2001

Question 29 — Astrophysics (25 marks)

(a)(i) Define the term *binary stars*. (1 mark)

(ii)Describe the characteristics of its spectrum that identify a spectroscopic binary. (2 marks

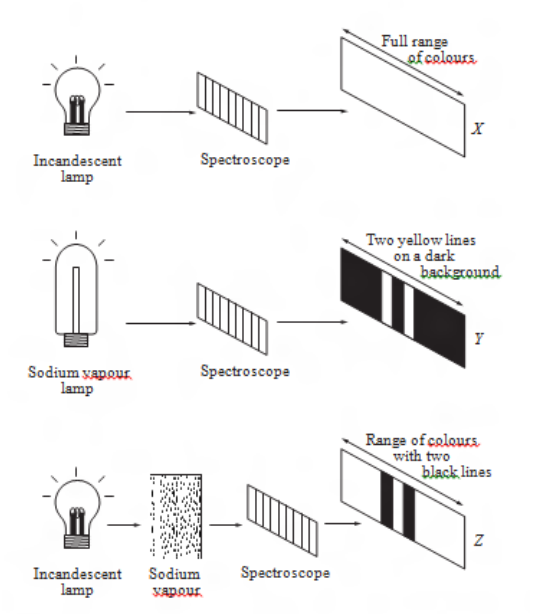
(b) The table shows information about three stars in the Milky Way galaxy.

Name	*Spectral class*	*Distance from Sun (parsecs)*	*Apparent magnitude*
Betelgeuse	M2	184	+0.41
Achernar	B5	20	+0.47
Deneb	A2	429	+1.24

(i) Identify which of the stars has the greatest surface temperature. (1 mark)

(ii) If Deneb and Betelgeuse were viewed from the same distance, which would appear brighter? Justify your answer. (3 marks)

(c) A student carried out an experiment to examine the spectra of various light sources through spectroscopes as shown in the diagram. The student observed three different spectra. (4 marks)



Account for the differences in the three observed spectra.

(d) A new generation of Earth-based optical telescopes is advancing optical astronomy. Describe the advances in design that have been incorporated in large telescopes over recent years. (6 marks)

(e) Explain how the data presented in Hertzsprung–Russell diagrams may be used to understand the evolution of stars. (8 marks)

2002
Question 30 — Astrophysics (25 marks)

(a)(i)The star Algol is an eclipsing binary as viewed from Earth. Describe the observations made by astronomers to identify a star as an eclipsing binary. (2 marks)

(ii) Binary stars are important in determining stellar masses. Explain how the total mass of a binary star system can be calculated. (4 marks)

(b) The table gives information about various nearby stars.

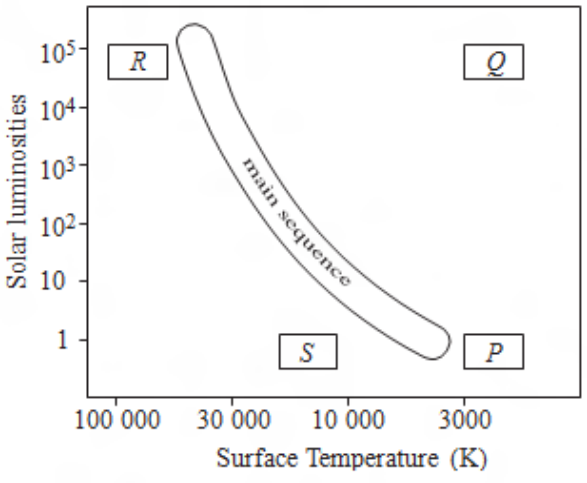
Star	*Distance* (parsecs)	*Apparent visual magnitude*	*Colour Index*
Proxima Centauri	1.29	11.01	1.90
Barnard's Star	1.82	9.54	1.74
Lalande 21185	2.55	7.49	1.51
Ross 154	2.97	10.37	1.75

(i) Which star from the table is the most blue in colour? (1 mark)

(ii) Calculate how much brighter Ross 154 is than Proxima Centauri when viewed from Earth. (2 marks)

(iii) Sketch a labelled diagram indicating the information required to use the trigonometric parallax method to determine the distance to Barnard's Star. (3 marks)

(c) An H-R diagram can be used to show the evolutionary track of stars.



(i) Select the position *P*, *Q*, *R* or *S* on the H-R diagram in which white dwarfs would be found. Justify your choice. (2 marks)

(ii) A white dwarf is considered to be in a stable condition. Explain why a white dwarf does not continue to shrink in size. (2 marks)

(iii) Describe ONE nuclear reaction taking place in a star located on the main sequence. (2 marks)

(d) Discuss how the development of adaptive optics and at least one other development have improved resolution and sensitivity of ground based astronomy. (7 marks)

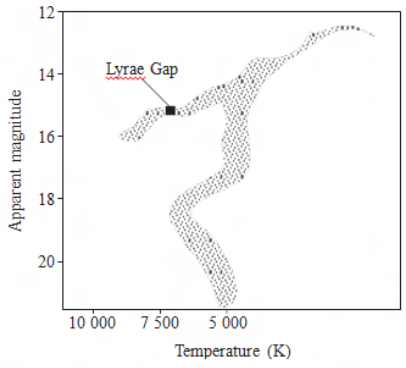
2003

Question 30 — Astrophysics (25 marks)

(a) (i) Define the term *resolution* of a telescope. (1 mark)

(ii) Describe ONE method by which the resolution of a ground-based system can be improved. (2 marks)

(b) An H-R diagram for the globular cluster M3 is shown below. (3 marks)



The stars in the Lyrae gap have an absolute magnitude of 0.6. Use this information and their position on the H-R diagram to determine the distance of M3 from Earth.

(c)The diagram below is a comparison of the spectrum of quasar 3C 273 and a spectrum from a light source on Earth.

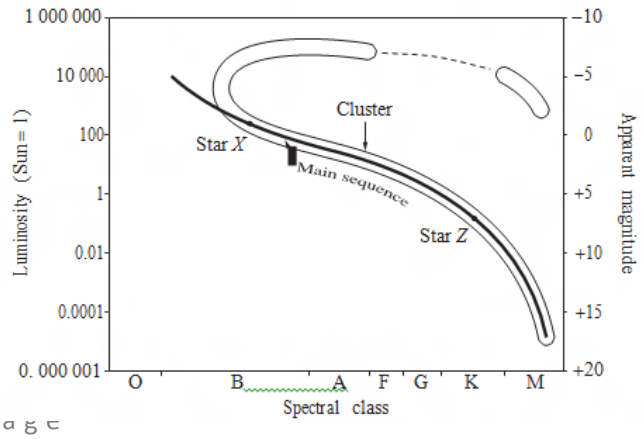
(i) From this comparison, identify the feature of the quasar spectrum that is representative of the spectra produced by quasars. (1 mark)

(ii) The spectra above are both examples of absorption spectra.

(1) Account for the production of a star's absorption spectrum. **(2 marks)**

(2) Describe how a spectrum from a star can provide information on the surface temperature of that star. Give a specific example to illustrate your answer. (2 marks)

(d) The H-R diagram for a cluster is shown below.



(i) Why is the cluster considered young? **(1 mark)**

(ii) Stars *X* and *Z* are both part of the same cluster but have different

main sequence nuclear reactions and different evolutionary pathways.

(1) Contrast the fusion reactions in star *X* and star *Z.* ***(*2 marks)**

(2) Predict TWO possible evolutionary pathways for star *X*. (**3 marks)**

(e) Evaluate the impact of studying the visible spectrum of light on our understanding of celestial objects.(8 marks)

2004

Question 30 — Astrophysics (25 marks)

(a) (i) Identify the initial and final elements of the principal sequence of nuclear reactions for a star on the Main Sequence. **2**

(ii) Identify the type of star that the Sun will initially turn into after it completes its Main Sequence evolution. State the main source of energy in the core at this stage. **2**

(b) The apparent magnitudes of three stars are measured with a telescope equipped with a camera, first with a red filter placed in front of the detector, and then with a blue filter placed in front of it. The absolute magnitudes of the three stars can be determined from their spectra, and are listed in the fourth column of the table for the red filter.

The results are shown in the table.

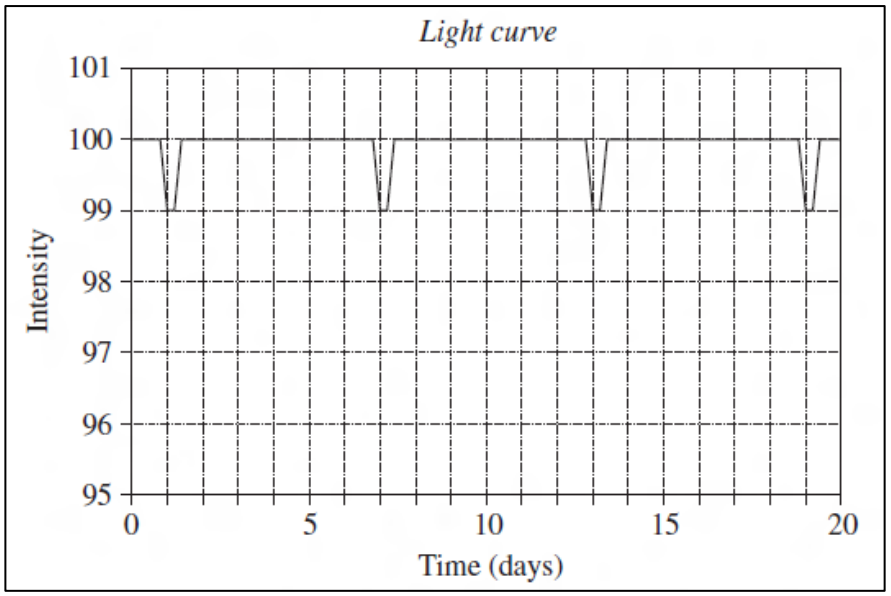
Star	*Apparent magnitude red filter*	*Apparent magnitude blue filter*	*Absolute magnitude red filter*
Betelgeuse	–0.89	+0.41	–6.47
Rigel	+0.18	+0.14	–6.69
Sirius	–1.46	–1.46	+1.46

(i) Use the data in the table to determine which is the bluest of these three stars. **3**

(ii) Calculate the distance to Rigel in parsecs. **3**

(c) Describe how the spectrum of a star can be used to determine its temperature, chemical composition and aspects of its motion. **7**

(d) An astronomer made regular measurements of the intensity of a star over the course of several days and obtained the light curve shown below.



(i) Describe the features of this light curve that suggest that the astronomer is observing an eclipsing binary system. **2**

(ii) If both stars have equal masses of 2 □ 10^{30} kg, determine the separation of the two stars. **3**

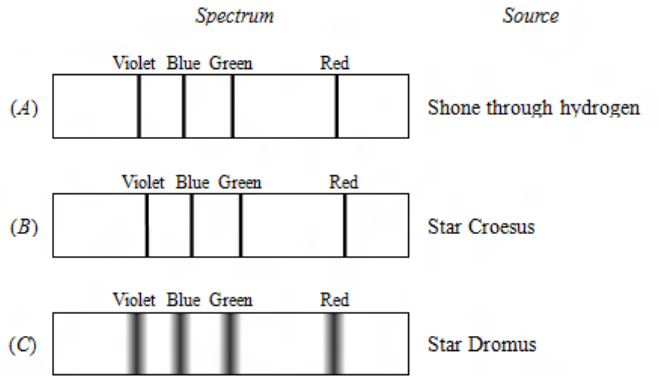
(iii) The astronomer concludes that the system is a white dwarf eclipsing the other star. The intensity of light from the star is proportional to its cross-sectional area. **3**

That is, I □ □r^2.

Using the data and diagram, calculate the radius of the white dwarf as a fraction of the radius of the other star. Assume that the white dwarf has negligible luminosity.

2005
Question 30 – Astrophysics (25 marks)

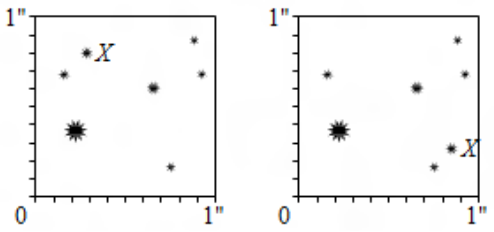
(a) Part *A* of the figure shows the absorption spectrum of light, produced by an incandescent filament, after it has been shone through a quantity of hydrogen gas. Also shown in the figure are the spectra obtained from two stars, Star Croesus in part *B* and Star Dromus in part *C*. The dark lines are absorption bands in *A*, *B* and *C*.



(i) For each star, Croesus and Dromus, identify the principal way in which its spectrum differs from the spectrum shown in part *A* of the figure. **2**

(ii) For each star, Croesus and Dromus, state what its spectrum tells us about the motion of that star. **2**

(b) (i) Photographs taken of a one arcsecond by one arcsecond sector of the night sky show a group of fixed stars. Scales have been added to the photographs. One star appears to change position, swinging backward and forward over a period of one year. Two photographic negatives taken when the star was at the furthest ends of its apparent travel are shown. The star is marked *X*. **2**



Calculate the distance of the star *X* from Earth.

(ii) When viewed through a telescope, the star Alpha Centauri is seen to be three stars close together. Two of them are the very bright Alpha Centauri *A* and the very faint Proxima Centauri. These stars are 1.3 pc from Earth. Their magnitudes are given in the table below. **4**

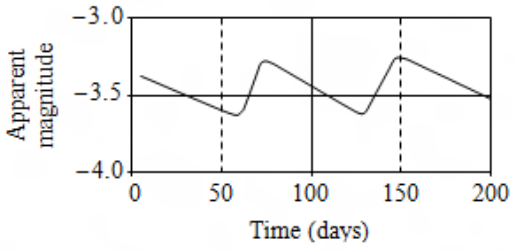
Star	*Absolute magnitude*
Alpha Centauri *A*	4.33
Proxima Centauri	14.93

What is the ratio of their apparent brightnesses?

(c) The Hertsprung–Russell (or H–R) diagram relates the magnitude or brightness of stars to their spectral classes or temperatures. **7**

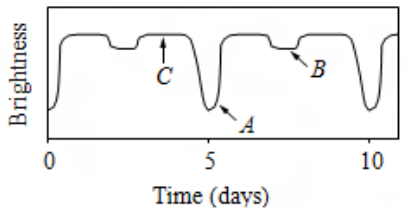
Describe the technological advances that have made it possible to add astrophysical data to the H–R diagram, and explain how this data contributes to our understanding of stellar evolution.

(d) (i) The graph shows the apparent magnitude of a supergiant star recorded over a period of time. The star is identified as a Type I Cepheid variable. **2**



Explain how the period of oscillations in apparent magnitude may be used to determine the distance of the star.

The graph shows the brightness of a star system recorded over a period of time. The star system is identified as a binary pair, and measurements show them to be 5.0×10^{10} m apart. One star is known to have four times the mass of the other.



(ii) Explain what causes each of the features *A*, *B* and *C* labelled on the graph. **3**

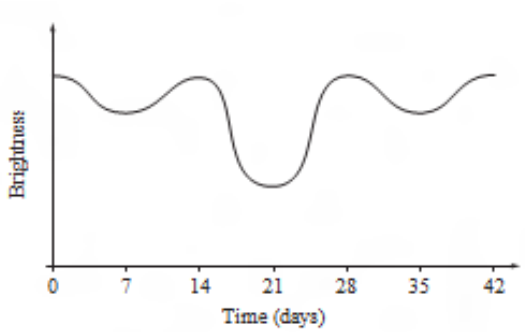
(iii) Determine the mass of the star with the smaller mass. **3**

2006

Question 30 – Astrophysics (25 marks)

(a) (i) Describe the spectroscopic observations that would determine whether a particular star is really a binary star system. **2**

(ii) The graph represents the variation in brightness of a binary star system. **3**



Given that the mass of the system is determined to be 6×10^{32} kg, calculate the average distance between the stars within the system.

(b) During your study of Astrophysics you performed a first-hand investigation into the spectra produced by different objects under different conditions.

(i) Explain how you determined that the data you obtained were reliable. **2**

(ii) Explain how the absorption spectrum of a star is produced, and how it can be used to determine the star's composition. **4**

(c) Astronomers employ a range of instruments and techniques to observe celestial objects. **7**

Assess the impact of technological advances on our understanding of the cosmos.

(d) The Hertsprung-Russell (H-R) diagram depicts a possible life cycle path of a known star.

(i) Describe the reactions that occur in stars at the points marked **A**, **B** and **C** in its life cycle. **3**

(ii) Explain what type and mass of star is most likely to be formed at point **A**. **2**

(iii) Compare the life cycle of a star that has a mass greater than 10 solar **2**

masses with the one depicted at point **A**.

2007

(a) (i) Describe how the existence of a binary star may be deduced. **2**

(ii) The distance from the Sun to Earth is 1 astronomical unit (1 AU). The apparent magnitude of the Sun, when viewed from Earth, is –26.5. Calculate the apparent magnitude of the Sun when viewed from Saturn, a distance of 10 AU from the Sun. **3**

(b) (i) In your study of Astrophysics you performed a first-hand investigation to demonstrate ONE characteristic of a star that can be deduced by observing the light received from it. **2**

Describe your investigation and the results obtained.

(ii) Explain how TWO other characteristics or properties of a star can be deduced by observing the light received from the star. **4**

(c) Evaluate the ways that TWO technologies used in modern astrophysics have changed scientific understanding of celestial objects. **7**

(d) The table shows some characteristics of selected stars.

Star	*Apparent magnitude*	*Absolute magnitude*	*Spectral class*
Sun	–26.5	+4.7	G2
Sirius A	–1.51	+1.4	A1
Betelgeuse	+0.41	–5.6	M2
Arcturus	+0.00	–0.3	K2
Vega	+0.04	+0.5	A0

(i) Which star is the most distant from Earth? Justify your answer. **1**

(ii) Sketch in your writing booklet a Hertzsprung-Russell diagram showing the positions of the stars in the table. Identify the position of the Main Sequence on your diagram. **3**

(iii) Compare the physical properties, nuclear reactions and relative stages of stellar evolution of the stars Sirius A and Arcturus. **3**

2008

(a) The analysis of electromagnetic radiation is widely used by astronomers.

(i) Contrast emission and absorption spectra in terms of how they are produced. **3**

(ii) Describe the physical characteristics of stars and their motion that can be revealed by spectroscopy. **3**

(b) The table shows some photometric measurements of certain stars.

Star	*Apparent magnitude*	*Absolute magnitude*	*Colour index*
Bellatrix	+1.64	-2.72	-0.22
Sirius A	-1.47	+1.42	+0.01
Regulus A	+1.35	-0.52	-0.11
Betelgeuse	+0.58	-5.14	+1.85

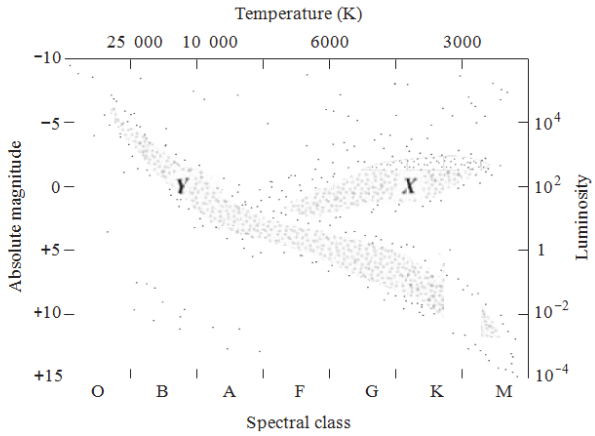
(i) How much brighter is Sirius A than Bellatrix when viewed from Earth? **2**

(ii) Calculate the distance from Earth to Regulus A. **2**

(iii) Explain why cooler stars have a more positive colour index than hotter stars. **3**

(c) (i) Describe the physical processes that precede nuclear fusion reactions in a newly formed star. **2**

(ii) Compare the nuclear reactions occurring in stars located at positions ***X*** and ***Y*** on the HR diagram below. **2**



(iii) Draw a flowchart summarising the possible pathways a red giant could follow as it evolves. **2**

(d) Explain how observations of binary and variable stars can be used to infer physical properties of these stars. **6**

2009

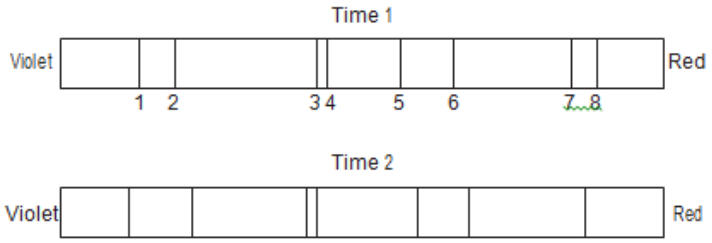
(a) (i) Distinguish between the terms resolution and sensitivity as used in astrophysics. (**2 marks)**

(ii)Interferometry and active optics are techniques that can be used to improve the resolution and/or sensitivity of ground based telescopes. Explain why only one of these techniques is useful in improving the resolution and sensitivity of radio telescopes. (**4 marks)**

(b) (i)Describe the modelling process used in a computer simulation which draws a light curve for an eclipsing binary star system. (**2 marks)**

(ii) Two stars in a visual binary system have an orbital period of 2.1×10^8 s and are determined to be 7.2 × 108 km apart. Calculate the combined mass of the stars.(**2 marks)**

(iii) The spectra below show absorption lines for a variable pair of spectroscopic binary stars at two different times, Time 1 and Time 2. Each spectrum contains the absorption lines from both stars. (**3 marks)**



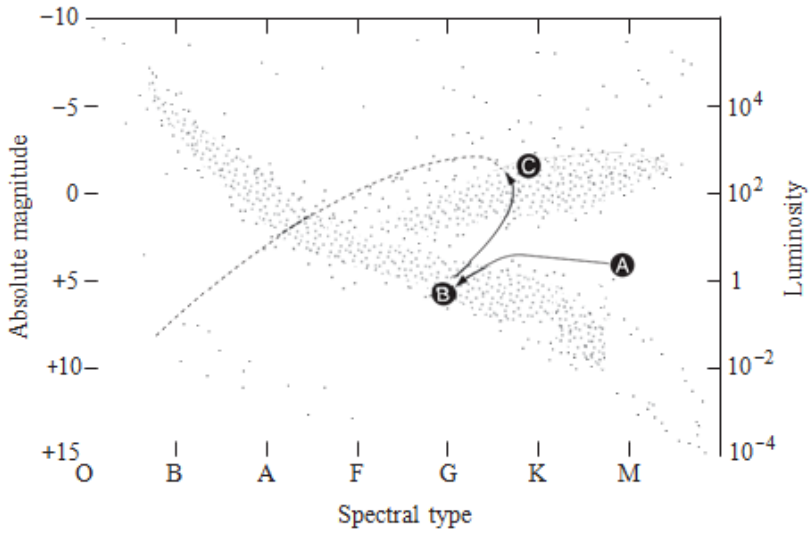
Explain why there are differences in the spectra.

(c)(i)A star was found to have a visual magnitude (V) of 2.9 and a photographic magnitude (B) of 4.6. Will the star be more blue or more red in colour? (**1 mark)**

(ii) How can the colour index (B–V) of a star be measured in an observatory? (**2 marks)**

(d)Describe the advantages of using photoelectric technologies over photographic methods in photometry. (**3 marks)**

(e)A possible evolutionary path of a star is shown on the Hertsprung-Russell (H-R) diagram. (**6 marks)**



Describe the sequence of events and the associated physical processes a star undergoes in moving from A to B to C.

2010

Answer parts (a)–(b) in a writing booklet.

(a) (i) The Japanese radio telescope HALCA was placed in an elliptical orbit which took it as far as 21 000 km from Earth. It took measurements simultaneously with ground-based radio telescopes. **3**

Explain the benefit that the HALCA telescope gives radio astronomers.

(ii) SOFIA is an infrared telescope. It is operated from high-altitude aircraft. Give TWO reasons for the greater validity of data from this telescope, compared to ground-based observations. **2**

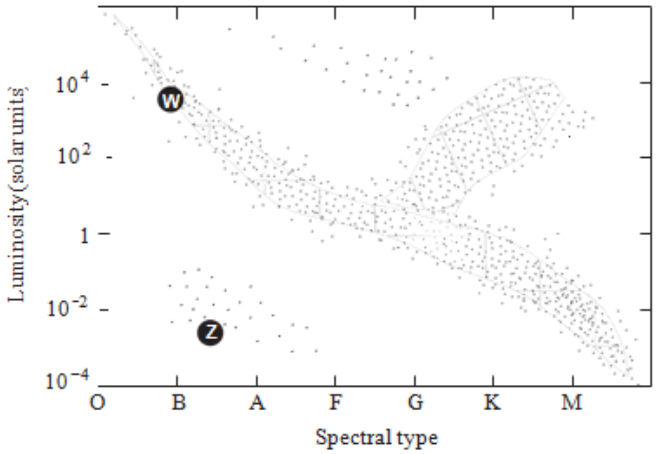
(b) Properties of stars, including their surface temperature and chemical composition, can be measured by using their spectra.

(i) Identify other properties of stars which can be determined from their spectra. **2**

(ii) Explain how surface temperatures and chemical compositions of stars can be determined from their spectra. **5**

Answer parts (c)–(d) in a SEPARATE writing booklet.

(c) Hertzsprung-Russell diagrams can be used to deduce the properties of stars.



(i) Identify the type of stars found in region Z on the above diagram. **1**

(ii) Describe the relationship between the masses of main sequence stars and their luminosities AND lifetimes. **2**

(iii) Contrast the energy production processes of stars in regions W and Z. **2**

(iv) Copy the axes from the above Hertzsprung-Russell diagram into your writing booklet. Sketch a Hertzsprung-Russell diagram for the stars in an ancient globular cluster on these axes. **2**

(d) Identify THREE advances in measurement technologies, and describe how they have improved our understanding of celestial objects. **6**

2011

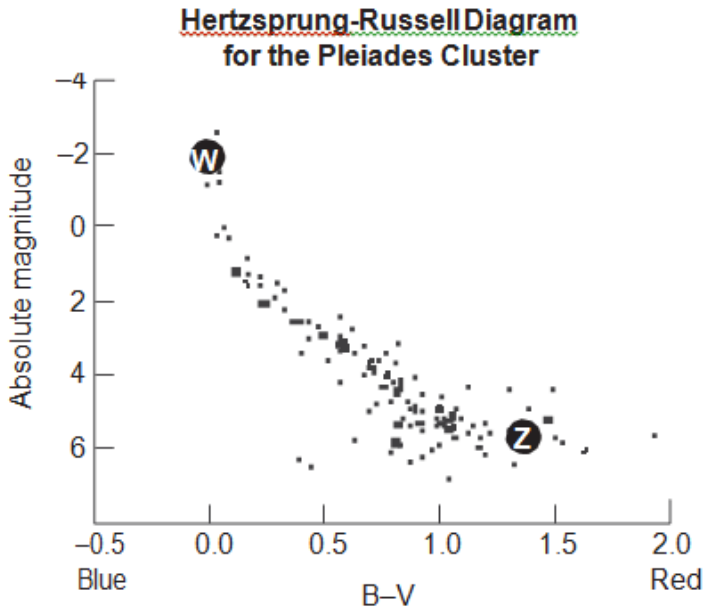
Question 33 — Astrophysics (25 marks)

Answer parts (a)–(b) in Section II Answer Booklet 1.

(a) (i) Using a diagram, define the term *parsec*. **2**

(ii) Why was the resolution of Galileo's telescope more important for his observations than its sensitivity? **3**

(iii) Describe ONE technology that has improved the resolution of telescopes. **2**



(i) Compare the nuclear processes in a star found at W to a star found at Z on the Hertzsprung-Russell diagram. **(3 marks)**

(ii) In 2008, the distance to the Pleiades cluster was determined as 135 pc. Calculate the apparent magnitude of a star at W . **(2 marks)**

(iii) Calculate the relative brightness of a star found at W to a star found at Z. **(2 marks)**

. Answer parts (c)–(d) in Section II Answer Booklet 2.

(c) Using a Cepheid and one other named example, explain the difference between intrinsic and extrinsic variable stars. **4**

(d) *Spectroscopy is an important tool in obtaining information about stars, but it is a much more powerful tool when combined with photometry.* **7**

Justify this statement.