

# Atoms and Isotopes

## Question Paper 1

Level	GCSE (9-1)
Subject	Combined Science: Trilogy - Physics
Exam Board	AQA
Topic	6.4 Atomic Structure
Sub-Topic	Atoms and Isotopes
Difficulty Level	Gold Level
Booklet	Question Paper 1

**Time Allowed:** 57 minutes

**Score:** /54

**Percentage:** /100

**Grade Boundaries:**

**Q1.** 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.



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Technetium-99 emits gamma radiation.

(a) What is gamma radiation?

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(1)

(b) Explain why a gamma emitter is used.

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(2)

(c) Technetium-99 has a **half-life** of 6 hours.

Give the meaning of the term **half-life**.

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(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.

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(3)

- (e) Some of the hospital equipment may also be irradiated during treatment.

Describe how equipment becomes irradiated.

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(1)

- (f) Why is irradiated equipment not hazardous?

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(1)

(Total 9 marks)

**Q2.** 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 .....

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(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.

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(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.

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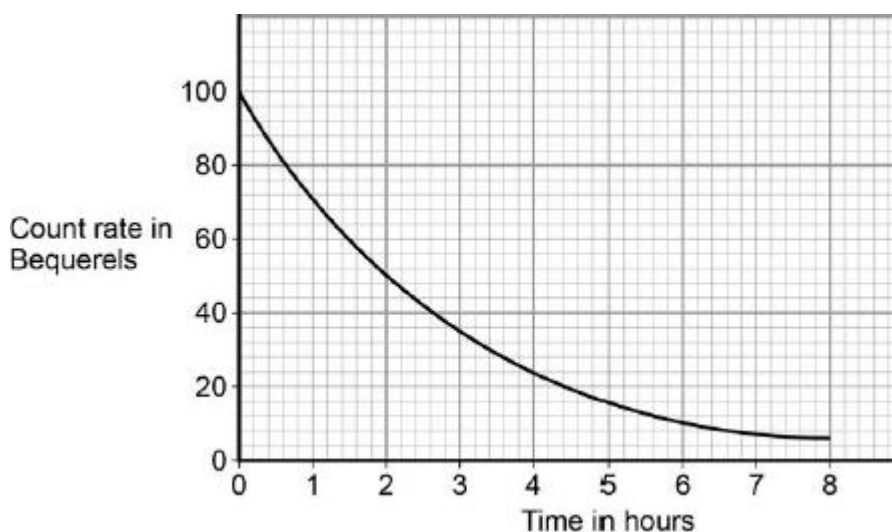
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(4)

(Total 9 marks)

**Q3.** 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.

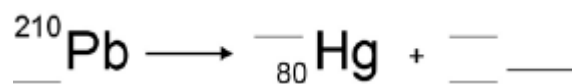
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Time = ..... hours

(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.



(3)

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

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(5)

(Total 10 marks)

**Q4.** 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 .....

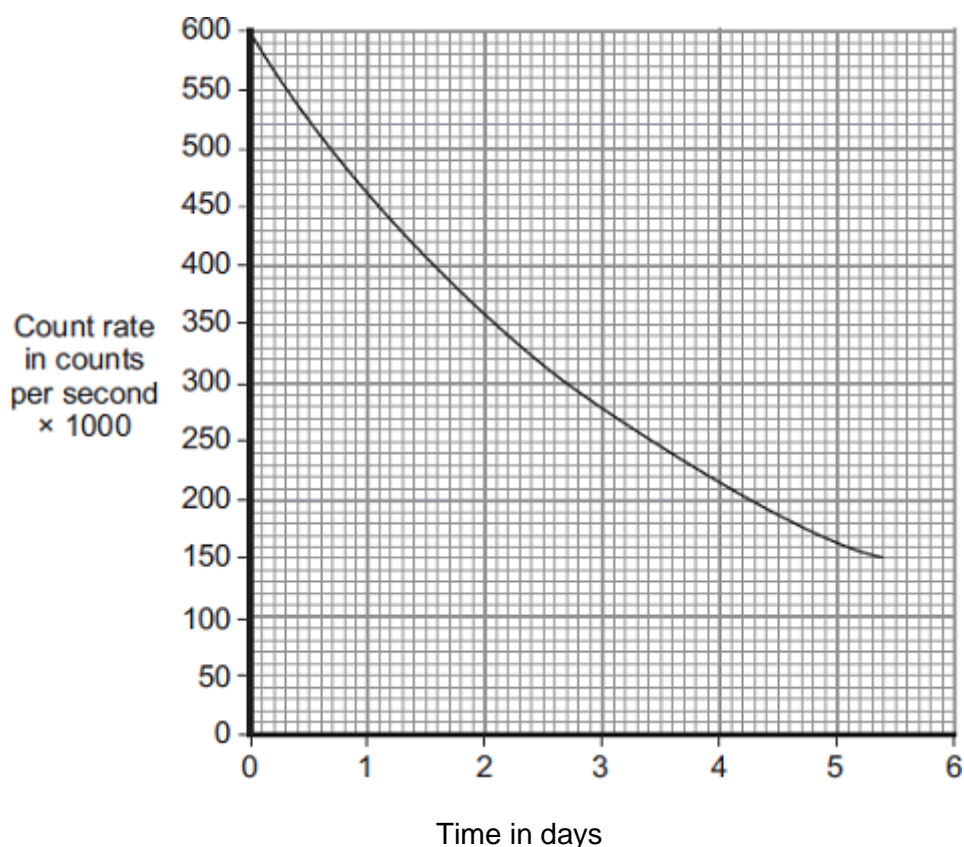
The atoms from different isotopes of gold have different numbers of .....

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.

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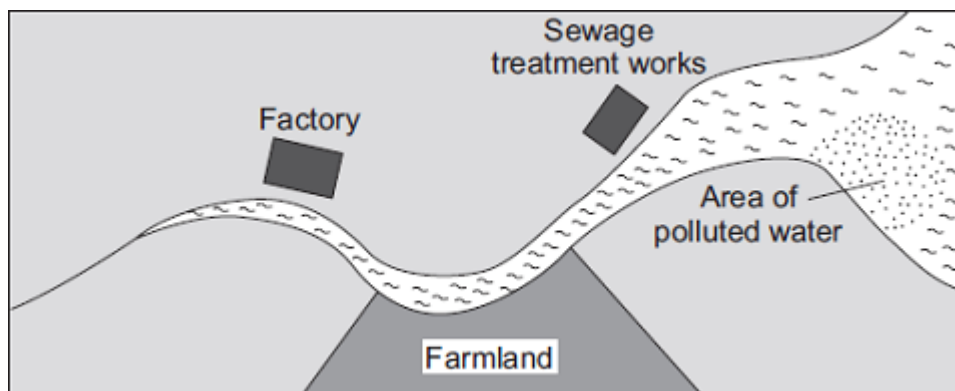
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Half-life = ..... days

(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.

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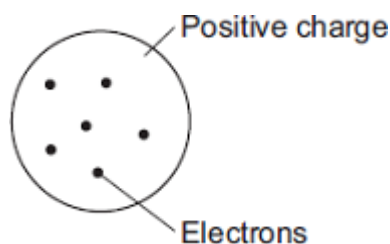
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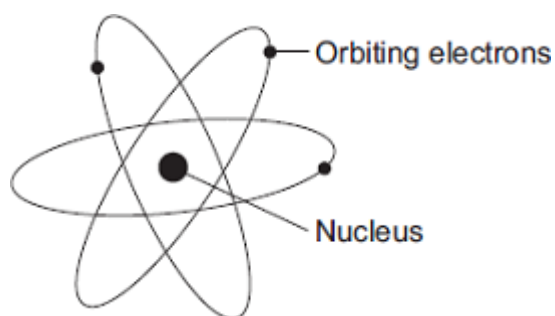
(2)  
(Total 7 marks)

**Q5.** 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.

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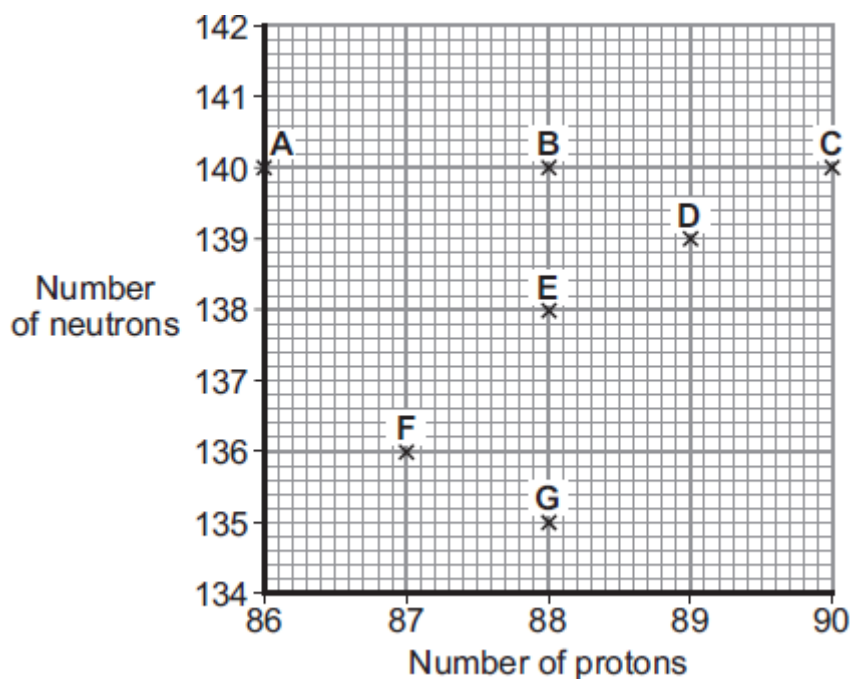
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(Total 4 marks)

- Q6.** (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?

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Give a reason for your answer.

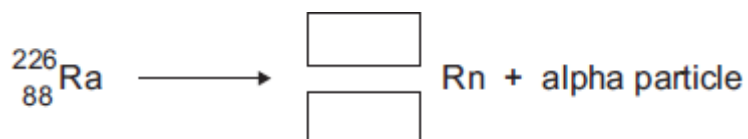
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(2)

- (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.



- (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.

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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.

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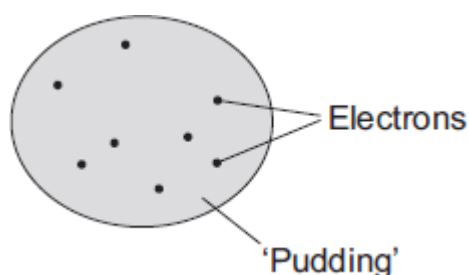
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(1)

(Total 9 marks)

**Q7.** The 'plum pudding' model of the atom was used by scientists in the early part of the 20th century to explain atomic structure.



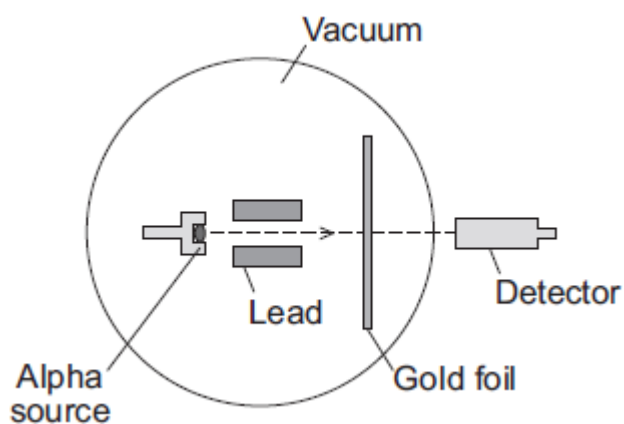
- (a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall.

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  $4^\circ$ .

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  $90^\circ$ .

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

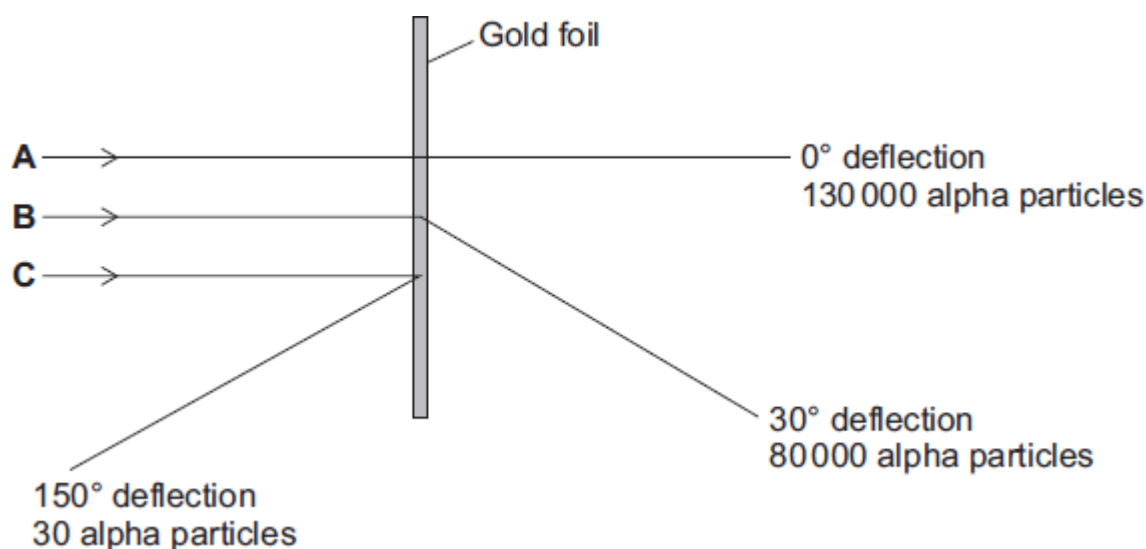
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(1)

- (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?

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(1)  
(Total 6 marks)