Astronomical Distances and Starts

Q1.

Which of the following is a valid unit for luminosity?

☒ **A** $W \, m^{-2}$

☒ **B** $N \, m \, s^{-2}$

☒ **C** $J \, s^{-1}$

☒ **D** $J \, m^{-2}$

(Total for question = 1 mark)

Q2.

Betelgeuse is a red giant star.

The surface temperature of Betelgeuse is T_B and the surface area of Betelgeuse is A_B.
The surface temperature of the Sun is T_S and the surface area of the Sun is A_S.

Which row in the table shows a correct comparison of the surface temperature and surface area of Betelgeuse with those of the Sun?

		$T_B > T_S$	$A_B > A_S$
☒	A	false	false
☒	B	false	true
☒	C	true	false
☒	D	true	true

(Total for question = 1 mark)

Q3.

Describe the characteristics of a main sequence star.

(2)

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(Total for question = 2 mark)

Q4.

In 2016 the Breakthrough Starshot initiative was announced. This project intends to send a fleet of small probes to Proxima Centauri, the nearest star to the Sun. This journey would take about twenty years.

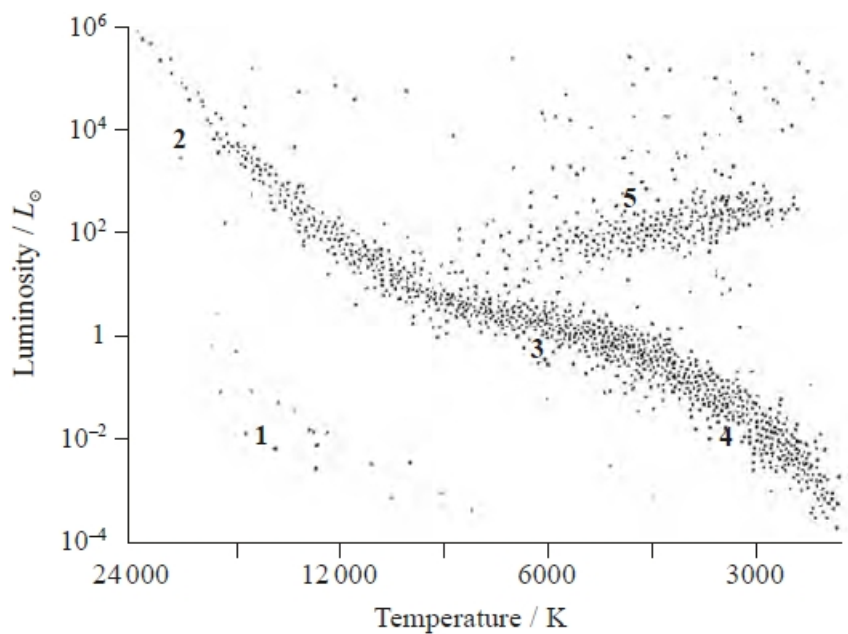Describe how the distance to nearby stars like Proxima Centauri is determined.

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(Total for question = 3 marks)

Q5.

Five regions are labelled on the Hertzsprung-Russell diagram shown.

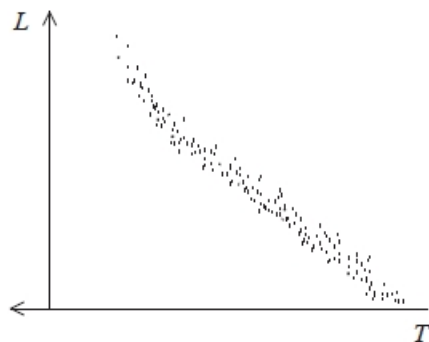Which sequence could show part of the evolution of a star like the Sun?

☒ **A**   1→5→3

☒ **B**   2→3→4

☒ **C**   3→5→1

☒ **D**   4→3→2

(Total for question = 1 mark)

Q6.

A Hertzsprung-Russell (HR) diagram shows how the luminosity *L* depends on the surface temperature *T* for a group of stars.

The HR diagram below is for a young star cluster.

(i) Explain how we can tell that the young star cluster is in the early stages of its evolution.

(2)

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(ii) Explain why the most massive stars in the cluster have the greatest luminosities.

(4)

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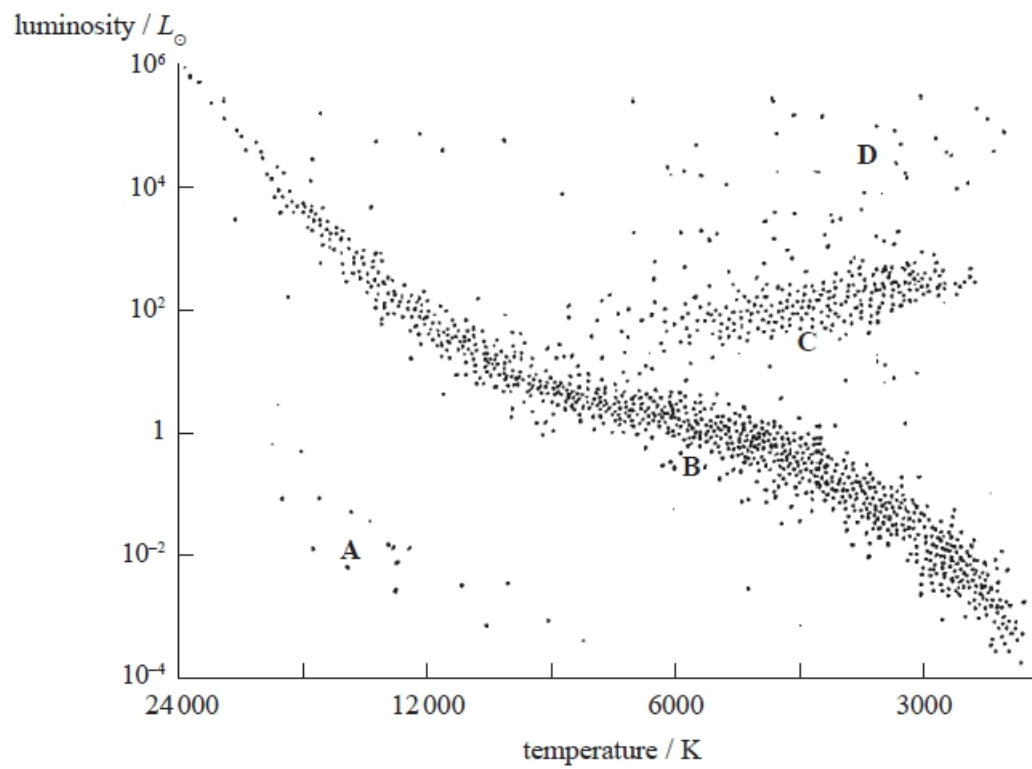
(Total for question = 6 marks)

Q7.

Four regions **A**, **B**, **C** and **D** are labelled on the Hertzsprung-Russell diagram.

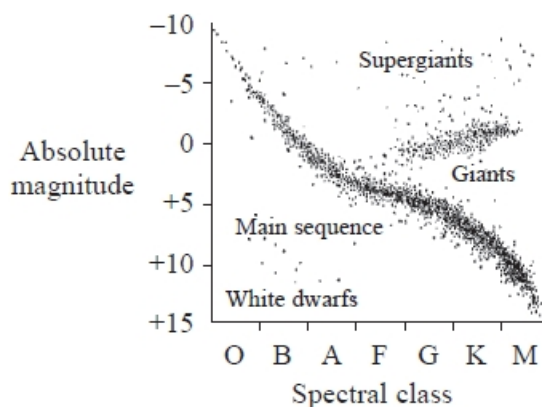
Which region includes the position of the Sun?

(1)

☒ **A**
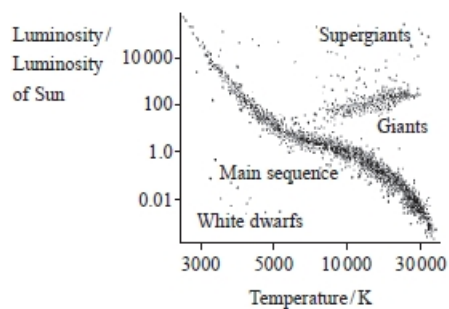
☒ **B**

☒ **C**

☒ **D**

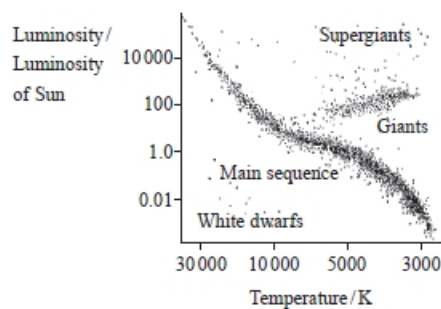**(Total for question = 1 mark)**

Q8.

A student finds a Hertzsprung-Russell diagram in an old astronomy book and notices that the axes aren't the same as in her current textbook.
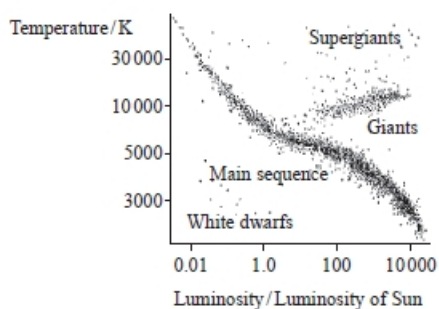

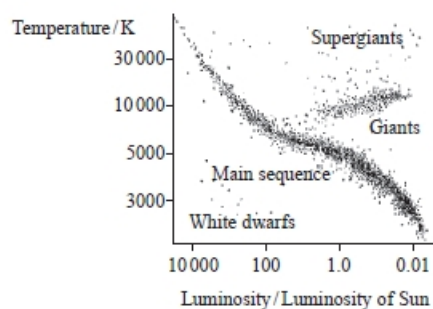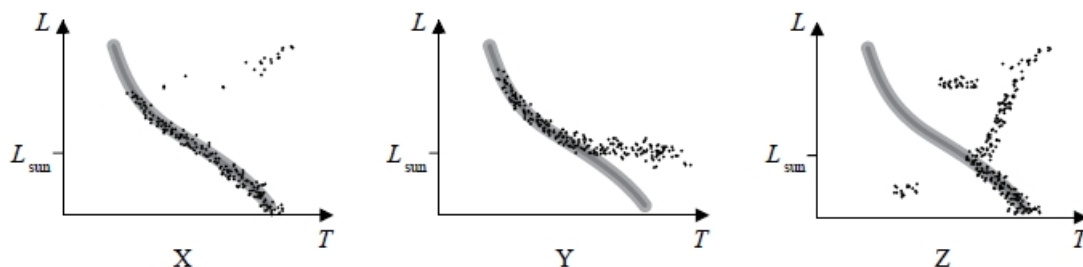Which of the following graphs shows a correct alternative way to label the axes?

☒ A

☒ B

☒ C

☒ D

(Total for question = 1 mark)

Q9.

Hertzsprung-Russell diagrams are shown for three star clusters.

Choose the row that correctly identifies the relative ages of the three clusters.

	Youngest ⟶ Oldest		
☐ A	X	Z	Y
☐ B	Y	X	Z
☐ C	Y	Z	X
☐ D	Z	X	Y

(Total for question = 1 mark)

Q10.

The Hertzsprung-Russell diagram is a diagram used by astronomers to illustrate the properties of stars.

Label the axes below (or the next page) and use them to sketch a Hertzsprung-Russell diagram.
Your diagram should include labelled regions where the following stars are found:

- main sequence
- red giants
- supergiants
- white dwarfs

(4)

Q11.

In 2016 the Breakthrough Starshot initiative was announced. This project intends to send a fleet of small probes to Proxima Centauri, the nearest star to the Sun. This journey would take about twenty years.

The radiation intensity at Earth from Proxima Centauri is 3.25×10^{-11} W m^{-2}. The luminosity of the Sun is $L_{\odot}$.

(i) Show that the luminosity of Proxima Centauri is about 0.002 $L_{\odot}$.

(3)

distance to Proxima Centauri = 4.00×10^{16} m
$L_{\odot}$ = 3.85×10^{26} W

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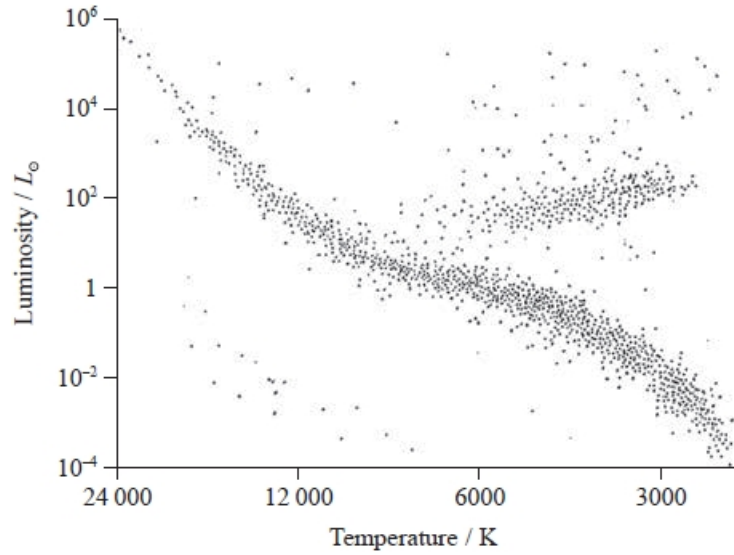
(ii) Proxima Centauri is described on a website as a main sequence star.

Determine whether the surface temperature of Proxima Centauri is consistent with a position on the main sequence of the Hertzsprung-Russell diagram.

(3)

radius of Proxima Centauri = 9.81×10^7 m

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(Total for question = 3 marks)

Q12.

There are several different methods that can be used to determine the distance from our solar system to astronomical objects. These include the measurement of red shift, trigonometrical parallax and the use of standard candles.

Which row of the table shows a suitable method for each of the objects named?

		Nearby star	Nearby galaxy	Very distant galaxy
☒	**A**	parallax	red shift	standard candle
☒	**B**	red shift	standard candle	parallax
☒	**C**	parallax	standard candle	red shift
☒	**D**	red shift	parallax	standard candle

(Total for question = 1 mark)

Q13.

Standard candles are used by astronomers to determine the distances to distant star clusters.

A standard candle has a

☒ **A** constant brightness.

☒ **B** constant luminosity.

☒ **C** known brightness.

☒ **D** known luminosity.

(Total for question = 1 mark)

Q14.

Astronomers observing stars at the centre of our galaxy have suggested that many of them are orbiting a supermassive black hole. The mass of this black hole is 9.2×10^{36} kg.

Trigonometric parallax and Hubble's law are two methods used to determine astronomical distances.

Explain whether either of these methods is suitable to determine the distance to S0-2.

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(Total for question = 3 marks)

Q15.

The distance to astronomical objects relatively close to the Sun is determined using trigonometric parallax. For objects beyond a certain distance standard candles are used.

(a) State what is meant by a standard candle.

(1)

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(b) Explain why trigonometric parallax is not used beyond a certain distance.

(2)

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(c) Describe how distances too large for the use of standard candles can be determined.

(3)

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(Total for question = 6 marks)

Mark Scheme – Astronomical Distances and Stars

Q1.

Question Number	Answers	Mark
	The only correct answer is C *A is incorrect because luminosity must have the units of power* *B is incorrect because luminosity must have the units of power* *D is incorrect because luminosity must have the units of power*	1

Q2.

Question Number	Answers	Mark
	The only correct answer is B *A is incorrect because a red giant star has larger surface area but a lower surface temperature than the Sun* *C is incorrect because a red giant star has larger surface area but a lower surface temperature than the Sun* *D is incorrect because a red giant star has larger surface area but a lower surface temperature than the Sun*	1

Q3.

Question Number	Acceptable answers	Additional guidance	Mark
	A description that makes reference to the following: • (main sequence) stars are (primarily) converting hydrogen to helium in their core (1) • stars on main sequence maintain a constant luminosity (for most of their lifetime) (1)		(2)

Q4.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• The star is viewed from two positions at 6 month intervals (1) **Or** The star is viewed from opposite ends of its orbit diameter about the Sun • The change in angle/position of the star against backdrop of fixed stars is measured (1) • Trigonometry is used to calculate the distance to the star [Do not accept Pythagoras] (1) **Or** The diameter/radius of the Earth's orbit about the Sun must be known	Marks may be obtained from suitably annotated diagrams e.g MP1 and MP2: 	3

Q5.

Question Number	Acceptable answer	Additional guidance	Mark
	C	The only correct answer is C: main sequence – red giant – white dwarf A is not correct because it is white dwarf – red giant – main sequence B is not correct because it moves along the main sequence from large to small D is not correct because it moves along the main sequence from small to large	1

Q6.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• All the stars are in the main sequence • In an older cluster there would be red giant stars	(1) (1)		2
(ii)	**MAX 4** • The most massive stars experience much greater gravitational forces • So core temperature and density is greatest • The rate of fusion in the core is greatest Or the power generated in the core is greatest • The (surface) temperature is greatest • The surface area of these stars is greatest • So according to Stefan's Law the power radiated from these massive stars is greatest	(1) (1) (1) (1) (1) (1)		4

Q7.

Question Number	Answer	Mark
	B – (point on graph with luminosity $\neq L_{\odot}$)	1
	Incorrect Answers: A – luminosity $\neq L_{\odot}$ C – luminosity $\neq L_{\odot}$ D – luminosity $\neq L_{\odot}$	

Q8.

Question Number	Acceptable answer	Additional guidance	Mark
	B	The only correct answer is B because the y axis is luminosity and the x axis shows temperature decreasing A is not the correct answer because the y axis is luminosity but the x axis shows temperature increasing C is not the correct answer because the x axis is luminosity and the y axis is luminosity D is not the correct answer because the x axis is luminosity and the y axis is luminosity	1

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	B		1

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
	• y axis: luminosity (1) (/ luminosity of Sun) • x axis: (surface) (1) temperature, with indication of decreasing temperature • 2 or 3 correct (1) regions • 4 correct regions (1)	Example of graph: Example of graph	**(4)**

Q11.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• use of $I = L / 4\pi d^2$ (1) • $L = 6.53 \times 10^{23}$ W (1) • = 0.17% of Sun (1)	Example of calculation 3.25×10^{-11} W m^{-2} = $L / 4\pi(4.00 \times 10^{16}$ m$)^2$ $L = 6.53 \times 10^{23}$ W 6.53×10^{23} W / 3.85×10^{26} W = 0.17%	3
(ii)	• use of $L = \sigma A T^4$ (1) • $T = 3124$ (K) (1) • Statement relating (1) calculated values of T and L to main sequence on H-R diagram	Example of calculation 6.53×10^{23} W = 5.67×10^{-8} W m^{-2}K^{-4} × 4π (9.81 × 10^7 m$)^2 \times T^4$ $T = 3124$ K	3

Q12.

Question Number	Acceptable answer	Additional guidance	Mark
	C	The only correct answer is C because the correct method for a nearby star is parallax, for a nearby galaxy is standard candle and for a very distant galaxy is red shift A is not correct because only the nearby star method is correct B is not correct because only the nearby galaxy method is correct D is not correct because none of the methods are correct	1

Q13.

Question Number	Acceptable answers	Additional guidance	Mark
	D		1

Q14.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: (1) • Hubble is for cosmological distances (1) • is not suitable since S2 is in our galaxy (1) • trigonometrical parallax is suitable for local stars because the parallax angles produced are large enough to measure accurately	e.g. to distant galaxies	3

Q15.

Question Number	Acceptable answers	Additional guidance	
(a)	• Object of known luminosity (1)		1

Question Number	Acceptable answers	Additional guidance	
(b)	• The (parallax) angle becomes very small (1) Or the diameter of the Earth's orbit is very small • Giving a (very) large percentage uncertainty (1)		2

Question Number	Acceptable answers	Additional guidance	
(c)	• Measure change in wavelength / frequency (1) • Determine relative velocity using redshift formula (1) • Then apply $v = H_0 d$ (1)		3