Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Physics A PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 20 May 2014 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 (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.

Do not write outside the box

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

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

1 (a) (i) What is the quark structure of the K^+?

[1 mark]

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1 (a) (ii) What is the baryon number of the K^+?

[1 mark]

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1 (a) (iii) What is the antiparticle of the K^+?

[1 mark]

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1 (b) The K^+ may decay into a neutrino and an antimuon in the following way.

$$K^+ \rightarrow \nu_\mu + \mu^+$$

1 (b) (i) Complete **Table 1** using ticks and crosses as indicated in the first row.

[3 marks]

Table 1

Classification	K^+	ν_μ	μ^+
lepton	×	✓	✓
charged particle			
hadron			
meson			

1 (b) (ii) In this decay, charge, energy and momentum are conserved.
Give another quantity that is conserved in this decay and one that is not conserved.

[2 marks]

Conserved .....

Not conserved .....

Do not write outside the box

1 (c) Another possible decay of the K^+ is shown in the following equation,

$K^+ \rightarrow \pi^+ + X$

1 (c) (i) Identify X by ticking **one** box from the following list.

[1 mark]

electron	
muon	
negative pion	
neutral pion	
neutrino	
neutron	
positron	

1 (c) (ii) Give **one** reason for your choice in part (c)(i).

[1 mark]

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2 (a) **Table 2** contains data for four different nuclei, P, Q, R and S.

Table 2

Nuclei	Number of neutrons	Nucleon number
P	5	11
Q	6	11
R	8	14
S	9	17

2 (a) (i) Which nucleus contains the fewest protons?

[1 mark]

nucleus .....

2 (a) (ii) Which **two** nuclei are isotopes of the same element?

[1 mark]

nuclei ..... and .....

2 (a) (iii) State and explain which nucleus has the smallest specific charge.

[2 marks]

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2 (a) (iv) Complete the following equation to represent β^- decay of nucleus R to form nucleus X.

[3 marks]

$$^{14}_{6}\mathrm{R} \rightarrow \overset{\ldots\ldots}{\underset{\ldots\ldots}{\ }}\mathrm{X} + \overset{\ldots\ldots}{\underset{\ldots\ldots}{\ }} \ldots\ldots\ldots + \ldots\ldots\ldots$$

Do not write outside the box

2 (b) (i) The strong nuclear force is responsible for keeping the protons and neutrons bound in a nucleus.
Describe how the strong nuclear force between two nucleons varies with the separation of the nucleons, quoting suitable values for separation.

[3 marks]

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2 (b) (ii) Another significant interaction acts between the protons in the nucleus of an atom.
Name the interaction and name the exchange particle responsible for the interaction.

[2 marks]

Interaction .....

Exchange particle .....

12

Turn over for the next question

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3 (a) What phenomenon can be used to demonstrate the wave properties of electrons?

[1 mark]

.....

3 (b) Calculate the wavelength of electrons travelling at a speed of $2.5 \times 10^5\,\text{m s}^{-1}$.

Give your answer to an appropriate number of significant figures.

[3 marks]

wavelength ..... m

3 (c) Calculate the speed of muons with the same wavelength as these electrons.

mass of muon = 207 × mass of electron

[2 marks]

speed ..... m s^{-1}

6

Turn to page 8 for the next question

Turn over for the next question

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4 (a) A fluorescent tube is filled with mercury vapour at low pressure. After mercury atoms have been excited they emit photons.

4 (a) (i) In which part of the electromagnetic spectrum are these photons?

[1 mark]

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4 (a) (ii) What is meant by an excited mercury atom?

[1 mark]

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4 (a) (iii) How do the mercury atoms in the fluorescent tube become excited?

[2 marks]

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4 (a) (iv) Why do the excited mercury atoms emit photons of characteristic frequencies?

[3 marks]

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4 (b) The wavelength of some of the photons emitted by excited mercury atoms is 254 nm.

4 (b) (i) Calculate the frequency of the photons.

[2 marks]

frequency ..... Hz

4 (b) (ii) Calculate the energy of the photons in electron volts (eV).

[2 marks]

energy ..... eV

4 (c) Explain how the coating on the inside of a fluorescent tube emits visible light.

[2 marks]

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Turn over for the next question

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5 A student investigates how the power dissipated in a variable resistor, Y, varies as the resistance is altered.

Figure 1 shows the circuit the student uses. Y is connected to a battery of emf ε and internal resistance r.

Figure 1

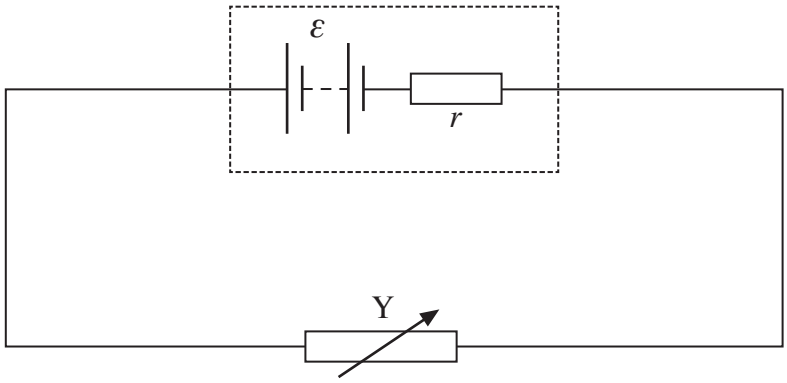
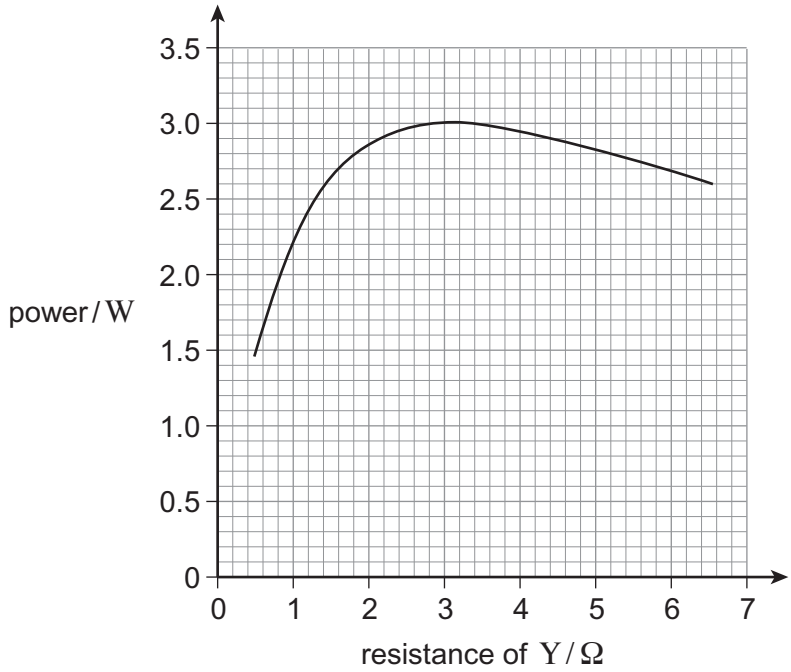


Figure 2 shows the results obtained by the student as the resistance of Y is varied from $0.5\,\Omega$ to $6.5\,\Omega$.

Figure 2



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5 (a) Describe how the power dissipated in Y varies as its resistance is increased from $0.5\,\Omega$ to $6.5\,\Omega$.

[2 marks]

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5 (b) The emf of the battery is $6.0\,\text{V}$ and the resistance of Y is set at $0.80\,\Omega$.

5 (b) (i) Use data from **Figure 2** to calculate the current through the battery.

[3 marks]

current ..... A

5 (b) (ii) Calculate the voltage across Y.

[2 marks]

voltage V

5 (b) (iii) Calculate the internal resistance of the battery.

[2 marks]

internal resistance ..... Ω

Question 5 continues on the next page

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5 (c) The student repeats the experiment with a battery of the same emf but negligible internal resistance. State and explain how you would now expect the power dissipated in Y to vary as the resistance of Y is increased from $0.5\,\Omega$ to $6.5\,\Omega$.

[3 marks]

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6 The critical temperature of tin is $-269\,°C$. The resistivity of tin increases as its temperature rises from $-269\,°C$.

6 (a) (i) Define resistivity.

[2 marks]

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6 (a) (ii) State the significance of the critical temperature of a material.

[2 marks]

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6 (b) A sample of tin in the form of a cylinder of diameter $1.0\,mm$ and length $4.8\,m$ has a resistance of $0.70\,\Omega$.

Use these data to calculate a value of the resistivity of tin.
State an appropriate unit for your answer.

[4 marks]

resistivity ..... unit .....

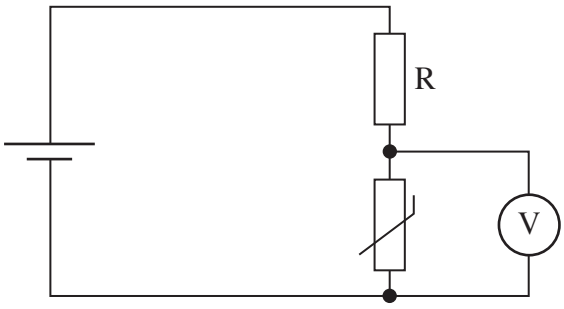
8

Turn over for the next question

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7 A thermistor is to be used as a temperature sensor. In order to find out how the voltage across the thermistor varies with temperature the circuit shown in **Figure 3** is set up.

Figure 3



7 (a) Data have to be obtained so that a graph can be plotted to show how the reading on the voltmeter varies with temperature between $0\,^{\circ}\mathrm{C}$ and $100\,^{\circ}\mathrm{C}$. Design an experiment, using this circuit, to obtain enough data to plot the graph. Your answer should include:

- details of the measurements taken
- details of how the temperature of the thermistor can be varied
- an explanation of the need for resistor R
- an explanation of how the thermistor can then be used to measure the temperature of a room.

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

[6 marks]

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7 (b) The experiment you designed in part (a) is repeated with the voltmeter connected across R instead.
State and explain how the readings on the voltmeter would be different.

[3 marks]

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9

END OF QUESTIONS

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