Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 31 May 2002 Afternoon 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.

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.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- 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.
- You may wish to detach this sheet before you begin work.

DATA SHEET

DATA SHEET

LEAVE MARGIN BLANK

1 An atom of argon $^{37}_{18}Ar$ is ionised by the removal of two orbiting electrons.

(a) How many protons and neutrons are there in this ion?

..... protons

..... neutrons *(2 marks)*

(b) What is the charge, in C, of this ion?

.....

.....

(2 marks)

(c) Which constituent particle of this ion has

(i) a zero charge per unit mass ratio,

.....

(ii) the largest charge per unit mass ratio?

.....

(2 marks)

(d) Calculate the percentage of the total mass of this ion that is accounted for by the mass of its electrons.

.....

.....

.....

.....

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

2 (a) (i) Why is it necessary to remove the air from the chamber in a Rutherford scattering experiment?

.....

.....

(ii) Give **two** conclusions that can be deduced about the nucleus from the results of such an experiment.

conclusion 1 .....

.....

conclusion 2 .....

.....

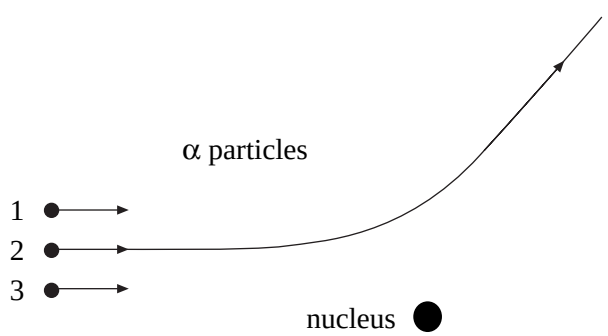
(iii) What force or interaction is responsible for Rutherford scattering?

.....

(4 marks)

(b) The figure shows three α particles, all with the same kinetic energy, directed at a nucleus. The path followed by α particle 2 is given.

Draw lines on the figure to show the paths followed by α particles 1 and 3.

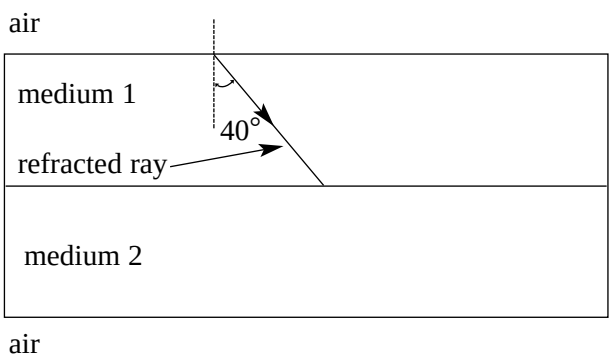


(2 marks)

6

TURN OVER FOR THE NEXT QUESTION

3 A glass plate surrounded by air is made up of two parallel sided sheets of glass in perfect contact as shown in the figure. Medium 1, the top sheet of glass, has a smaller refractive index than medium 2.



(a) A ray of light in air is incident on the top sheet of glass and is refracted at an angle of 40° as shown in the figure. At the boundary between medium 1 and medium 2 some light is transmitted and the remainder reflected.

On the figure, sketch without calculation, the following:

(i) the path followed by the transmitted ray showing it entering from the air at the top and emerging into the air at the bottom;

(ii) the path followed by the reflected ray showing it emerging from medium 1 into the air.

(4 marks)

(b) The refractive index of medium 1 is 1.35 and that of medium 2 is 1.65.

(i) Calculate the angle of incidence where the ray enters medium 1 from the air.

.....

.....

.....

.....

(ii) Calculate the angle of refraction at the boundary between medium 1 and medium 2.

.....

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.....

.....

.....

(5 marks)

(c) Total internal reflection will not occur for any ray incident in medium 1 at the boundary with medium 2.

Explain, without calculation, why this statement is true.

.....

.....

.....

(1 mark)

10

TURN OVER FOR THE NEXT QUESTION

4 (a) A fluorescent tube is filled with mercury vapour at low pressure. In order to emit light the mercury atoms must first be *excited.*

(i) What is meant by an excited mercury atom?

.....

.....

(ii) Describe the process by which mercury atoms become excited in a fluorescent tube.

.....

.....

.....

(3 marks)

(b) What is the purpose of the coating on the inside surface of the glass in a fluorescent tube?

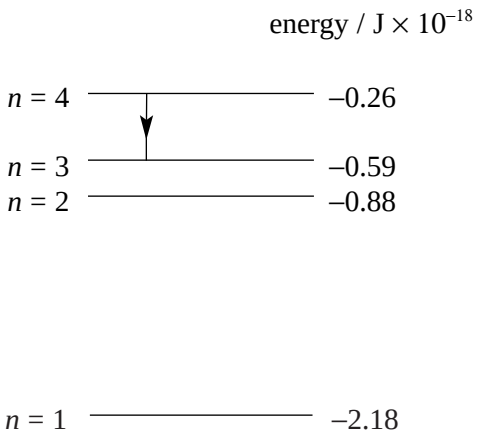
.....

.....

.....

(2 marks)

(c) The lowest energy levels of a mercury atom are shown below. The diagram is **not** to scale.



(i) Calculate the frequency of an emitted photon due to a transition, shown by an arrow, from level $n = 4$ to level $n = 3$.

.....

.....

.....

.....

(ii) Draw a line on the diagram to show a transition which emits a photon of a longer wavelength than that emitted in the transition from level $n = 4$ to level $n = 3$.

(3 marks)

8

TURN OVER FOR THE NEXT QUESTION

5 (a) (i) What class of particle is represented by the combination of three antiquarks, $\bar{q}\bar{q}\bar{q}$?

.....

(ii) Name a hadron that has an antiparticle identical to itself.

.....

(3 marks)

(b) The kaon K^+ has a strangeness of +1.

(i) Give its quark composition.

.....

.....

(ii) The K^+ may decay via the process

$$K^+ \rightarrow \pi^+ + \pi^0.$$

State the interaction responsible for this decay.

.....

(iii) The K^+ may also decay via the process

$$K^+ \rightarrow \mu^+ + \nu_\mu.$$

Change each particle in this equation to its corresponding antiparticle in order to complete an allowed decay process for the negative kaon K^-.

$$K^- \rightarrow$$

(iv) Into what class of particle can both the μ^+ and the ν_μ be placed?

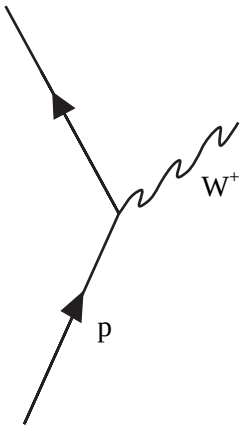
.....

(v) State **one** difference between a positive muon, μ^+, and a positron, e^+.

.....

(6 marks)

(c) The figure below shows a partially completed Feynman diagram of β^+ decay.



Complete the figure and label all the particles involved.

(3 marks)

12

TURN OVER FOR THE NEXT QUESTION

6 (a) When monochromatic light is incident on a particular metal plate, electrons are emitted. The intensity of the light is then increased.

Explain

(i) why the maximum kinetic energy of the emitted electrons does **not** change,

.....

.....

.....

.....

(ii) why the number of electrons emitted per second increases.

.....

.....

.....

.....

(3 marks)

(b) A potassium metal plate is illuminated with incident light of wavelength 5.10×10^{-7} m. The work function of potassium is 3.58×10^{-19} J.

(i) Show that the frequency of the incident light is approximately 6×10^{14} Hz.

.....

.....

.....

(ii) Calculate the energy, in J, of an incident photon.

.....

.....

.....

(iii) Calculate the maximum kinetic energy, in J, of an emitted electron.

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.....

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(iv) The table gives the work function of four metals.

metal	work function / J $\times 10^{-19}$
caesium	3.04
silver	7.57
sodium	3.94
tungsten	7.33

Which of these metals would emit electrons when illuminated with light of wavelength 5.10×10^{-7} m?

.....

(7 marks)

10

TURN OVER FOR THE NEXT QUESTION

7 (i) Calculate the de Broglie wavelength of an electron travelling at 2.00% of the speed of light.

.....

.....

.....

.....

(ii) Determine the frequency of the electromagnetic radiation that would have the same wavelength as this electron.

.....

.....

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.....

(5 marks)

5

END OF QUESTIONS