Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

For Examiner's Use

General Certificate of Education
June 2009
Advanced Subsidiary Examination

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

Thursday 21 May 2009 1.30 pm to 2.30 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a *Data Sheet* insert enclosed.

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 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 2(a) and 3(a)(i) 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 When a neutron is in collision with a nucleus of boron, $^{11}_{5}B$, it is absorbed. The resulting nucleus, X, may rapidly undergo β^- decay to become nucleus Y. The process is represented by the equation.

$$^{11}_{5}B + n \longrightarrow X \longrightarrow {}^{A}_{Z}Y + \beta^- + \overline{\nu}_e$$

1 (a) To which element does the nucleus X belong?

.....

(1 mark)

1 (b) What are the values of A and Z for nucleus Y?

A = ...

Z = ...

(1 mark)

1 (c) Calculate the $\frac{\text{charge}}{\text{mass}}$ ratio for the nucleus $^{11}_{5}B$.

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(3 marks)

5

2 (a) Monochromatic light is incident on a particular metal plate causing photoelectrons to be emitted. The intensity of the monochromatic light is halved.

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

State and explain the effect, if any, this change has on

2 (a) (i) the rate of emission of the photoelectrons,

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2 (a) (ii) the maximum kinetic energy of the photoelectrons.

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(4 marks)

Question 2 continues on the next page

2 (b) The table gives the work function of five metals.

metal	**work function / × 10^{-19} J**
caesium	3.04
potassium	3.58
silver	7.57
sodium	3.94
tungsten	7.33

2 (b) (i) What is the minimum frequency of the incident electromagnetic radiation that will only just remove photoelectrons from a sodium metal plate?

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2 (b) (ii) What is the longest wavelength of electromagnetic radiation incident on a metal plate that will remove photoelectrons from **all** of the metals listed in the table?

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2 (b) (iii) When a potassium metal plate is illuminated with monochromatic light the maximum kinetic energy of the emitted photoelectrons is 4.00×10^{-19} J.
A tungsten metal plate is illuminated by the same light source. What now is the maximum kinetic energy of the emitted photoelectrons?

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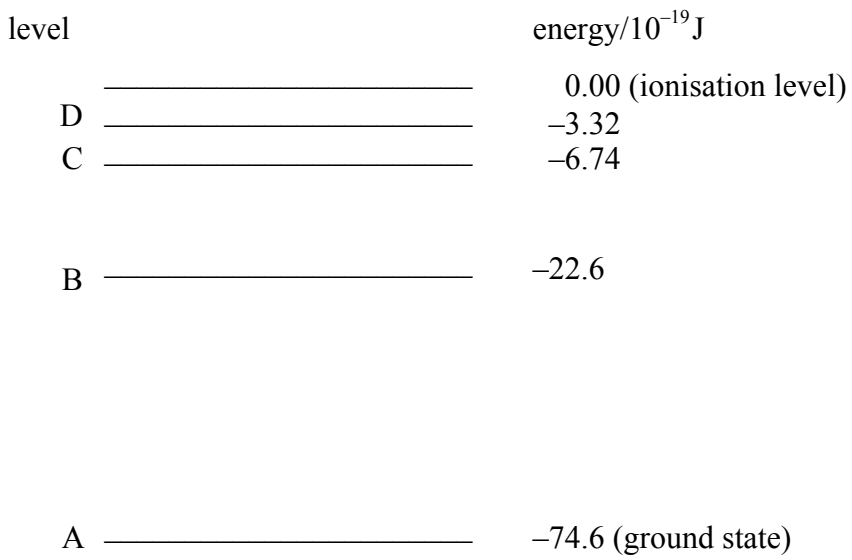
(6 marks)

10

Turn over for the next question

3 The diagram shows the lowest four of the many energy levels of an atom and its ionisation level, not drawn to scale.



3 (a) (i) Explain what is meant by excitation and describe how this atom may be excited.

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

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3 (a) (ii) Explain why this atom would normally emit many photons after it had been excited.

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3 (a) (iii) Describe and explain the nature of the optical spectrum produced from a vapour containing these excited atoms.

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(7 marks)

3 (b) (i) What is the minimum energy, in eV, required to ionise the atom when an electron is in energy level C?

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3 (b) (ii) Calculate the frequency of a photon emitted when the energy of an electron changes from level D to level C.

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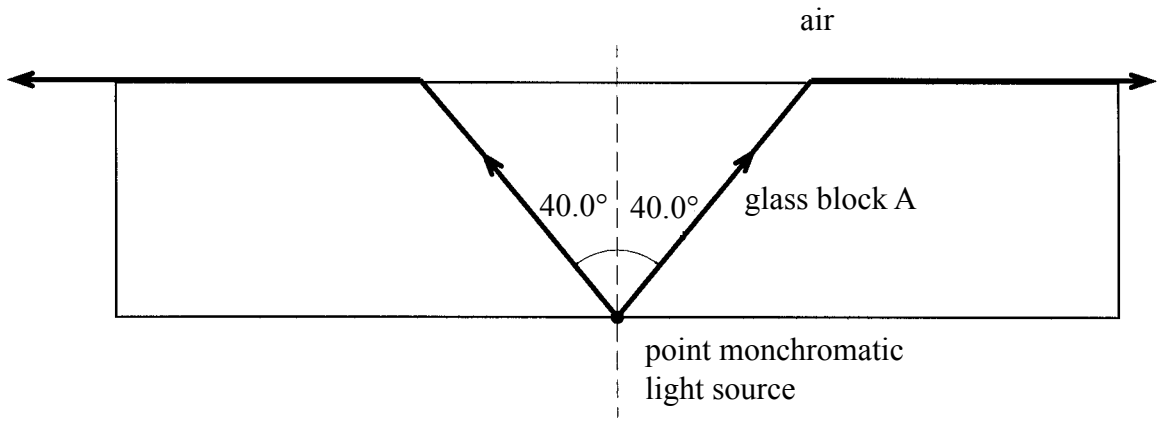
(3 marks)

10

Turn over for the next question

4 **Figure 1** shows two rays of monochromatic light emerging from a point source in contact with a horizontal parallel sided glass block. Both rays are at 40.0° to the vertical and strike the top of the block at the critical angle.

Figure 1



4 (a) Calculate

4 (a) (i) the refractive index of the glass from which block A is made,

.....

.....

4 (a) (ii) the angle to the vertical at which a ray must emerge from the point source in order to leave the top surface of block A at an angle of refraction of 45.0°.

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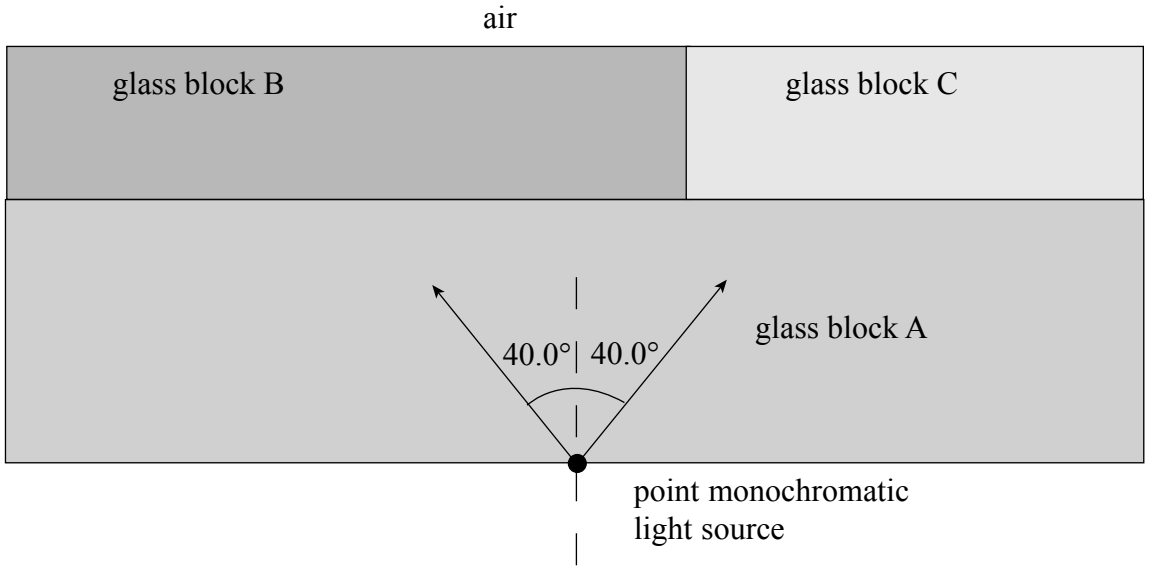
(3 marks)

4 (b) Two parallel sided blocks of glass, B and C, are placed on top of block A as shown in **Figure 2**. The refractive indices, n_A, n_B, and n_C, of the glass from which the three blocks are made are such that n_B is greater than n_A which is greater than n_C ($n_B > n_A > n_C$).

Figure 2



4 (b) (i) Draw on **Figure 2** the continuation of the two rays emerging from the point light source. Ignore partially reflected rays.

($n_B > n_A > n_C$)

4 (b) (ii) The speed of light is $1.92 \times 10^8\,m\,s^{-1}$ in block A and is $2.00 \times 10^8\,m\,s^{-1}$ in block C. Calculate the critical angle for the boundary between glass blocks A and C.

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(6 marks)

9

Turn over ▶

5 (a) In a neutrino – neutron collision an electron neutrino may interact with a down quark.

5 (a) (i) Complete the following equation that represents this interaction.

$$\nu_e + d \longrightarrow \text{.....} + \text{.....}$$

5 (a) (ii) What fundamental force is involved in the interaction?

.....

5 (a) (iii) Name the mediating particle in this interaction and state what role it plays.

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(5 marks)

5 (b) The Δ^{++} is a doubly charged particle made from three quarks, which all have zero strangeness.

5 (b) (i) To what class of particle does the Δ^{++} belong?

.....

5 (b) (ii) Which three quarks make up a Δ^{++} particle?

.....

5 (b) (iii) Which three quarks will the Δ^{++} decay into eventually?

.....

(3 marks)

8

6 (a) A high energy photon may be converted into a proton and an antiproton.

6 (a) (i) What is this process called?

.....

6 (a) (ii) Calculate the minimum energy, in MeV, of a photon that undergoes this conversion.

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6 (a) (iii) A photon, which has more than the minimum energy calculated in part (ii) produces a proton and an antiproton.
What happens to the excess energy?

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(4 marks)

6 (b) Name and classify the particle made from an up quark and an antidown quark.

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(2 marks)

Quality of Written Communication *(2 marks)*

END OF QUESTIONS

There are no questions printed on this page

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