Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS PHYSICS A

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 24 May 2016 Morning Time allowed: 1 hour 15 minutes

Materials

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

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.
- Show all your working.

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.

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

1 The element uranium has an isotope $^{237}_{92}\mathrm{U}$.

1 (a) Explain what is meant by an isotope.

[2 marks]

1 (b) Determine the charge in coulomb of the $^{237}_{92}\mathrm{U}$ nucleus.

[2 marks]

charge = _____ C

1 (c) A positive ion of $^{237}_{92}\mathrm{U}$ has a charge of $+4.80 \times 10^{-19}$ C.

Determine the number of electrons in the ion.

[2 marks]

number of electrons = _____

1 (d) $^{237}_{92}\mathrm{U}$ decays by β^- emission to form an isotope of neptunium (Np).

Complete the equation for this decay.

[3 marks]

$$^{237}_{92}\mathrm{U} \longrightarrow \;^{\quad}_{\quad}\mathrm{Np} + \;^{\quad}_{\quad}\beta^- + \;\_\_\_\_$$

9

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2 The positive kaon (K^+) has a strangeness of +1.

2 (a) Which of the following is the quark composition of the positive kaon?
Tick (✓) the correct answer.

[1 mark]

	✓ if correct
$\bar{u}s$	
$uu\bar{s}$	
$u\bar{s}$	
$\bar{d}\bar{d}s$	

2 (b) The equation shows a possible decay of the positive kaon.

$$K^+ \longrightarrow \mu^+ + \nu_\mu$$

2 (b) (i) Show that lepton number is conserved in this decay.

[1 mark]

2 (b) (ii) State a quantity that is not conserved in this decay.

[1 mark]

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2 (b) (iii) Complete the following table using ticks to indicate correct classifications for each particle. The first column has been completed for you.

[3 marks]

	Charged	Hadron	Meson	Baryon	Lepton
K^+	✓				
μ^+	✓				
ν_μ					

2 (c) The positive kaon can also decay to form a π^+ and one other particle X.

Deduce the identity of X.

[3 marks]

9

Turn over for the next question

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3 Under certain conditions a photon may be converted into an electron and a positron.

3 (a) State the name of this process.

[1 mark]

_____

3 (b) For the conversion to take place the photon has to have an energy equal to or greater than a certain minimum energy.

3 (b) (i) Explain why there is a minimum energy.

[2 marks]

_____

_____

3 (b) (ii) Show that this minimum energy is about $1\ \mathrm{MeV}$.
Use values from the Data and Formulae Booklet.

[1 mark]

3 (b) (iii) Explain what happens to the excess energy when the photon energy is greater than the minimum energy.

[1 mark]

_____

_____

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3 (b) (iv) A photon has an energy of $1.0\ \text{MeV}$.

Calculate the frequency associated with this photon energy.
State an appropriate unit in your answer.

[4 marks]

frequency = _____ unit = _____

9

Turn over for the next question

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4 (a) The mercury atoms in a fluorescent tube are excited and then emit photons in the ultraviolet region of the electromagnetic spectrum.

4 (a) (i) Explain how the mercury atoms become excited.

[3 marks]

4 (a) (ii) Explain how the excited mercury atoms emit photons.

[2 marks]

4 (b) Explain how the ultraviolet photons in the tube are converted into photons in the visible part of the electromagnetic spectrum.

[2 marks]

7

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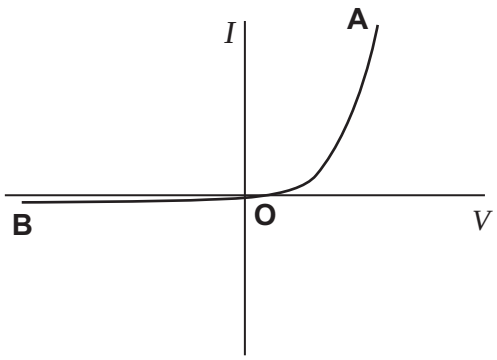
5 (a) The graph in **Figure 1** shows the current–voltage (I–V) characteristic curve for a semiconductor diode.

Figure 1



In order to produce this characteristic a student is given suitable equipment including an ammeter and a voltmeter.

5 (a) (i) Draw a labelled circuit diagram of the apparatus that the student could use to obtain the part of the characteristic from **O** to **A**.

[2 marks]

Question 5 continues on the next page

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5 (a) (ii) Describe how the student could use the circuit in part (a)(i) to obtain sufficient measurements to draw the part of the characteristic from **O** to **A**. Your account should include:

- details of how different readings of I and V are obtained
- a consideration of safety precautions when using the diode
- a discussion of the range and number of measurements that need to be taken
- a discussion of the advantages of using a data logger to obtain the measurements.

The quality of your written communication will be assessed in your answer.

[6 marks]

Question 5 continues on the next page

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5 (a) (iii) Suggest how the circuit you drew in part (a)(i) could be modified to obtain the characteristic from **O** to **B**.

[1 mark]

5 (b) The student wants to find out how the resistance of the diode changes between **O** and **A**.

5 (b) (i) Describe how the student could use the characteristic to determine how the resistance varies as the potential difference (pd) between **O** and **A** increases.

[2 marks]

5 (b) (ii) State how you would expect the resistance of the diode to vary as the pd increases.

[1 mark]

12

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6 An electric oven is connected to a 230 V root mean square (rms) mains supply using a cable of negligible resistance.

6 (a) (i) Calculate the peak-to-peak voltage of the mains supply.

[2 marks]

peak-to-peak voltage = _____ V

6 (a) (ii) The resistance of the heating element in the oven at its working temperature is 12 Ω.

Calculate the power dissipated by the heating element in the oven.
Give your answer to an appropriate number of significant figures.

[3 marks]

power = _____ W

Question 6 continues on the next page

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6 (b) In practice the resistance of the cable connecting the oven to the mains supply is not negligible. Each of the **two** wires connecting the heating element to the mains electricity supply has a length of $3.15\ \text{m}$. Each metre of wire has a resistance of $0.0150\ \Omega$.

6 (b) (i) Explain why the rms voltage across the heating element in the oven will be less than $230\ \text{V}$.

[2 marks]

_____

_____

_____

_____

6 (b) (ii) Calculate the rms voltage across the heating element in the oven when it is at its working temperature.

[3 marks]

rms voltage = _____ V

Do not write outside the box

6 (b) (iii) Calculate the average power wasted in the cable due to the heating effect of the electric current.

[2 marks]

average power = _____ W

6 (b) (iv) State **two** reasons why it is important that the cable has a low resistance.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

14

Turn over for the next question

7 **Figure 2** shows a circuit that includes an oscilloscope used to find the internal resistance r of a battery.

Figure 2

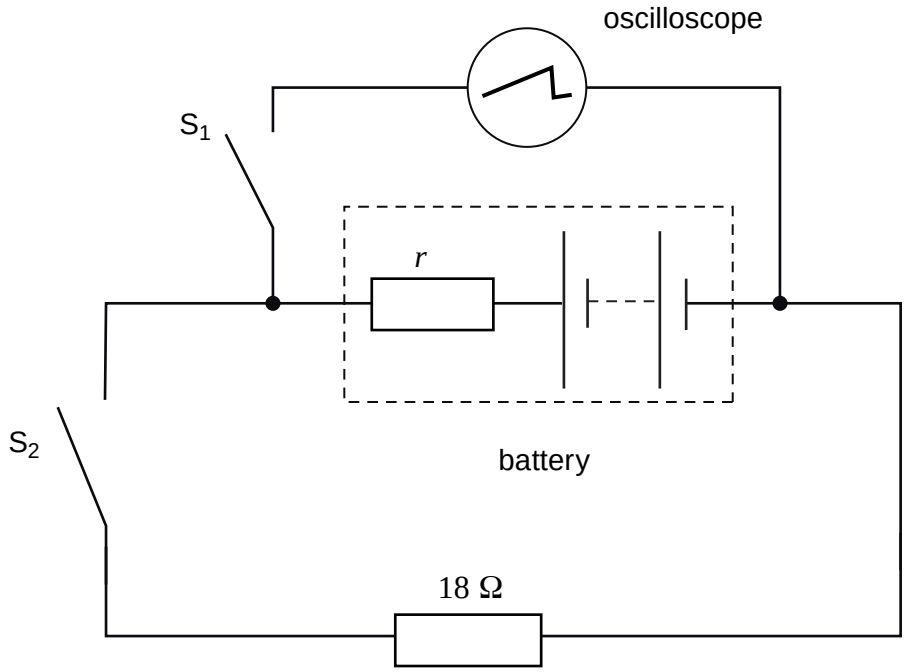
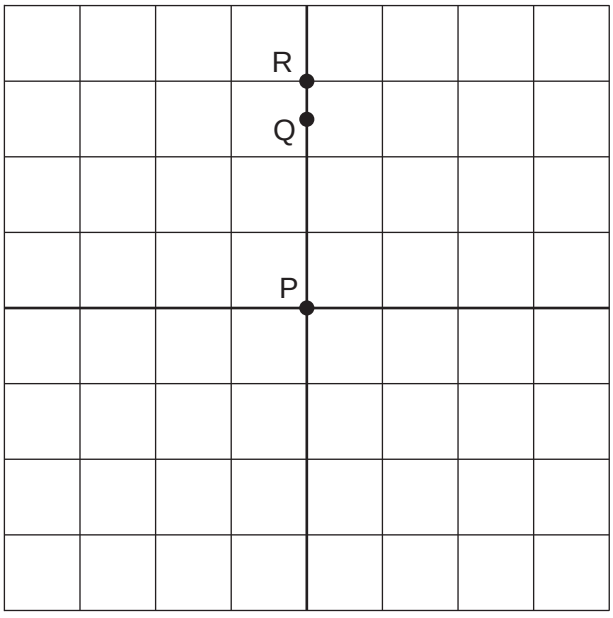


Figure 3 represents the screen of the oscilloscope. With switches S_1 and S_2 open, a bright spot is seen on the screen at P.

Figure 3



The vertical sensitivity of the oscilloscope is set at $2.0\ \text{V}$ per division.

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7 (a) Explain why the oscilloscope shows a bright spot rather than a horizontal line.

[1 mark]

_____

_____

7 (b) When switch S_1 is closed, the spot moves to R.

7 (b) (i) State the electrical property of the battery represented by the deflection PR.

[1 mark]

_____

_____

7 (b) (ii) Determine the value of the electrical quantity represented by the deflection PR.

[1 mark]

electrical quantity = _____

7 (c) With switch S_1 kept closed, switch S_2 is also closed. The spot moves to Q.

Explain why the spot moves from R to Q.

[3 marks]

_____

_____

_____

_____

_____

Question 7 continues on the next page

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7 (d) Calculate the current in the battery when both switches are closed.

[2 marks]

current = _____ A

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

[2 marks]

internal resistance = _____ Ω

10

END OF QUESTIONS

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