Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Physics A PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 19 May 2015 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 **Table 1** contains five statements that refer to isotopes and some radium isotopes.

Table 1

	$^{223}_{88}\mathrm{Ra}$	$^{224}_{88}\mathrm{Ra}$	$^{225}_{88}\mathrm{Ra}$	$^{226}_{88}\mathrm{Ra}$
Isotope with the smallest mass number	✓			
Isotope with most neutrons in nucleus				
Isotope with nucleus which has the largest specific charge				
Isotope decays by β^- decay to form $^{225}_{89}\mathrm{Ac}$				
Isotope decays by alpha decay to form $^{220}_{86}\mathrm{Rn}$				

1 (a) Complete **Table 1** by ticking **one** box in each row to identify the appropriate isotope. The first row has been completed for you.

[4 marks]

1 (b) (i) An atom of one of the radium isotopes in **Table 1** is ionised so that it has a charge of $+3.2 \times 10^{-19}$ C.

State what happens in the process of ionising this radium atom.

[1 mark]

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1 (b) (ii) The specific charge of the ion formed is 8.57×10^5 C kg^{-1}.

Deduce which isotope in the table has been ionised. Assume that both the mass of a proton and the mass of a neutron in the nucleus is 1.66×10^{-27} kg.

[3 marks]

isotope = ...

8

Do not write outside the box

2 The equation shows an interaction between a proton and a negative kaon that results in the formation of particle, X.

$$K^- + p \rightarrow K^+ + K^0 + X$$

2 (a) (i) State and explain whether X is a charged particle.

[2 marks]

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2 (a) (ii) State and explain whether X is a lepton, baryon or meson.

[2 marks]

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2 (a) (iii) State the quark structure of the K^-, K^+ and the K^0.

[3 marks]

K^-.....

K^+ .....

K^0.....

2 (a) (iv) Strangeness is conserved in the interaction.

Determine, explaining your answer, the quark structure of X.

[3 marks]

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3 (a) Baryons, mesons and leptons are affected by particle interactions.

Write an account of these interactions. Your account should:

- include the names of the interactions
- identify the groups of particles that are affected by the interaction
- identify the exchange particles involved in the interaction
- give examples of **two** of the interactions you mention.

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

[6 marks]

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3 (b) Draw a labelled Feynman diagram that represents a particle interaction.

[3 marks]

Turn over for the next question

9

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4 Sodium metal has a work function of 2.28 eV. An atom of sodium has an ionisation energy of 5.15 eV.

4 (a) (i) State what is meant by work function.

[2 marks]

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4 (a) (ii) State what is meant by ionisation energy.

[2 marks]

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4 (b) Show that the minimum frequency of electromagnetic radiation needed for a photon to ionise an atom of sodium is about 1.2×10^{15} Hz.

[2 marks]

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4 (c) Electromagnetic radiation with the frequency calculated in part (b) is incident on the surface of a piece of sodium.

Calculate the maximum possible kinetic energy of an electron that is emitted when a photon of this radiation is incident on the surface.
Give your answer to an appropriate number of significant figures.

[3 marks]

maximum kinetic energy = ... J

4 (d) Calculate the speed of an electron that has the same de Broglie wavelength as the electromagnetic radiation in part (b).

[3 marks]

speed = ... $m\ s^{-1}$

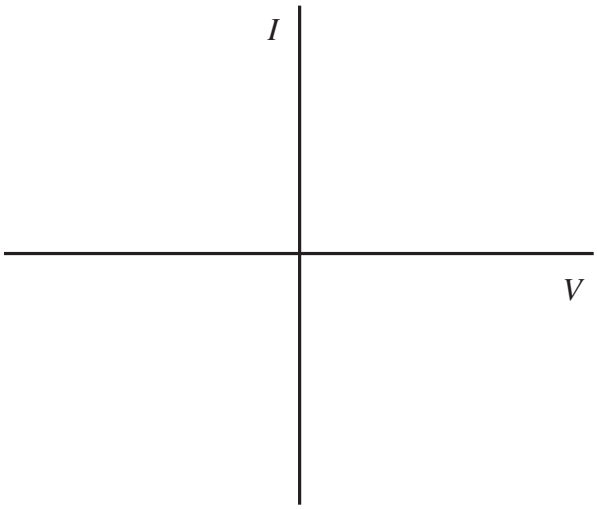
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5 (a) Sketch, on **Figure 1**, the current–voltage (IV) characteristic for a filament lamp for currents up to its working power.

[2 marks]

Figure 1



5 (b) (i) State what happens to the resistance of the filament lamp as the current increases.

[1 mark]

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5 (b) (ii) State and explain whether a filament lamp is an ohmic or non-ohmic conductor up to its working power.

[1 mark]

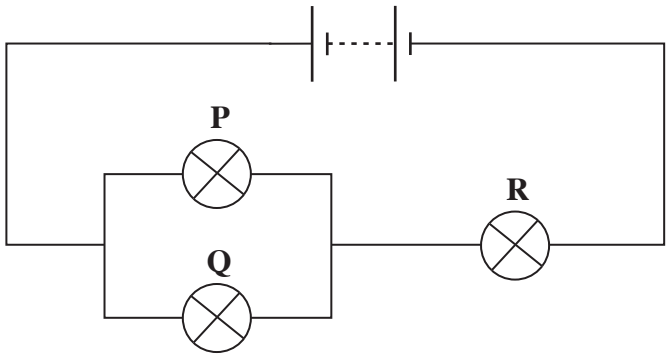
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5 (c) Three identical filament lamps, **P**, **Q** and **R** are connected in the circuit shown in **Figure 2.**

Figure 2



The filament in lamp **Q** melts so that it no longer conducts. Explain why lamp **P** becomes brighter and lamp **R** becomes dimmer.

[2 marks]

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Question 5 continues on the next page

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5 (d) A filament lamp, **X**, is rated at 60 W 230 V. Another type of lamp, **Y**, described as 'energy saving' has the same light intensity output but is rated at 11 W 230 V.

5 (d) (i) Calculate the electrical energy converted by each lamp if both are on for 4 hours a day for a period of 30 days.

[2 marks]

electrical energy converted by **X** = ... J

electrical energy converted by **Y** = ... J

5 (d) (ii) Suggest why the two lamps can have different power ratings but have the same light intensity output.

[2 marks]

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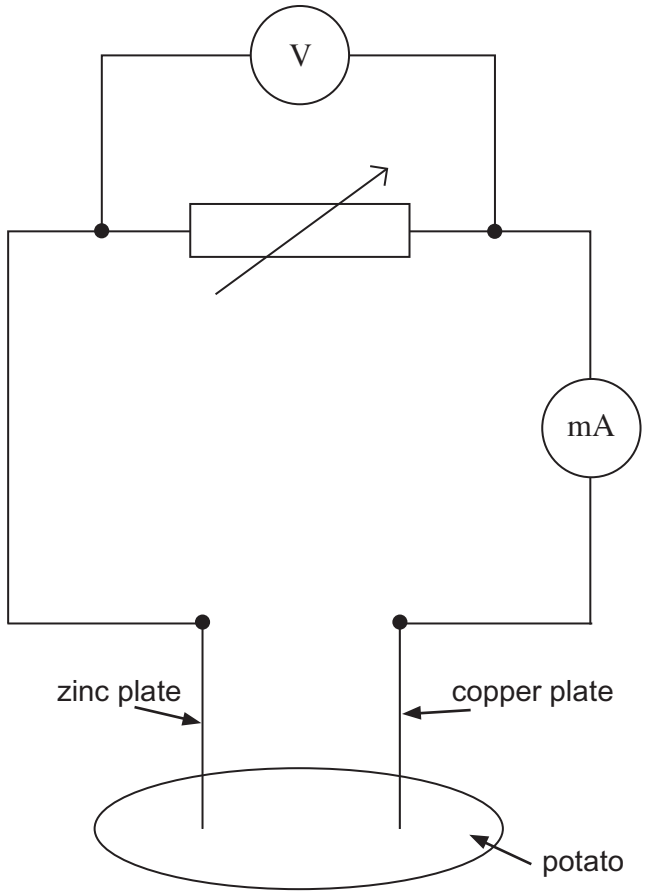
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6 A 'potato cell' is formed by inserting a copper plate and a zinc plate into a potato. The circuit shown in **Figure 3** is used in an investigation to determine the electromotive force and internal resistance of the potato cell.

Figure 3



6 (a) State what is meant by electromotive force.

[2 marks]

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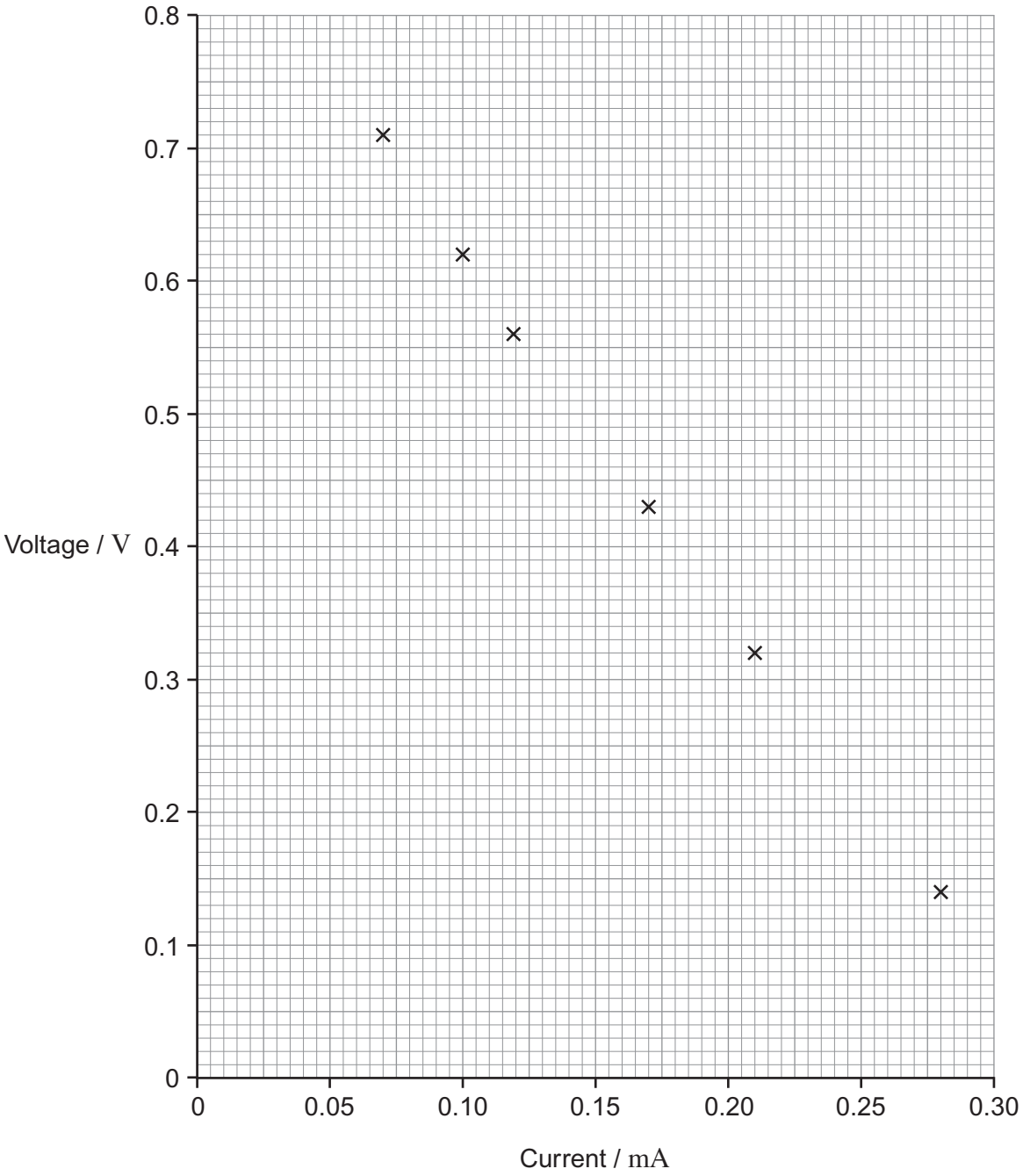
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Question 6 continues on the next page

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6 (b) The plotted points on **Figure 4** show the data for current and voltage that were obtained in the investigation.

Figure 4



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6 (b) (i) Suggest what was done to obtain the data for the plotted points.

[1 mark]

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6 (b) (ii) The electromotive force (emf) of the potato cell is 0.89 V. Explain why the voltages plotted on **Figure 4** are always less than this and why the difference between the emf and the plotted voltage becomes larger with increasing current.

[3 marks]

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6 (b) (iii) Use **Figure 4** to determine the internal resistance of the potato cell.

[3 marks]

internal resistance = ... Ω

Question 6 continues on the next page

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6 (c) A student decides to use two potato cells in series as a power supply for a light emitting diode (LED). In order for the LED to work as required, it needs a voltage of at least 1.6 V and a current of 20 mA.

Explain whether the LED will work as required.

[2 marks]

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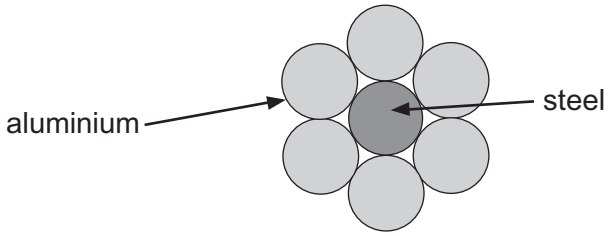
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7 A cable used in high-voltage power transmission consists of six aluminium wires surrounding a steel wire. A cross-section is shown in **Figure 5**.

Figure 5



The resistance of a length of 1.0 km of the steel wire is 3.3 Ω. The resistance of a length of 1.0 km of **one** of the aluminium wires is 1.1 Ω.

7 (a) The steel wire has a diameter of 7.4 mm.
Calculate the resistivity of steel. State an appropriate unit.

[4 marks]

resistivity = ... unit .....

Question 7 continues on the next page

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7 (b) Explain why only a small percentage of the total current in the cable passes through the steel wire.

[3 marks]

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7 (c) The potential difference across a length of 1.0 km of the cable is 75 V.

Calculate the total power loss for a 1.0 km length of cable.

[3 marks]

Total power loss ..... W

10

END OF QUESTIONS

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