Surname

Other Names

Candidate Signature

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2010

Physics A   PHYA1

Unit 1   Particles, Quantum Phenomena and Electricity

Thursday 27 May 2010   1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Answer **all** questions in the spaces provided.

1   A $_{11}^{22}$Na nucleus decays, forming a new nucleus, by releasing a β^+ particle and one other particle which is difficult to detect.

1 (a)   Name the particle which is difficult to detect.

answer = ...
(1 mark)

1 (b)   Write down the proton number and the nucleon number of the new nucleus.

proton number ....

nucleon number ....
(2 marks)

1 (c)   Name the baryon and each of the leptons formed as a result of this decay.

baryon ....

lepton ....

lepton ....
(3 marks)

1 (d)   Give the quark structure for a neutron and a proton.

neutron ....

proton ....
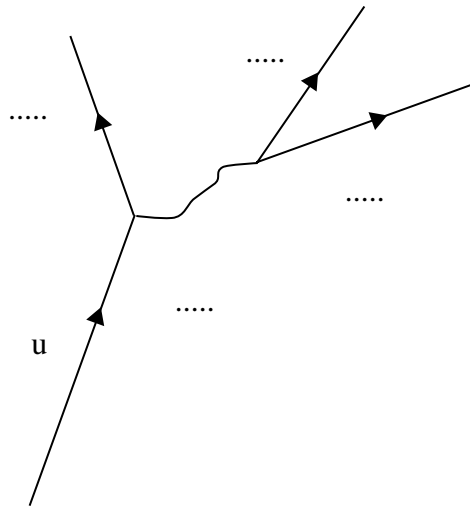*(1 mark)*

1 (e) Complete the following Feynman diagram so that it represents β^+ decay.

(3 marks)

10

Turn over for the next question

Turn over ▶

2 (a)   Describe how the strong nuclear force between two nucleons varies with the separation of the nucleons quoting suitable values for separation.

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(3 marks)

2 (b)   An unstable nucleus can decay by the emission of an *alpha particle*.

2 (b) (i)   State the nature of an alpha particle.

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(1 mark)

2 (b) (ii)   Complete the equation below to represent the emission of an α particle by a $^{238}_{92}U$ nucleus.

$$^{238}_{92}U \rightarrow {}^{......}_{......}Th + {}^{......}_{......}\alpha$$
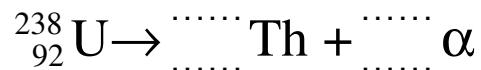
(2 marks)

2 (c) $^{238}_{92}$U decays in stages by emitting α particles and β⁻ particles, eventually forming $^{206}_{82}$Pb, a stable *isotope* of lead.

2 (c) (i) State what is meant by isotopes.

....

....

(2 marks)

2 (c) (ii) If there are eight alpha decays involved in the sequence of decays from $^{238}_{92}$U to $^{206}_{82}$Pb deduce how many β⁻ decays are involved.

answer = ...

(3 marks)

___
11

Turn over for the next question

Turn over ▶

3   When a clean metal surface in a vacuum is irradiated with ultraviolet radiation of a certain frequency, electrons are emitted from the metal.

3 (a) (i) Explain why the kinetic energy of the emitted electrons has a maximum value.

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(2 marks)

3 (a) (ii) Explain with reference to the work function why, if the frequency of the radiation is below a certain value, electrons are not emitted.

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(2 marks)

3 (a) (iii) State a unit for work function.

....
(1 mark)

3 (b)   Light energy is incident on each square millimetre of the surface at a rate of $3.0 \times 10^{-10}\,\text{J s}^{-1}$. The frequency of the light is $1.5 \times 10^{15}\,\text{Hz}$.

3 (b) (i) Calculate the energy of an incident photon.

answer = ... J
(2 marks)

3 (b) (ii) Calculate the number of photons incident per second on each square millimetre of the metal surface.

answer = ...

(2 marks)

3 (c) In the wave theory model of light, electrons on the surface of a metal absorb energy from a small area of the surface.

3 (c) (i) The light striking the surface delivers energy to this small area at a rate of $3.0 \times 10^{-22} \, \text{J s}^{-1}$.
The minimum energy required to liberate the electron is $6.8 \times 10^{-19} \, \text{J}$.
Calculate the minimum time it would take an electron to absorb this amount of energy.

answer = ... s

(1 mark)

3 (c) (ii) In practice the time delay calculated in part c (i) does not occur. Explain how this experimental evidence was used to develop the particle model for the behaviour of light.

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(2 marks)

12

Turn over ▶

4 Electrons exhibit *wave properties*.

4 (a) What phenomenon can be used to demonstrate the wave properties of electrons? Details of any apparatus used are not required.

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....

(1 mark)

4 (b) Calculate the de Broglie wavelength of electrons travelling at a speed of $4.50 \times 10^5 \ \text{m s}^{-1}$.

answer = ... m

(2 marks)

4 (c) The muon has a mass equal to 207 times the mass of an electron.
Calculate the speed of muons with the same de Broglie wavelength as the electrons in part (b).

answer = ... m s^{-1}

(3 marks)

6

5 (a) A student wishes to investigate how the resistance of a thermistor changes with temperature.

5 (a) (i) Draw a labelled diagram of a suitable circuit that would enable the student to measure the resistance of the thermistor.

(2 marks)

5 (a) (ii) Describe the procedure the student would follow in order to obtain accurate and reliable measurements of the resistance of the thermistor at different temperatures.

The quality of your written communication will be assessed in this question.

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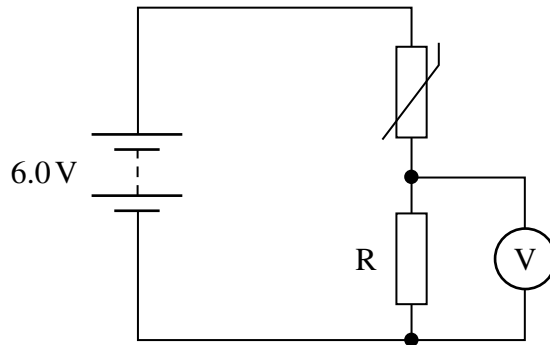
(6 marks)

Question 5 continues on the next page

Turn over ▶

5 (b) **Figure 1** shows a thermistor connected in series with a resistor, R, and battery of emf 6.0 V and negligible internal resistance.

Figure 1

When the temperature is 50 °C the resistance of the thermistor is 1.2 kΩ. The voltmeter connected across *R* reads 1.6 V.

5 (b) (i) Calculate the pd across the thermistor.

answer = ... V

(1 mark)

5 (b) (ii) Calculate the current in the circuit.

answer = ... A

(1 mark)

5 (b) (iii) Calculate the resistance of R quoting your answer to an appropriate number of significant figures.

answer = ... Ω

(2 marks)

5 (c) State and explain the effect on the voltmeter reading if the internal resistance of the battery in the circuit in part (b) was not negligible.

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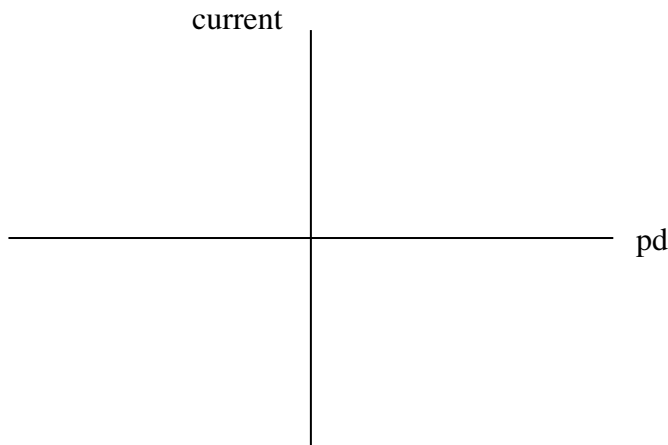*(2 marks)*

14

Turn over for the next question

Turn over ▶

6 (a)   A semiconducting diode is an example of a *non-ohmic* component. State what is meant by a non-ohmic component.

....

....
(1 mark)

6 (b)   A filament lamp is also an example of a non-ohmic component.

6 (b) (i)   Sketch on the axes below the current-voltage characteristic for a filament lamp.

current

pd

(2 marks)

6 (b) (ii)   State, with reference to the current-voltage characteristic you have drawn, how the resistance of the lamp changes as the pd across its terminals changes.

....

....
(1 mark)

6 (c)   A filament lamp has a power rating of 36 W when there is a pd across its terminals of 12 V.

6 (c) (i)   Calculate the resistance of the filament when the pd across its terminals is 12 V.

answer = ... Ω
(2 marks)

6 (c) (ii) A student predicts that if the pd across the bulb is reduced to 6.0 V the power rating of the bulb would be 9.0 W. State and explain how in practice the power rating will be slightly different from this value.

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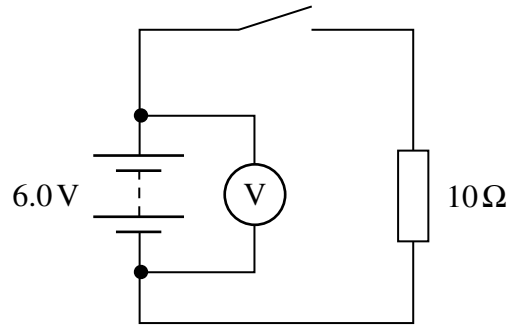
(3 marks)

9

Turn over for the next question

7   A battery is connected to a $10\,\Omega$ resistor as shown in **Figure 2**. The emf (electromotive force) of the battery is 6.0 V.

Figure 2

7 (a) (i)   Define the emf of a battery.

....

....

(1 mark)

7 (a) (ii)   When the switch is open the voltmeter reads 6.0 V and when it is closed it reads 5.8 V. Explain why the readings are different.

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(2 marks)

7 (b) Calculate the internal resistance of the battery.

answer = ... Ω

(3 marks)

7 (c) State and explain why it is important for car batteries to have a very low internal resistance.

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(2 marks)

END OF QUESTIONS

8

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED**