Centre Number						Candidate Number				
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Candidate Signature										

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

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Physics A PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Monday 20 May 2013 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 (enclosed).

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.
- 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.

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

1 An atom of calcium, ${}^{48}_{20}\text{Ca}$, is ionised by removing two electrons.

1 (i) State the number of protons, neutrons and electrons in the ion formed.

protons ....

neutrons ....

electrons ....

(3 marks)

1 (ii) Calculate the charge of the ion.

charge C

(1 mark)

1 (iii) Calculate the specific charge of the ion.

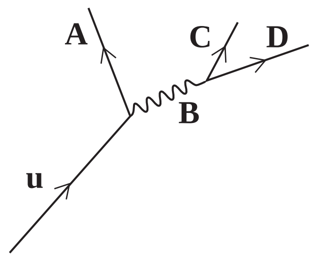
specific charge .... C kg^{-1}

(2 marks)

6

2 A positron is emitted from a nucleus when a proton changes to a neutron in the nucleus. The Feynman diagram for the quark interaction is shown in **Figure 1**.

Figure 1



2 (a) Identify the particles labelled **A**, **B**, **C** and **D** in the diagram.

A ....

B ....

C ....

D ....

(3 marks)

2 (b) (i) State the interaction responsible for this process.

....

(1 mark)

2 (b) (ii) State which letter in **Figure 1** represents an exchange particle.

....

(1 mark)

2 (b) (iii) State **one** difference between this exchange particle and a photon.

....

(1 mark)

Question 2 continues on the next page

2 (c) Energy and momentum have to be conserved in this process. State **two** other quantities that need to be conserved and show that they are conserved in the process.

quantity 1 ....

....

....

quantity 2 ....

....

....

(4 marks)

10

3 (a) Hadrons and leptons are two groups of particles.
Write an account of how particles are placed into one or other of these two groups.
Your account should include the following:

- how the type of interaction is used to classify the particles
- examples of each type of particle
- details of any similarities between the two groups
- details of how **one** group may be further sub-divided.

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

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(6 marks)

3 (b) Every type of particle has a corresponding antiparticle.

3 (b) (i) Give **one** example of a particle and its corresponding antiparticle.

particle ....

antiparticle ....

(1 mark)

3 (b) (ii) State **one** difference between this particle and its antiparticle.

....

....

(1 mark)

8

4 When ultraviolet light of frequency 3.0×10^{15} Hz is incident on the surface of a metal, electrons of maximum kinetic energy 1.7×10^{-18} J are emitted.

4 (a) Explain why the emitted electrons have a range of kinetic energies up to a maximum value.

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(3 marks)

4 (b) (i) Show that the work function of the metal is 1.8 eV.

(3 marks)

4 (b) (ii) Calculate the threshold frequency of the metal. Give your answer to an appropriate number of significant figures.

threshold frequency .... Hz

(3 marks)

Turn over ▶

4 (c) (i) State and explain the effect on the emitted electrons of decreasing the frequency of the incident radiation whilst keeping the intensity constant.

....

....

....

....

(2 marks)

4 (c) (ii) State and explain the effect on the emitted electrons of doubling the intensity of the incident radiation whilst keeping the frequency constant.

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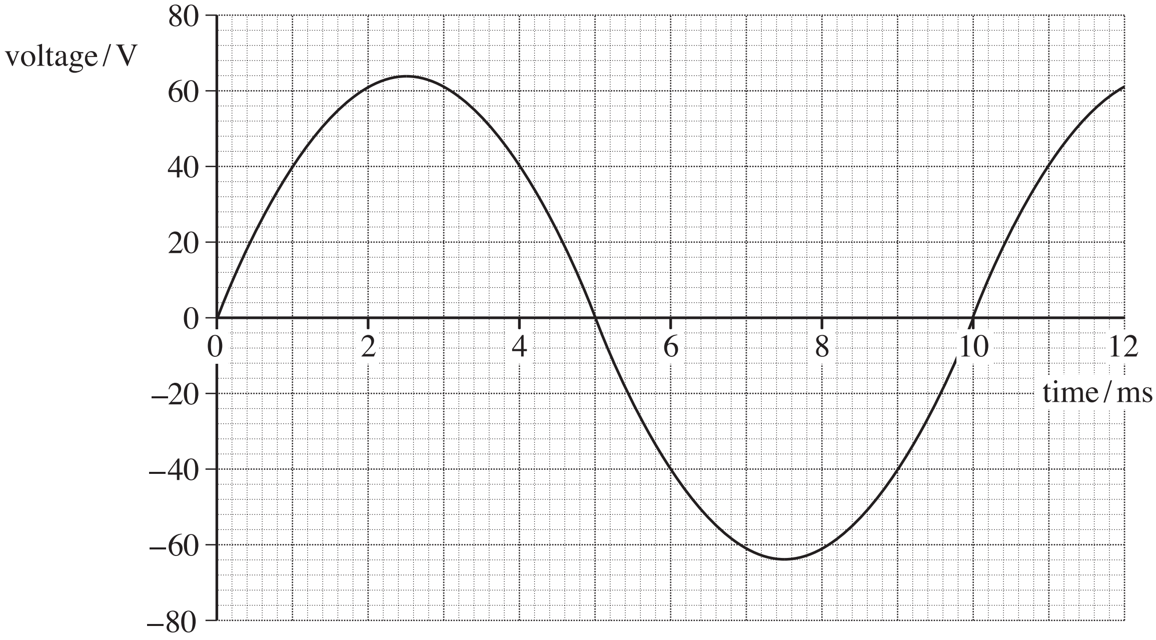
(2 marks)

13

5 **Figure 2** shows how a sinusoidal alternating voltage varies with time when connected across a resistor, R.

Figure 2



5 (a) (i) State the peak-to-peak voltage.

peak-to-peak voltage V
(1 mark)

5 (a) (ii) State the peak voltage.

peak voltage V
(1 mark)

5 (a) (iii) Calculate the root mean square (rms) value of the alternating voltage.

rms voltage V
(2 marks)

Question 5 continues on the next page

5 (a) (iv) Calculate the frequency of the alternating voltage. State an appropriate unit.

frequency .... unit ....

(3 marks)

5 (b) On **Figure 2** draw a line to show the dc voltage that gives the same rate of energy dissipation in R as produced by the alternating waveform.

(2 marks)

5 (c) An oscilloscope has a screen of eight vertical and ten horizontal divisions. Describe how you would use the oscilloscope to display the alternating waveform in **Figure 2** so that two complete cycles are visible.

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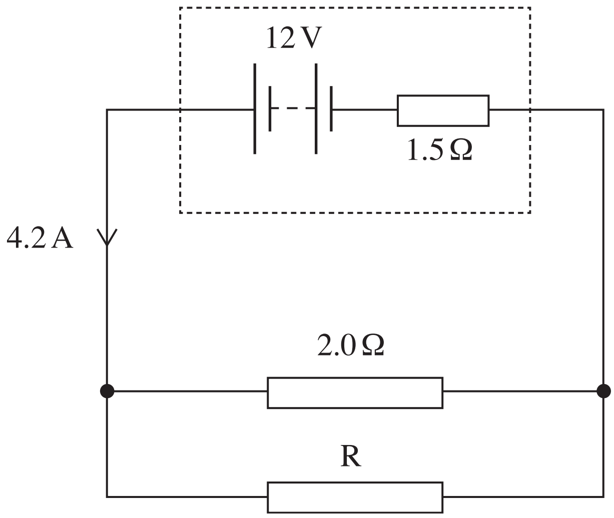
(3 marks)

12

6 The circuit in **Figure 3** shows a battery of electromotive force (emf) 12 V and internal resistance 1.5 Ω connected to a 2.0 Ω resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.

Figure 3



6 (a) (i) Show that the potential difference (pd) across the internal resistance is 6.3 V.

(1 mark)

6 (a) (ii) Calculate the pd across the 2.0 Ω resistor.

pd V

(1 mark)

6 (a) (iii) Calculate the current in the 2.0 Ω resistor.

current .... A

(1 mark)

6 (a) (iv) Determine the current in R.

current .... A

(1 mark)

6 (a) (v) Calculate the resistance of R.

R .... Ω
(1 mark)

6 (a) (vi) Calculate the total resistance of the circuit.

circuit resistance .... Ω
(2 marks)

6 (b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

6 (b) (i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	**rate of energy dissipation / W**
internal resistance	
2.0 Ω	
R	

(3 marks)

6 (b) (ii) Hence show that energy is conserved in the circuit.

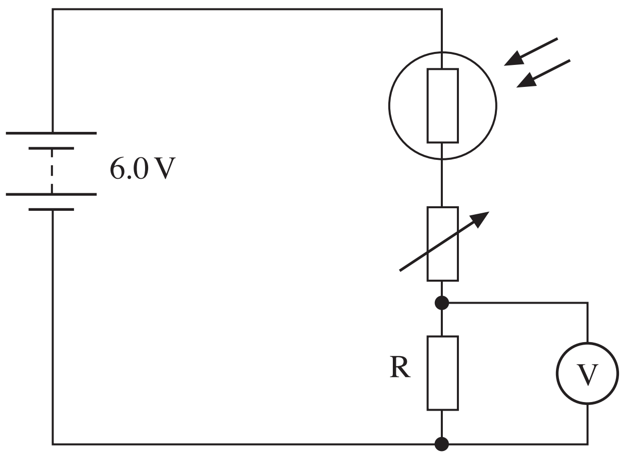
....

....
(2 marks)

12

7 **Figure 4** shows a 6.0 V battery of negligible internal resistance connected in series to a light dependent resistor (LDR), a variable resistor and a fixed resistor, R.

Figure 4



7 (a) For a particular light intensity the resistance of the LDR is 50 kΩ. The resistance of R is 5.0 kΩ and the variable resistor is set to a value of 35 kΩ.

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

current .... A
(2 marks)

7 (a) (ii) Calculate the reading on the voltmeter.

voltmeter reading V
(2 marks)

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

....

....

....
(2 marks)

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7 (c) For a certain application at a particular light intensity the pd across R needs to be 0.75 V. The resistance of the LDR at this intensity is 5.0 kΩ.

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

resistance .... Ω

(3 marks)

9

END OF QUESTIONS

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