

Nuclear Physics

Question paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Physics on the move
Sub Topic	Nuclear Physics
Booklet	Question paper

Time Allowed: 46 minutes

Score: /38

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The number of neutrons in a nucleus of ${}^{197}_{79}\text{Au}$ is

- A 276
- B 197
- C 118
- D 79

(Total for Question 1 = 1 mark)

2 A positron enters a particle accelerator. As it emerges from the accelerator its mass is measured to be 3.8×10^{-29} kg.

It can be concluded that the positron

- A has become a different particle.
- B is travelling in a circle.
- C is travelling at close to the speed of light.
- D is travelling at a non-relativistic speed.

(Total for Question 2 = 1 mark)

3 Which of the following is **not** a valid conclusion from Rutherford's alpha scattering experiment?

- A The nucleus contains most of the mass of the atom.
- B The nucleus contains protons.
- C The nucleus must be charged.
- D The nucleus is very small compared to the atom.

(Total for Question 3 = 1 mark)

4 A radioactive isotope of carbon is $^{14}_6\text{C}$.

Select the row in the table that correctly identifies a neutral atom of this isotope.

		Neutrons	Protons	Electrons
<input checked="" type="checkbox"/>	A	8	6	8
<input checked="" type="checkbox"/>	B	6	8	6
<input checked="" type="checkbox"/>	C	6	8	8
<input checked="" type="checkbox"/>	D	8	6	6

(Total for Question 4 = 1 mark)

5 Between 1909 and 1911 Rutherford’s alpha particle scattering experiment provided evidence for the nuclear model of the atom. Alpha particles were fired at a thin gold foil and their paths observed.

(a) Describe the observations from the alpha particle scattering experiment.

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(b) An alpha particle approaches a gold nucleus. It reaches a distance of 4.5×10^{-14} m from the gold nucleus. Calculate the force between the alpha particle and the gold nucleus.

proton number for gold = 79

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Force =

(Total for Question 5 = 6 marks)

6 An electron is accelerated through a potential difference of 3000 V.

Calculate the de Broglie wavelength associated with this electron.

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Wavelength =

(Total for Question 6 = 4 marks)

7 The equation for β^+ decay is

$$p \rightarrow n + e^+ + \nu_e$$

(a) Using information in the table, describe how a proton changes into a neutron.

Type of quark	Charge / e
u	+2/3
d	-1/3

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(b) With reference to the charges of the particles, show that this decay is possible.

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- (c) The kinetic energy of the positron is 1.58 MeV. It annihilates with a stationary electron and two photons of equal energy are emitted.

Calculate the wavelength of the emitted photons.

mass of stationary electron = 0.511 MeV/c²

mass of stationary positron = 0.511 MeV/c²

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Wavelength =

- (d) Linear accelerators (linacs) can produce electrons with energies up to 20 GeV.

- (i) Calculate the de Broglie wavelength associated with 20 GeV electrons.
At these energies, the energy and momentum of a particle are connected by the relativistic equation $E = pc$.

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Wavelength =

- (ii) Experiments have been carried out where these 20 GeV electrons are aimed at a hydrogen target which consists of protons. Suggest, with reasons, what happens to the path of the electrons.

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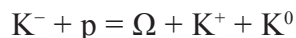
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(Total for Question 7 = 13 marks)

- 8 (a) In 1962, the existence of a particle with strangeness -3 was predicted. Two years later it was identified in an experiment involving the interaction of a proton and a K^- meson which has a strangeness of -1 . The new particle was given the name omega, Ω .

The interaction, which conserves strangeness, was



- (i) Deduce with reasons the charge on the Ω and whether it is a baryon or a meson.

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- (ii) Using the information given in the table below deduce the quark composition of each of the particles involved.

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Type of quark	Charge/ e	Strangeness
u	$+2/3$	0
d	$-1/3$	0
s	$-1/3$	-1

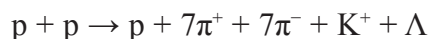
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(b) In another experiment, involving a head-on collision between two protons, the following interaction was observed.



mass of p = 938 MeV/c²

mass of π^+ and π^- = 140 MeV/c²

mass of K⁺ = 494 MeV/c²

mass of Λ = 1115 MeV/c²

(i) Calculate the minimum kinetic energy of each proton, in MeV, for this interaction to occur.

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Minimum kinetic energy =

(ii) This interaction would **not** have taken place if one of the protons had been stationary and the other had twice the calculated value of kinetic energy.

Explain why.

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(Total for Question 8 = 11 marks)