Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2009
Advanced Level Examination

AQA

PHYSICS (SPECIFICATION A) PHA5/W
Unit 5 Nuclear Instability: Astrophysics Option

Wednesday 10 June 2009 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil
- a ruler
- a calculator
- a *Data Sheet* insert.

Time allowed: 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The maximum mark for this paper is 40.
- Two of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided as a loose insert to this question paper.
- You are expected to use a calculator where appropriate.
- Questions 1(a)(iii) and 4(b)(ii) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

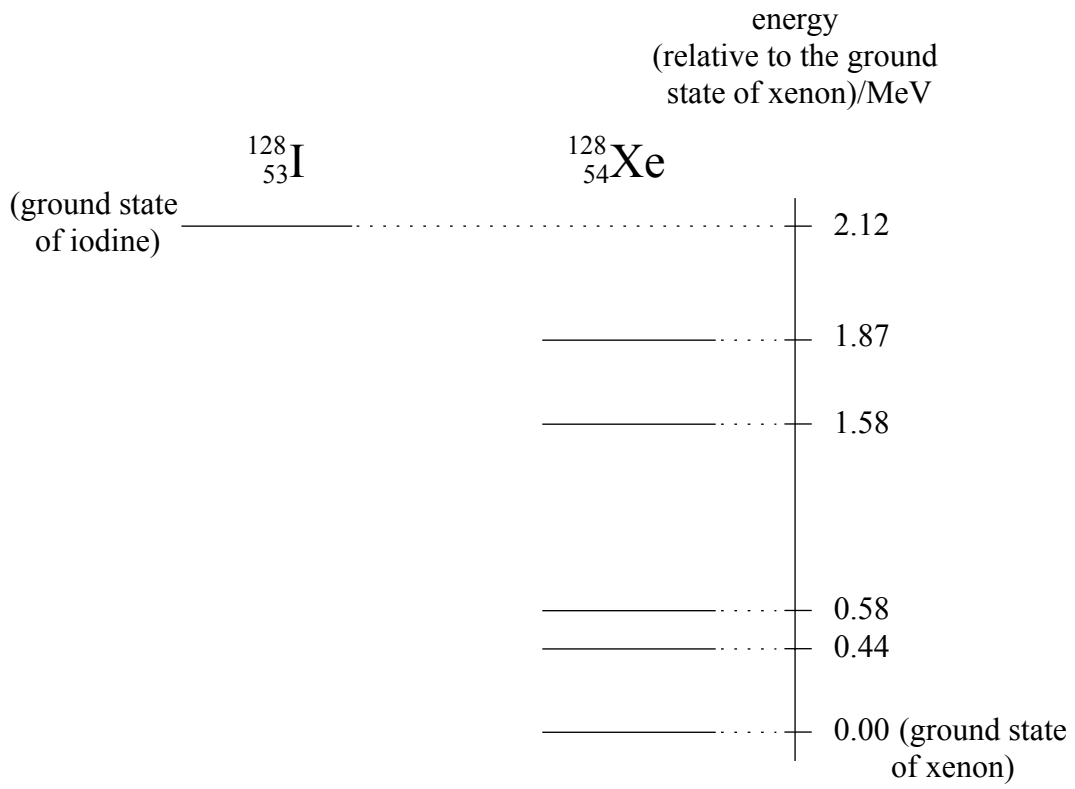
For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			

SECTION A: NUCLEAR INSTABILITY

Answer all of this question.

1 (a) **Figure 1** represents both the ground state of the nucleus of iodine, $^{128}_{53}\text{I}$, and the five lowest nuclear energy levels for a xenon nucleus, $^{128}_{54}\text{Xe}$.

Figure 1



The $^{128}_{53}\text{I}$ nucleus is a β^- emitter. When an $^{128}_{53}\text{I}$ nucleus in its ground state decays into $^{128}_{54}\text{Xe}$ by β^- decay, the xenon nucleus will be formed in one of the five levels shown.

1 (a) (i) State the energy of the most energetic β^- particle emitted from a nucleus of $^{128}_{53}\text{I}$ in its ground state.

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1 (a) (ii) Calculate the energy of the least energetic gamma ray that may follow the β^- decay of a $^{128}_{53}\text{I}$ nucleus.

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1 (a) (iii) Explain why the emission of gamma rays of discrete frequencies may follow the β^- decay of $^{128}_{53}$I nuclei.
You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(6 marks)

1 (b) Nuclear radii can be determined by observing the scattering of electrons accelerated to high energy. Give **one** advantage of using electrons for this determination and state why the electrons must be of high energy.

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(2 marks)

1 (c) Given that the radius of the $^{120}_{50}$Sn nucleus is 5.99×10^{-15} m, calculate the radius of the lead $^{208}_{82}$Pb nucleus.

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(2 marks)

10

Turn over ▶

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ANSWER IN THE SPACES PROVIDED

SECTION B: ASTROPHYSICS

Answer **all** questions.

2 (a) Draw a ray diagram to show the path of two rays, initially parallel to the axis, through a Cassegrain telescope, as far as the eyepiece.

(3 marks)

2 (b) The Bradford Robotic Telescope in Tenerife is a Cassegrain arrangement with an objective of diameter 356 mm.

2 (b) (i) Calculate the resolving power of this telescope when used with light of wavelength 570 nm.

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2 (b) (ii) The images are collected using a charge coupled device (CCD). What feature of the structure of a CCD can affect the resolution of the final image obtained?

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Question 2 continues on the next page

2 (b) (iii) The *quantum efficiency* of a CCD is typically greater than 70%.
What is meant by quantum efficiency?

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(3 marks)

6

3 The properties of some of the stars in Ursa Major are given in the table.

name	**apparent magnitude**	**distance /light year**	**spectral class**
Dubhe	1.8	124	K
Merak	2.4	79	A
Megrez	3.3	81	A
Mizar	2.1	78	A
Alkaid	1.9	101	B

3 (a) (i) Which of these stars appears dimmest? Explain your answer.

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3 (a) (ii) Which star is the hottest? Explain your answer.

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(2 marks)

3 (b) (i) Define absolute magnitude.

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3 (b) (ii) Which star has the brightest absolute magnitude? Explain your answer.

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(2 marks)

3 (c) (i) Define the parsec.

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3 (c) (ii) Calculate the distance to Alkaid in parsecs.

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3 (c) (iii) Calculate the absolute magnitude of Alkaid.

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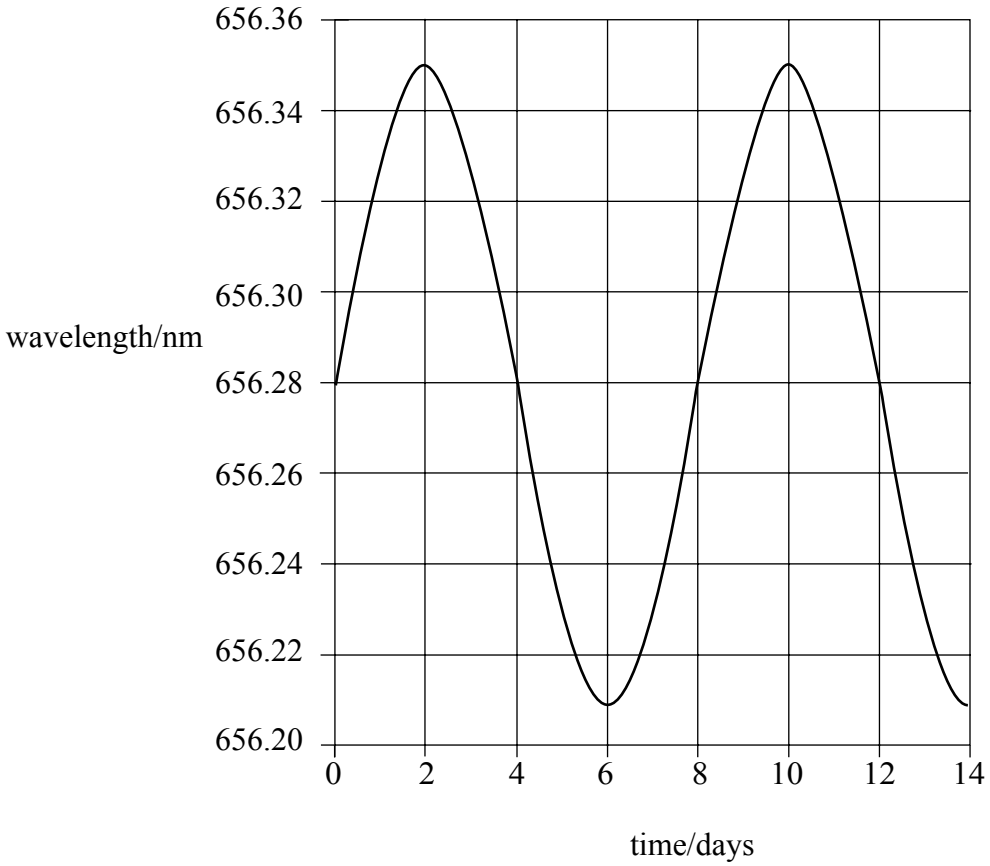
(5 marks)

9

Turn over for the next question

4 Eta Orionis is an eclipsing binary system. Analysis of the light from one of the stars shows that a particular spectral line varies in wavelength as shown in **Figure 2**.

Figure 2



4 (a) (i) Show that the star has an orbital velocity of approximately $30\,\text{km}\,\text{s}^{-1}$.

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4 (a) (ii) Calculate the diameter of the orbit of the star.

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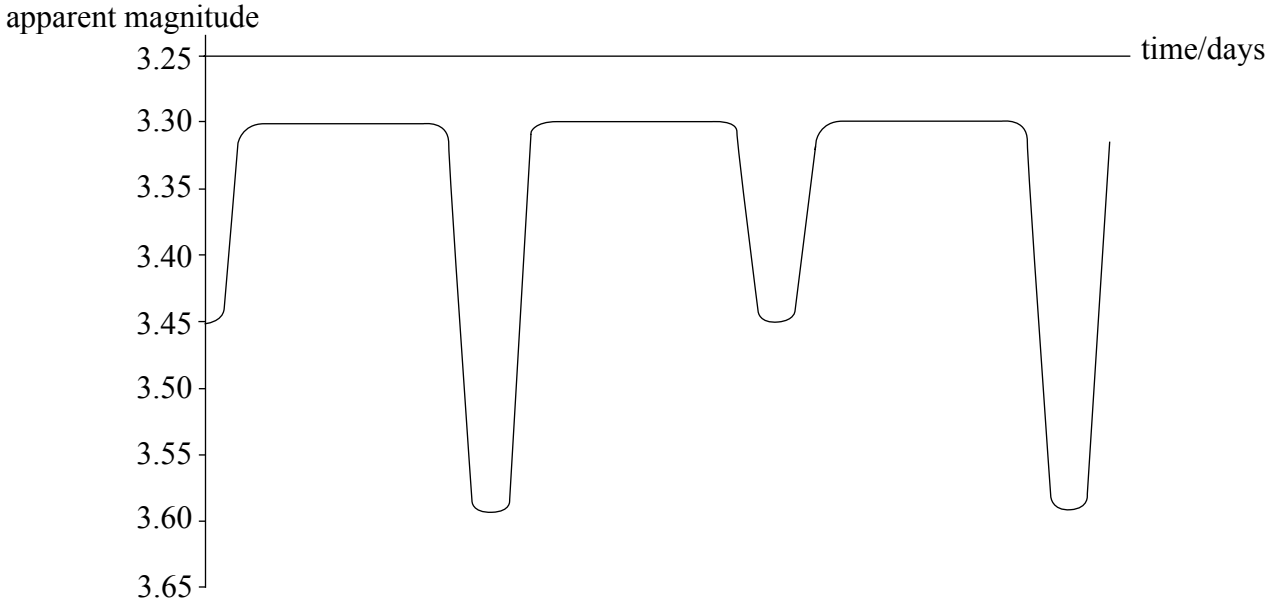
(4 marks)

4 (b) The graph of apparent magnitude against time (light curve) for this binary system is shown in **Figure 3**.

Figure 3



4 (b) (i) Label the time axis with a suitable scale.

4 (b) (ii) Explain, in terms of the movement of the two stars, how this light curve is produced.
You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(4 marks)

8

5 (a) The Westerlund 1 star cluster contains a *neutron star* whose mass is forty times the mass of the Sun. Before its discovery, many astronomers believed that a star remnant of this size would be more likely to form a *black hole*.

Explain what is meant by

5 (a) (i) a neutron star,

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5 (a) (ii) a black hole.

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(3 marks)

5 (b) Calculate the Schwarzschild radius of a black hole whose mass is forty times the mass of the Sun.

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(2 marks)

5

Quality of Written Communication *(2 marks)*

2

END OF QUESTIONS

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