Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

Leave blank

General Certificate of Education
January 2001
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 18 January 2001 Morning Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- The paper carries 30% of the total marks for Physics Advanced Subsidiary and carries 15% of the total marks for Physics Advanced.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated Data Sheet is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this sheet before you begin work.

THE DATA SHEET WILL REPLACE THIS PAGE

THE DATA SHEET WILL REPLACE THIS PAGE

1 A neutral atom of carbon is represented by $^{14}_{6}C$.

(i) Name the constituents of this atom and state how many of each are present.

.....

.....

.....

(ii) Which constituent of an atom has the largest charge-to-mass ratio?

.....

(iii) Carbon has several isotopes. Explain the term *isotope*.

.....

.....

(6 marks)

6

TURN OVER FOR THE NEXT QUESTION

2 (a) The photoelectric effect is represented by the equation

$$hf = \Phi + E_k.$$

Name the following terms and explain their significance in this equation.

Φ .....

.....

.....

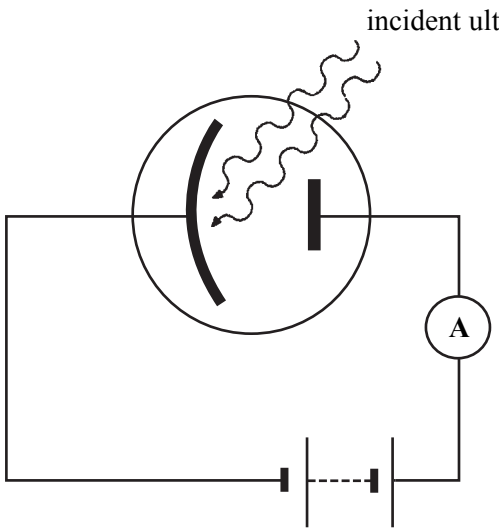
E_k .....

.....

.....

(5 marks)

(b) In the photoelectric apparatus shown, the incident ultraviolet radiation has a wavelength of 220 nm and the current is 2.0 μA.



(i) Give the value of the current when the intensity of the incident radiation is doubled whilst keeping the wavelength constant.

.....

Explain your answer, stating any assumptions you make.

.....

.....

.....

.....

(ii) The wavelength of the incident radiation is now increased and at 350 nm the current falls to zero. Calculate the threshold frequency and Φ.

threshold frequency .....

.....

Φ .....

.....

(5 marks)

10

TURN OVER FOR THE NEXT QUESTION

3 (a) (i) How many quarks are there in a baryon?

.....

(ii) Hadrons fall into two groups, baryons being one of them. What name is given to the other group of hadrons?

.....

(iii) What distinguishes hadrons from other particles?

.....

.....

(3 marks)

(b) (i) Give the name of one antiparticle that is also a lepton.

.....

(ii) What distinguishes leptons from other particles?

.....

.....

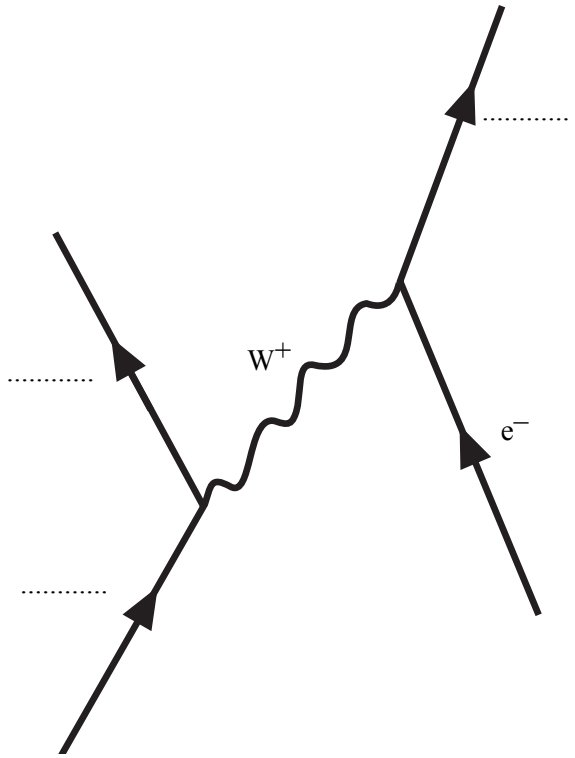
(2 marks)

(c) A neutron decays by the weak interaction.
Complete the equation.

$$n \rightarrow p + \text{.....} + \text{.....}$$

(2 marks)

(d) The Feynman diagram representing electron capture is given below. Complete the labelling of the diagram.

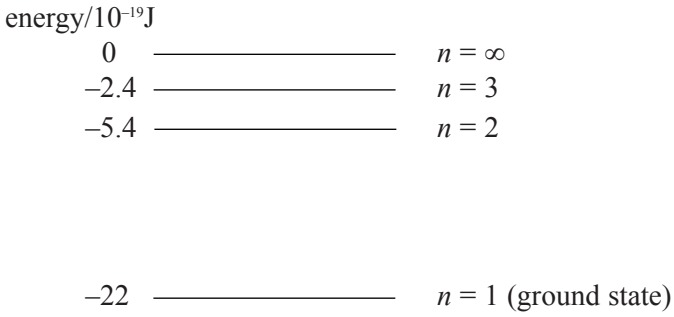


(3 marks)

10

TURN OVER FOR THE NEXT QUESTION

4 The diagram below shows some of the energy levels of the hydrogen atom.



(a) Explain how changes of electron energies can produce a line emission spectrum.

.....

.....

.....

.....

.....

.....

(3 marks)

(b) (i) What is meant by *ionisation*?

.....

.....

(ii) State the energy, in J, required to ionise a hydrogen atom from its ground state.

.....

(iii) Calculate the minimum frequency of radiation that can ionise a hydrogen atom from its ground state.

.....

.....

.....

(iv) Explain what happens to an electron in the ground state of a hydrogen atom when it receives radiation of a frequency greater than the minimum frequency obtained in part (b)(iii).

.....

.....

(5 marks)

(c) Calculate the wavelength of the radiation emitted when an electron falls from level $n = 3$ to level $n = 2$ in the hydrogen atom.

.....

.....

.....

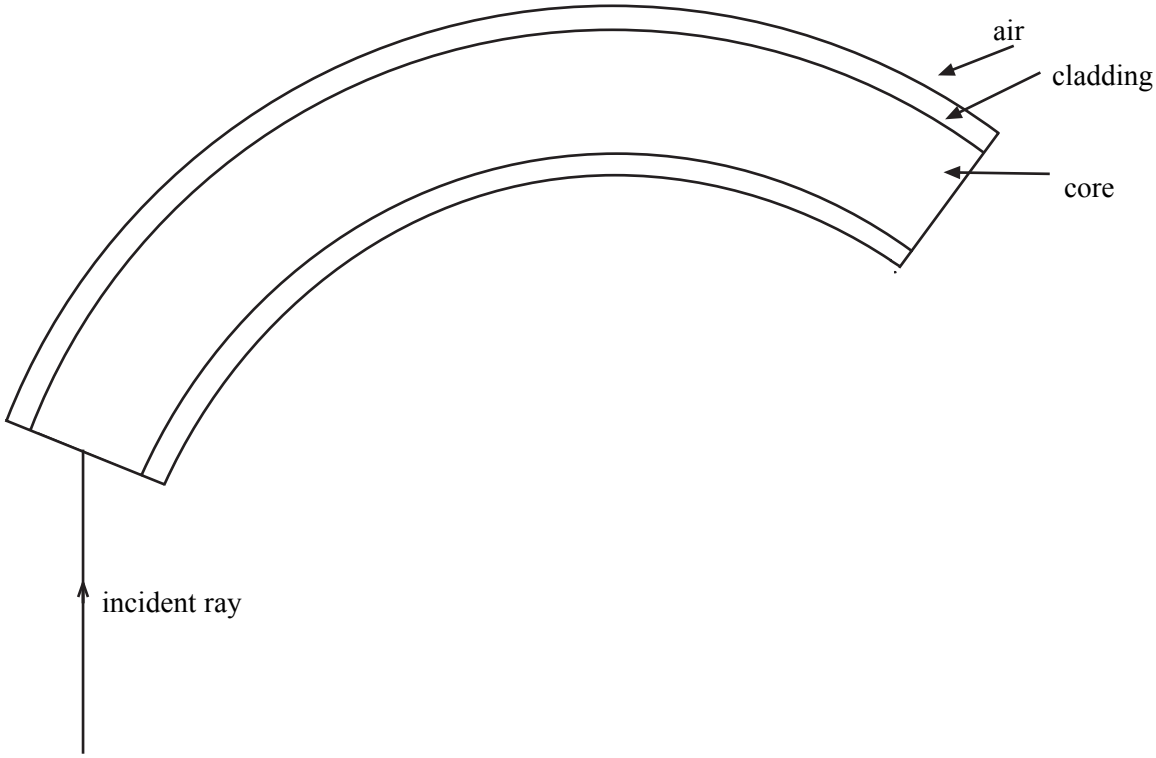
.....

(3 marks)

11

TURN OVER FOR THE NEXT QUESTION

5 (a) The diagram shows a 'step index' optical fibre. A ray of monochromatic light, in the plane of the paper, is incident in air on the end face of the optical fibre as shown in the diagram.



(i) Draw on the diagram the complete path followed by the ray until it emerges at the far end.

(ii) Name the process which occurs as the ray enters the end of the optical fibre.

.....

(iii) The core has a refractive index of 1.50, clad in a material of refractive index 1.45. Calculate the critical angle of incidence at the core-cladding interface.

.....

.....

.....

.....

.....

.....

.....

(7 marks)

(b) (i) Give **one** reason why a cladding material is used in an optical fibre.

.....

.....

(ii) In part (a)(iii), the cladding material has a refractive index of 1.45. Explain why it would be advantageous to use cladding material of refractive index less than 1.45.

.....

.....

.....

.....

(3 marks)

(c) State **one** use of optical fibres.

.....

(1 mark)

11

TURN OVER FOR THE NEXT QUESTION

6 (a) Electrons and electromagnetic waves exhibit properties of both waves and particles. Suggest evidence which indicates that

(i) electrons have wave properties,

.....

(ii) electromagnetic radiation has particle properties,

.....

(iii) electromagnetic radiation has wave properties.

.....

(3 marks)

(b) Calculate the de Broglie wavelength of an electron travelling at $5.0 \times 10^{6}\,\text{m}\,\text{s}^{-1}$. You should ignore relativistic effects.

.....

.....

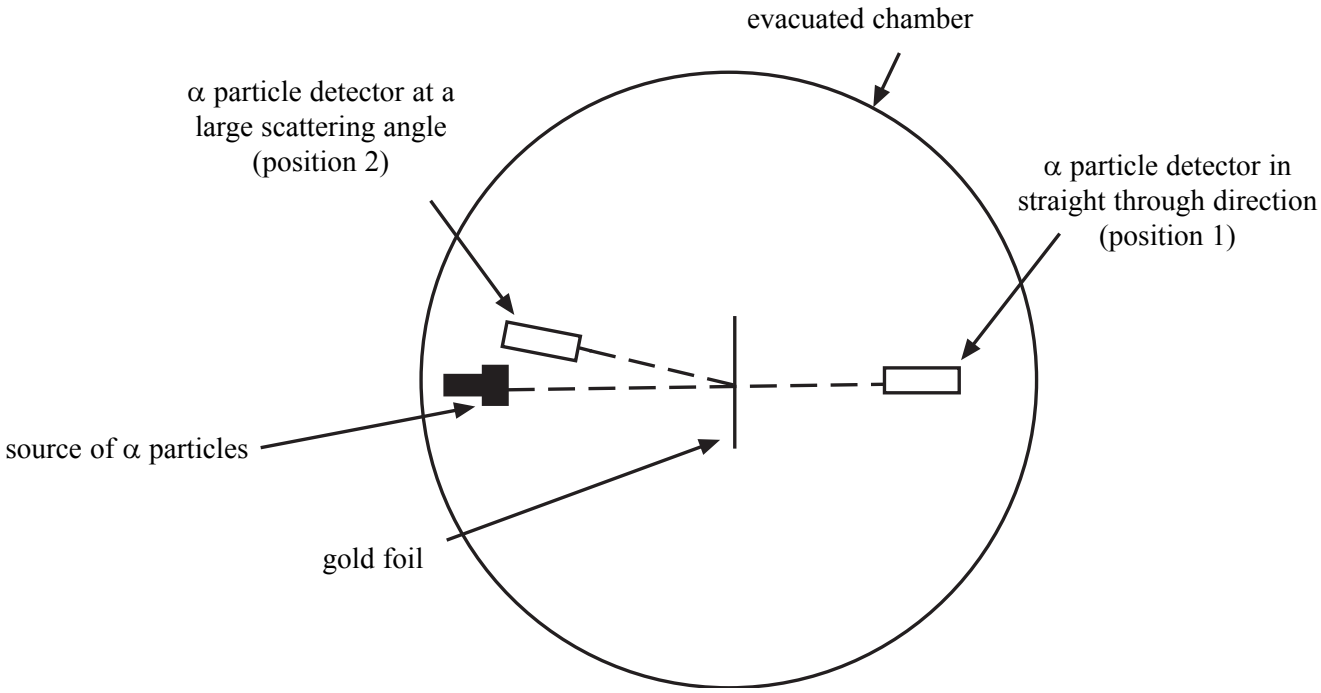
.....

.....

(3 marks)

6

7 The figure below represents an experiment on Rutherford scattering in which α particles are directed at a gold foil. The detector is shown in two positions in the evacuated chamber.



(i) Why is it necessary to remove the air from the apparatus?

.....

.....

(ii) Explain why the gold foil should be very thin.

.....

.....

(iii) Explain why the count rate from the α particle detector in position 1 is much greater than that in position 2.
What can be deduced from this observation about the structure of the atom and the properties of the nucleus of gold?

.....

.....

.....

.....

.....

(6 marks)

6

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE