Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2002
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) PHA6/W
Unit 6 Nuclear Instability: Medical Physics Option

Friday 21 June 2002 Afternoon 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			
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

TURN OVER FOR THE FIRST QUESTION

SECTION A NUCLEAR INSTABILITY

Answer **all** parts of the question.

1 (a) State which type of radiation, α, β or γ,

(i) produces the greatest number of ion pairs per mm in air,

.....

(ii) could be used to test for cracks in metal pipes.

.....

(2 marks)

(b) Specific radioisotope sources are chosen for tracing the passage of particular substances through the human body.

(i) Why is a γ emitting source commonly used?

.....

.....

(ii) State why the source should **not** have a very short half-life.

.....

.....

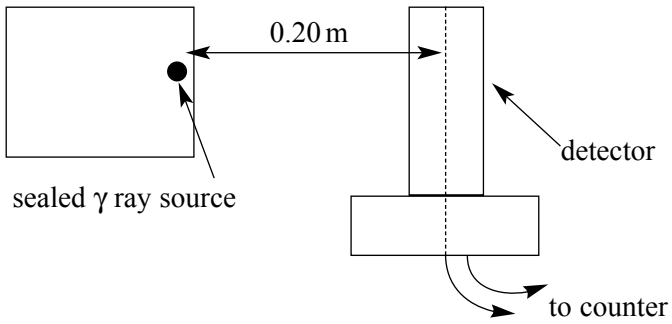
(iii) State why the source should **not** have a very long half-life.

.....

.....

(3 marks)

(c) A detector, placed 0.20 m from a sealed γ ray source, receives a mean count rate of 2550 counts per minute. The experimental arrangement is shown in the diagram below. The mean background radiation is measured as 50 counts per minute.



Calculate the least distance between the source and the detector if the count rate is not to exceed 6000 counts per minute.

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(5 marks)

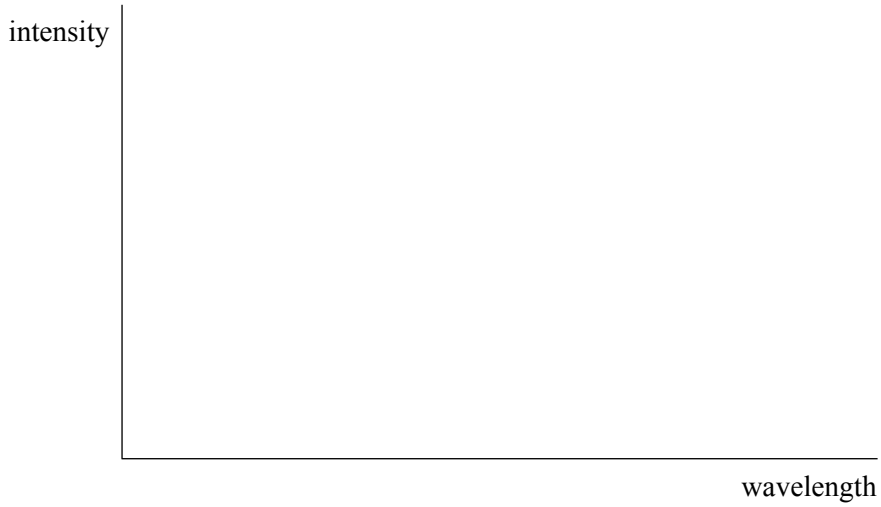
10

TURN OVER FOR THE NEXT QUESTION

SECTION B MEDICAL PHYSICS

Answer **all** questions.

2 (a) Sketch, on the axes below, the response curves for the colour cones of the eye. Label the wavelength axis with a scale appropriate for your curves.



(4 marks)

(b) In terms of receptors,

(i) give the condition for two different images to be resolved by the eye,

.....

.....

.....

.....

(ii) explain why finer detail can be seen in bright light than in dim light.

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.....

.....

(3 marks)

(c) (i) State what is meant by *persistence of vision*.

.....

.....

(ii) Give an example of a practical situation where persistence of vision is used to advantage.

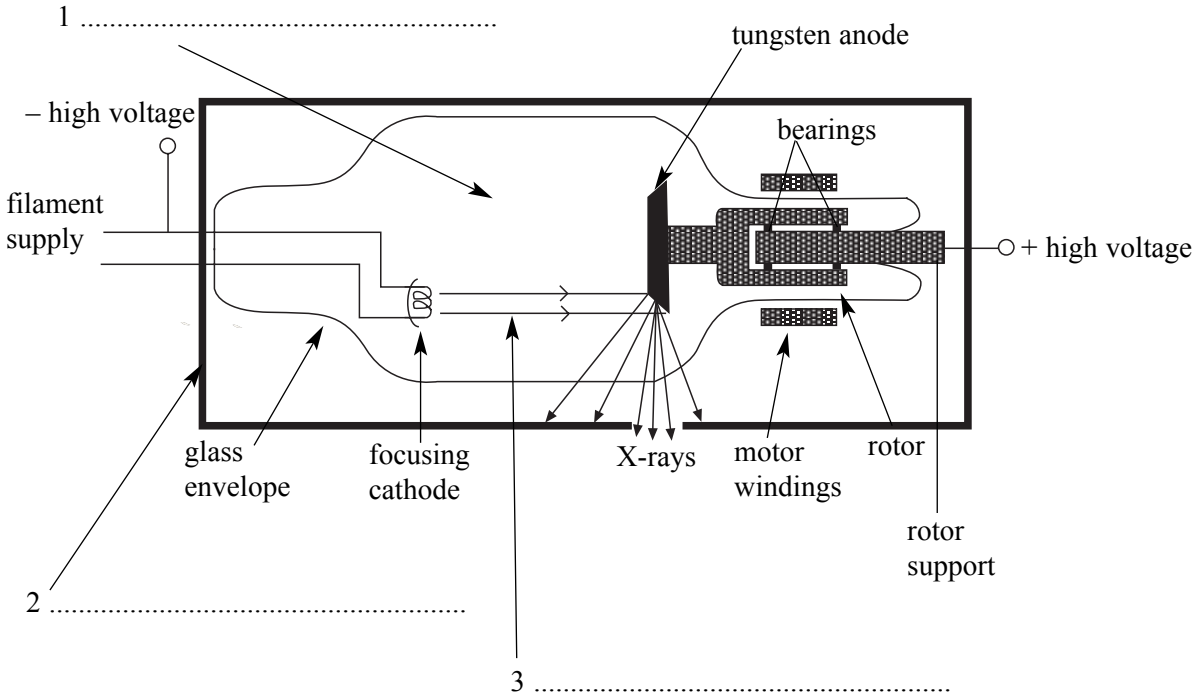
.....

(2 marks)

9

TURN OVER F0R THE NEXT QUESTION

3 (a) The diagram shows a rotating-anode X-ray tube. Complete the labelling of the **three** numbered arrows in the diagram.



(3 marks)

(b) Explain why the anode

(i) is rotated,

.....

.....

.....

(ii) has a bevelled edge.

.....

.....

.....

(3 marks)

(c) Define for a material,

(i) the linear attenuation coefficient, μ,

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.....

.....

(ii) the half-value thickness.

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.....

.....

(2 marks)

(d) A monochromatic X-ray beam of intensity $6.0\,W\,m^{-2}$ is incident on an aluminium sheet of thickness 2.0 mm. For these X-rays, the half-value thickness of aluminium is 3.2 mm. Calculate the intensity of the transmitted beam.

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(3 marks)

11

TURN OVER FOR THE NEXT QUESTION

4 (a) The acoustic impedance, Z, of a medium is equal to the product of the medium's density and the speed of sound in that medium. When sound is incident on the boundary between two media of acoustic impedances Z_1 and Z_2 respectively, some sound is reflected and some transmitted. The ratio of the reflected intensity, I_r, to the incident intensity, I_i, is given by the equation

$$\frac{I_r}{I_i} = \left[\frac{(Z_2 - Z_1)}{(Z_2 + Z_1)}\right]^2.$$

speed of sound in air = $330\,m\,s^{-1}$
speed of sound in tissue = $1540\,m\,s^{-1}$
density of air = $1.3\,kg\,m^{-3}$
density of tissue = $1100\ kg\,m^{-3}$

(i) Calculate, giving the appropriate unit, the acoustic impedance of air.

.....

.....

(ii) Calculate the acoustic impedance of tissue.

.....

.....

(iii) Show that the ratio $\frac{I_r}{I_i}$ at an air/tissue boundary is approximately 1.

.....

.....

.....

(3 marks)

(b) Use your answer to part (a)(iii) to explain why a coupling gel is needed between an ultrasound probe and a patient's skin. State and explain what the ideal value of the acoustic impedance would be for such a gel.

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(3 marks)

(c) An A-scan is used to find information about the depth and size of organs within a patient's body. Explain

(i) the basic physical principles behind the A-scan,

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(ii) how the results are used to find the size of an organ.

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(4 marks)

10

END OF QUESTIONS

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