AQA

Please write clearly in block capitals.

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

Surname _____

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Candidate signature _____

AS PHYSICS A

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 23 May 2017 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.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

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

1 (a) Hadrons are a group of particles composed of quarks. Hadrons can be either baryons or mesons.

1 (a) (i) State the property that defines a hadron.

[1 mark]

_____

1 (a) (ii) State the quark structure of a baryon.

[1 mark]

_____

1 (a) (iii) State the quark structure of a meson.

[1 mark]

_____

1 (b) State **one** similarity and **one** difference between a particle and its antiparticle.

[2 marks]

similarity _____

_____

difference _____

_____

Do not write outside the box

1 (c) Complete **Table 1** to show the properties of the antiproton.

[2 marks]

Table 1

	charge/C	baryon number	quark structure
antiproton			

1 (d) The K^- is an example of a meson with strangeness -1.
The K^- decays in the following way:

$$K^- \longrightarrow \mu^- + \overline{\nu_\mu}$$

1 (d) (i) State, with a reason, what interaction is responsible for this decay.

[2 marks]

1 (d) (ii) State **two** properties, other than energy and momentum, that are conserved in this decay.

[2 marks]

1 _____

2 _____

11

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

[3 marks]

2 (b) An unstable nucleus can decay by emitting an alpha (α) particle.

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

[1 mark]

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

[2 marks]

$$^{238}_{92}\mathrm{U} \rightarrow \underline{\quad}\mathrm{Th} + \underline{\quad}\alpha$$

Do not write outside the box

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

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

[2 marks]

2 (c) (ii) State the name of the interaction responsible for the emission of β^- particles.

[1 mark]

2 (c) (iii) There are eight α decays involved in the sequence of decays from $^{238}_{92}\mathrm{U}$ to $^{206}_{82}\mathrm{Pb}$.

Deduce how many β^- decays are involved.

[3 marks]

number of β^- decays = _____

12

Turn over for the next question

Do not write outside the box

3 (a) What phenomenon can be used to demonstrate the wave properties of electrons?
Tick (✓) the correct answer.

[1 mark]

Annihilation ☐

Diffraction ☐

Photoelectric effect ☐

Polarisation ☐

3 (b) Calculate the wavelength of an electron travelling at a speed of 2.7×10^5 m s^{-1}.
Give your answer to an appropriate number of significant figures.

[3 marks]

wavelength = _____ m

3 (c) Calculate the speed of a muon that has the same wavelength as the electron in part **(b)**.

mass of muon = 207 × mass of electron

[2 marks]

speed = _____ m s^{-1}

6

Do not write outside the box

4 (a) When energetic electrons bombard the atoms in a gas discharge tube, light is emitted. This light forms a spectrum that consists of lines, each of which has a definite wavelength.

Explain how:

- the bombarding electrons cause the atoms of the gas to emit light
- the existence of a spectrum consisting of lines of definite wavelengths supports the view that atoms have discrete energy levels.

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

[6 marks]

Extra space is available on the next page if needed

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4 (b) The ionisation energy of hydrogen is $13.6\ \text{eV}$.

4 (b) (i) State what is meant by the ionisation energy of hydrogen.

[2 marks]

Do not write outside the box

4 (b) (ii) Calculate, in J, the ionisation energy of hydrogen.

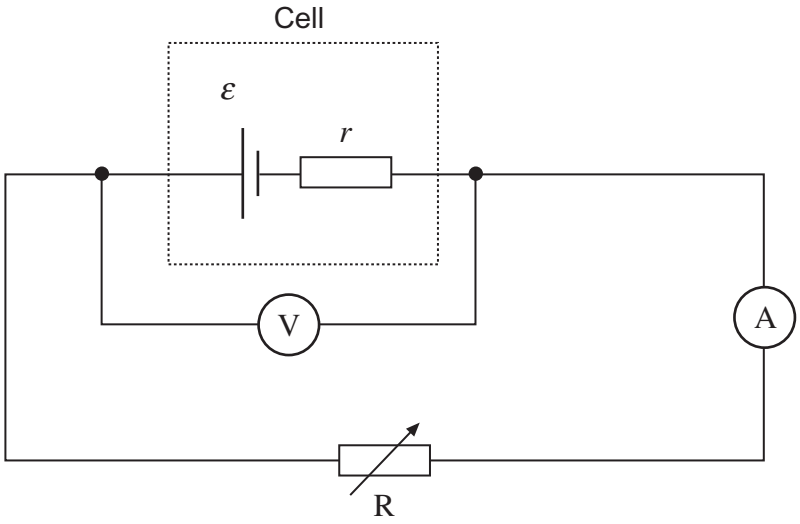
[2 marks]

ionisation energy =_____ J

10

5 A cell of emf ε and internal resistance r is connected to a variable resistor R. The current through the cell and the terminal potential difference (terminal pd) of the cell are measured as R is decreased. The circuit is shown in **Figure 1**.

Figure 1



Question 5 continues on the next page

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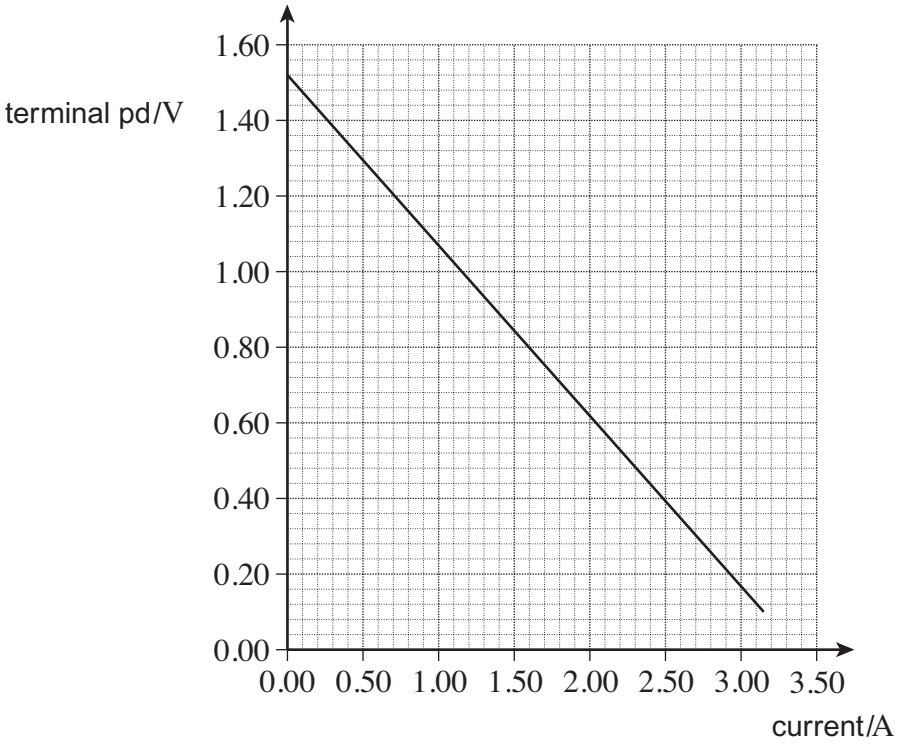
Figure 2 shows the results from the experiment.

Figure 2



5 (a) Explain why the terminal pd decreases as the current increases.

[2 marks]

5 (b) (i) Use **Figure 2** to find the emf ε of the cell.

[1 mark]

ε = _____ V

Do not write outside the box

5 (b) (ii) Use **Figure 2** to find the internal resistance r of the cell.

[3 marks]

r = _____ Ω

5 (c) (i) Draw a line on **Figure 2** to show the results obtained using a cell with the same emf but double the internal resistance of the first cell. Label this line **A**.

[2 marks]

5 (c) (ii) Draw a line on **Figure 2** to show the results obtained using a cell with the same emf but negligible internal resistance. Label this line **B**.

[1 mark]

5 (d) In the original circuit shown in **Figure 1**, the variable resistor is set at a value such that the current through the cell is 1.2 A.

5 (d) (i) Calculate the charge that flows through the cell in 25 s.
State an appropriate unit for your answer.

[2 marks]

charge flowing = _____ unit = _____

5 (d) (ii) Calculate the power dissipated in the internal resistance of the cell.

[2 marks]

power dissipated = _____ W

13

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6 (a) A semiconducting diode is an example of a non-ohmic component.

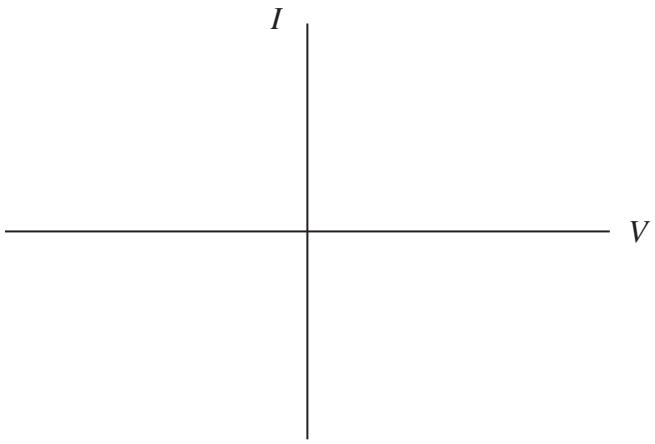
State what is meant by a non-ohmic component.

[1 mark]

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

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

[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 voltage across its terminals changes.

[1 mark]

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6 (c) A filament lamp has a power rating of $24\ \text{W}$ when there is a voltage of $6.0\ \text{V}$ across its terminals.

6 (c) (i) Calculate the resistance of the filament when the voltage across its terminals is $6.0\ \text{V}$.

[2 marks]

resistance = _____ Ω

6 (c) (ii) A student predicts that if the voltage across the terminals of the lamp is reduced to $3.0\ \text{V}$ the power rating of the lamp will be $6.0\ \text{W}$.

State and explain how in practice the power rating will be slightly different from this value.

[3 marks]

Turn over for the next question

9

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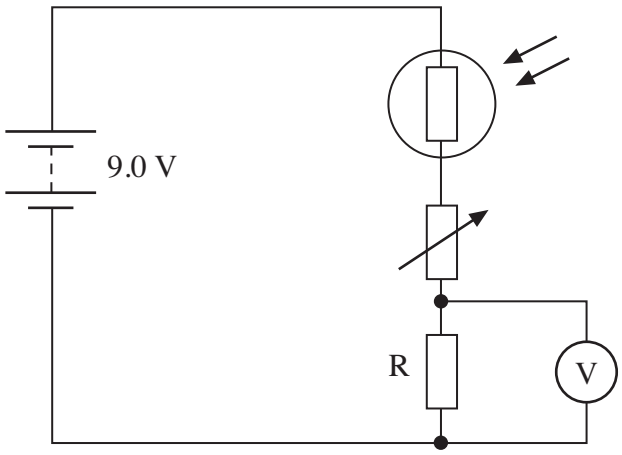
7 **Figure 3** shows a $9.0\ \text{V}$ battery of negligible internal resistance connected in series to a light-dependent resistor (LDR), a variable resistor and a fixed resistor, R.

Figure 3



7 (a) For a particular light intensity the resistance of the LDR is $45\ \text{k}\Omega$. The resistance of R is $6.0\ \text{k}\Omega$ and the variable resistor is set to a value of $39\ \text{k}\Omega$.

7 (a) (i) Calculate the current in the circuit.

[2 marks]

current = _____ A

7 (a) (ii) Calculate the reading on the ideal voltmeter in **Figure 3**.

[2 marks]

voltmeter reading = _____ V

Do not write outside the box

7 (b) State and explain what happens to the voltmeter reading when the intensity of the light incident on the LDR increases.

[2 marks]

7 (c) For a certain application at a particular light intensity the voltage across R needs to be $0.82\ \text{V}$. The resistance of the LDR at this intensity is $4.5\ \text{k}\Omega$.

Calculate the required resistance of the variable resistor in this situation.

[3 marks]

resistance = _____ Ω

9

END OF QUESTIONS

There are no questions printed on this page

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