Atomic Structure Part 1

35 Questions

Name: _____

Class: _____

Date: _____

Time:

Marks:

Comments:

Q1.

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

$$^{40}_{19}\text{potassium} \longrightarrow {}^{40}_{20}\text{calcium} + {}^{0}_{-1}e$$

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**

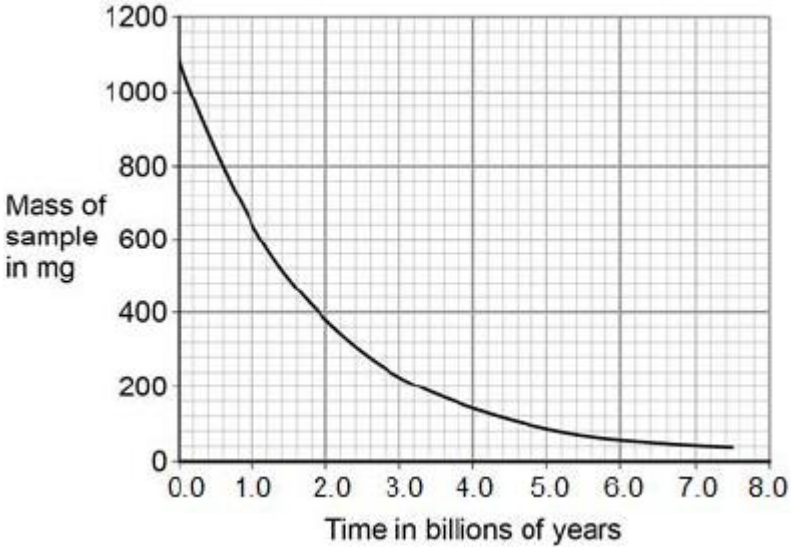
Which of the following statements explains why the readings are different?

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 ☐

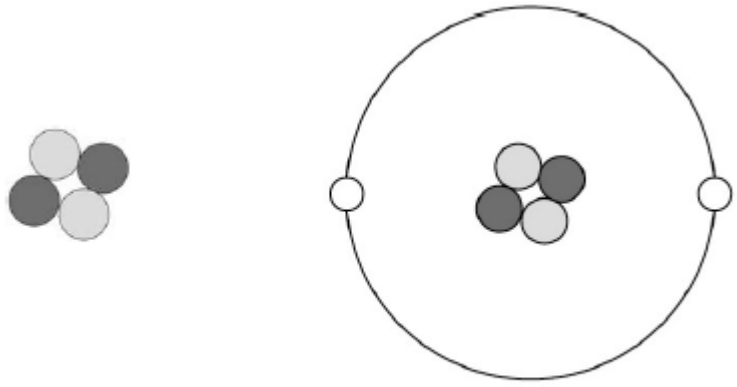
gamma ☐

(1)

(Total 7 marks)

Q2.

The figure below is a diagram of an alpha particle and a helium atom.



Alpha particle Helium atom

(a) What is the approximate size of a helium atom?

Tick **one** box.

1×10^{-5} m ☐

1×10^{-10} m ☐

1×10^{-15} m ☐

1×10^{-20} m ☐

(1)

(b) A helium atom is much larger than an alpha particle.

Give **one** other difference between a helium atom and an alpha particle.

_____

_____

(1)

(c) What is the atomic number of the helium atom in the figure above?

Tick **one** box.

2 ☐

4 ☐

6 ☐

8 ☐

(1)

(d) What is the charge on the helium atom in the figure above?

Explain your answer.

_____

_____

_____

_____

_____

(3)

(e) Helium is a gas that occurs naturally.

There is very little helium on Earth.

Helium has important uses in medicine and is also used to inflate party balloons.

Some scientists believe that helium should **not** be used to inflate party balloons.

Why?

_____

_____

_____

_____

(2)

(Total 8 marks)

Q3.

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.

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.

_____

_____

_____

_____

_____

_____

(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)

Q4.

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 ☐

1000 ☐

10 000 ☐

100 000 ☐

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

Q5.

This question is about radioactive decay.

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

Figure 1

$$^{235}_{92}U \longrightarrow ^{231}_{90}Th + ^{4}_{2}He$$

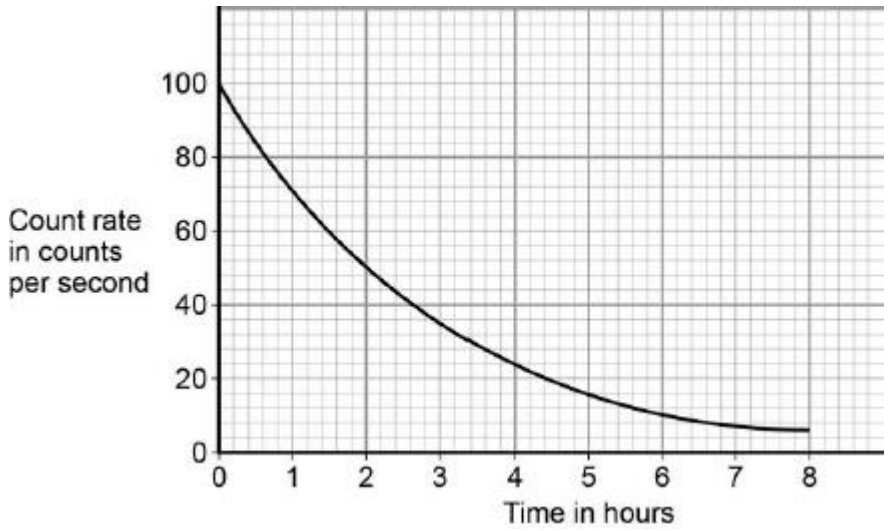
Use information from **Figure 1** to complete the table below.

	U	**Th**
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.

benign	**controlled**	**differentiated**	**malignant**	**slow**	**uncontrolled**

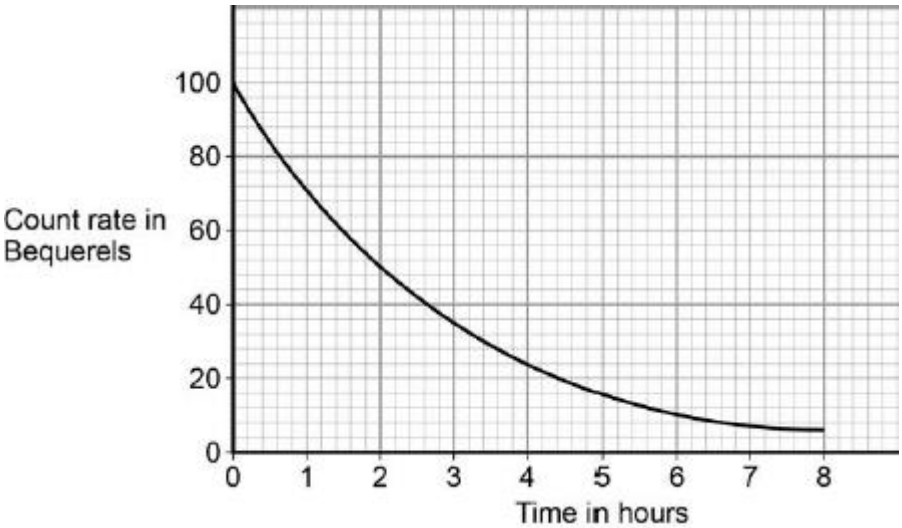
Tumours form when cell division is _____

Tumours that do not invade other tissues are called _____

(2)
(Total 8 marks)

Q6.

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.

_____

_____

_____

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.

$$^{210}_{\_\_}Pb \longrightarrow \,^{\_\_}_{80}Hg + \,^{\_\_}_{\_\_}\_\_$$

(3)

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

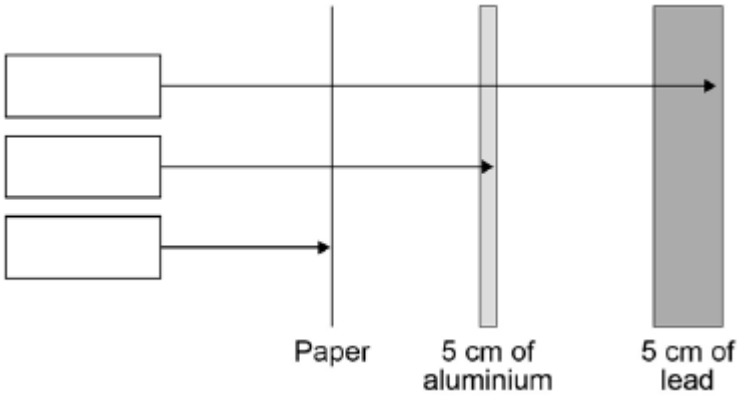
(Total 10 marks)

Q7.

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.

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

Describe the relationship shown in the table above.

_____

_____

_____

_____

(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.

_____

_____

(1)

(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)

(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)

(d) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Some substances are radioactive. They may emit alpha or beta particles.

Describe the characteristics of alpha particles and beta particles in terms of their:

- structure
- penetration through air and other materials
- deflection in an electric field.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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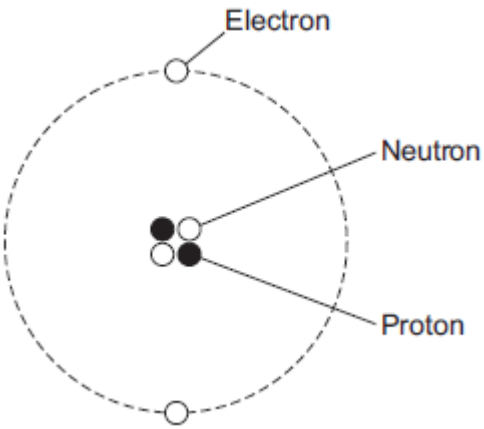
_____

_____

(6)
(Total 13 marks)

Q9.

(a) The figure below shows a helium atom.



(i) Which **one** of the particles in the atom is **not** charged?

Draw a ring around the correct answer.

electron **neutron** **proton**

(1)

(ii) Which **two** types of particle in the atom have the same mass?

_____ and _____

(1)

(iii) What is the atomic number of a helium atom?

Draw a ring around the correct answer.

2 **4** **6**

Give a reason for your answer.

_____

_____

(2)

(b) Alpha particles are one type of nuclear radiation.

(i) Name **one** other type of nuclear radiation.

_____

(1)

(ii) Use the correct answer from the box to complete the sentence.

electrons	**neutrons**	**protons**

The difference between an alpha particle and a helium atom is that the alpha

particle does **not** have any _____ .

(1)

(iii) Which **one** of the following is a property of alpha particles?

Tick (✓) **one** box.

Have a long range in air	☐
Are highly ionising	☐
Will pass through metals	☐

(1)

(c) Doctors may use nuclear radiation to treat certain types of illness.

Treating an illness with radiation may also harm a patient.

(i) Complete the following sentence.

The risk from treating a patient with radiation is that the radiation may

_____ healthy body cells.

(1)

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

Radiation may be used to treat a patient if the risk from the

radiation is

much bigger than
about the same as
much smaller than

the possible benefit of having

the treatment.

(1)

(Total 9 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**.

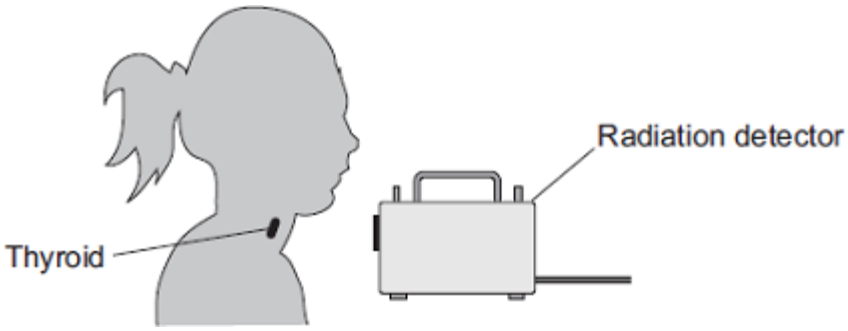
Draw **one** line from each type of radiation in **List A** to its correct property in **List B**.

List A **Type of radiation**	**List B** **Property of radiation**
	will pass through paper but is stopped by thin metal
alpha	

beta	has the shortest range in air
gamma	will not harm human cells
	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)

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

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

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

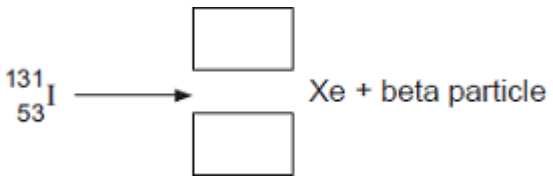
the _____ number.

(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.

_____

_____

_____

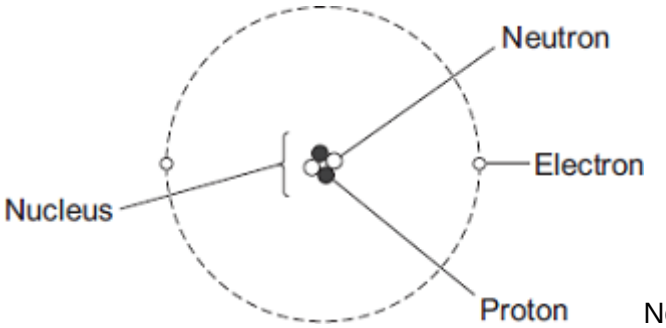
_____

(2)

(Total 8 marks)

Q12.

The diagram shows the structure of an atom.



Not drawn to scale

(a) In 1931 scientists thought that atoms contained **only** protons and electrons.

Suggest what happened in 1932 to change the idea that atoms contained only protons and electrons.

_____

_____

(1)

(b) The table gives information about the particles in an atom.

Complete the table by adding the names of the particles.

Particle	Relative Mass	Relative Charge
	1	0
	very small	–1
	1	+1

(2)

(Total 3 marks)

Q13.

There are many different isotopes of gold. The isotope, gold-198, is radioactive.
An atom of gold-198 decays by emitting a beta particle.

(a) Complete the following sentences.

All atoms of gold have the same number of _____

and the same number of _____ .

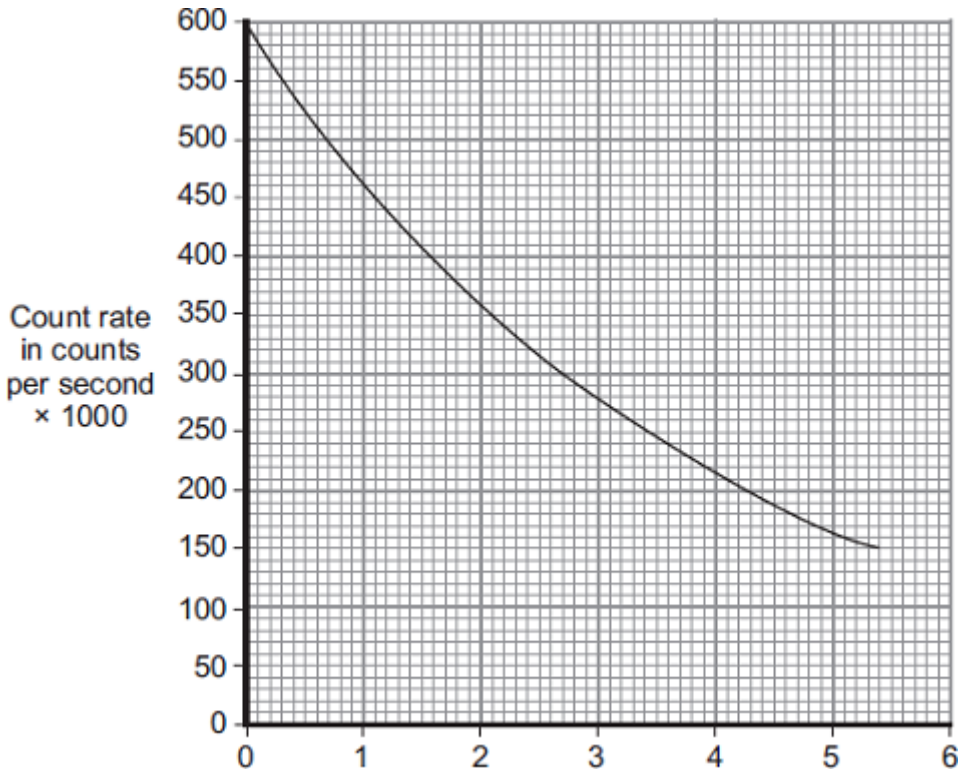
The atoms from different isotopes of gold have different numbers of _____ .

A beta particle is an _____ emitted

from the _____ of an atom.

(3)

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



Time in days

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

Show clearly on the graph how you obtain your answer.

_____

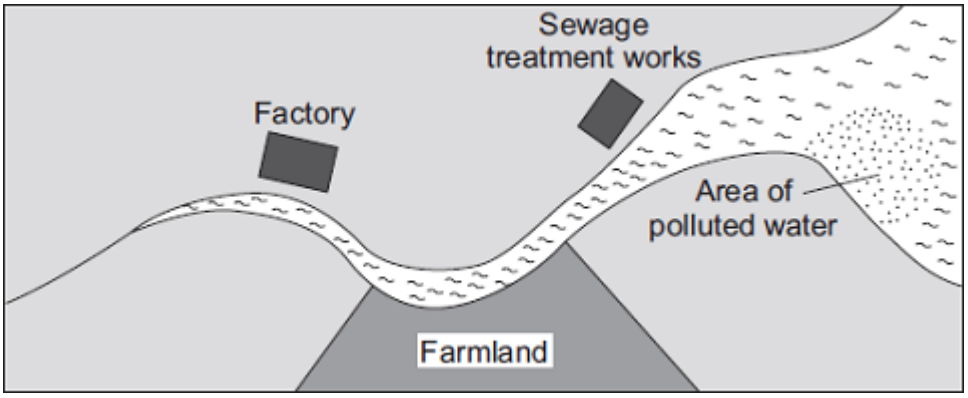
_____

Half-life = _____ days

(2)

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

Environmental scientists have found that 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.



The gold-198 is used to find where the pollution is coming from.

Explain how.

_____

_____

_____

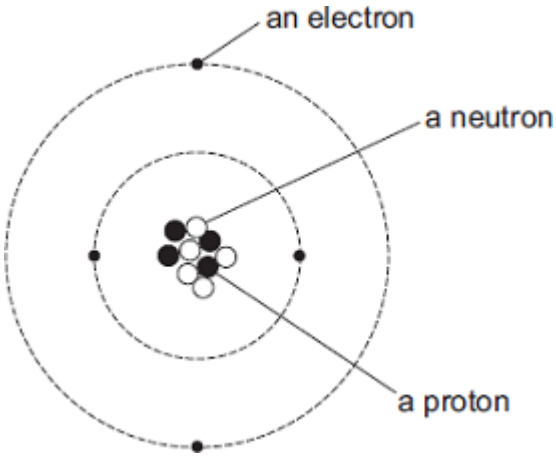
_____

(2)

(Total 7 marks)

Q14.

The diagram represents an atom of beryllium. The three types of particle that make up the atom have been labelled.



(a) Use the labels from the diagram to complete the following statements.

Each label should be used once.

The particle with a positive charge is _____ .

The particle with the smallest mass is _____ .

The particle with no charge is _____ .

(2)

(b) What is the mass number of a beryllium atom?

Draw a ring around your answer.

4	**5**	**9**	**13**

Give a reason for your answer.

_____

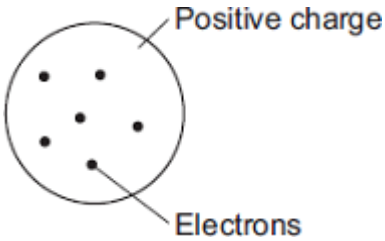
_____

(2)

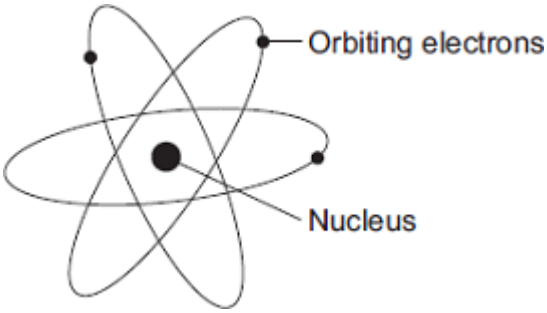
(Total 4 marks)

Q15.

In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.



Describe the differences between the two models of the atom.

_____

_____

_____

_____

_____

_____

_____

_____

(Total 4 marks)

Q16.

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.

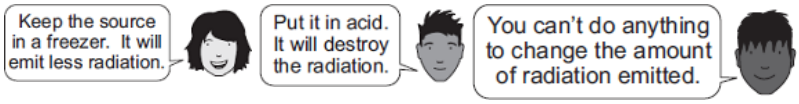
Why is it important to warn people that a radiation source is being used?

_____

_____

(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.



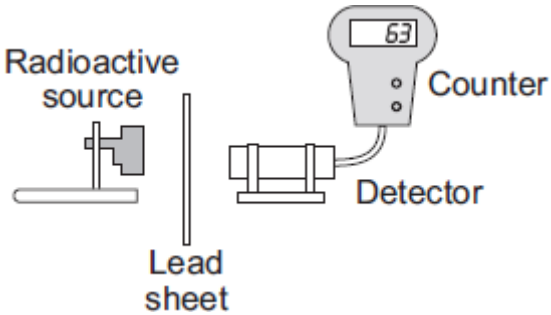
A **B** **C**

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
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.

_____

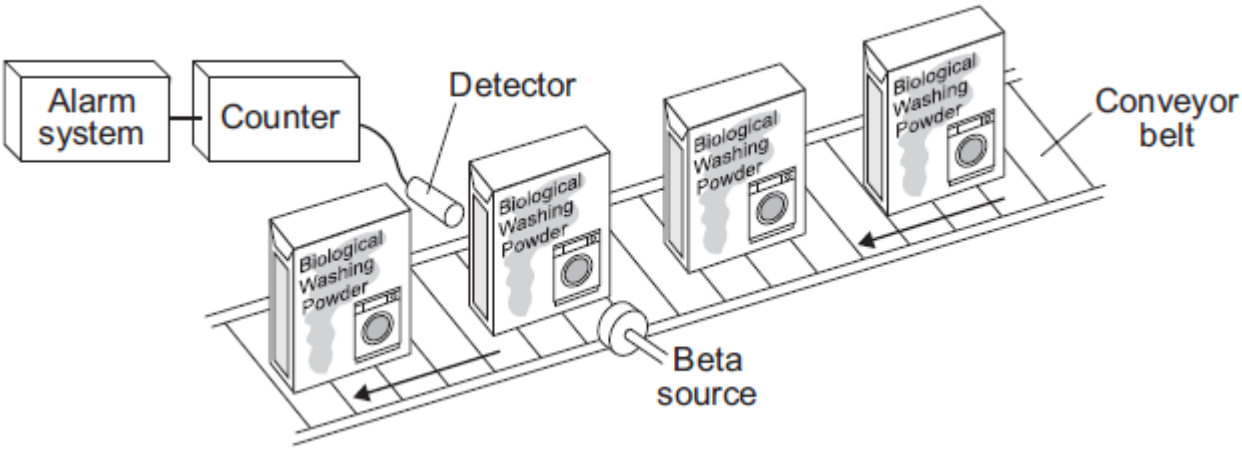
_____

_____

(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.



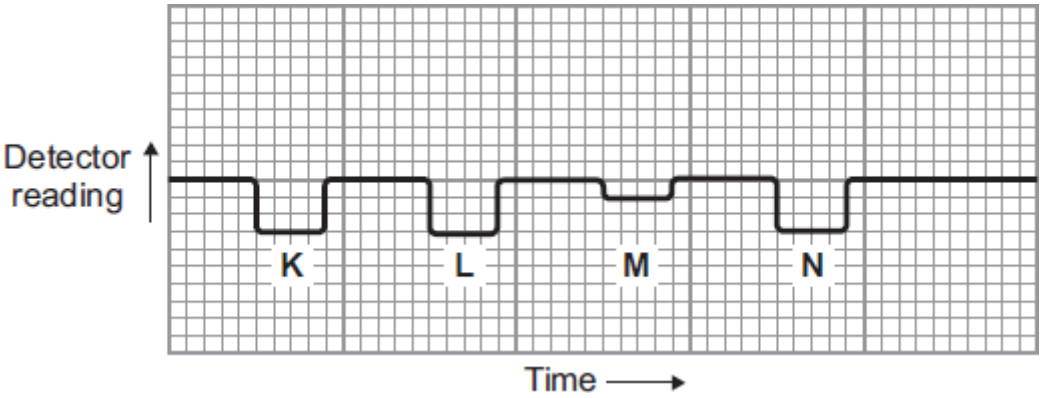
(i) Why would this system **not** work if an alpha source were used instead of the beta source?

_____

_____

(1)

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



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.

_____

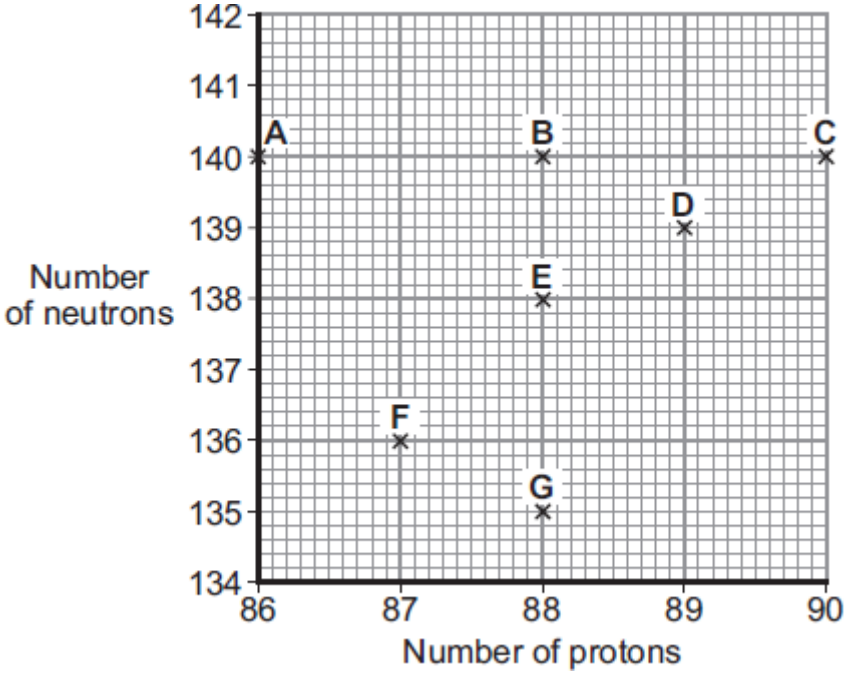
_____

(2)

(Total 8 marks)

Q17.

(a) The chart gives the number of protons and neutrons within the nuclei of 7 different atoms, **A – G**.



Which of these atoms are isotopes of the same element?

_____

Give a reason for your answer.

_____

_____

(2)

(b) Radium-226 is a radioactive isotope that decays into radon gas by emitting alpha particles.

The decay can be represented by the equation below.

$$^{226}_{88}\text{Ra} \longrightarrow \boxed{}\ \boxed{}\ \text{Rn} + \text{alpha particle}$$

(i) Complete the equation by writing the correct number in each of the boxes.

(2)

(ii) A sample of radium-226 has a count rate of 400 counts per second.
The half-life of radium-226 is 1600 years.

How long will it be before the count rate has fallen to 50 counts per second?

Show clearly how you work out your answer.

_____

_____

_____

Length of time = _____ years

(2)

(c) In 1927, a group of women who had been employed to paint watch faces with a luminous paint sued their former employer over the illnesses caused by the paint. The women had been told that the paint, which contained radium, was harmless.

The company owners and the scientists working for the company knew that radium was harmful and took precautions to protect themselves from the radiation. The women were given no protection.

What important issue did the treatment of the women by the company owners and scientists raise?

Draw a ring around your answer.

economic **environmental** **ethical** **social**

Give a reason for your answer.

_____

_____

(2)

(d) In the 1920s, many people, including doctors, thought that radium could be used as a treatment for a wide range of illnesses. Medical records that suggested radium could be harmful were generally ignored. When some of the women who had used the luminous paint died, their deaths were not blamed on radium.

Suggest a reason why the evidence suggesting that radium was harmful was generally ignored.

_____

_____

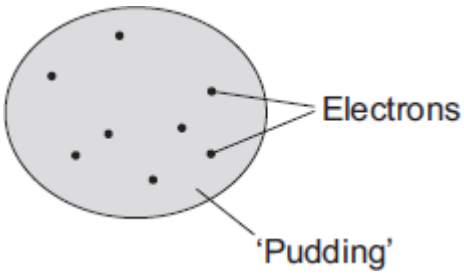
_____

(1)

(Total 9 marks)

Q18.

The ‘plum pudding’ model of the atom was used by scientists in the early part of the 20th century to explain atomic structure.



(a) Those scientists knew that atoms contained electrons and that the electrons had a

negative charge. They also knew that an atom was electrically neutral overall.

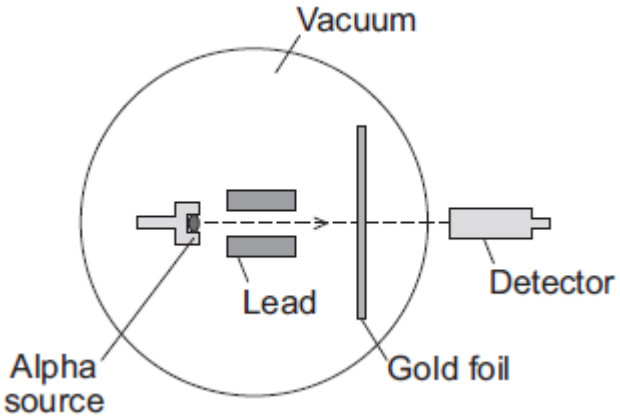
What did this allow the scientists to deduce about the ‘pudding’ part of the atom?

_____

_____

(1)

(b) An experiment, designed to investigate the ‘plum pudding’ model, involved firing alpha particles at a thin gold foil.



If the ‘plum pudding’ model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4 °.

The results of the experiment were unexpected. Although most of the alpha particles did go straight through the gold foil, about 1 in every 8 000 was deflected by more than 90 °.

Why did this experiment lead to a new model of the atom, called the nuclear model, replacing the ‘plum pudding’ model?

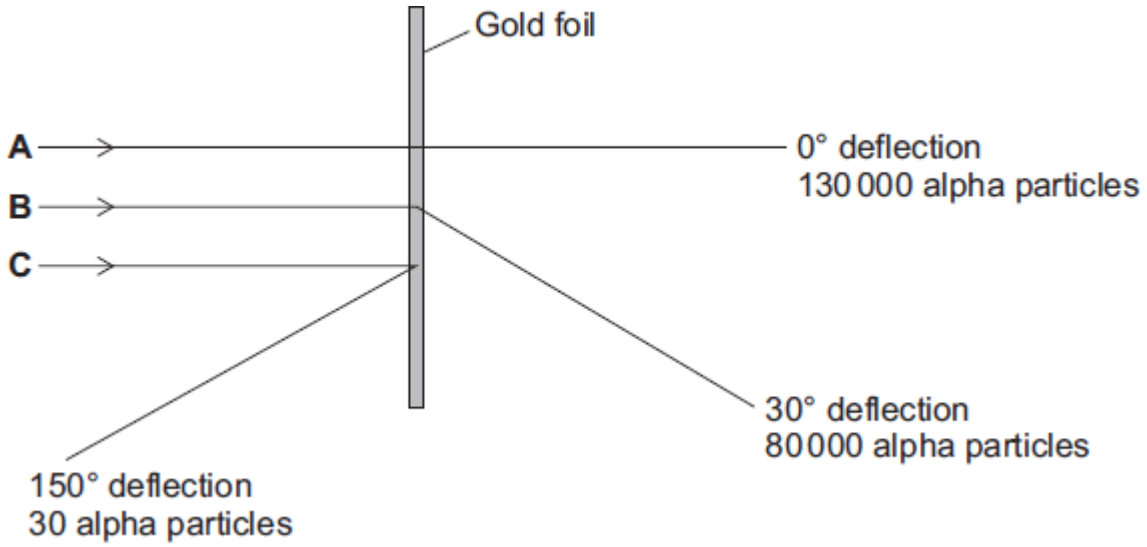
_____

_____

_____

(1)

(c) The diagram shows the paths, **A**, **B** and **C**, of three alpha particles. The total number of alpha particles deflected through each angle is also given.



(i) Using the nuclear model of the atom, explain the three paths, **A**, **B** and **C**.

A _____

_____

B _____

_____

C _____

_____

(3)

(ii) Using the nuclear model, the scientist E. Rutherford devised an equation to predict the proportion of alpha particles that would be deflected through various angles.

The results of the experiment were the same as the predictions made by Rutherford.

What was the importance of the experimental results and the predictions being the same?

_____

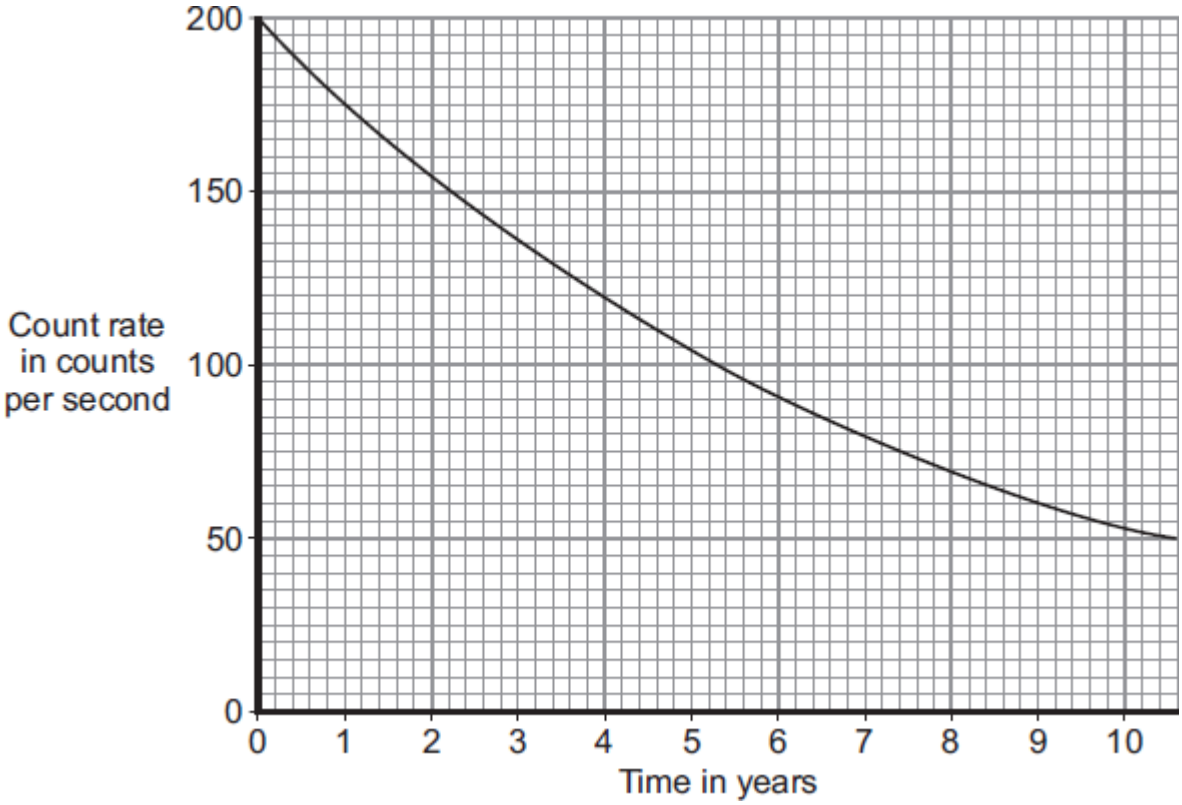
_____

(1)

(Total 6 marks)

Q19.

(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)

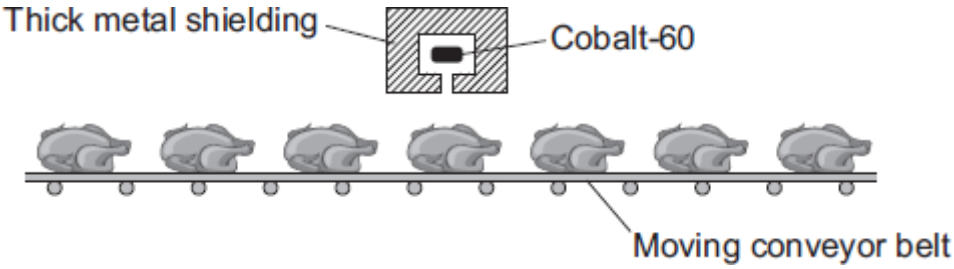
(iii) What is the half-life of cobalt-60?

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)

Q20.

(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.

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

$$^{212}_{83}Bi \longrightarrow \boxed{}\ \boxed{}\ Tl + ^{4}_{2}He$$

(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)

Q21.

(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**.

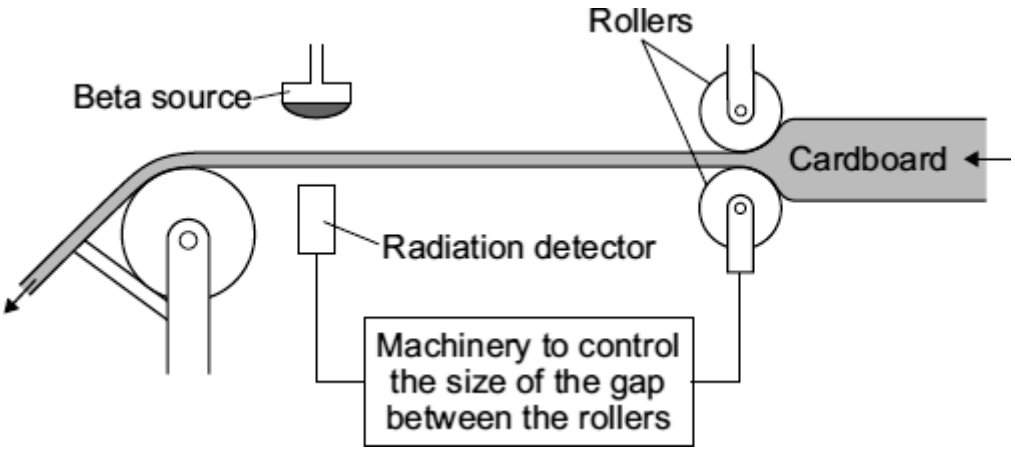
Draw a straight line to link each type of radiation in **List A** to its correct property in **List B**.

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)

(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)

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

Why not?

_____

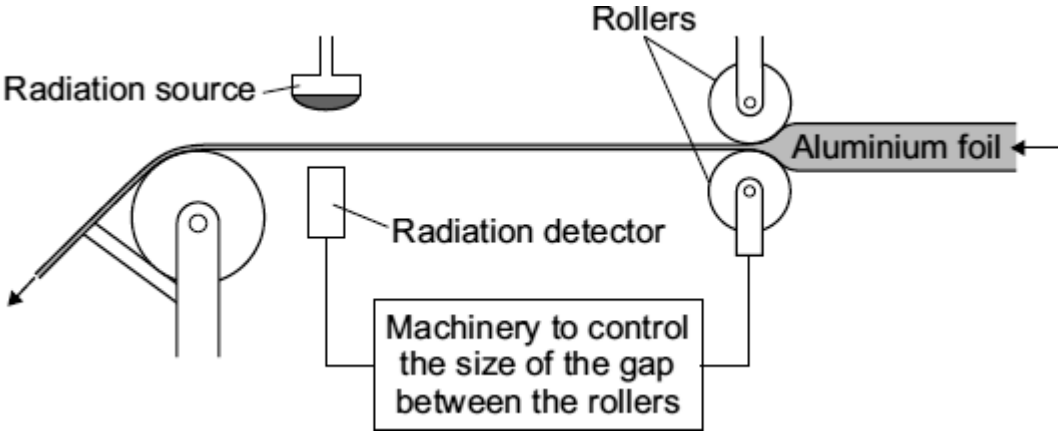
_____

(1)

(Total 7 marks)

Q22.

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.

_____

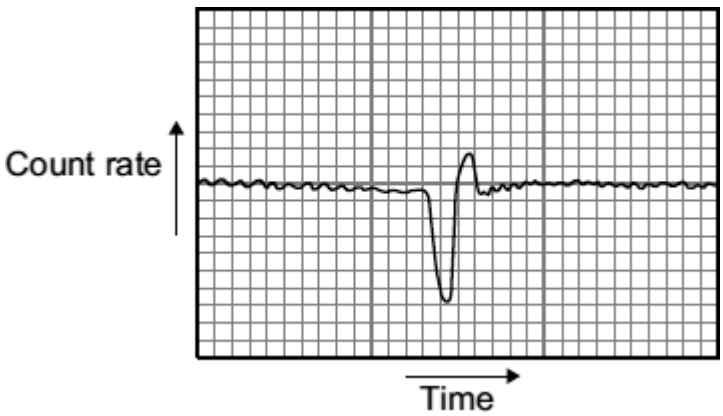
_____

_____

_____

(3)

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



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

_____

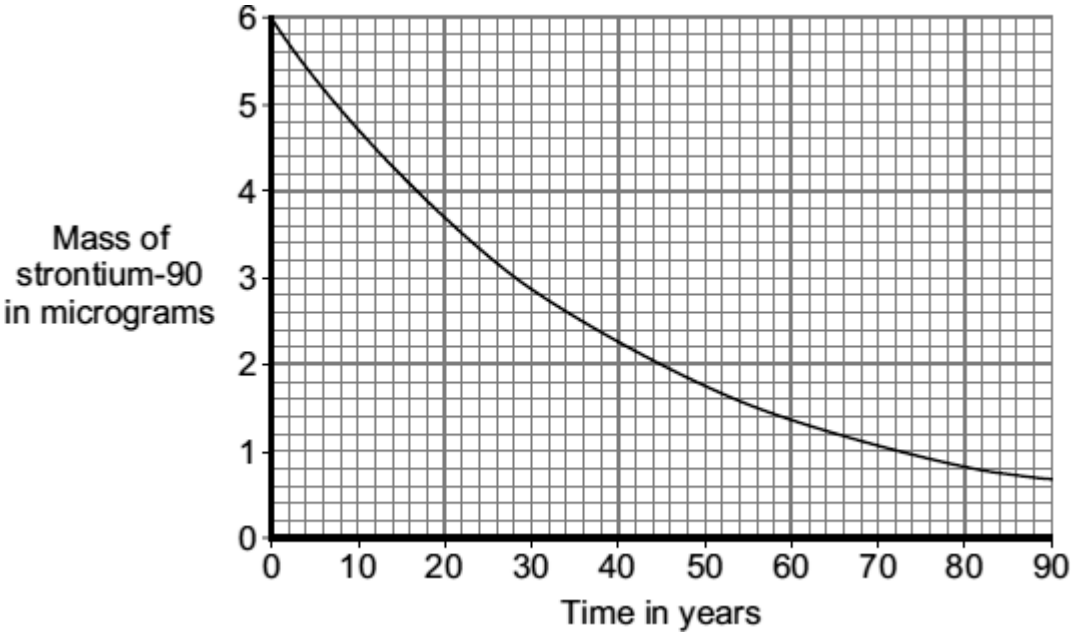
_____

_____

_____

(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.

_____

_____

_____

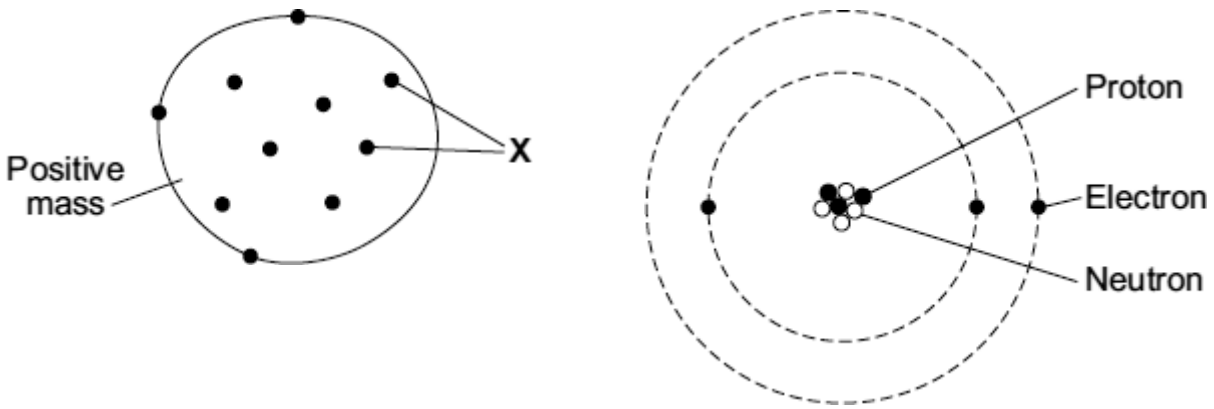
Number of years = _____

(2)

(Total 7 marks)

Q23.

The diagrams show two different models of an atom.



'Plum pudding' model **Model used today**

(a) The particles labelled '**X**' in the plum pudding model are also included in the model of the atom used today.

What are the particles labelled '**X**' ?

_____

(1)

(b) Scientists decided that the 'plum pudding' model was wrong and needed replacing.

Which **one** of the following statements gives a reason for deciding that a scientific model needs replacing?

Tick (✓) **one** box.

The model is too simple. ☐

The model has been used by scientists for a long time. ☐

The model cannot explain the results from a new experiment. ☐

(1)

(c) The table gives information about the three types of particle that are in the model of the atom used today.

Particle	Relative mass	Relative charge
	1	+1

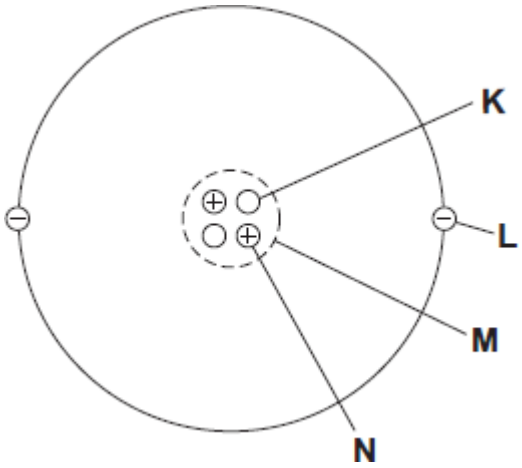
	very small	–1
	1	0

Complete the table by adding the names of the particles.

(2)
(Total 4 marks)

Q24.

(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.

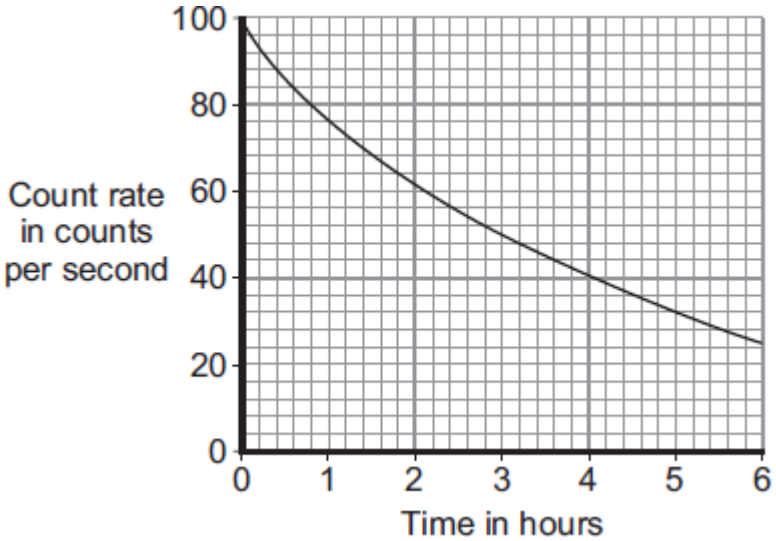
to monitor the thickness of aluminium foil as it is made in a factory ☐

to make a smoke detector work ☐

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)

Q25.

(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.

How is this possible?

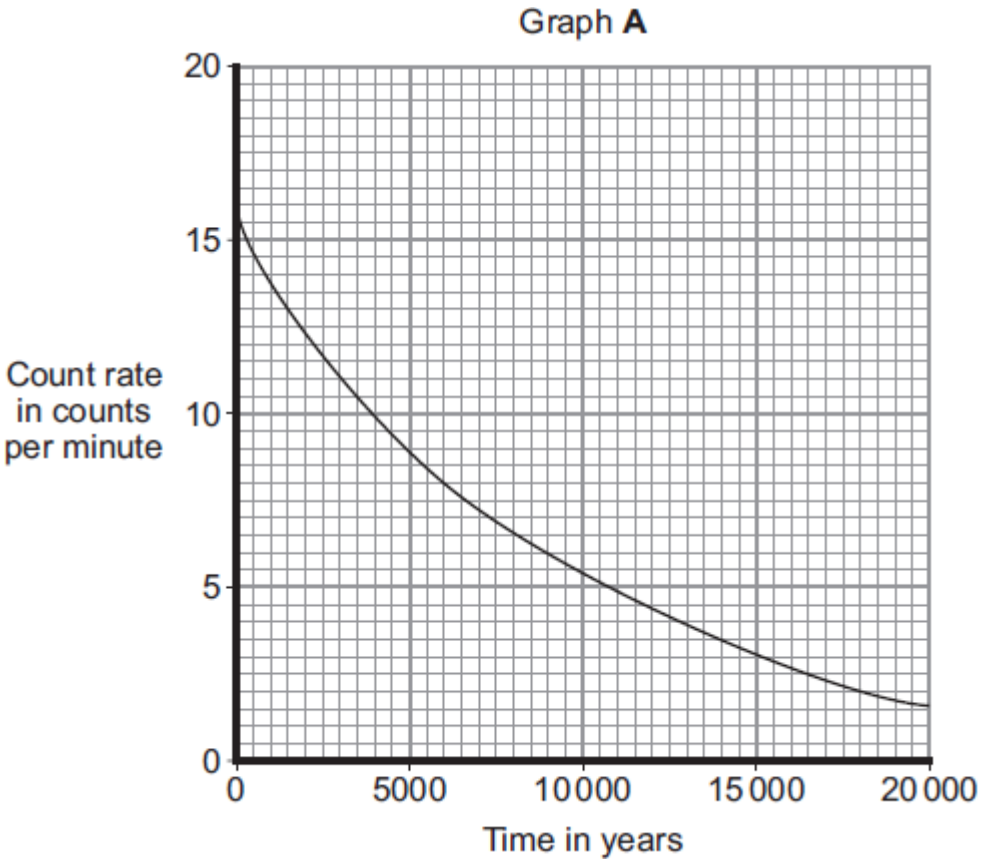
_____

_____

(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.



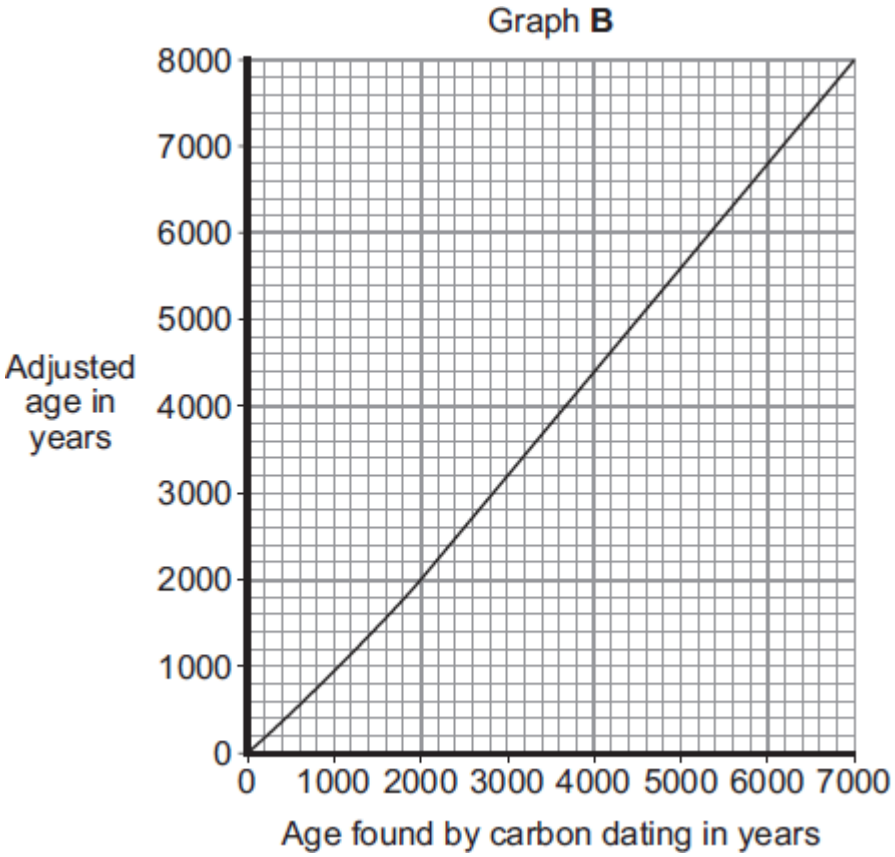
(i) Lake Cuicocha in Ecuador was formed after a volcanic eruption.
Carbon taken from a tree killed by the eruption was found to have a count rate of 10.5 counts per minute.
At the time of the eruption, the count rate would have been 16 counts per minute.

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.



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.

_____

_____

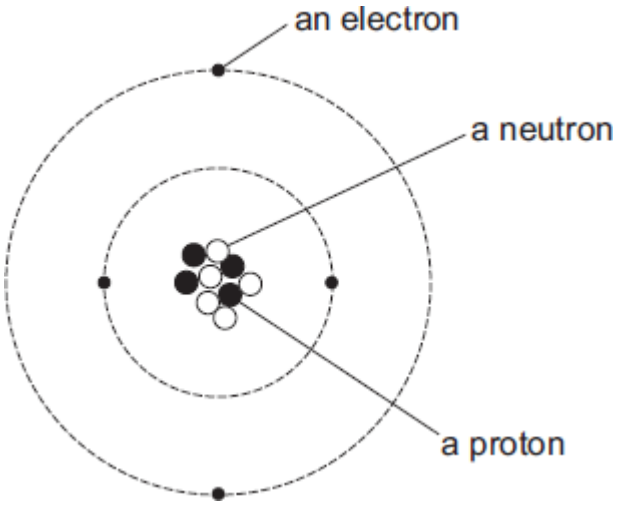
Maximum age of Lake Cuicocha = _____ years

(2)

(Total 7 marks)

Q26.

The diagram represents an atom of beryllium. The three types of particle that make up the atom have been labelled.



(a) Use the labels from the diagram to complete the following statements.

Each label should be used once.

The particle with a positive charge is _____

The particle with the smallest mass is _____

The particle with no charge is _____

(2)

(b) What is the atomic number of a beryllium atom?

Draw a ring around your answer.

4	**5**	**9**	**13**

Give a reason for your answer.

_____

_____

(2)

(c) Which **one** of the following statements describes what can happen to an atom to change it into an ion?

Tick (✓) **one** box.

The atom loses a neutron. ☐

The atom loses an electron. ☐

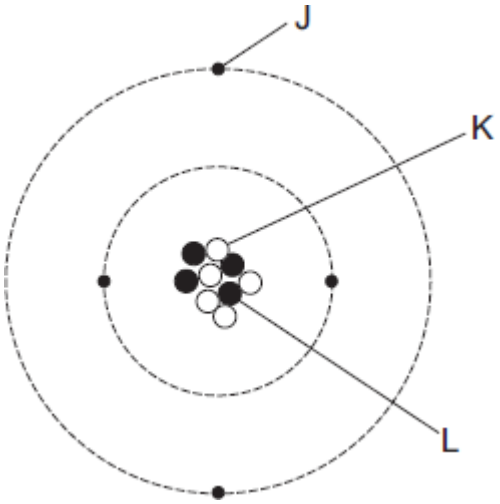
The atom loses a proton. ☐

(1)

(Total 5 marks)

Q27.

The diagram represents an atom of beryllium.



(a) Complete the following statements by writing one of the letters, **J**, **K** or **L**, in each box.

Each letter should be used only **once**.

The particle with a positive charge is ☐

The particle with the smallest mass is ☐

The particle with no charge is ☐

(2)

(b) Give the reason why all atoms have a total charge of zero.

_____

_____

(1)

(c) Complete the following sentence.

There are several isotopes of beryllium. Atoms of different beryllium isotopes will have different numbers of _____

(1)

(d) What happens to the structure of an atom to change it into an ion?

_____

_____

(1)

(Total 5 marks)

Q28.

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.

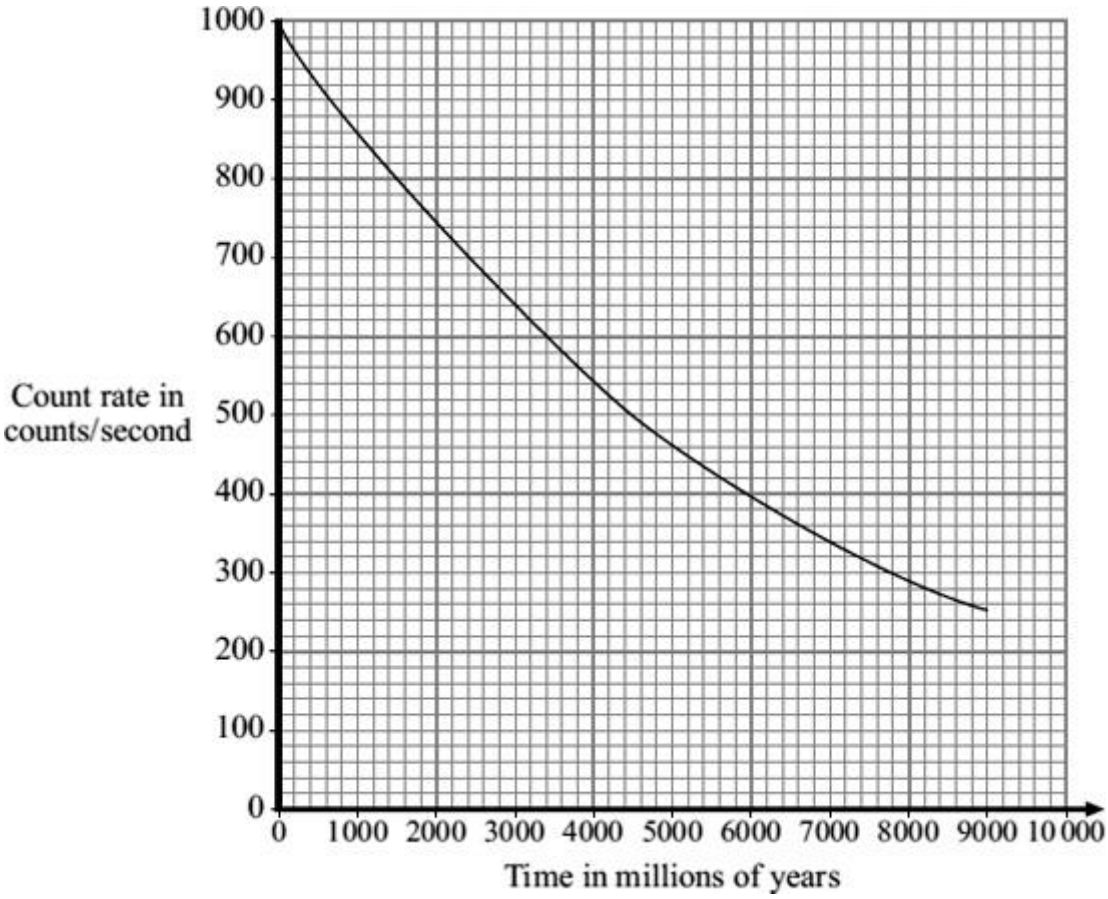
Write down your **new** statement.

_____

_____

(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.

_____

_____

_____

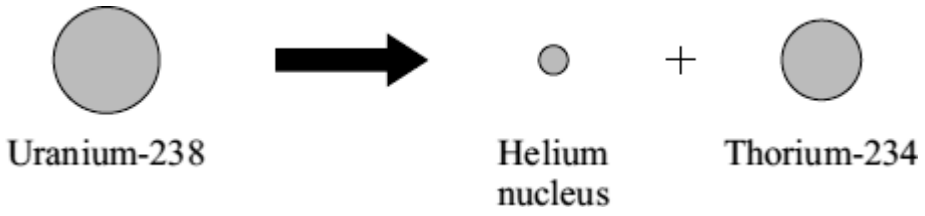
_____

(2)

(Total 5 marks)

Q29.

(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.

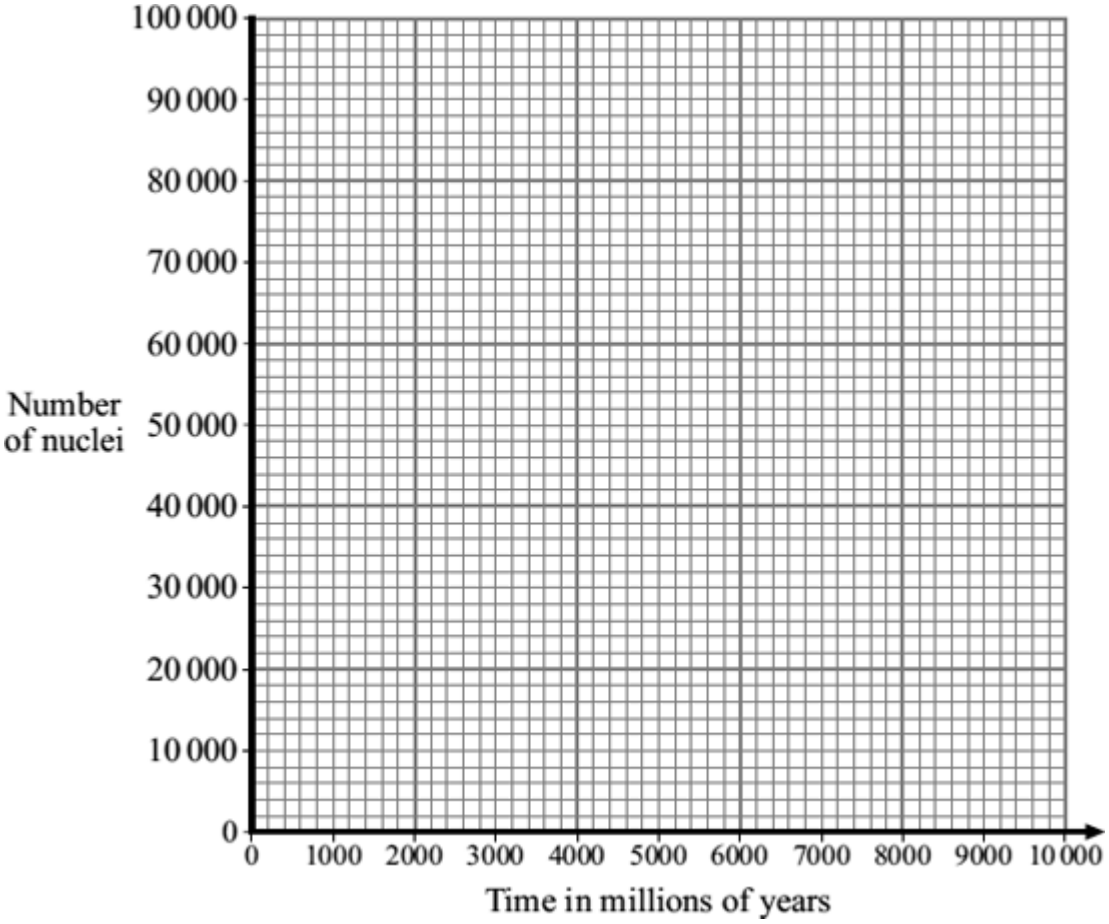
(i) When the Earth was formed, there was twice as much uranium-238 in the rocks as there is now.

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.

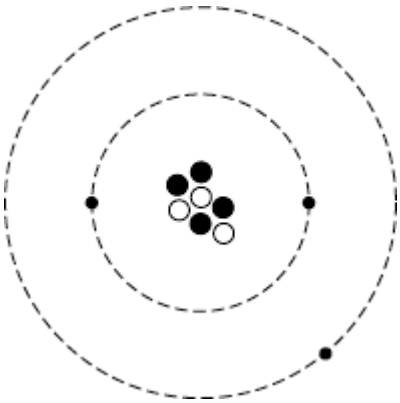


(2)

(Total 6 marks)

Q30.

The diagram represents an atom of lithium.



(a) (i) Complete the following table of information for an atom of lithium.

Number of protons	
Number of electrons	
Number of neutrons	

(2)

(ii) What is the mass number of a lithium atom?

Draw a ring around your answer.

3	**4**	**7**	**10**

Give a reason for your answer.

_____

_____

(2)

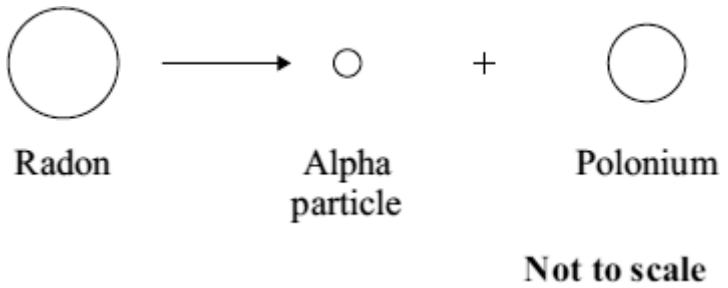
(b) Complete the following sentence by drawing a ring around the correct line in the box.

An atom that has lost an electron is called

an ion
an isotope
a positive atom

(1)

(c) When an alpha particle is emitted from the nucleus of a radon atom, the radon changes into polonium.



An alpha particle consists of 2 protons and 2 neutrons.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

The mass of a polonium atom is

greater than
the same as
smaller than

the mass of a radon atom.

(1)

(ii) Give a reason for your answer to part (c)(i).

_____

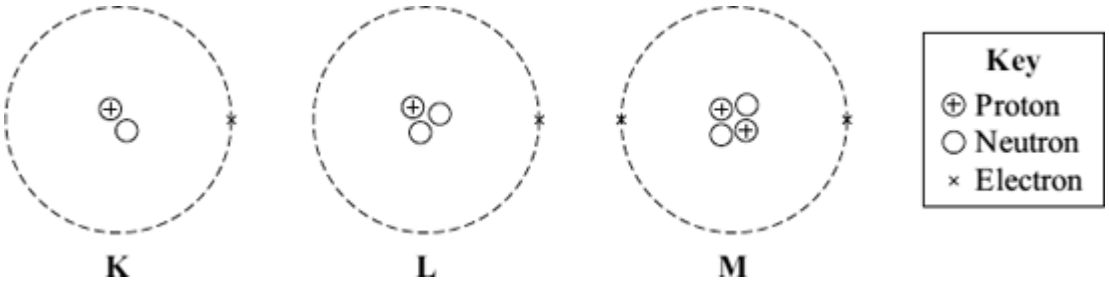
_____

(1)

(Total 7 marks)

Q31.

(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.

_____

_____

_____

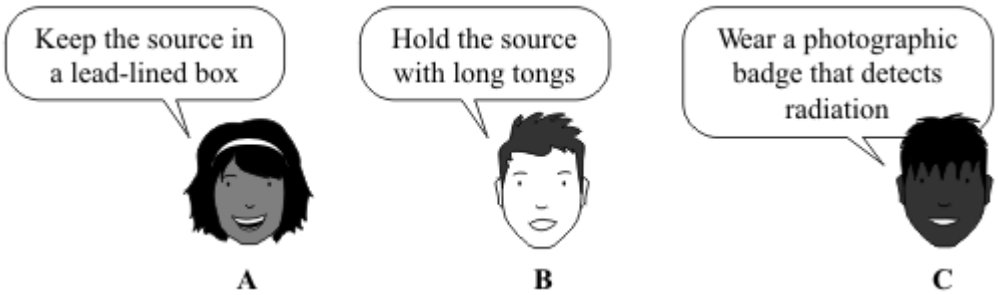
_____

_____

(3)
(Total 8 marks)

Q32.

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

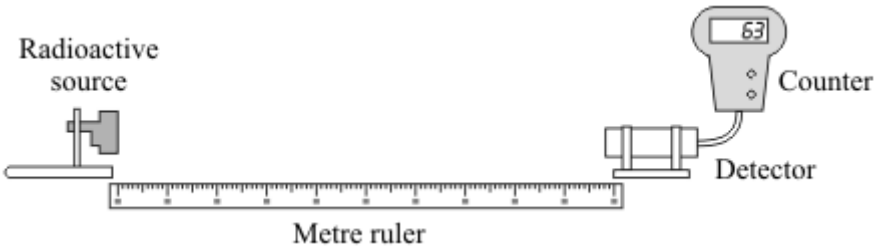


(a) Which suggestion, **A**, **B** or **C**, would **not** reduce the exposure of the teacher to radiation?

_____

(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.

_____

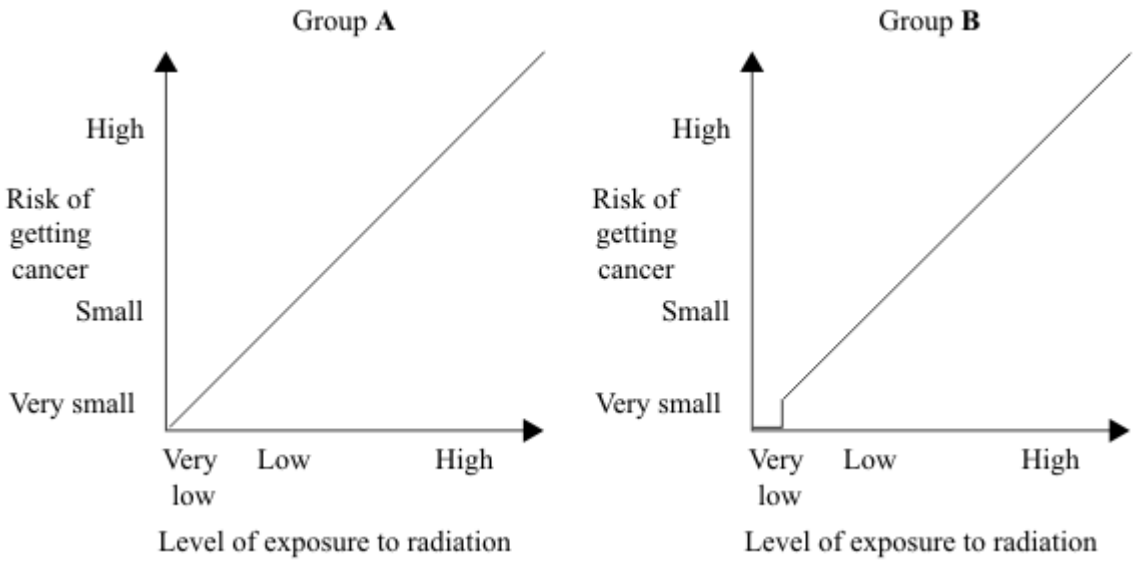
_____

_____

_____

(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)

Q33.

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

(a) What is meant by the terms:

(i) *isotopes*

_____

_____

(1)

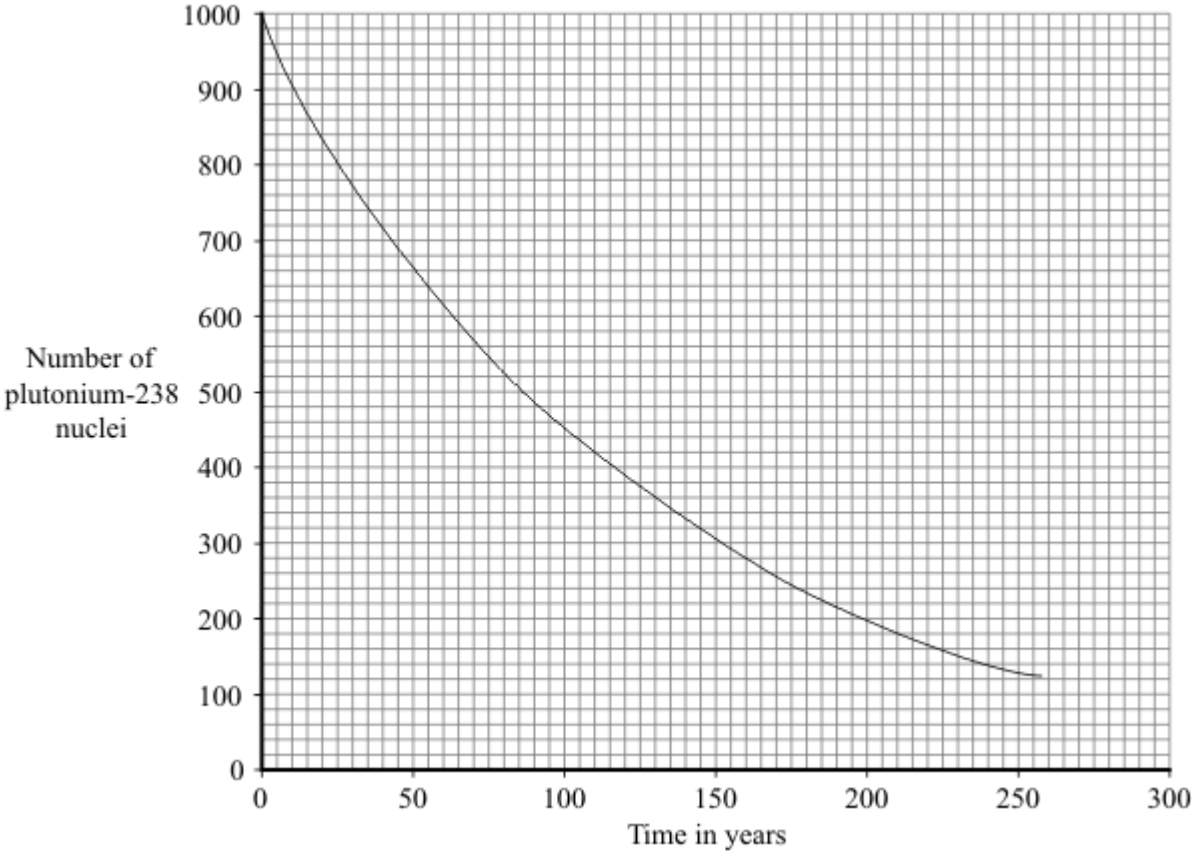
(ii) *radioactive*?

_____

_____

(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.

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)

Q34.

(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

_____ .

(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?

_____

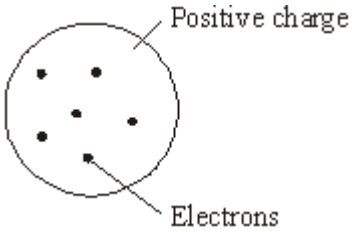
_____

(1)

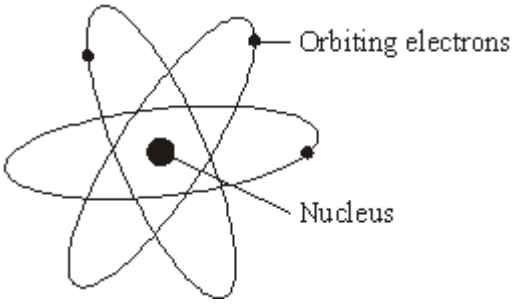
(Total 4 marks)

Q35.

In the early part of the 20th century, scientists used the ‘plum pudding’ model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the ‘nuclear’ model, was suggested.



(a) Describe the differences between the two models of the atom.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) In their investigation, Rutherford and Marsden fired positively charged alpha particles at a very thin sheet of gold. Over a period of several months, the scientists made over 100 000 measurements. These measurements showed that:

- a very small number of alpha particles were deflected backwards from the gold foil.

Use the nuclear model to explain this experimental result.

_____

_____

_____

_____

(2)

(c) Why did the work of Rutherford and Marsden convince many scientists that the 'plum pudding' model of the atom was incorrect?

_____

_____

_____

_____

(2)

(Total 8 marks)

Mark schemes

Q1.

(a) The nucleus will emit a neutron.

1

(b) **<u>Similarity</u>**

same mass number

allow same number of nucleons (protons + neutrons)

1

<u>difference</u>

different atomic number

allow different number of protons

1

(c) Radioactive decay is random.

1

(d) 1.3 (billion years)

allow 1.2-1.4 (billion years)

2

*allow **1** mark for horizontal line drawn from ~ 550*

(e) alpha

1

[7]

Q2.

(a) 1×10^{-10} m

1

(b) (a helium atom) has 2 <u>electrons</u>

accept it has more mass

allow it is not charged

1

(c) 2

1

(d) neutral

accept 0 or 'no charge'

1

(because) protons have positive charge and electrons have negative charge

1

(and) there are equal numbers of protons and electrons

1

(e) helium will one day run out

1

there will be none left for medical uses so balloons waste helium

1

[8]

Q3.

(a) electromagnetic radiation from the nucleus

'electromagnetic radiation' is insufficient

1

(b) (Gamma is the most penetrating) so a large proportion of the emitted radiation will leave
the body

1

more easily detected outside the body

1

(c) (average) time it takes for the number of nuclei of the isotope in a sample to halve

or

(average) time it takes for the count rate from a sample containing the isotope to fall to half its initial level

1

(d) initially there is a high level of hazard.

1

level of hazard drops to a low level quickly

1

answer must imply short period of time

(activity initially high) due to short half-life

or

(drops to safe level quickly) due to short half-life

1

(e) it is exposed to ionising radiation

1

(f) does not become radioactive

1

[9]

Q4.

(a) 10 000

1

(b) **Increase**

absorb electromagnetic radiation

1

Decrease

emit electromagnetic radiation

1

(c) atomic number is the number of protons

1

mass number is the number of protons and neutrons

1

(d) **Level 2 (3–4 marks):**
A clear comparison, with logical structure.

Level 1 (1–2 marks):
Fragmented points, with no logical structure.

0 marks:
No relevant content

Indicative content

Beta decay
- Atomic number increases by one
- When a neutron decays into a proton

Alpha decay
- Atomic number decreases by two
- When an alpha particle is emitted

Comparison

Both change number of protons (hence new element / transmutation)
Beta decay increases atomic number and alpha decay decreases (explicit)

NB No credit is given for different number of protons = new element.

4

[9]

Q5.

(a) (mass number) 231

1

(protons) 92

1

(neutrons) 141

1

(b) 2 / two (hours)

1

(because) count rate halves in that time

1

(c) A high-speed electron

1

(d) uncontrolled

1

benign

1

[8]

Q6.

(a) half-life read from graph = 2 hours

1

time to fall to 1.56 is six half lives = 6 × 2 = 12 (hours)

1

(b) $^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He$

one mark for each correct element in the equation

3

(c) ionising radiation turns atoms into ions

1

which can break up molecules

1

this can change DNA

1

causing mutations to genes

1

which can cause cancer

1

[10]

Q7.

(a) gamma

*allow **1** mark for 1 or 2 correct*

beta

alpha

2

(b) any **two** from:

- do not point (radioactive) source at students
- keep (radioactive) source outside the box for minimum time necessary
- wear safety glasses **or** eye protection **or** do not look at source
- wear gloves
- hold (radioactive) source away from body
- hold (radioactive) source with tongs / forceps

2

(c) as time increases count rate decreases

1

count rate halves every 80 seconds

1

(d) half-life is 80 seconds

1

so after 200 seconds count rate = 113

1

(e) because a very small amount of radiation will be emitted **or** will be similar to / same as background radiation

1

[9]

Q8.

(a) neutrons and protons

1

(b) 0

1

(+)1

1

(c) (i) total positive charge = total negative charge

accept protons and electrons have an equal opposite charge

1

(because) no of protons = no of electrons

1

(ii) ion

1

positive

1

(d) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a best-fit approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
There is a basic description of at least **one** of the particles in terms of its characteristics.

Level 2 (3 – 4 marks)
There is a clear description of the characteristics of **both** particles
or
a full description of either alpha **or** beta particles in terms of their characteristics.

Level 3 (5 – 6 marks)
There is a clear and detailed description of **both** alpha and beta particles in terms of their characteristics.

examples of the physics points made in the response:

structure

- alpha particle consists of a helium nucleus
- alpha particle consists of 2 protons and 2 neutrons
- a beta particle is an electron
- a beta particle comes from the nucleus

penetration

- alpha particles are very poorly penetrating
- alpha particles can penetrate a few cm in air
- alpha particles are absorbed by skin
- alpha particles are absorbed by thin paper
- beta particles can penetrate several metres of air
- beta particles can pass through thin metal plate / foil

- beta particles can travel further than alpha particles in air
- beta particles can travel further than alpha particles in materials eg metals

deflection

- alpha particles and beta particles are deflected in opposite directions in an electric field
- beta particles are deflected more than alpha particles
- alpha particles have a greater charge than beta particles but beta particles have much less mass
  or
  beta particles have a greater specific charge than alpha particles

6

[13]

Q9.

(a) (i) neutron

1

(ii) neutron
proton
both required, either order

1

(iii) 2

1

number of <u>protons</u>
do not accept number of electrons

1

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

- beta
- gamma
  accept correct symbols
  accept positron / neutrino / neutron
  cosmic rays is insufficient

1

(ii) electrons

1

(iii) are highly ionising

1

(c) (i) mutate / destroy / kill / damage / change / ionise
Harm is insufficient

1

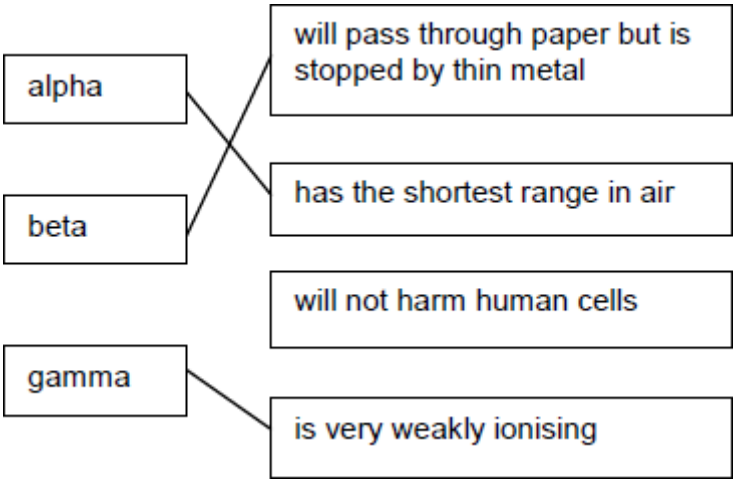
(ii) much smaller than

1

[9]

Q10.

(a) 3 lines correct



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

if more than one line is drawn from any type of radiation box then all of those lines are wrong

3

(b) Gamma radiation will pass through the body

1

(c) half

1

(d) protons

1

[6]

Q11.

(a) 78

1

(b) atomic

1

(c) (i) 131

correct order only

1

54

1

(ii) 32 (days)

*allow **1** mark for showing 4 half-lives provided no subsequent step*

2

(iii) limits amount of iodine-131 / radioactive iodine that can be absorbed

accept increases level of non-radioactive iodine in thyroid

*do **not** accept cancels out iodine-131*

1

so reducing risk of cancer (of the thyroid)

accept stops risk of cancer (of the thyroid)

1

[8]

Q12.

(a) neutron discovered

1

(b) neutron

all 3 in correct order

electron

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

proton

2

[3]

Q13.

(a) protons, electrons

both required, either order

1

neutrons

1

electron, nucleus

both required, this order

1

(b) 2.7 (days)

*allow **1** mark for showing correct use of the graph*

2

(c) put source into water at **one** point on bank

accept the idea of testing different parts of the river bank at different times

1

see if radiation is detected in polluted area

accept idea of tracing

or

put source into water at three points on bank (1)
see if radiation is detected downstream of factory **or** farmland **or** sewage treatment works (1)

1

[7]

Q14.

(a) proton

all 3 in correct order

electron

*allow **1** mark for 1 correct do **not***

neutron

accept letters p, e, n

2

(b) 9

reason only scores if 9 is chosen

1

number of neutrons and protons

1

[4]

Q15.

any **two** pairs from:

to gain credit it must be clear which model is being described

*do **not** accept simple descriptions of the diagram without comparison*

- nuclear model mass is concentrated at the centre / nucleus (1)

  *accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for **1** mark*

  plum pudding model mass is evenly distributed (1)

- nuclear model positive charge occupies only a small part of the atom (1)

  plum pudding model positive charge spread throughout the atom (1)

- nuclear model electrons orbit some distance from the centre (1)

  accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model

  plum pudding electrons embedded in the (mass) of positive (charge) (1)

  *do **not** accept electrons at edge of plum pudding*

- nuclear model the atom mainly empty space (1)

  plum pudding model is a ‘solid’ mass (1)

[4]

Q16.

(a) nucleus

*do **not** accept core / centre / middle*

1

(b) radiation damages our cells

accept radiation is dangerous / poisonous / harmful / toxic

accept radiation can cause cancer / kills cells / change DNA / cause mutations / harm health

accept so precautions can be taken

accept so they know they may be exposed to / harmed by radiation it refers to radiation (source)

to stop people being harmed is insufficient

1

(c) **C**

1

(d) gamma

1

gamma will pass through the lead

reason only scores if gamma chosen

or

alpha and beta will not pass through lead

accept correct symbols for alpha, beta and gamma

1

(e) (i) range of alpha too short

accept alpha would not reach detector

or

alpha absorbed whether box is full or empty

accept alpha (always) absorbed by box / card

accept alpha will not pass through the box / card

alphas cannot pass through objects / solids is insufficient

alpha not strong enough is insufficient

1

(ii) **M**

*reason only scores if **M** chosen*

1

less radiation / beta (particles) absorbed

accept more radiation / beta particles pass through

or

more radiation absorbed by full boxes

accept reading is higher

1

[8]

Q17.

(a) **B E G**

all 3 required and no other

any order

1

same number of / 88 protons (and different numbers of neutrons)

same number of electrons is insufficient

1

(b) (i) 222

1

86

1

(ii) 4800

*allow **1** mark for obtaining 3 half-lives*

2

(c) ethical

1

deceived / lied to (about safety of working conditions)

accept (women) not warned of the dangers

given no protection is insufficient

or

value own / scientists' lives more than women
or
did not treat women humanely

1

(d) accept any sensible suggestion
eg
too many interests in continued use of radium

evidence may cause public unrest
*do **not** accept not enough evidence*

doctors not want to be blamed for illnesses (caused by radium)
accept doctors not wanting to be sued (for harm caused by using radium)

doctors thought (possible) benefits outweighed (possible) risks
*do **not** accept did not know radium could be harmful*
believe radium could treat illnesses is insufficient

1

[9]

Q18.

(a) has an equal amount of positive charge
accept pudding/it is positive

1

(b) (experimental) results could not be explained using 'plum pudding' model
or
(experimental) results did not support plum pudding model
accept (experimental) results disproved plum pudding model

1

(c) (i) **A** – most of atom is empty space**or**most of atom concentrated at the centre

1

B – nucleus is positive (so repels alpha particles)
accept nucleus has the same charge as alpha

1

C – nucleus is very small
accept nucleus is positive if not scored for B
or
nucleus is a concentrated mass
accept nucleus has a very concentrated charge

1

(ii) (if predictions correct, this) supports the new model
answers should be in terms of the nuclear model
accept supports his/new/nuclear theory
accept proves for supports
accept shows predictions/ Rutherford was correct

1

[6]

Q19.

(a) (i) 200 to 50

accept either order

1

(ii) 5.3

accept values between 5.2 and 5.4 inclusive

1

(iii) 5.3

accept values between 5.2 and 5.4 inclusive

or

their (a)(ii)

1

(b) (i) Make the conveyor belt move more slowly

1

(ii) lead

1

(c) Exposure increased the content of some types of vitamin.

1

[6]

Q20.

(a) (i) (total) number of protons plus neutrons

accept number of nucleons

accept amount for number

do not accept number of particles in the nucleus

1

(ii) number of neutrons decreases by one

1

number of protons increases by one

accept for both marks a neutron changes into a proton

1

(b) (i) $^{208}_{81}Th$

1

correct order only

1

(ii) the number of protons determines the element

accept atomic number for number of protons

1

alpha and beta decay produce different changes to the number of protons

there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or

alpha and beta decay produce different atomic numbers

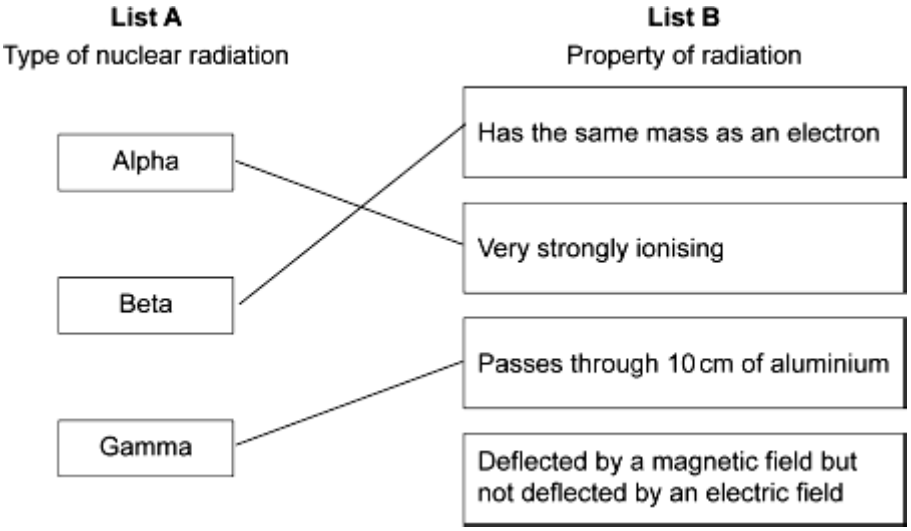
ignore correct reference to mass number

1

[7]

Q21.

(a) **1** mark for each correct line



*if more than 1 line is drawn from any box in List **A**, none of those lines gain any credit*

3

(b) (i) (the detector) reading had gone down

'it' equals detector reading

accept the reading in the table is the smallest

accept 101 is (much) lower than other readings / a specific value eg 150

*do **not** accept this answer if it indicates the readings are the thickness*

1

more beta (particles / radiation) is being absorbed / stopped

accept radiation for beta particles / radiation

accept fewer particles being detected

1

(ii) six years

1

(iii) alpha would not penetrate the cardboard

accept the basic property – alpha (particles) cannot pass through paper / card

accept alpha (particles) are less penetrating (than beta)

range in air is neutral

1

[7]

Q22.

(a) beta

1

alpha: would not pass through (the aluminium / foil)

1

gamma: no change in count rate when thickness changes

must be a connection between detection / count rate / passing through and change in thickness

1

(b) foil thickness increases then decreases (then back to normal / correct thickness)

a description of count rate changes is insufficient

1

gap between rollers decreases, then increases (then back to correct size)
or
pressure from rollers increases then decreases

accept tightness for pressure

answers may link change in thickness and gap width for full credit ie:

foil thickness increases so gap between rollers decreases (1)

foil thickness decreases so gap between rollers increases (1)

1

(c) 56 (years)

accept any value between 55-57 inclusive

*allow **1** mark for correct calculation of mass remaining as 1.5 (micrograms)*

*allow **1** mark for a mass of 4.5 micrograms plus correct use of graph with an answer of 12*

*maximum of **1** compensation mark can be awarded*

2

[7]

Q23.

(a) electron(s)

1

(b) 3rd box ticked

The model cannot explain the results from a new experiment

1

(c) all three correct

Particle
Proton
Electron
Neutron

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

2

[4]

Q24.

(a) (i) **L**

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

Q25.

(a) (i) number of protons are the same

accept atomic number / number of electrons for number of protons

1

number of neutrons are different

accept mass numbers are different – only if the first mark is awarded

1

(ii) an electron from the nucleus

both parts needed

1

(b) decays at the same rate as it is made

accept decays as fast as it is made

accept absorbed / used by plants (in CO_2) at same rate as it is being made

1

(c) (i) 3500

no tolerance

1

(ii) adjusted age correctly obtained from the graph

accept values between 3700–3800 inclusive

accept their (c)(i) used correctly to obtain an adjusted age from the graph

1

adjusted age +50

second mark can only be scored if first mark awarded

if no working shown an answer between 3750–3850 inclusive scores both marks

note: any line or mark made on the graph counts as working out

1

[7]

Q26.

(a) proton

electron

neutron

all 3 in correct order
*allow **1** mark for 1 correct*
*do **not** accept letters p, e, n*

2

(b) *4*

reason only scores if 4 is chosen

1

number of protons

accept number of electrons
accept there are 4 protons and 4 electrons
*do **not** accept there are 4 protons and electrons*

1

(c) *The atom loses an electron.*

1

[5]

Q27.

(a) ***L***

J

K

all 3 in correct order
*allow **1** mark for 1 correct*

2

(b) *number of electrons = number of protons*

accept amount for number

1

(c) *neutrons*

this answer only

1

(d) *loses / gains electron(s)*

1

[5]

Q28.

(a) *alpha particles **cannot** pass through…*

*do **not** accept gamma particles…*

or

*alpha particles can pass through a very thin sheet of **paper** / **card***

credit answers where correct amendments are made to boxed statement

1

(b) *(i)* *horizontal and vertical line drawn at correct positions on the graph*

accept a cross drawn at 4500 / 500 on the curve

or

two pairs of lines drawn, for example, at 600 and 300

accept a horizontal line drawn at 500 on its own
*do **not** accept vertical lines only*

1

(ii) 4500 million years

1

(iii) half-life too long
*do **not** accept simply its half-life is 4500 million years*

1

no (measurable) change in count rate
*do **not** accept have not got the equipment*
*do **not** accept it's harmful (to children)*
*if neither of the above points scored, accept not enough time to measure it for **1** mark*

1

[5]

Q29.

(a) (i) alpha (particle)

1

(ii) (unstable) nucleus
accept (unstable) nuclei
*do **not** accept middle*
*do **not** accept helium nucleus*

1

(iii) same number of protons
accept same number of electrons
accept same atomic / proton number
accept they both have 92 protons
same number of neutrons negates answer

1

(b) (i) 4500 million years
*do **not** accept 4500 years*

1

(ii) curve starting at 100 000 with a correct general shape

1

passing through (4500, 50 000) and (9000, 25 000)
*allow **1** mark for points plotted*
or
line passing through (4500, 50 000) and (9000, 25 000)

1

[6]

Q30.

(a) (i) all correct
accept presented as a tally chart

Number of protons	*3*
Number of electrons	*3*
Number of neutrons	*4*

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

2

(ii) *7*

reason may score even if 7 not chosen

1

number of protons and neutrons

accept number of particles in the nucleus

accept number of nucleons

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

1

(b) *an ion*

1

(c) (i) *smaller than*

1

(ii) *radon loses an alpha (particle)*

or

radon loses an (alpha) particle

or

(mass of) polonium plus an alpha = (mass) radon

or

radon loses 2 protons and 2 neutrons (to become polonium)

accept radon has less protons and neutrons

1

[7]

Q31.

(a) (i) ***K*** *and* ***L***

both answers required either order

1

(ii) *(1) same number of protons*

accept same number of electrons

accept same atomic number

1

(2) different numbers of neutrons

1

(b) (i) *90*

1

(ii) *140*

1

(c) *alpha (particle)*

reason may score even if beta or gamma is chosen

1

mass number goes down by 4
or
number of protons and neutrons goes down by 4
or
number of neutrons goes down by 2

*candidates that answer correctly in terms of why gamma **and** beta decay are not possible gain full credit*

1

atomic / proton number goes down by 2
or
number of protons goes down by 2

*accept an alpha particle consists of 2 neutrons and 2 protons for **1** mark*

accept alpha equals $^{4}_{2}He$ *or* $^{4}_{2}\alpha$ *for **1** mark*

an alpha particle is a helium nucleus is insufficient for this mark

1

[8]

Q32.

(a) ***C***

1

(b) *beta*

accept gamma

if answer alpha can still gain marks for saying why not beta or gamma

1

*any **two** from:*

*must have at least one quantitative statement to get **2** marks*

- *range in air for beta is (at least) 50cm*
- *count-rate does not drop (much) in first 40cm*
- *count-rate does not fall much until distance is 60cm*
- *alphas cannot travel more than 5cm in air / alphas could not travel 100cm in air*

  accept alphas cannot travel that far
- *alphas would not be detected*
- *gammas not absorbed by 100cm of air*

  accept gammas not stopped by air
  accept gammas travel further than alphas and betas

  strength of source is neutral

  references to penetrating power is neutral

2

(c) *(i)* *increases*

1

(ii) *Group **A** think that (even a very small level of exposure) gives some risk*

accept there is always a risk, no matter how small the level

of exposure

1

*Group **B** think that there is no risk (from a very low level of exposure)*

accept below a certain level of exposure there is no risk

no marks for a simple graph description

1

[7]

Q33.

(a) (i) (atoms / elements with) the same number of protons but different numbers of neutrons

accept (atoms / elements with) different mass number but same atomic number

1

(ii) substances that give out radiation

accept alpha, beta or gamma for radiation

accept an unstable nucleus that decays

radioactive decay takes place is insufficient

1

(b) 85 years

± 2 years

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

2

(c) (i) a helium nucleus

accept 2 neutrons and 2 protons

accept $_{2}^{4}He$

*do **not** accept helium atom*

1

(ii) the rate of decay (of plutonium) decreases

accept fewer (plutonium) nuclei (to decay)

accept radioactivity decreases

1

less heat produced

*do **not** accept energy for heat*

1

(d) (i) (outside the body)

alpha (particles) cannot penetrate into the body

(inside the body)

1

(heat produced from decay) damages / kills cells / tissues

accept causes cancer for damages / kills cells / tissues

*accept **highly** toxic*

1

*(ii) any **one** from:*

- *worried same could happen again*

- *an accident may cause radiation to be spread around the Earth / atmosphere*

- *idea of soil contamination resulting from accident / release of radioactive material*

- *idea of negative effect on health resulting from accident / release of radioactive material*

  accept any sensible suggestion

1

[10]

Q34.

(a) *146*

1

(b) *atomic number*

1

(c) (i) *alpha*

1

(ii) *number of protons changes*

accept atomic number changes

accept <u>loses or gains</u> protons

*do **not** accept protons with any other particle e.g. number of protons and neutrons changes incorrect*

*do **not** accept any reference to mass number*

1

[4]

Q35.

(a) *any **two** pairs from:*

- *nuclear model mass is concentrated at the centre / nucleus (1)*

  plum pudding model mass is evenly distributed (1)

  accept the nuclear model has a nucleus/the plum pudding model does not have a nucleus for 1 mark

- *nuclear model positive charge occupies only a small part of the atom (1)*

  plum pudding model positive charge spread throughout the atom (1)

  accept electrons in shells/ orbits provided a valid comparison is made with the plum pudding model
  *do **not** accept on its own*
  *do **not** accept electrons at edge of plum pudding*

- *nuclear model electrons orbit some distance from the centre / nucleus (1)*

  plum pudding electrons embedded in the (mass) of positive (charge) (1)

- *nuclear model the atom mainly empty space (1)*

  plum pudding model is a 'solid' mass (1)

  to gain credit it must be clear which model is being described

*do **not** accept simple descriptions on the diagram without comparison*

4

(b) nucleus must be positive to deflect/ repel alpha particles

answers in terms of electrons/negative charge causing deflection negates mark answers in terms of reflection negates mark

1

nucleus (very) small so few alpha particles deflected backwards

accept most of atom empty space so most pass through

1

(c) many/ 100 000 measurements taken

accept results for measurements accept data valid / reliable

1

findings could not be explained by plum pudding model

accept a specific finding that could not be explained eg some alpha particles were deflected backwards

1

[8]