Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2001
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 6 June 2001 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 a blue or black 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

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

1 (a) $^{232}_{90}Th$ is a neutral atom of thorium. How many protons, neutrons and electrons does it contain?

..... protons

..... neutrons

..... electrons *(2 marks)*

(b) $^{Y}_{X}Th$ is a neutral atom of a different isotope of thorium which contains Z electrons. Give possible values for X, Y and Z.

X = ...

Y = ...

Z = ... *(3 marks)*

5

2 In a particle accelerator a proton and an antiproton, travelling at the same speed, undergo a head-on collision and produce subatomic particles.

(a) The total kinetic energy of the two particles just before the collision is 3.2×10^{-10} J.

(i) What happens to the proton and antiproton during the collision?

.....

.....

(ii) State why the total energy after the collision is more than 3.2×10^{-10} J.

.....

.....

.....

(2 marks)

(b) In a second experiment the total kinetic energy of the colliding proton and antiproton is greater than 3.2×10^{-10} J.

State **two** possible differences this could make to the subatomic particles produced.

1 .....

2 .....

(2 marks)

4

3 **Figure 1** shows the apparatus used to investigate Rutherford scattering, in which α particles are fired at a gold foil.

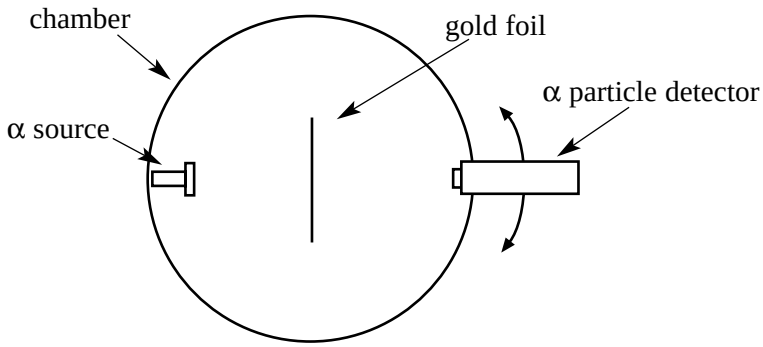


Figure 1

(a) Why is it essential for there to be a vacuum in the chamber?

.....

.....

(2 marks)

(b) What observations made with this apparatus support each of the following conclusions? No explanation is required.

(i) The nuclear radius of gold is much smaller than its atomic radius.

.....

.....

(ii) Most of the mass of an atom of gold is contained in its nucleus.

.....

.....

(3 marks)

(c) **Figure 2** shows α particles incident on a layer of atoms in a gold foil.

On this figure draw the complete path followed by **each** of the α particles shown.

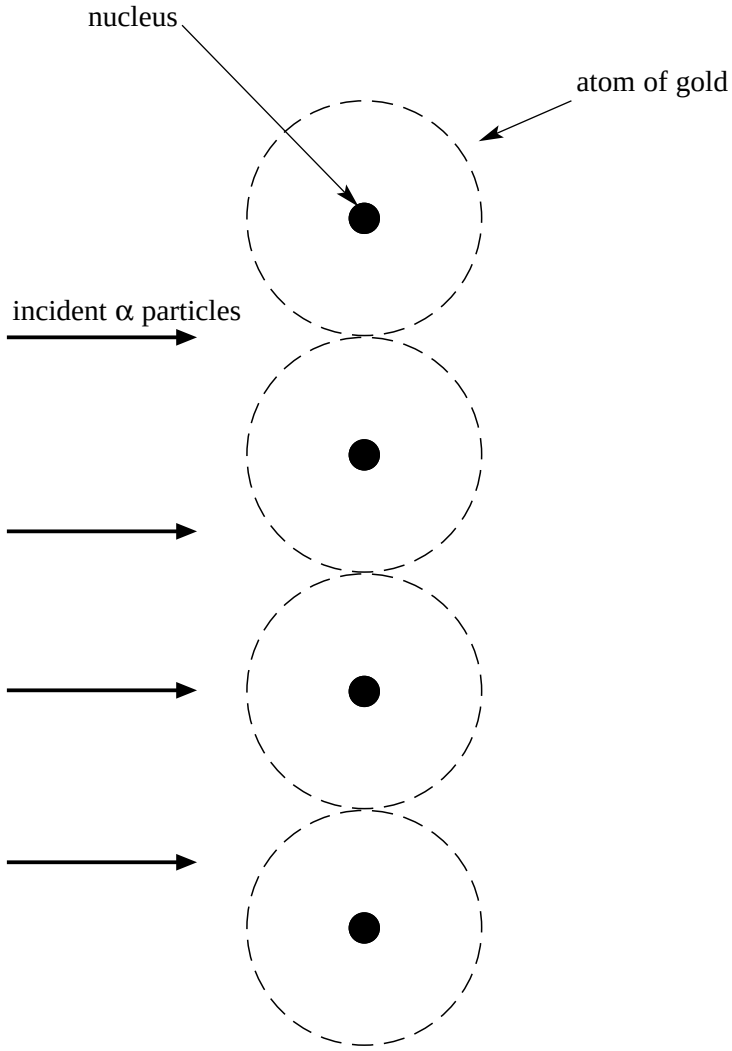


Figure 2

(3 marks)

8

TURN OVER FOR THE NEXT QUESTION

4 (a) The negative kaon, K^-, has a strangeness of –1.
Write down its quark composition.

.....

(2 marks)

(b) The kaon, K^-, may decay into a muon and an antineutrino in the following way:

$$K^- \rightarrow \mu^- + \bar{\nu}_\mu .$$

(i) Complete the following table using ticks and crosses as indicated in the first row.

	K^-	μ^-	$\bar{\nu}_\mu$
charged particle	✓	✓	×
hadron			
meson			
baryon			
lepton			

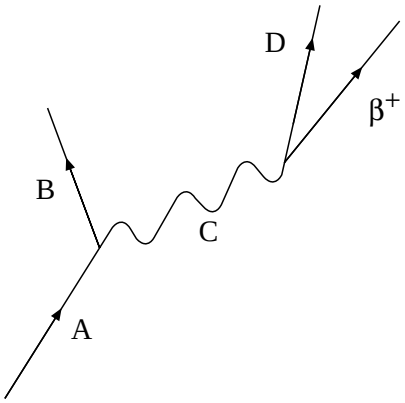
(ii) In the decay shown above, charge is conserved. Give another quantity that is conserved and a quantity that is not conserved in the decay of K^- .

quantity conserved .....

quantity not conserved .....

(6 marks)

(c) The Feynman diagram below represents the β^+ decay process.



(i) What quantity changes continuously in moving from the bottom to the top of the diagram?

.....

(ii) Name the particles represented by the letters A to D.

A .....

B .....

C .....

D .....

(iii) What type of interaction is responsible for β^+ decay?

.....

(6 marks)

14

5 (a) State what happens in an atom when line spectra are produced.

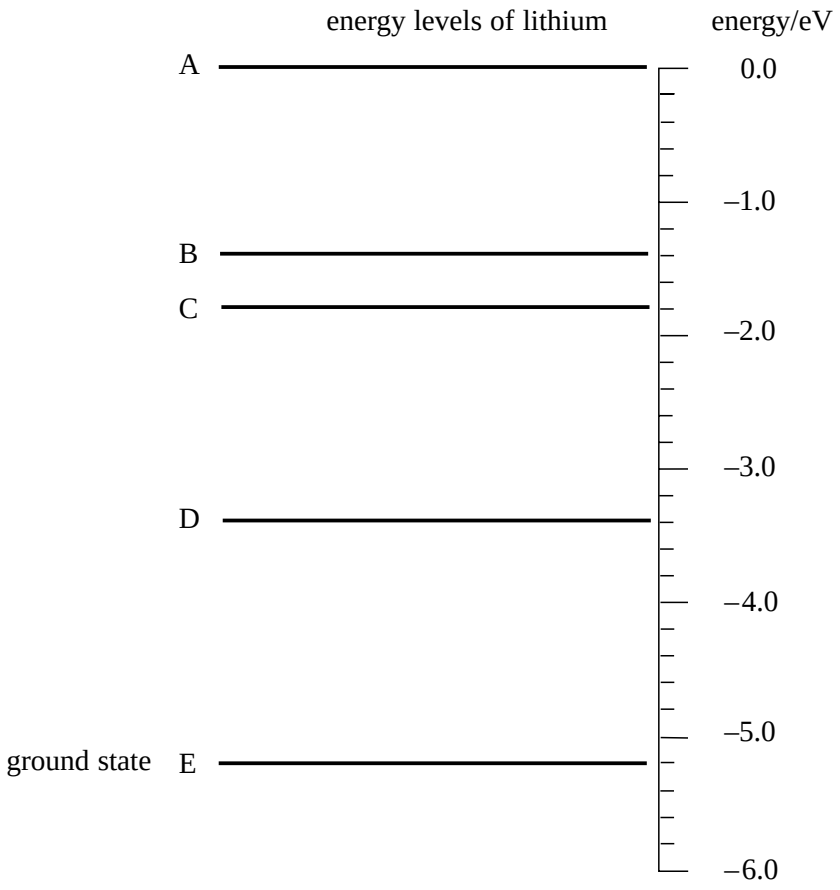
.....

.....

.....

(2 marks)

(b) The diagram below represents some energy levels of the lithium atom.



(i) Calculate the ionisation energy, in J, of the lithium atom.

.....

.....

(ii) An excited lithium atom may emit radiation of wavelength 6.1×10^{-7}m.
Show that the frequency of this radiation is approximately 5.0×10^{14}Hz.

.....

.....

(iii) Calculate the energy, in J, of each photon of this radiation.

.....

.....

(iv) Draw, on the diagram, an arrow between two energy levels which shows the transition responsible for the emission of a photon of energy 2.0 eV.

(v) Two transitions emit radiation of similar frequencies. One of them is the transition between A and C.
What is the other?

.....

(vi) A transition between which two levels would give radiation of the longest possible wavelength?

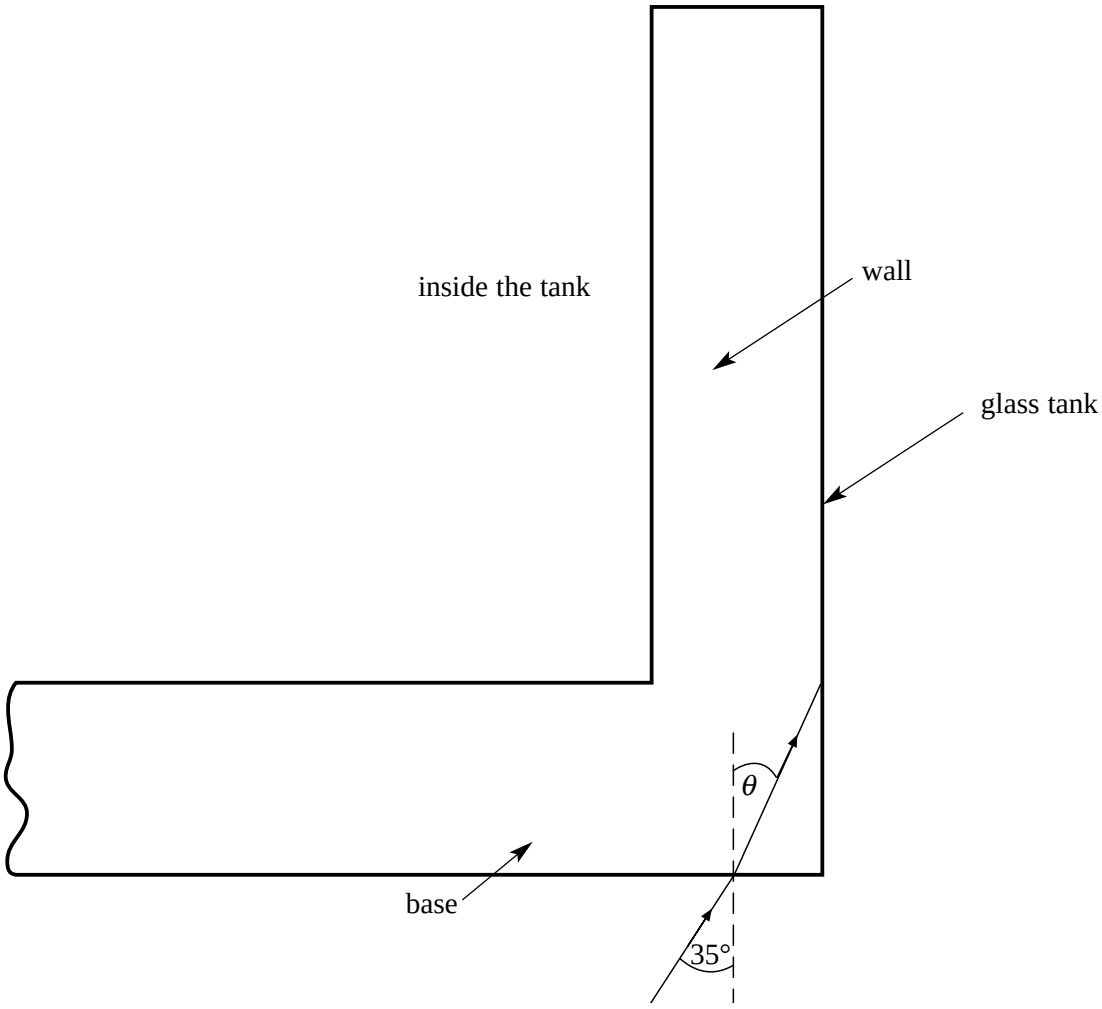
.....

(9 marks)

11

TURN OVER FOR THE NEXT QUESTION

6 The diagram shows a cross-section of one wall and part of the base of an empty fish tank, viewed from the side. It is made from glass of refractive index 1.5. A ray of light travelling in air is incident on the base at an angle of 35° as shown.



(a) Calculate the angle θ.

.....

.....

.....

.....

(2 marks)

(b) (i) Calculate the critical angle for the glass-air interface.

.....

.....

.....

(ii) Hence, draw on the diagram the continuation of the path of the ray through the glass wall and out into the air. Mark in the values of all angles of incidence, refraction and reflection.

(6 marks)

8

TURN OVER FOR THE NEXT QUESTION

7 (a) (i) State what is meant by the *wave-particle duality* of electromagnetic radiation.

.....

.....

(ii) Which aspect of the dual nature of electromagnetic radiation is demonstrated by the photoelectric effect?

.....

(2 marks)

(b) A metal plate is illuminated with ultra violet radiation of frequency 1.67×10^{15}Hz.
The maximum kinetic energy of the liberated electrons is 3.0×10^{-19}J.

(i) Calculate the work function of the metal.

.....

.....

.....

.....

.....

.....

(ii) The radiation is maintained at the same frequency but the intensity is doubled. State what changes, if any, occur to the number of electrons released per second and to the maximum kinetic energy of these electrons.

number per second .....

maximum kinetic energy .....

(iii) The metal plate is replaced by another metal plate of different material. When illuminated by radiation of the same frequency no electrons are liberated.

Explain why this happens and what can be deduced about the work function of the new metal.

.....

.....

.....

.....

(8 marks)

10

END OF QUESTIONS

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