

# Nuclear Physics

## Question paper

<b>Level</b>	International A Level
<b>Subject</b>	Physics
<b>Exam Board</b>	Edexcel
<b>Topic</b>	Physics on the move
<b>Sub Topic</b>	Nuclear Physics
<b>Booklet</b>	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

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(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  $3.8 \times 10^{-29}$  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.

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(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.

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(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

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(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  $4.5 \times 10^{-14}$  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)**

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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)**

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7 The equation for  $\beta^+$  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/c<sup>2</sup>

mass of stationary positron = 0.511 MeV/c<sup>2</sup>

(4)

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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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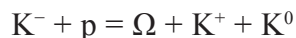
**(Total for Question 7 = 13 marks)**

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- 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,  $\Omega$ .

The interaction, which conserves strangeness, was



- (i) Deduce with reasons the charge on the  $\Omega$  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.

(4)

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

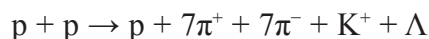
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(b) In another experiment, involving a head-on collision between two protons, the following interaction was observed.



mass of p = 938 MeV/c<sup>2</sup>

mass of  $\pi^+$  and  $\pi^-$  = 140 MeV/c<sup>2</sup>

mass of K<sup>+</sup> = 494 MeV/c<sup>2</sup>

mass of  $\Lambda$  = 1115 MeV/c<sup>2</sup>

(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)**