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
January 2009

Physics A PHYA1

Unit 1 Particles, Quantum Phenomena and Electricity

Tuesday 13 January 2009 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae book.

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. Answers written in margins or on blank pages will not be marked.
- 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 calculater where appropriate.
- A *Data and Formulae Book* 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.

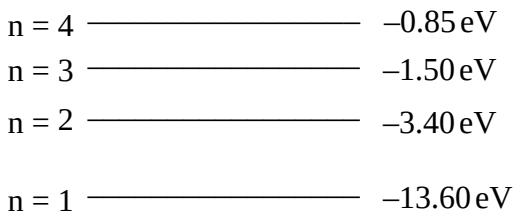
There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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

1 **Figure 1** shows part of an energy level diagram for a hydrogen atom.

Figure 1



1 (a) The level, n = 1, is the ground state of the atom.
State the ionisation energy of the atom in eV.

answer = ... eV
(1 mark)

1 (b) When an electron of energy 12.1 eV collides with the atom, photons of three different energies are emitted.

1 (b) (i) On **Figure 1** show with arrows the transitions responsible for these photons.
(3 marks)

1 (b) (ii) Calculate the wavelength of the photon with the smallest energy. Give your answer to an appropriate number of significant figures.

answer =..... m
(5 marks)

9

Turn over ▶

2 When light of a certain frequency is shone on a particular metal surface, electrons are emitted with a range of kinetic energies.

2 (a) Explain

- in terms of photons why electrons are released from the metal surface, and
- why the kinetic energy of the emitted electrons varies upto a maximum value.

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

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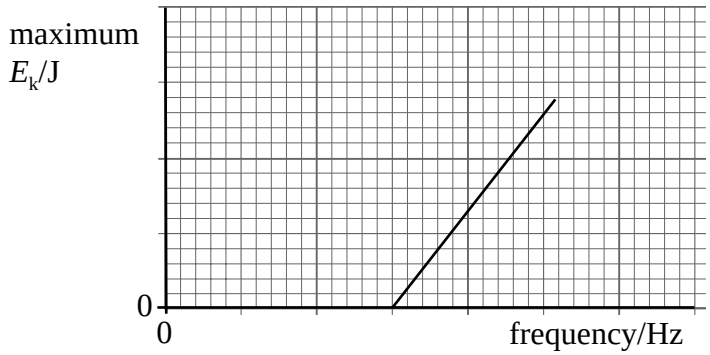
(6 marks)

2 (b) The graph below shows how the maximum kinetic energy of the electrons varies with the frequency of the light shining on the metal surface.



2 (b) (i) On the graph mark the *threshold frequency* and label it f_0.

(1 mark)

2 (b) (ii) On the graph draw a line for a metal which has a higher threshold frequency.

(2 marks)

2 (b) (iii) State what is represented by the gradient of the graph.

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(1 mark)

2 (c) The threshold frequency of a particular metal surface is 5.6×10^{14}Hz. Calculate the maximum kinetic energy of emitted electrons if the frequency of the light striking the metal surface is double the threshold frequency.

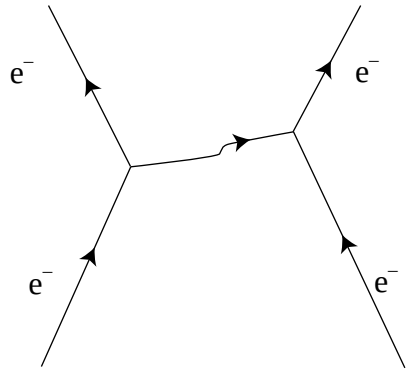
answer = ... J

(3 marks)

13

3 (a) **Figure 2** shows the Feynman diagram for a particular interaction.

Figure 2



3 (a) (i) State the type of interaction involved and name the exchange particle.

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(2 marks)

3 (a) (ii) State **two** quantities other than energy and momentum, that are conserved in this interaction.

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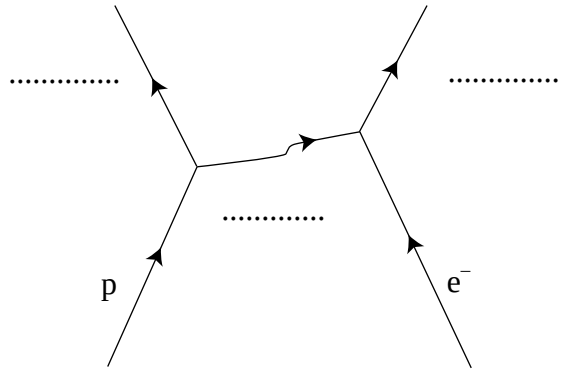
(2 marks)

3 (b) **Figure 3** shows the Feynman diagram for another type of interaction.

Figure 3



3 (b) (i) Complete the diagram to show the two particles formed in the interaction and the exchange particle. *(3 marks)*

3 (b) (ii) Name the type of interaction responsible for this exchange particle.

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(1 mark)

3 (b) (iii) Energy and momentum are conserved in this interaction.
State **two** other quantities that must be conserved and show that they are conserved in this interaction.

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(4 marks)

3 (b) (iv) The exchange particle in this interaction was discovered by experiment with a rest mass that had been predicted. Why is it important to test by experiment the prediction of a scientific theory?

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(2 marks)

14

Turn over ▶

4 (a) State what is meant by the wave-particle duality of electrons.

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(1 mark)

4 (b) Electrons of wavelength 1.2×10^{-10}m are required to investigate the spacing between planes of atoms in a crystal.

4 (b) (i) Calculate the momentum of an electron of this wavelength stating an appropriate unit.

momentum of electron = ...

(3 marks)

4 (b) (ii) Calculate the speed of such an electron.

speed of electron = ... m s^{-1}

(2 marks)

4 (b) (iii) Calculate the kinetic energy of such an electron.

kinetic energy of electron = ... J

(2 marks)

8

5 (a) Some materials exhibit the property of *superconductivity* under certain conditions.

- State what is meant by superconductivity.
- Explain the required conditions for the material to become superconducting.

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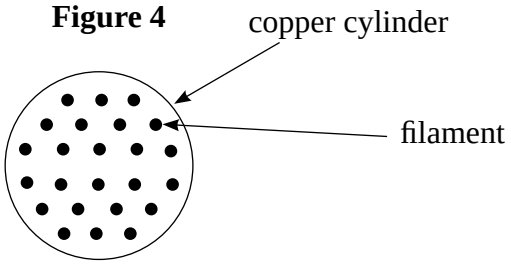
(3 marks)

5 (b) **Figure 4** shows the cross-section of a cable consisting of parallel filaments that can be made superconducting, embedded in a cylinder of copper.

Figure 4



5 (b) (i) The cross-sectional area of the copper in the cable is $2.28 \times 10^{-7} m^2$. The resistance of the copper in a 1.0m length of the cable is 0.075Ω. Calculate the resistivity of the copper, stating an appropriate unit.

answer = ...

(3 marks)

5 (b) (ii) State and explain what happens to the resistance of the cable when the embedded filaments of wire are made superconducting.

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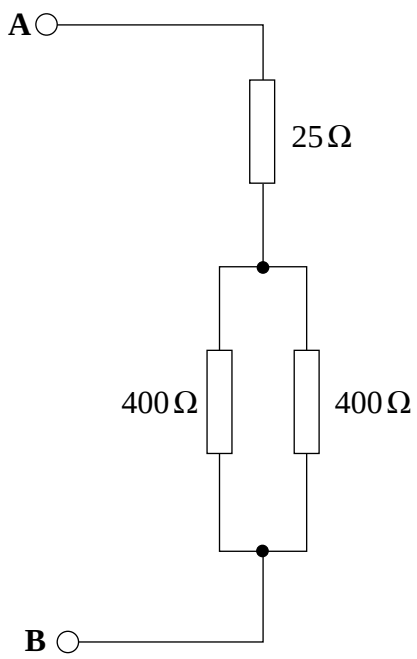
(3 marks)

Turn over ▶

9

6 **Figure 5** shows an arrangement of resistors.

Figure 5



6 (a) Calculate the total resistance between terminals **A** and **B**.

answer = ... Ω

(2 marks)

6 (b) A potential difference is applied between the two terminals, **A** and **B**, and the power dissipated in each of the 400 Ω resistors is 1.0 W.

6 (b) (i) Calculate the potential difference across the 400 Ω resistors.

answer = ... V

6 (b) (ii) Calculate the current through the 25 Ω resistor.

answer = ...A

6 (b) (iii) Calculate the potential difference applied to terminals **A** and **B**.

answer = ... V

(6 marks)

8

Turn over for the next question

7 A car battery has an *emf* of 12V and an *internal resistance* of $5.0 \times 10^{-3}\Omega$.

7 (a) (i) Explain what is meant by the emf of the battery.

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(1 mark)

7 (a) (ii) Explain what is meant by the internal resistance of the battery.

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(1 mark)

7 (b) The battery is used to provide the starting motor of a car with a current of 800 A.

7 (b) (i) Calculate the potential difference across the terminals of the battery.

answer = ... V

(2 marks)

7 (b) (ii) Calculate the rate of dissipation of energy due to its internal resistance stating an appropriate unit.

answer = ...

(3 marks)

7 (c) State and explain the effect of attempting to use a battery with a much higher internal resistance to start the car.

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(2 marks)

END OF QUESTIONS