

Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education  
 January 2009  
 Advanced Subsidiary Examination



**PHYSICS (SPECIFICATION A) PA01**  
**Unit 1 Particles, Radiation and Quantum Phenomena**

Tuesday 13 January 2009 1.30 pm to 2.30 pm

<p><b>For this paper you must have:</b></p> <ul style="list-style-type: none"> <li>• a pencil and a ruler</li> <li>• a calculator</li> <li>• a data sheet insert.</li> </ul>
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Time allowed: 1 hour

**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 the margins or on blank pages will not be marked.
- Show all your working
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

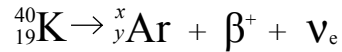
- The maximum mark for this paper is 50. This includes up to two marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided as a loose insert to this question paper.
- You are expected to use a calculator where appropriate.
- Questions 3(a), and 6(a) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			



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

- 1 Potassium  ${}_{19}^{40}\text{K}$ , may undergo  $\beta^+$  decay producing an *isotope* of argon as represented in the following equation,



- 1 (a) What is meant by the word isotope?

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(2 marks)

- 1 (b) How many hadrons are there in an atom of  ${}_{19}^{40}\text{K}$ ?

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(1 mark)

- 1 (c) Calculate the  $\frac{\text{charge}}{\text{mass}}$  ratio for a nucleus of an atom of  ${}_{19}^{40}\text{K}$ .

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(3 marks)

- 1 (d) Write down the numbers represented by  $x$  and  $y$  in the equation.

$x$  .....

$y$  .....

(1 mark)

7
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2 A fluorescent light tube contains mercury vapour at low pressure. The tube is coated on the inside surface and contains two electrodes.

2 (a) Describe and explain the processes which occur involving some of the atoms of mercury in the vapour when the fluorescent tube is in operation.

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(4 marks)

2 (b) Explain the purpose of the coating on the inside surface of the glass tube.

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(3 marks)

**Turn over for the next question**

7

**Turn over ▶**



- 3 (a) When electromagnetic radiation is incident on a particular metal plate, photoelectrons are emitted only when the wavelength of the electromagnetic radiation is below a specific value.

Explain, in terms of energy, why no photoelectron emission occurs above this specific wavelength.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3 marks)

- 3 (b) A sodium metal plate is illuminated with electromagnetic radiation of wavelength  $4.90 \times 10^{-7} \text{ m}$ .  
The work function of sodium is  $3.94 \times 10^{-19} \text{ J}$

- 3 (b) (i) Calculate the frequency of the incident radiation.

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- 3 (b) (ii) Show that the energy of a single photon of the incident radiation is about  $4 \times 10^{-19} \text{ J}$ .

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3 (b) (iii) Calculate the maximum kinetic energy, in J, of the emitted photoelectrons.

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3 (b) (iv) Convert this maximum kinetic energy into eV.

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(5 marks)

8

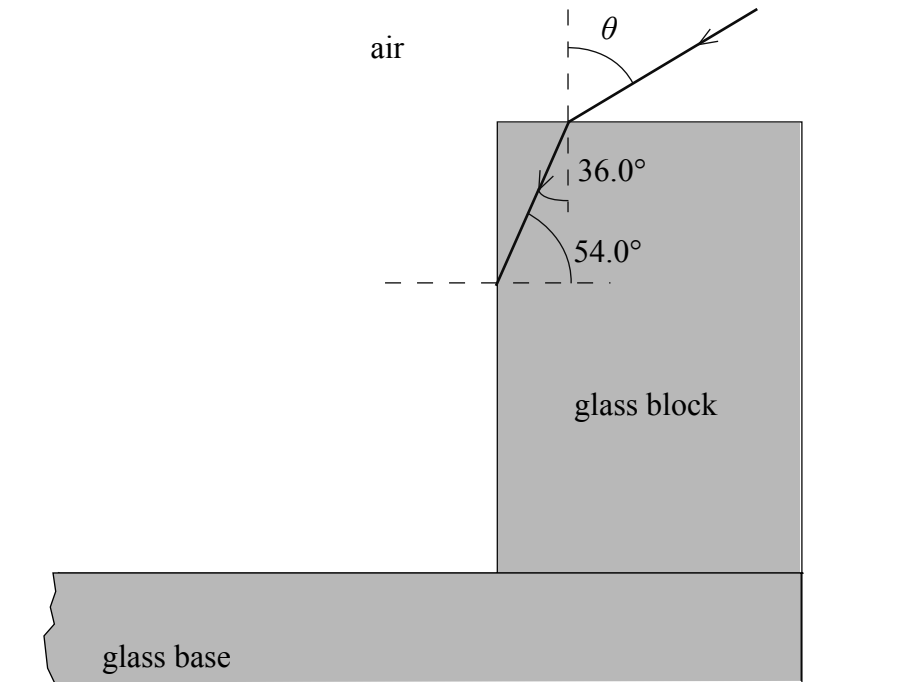
**Turn over for the next question**

**Turn over ▶**



- 4 **Figure 1** shows a vertical rectangular glass block standing on a glass base with a ray of monochromatic light incident on the top surface at an angle  $\theta$ . The ray refracts to an angle of  $36.0^\circ$  in the glass.  
refractive index of the glass block and glass base = 1.60

**Figure 1**



- 4 (a) (i) Calculate the angle of incidence  $\theta$ .

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- 4 (a) (ii) Calculate the critical angle at the glass-air boundary.

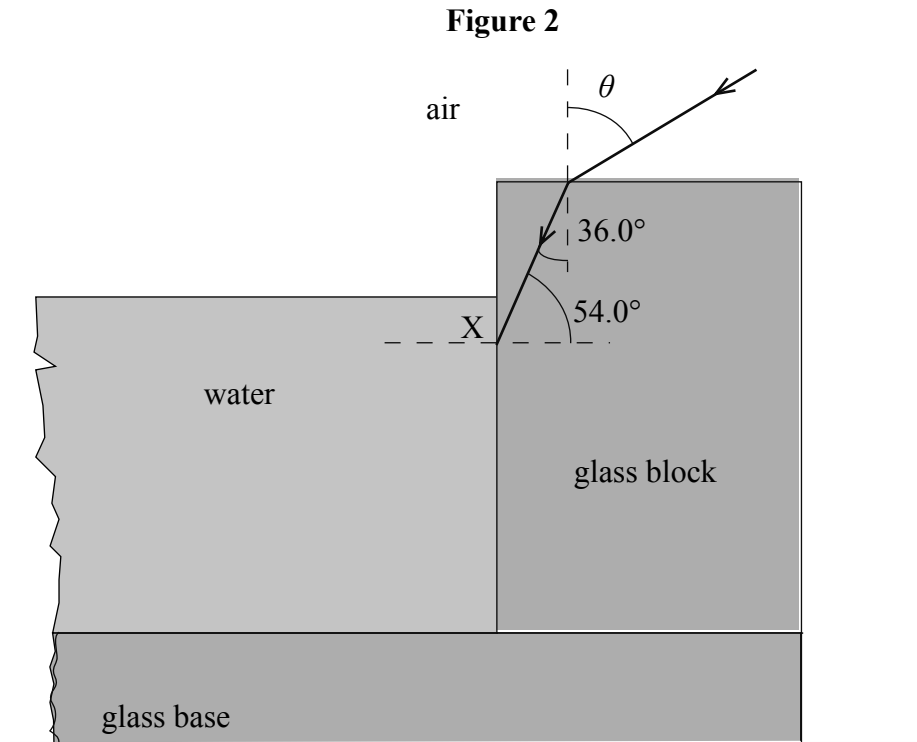
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- 4 (a) (iii) On **Figure 1** continue the path of the ray, show it entering the glass base. Ignore partially reflected rays.

(5 marks)



- 4 (b) The rectangular glass block now acts as a barrier to a pool of water as in **Figure 2**.  
refractive index of water = 1.33



- 4 (b) (i) Show, with a suitable calculation, that the ray does not undergo total internal reflection at the glass-water boundary at X.

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- 4 (b) (ii) On **Figure 2** continue the path of the ray showing it entering the glass base. Ignore partially reflected rays.

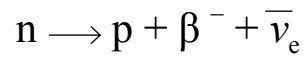
(6 marks)

11

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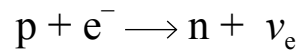
- 5 (a)  $\beta^-$  decay is represented by the equation



Draw a Feynman diagram that shows the change in quark composition in a  $\beta^-$  decay.

(3 marks)

- 5 (b) In electron capture as represented by the equation



energy, momentum and strangeness are all conserved.

Identify **three** other conserved properties and show how each is conserved in electron capture.

Property 1 .....

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Property 2 .....

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Property 3 .....

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(4 marks)

7
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- 6 (a) Electrons behave in two distinct ways; this behaviour is referred to as the duality of electrons.

Identify, and give **one** example of each type of behaviour of electrons.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3 marks)

- 6 (b) (i) Calculate the speed of an electron that has a de Broglie wavelength of  $2.30 \times 10^{-10}$  m.

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**Question 6 continues on the next page**

**Turn over ▶**



- 6 (b) (ii) A different lepton particle, travelling at a speed of  $911 \text{ m s}^{-1}$ , has the same de Broglie wavelength as the electron in part (b)(i). Calculate the mass of this lepton particle.

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(5 marks)

8

**Quality of Written Communication** (2 marks)

2

**END OF QUESTIONS**



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