



Please write clearly in block capitals.

Centre number

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Candidate number

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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.



J U N 1 6 P H Y A 1 0 1

WMP/Jun16/E4

PHYA1

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ANSWER IN THE SPACES PROVIDED**



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

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

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

[2 marks]

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

[2 marks]

charge = _____ C

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

Determine the number of electrons in the ion.

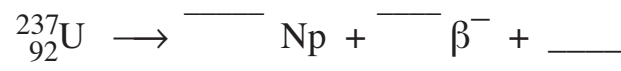
[2 marks]

number of electrons = _____

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

Complete the equation for this decay.

[3 marks]



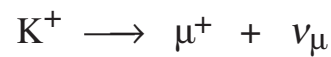
2 The positive kaon (K^+) has a strangeness of +1.

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.



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]



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

Turn over ►



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 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]



3 (b) (iv) A photon has an energy of 1.0 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

Turn over ►



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]

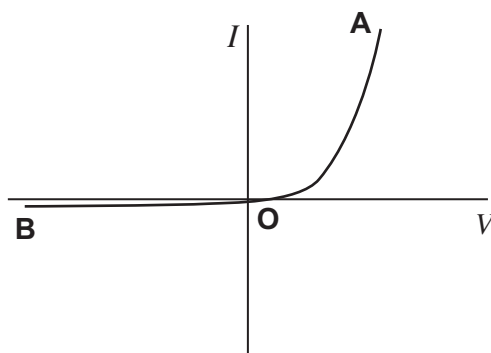
4 (b) Explain how the ultraviolet photons in the tube are converted into photons in the visible part of the electromagnetic spectrum.

[2 marks]



- 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

Turn over ►



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]



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

Turn over ►



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 m. Each metre of wire has a resistance of 0.0150Ω .

6 (b) (i) Explain why the rms voltage across the heating element in the oven will be less than 230 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



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

Turn over ►



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

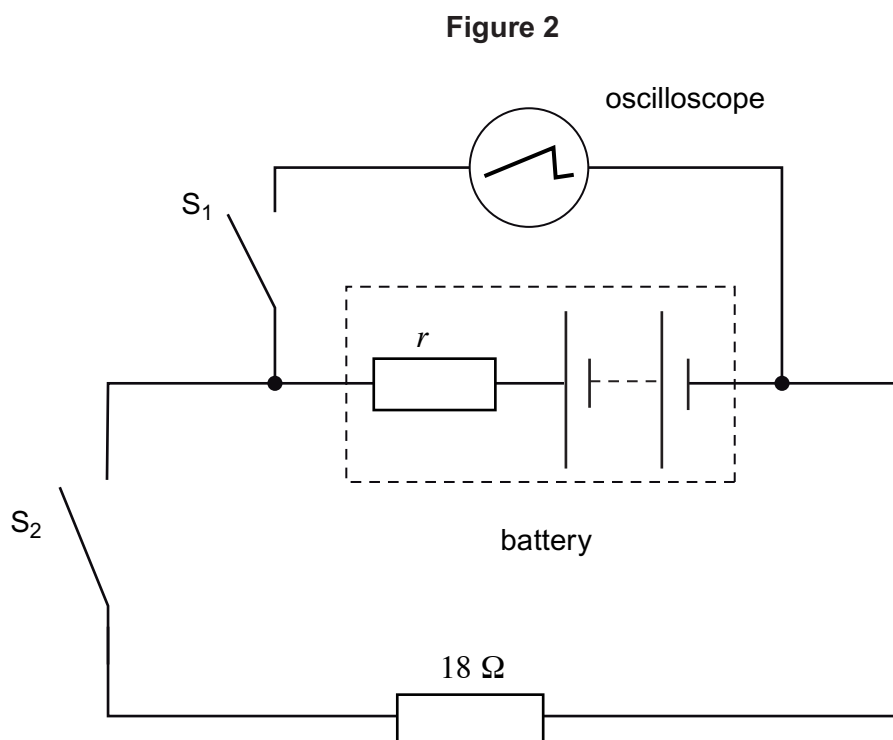
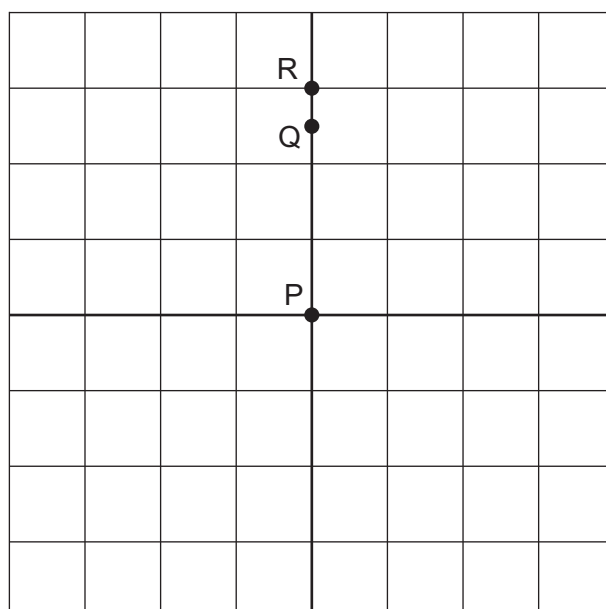


Figure 3 represents the screen of the oscilloscope. With switches S_1 and S_2 open, a bright spot is seen on the screen at P.

Figure 3



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



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

Turn over ►



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

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END OF QUESTIONS



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