

Atoms and Nuclear Radiation

Question Paper 1

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

Time Allowed: 60 minutes

Score: /57

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

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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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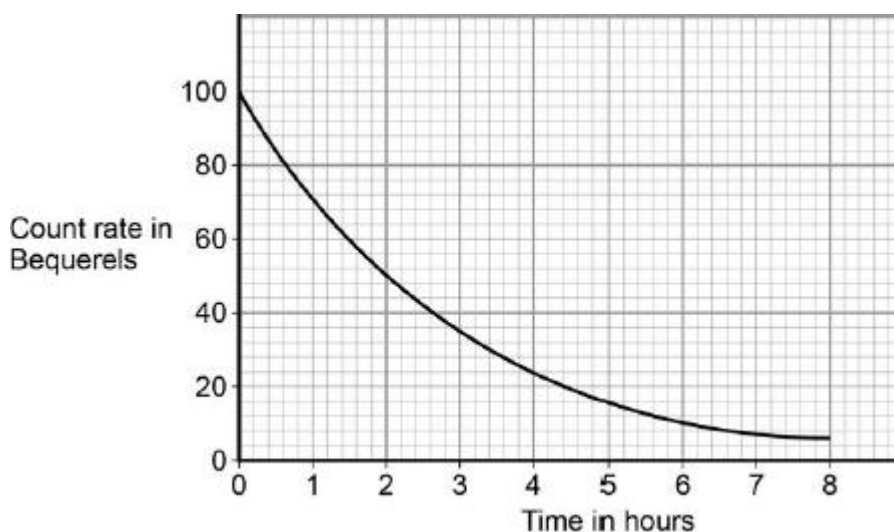
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(4)

(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.

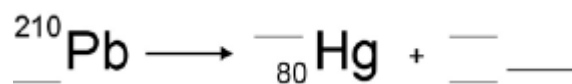
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Time = hours

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

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

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

- (b) Complete the sentence.

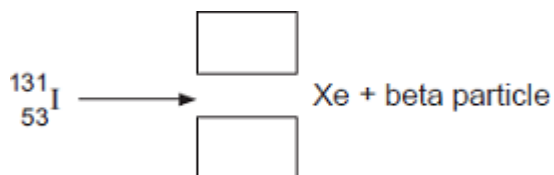
The number of protons in an atom is called the proton number or the number.

(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.

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..... 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.

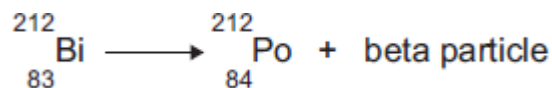
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(2)

(Total 8 marks)

- Q5.(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.



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

What is the *mass number* of an atom?

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(1)

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

Explain why not.

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(2)

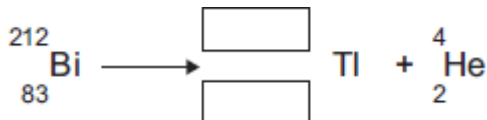
- (b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

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



- (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.



(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.

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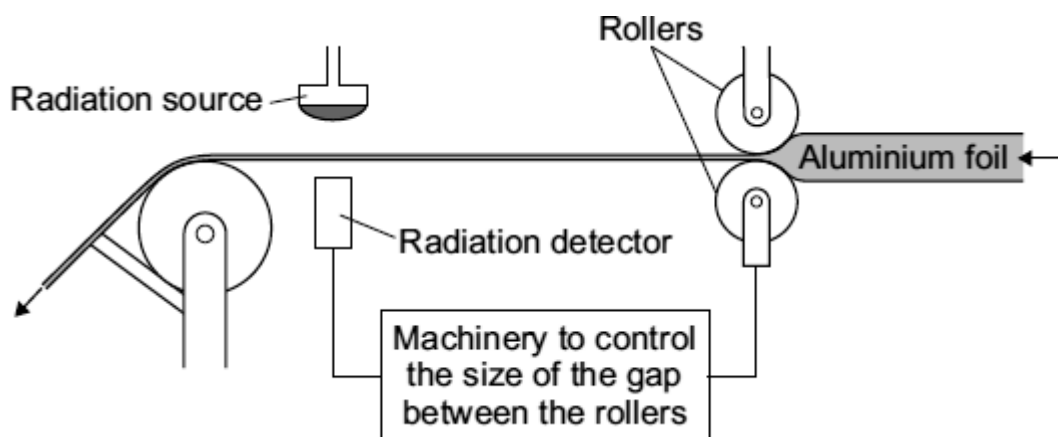
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(2)

(Total 7 marks)

- Q6.** 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?

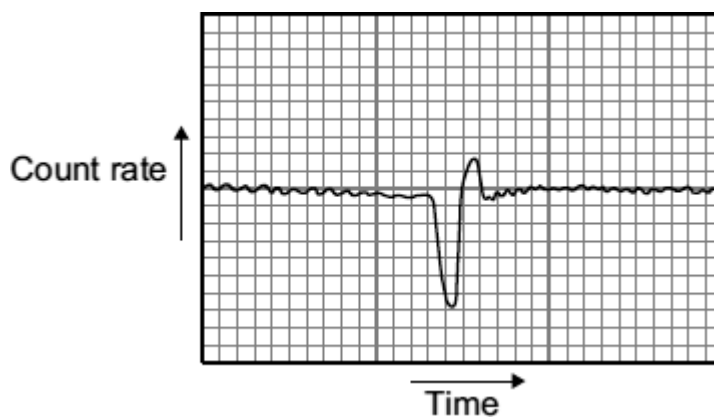
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Explain why each of the other two types of source would **not** be suitable.

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(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.

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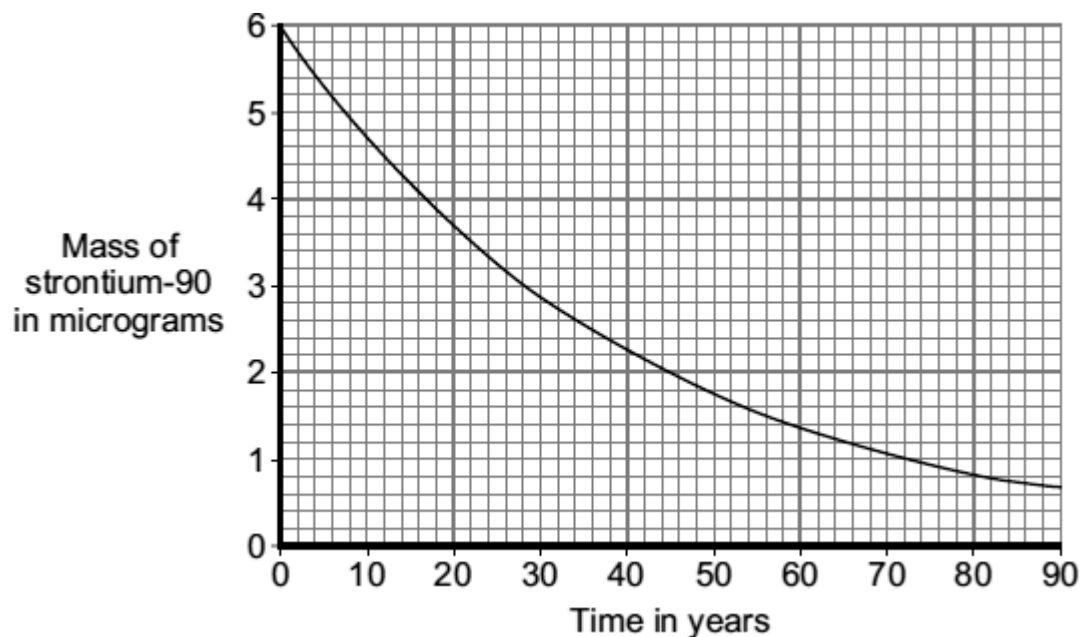
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(2)

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



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

After how many years will the source need replacing?

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

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Number of years =

(2)

(Total 7 marks)

- Q7.** (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?

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(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?

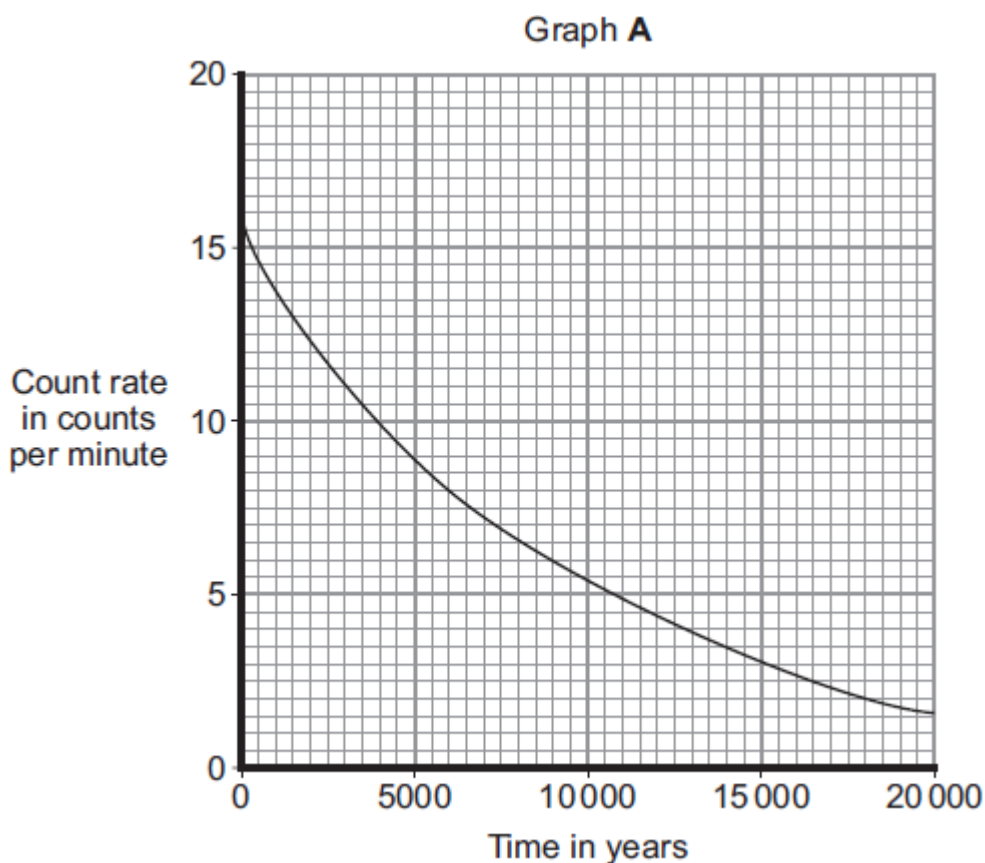
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(1)

- (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.



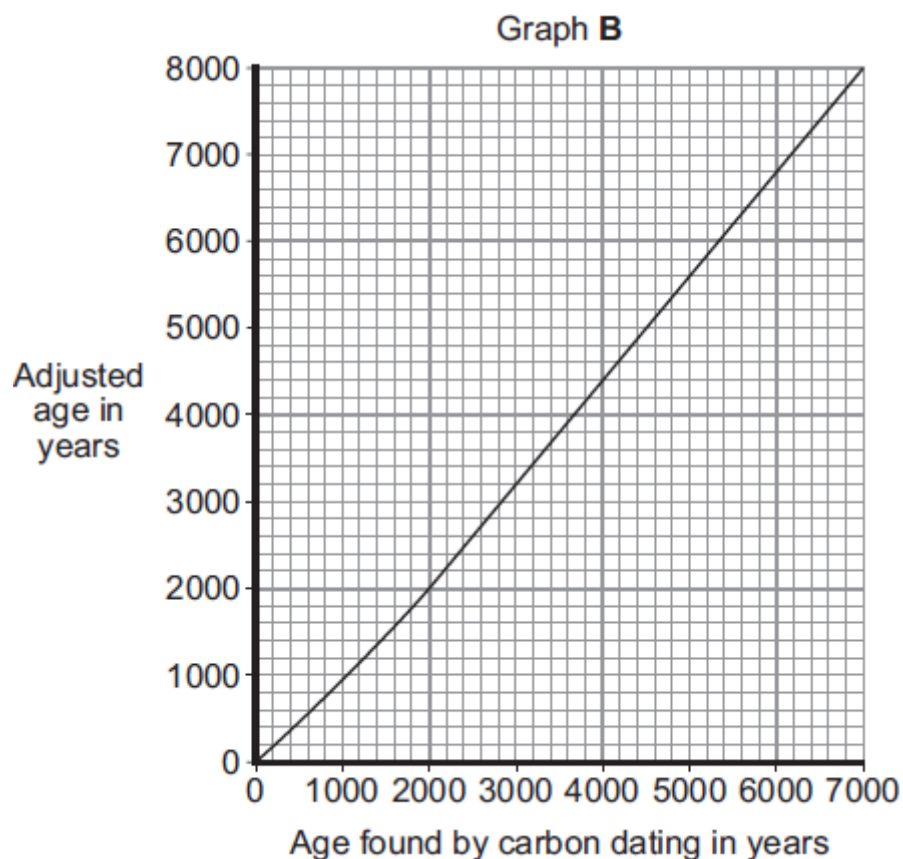
- (i) Lake Cuicocha in Ecuador was formed after a volcanic eruption. Carbon taken from a tree killed by the eruption was found to have a count rate of 10.5 counts per minute. At the time of the eruption, the count rate would have been 16 counts per minute.

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.

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Maximum age of Lake Cuicocha = years

(2)
(Total 7 marks)