AQA

Please write clearly in block capitals.

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I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Astrophysics

Tuesday 17 June 2025 Morning

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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Section B

Answer **all** questions in this section.

0 1 HIP 56948 is a star with a black-body temperature of $5800\ \mathrm{K}$. The star is at a distance of $210\ \mathrm{ly}$ from the Sun.

0 1 . 1 Sketch, on **Figure 1**, the black-body curve for HIP 56948.
Label the wavelength axis with a suitable scale and unit.

[3 marks]

Figure 1



0 1 . 2 The diameter of HIP 56948 is the same as the diameter of the Sun.

Suggest a value for the absolute magnitude of HIP 56948.

[1 mark]

absolute magnitude = _____

0 1 . 3 Astronomers study HIP 56948 in their search for Earth-like exoplanets because HIP 56948 is similar to the Sun.

Suggest **one** difficulty in detecting an Earth-like planet around HIP 56948.

[1 mark]

_____

_____

_____

5

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0 2 . 1 Draw a ray diagram for an astronomical telescope in normal adjustment.

Include in your diagram:
- three non-axial rays
- labelled principal foci for the lenses.

[2 marks]

Question 2 continues on the next page

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0 2 . 2 An astronomer has two telescopes **A** and **B**.

The astronomer uses each telescope to make observations of Mars when Mars is $0.55\ \text{AU}$ from the Earth.

Table 1 gives information about **A** and **B**.

Table 1

Telescope	Type	Objective diameter / m	Angular magnification
A	refractor	0.12	25
B	reflector	0.18	40

diameter of Mars $= 6.8 \times 10^3\ \text{km}$
angular resolution of the eye $\approx 3 \times 10^{-4}\ \text{rad}$

Compare the images formed by **A** and **B**.

In your answer, refer to:
- the relative brightness of the images
- the ability of each telescope to show features on Mars
- the effect of any aberrations caused by each type of telescope.

[6 marks]

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Question 2 continues on the next page

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0 2 . 3 One advantage of using a CCD with a telescope is that the data can be stored and processed on a computer.

Explain **two** other advantages of using a CCD rather than the eye when making an observation with a telescope.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

10

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0 3 . 1 The galaxy M87 is at a distance of 5.3×10^7 ly from the Earth.

Determine, in $\mathrm{m\ s^{-1}}$, the recessional velocity of M87 relative to the Earth.

[3 marks]

recessional velocity = _____ $\mathrm{m\ s^{-1}}$

0 3 . 2 Astronomers believe that M87 has an active supermassive black hole at its centre.

Suggest **one** observation that leads to this conclusion.

[1 mark]

_____

_____

0 3 . 3 Which provides evidence for the existence of dark energy?

Tick (✓) **one** box.

[1 mark]

Some type 1a supernovae are brighter than expected. ☐

Hubble's constant changes with time. ☐

The light from some galaxies is blue-shifted. ☐

5

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0 4 Mintaka Aa1 and Mintaka Aa2 are two stars in a binary system. This means that they orbit their common centre of mass with the same period.

Table 2 gives information about the two stars.

Table 2

Star	Absolute magnitude	Apparent magnitude	Spectral class
Mintaka Aa1	−5.4	2.5	O
Mintaka Aa2	−2.9	5.0	B

0 4 . 1 Show that the data in **Table 2** are consistent with the two stars being in a binary system.

[3 marks]

0 4 . 2 State the most prominent absorption lines in the spectrum of Mintaka Aa2.

[1 mark]

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0 4 . 3 Explain which star in **Table 2** has the greater temperature.

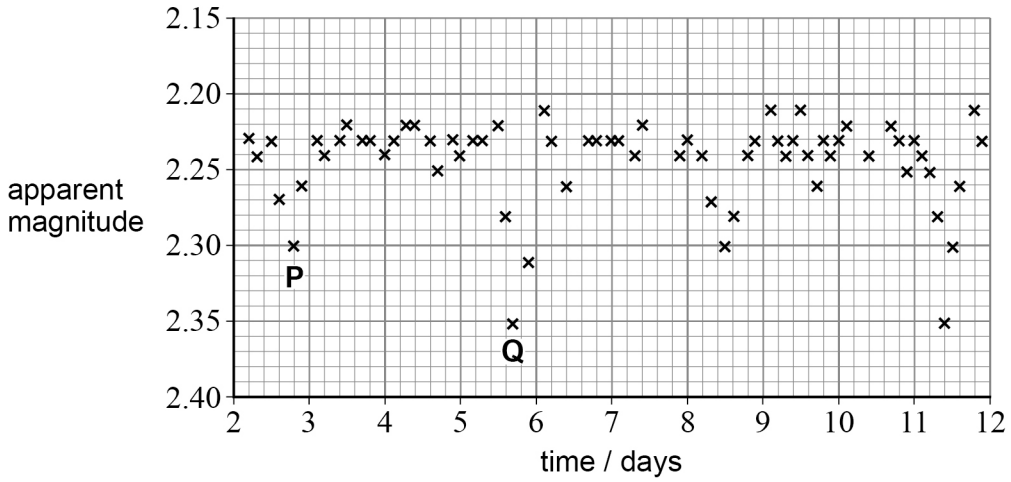
[1 mark]

Question 4 continues on the next page

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Figure 2 shows how the apparent magnitude of the binary system varies with time.

Figure 2



0 4 . 4 Explain the variation in apparent magnitude shown in **Figure 2**.

In your answer you should explain:
- the changes in observed brightness at **P** and **Q**, as shown in **Figure 2**
- why the observed brightness at **P** is different from the observed brightness at **Q**.

[3 marks]

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0 4 . 5 Determine the angular velocity of the binary system.

[2 marks]

angular velocity = _____ rad s^{-1}

10

Turn over for the next question

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0 5 Early observations of the star Betelgeuse indicated that:

radius r of Betelgeuse = 700 × radius of the Sun
distance d of Betelgeuse from the Earth = 548 ly
intensity received from Betelgeuse = I.

Recent data suggest that the intensity received from Betelgeuse is actually $1.15I$.

Based on these recent data, two groups of students reach different conclusions.

Group **X** suggest that:
- r is correct
- d is actually 530 ly.

Group **Y** suggest that:
- d is correct
- r is actually 750 × radius of the Sun.

Discuss for each group whether their conclusion could be correct.
Assume that the measured temperature of Betelgeuse is constant.

[5 marks]

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END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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