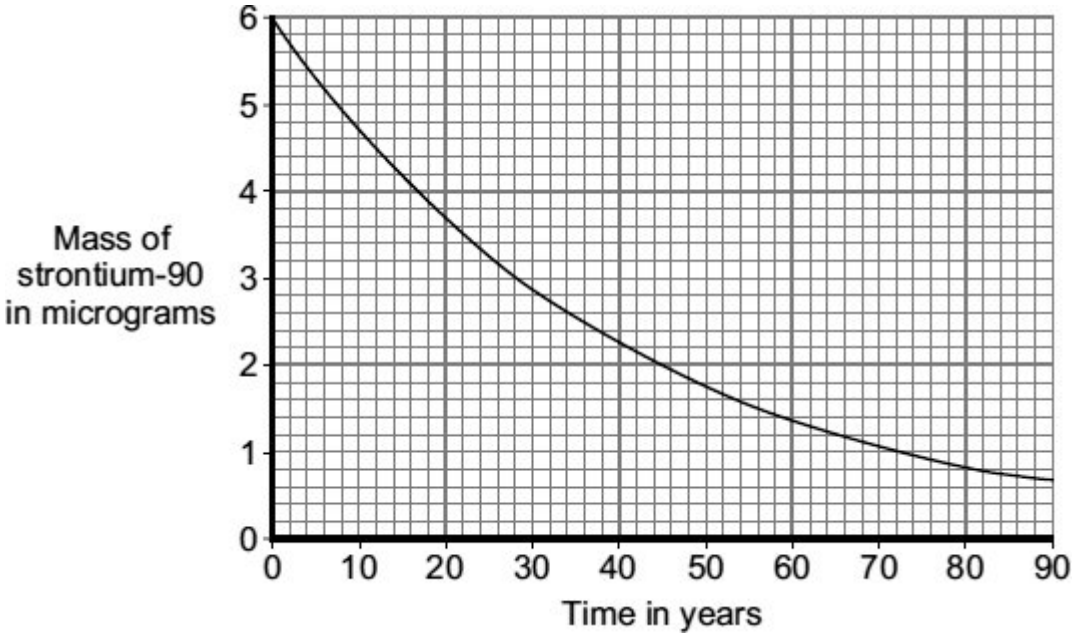
_____

_____

_____

(2)

(c) When first used, the radiation source contains 6 micrograms of strontium-90. The graph shows how the mass of the strontium-90 will decrease as the nuclei decay.



The control system will continue to work with the same source until 75 % of the original strontium-90 nuclei have decayed.

After how many years will the source need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

_____

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_____

_____

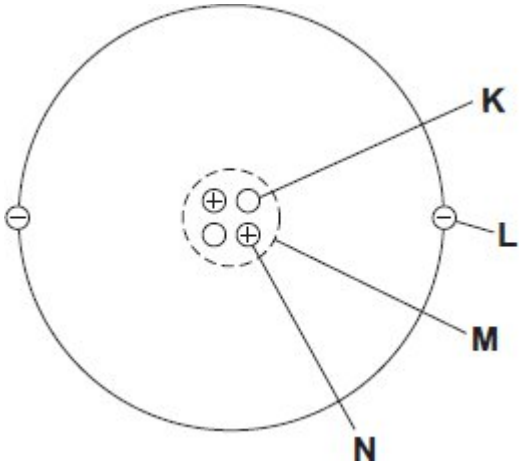
Number of years = _____

(2)

(Total 7 marks)

Q19.

(a) The diagram represents a helium atom.



(i) Which part of the atom, **K**, **L**, **M** or **N**, is an electron?

Part ☐

(1)

(ii) Which part of the atom, **K**, **L**, **M** or **N**, is the same as an alpha particle?

Part ☐

(1)

(b) A radioactive source emits alpha particles.

What might this source be used for?

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

to monitor the thickness of aluminium foil as it is made in a factory ☐

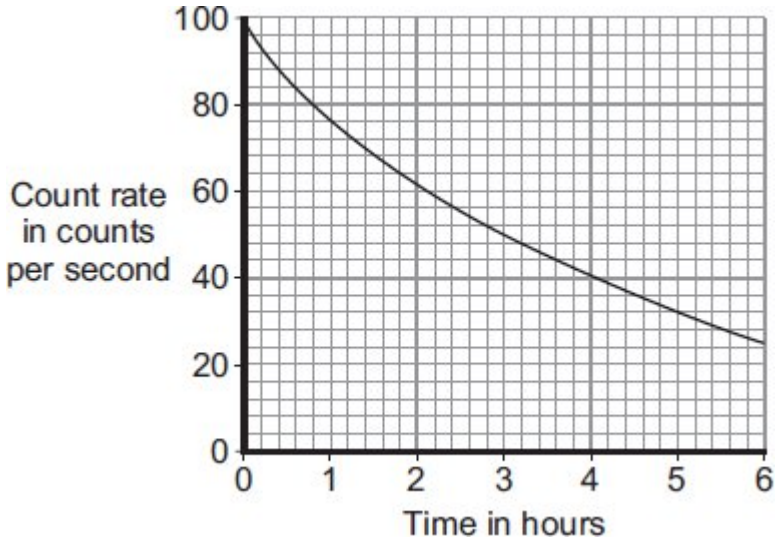
to make a smoke detector work ☐

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to inject into a person as a medical tracer

(1)

(c) The graph shows how the count rate from a source of alpha radiation changes with time.



What is the count rate after 4 hours?

_____ counts per second

(1)

(Total 4 marks)

Q20.

(a) Carbon has three naturally occurring isotopes. The isotope, carbon-14, is radioactive.
An atom of carbon-14 decays by emitting a beta particle.

(i) Complete the following sentences.

The atoms of the three carbon isotopes are the same as each other because

_____

The atoms of the three carbon isotopes are different from each other because

_____

(2)

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

_____

_____

(1)

(b) Carbon-14 is constantly being made in the atmosphere, yet for most of the last million years, the amount of carbon-14 in the atmosphere has not changed.

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How is this possible?

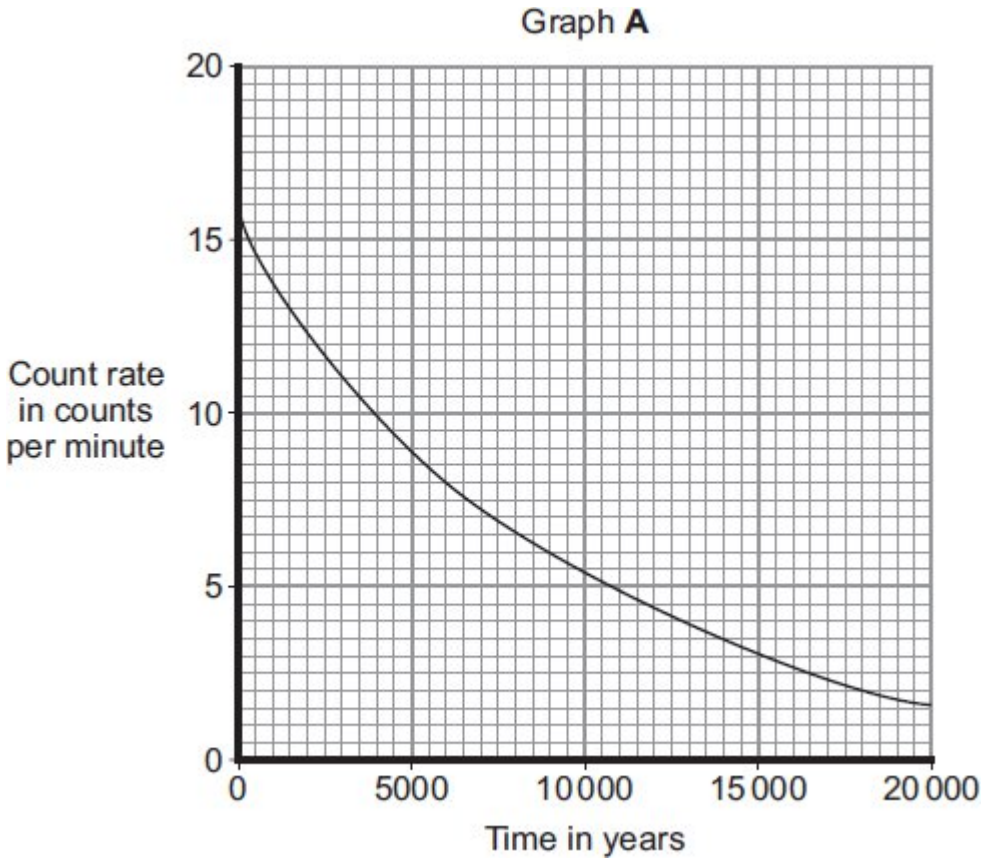
_____

_____

(1)

(c) Trees take in carbon-12 and carbon-14 from the atmosphere. After the tree dies, the proportion of carbon-14 that the tree contains decreases.

Graph **A** shows the decay curve for carbon-14.



(i) Lake Cuicocha in Ecuador was formed after a volcanic eruption.
Carbon taken from a tree killed by the eruption was found to have a count rate of 10.5 counts per minute.
At the time of the eruption, the count rate would have been 16 counts per minute.

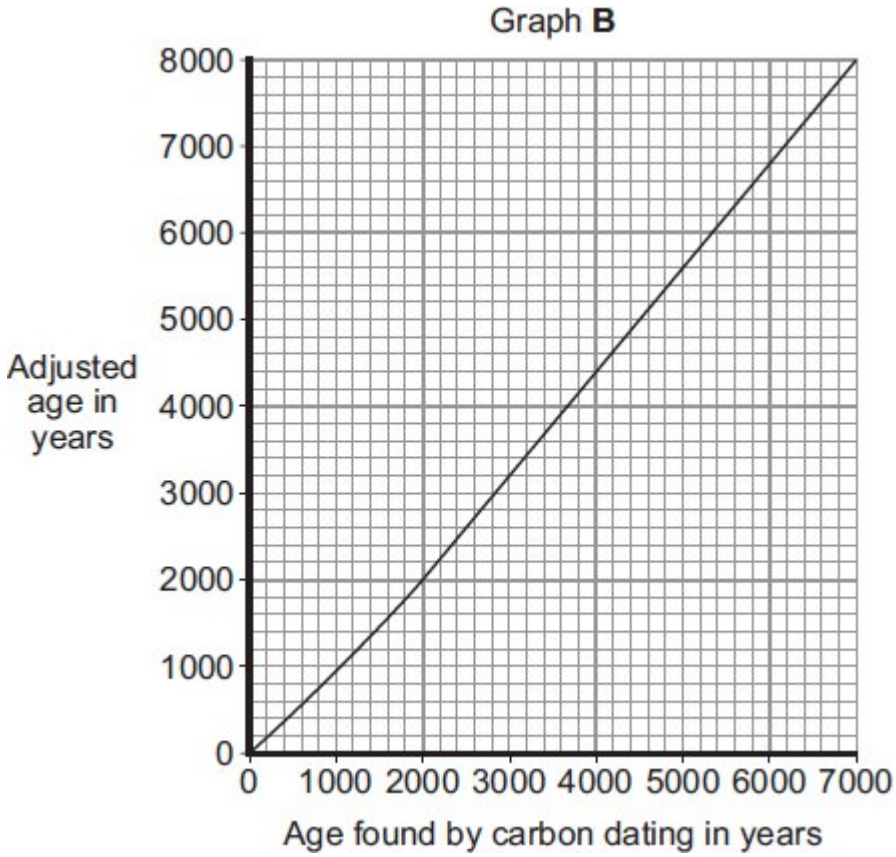
Use graph **A** to find the age of Lake Cuicocha.

Age of Lake Cuicocha = _____ years

(1)

(ii) Finding the age of organic matter by measuring the proportion of carbon-14 that it contains is called carbon dating. This technique relies on the ratio of carbon-14 to carbon-12 in the atmosphere remaining constant. However, this ratio is not constant so the age found by carbon dating needs to be adjusted.

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Graph **B** is used to adjust the age of an object found by carbon dating.
The value obtained from graph **B** will be no more than 50 years different to the true age of the object.

Use graph **B** and the information above to find the maximum age that Lake Cuicocha could be.

Show clearly how you obtain your answer.

_____

_____

Maximum age of Lake Cuicocha = _____ years

(2)

(Total 7 marks)

Q21.

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.

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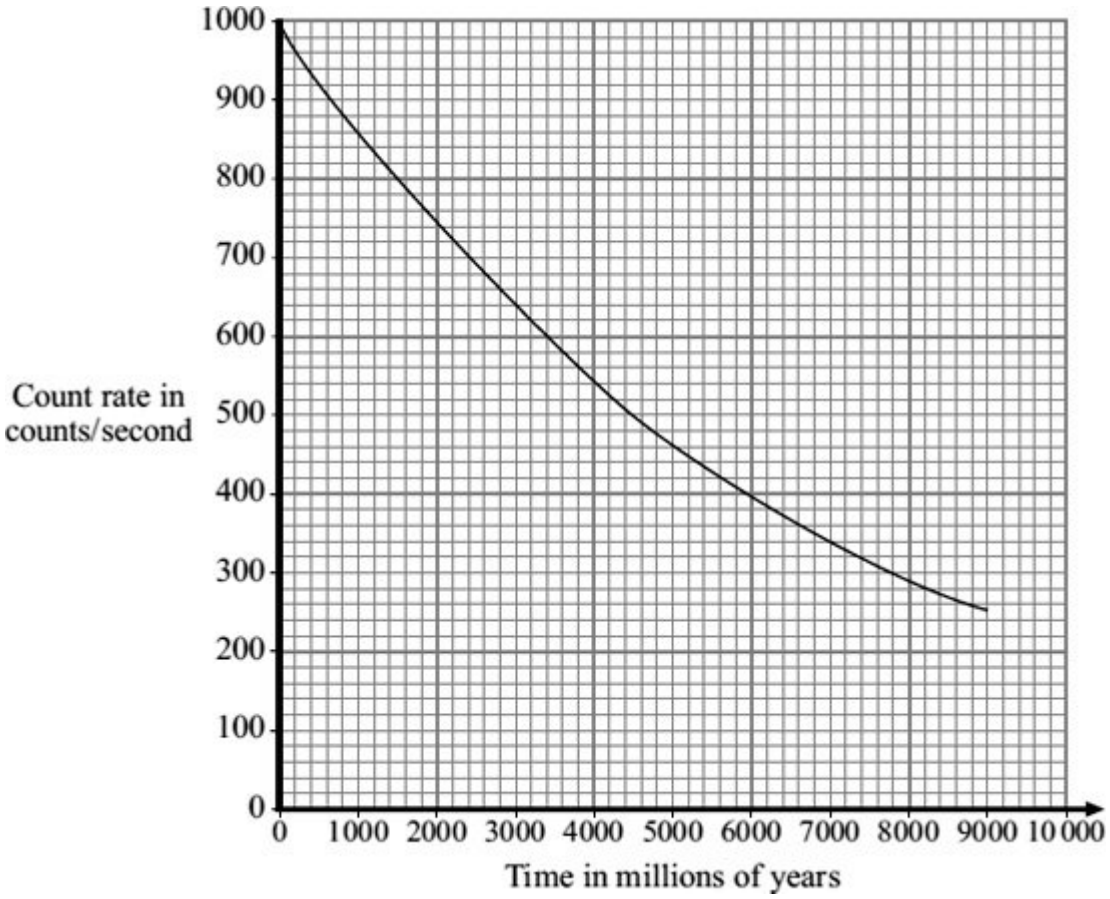
Write down your **new** statement.

_____

_____

(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.

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Explain why.

_____

_____

_____

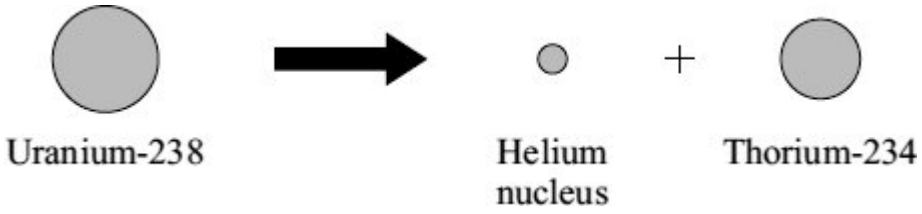
_____

(2)

(Total 5 marks)

Q22.

(a) Some rocks inside the Earth contain uranium-238, a radioactive isotope of uranium. When an atom of uranium-238 decays, it gives out radiation and changes into a thorium-234 atom.



(i) What type of radiation is emitted when a uranium-238 atom decays?

_____

(1)

(ii) From which part of a uranium-238 atom is the radiation emitted?

_____

(1)

(iii) Uranium-235 is another isotope of uranium.

How is an atom of uranium-235 similar to an atom of uranium-238?

_____

(1)

(b) Uranium-238 has a half-life of 4500 million years.

(i) When the Earth was formed, there was twice as much uranium-238 in the rocks as there is now.

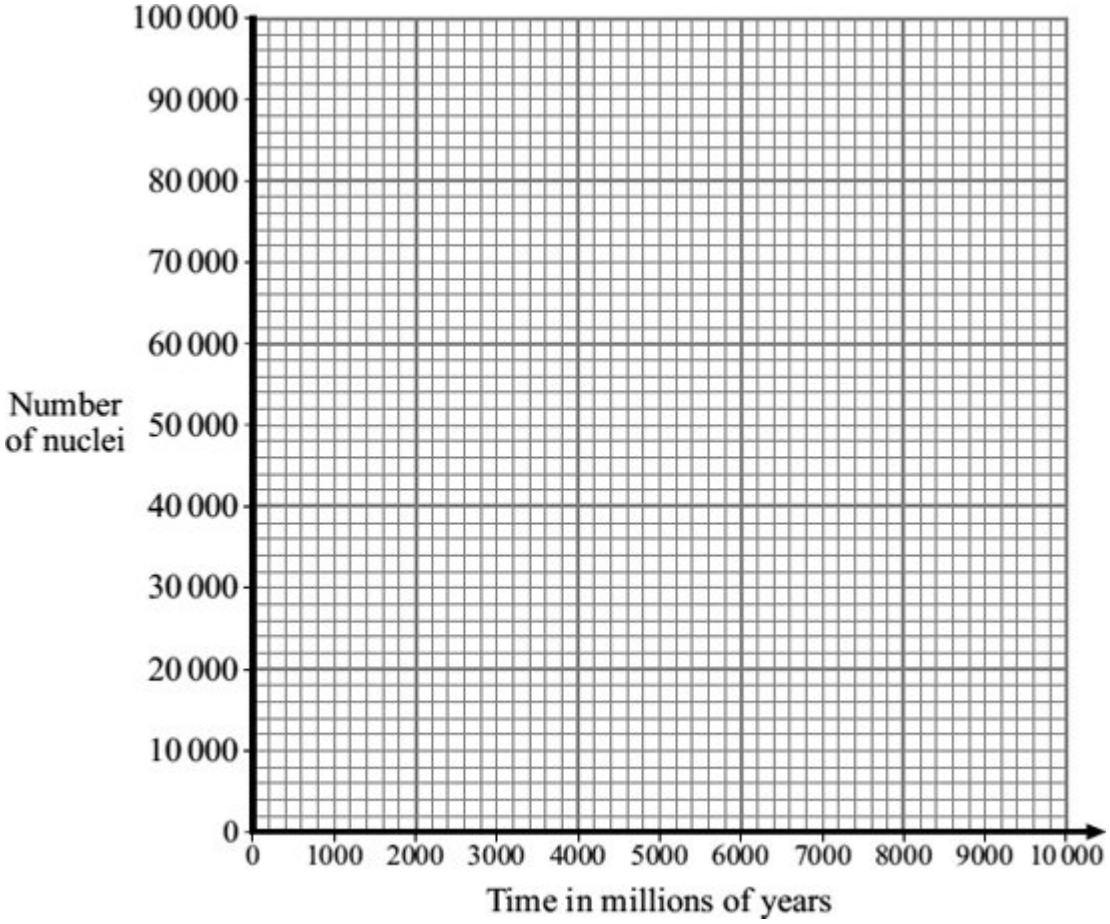
What is the age of the Earth?

_____

(1)

(ii) Complete the graph to show how the number of nuclei in a sample of uranium-238 will change with time.
Initially, there were 100 000 nuclei in the sample.

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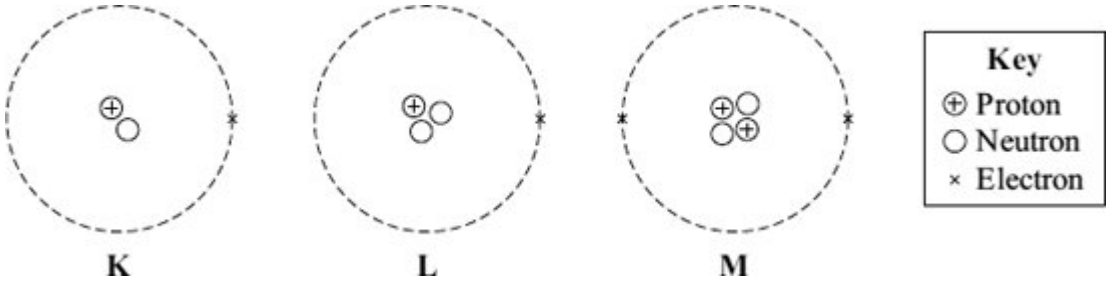


(2)

(Total 6 marks)

Q23.

(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. _____

_____

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_____

(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.

_____

_____

_____

_____

_____

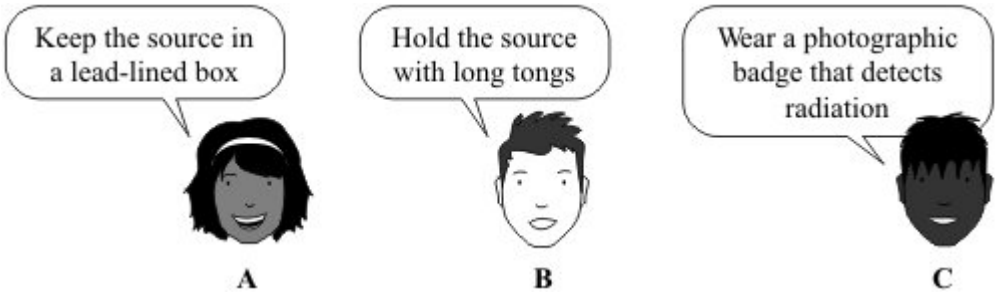
(3)

(Total 8 marks)

Q24.

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

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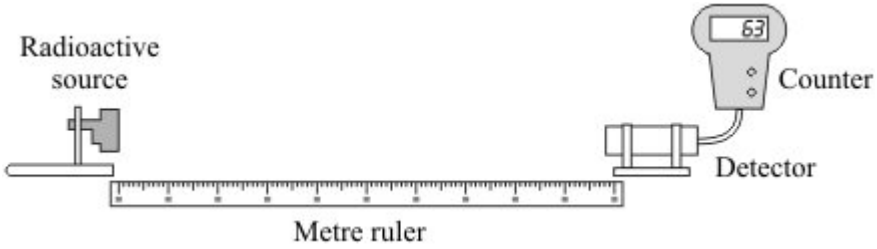


(a) Which suggestion, **A**, **B** or **C**, would **not** reduce the exposure of the teacher to radiation?

_____

(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.

_____

_____

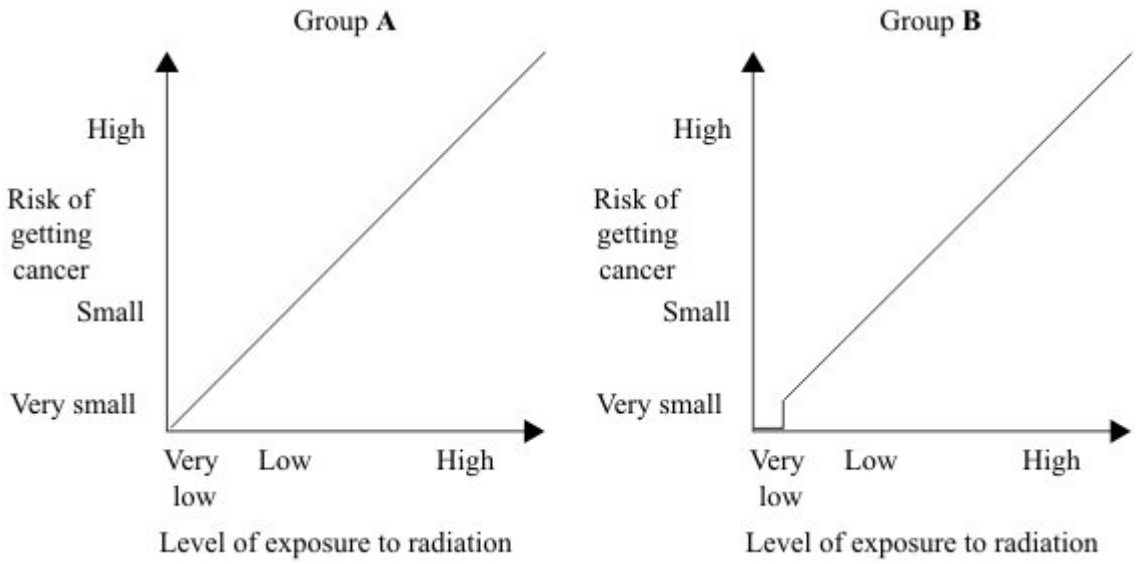
_____

_____

(3)

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(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)

Q25.

Most elements have some *isotopes* which are *radioactive*.

(a) What is meant by the terms:

(i) *isotopes*

_____

_____

(1)

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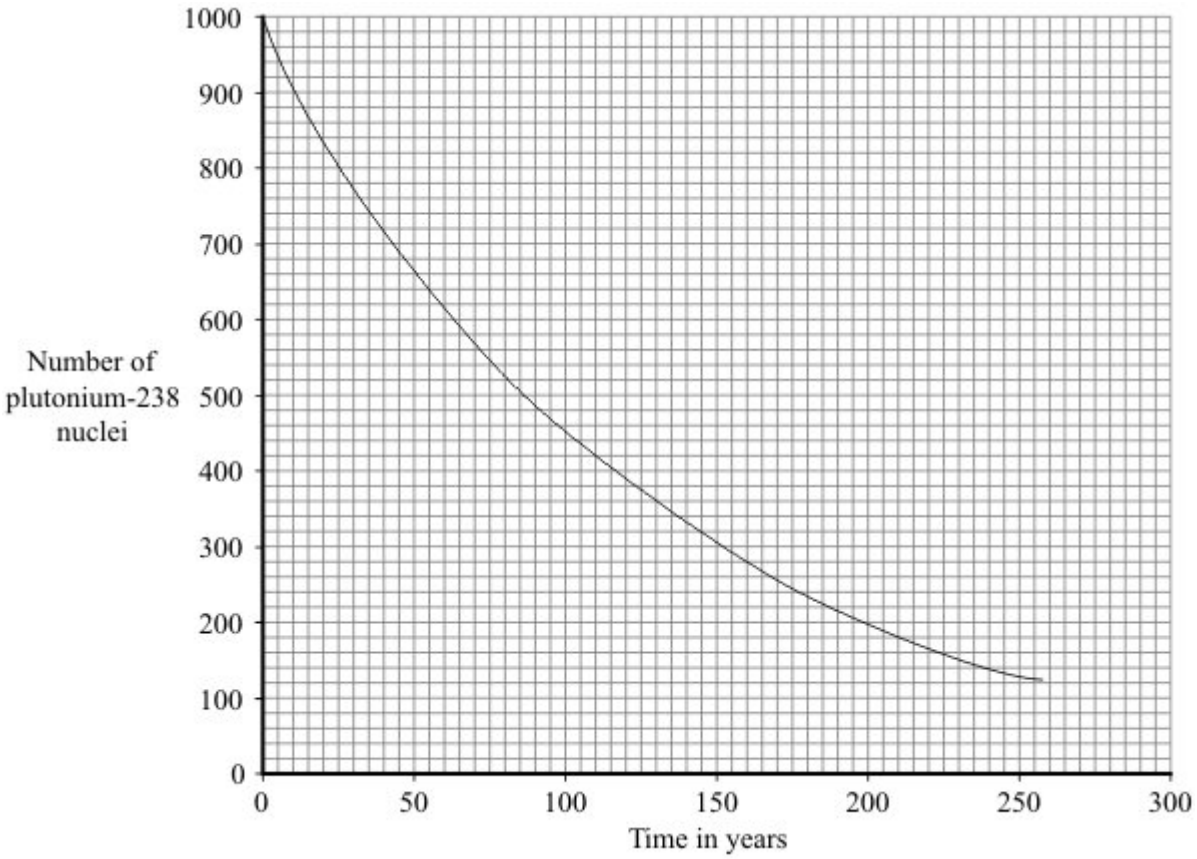
(ii) *radioactive*?

_____

_____

(1)

(b) The graph shows how the number of nuclei in a sample of the radioactive isotope plutonium-238 changes with time.



Use the graph to find the half-life of plutonium-238.

Show clearly on the graph how you obtain your answer.

Half-life = _____ years

(2)

(c) The Cassini spacecraft launched in 1997 took seven years to reach Saturn.

The electricity to power the instruments on board the spacecraft is generated using the heat produced from the decay of plutonium-238.

(i) Plutonium-238 decays by emitting alpha particles.

What is an alpha particle?

_____

(1)

(ii) During the 11 years that Cassini will orbit Saturn, the output from the generators will decrease.

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Explain why.

_____

_____

_____

_____

(2)

(d) Plutonium-238 is highly dangerous. A tiny amount taken into the body is enough to kill a human.

(i) Plutonium-238 is unlikely to cause any harm if it is outside the body but is likely to kill if it is inside the body.

Explain why.

_____

_____

_____

_____

(2)

(ii) In 1964, a satellite powered by plutonium-238 was destroyed, causing the release of radioactive material into the atmosphere.

Suggest why some environmental groups protested about the launch of Cassini.

_____

_____

(1)

(Total 10 marks)

Q26.

(a) Complete the following table for an atom of uranium-238 ($^{238}_{92}U$)

mass number	238
number of protons	92
number of neutrons	

(1)

(b) Complete the following sentence.

The name given to the number of protons in an atom is the proton number or the

_____ .

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(1)

(c) An atom of uranium-238 ($^{238}_{92}U$) decays to form an atom of thorium-234 ($^{234}_{90}Th$).

(i) What type of radiation, alpha, beta or gamma, is emitted by uranium-238?

_____

(1)

(ii) Why does an atom that decays by emitting alpha or beta radiation become an atom of a different element?

_____

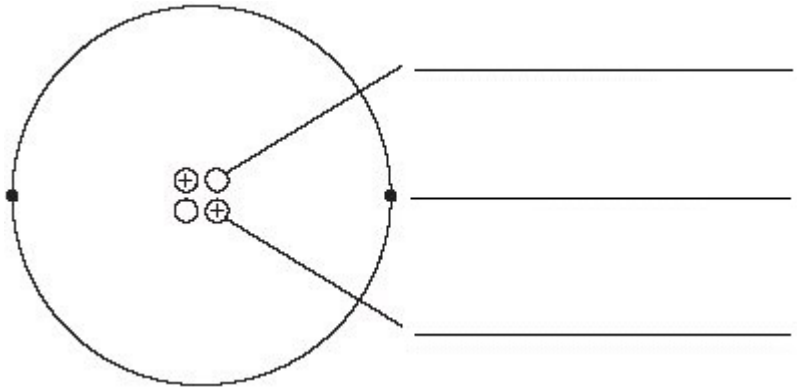
_____

(1)

(Total 4 marks)

Q27.

The diagram shows a helium atom.



(a) (i) Use the words in the box to label the diagram.

electron	**neutron**	**proton**

(2)

(ii) An alpha particle is the same as the nucleus of a helium atom.

How is an alpha particle different from a helium atom?

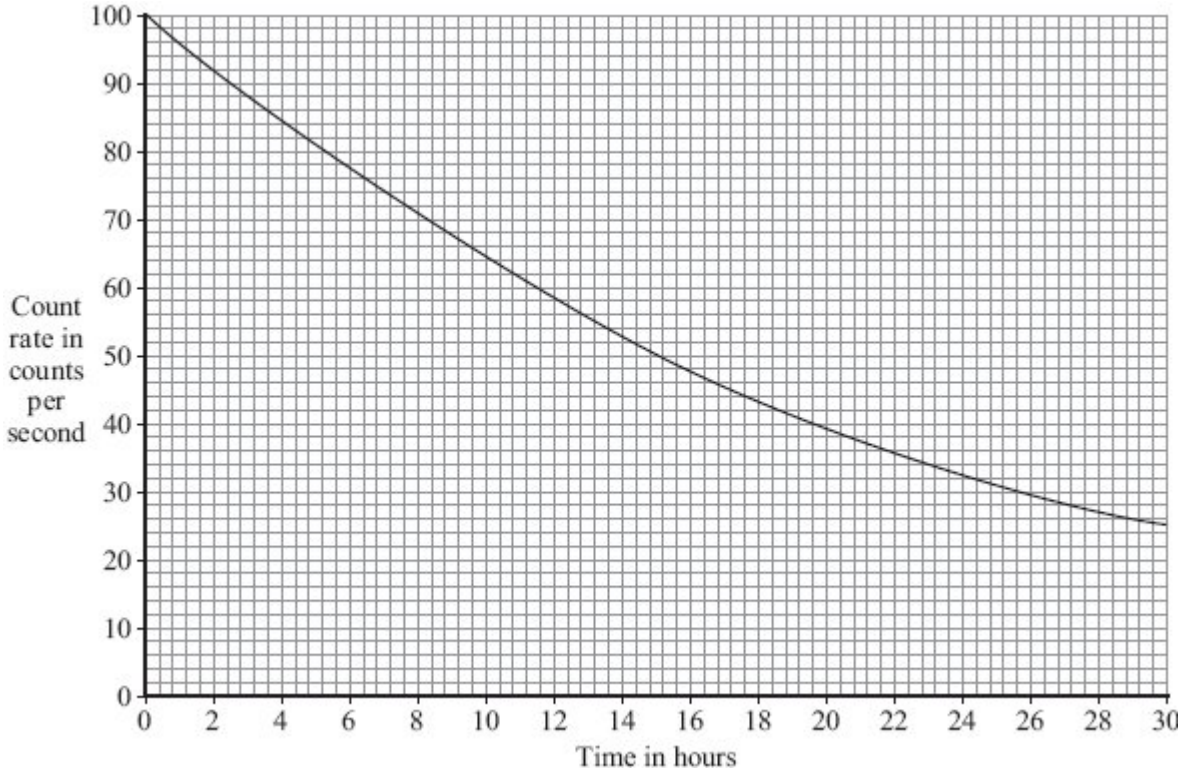
_____

_____

(1)

(b) The graph shows how the count rate from a sample of radioactive sodium-24 changes with time.

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(i) How many hours does it take for the count rate to fall from 100 counts per second to 50 counts per second?

Time = _____ hours

(1)

(ii) What is the half-life of sodium-24?

Half-life = _____ hours

(1)

(c) A smoke detector contains a small amount of americium-241.

Americium-241 is a radioactive substance which emits alpha particles. It has a half-life of 432 years.

(i) Which **one** of the following statements gives a reason why the americium-241 inside the smoke detector will **not** need replacing?

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

The alpha particles have a low energy. ☐

People replace smoke detectors every few years. ☐

Americium-241 has a long half-life. ☐

(1)

(ii) The diagram shows the label on the back of the smoke detector.

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Why do people need to know that the smoke detector contains a radioactive material?

_____

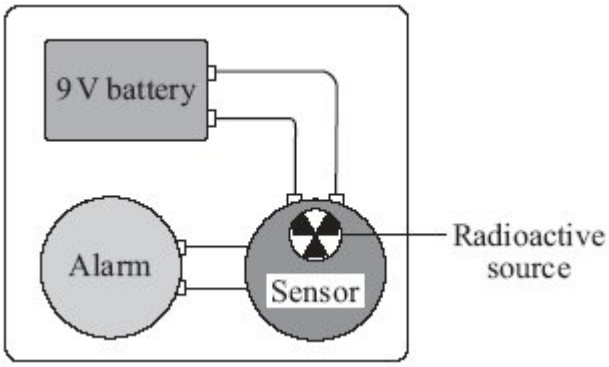
_____

(1)

(Total 7 marks)

Q28.

(a) The diagram shows the parts of a smoke detector. The radioactive source emits alpha particles.



The alpha particles ionise the air inside the sensor which causes a small electric current. Any smoke getting into the sensor changes the current. The change in current sets the alarm off.

(i) The smoke detector would **not** work if a radioactive source that emitted only gamma rays was used.

Why not?

_____

_____

(1)

(ii) Curium-242 is a radioactive isotope with a half-life of 160 days. It emits alpha particles.

Why is curium-242 **not** suitable for use inside smoke detectors?

_____

_____

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(1)

(iii) Curium-242 and curium-244 are two of the isotopes of the element curium.

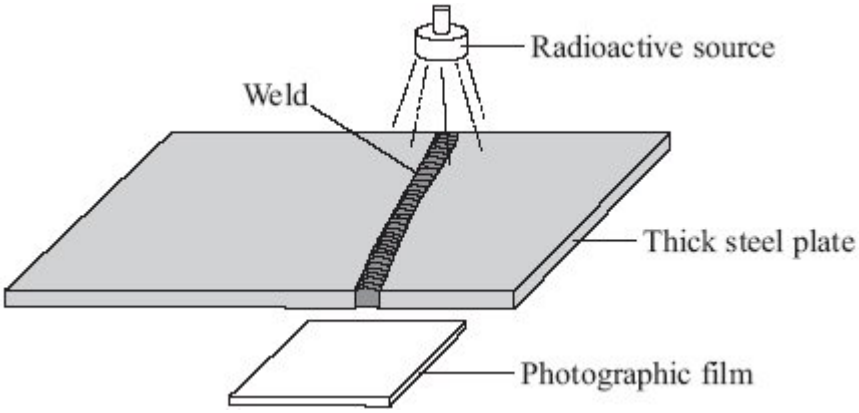
How is an atom of curium-242 different from an atom of curium-244?

_____

_____

(1)

(b) Sections of steel are often joined by welding them together. The diagram shows how a radioactive source can be used to check for tiny cracks in the weld.



Cracks in the weld will be shown up on the photographic film below the thick steel plate.

(i) Which type of source, alpha, beta or gamma, should be used to check the weld?

_____

(1)

(ii) Give a reason why the other two types of source **cannot** be used.

_____

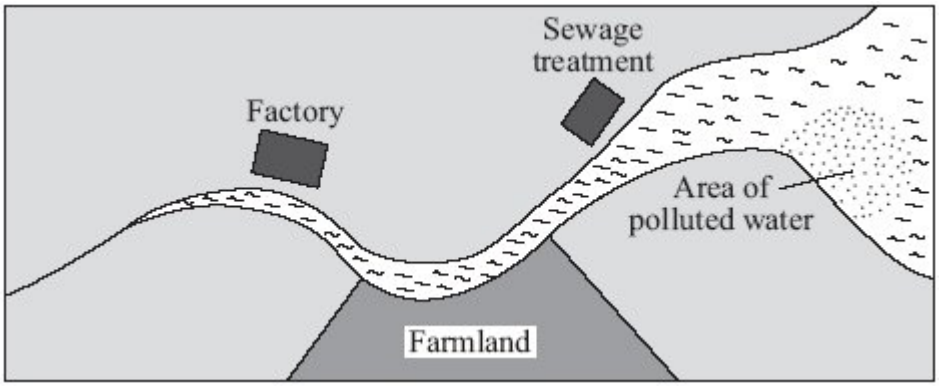
_____

(1)

(c) The diagram shows a map of a river and its estuary.

Environmental scientists have found that the water flowing into one part of the river estuary is polluted. To find where the pollution is coming from, the scientists use a radioactive isotope, gold-198.

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(i) Explain how the gold-198 is used to find where the pollution is coming from.

_____

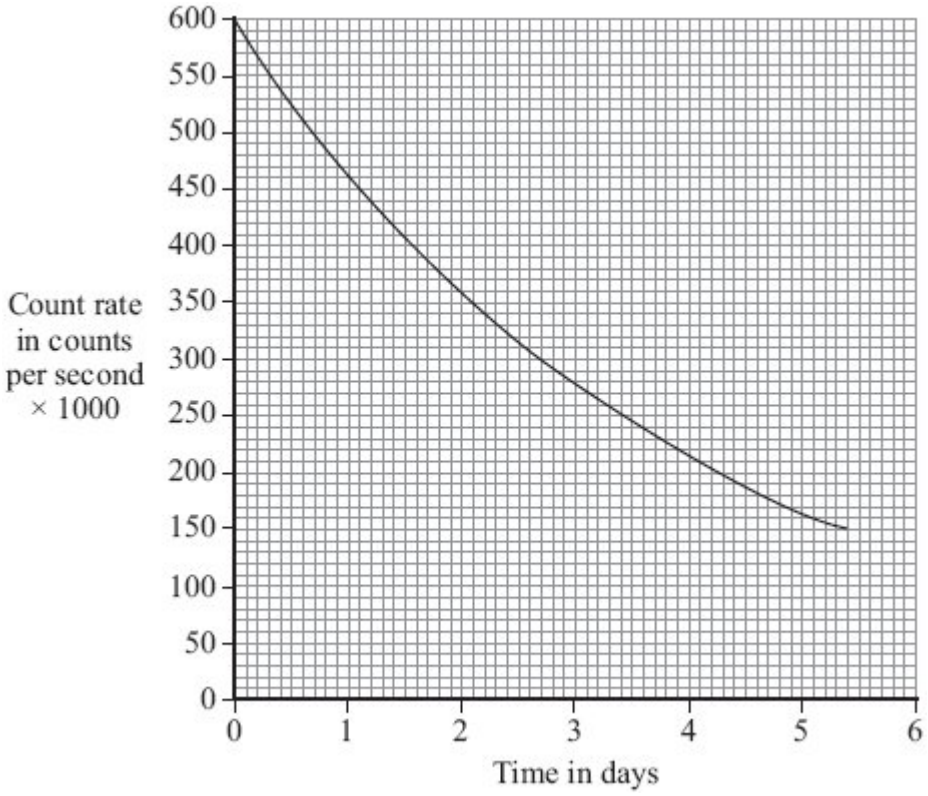
_____

_____

_____

(2)

(ii) The graph shows how the count rate from a sample of gold-198 changes with time.



Use the graph to calculate the half-life of gold-198.

Show clearly on the graph how you obtain your answer.

_____

_____

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Half-life = _____ days

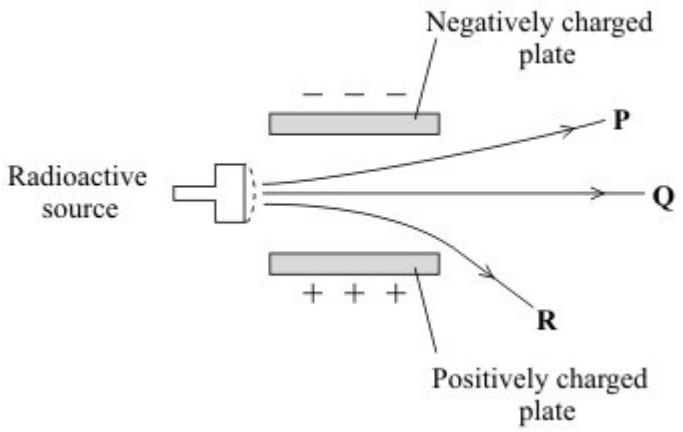
(2)

(Total 9 marks)

Q29.

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 _____

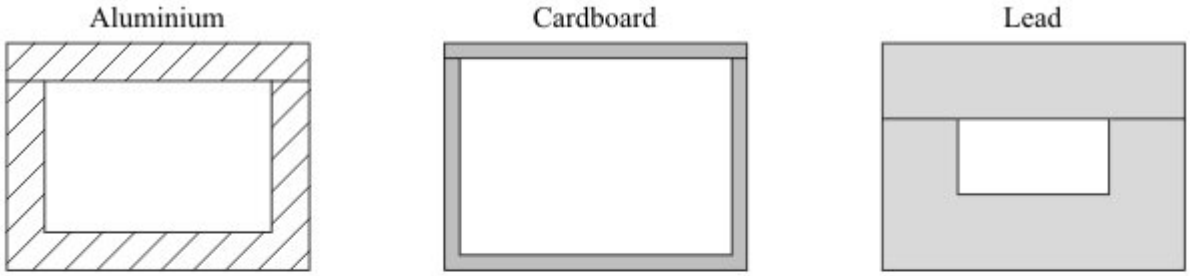
(1)

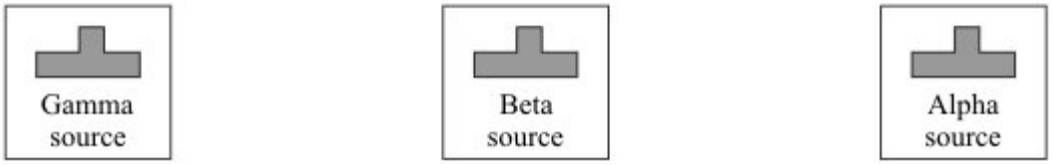
(ii) gamma radiation? _____

(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.

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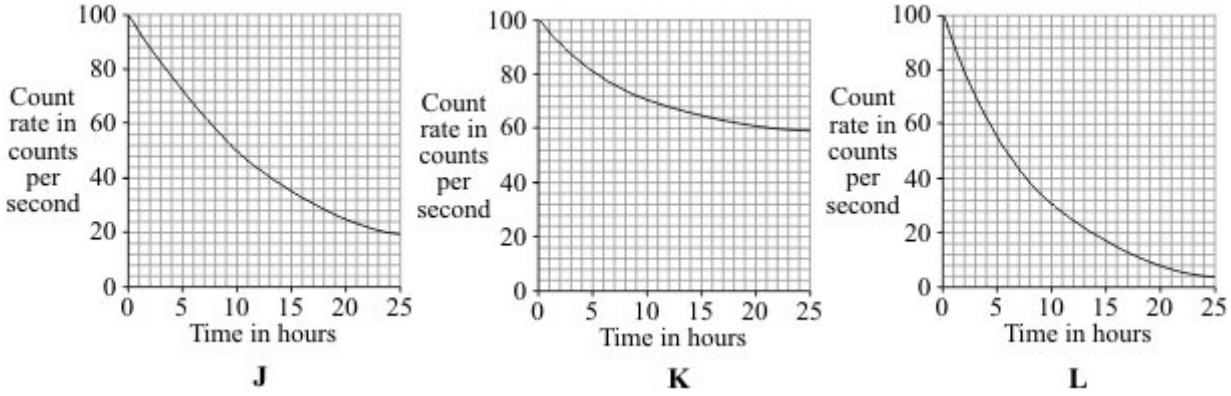




Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.

(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)

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(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)

Q30.

(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?

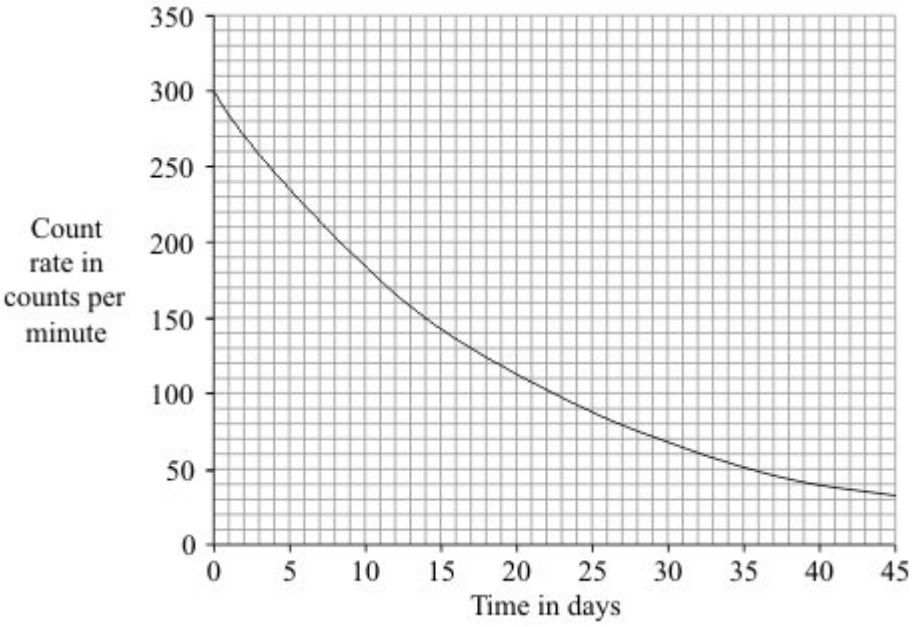
_____

_____

(1)

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(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.

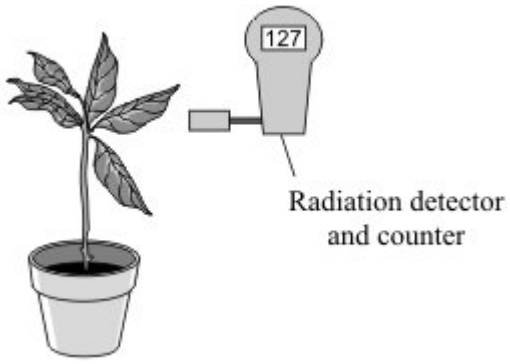
_____

_____

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.

_____

_____

_____

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_____

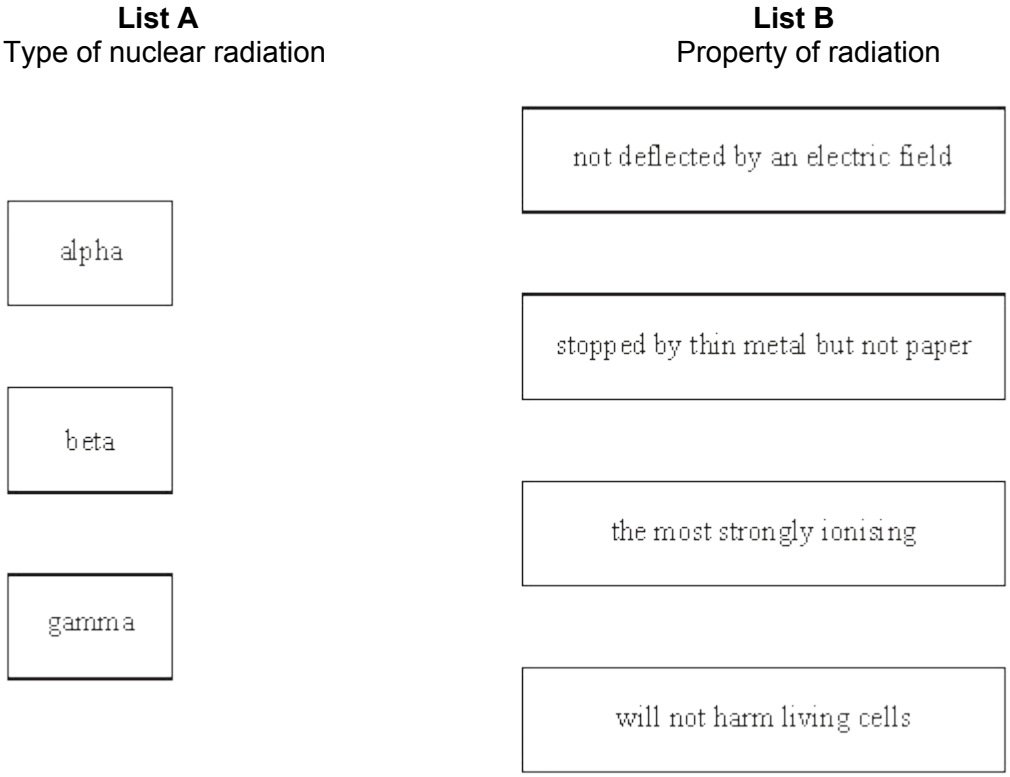
(2)

(Total 9 marks)

Q31.

(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.



(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

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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.

_____

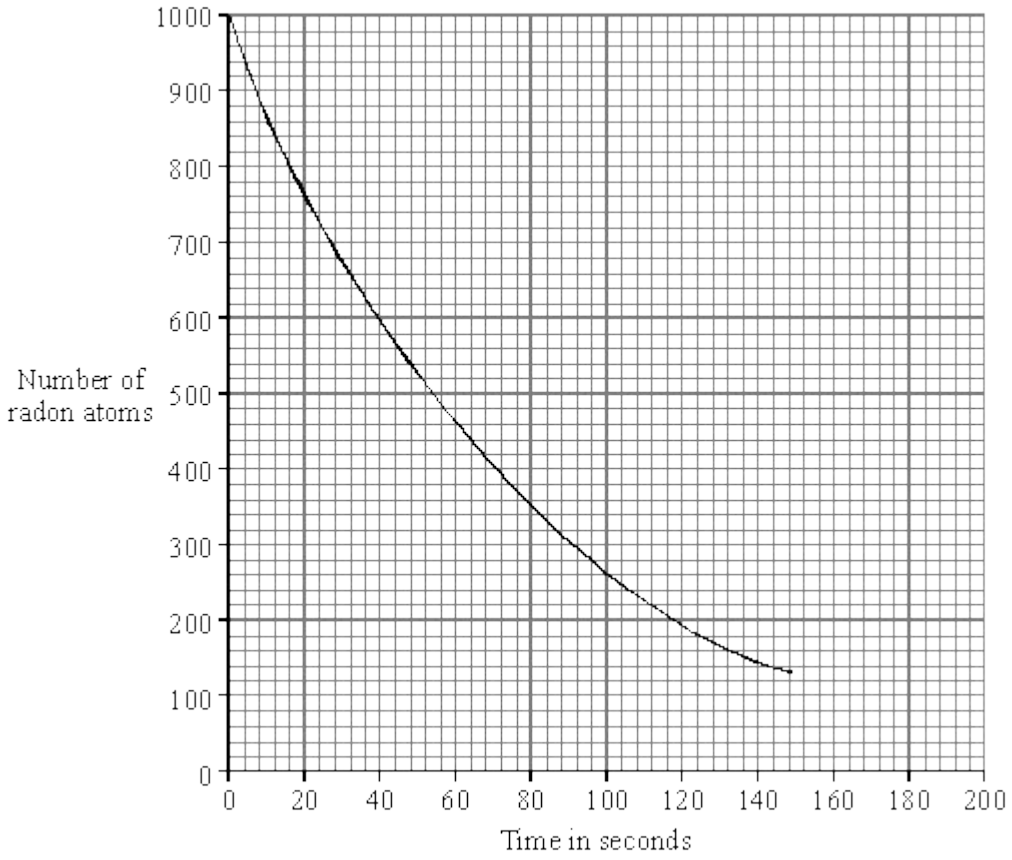
_____

(1)

(Total 8 marks)

Q32.

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?

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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

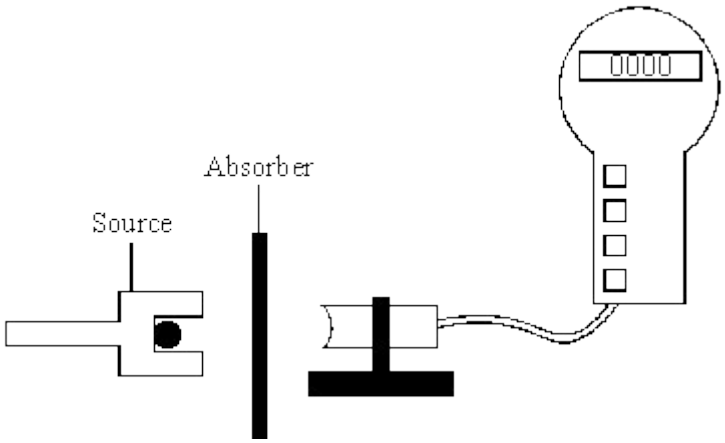
radiation per second.

(1)

(Total 3 marks)

Q33.

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)

Q34.

(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.

_____

_____

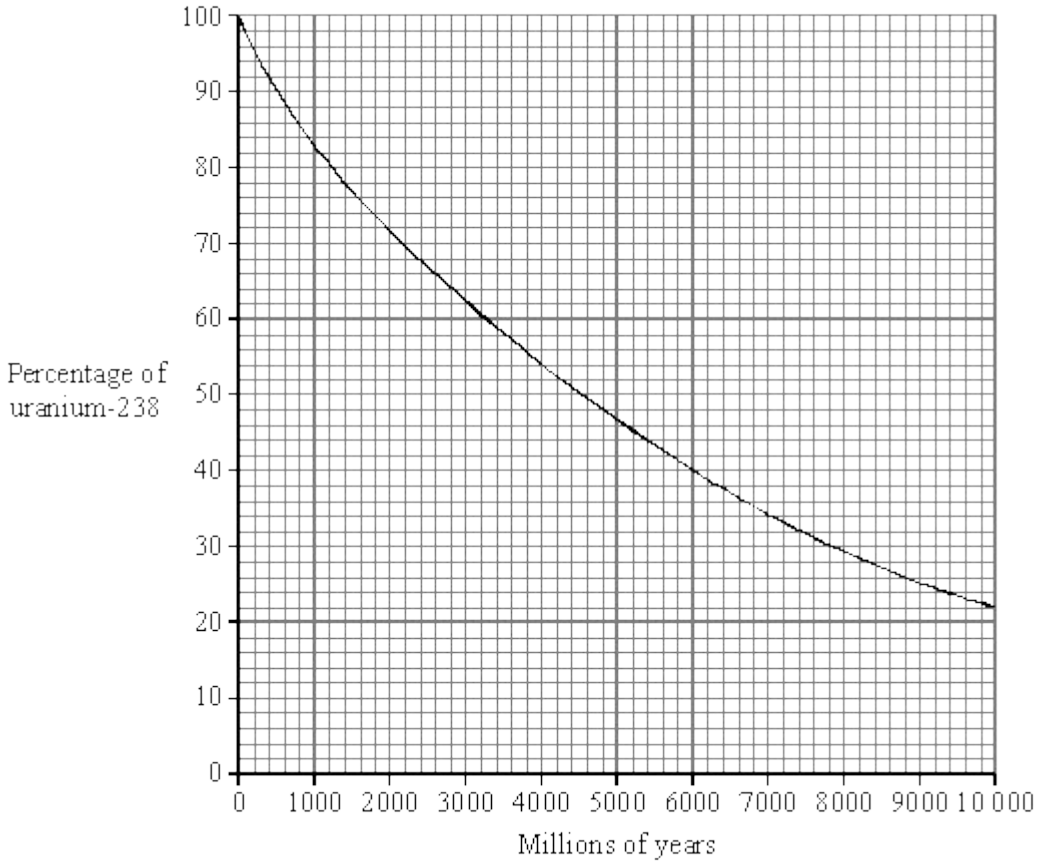
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_____

_____

(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)

Q35.

A smoke detector fitted inside a house contains a radioactive source, americium 241.

(a) Complete the following table of information for an atom of americium 241.

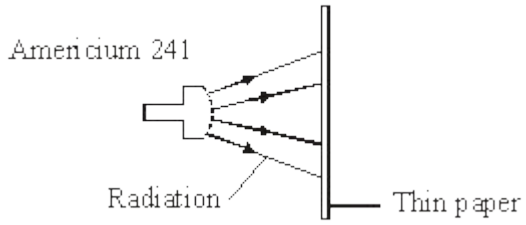
Number ofneutrons	146

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Number ofprotons	95
Number ofelectrons	

(1)

(b) The diagram shows that the radiation given out by americium 241 does not go through paper.



Which type of radiation, alpha (α), beta (β), or gamma (γ) is given out by americium 241?

_____

(1)

(c) Explain why the radiation given out by the americium 241 is unlikely to do any harm to people living in the house.

_____

_____

_____

_____

(2)

(d) Complete the sentence by choosing an answer from the box.

less than	**more than**	**the same as**

After many years the radiation emitted by americium 241 will be _____

when the smoke detector was new.

(1)

(Total 5 marks)

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