

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



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 calculator 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.

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



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

$n = 4$	_____	-0.85 eV
$n = 3$	_____	-1.50 eV
$n = 2$	_____	-3.40 eV
$n = 1$	_____	-13.60 eV

- 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)

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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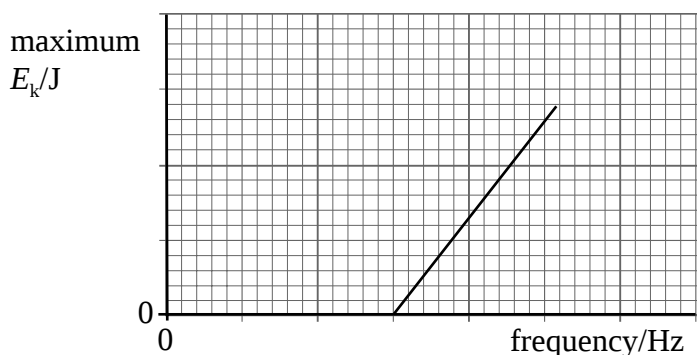
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(6 marks)



- 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.

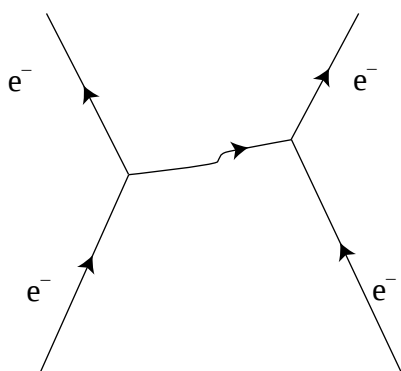


- 2 (b) (i) On the graph mark the *threshold frequency* and label it f_0 . (1 mark)
- 2 (b) (ii) On the graph draw a line for a metal which has a higher threshold frequency. (2 marks)
- 2 (b) (iii) State what is represented by the gradient of the graph.
- (1 mark)
- 2 (c) The threshold frequency of a 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)

- 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)

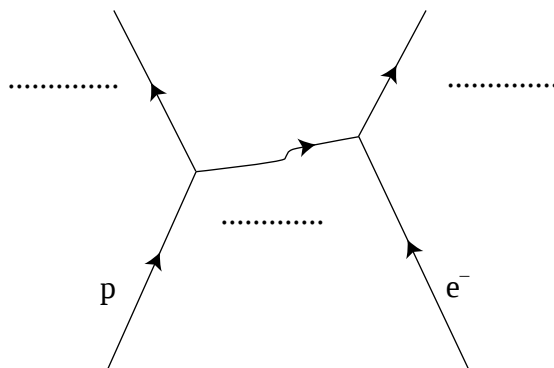
- 3 (a) (ii) State **two** quantities other than energy and momentum, that are conserved in this interaction.

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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.

.....
(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)

- 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)

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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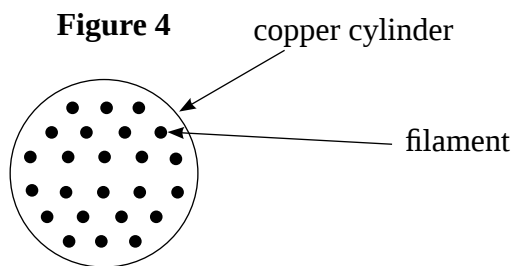
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(3 marks)

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.



5 (b) (i) The cross-sectional area of the copper in the cable is $2.28 \times 10^{-7} \text{ m}^2$. 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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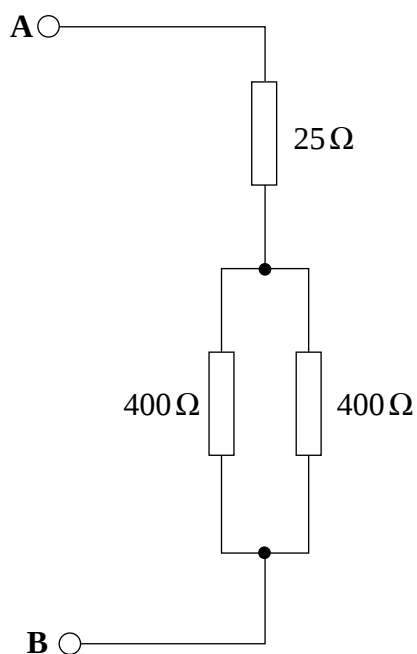
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(3 marks)

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 400Ω resistors is 1.0 W .

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

answer = V

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

.....

 (1 mark)

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

.....

 (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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END OF QUESTIONS

(2 marks)