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) PHA5/W
Unit 5 Nuclear Instability: Astrophysics 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			
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

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.

.....

.....

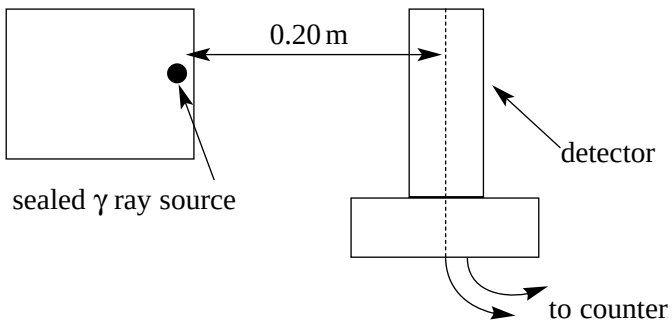
(iii) State why the source should **not** have a very long half-life.

.....

.....

(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)

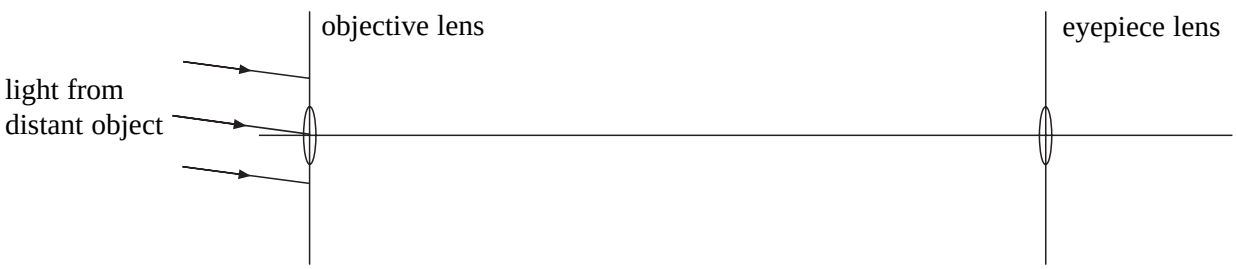
10

TURN OVER FOR THE NEXT QUESTION

SECTION B ASTROPHYSICS

Answer **all** questions.

2 (a) Complete the ray diagram for an astronomical refracting telescope in normal adjustment. Your diagram should show the paths of the three non-axial rays, through both lenses. Label the positions of the principal foci of the two lenses.



(3 marks)

(b) In 1656 Huygens made an astronomical telescope with an angular magnification of approximately 100. The distance between the two lenses was approximately 3.5 m when in normal adjustment.

(i) Estimate the focal length of the objective lens and the focal length of the eyepiece lens used to make this telescope.

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(ii) Using this telescope, Huygens discovered Titan, a satellite of Saturn. At this angular magnification, the image of Titan subtends an angle 4.0×10^{-3} radians when it is approximately 1.3×10^{9} km from the Earth. Calculate the diameter of Titan.

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(3 marks)

(c) Most modern large optical telescopes use mirrors rather than lenses. State and explain **two** optical advantages reflecting telescopes have compared with refracting telescopes.

advantage 1 .....

.....

advantage 2 .....

.....

(2 marks)

8

TURN OVER FOR THE NEXT QUESTION

3 The table compares two properties of the Sun with Arcturus, a star in the constellation Bootes.

	Sun	Arcturus
surface temperature / K	6 000	5 000
absolute magnitude	5	0

(a) (i) Assuming the Sun acts as a black body, calculate the wavelength at which maximum emission occurs in its spectrum.

.....

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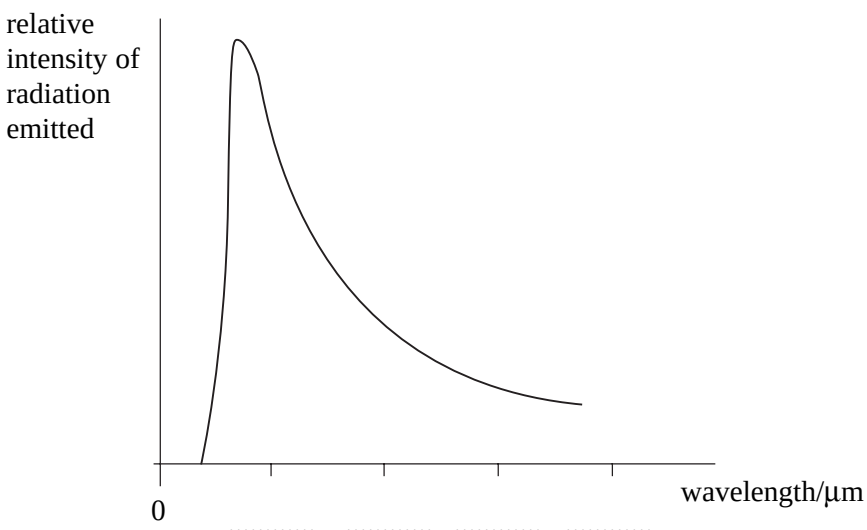
(ii) The graph shows the black body radiation curve for the Sun. Use your answer to (a) (i) to enter values on the wavelength axis in the 4 places provided.



....

(iii) Without calculation, sketch on the axes above a black body curve for Arcturus.

(4 marks)

(b) (i) Explain how the information in the table indicates that Arcturus is 100 times brighter than the Sun.

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(ii) Assuming that the power output of Arcturus is 100 times greater than that of the Sun, show that its surface area must be approximately 200 times greater.

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(4 marks)

4 The charged coupled device (CCD) camera is often used with telescopes because of its high *quantum efficiency*.

(a) State what is meant by quantum efficiency and give a typical value for the quantum efficiency of a CCD.

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(2 marks)

(b) Describe the mode of action of a CCD.

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(5 marks)

7

TURN OVER FOR THE NEXT QUESTION

5 (a) In 1054 a *supernova* was observed in the constellation Taurus. The remnants can be seen as the Crab Nebula, which has a very faint neutron star at its centre.

(i) State what is meant by a supernova.

.....

.....

(ii) State **two** properties of a typical neutron star.

.....

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.....

(3 marks)

(b) Much evidence is being produced suggesting that galaxies have black holes at their centres. For example, the spiral galaxy M51 may contain a black hole with a mass one million times greater than the Sun.

(i) Explain what is meant by the term *event horizon*.

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(ii) Calculate the radius of the event horizon for the black hole in M51.

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(4 marks)

7

END OF QUESTIONS