

GCSE Physics (9 – 1)

Nuclear Equations

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/4
2	/8
3	/9
4	/11
5	/10
6	/9
Total	/51
%	
Grade	

Information

- The maximum mark for this paper is 51 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. Just like chemical equations show us how atoms rearrange in a chemical reaction, nuclear equations show us how the nucleus of an atom changes during radioactive decay.

For each of the following questions **circle** the letter of the correct answer.

- a) Uranium-238 ($^{238}_{92}\text{U}$) undergoes alpha decay to become an isotope of Thorium (Th).

What are the mass number and atomic number of the Thorium nucleus produced?

	Mass number	Atomic number
A	238	93
B	234	92
C	234	90
D	242	94

(1 mark)

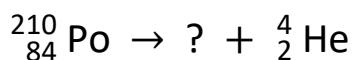
- b) Carbon-14 ($^{14}_6\text{C}$) decays into Nitrogen-14 ($^{14}_7\text{N}$) by emitting a beta particle.

Which symbol correctly represents a beta particle in a nuclear equation?

A	B	C	D
^4_2He	$^0_{-1}\beta$	$^0_0\gamma$	^1_0n

(1 mark)

- c) Look at the incomplete nuclear equation below for the decay of Polonium-210:



Which isotope correctly fills in the missing gap to balance the equation?

A	B	C	D
$^{206}_{82}\text{Pb}$	$^{214}_{86}\text{Rn}$	$^{210}_{83}\text{Bi}$	$^{206}_{84}\text{Po}$

(1 mark)

- d) A highly excited nucleus of Cobalt-60 ($^{60}_{27}\text{Co}$) emits a gamma ray.

What happens to the mass number and the atomic number of the nucleus after this emission?

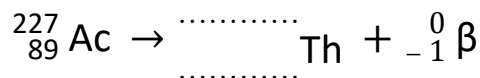
- A** The mass number decreases by 4 and the atomic number decreases by 2.
- B** The mass number stays the same and the atomic number increases by 1.
- C** The mass number decreases by 1 and the atomic number remains the same.
- D** Both the mass number and the atomic number remain exactly the same.

(1 mark)

(Total for Question 1 is 4 marks)

2. Actinium-227 ($^{227}_{89}\text{Ac}$) is an unstable, radioactive isotope.
Actinium-227 decays to form an isotope of Thorium (Th).

a) Complete the incomplete nuclear equation below for this decay.



(2 marks)

b) Identify the type of decay that Actinium-227 undergoes.

.....
(1 mark)

The Thorium nucleus produced in part (a) is also unstable.

It decays by emitting an **alpha** particle to form an isotope of Radium (Ra).

c) Write the fully balanced **nuclear equation** for this decay.

.....
(3 marks)

d) Following radioactive decay, a nucleus will often emit gamma radiation to release excess energy.

Explain why the emission of a gamma ray does not change the mass number or the atomic number of the nucleus.

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(2 marks)

(Total for Question 2 is 8 marks)

3. Iodine-131 ($^{131}_{53}\text{I}$) is radioactive. It has a half-life of 8 days.

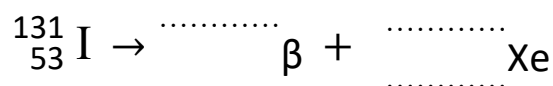
a) State the composition of the nucleus of iodine-131.

.....
.....

(2 marks)

Iodine-131 decays by β -decay to an isotope of xenon, Xe.

b) Complete the equation for the decay of iodine-131.



(3 marks)

The count rate from a sample of iodine-131 is 480 counts/s.

c) Predict the count rate from the sample after 24 days.

count rate = ...

(2 marks)

d) State **two** of the social, economic or environmental issues involved in the storage of radioactive materials with very long half-lives.

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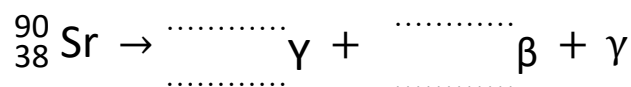
(2 marks)

(Total for Question 3 is 9 marks)

4. The isotope strontium-90 ($^{90}_{38}\text{Sr}$) is radioactive.

a) Strontium-90 decays to an isotope of yttrium (Y).

i. Complete the equation for this decay.



(3 marks)

ii. Identify the types of radioactive decay that are shown by the equation above.

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(2 marks)

iii. Explain why this γ -emission does not affect the numbers in the equation in (a)(i).

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(2 marks)

iv. Suggest **one** reason why a nucleus of strontium-90 is unstable.

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(1 mark)

b) Strontium-90 is often produced in nuclear reactors alongside heavier radioactive isotopes, such as Plutonium-239 ($^{239}_{94}\text{Pu}$).

Plutonium-239 decays by emitting an alpha (α) particle to form an isotope of Uranium (U).

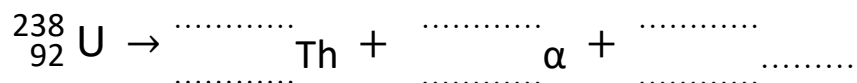
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(3 marks)

(Total for Question 4 is 11 marks)

5. Uranium-238 ($^{238}_{92}\text{U}$) is a naturally occurring radioactive isotope that undergoes a long series of decays to eventually become a stable atom.

a) Complete the nuclear equation for this decay.



(4 marks)

- b) The Thorium nucleus produced in part (a) is also unstable. It decays into Protactinium (Pa) by emitting a beta (β) particle.

Write the fully balanced nuclear equation for this decay.

.....

(3 marks)

- c) Later in the decay chain, a nucleus emits one alpha particle, followed immediately by two beta particles.

A student states: "*After these three decays, the nucleus will be an isotope of the original element.*"

Explain why the student is correct. You may use numbers to support your answer.

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(3 marks)

(Total for Question 5 is 10 marks)

6. Radioactive isotopes often undergo multiple decays or nuclear reactions.
- a) An unknown radioactive nucleus, X, has a mass number of A and an atomic number of Z. It undergoes one α -decay followed immediately by one β -decay to form a new nucleus, Y.
- Write the mass number and atomic number of nucleus Y in terms of A and Z.

Mass number of Y = ...

Atomic number of Y = ...

(2 marks)

- b) Radon-222 ($^{222}_{86}\text{Rn}$) decays through a series of steps to become the stable isotope Lead-210 ($^{210}_{82}\text{Pb}$).

During this sequence, the nucleus emits a mixture of alpha (α) and beta (β) particles.

Calculate the exact number of alpha particles and beta particles emitted in this decay chain.

You must show your working.

Number of α particles = ...

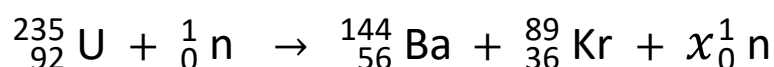
Number of β particles = ...

(4 marks)

- c) Nuclear equations are also used to show artificial reactions, such as nuclear fission.

When a nucleus of Uranium-235 absorbs a neutron (^1_0n), it splits into Barium-144, Krypton-89, and a number of spare neutrons.

Complete the balanced equation for this fission reaction and determine the number of spare neutrons produced (represented by the letter x).



Value of Number of x particles = ...

(3 marks)

(Total for Question 6 is 9 marks)