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 $^{197}_{79}Au$ is

☒ **A** 276

☒ **B** 197

☒ **C** 118

☒ **D** 79

(Total for Question 1 = 1 mark)

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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)

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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)

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4 A radioactive isotope of carbon is $^{14}_{6}C$.

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

		Neutrons	Protons	Electrons
☒	**A**	8	6	8
☒	**B**	6	8	6
☒	**C**	6	8	8
☒	**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.

(3)

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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

(3)

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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.

(4)

Wavelength = ...

(Total for Question 6 = 4 marks)

7 The equation for β^+ decay is

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

(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

(2)

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

(2)

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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^2
mass of stationary positron = 0.511 MeV/c^2

(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 $E = pc$.

(3)

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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.

(2)

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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

$$K^- + p = \Omega + K^+ + K^0$$

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

(2)

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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.

$$p + p \rightarrow p + 7\pi^+ + 7\pi^- + K^+ + \Lambda$$

mass of p = 938 MeV/c^2

mass of π^+ and π^- = 140 MeV/c^2

mass of K^+ = 494 MeV/c^2

mass of Λ = 1115 MeV/c^2

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

(3)

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.

(2)

(Total for Question 8 = 11 marks)