Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS A

Unit 5A Astrophysics
Section B

Wednesday 21 June 2017 Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

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.
  Do not write outside the box around each page or on blank pages.
- Do all rough work in this book.
  Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	

Section B

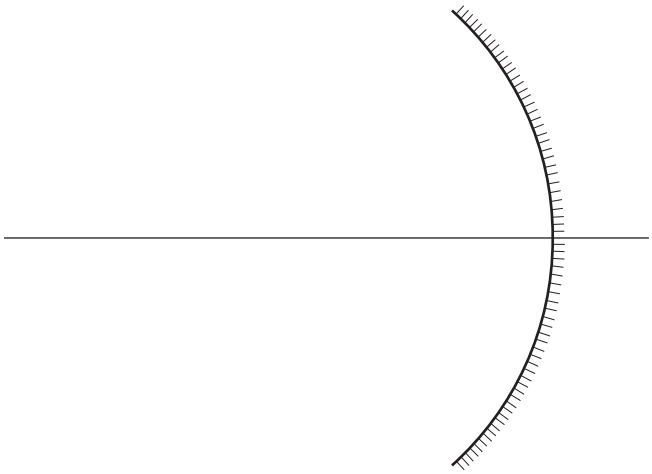
The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 (a) Spherical aberration can be a problem with reflecting telescopes.

1 (a) (i) Complete the ray diagram in **Figure 1** to show how spherical aberration occurs in a reflecting telescope.

[2 marks]

Figure 1



1 (a) (ii) State how this problem can be prevented.

[1 mark]

1 (b) A refracting telescope can produce a clearer image than a reflector of similar diameter because of the position of the secondary mirror.

1 (b) (i) Sketch a diagram to show the positions of the mirrors in a Cassegrain telescope.

[1 mark]

1 (b) (ii) Give **two** reasons why the secondary mirror in the Cassegrain telescope affects the clarity of the image.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

1 (c) The Very Large Telescope (VLT) in the Atacama Desert in Chile is a combination of four Cassegrain telescopes each of diameter $8.2\ \text{m}$. It is used to detect electromagnetic radiation of wavelengths in the range $300\ \text{nm}$ to $20\ \mu\text{m}$.

1 (c) (i) Show that the combination has a similar light-collecting power to that of a single telescope of diameter $16\ \text{m}$.

[2 marks]

Question 1 continues on the next page

1 (c) (ii) The VLT is capable of an angular resolution similar to that of a $130\ \text{m}$ diameter telescope.

Calculate the minimum angular resolution of the VLT.

[1 mark]

minimum angular resolution = _____ rad

1 (c) (iii) What part of the electromagnetic spectrum is significantly absorbed by water vapour?
Tick (✓) **one** box next to the correct answer.

[1 mark]

Infrared ☐

Radio waves ☐

Ultraviolet ☐

X-rays ☐

10

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

2 **Table 1** gives some properties of the Garnet Star.

Table 1

apparent magnitude	4.08
absolute magnitude	– 7.63
surface temperature	3750 K

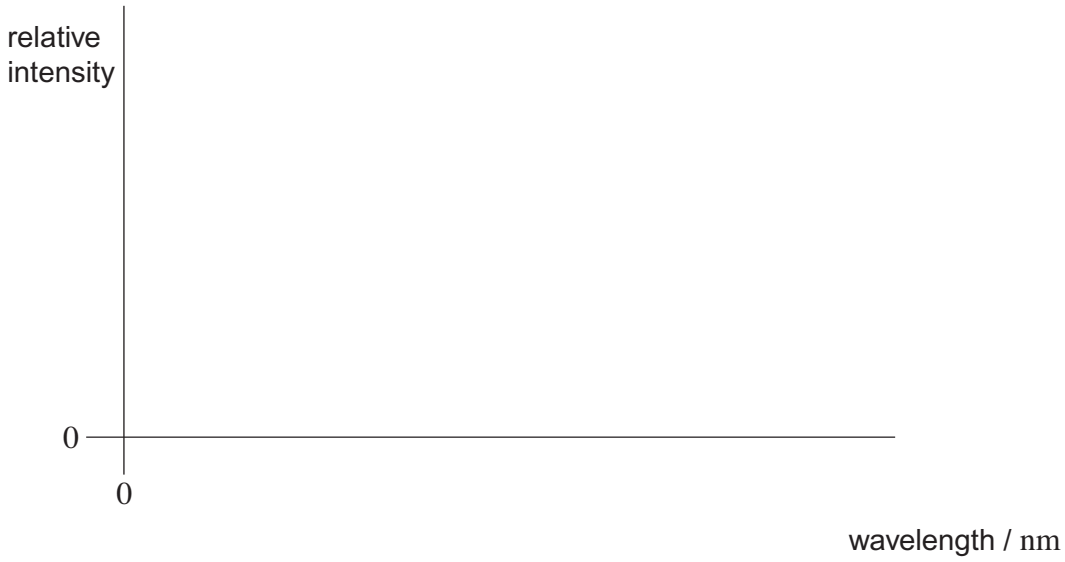
2 (a) (i) Calculate the wavelength of the peak in the black-body radiation curve for the Garnet Star.

[1 mark]

wavelength = _____ m

2 (a) (ii) Sketch the black-body radiation curve for the Garnet Star on the axes below. Label the wavelength axis with a suitable scale.

[2 marks]



2 (b) Calculate, in ly, the distance from Earth to the Garnet Star.

[3 marks]

distance = _____ ly

2 (c) The Garnet Star is one of the largest stars yet discovered. Its radius is 1.2×10^9 km.

Calculate the ratio $\frac{\text{power output of the Garnet Star}}{\text{power output of the Sun}}$.

surface temperature of the Sun = 5800 K
radius of the Sun = 6.9×10^5 km

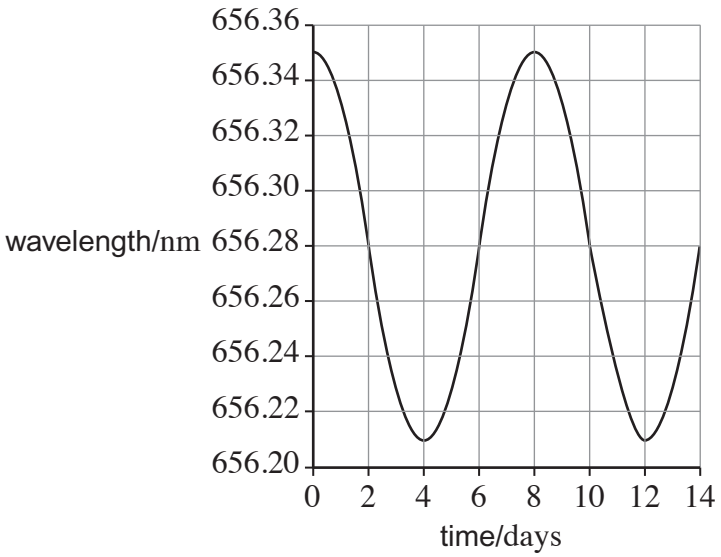
[2 marks]

ratio = _____

8

3 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



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

[2 marks]

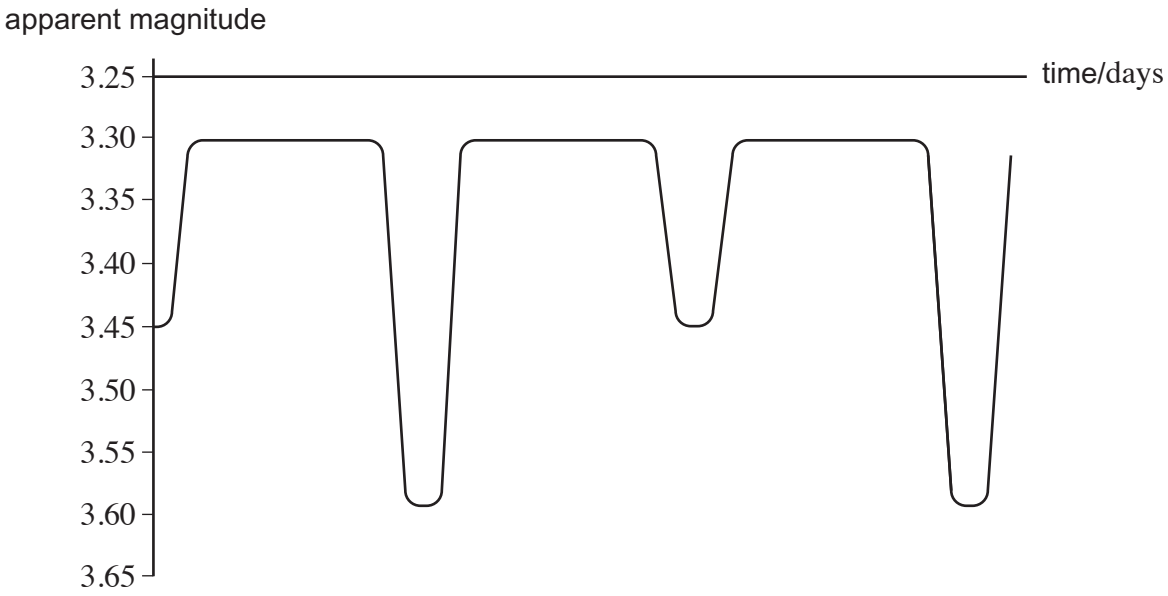
3 (a) (ii) Calculate the diameter of the orbit of the star.

[2 marks]

diameter = _____ m

3 (b) **Figure 3** shows how the apparent magnitude varies with time (the light curve) for this binary system.

Figure 3



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

[1 mark]

3 (b) (ii) Explain, in terms of the movement of the two stars, how this light curve is produced.

[3 marks]

8

Turn over ▶

4 (a) In 1997 a type 1a supernova was observed which contributed to the controversial conclusion that the expansion of the Universe is accelerating.

Explain why observations of supernovae led to the conclusion that the Universe is expanding at an accelerating rate and discuss why this conclusion is controversial.

The quality of your written communication will be assessed in your answer.

[6 marks]

Question 4 continues on the next page

4 (b) Measurements of the shift in the $21\ \text{cm}$ line in the hydrogen spectrum of galaxy M84 suggest that it is receding at a velocity of $1100\ \text{km s}^{-1}$.

4 (b) (i) Calculate the value of the red shift z for this galaxy.

[1 mark]

z = _____

4 (b) (ii) Calculate, in Mpc, the distance from Earth to this galaxy.

[2 marks]

distance = _____ Mpc

END OF QUESTIONS

9