Centre Number						Candidate Number				
Surname										
Other Names										
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 2011

Physics A PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 24 May 2011 9.00 am to 10.15 am

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.

Do not write outside the box

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

1 (a) (i) Name two baryons.

.....

(2 marks)

1 (a) (ii) State the quark structure of the pion π^+.

.....

(1 mark)

1 (b) (i) The K^+ kaon is a strange particle. Give **one** characteristic of a strange particle that makes it different from a particle that is not strange.

.....

.....

(1 mark)

1 (b) (ii) One of the following equations represent a possible decay of the K^+ kaon.

$$K^+ \rightarrow \pi^+ + \pi^0$$

$$K^+ \rightarrow \mu^+ + \overline{\nu}_\mu$$

State, with a reason, which one of these decays is not possible.

.....

.....

(2 marks)

1 (c) Another strange particle, X, decays in the following way:

$$X \rightarrow \pi^- + p$$

1 (c) (i) State what interaction is involved in this decay.

.....

(1 mark)

1 (c) (ii) Show that X must be a neutral particle.

.....

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(1 mark)

Do not write outside the box

1 (c) (iii) Deduce whether X is a meson, baryon or lepton, explaining how you arrive at your answer.

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(2 marks)

1 (c) (iv) Which particle in this interaction is the most stable?

.....

(1 mark)

11

Turn over for the next question

Do not write outside the box

2 Alpha decay is a process by which an unstable *isotope* of an element may decay.

2 (i) State what is meant by isotopes.

.....

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.....

(2 marks)

2 (ii) Complete this equation for alpha decay.

$$^{A}_{Z}X \rightarrow ^{\cdots\cdots}_{\cdots\cdots}Y + ^{4}_{2}\alpha$$

(2 marks)

2 (iii) Calculate the specific charge of an alpha particle, stating an appropriate unit.

answer = ...

(4 marks)

Do not write outside the box

2 (iv) Explain why the alpha particle, once outside the nucleus, is unaffected by the strong nuclear force.

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(2 marks)

10

Turn over for the next question

Do not write outside the box

3 The isotope of potassium $^{40}_{19}\mathrm{K}$ can decay by positron emission to form an isotope of argon, Ar.

3 (a) Complete the following equation which represents this decay.

$$^{40}_{19}\mathrm{K} \rightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{\cdots\cdots}} + \cdots\cdots + \cdots\cdots$$

(4 marks)

3 (b) The following equation represents another possible decay for $^{40}_{19}\mathrm{K}$.

$$^{40}_{19}\mathrm{K} + {}^{0}_{-1}\mathrm{e} \rightarrow {}^{40}_{18}\mathrm{Ar} + \nu_{\mathrm{e}}$$

3 (b) (i) What is this type of decay called?

.....

(1 mark)

3 (b) (ii) Where does the electron on the left-hand side of the equation come from?

.....

(1 mark)

3 (b) (iii) Explain why this reaction has to produce a neutrino rather than an antineutrino.

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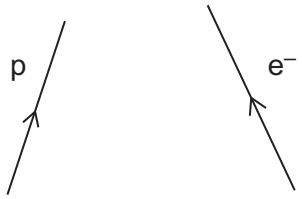
.....

(1 mark)

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3 (b) (iv) Complete the Feynman diagram shown in **Figure 1** that represents this decay.

Figure 1



(3 marks)

10

Turn over for the next question

Do not write outside the box

4 (a) Line spectra were observed before they could be explained by theory. We now know that photons of characteristic frequency are emitted when the vapour of an element is bombarded by energetic electrons. The spectrum of the light emitted contains lines, each of a definite wavelength.

Explain how

- the bombarding electrons cause the atoms of the vapour to emit photons
- the existence of a spectrum consisting of lines of a definite frequency supports the view that atoms have discrete energy levels.

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

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(6 marks)

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4 (b) The *ionisation energy* of a hydrogen atom is 13.6 eV.

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

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(2 marks)

4 (b) (ii) Express the ionisation energy of hydrogen in joules, giving your answer to an appropriate number of significant figures.

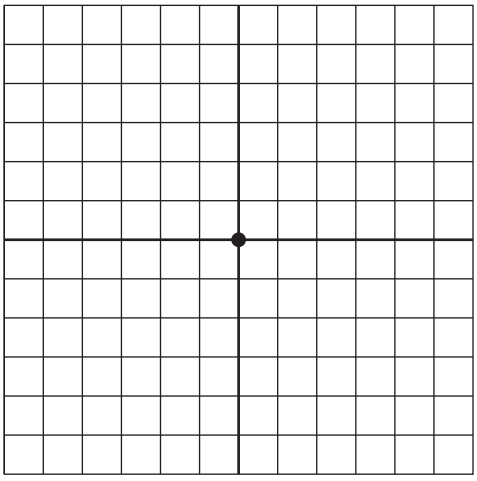
answer = ... J

(3 marks)

11

5 An oscilloscope is used to investigate various voltage sources. In order to do this a voltage source is connected to the y-input and the time base is switched off. **Figure 2** shows the screen of the oscilloscope when the y-input is not connected to a voltage source.

Figure 2

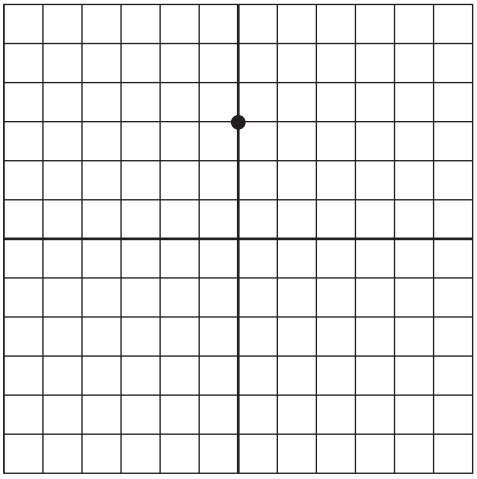


Question 5 continues on the next page

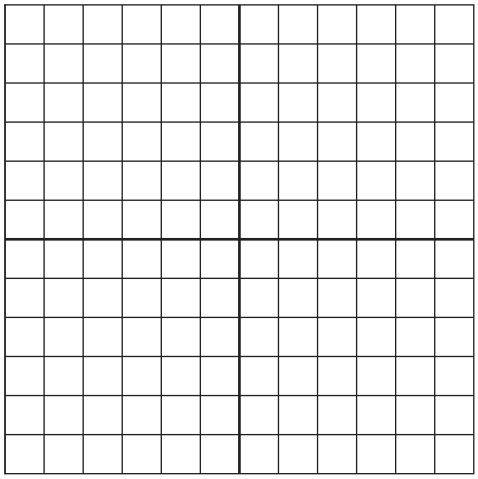
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Figure 3 shows the screen when a 1.5 V cell is connected to the y-input.

Figure 3



5 (a) On the grid below show the appearance of the screen if the y-input is connected to a 2.5 V dc supply.

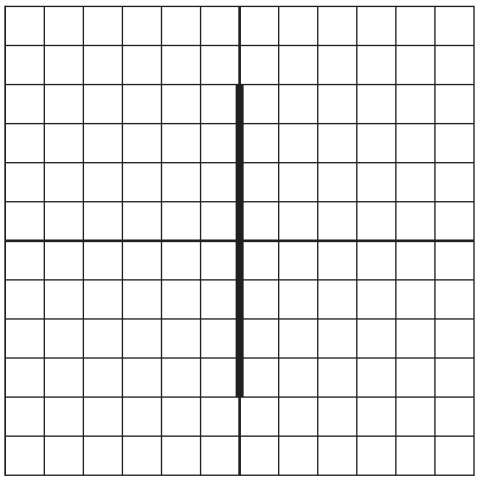


(1 mark)

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5 (b) The y-input is now connected to a sinusoidal ac voltage supply and the screen is shown in **Figure 4**.

Figure 4



5 (b) (i) Explain why a vertical line is now seen on the screen.

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(2 marks)

5 (b) (ii) Calculate the peak-to-peak voltage of the ac supply.

answer = ... V

(2 marks)

Question 5 continues on the next page

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5 (b) (iii) Calculate the root mean square voltage of the supply.

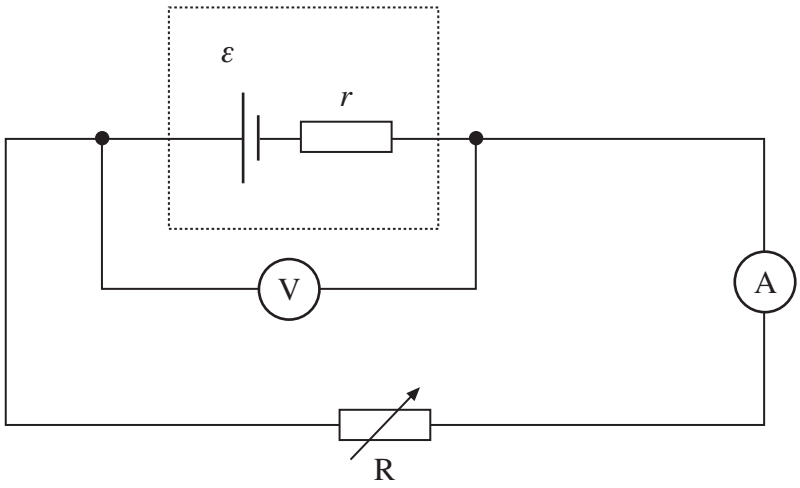
answer = ... V

(2 marks)

7

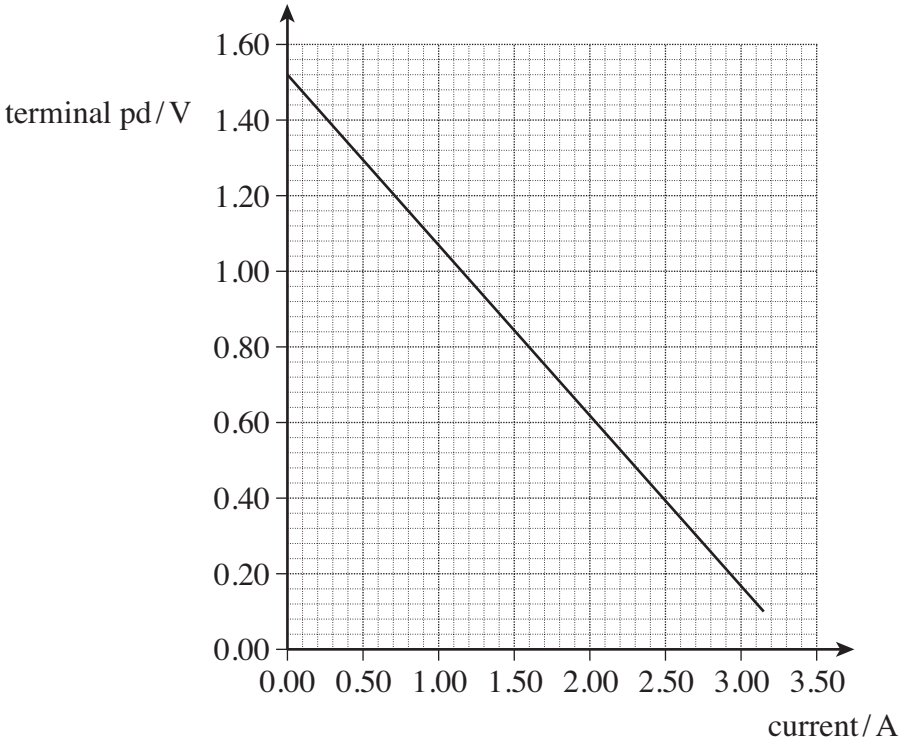
6 A cell of emf, ε, and internal resistance, r, is connected to a variable resistor R. The current through the cell and the terminal pd of the cell are measured as R is decreased. The circuit is shown in **Figure 5**.

Figure 5



Do not write outside the box

The graph below shows the results from the experiment.



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

.....

.....

.....

.....

(2 marks)

6 (b) (i) Use the graph to find the emf, ε, of the cell.

answer = ... V

(1 mark)

Question 6 continues on the next page

Do not write outside the box

6 (b) (ii) Use the graph, on page 13, to find the internal resistance, r, of the cell.

answer = ... Ω

(3 marks)

6 (c) Draw a line on the graph, on page 13, that shows the results obtained from a cell with

6 (c) (i) the same emf but double the internal resistance of the first cell labelling your graph **A**

(2 marks)

6 (c) (ii) the same emf but negligible internal resistance labelling your graph **B**.

(1 mark)

6 (d) In the original circuit shown in **Figure 5**, on page 12, the variable resistor is set at a value such that the current through the cell is 0.89 A.

6 (d) (i) Calculate the charge flowing through the cell in 15 s, stating an appropriate unit.

answer = ...

(2 marks)

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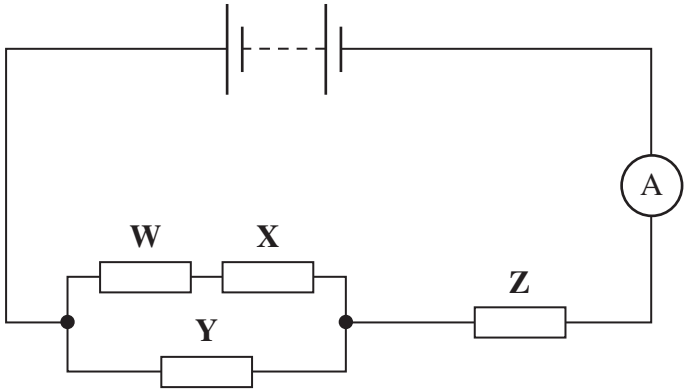
6 (d) (ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = ... W
(2 marks)

13

7 The circuit shown in **Figure 6** shows an arrangement of resistors, **W**, **X**, **Y**, **Z**, connected to a battery of negligible internal resistance.

Figure 6



The emf of the battery is 10 V and the reading on the ammeter is 2.0 A.

7 (a) (i) Calculate the total resistance of the circuit.

answer = ... Ω
(1 mark)

Question 7 continues on the next page

Do not write outside the box

7 (a) (ii) The resistors **W**, **X**, **Y**, and **Z** all have the same resistance. Show that your answer to part (a) (i) is consistent with the resistance of each resistor being 3.0 Ω.

answer = ... Ω
(3 marks)

7 (b) (i) Calculate the current through resistor **Y**.

answer = ... A
(2 marks)

7 (b) (ii) Calculate the pd across resistor **W**.

answer = ... V
(2 marks)

END OF QUESTIONS

8

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