

Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
 June 2005
 Advanced Level Examination



PHYSICS (SPECIFICATION A) PHA8/W
Unit 8 Nuclear Instability: Turning Points in Physics Option

Thursday 16 June 2005 Morning Session

In addition to this paper you will require:

- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 15 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 40.
- Mark allocations are shown in brackets.
- The paper carries 10% 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			
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

$$\text{magnitude of induced e.m.f.} = N \frac{\Delta\Phi}{\Delta t}$$

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

Mechanical and Thermal Properties

$$\text{the Young modulus} = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F}{A} \frac{l}{e}$$

$$\text{energy stored} = \frac{1}{2} Fe$$

$$\Delta Q = mc \Delta\theta$$

$$\Delta Q = ml$$

$$pV = \frac{1}{3} Nmc^2$$

$$\frac{1}{2} mc^2 = \frac{3}{2} kT = \frac{3RT}{2N_A}$$

Nuclear Physics and Turning Points in Physics

$$\text{force} = \frac{eV_p}{d}$$

$$\text{force} = Bev$$

$$\text{radius of curvature} = \frac{mv}{Be}$$

$$\frac{eV}{d} = mg$$

$$\text{work done} = eV$$

$$F = 6\pi\eta rv$$

$$I = k \frac{I_0}{x^2}$$

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$N = N_0 e^{-\lambda t}$$

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

$$R = r_0 A^{\frac{1}{3}}$$

$$E = mc^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$l = l_0 \left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$$

$$t = \frac{t_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

Astrophysics and Medical Physics

Body	Mass/kg	Mean radius/m
Sun	2.00×10^{30}	7.00×10^8
Earth	6.00×10^{24}	6.40×10^6

$$1 \text{ astronomical unit} = 1.50 \times 10^{11} \text{ m}$$

$$1 \text{ parsec} = 206265 \text{ AU} = 3.08 \times 10^{16} \text{ m} = 3.26 \text{ ly}$$

$$1 \text{ light year} = 9.45 \times 10^{15} \text{ m}$$

$$\text{Hubble constant } (H) = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

$$M = \frac{f_o}{f_c}$$

$$m - M = 5 \log \frac{d}{10}$$

$$\lambda_{\text{max}} T = \text{constant} = 0.0029 \text{ m K}$$

$$v = Hd$$

$$P = \sigma AT^4$$

$$\frac{\Delta f}{f} = \frac{v}{c}$$

$$\frac{\Delta \lambda}{\lambda} = -\frac{v}{c}$$

$$R_s \approx \frac{2GM}{c^2}$$

Medical Physics

$$\text{power} = \frac{1}{f}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ and } m = \frac{v}{u}$$

$$\text{intensity level} = 10 \log \frac{I}{I_0}$$

$$I = I_0 e^{-\mu x}$$

$$\mu_m = \frac{\mu}{\rho}$$

Electronics

Resistors

Preferred values for resistors (E24)
Series: 1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2
2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2
6.8 7.5 8.2 9.1 ohms
and multiples that are ten times greater

$$Z = \frac{V_{\text{rms}}}{I_{\text{rms}}}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

$$C_T = C_1 + C_2 + C_3 + \dots$$

$$X_C = \frac{1}{2\pi f C}$$

Alternating Currents

$$f = \frac{1}{T}$$

Operational amplifier

$$G = \frac{V_{\text{out}}}{V_{\text{in}}} \quad \text{voltage gain}$$

$$G = -\frac{R_f}{R_1} \quad \text{inverting}$$

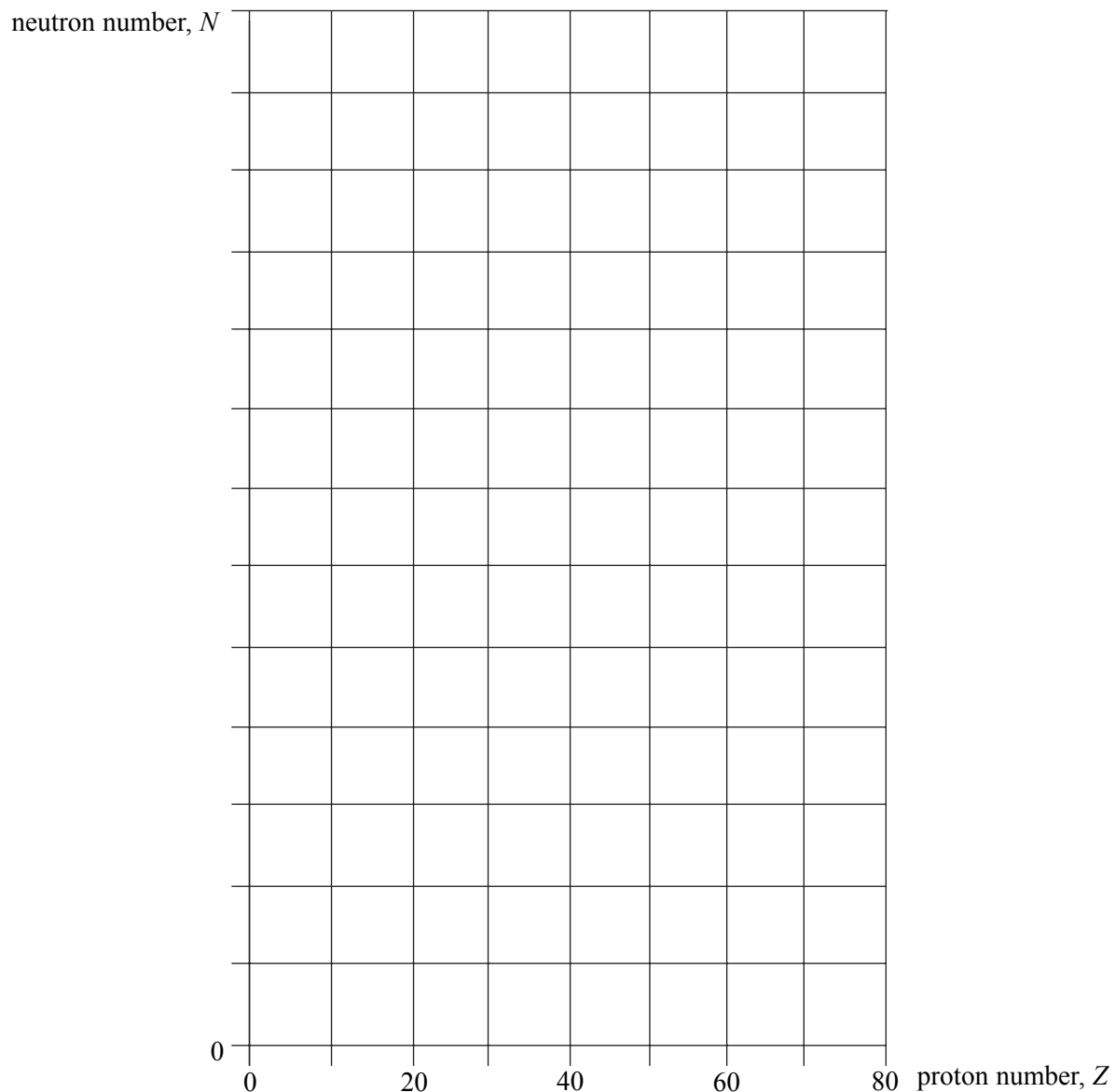
$$G = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{\text{out}} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) \quad \text{summing}$$

TURN OVER FOR THE FIRST QUESTION

SECTION A: NUCLEAR INSTABILITYAnswer **all** parts of the question.

- 1 (a) Sketch, using the axes provided, a graph of neutron number, N , against proton number, Z , for stable nuclei over the range $Z = 0$ to $Z = 80$. Show suitable numerical values on the N axis.

*(2 marks)*

- (b) On the graph indicate, for each of the following, a possible position of a nuclide that may decay by
- α emission, labelling the position with **W**,
 - β^- emission, labelling the position with **X**,
 - β^+ emission, labelling the position with **Y**.

(3 marks)

- (c) The isotope ${}^{222}_{86}\text{Rn}$ decays sequentially by emitting α particles and β^- particles, eventually forming the isotope ${}^{206}_{82}\text{Pb}$. Four α particles are emitted in the sequence.

Calculate the number of β^- particles in the sequence.

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(2 marks)

- (d) A particular nuclide is described as proton-rich. Discuss **two** ways in which the nuclide may decay.

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

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(3 marks)

10

TURN OVER FOR SECTION B

SECTION B: TURNING POINTS IN PHYSICS

Answer **all** questions.

- 2 In a transmission electron microscope, electrons from a heated filament are accelerated through a certain potential difference and then directed in a beam through a thin sample. The electrons scattered by the sample are focused by magnetic lenses onto a fluorescent screen where an image of the sample is formed, as shown in **Figure 1**.

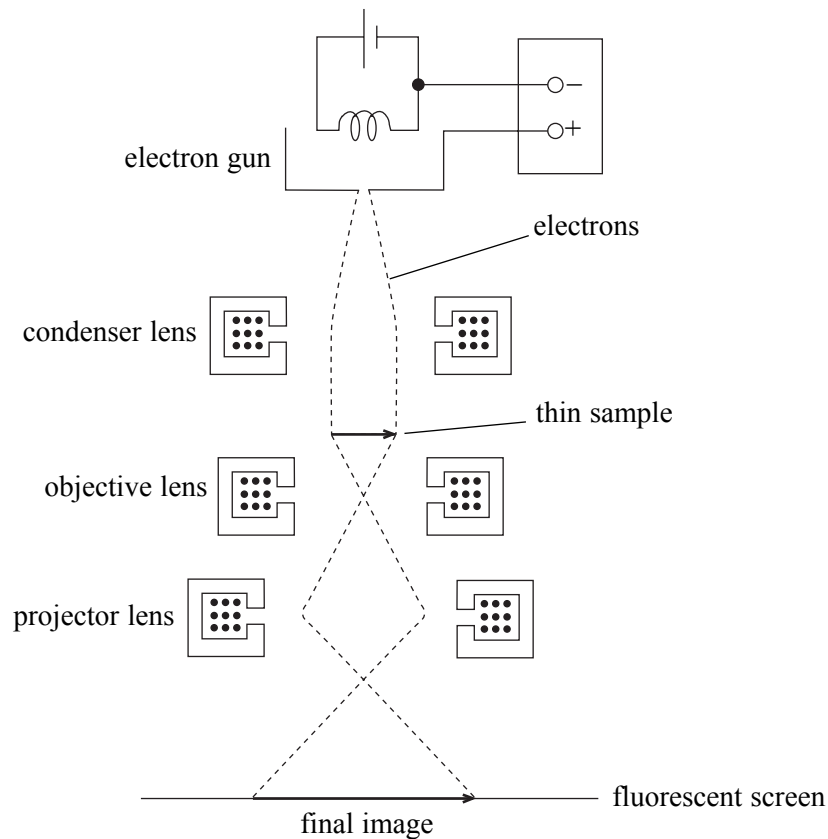


Figure 1

- (a) State and explain **one** reason why it is important that the electrons in the beam have the same speed.

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(2 marks)

(b) When the potential difference is increased, a more detailed image is seen. Explain why this change happens.

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(3 marks)

5

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

3 Photoelectric emission occurs from a certain metal plate when the plate is illuminated by blue light but not by red light.

(a) Explain why photoelectric emission occurs from this plate using blue light but not using red light.

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(4 marks)

(b) Outline why Huygens' wave theory of light fails to explain the fact that blue light causes photoelectric emission from this plate but red light does not.

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(2 marks)

6

4 (a) Calculate the speed at which a matter particle has a mass equal to 10 times its rest mass.

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(3 marks)

(b) Explain why a matter particle can not travel as fast as a photon in free space even though its kinetic energy can be increased without limit.

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(3 marks)

6

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

- 5 A narrow beam of electrons is directed into a uniform electric field created by two oppositely charged parallel horizontal plates, as shown in **Figure 2**. The initial direction of the beam is perpendicular to the direction of the electric field. The beam makes a visible trace on a vertical fluorescent screen.

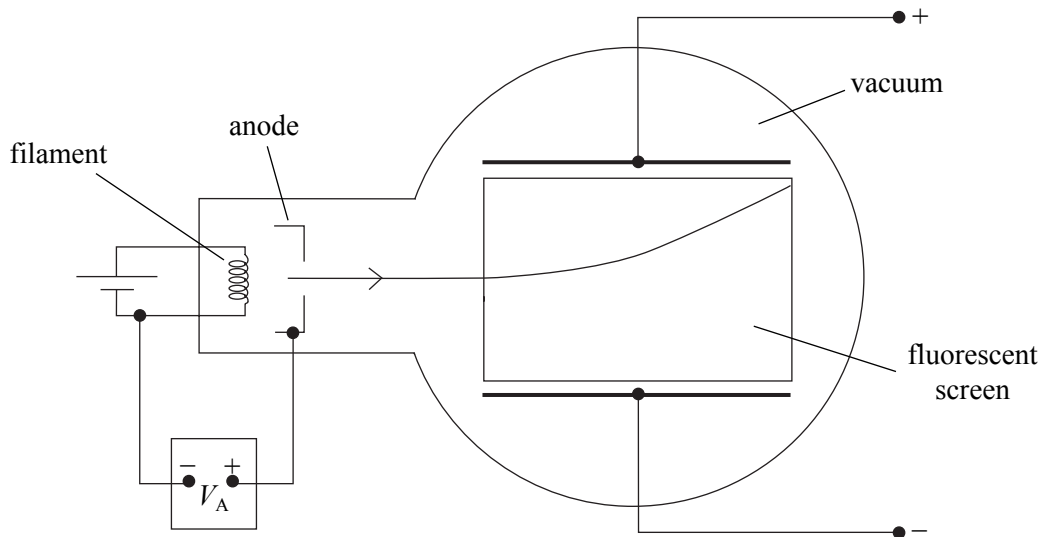


Figure 2

- (a) Explain why the beam curves upwards at an increasing angle to the horizontal.

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

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(4 marks)

(b) When a uniform magnetic field of a certain flux density is applied perpendicular to the screen, the beam passes between the plates undeflected.

(i) Show that the beam is undeflected when the magnetic flux density $B = \frac{E}{v}$, where E is the electric field strength between the plates and v is the speed of the electrons.

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(ii) Hence show that the specific charge, e/m , of the electron can be calculated using

$$\frac{e}{m} = \frac{E^2}{2B^2V_A}$$

where V_A is the anode voltage and B is the magnetic flux density needed for zero deflection.

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(iii) Determine the specific charge of the electron using the following data:

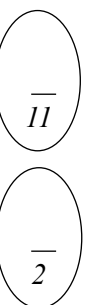
anode voltage	=	4500 V
potential difference between the plates	=	3800 V
plate separation	=	50 mm
magnetic flux density	=	1.9 mT

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(7 marks)

QUALITY OF WRITTEN COMMUNICATION (2 marks)

END OF QUESTIONS



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