EXAM PAPERS PRACTICE

Atoms And Isotopes

These practice questions can be used by students and teachers and is

Suitable for GCSE AQA Physics Topic Question 8463

Level: GSCE AQA 8463

Subject: Physics

Exam Board: GCSE AQA

Topic: Atoms And Isotopes

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.

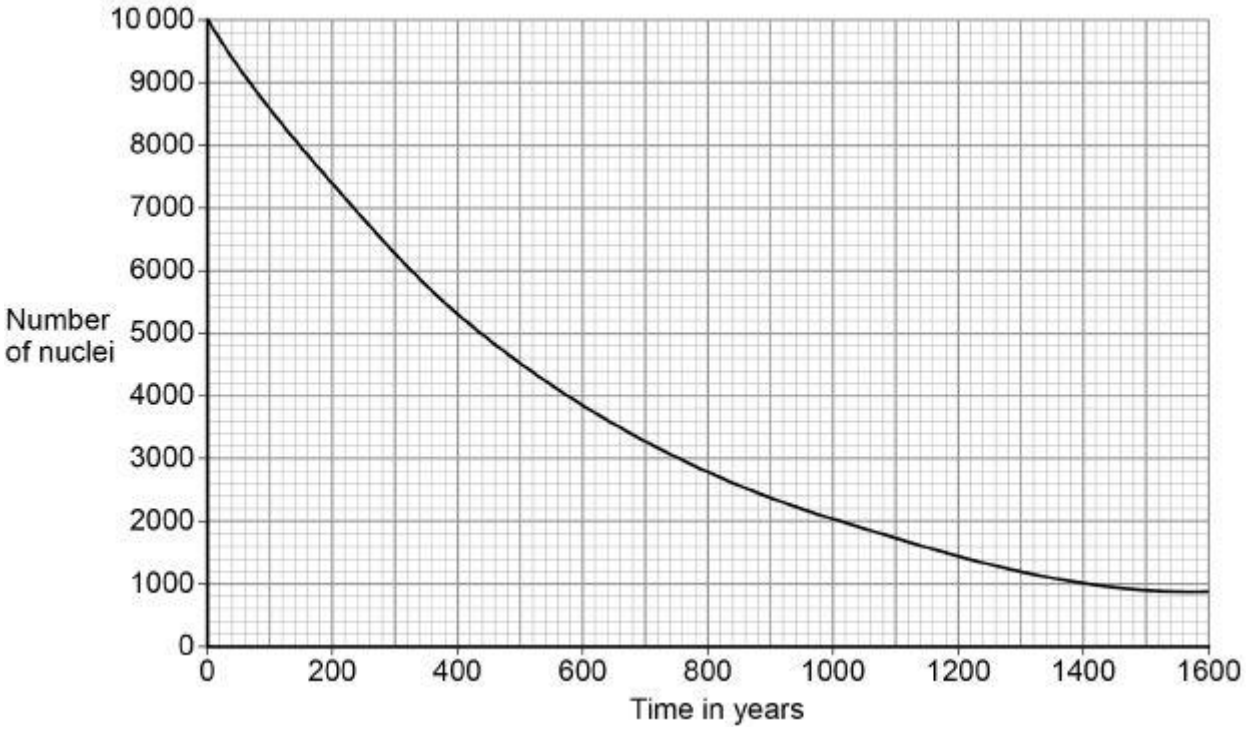
_____

_____

_____

(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

(1)

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

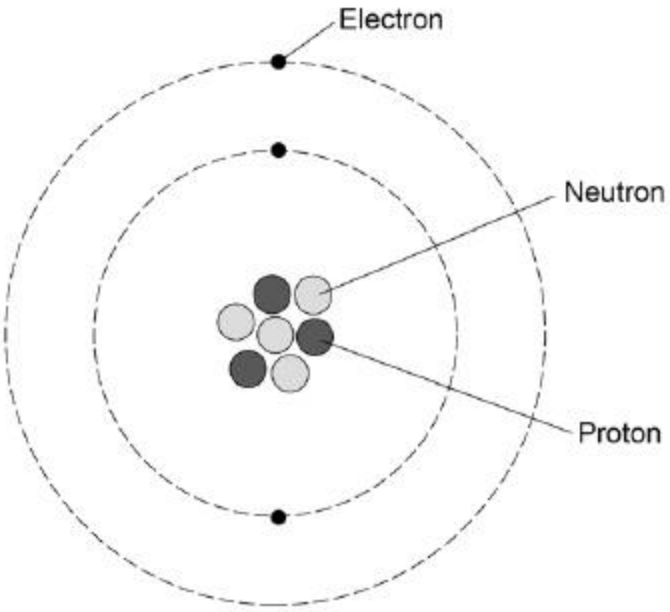
Half-life = _____ years

(1)

(Total 4 marks)

Q2.

The diagram shows a lithium atom.



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

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

(1)

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

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

Give a reason for your answer.

_____

(2)

(c) Complete the sentence.

Choose the answer from the box.

circles	levels	rings

The electrons in an atom orbit in different energy _____ .

(1)

(d) Some atomic nuclei are unstable and decay by emitting an alpha particle or a beta particle.

Complete the symbols for an alpha particle and a beta particle.

Use answers from the box.

–1	0	1	2	4

Alpha $\square^{\square}_{\square}He$

Beta $\square^{0}_{\square}e$

(3)

(e) Doctors may use nuclear radiation to diagnose certain types of illness.

The table below gives data about three radiation sources used.

Each source emits beta radiation.

Radiation source	Half-life in minutes
Carbon-11	20
Nitrogen-13	10
Oxygen-15	2

Explain why oxygen-15 is likely to pose the least risk to a patient.

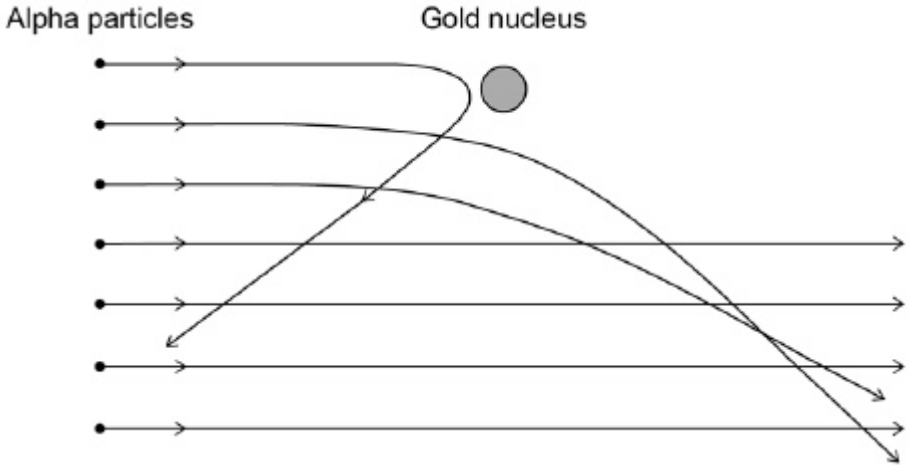
(2)

(Total 9 marks)

Q3.

In the early 20th century, scientists developed an alpha particle scattering experiment using gold foil.

The diagram shows the paths of some of the alpha particles in the alpha particle scattering experiment.



(a) Explain how the paths of the alpha particles were used to develop the nuclear model of the atom.

(4)

(b) Niels Bohr adapted the nuclear model by suggesting electrons orbited the nucleus at specific distances.

Explain how the distance at which an electron orbits the nucleus may be changed.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q4.

Scientists sometimes replace one scientific model with a different model.

For example, in the early 20th Century the plum pudding model of the atom was replaced by the nuclear model of the atom.

Explain what led to the plum pudding model of the atom being replaced by the nuclear model of the atom.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 6 marks)

Q5.

A student models the random nature of radioactive decay using 100 dice.

He rolls the dice and removes any that land with the number 6 facing upwards.

He rolls the remaining dice again.

The student repeats this process a number of times.

The table below shows his results.

Roll number	Number of dice remaining
0	100
1	84
2	70
3	59
4	46
5	40
6	32
7	27
8	23

(a) Give **two** reasons why this is a good model for the random nature of radioactive decay.

1. _____

_____

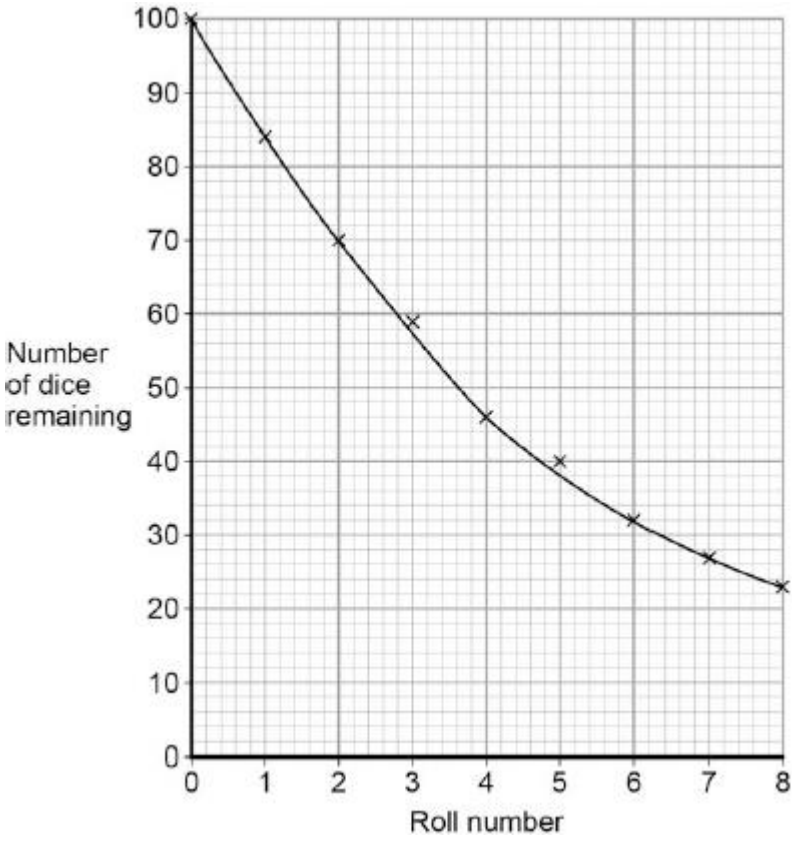
2. _____

_____

(2)

(b) The student's results are shown in **Figure 1**.

Figure 1



Use **Figure 1** to determine the half-life for these dice using this model.

Show on **Figure 1** how you work out your answer.

Half-life = _____ rolls

(2)

(c) A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

In the first stage in the protactinium generator, uranium (U) decays into thorium (Th) and alpha (α) radiation is emitted.

The decay can be represented by the equation shown in **Figure 2**.

Figure 2

$$^{238}_{92}U \longrightarrow \square^{234}Th + \alpha$$

Determine the atomic number of thorium (Th) 234.

Atomic number = _____

(1)

(d) When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 3**.

Figure 3

$$^{234}_{91}Pa \rightarrow {}^{234}_{92}X + radiation$$

When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 2** and **Figure 3** to determine the name of element **X**.

_____

(1)

(e) Determine the type of radiation emitted as protactinium decays into a new element.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(f) The teacher wears polythene gloves as a safety precaution when handling radioactive materials.

The polythene gloves do **not** stop the teacher's hands from being irradiated.

Explain why the teacher wears polythene gloves.

_____

_____

_____

_____

(2)

(Total 10 marks)

Q6.

Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

Two of its isotopes are lead-206 ($^{206}_{82}Pb$) and lead-208 ($^{208}_{82}Pb$).

(a) (i) What is meant by 'isotopes'?

_____

_____

_____

_____

(2)

(ii) How many protons are in the nucleus of a $^{206}_{82}Pb$ atom?

_____

(1)

(iii) How many neutrons are in the nucleus of a $^{206}_{82}Pb$ atom?

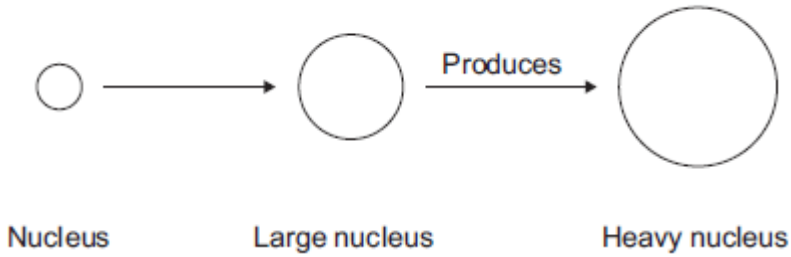
_____

(1)

(b) A nucleus can be accelerated in a particle accelerator and directed at a large nucleus. This produces a heavy nucleus that will decay after a short time.

This is shown in **Figure 1**.

Figure 1



(i) In 1984, nuclei of iron (Fe) were directed at nuclei of lead (Pb). This produced nuclei of hassium (Hs).

Complete the equation for this reaction by writing numbers in the empty boxes.

$$\square^{58}Fe + \frac{\square}{\square}Pb = {}^{265}_{108}Hs + {}^{1}_{0}X$$

(3)

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

an electron	**a proton**	**a neutron**

The particle **X** in part (b)(i) is _____ .

(1)

(iii) After acceleration the iron nuclei travel at a steady speed of one-tenth of the speed of light.

The speed of light is 3.00×10^8 m/s.

Calculate the time taken for the iron nuclei to travel a distance of 12 000 m.

_____

_____

Time taken = _____ s

(2)

(iv) Linear accelerators, in which particles are accelerated in a straight line, are **not** used for these experiments. Circular particle accelerators are used.

Suggest why.

_____

_____

_____

_____

_____

_____

(3)

(c) Hassium-265 ($^{265}_{108}Hs$) decays by alpha emission with a half-life of 0.002 seconds.

(i) What is meant by 'half-life'?

Tick (✓) **two** boxes.

	Tick (✓)
The average time for the number of nuclei to halve	
The time for count rate to be equal to background count	
The time for background count to halve	
The time for count rate to halve	

(2)

(ii) Complete the equation for the decay of Hs-265 by writing numbers in the empty

boxes.

$$^{265}_{108}Hs = \frac{\square}{\square}Sg + \frac{\square}{\square}\alpha$$

(2)

(d) The table below shows how the atomic radius of some atoms varies with atomic number.

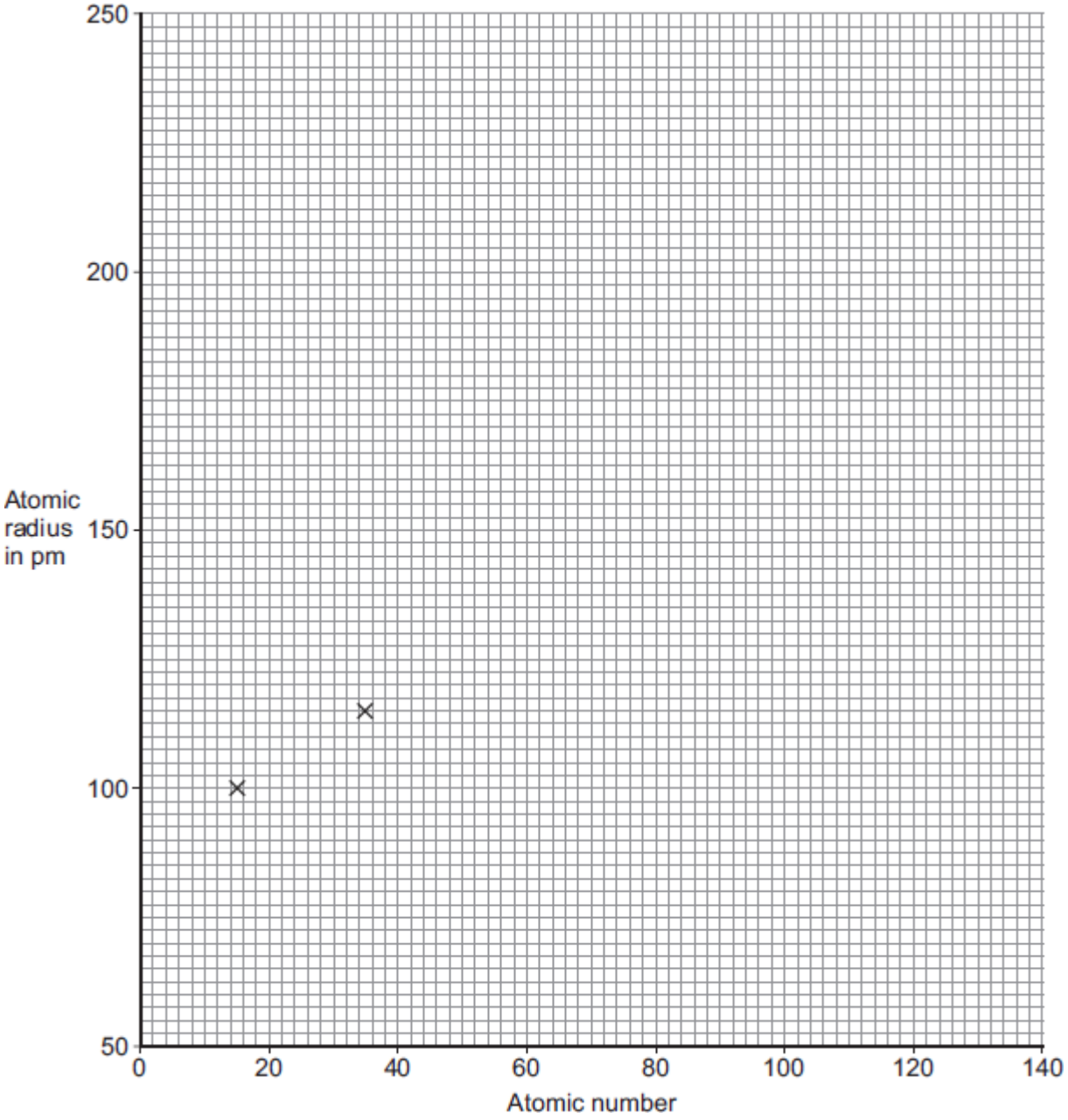
Atomic number	Atomic radius in picometres (pm)
15	100
35	115
50	130
70	150
95	170

1 pm = 10^{-12} m

(i) On **Figure 2**, use the data from the table above to plot a graph of atomic radius against atomic number and draw a line of best fit.

Two points have been plotted for you.

Figure 2



(2)

(ii) Scientists believe that the element with atomic number 126 can be produced and that it will be stable.

Use your graph in **Figure 2** to predict the atomic radius of an atom with atomic number 126.

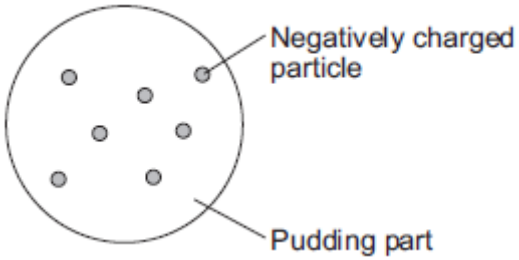
Atomic radius = _____ pm

(1)

(Total 20 marks)

Q7.

(a) Over 100 years ago, scientists thought the atom was like a 'plum pudding'. The diagram below shows the plum pudding model of the atom.



The scientists knew that an atom has negatively charged particles. They also knew that an atom has no overall charge.

What did the scientists conclude about the **charge** on the 'pudding part' of the atom?

_____

_____

(1)

(b) Two scientists named Rutherford and Marsden devised an experiment to investigate the plum pudding model of the atom. The experiment involved firing alpha particles at a thin sheet of gold. The scientists measured how many of the alpha particles were scattered.

Using the plum pudding model, the scientists predicted that only a few of the alpha particles would be scattered by more than 4°.

Over several months, more than 100 000 measurements were made.

(i) The results from this experiment caused the plum pudding model to be replaced by a new model of the atom.

Explain why.

_____

_____

_____

_____

_____

_____

(2)

(ii) Suggest **one** reason why other scientists thought this experiment provided valid evidence for a new model of the atom.

_____

_____

_____

(1)

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

Describe the model now used for the structure of an atom.

In your answer you should:
- give details of the individual particles that make up an atom
- include the relative masses and relative charges of these particles.

Do **not** include a diagram in your answer.

(6)

(Total 10 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 _____

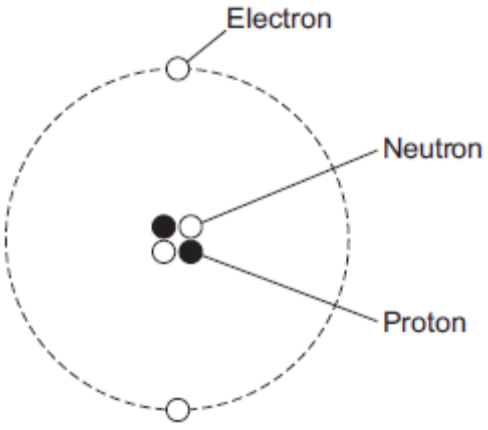
and has an overall _____ charge.

(2)

(Total 7 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

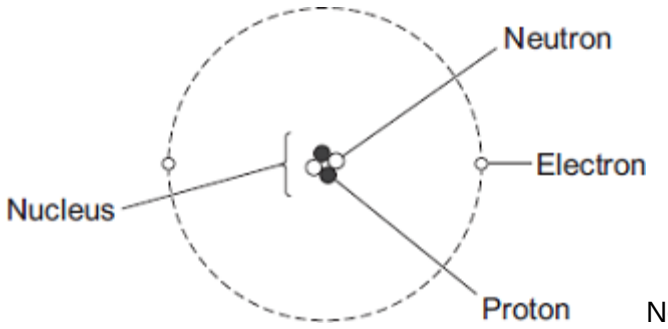
the treatment.

(1)

(Total 9 marks)

Q10.

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)

Q11.

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 _____ .

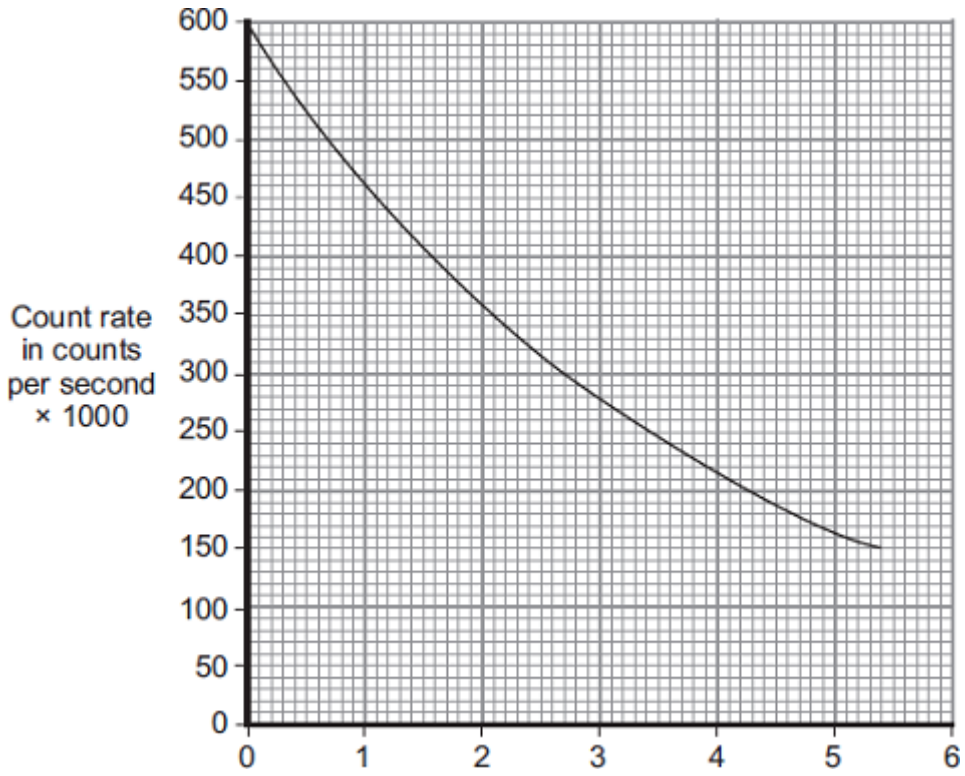
The atoms from different isotopes of gold have different numbers of _____ .

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.



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

Show clearly on the graph how you obtain your answer.

_____

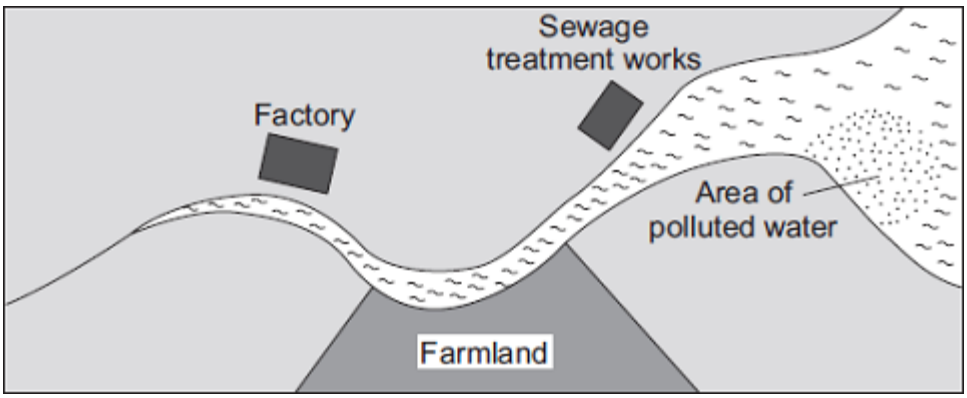
_____

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.

_____

_____

_____

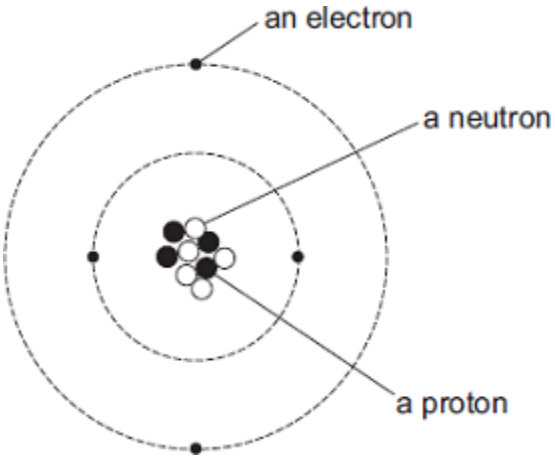
_____

(2)

(Total 7 marks)

Q12.

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.

_____

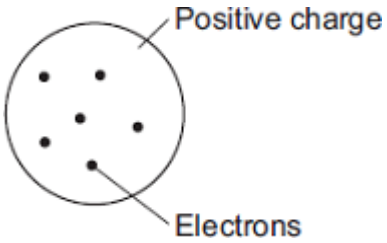
_____

(2)

(Total 4 marks)

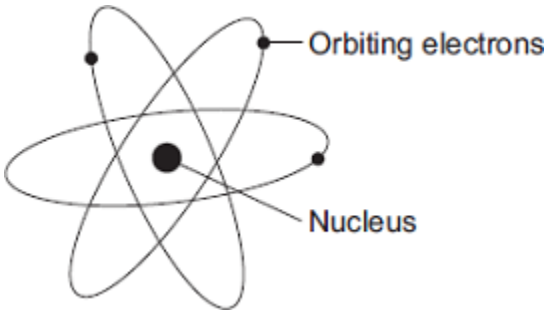
Q13.

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.

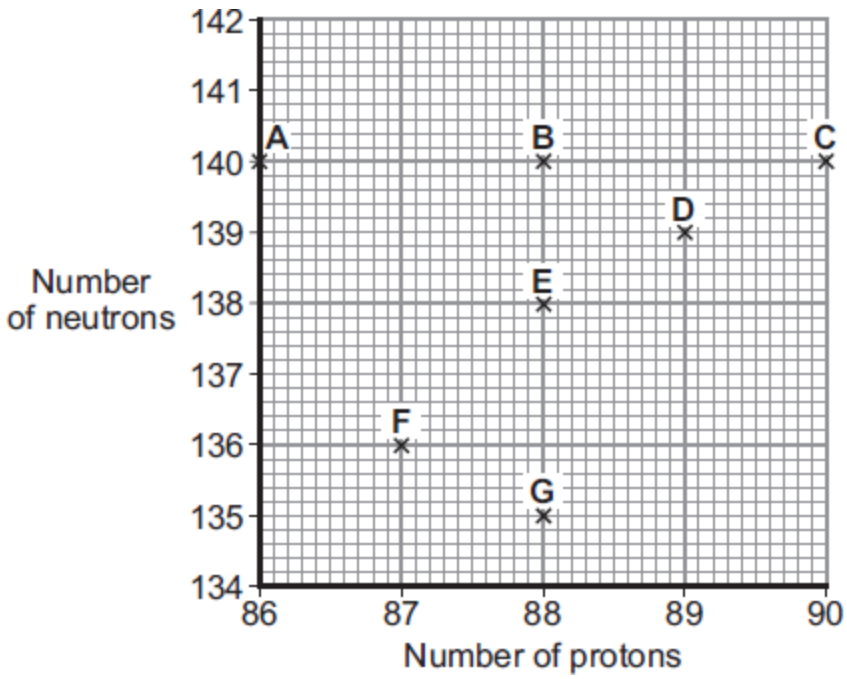


Describe the differences between the two models of the atom.

(Total 4 marks)

Q14.

(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.

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

(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.

_____

_____

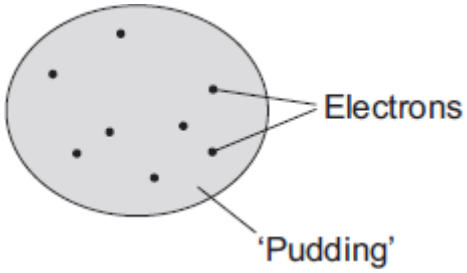
_____

(1)

(Total 9 marks)

Q15.

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.

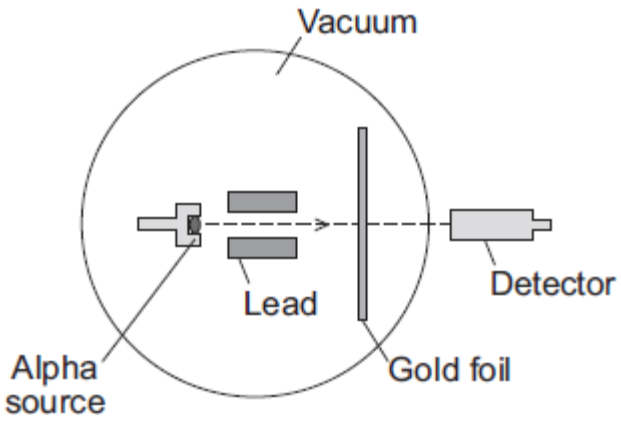
What did this allow the scientists to deduce about the 'pudding' part of the atom?

_____

_____

(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?

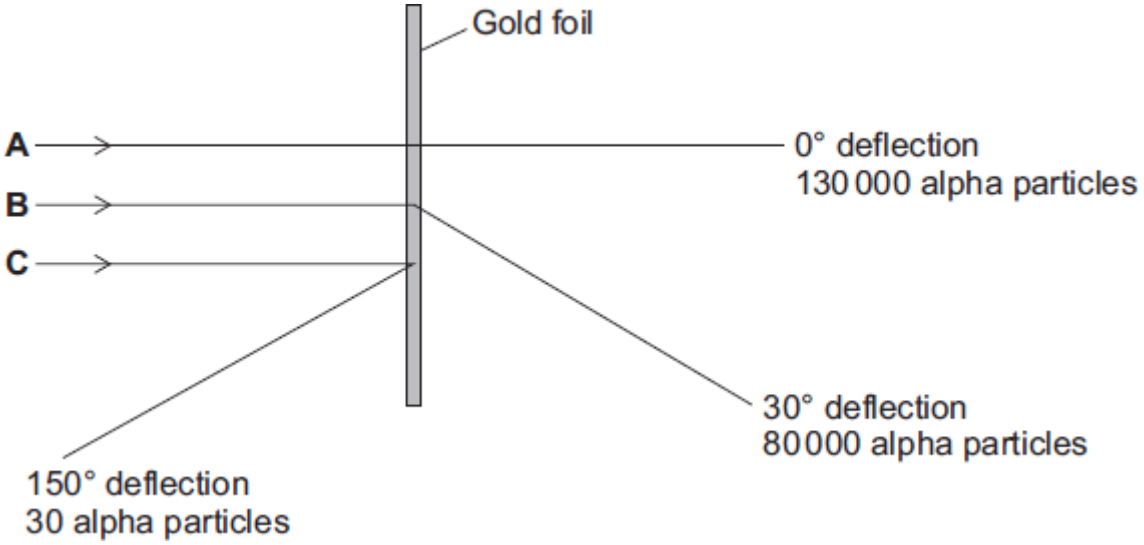
_____

_____

_____

(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?

_____

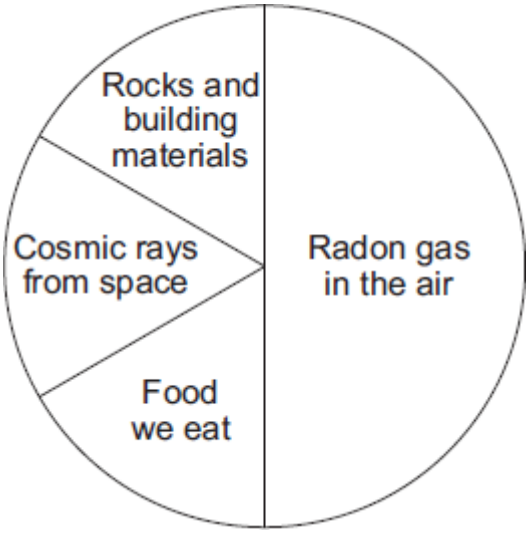
_____

(1)

(Total 6 marks)

Q16.

The pie chart shows the average proportions of natural background radiation from various sources in the UK.



(a) (i) Complete the following sentence.

On average, _____ of the natural background radiation in the UK comes from radon gas.

(1)

(ii) Radon gas is found inside homes.

The table shows the results from measuring the level of radon gas inside four homes in one area of the UK.

Home	Level of radon gas in Bq per m^3 of air
1	25
2	75
3	210
4	46
Mean	89

One of the homes has a much higher level of radon gas than the other three homes.

What should be done to give a more reliable mean for the homes in this area of the UK?

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

ignore the data for home number 3 ☐

measure the radon gas level in more homes in this area ☐

include data for homes from different areas of the UK ☐

(1)

(b) Each atom of radon has 86 protons and 136 neutrons.

(i) How many electrons does each atom of radon have?

Draw a ring around your answer.

50 **86** **136** **222**

(1)

(ii) How many particles are there in the nucleus of a radon atom?

Draw a ring around your answer.

50 **86** **136** **222**

(1)

(Total 4 marks)

Q17.

(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.

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

(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.

$$^{212}_{83}Bi \longrightarrow \square \quad \square \; Tl + {}^{4}_{2}He$$

(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)

Q18.

The names of three different processes are given in **List A**.
Where these processes happen is given in **List B**.

Draw a line to link each process in **List A** to where the process happens in **List B**.

Draw only **three** lines.

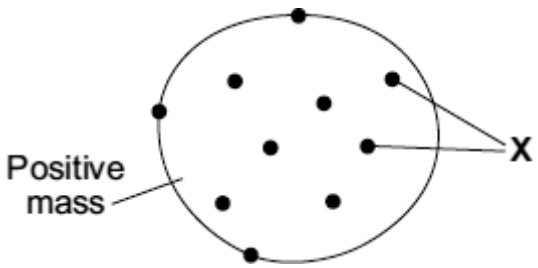
List A **List B**

Process	Where it happens
fusion	in a star
chain reaction	in a nuclear reactor
alpha decay	in a smoke precipitator
	in the nucleus of an atom

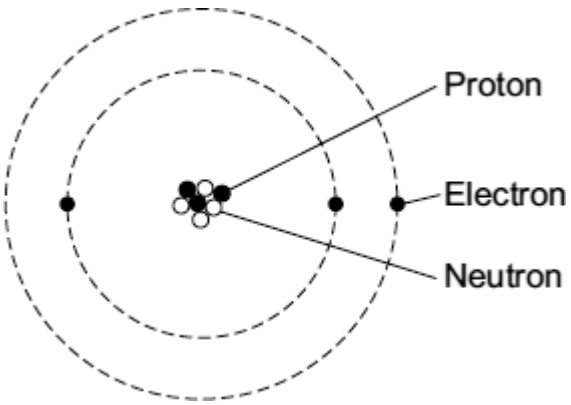
(Total 3 marks)

Q19.

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)

Q20.

(a) Background radiation is all around us all the time.

(i) Radon is a natural source of background radiation.

Name another natural source of background radiation.

_____

(1)

(ii) X-rays are an artificial source of background radiation.

Name another artificial source of background radiation.

_____

(1)

(iii) An atom of radon-222 decays by emitting an alpha particle.
The equation representing the decay is shown below.

$$^{222}_{86}Rn \longrightarrow {}^{218}_{84}X + \text{alpha particle}$$

How can you tell from the equation that 'X' is not an atom of radon?

_____

_____

(1)

(b) Having an X-ray taken increases your exposure to radiation.

The table gives:

- the radiation doses received for 6 different medical X-rays;
- the number of days' of exposure to natural background radiation each dose is equivalent to.

Medical X-ray	Radiation dose received (in arbitrary units)	Equivalent number of days of exposure to natural background radiation
Chest	2	2.4
Skull	7	8.4
Pelvis	22	26.4
Hip	44	52.8
Spine	140	
CT head scan	200	240

A hospital patient has an X-ray of the spine taken.
Calculate the number of days of exposure to natural background radiation that an X-ray of the spine is equivalent to.

Show how you work out your answer.

_____

_____

_____

Equivalent number of days = _____

(2)

(c) Scientists have shown that X-rays increase the risk of developing cancer.
The scientists came to this conclusion by studying the medical history of people placed in one of two groups, **A** or **B**.
The group into which people were put depended on their X-ray record.

(i) Person **J** has been placed into group **A**.
Place each of the people, **K**, **L**, **M**, **N** and **O**, into the appropriate group, **A** or **B**.

Person	**J**	**K**	**L**	**M**	**N**	**O**
						
Medical X-ray record	3 arm	None	None	2 skull	None	4 leg

Group A	**Group B**
J	

(1)

(ii) To be able to make a fair comparison, what is important about the number of people in each of the two groups studied by the scientists?

_____

_____

(1)

(iii) What data would the scientists have compared in order to come to the conclusion that X-rays increase the risk of developing cancer?

_____

_____

(1)

(iv) The chance of developing cancer due to a CT head scan is about 1 in 10 000. The chance of developing cancer naturally is about 1 in 4.

A hospital patient is advised by a doctor that she needs to have a CT head scan. The doctor explains to the patient the risks involved.

Do you think that the patient should give her permission for the CT scan to be taken?

Draw a ring around your answer.

Yes **No**

Give a reason for your answer.

_____

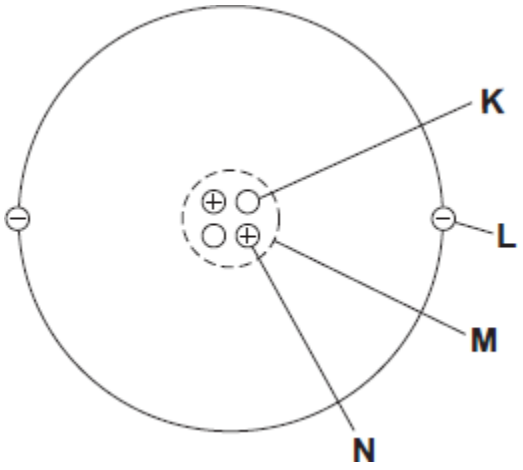
_____

(1)

(Total 9 marks)

Q21.

(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.

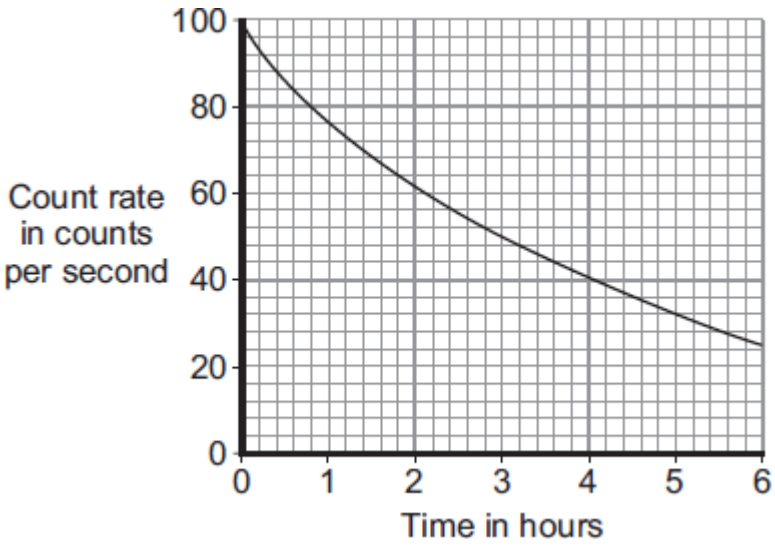
to monitor the thickness of aluminium foil as it is made in a factory ☐

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?

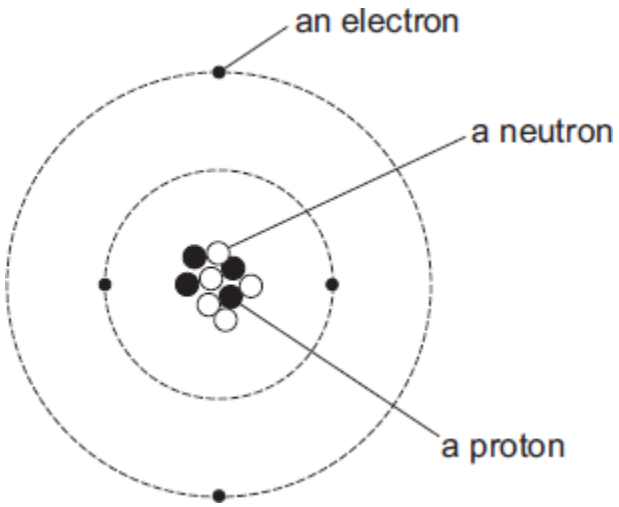
_____ counts per second

(1)

(Total 4 marks)

Q22.

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. ☐

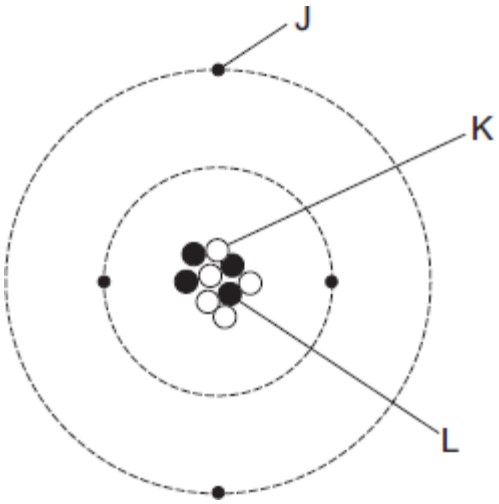
The atom loses a proton. ☐

(1)

(Total 5 marks)

Q23.

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?

_____

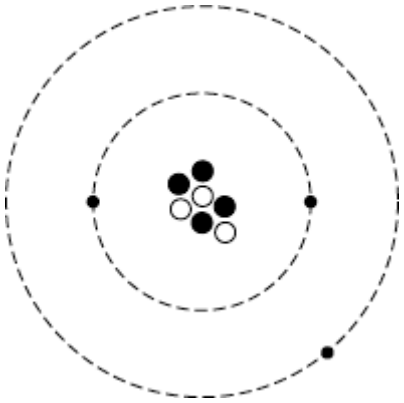
_____

(1)

(Total 5 marks)

Q24.

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)

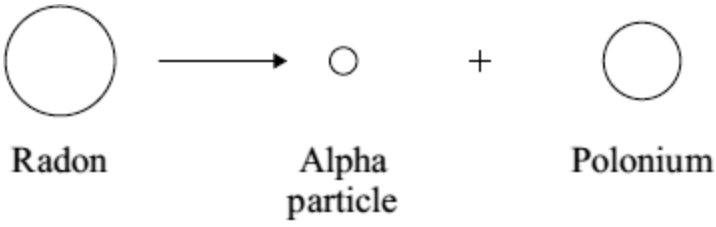
(b) Complete the following sentence by drawing a ring around the correct line in the box.

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.



Not to scale

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).

_____

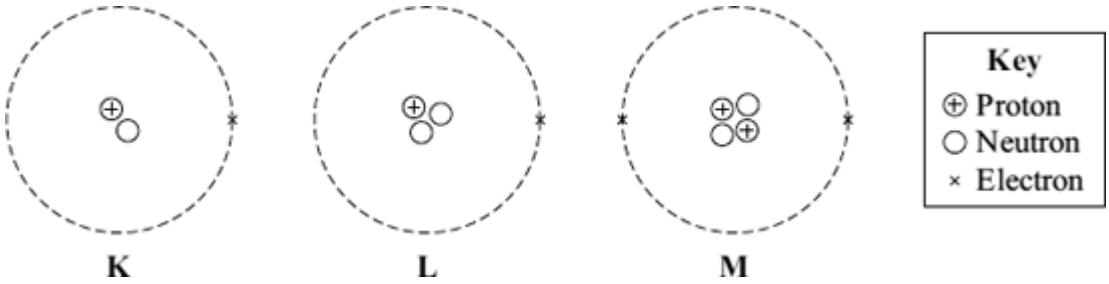
_____

(1)

(Total 7 marks)

Q25.

(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)

Q26.

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

(a) What is meant by the terms:

(i) *isotopes*

_____

_____

(1)

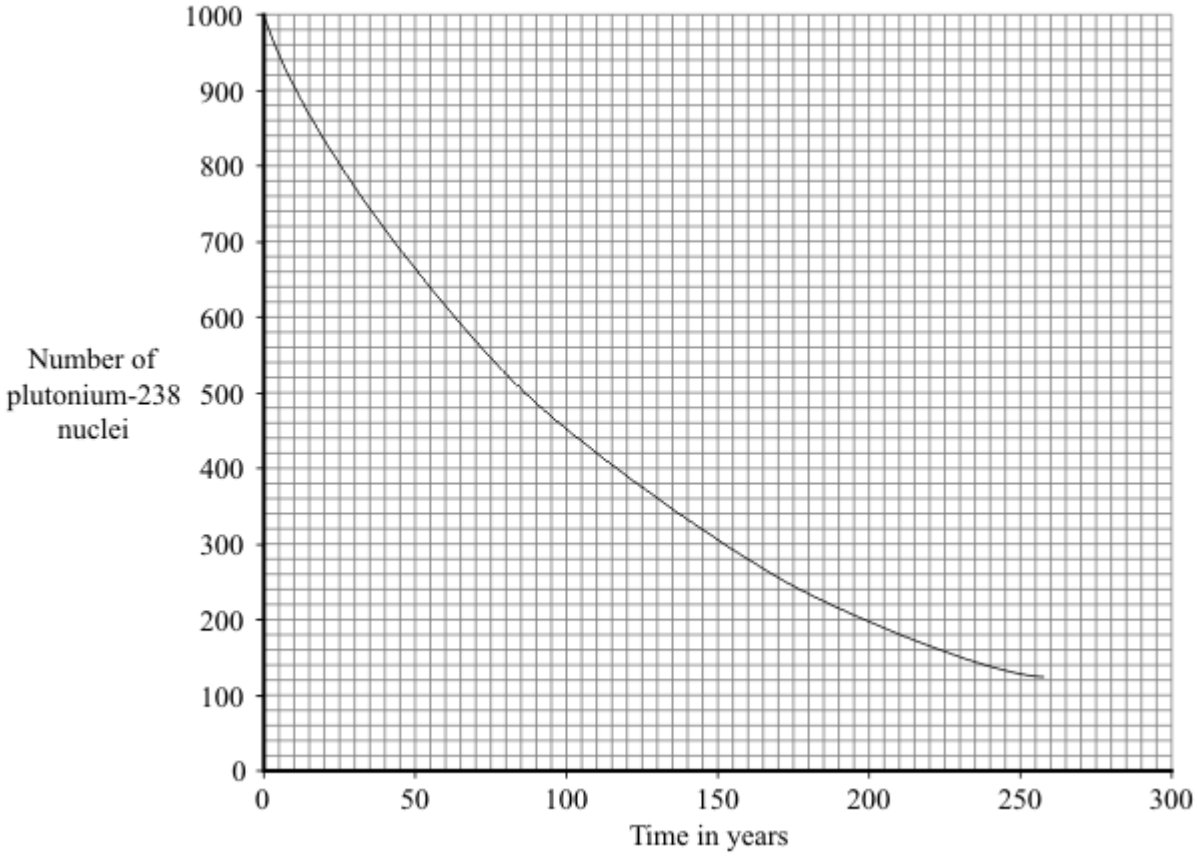
(ii) *radioactive*?

_____

_____

(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)

Q27.

(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?

_____

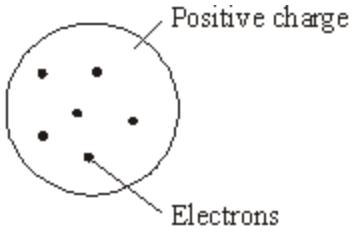
_____

(1)

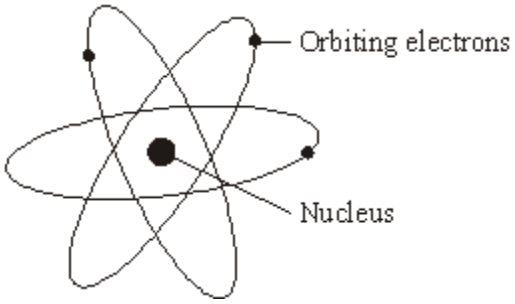
(Total 4 marks)

Q28.

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?

_____

_____

_____

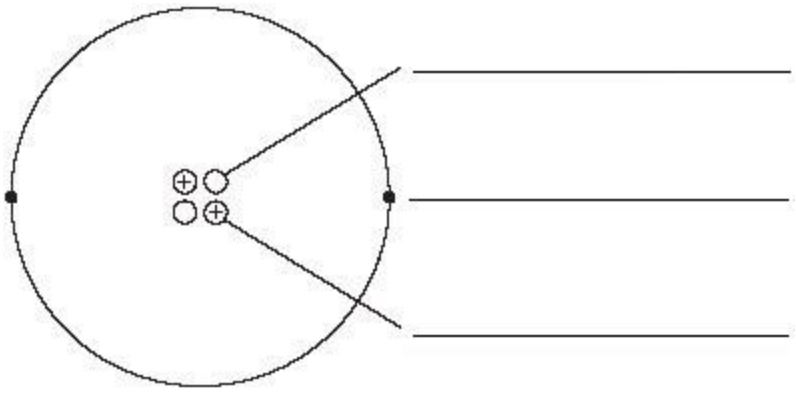
_____

(2)

(Total 8 marks)

Q29.

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.

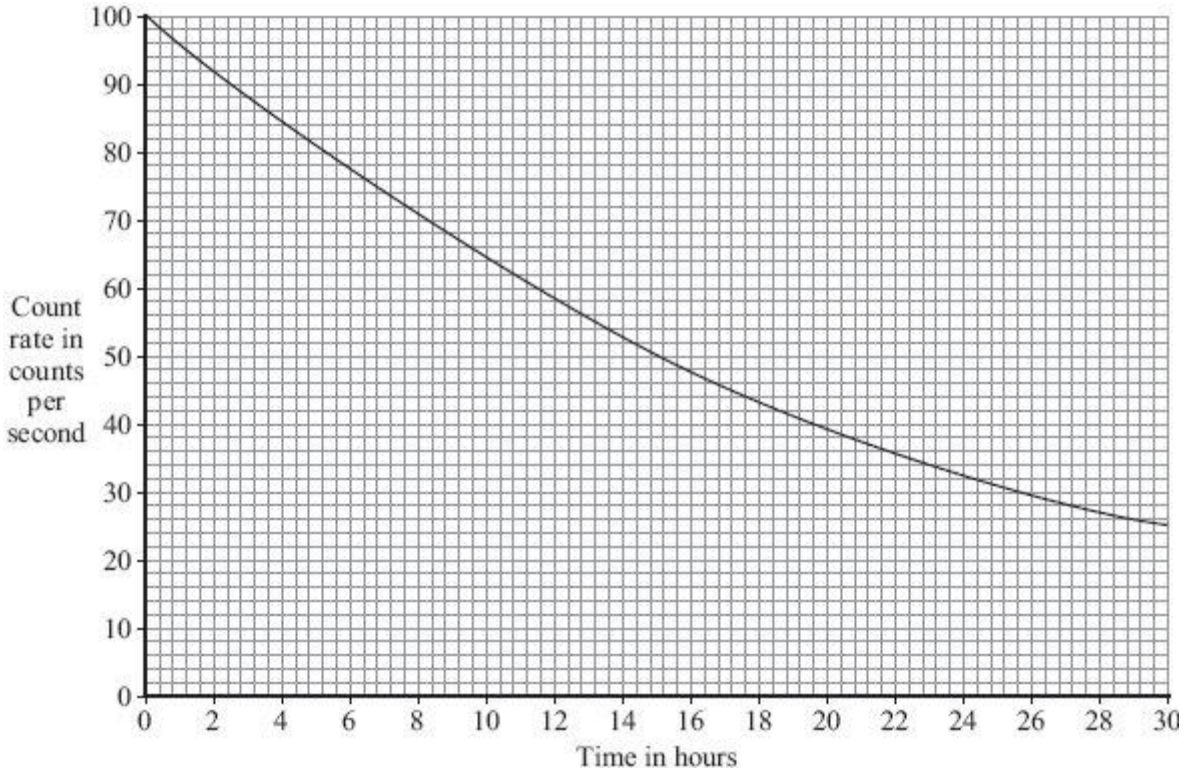
How is an alpha particle different from a helium atom?

_____

_____

(1)

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



(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.

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

_____

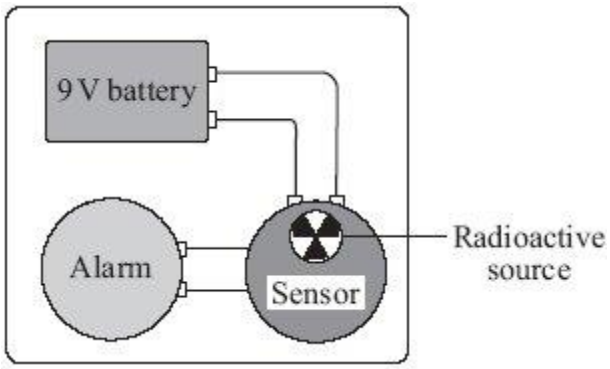
_____

(1)

(Total 7 marks)

Q30.

(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?

_____

_____

(1)

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

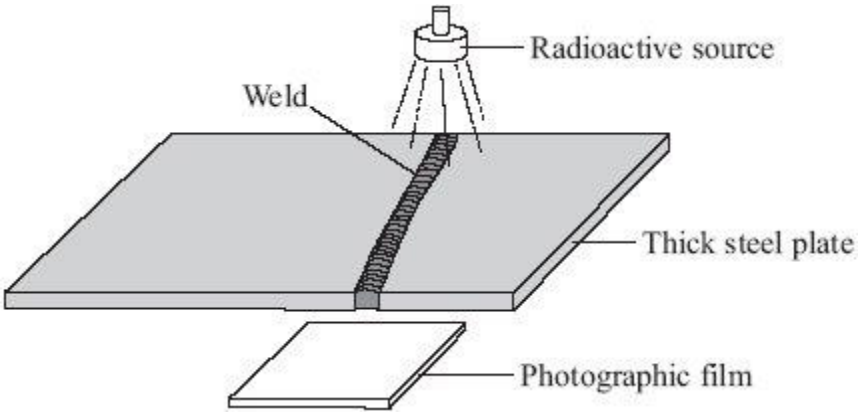
How is an atom of curium-242 different from an atom of curium-244?

_____

_____

(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.

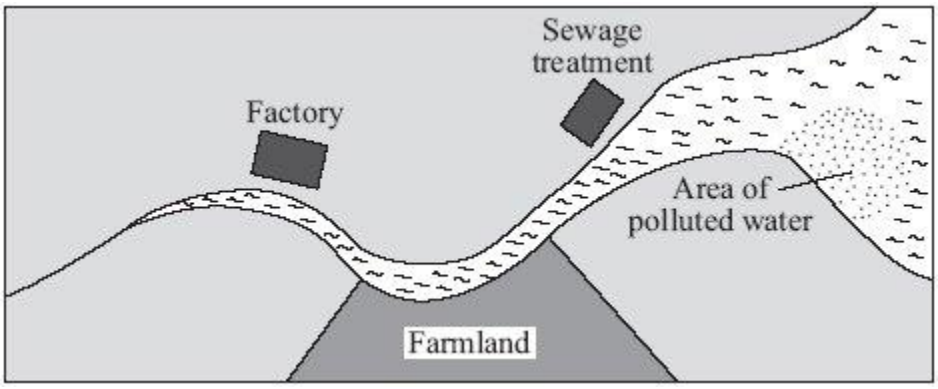
_____

_____

(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.



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

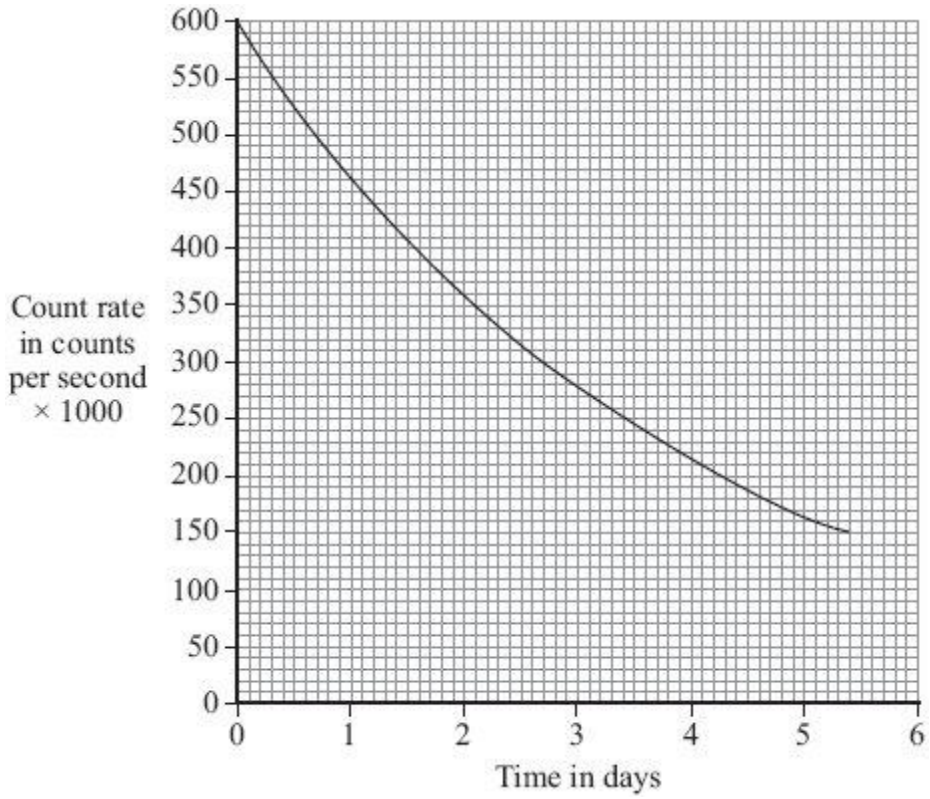
_____

_____

_____

(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.

Half-life = _____ days

(2)

(Total 9 marks)

Q31.

The table gives information about the three types of particle that make up an atom.

Particle	Relative mass	Relative charge
Proton		+1
Neutron	1	

Electron	very small	–1

(a) Complete the table by adding the **two** missing values.

(2)

(b) Use the information in the table to explain why an atom has no overall electrical charge.

_____

_____

_____

_____

(2)

(c) Uranium has two natural isotopes, uranium-235 and uranium-238.
Uranium-235 is used as a fuel inside a nuclear reactor.
Inside the reactor, atoms of uranium-235 are split and energy is released.

(i) How is the structure of an atom of uranium-235 different from the structure of an atom of uranium-238?

_____

_____

(1)

(ii) The nucleus of a uranium-235 atom must absorb a particle before the atom is able to split.

What type of particle is absorbed?

_____

(1)

(iii) The nucleus of an atom splits into smaller parts in a reactor.

What name is given to this process?

_____

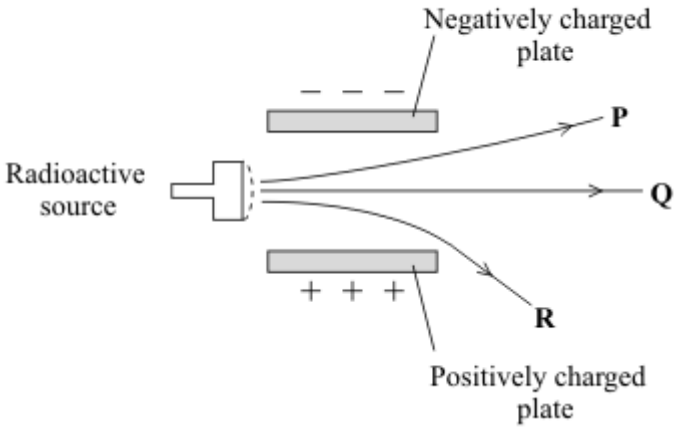
(1)

(Total 7 marks)

Q32.

A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation. The diagram shows what happens to the radiation as it passes between two charged metal plates.

Diagram 1



(a) Which line **P**, **Q** or **R** shows the path taken by:

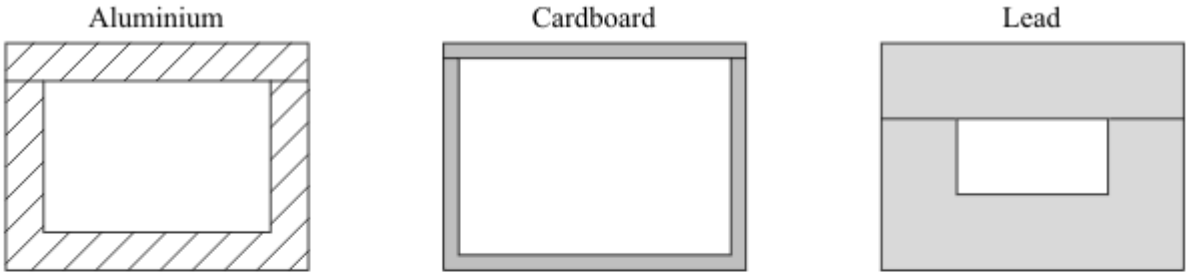
(i) alpha radiation _____

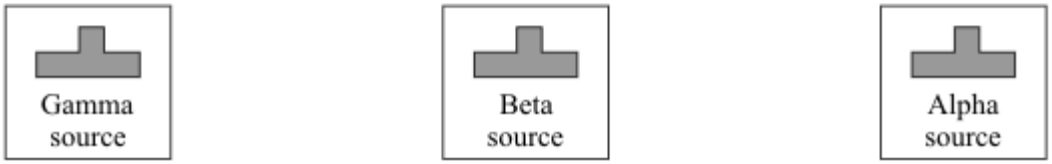
(1)

(ii) gamma radiation? _____

(1)

(b) The diagram shows three different boxes and three radioactive sources. Each source emits only one type of radiation and is stored in a different box. The box reduces the amount of radiation getting into the air.

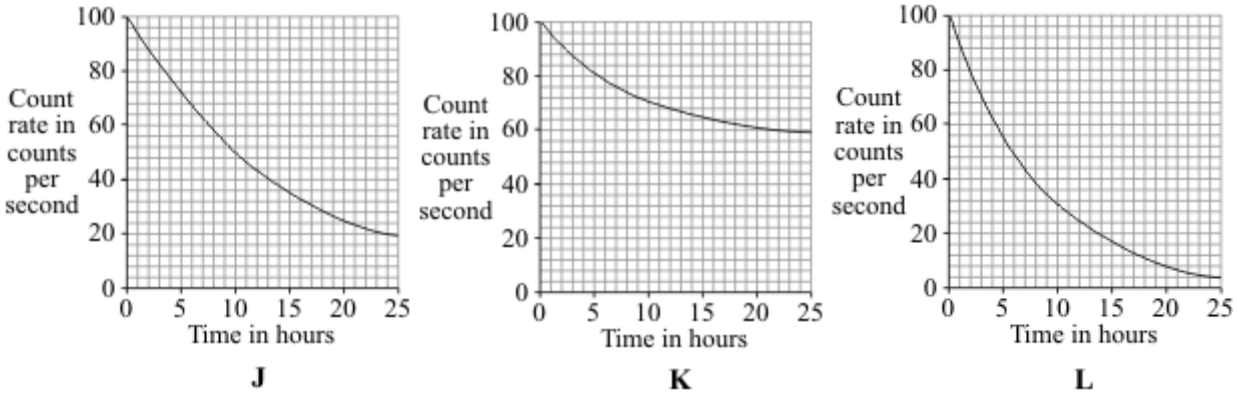




Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.

(2)

(c) The graphs show how the count rates from three different radioactive sources, **J**, **K**, and **L**, change with time.



(i) Which source, **J, K**, or **L**, has the highest count rate after 24 hours?

_____

(1)

(ii) For source **L**, what is the count rate after 5 hours?

_____ counts per second

(1)

(iii) Which source, **J, K,** or **L**, has the longest half-life?

_____

(1)

(iv) A radioactive source has a half-life of 6 hours.

What might this source be used for?

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

To monitor the thickness of paper as it is made in a factory ☐

To inject into a person as a medical tracer ☐

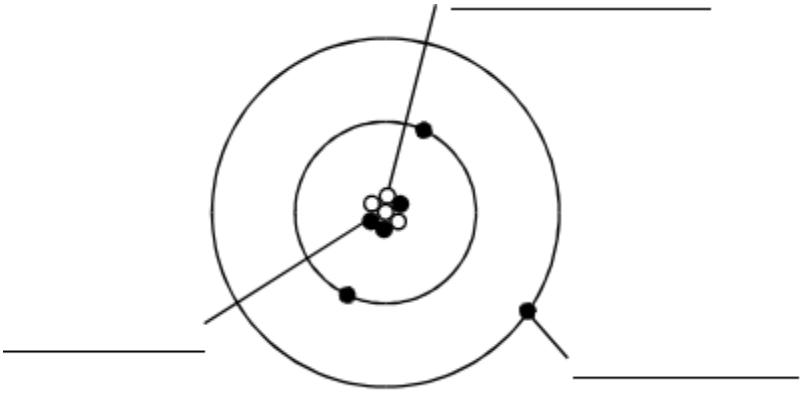
To make a smoke alarm work ☐

(1)

(Total 8 marks)

Q33.

The diagram represents an atom of lithium.



(i) Complete the diagram by writing in the spaces the name of each type of particle. Use only words given in the box. Each word may be used once or not at all.

electron	**neutron**	**nucleus**	**proton**

(3)

(ii) Which type of particle found inside the atom is uncharged?

_____

(1)

(iii) What is the mass number of this atom, 3, 4, 7 or 10?

_____

Give a reason for your choice.

_____

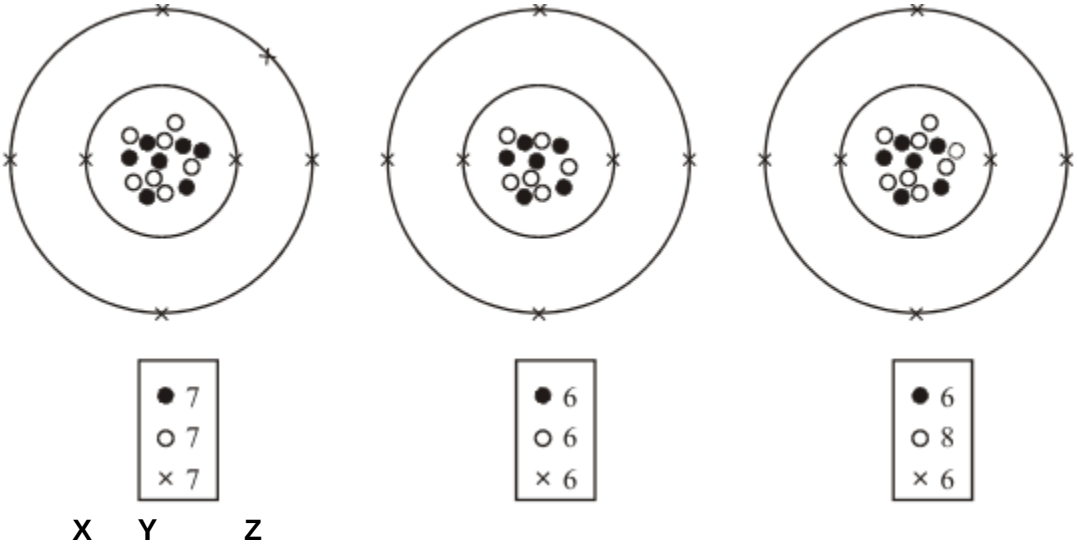
_____

(2)

(Total 6 marks)

Q34.

(a) The diagrams represent three atoms **X**, **Y** and **Z**.



Which **two** of the atoms are from the same element?

_____

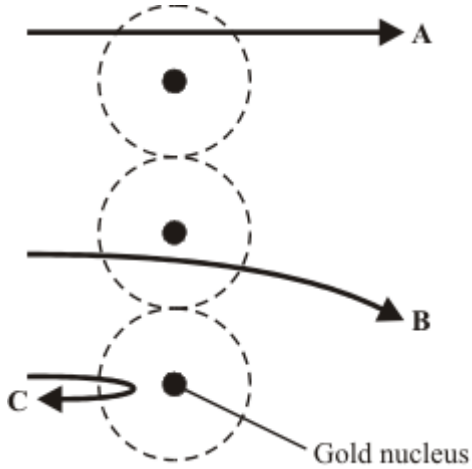
Give a reason for your answer.

_____

_____

(2)

(b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.



Explain the different paths **A**, **B** and **C** of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

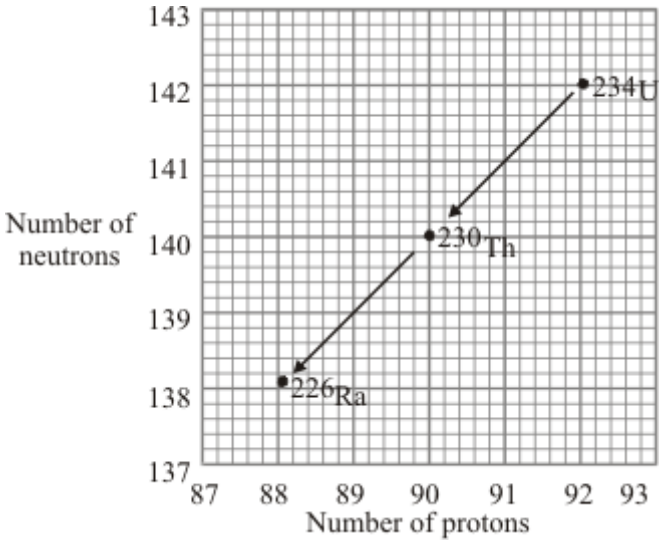
_____

(3)

(Total 5 marks)

Q35.

(a) Uranium-234 (^{234}U) is a radioactive element. The graph shows the number of protons and neutrons in the nuclei of the elements formed when uranium-234 decays.



(i) How does the graph show that uranium-234 (^{234}U) and thorium-230 (^{230}Th) emit alpha particles?

_____

(1)

(ii) What makes uranium and thorium different elements?

_____

(1)

(iii) Radioactive decay may also produce gamma radiation.

Why does the emission of gamma radiation **not** cause a new element to be formed?

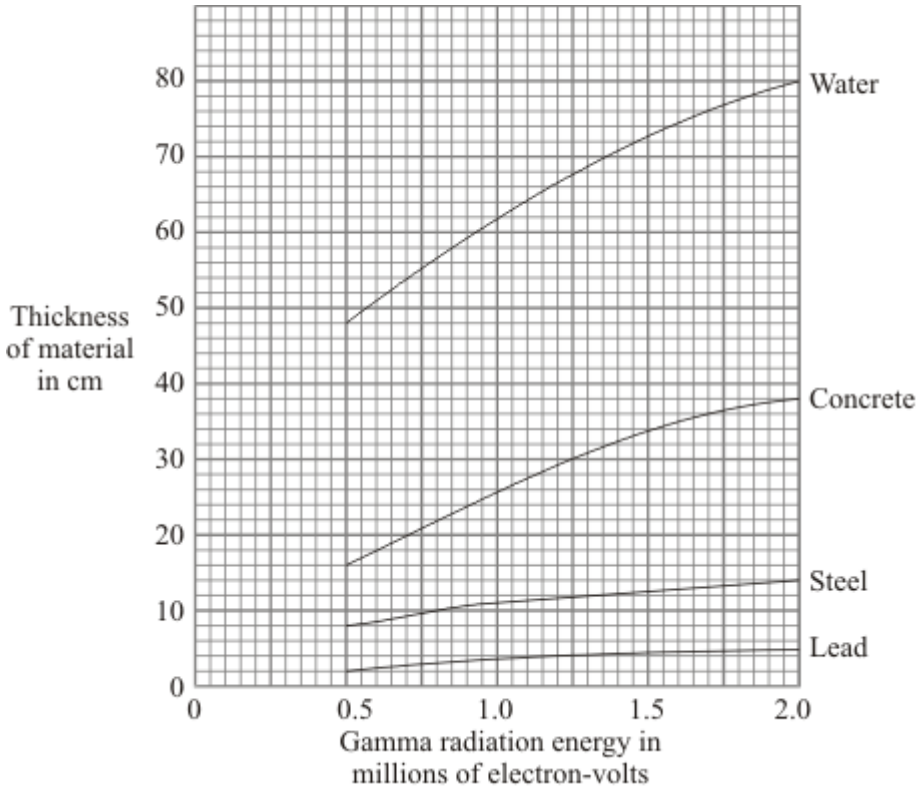
_____

_____

(1)

(b) The graph shows how the thickness of different materials needed to absorb 90% of

the gamma radiation emitted by a source depends on the energy of the radiation. The energy of the gamma radiation is given in units called electron-volts.



(i) Which of the materials shown is least effective at absorbing gamma radiation? Use the information in the graph to give a reason for your answer.

_____

_____

(1)

(ii) For gamma radiation of energy 1.5 million electron-volts, how many times more effective is steel than water at absorbing the radiation? Show clearly how you obtain your answer.

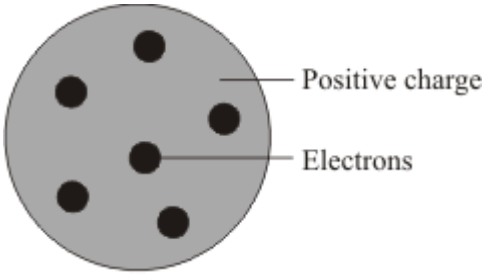
_____

_____

_____

(2)

(c) Scientists in the early twentieth century thought that atoms were made up of electrons scattered inside a ball of positive charge. This was called the 'plum-pudding' model of the atom.



Plum pudding model

Rutherford and Marsden did an experiment, in which a beam of alpha particles was aimed at a thin sheet of gold.
Explain how the results of this experiment led to a new model of the atom.
You may include one or more diagrams in your answer.

(3)
(Total 9 marks)

Mark schemes

Q1.

(a) B

reason only scores if B is chosen

1

americium has an atomic number of 95

allow proton number for atomic number

allow B has a different atomic number

allow B has an atomic number of 94

1

(b) 430 (years)

allow an answer between 420 and 440 (years)

1

(c) 430 (years)

or

their answer to part **(b)**

allow an answer between 420 and 440 (years)

1

[4]

Q2.

(a) 7

1

(b) 3

1

number of <u>protons</u>

reason only scores if 3 chosen

1

(c) levels

1

(d) $^{4}_{2}He$

correct order only

1

1

$^{0}_{-1}e$

1

(e) shorter half-life (than the other sources)

1

exposure time to radiation is shorter

1

[9]

Q3.

(a) most alpha particles pass straight through the atom

1

which shows that the atom is mostly empty space

1

very few alpha particles are deflected through a large angle

1

which shows the atom contains a nucleus where the mass / charge of the atom is concentrated

1

(b) electron may absorb electromagnetic radiation

full credit may be scored for a description of an electron emitting electromagnetic radiation

1

(and) move further from the nucleus

1

to a higher energy level

1

[7]

Q4.

Level 3 (5–6 marks):
A detailed and coherent explanation is provided. The student gives examples that argue a strong case and demonstrate deep knowledge. The student makes logical links between clearly identified, relevant points.

Level 2 (3–4 marks):
An attempt to link the description of the experiment and the results with differences between the two models. The student gives examples of where the plum pudding model does not explain observations. The logic used may not be clear.

Level 1 (1–2 marks):
Simple statements are made that the nuclear model is a better model. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

- alpha particle scattering experiment
- alpha particles directed at gold foil
- most alpha particles pass straight through
- (so) most of atom is empty space
- a few alpha particles deflected through large angles
- (so) mass is concentrated at centre of atom

- (and) nucleus is (positively) charged
- plum pudding model has mass spread throughout atom
- plum pudding model has charge spread throughout atom

[6]

Q5.

(a) cannot predict <u>which</u> dice / atom will 'decay'

accept answers given in terms of 'roll a 6'

1

cannot predict <u>when</u> a dice / atom will 'decay'

1

(b) 3.6 to 3.7 (rolls)

*allow **1** mark for attempt to read graph when number of dice = 50*

2

(c) 90

1

(d) uranium

1

(e) beta

1

proton number has gone up (as neutron decays to proton and e^-)

1

(f) prevents contamination

or

prevents transfer of radioactive material to teacher's hands

1

which would cause damage / irradiation over a longer time period.

1

[10]

Q6.

(a) (i) (atoms with the) same number of protons

allow same atomic number

***or** same proton number*

1

(atoms with) different number of neutrons

allow different mass number

1

(ii) 82

1

(iii) 124

1

(b) (i) $^{58}_{26}Fe + ^{208}_{82}Pb$

1 *mark for each correct box*

3

(ii) (a) neutron

1

(iii) 4.0×10^{-4} (s)
or
0.0004

$3.00 \times 10^{8} \times 0.1 = 12\,000 / t$
*gains **1** mark*

2

(iv) particles need to travel a large distance

1

equipment would have to be very long

1

with circular paths long distances can be accommodated in a smaller space

1

(c) (i) the average time for the number of nuclei to halve

1

the time for count rate to halve

1

(ii) $^{261}_{106}Sg + ^{4}_{2}\alpha$

1 *mark if top boxes total = 265*
and *bottom boxes total = 108*
1 *mark for 4 and 2 for alpha*

2

(d) (i) 3 plotted points
± ½ small square

1

best line through points

1

(ii) 190−205 (pm)
or correct from student's line

1

[20]

Q7.

(a) (an equal amount of) positive charge
*do **not** accept charge on the atom / nucleus is positive*

1

(b) (i) a (significant) number of alpha particles were scattered by more than 4°
or
alpha particles deflected backwards
accept (some) measurements / results were unexpected

1

measurements / results could not be explained by 'plum pudding' model
or
measurements / results did not support predictions
can be explained by the nuclear model is insufficient
accept measurements / results did not support hypothesis

1

(ii) many / (over)100 000 measurements / results taken
accept Rutherford(and Marsden) were respected scientists
or
scientists were respected
accept measurements / results taken over several months
the experiment was repeated many times is insufficient

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1−2 marks)
A brief description is given with some particles correctly named

Level 2 (3−4 marks)
A description is given with all three particles named
plus either

the polarity of charge associated with the
three particles
or
the relative mass of the three particles
or
the relative mass for one particle and the relative charge for one particle given

Level 3 (5−6 marks)
A more detailed description is given, naming the particles and polarity of charge
and either
the relative mass is given for at least two particles
or
the relative charge is given for at least two particles

Examples of the points made in the response

brief description

contains protons, neutrons and electrons

protons are positive
electrons are negative
neutrons are uncharged

has a nucleus

relative charge

proton +1
electron − 1
neutron 0

relative mass

proton 1
neutron 1
electron (about) 1 / 2000

accept protons and neutrons have the same mass
accept electrons have tiny / negligible mass
zero mass is neutral

more detailed description

protons and neutrons make up the nucleus
electrons orbit the nucleus
electrons are in shells
most of the atom is empty space
nucleus occupies a very small fraction of the volume of the atom
electrons orbit at a relatively large distance from the nucleus
most of the mass of the atom is contained in the nucleus
the nucleus as a whole is positively charged total number of protons in the nucleus equals the total number of electrons orbiting it in an atom

6

[10]

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

[7]

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) neutron discovered

1

(b) neutron

all 3 in correct order

electron

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

proton

2

[3]

Q11.

(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]

Q12.

(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]

Q13.

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]

Q14.

(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]

Q15.

(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]

Q16.

(a) (i) half / 50 %

1

(ii) Measure the radon gas level in more homes in this area

1

(b) (i) 86

1

(ii) 222

1

[4]

Q17.

(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

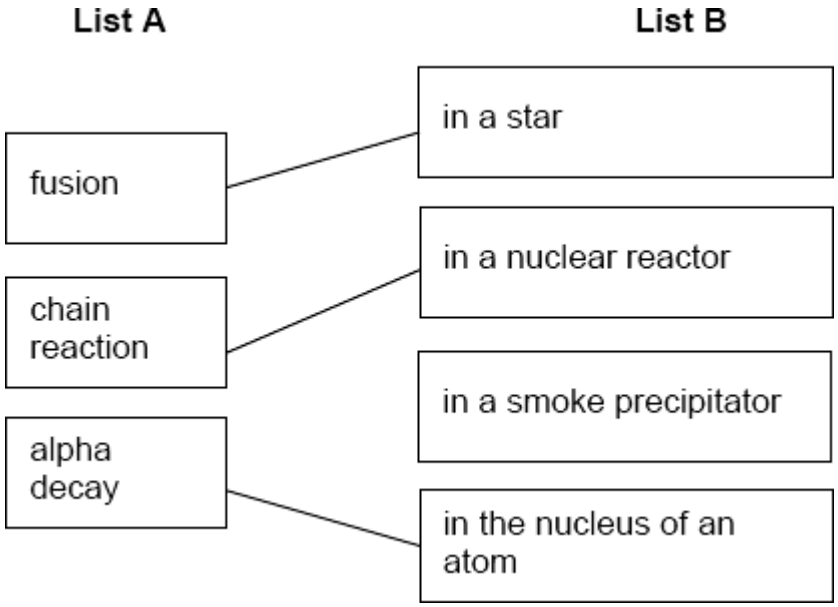
[7]

Q18.

three lines correct

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

*if more than 1 line is drawn from a box in **List A**, mark each line incorrect*



[3]

Q19.

(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]

Q20.

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

- food / drink
- rocks / building materials
- cosmic rays / rays from space
  accept correctly named example

1

(ii) any **one** from:

- nuclear power / coal power (stations)
  accept nuclear waste
- nuclear accidents
  accept named accident eg Chernobyl
- nuclear weapons testing
  accept named medical procedure which involves a radioactive source
  accept radiotherapy
  nuclear activity / radiation is insufficient
  *do **not** accept CT scans*

1

(iii) different number of / fewer protons

accept does not have 86 protons
accept only has 84 protons

or

different atomic number

*do **not** accept bottom number different*
reference to mass number negates this mark

1

(b) 168

accept 169 if clear, correct method is shown
*allow **1** mark for a correct dose ratio involving the spine*
eg 2:140 etc
***or** ratio of days to dose is 1.2*
***or** ratio of dose to days is 0.83*

2

(c) (i)

Group A	Group B
J M O	K L N

all correct
any order within each group

1

(ii) similar (number) / same (number) / large (number)

accept the same specific number in each group eg three
reference to other factors such as age is neutral

1

(iii) how many people in each group developed cancer

a clear comparison is required

1

(iv) *there are no marks for **Yes** or **No** the mark is for the reason*

Yes
the benefit of having the scan is greater than the risk
or
the risk is (very) small (compared to the chance from natural causes)

accept the risk is much greater from natural causes

No
no additional risk is acceptable

1

[9]

Q21.

(a) (i) **L**

1

(ii) **M**

1

(b) To make a smoke detector work.

1

(c) **40**

no tolerance

1

[4]

Q22.

(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]

Q23.

(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]

Q24.

(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]

Q25.

(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]

Q26.

(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 $_2{}^4He$

*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]

Q27.

(a) 146

1

(b) atomic number

1

(c) (i) alpha

1

(ii) number of protons changes

accept atomic number changes

accept loses or gains 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]

Q28.

(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

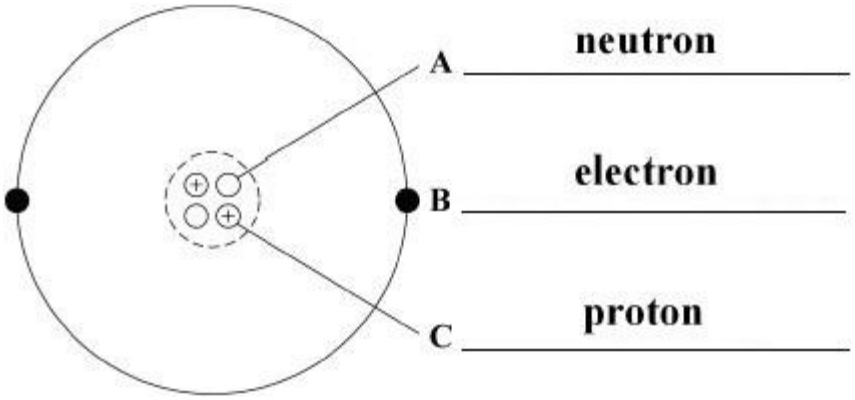
accept a specific finding that could not be explained
eg some alpha particles were deflected backwards

1

[8]

Q29.

(a) (i)



all 3 labels correct

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

2

(ii) has no electrons

it = alpha

allow alpha has a positive(charge)
allow a helium (atom) has no (charge)

*do **not** accept general properties of alpha*
*do **not** accept general answers in terms of size / density / mass etc*

1

(b) (i) 15 (hours)

accept any answer between 14.8 and 15.2 inclusive

1

(ii) 15 (hours) or their (b) (i)

1

(c) (i) americium-241 has a long half life

1

(ii) any **one** from:

- alpha (particles) are harmful to …

accept radiation / radioactive material is harmful to …
accept specific example of harm
eg can cause cancer
accept radiation is poisonous if ingested / inhaled
*do **not** accept it is poisonous / in case of leakage*

- so they dispose of it safely / appropriately

- so they don't break it open / open it
  *accept do **not** touch the radioactive source*

- so they can make a choice about having a radioactive source (in the house)
  it = radioactive material

1

[7]

Q30.

(a) (i) gamma hardly ionises the air
accept does not ionise
accept gamma radiation is not charged
*do **not** accept answers in terms of danger of gamma or other properties*

1

(ii) half-life (too) short
accept need frequent replacement 'it' refers to curium-242

1

(iii) (two) fewer neutrons
accept different numbers of neutrons if a number is specified it must be correct
*do **not** accept more neutrons unless curium-244 is specified*

1

(b) (i) gamma
accept correct symbol

1

(ii) both absorbed by the metal / steel / weld
only scores if (b)(i) is correct
accept cannot pass through the metal / steel / weld

1

(c) (i) 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

1

(ii) 2.7 (days)

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

2

[9]

Q31.

(a)

Particle	Relative Mass	Relative charge
Proton	1	
Neutron		0

accept one, accept +1
*do **not** accept –1*

1

accept zero
*do **not** accept no charge/ nothing/neutral unless given with 0*

1

(b) equal numbers/amounts of protons and electrons

1

protons and electrons have equal but opposite charge

accept protons charge +1 and electron charge –1
accept (charge) on proton cancels/balances (charge) on electron
accept positive (charges) cancel out the negative(charges)
neutrons have no charge is neutral
*do **not** accept total charge of protons, electrons (and neutrons) is 0 unless qualified*

1

(c) (i) (3) fewer neutrons

accept lower/ smaller mass number
*do **not** accept different numbers of neutrons*
any mention of fewer/more protons/electrons negates mark
accept answers in terms of U-238 providing U-238 is specifically stated i.e. U-238 has (3) more neutrons

1

(ii) neutron

1

(iii) (nuclear) fission

accept fision
*do **not** accept any spelling that may be taken as fusion*

1

[7]

Q32.

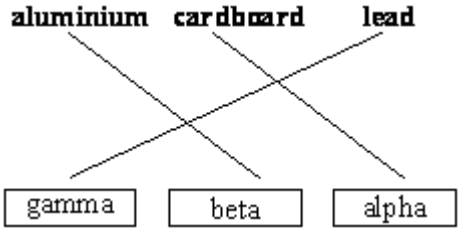
(a) (i) **P**

1

(ii) **Q**

1

(b) 3 lines correct



*allow **1** mark for 1 correct line*
two lines drawn from any source or box – both incorrect

2

(c) (i) **K**

1

(ii) 56

accept 50 – 60 inclusive

1

(iii) **K**

1

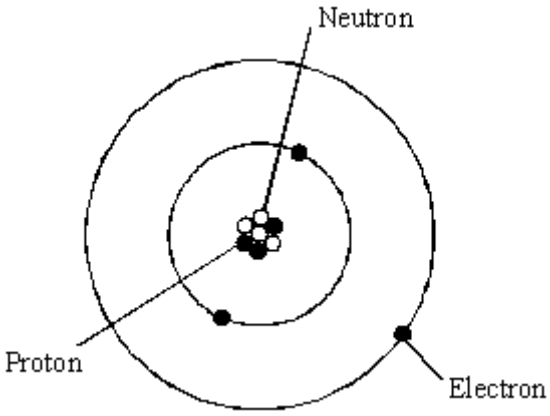
(iv) to inject... tracer

1

[8]

Q33.

(i) each correct label scores 1 mark



3

(ii) neutron

1

(iii) 7

1

number of protons and neutrons **or** number of nucleons or number of particles in the nucleus

accept number of particles in the centre only if first answer = 7

1

[6]

Q34.

(a) **Y** and **Z**

1

they have the same number of protons **or** same atomic number

*accept they have the same number of electrons **or** same number of protons **and** electrons*
allow only different in number of neutrons N.B. independent marks

1

(b) **Quality of written communication**

*for correct use of terms underlined in B **or** C*

Q ✓ *Q* ✗

1

A – alpha particle passes straight through the empty space of the atom **or** it is a long way from the nucleus

*describes 3 tracks correctly for **2** marks*
*describes 2 or 1 track correctly for **1** mark*

B – alpha particle <u>deflected</u> / <u>repelled</u> / <u>repulsed</u> by the (positive) <u>nucleus</u>

C – alpha particle heading straight for the <u>nucleus</u> is <u>deflected</u> / <u>repelled</u> / <u>repulsed</u> backwards

*do **not** accept hits the nucleus*
*do **not** accept answers referring to refraction*
*do **not** accept answers in terms of reflected backwards unless qualified in terms of repulsion*

mention of difference in charge on nucleus negates that track

max 2

[5]

Q35.

(a) (i) both lose <u>2</u> protons and (<u>2</u>) neutrons

accept changes by 2 protons and 2 neutrons

1

(ii) different number of protons (in the nucleus)

accept different atomic number
*do **not** accept different number of protons and neutrons or different mass number*
ignore electrons

1

(iii) gamma involves no change in the number of protons (in the nucleus) **or** gamma is a wave (not a particle)

*do **not** accept number of neutrons and / or protons*
ignore electrons

1

(b) (i) water because

*both material **and** reason required*

for all energy values the thickness of water needed to absorb (90% of) the radiation is more than the other materials

accept thickness of water required is always more than the other materials

1

(ii) 6

*allow **1** mark for obtaining both correct values 72 **and** 12 from graph*
*allow **1** mark for incorrect values 71 and / or 11 from graph evaluated correctly*

2

(c) any **three** from:

may be scored on annotated diagram provided not negated elsewhere

- most (alpha) particles passed undeflected / straight through the gold
- suggesting most of the atom is empty (space)
- a few (alpha) particles scattered / deflected through (very) large angles

accept repelled
*do **not** accept reflected / rebound / bounce back*

- suggesting a concentrated / small nucleus
- nucleus is positive because it repels the positive (alpha) particles

*no reference to experiment, maximum **1** mark*

3

[9]