PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 10: SPACE

ASTRONOMICAL DISTANCES AND STARS

SCORE	PERCENTAGE
/180	%

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Q1.

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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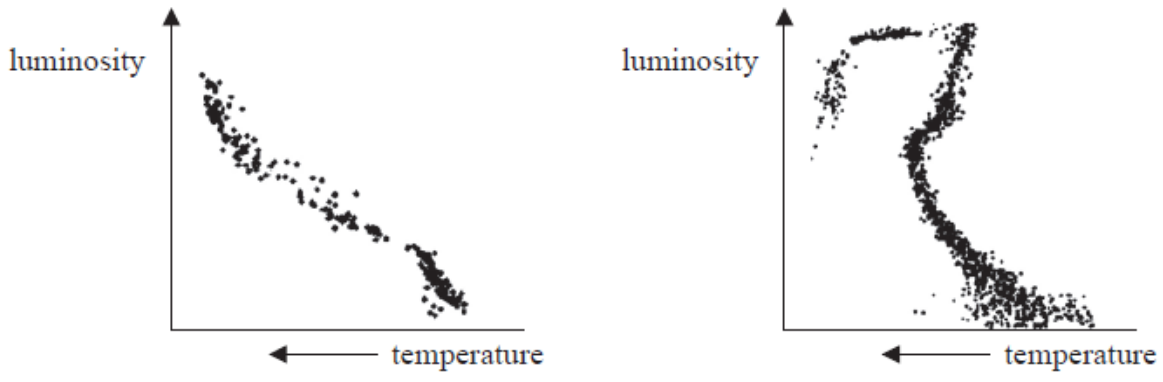
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(Total for question = 3 marks)

Q2.

(a) The Herzsprung-Russell (H-R) diagram is one of the most important tools in the study of stellar evolution.

The H-R diagrams below are for a young star cluster and an old star cluster.



Young star cluster **Old star cluster**

Use the diagrams to describe and explain how the old star cluster is different from the young

star cluster.

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(b) Trigonometric parallax is one way in which stellar distances can be measured.

Astronomers measure the parallax angle for two nearby stars. The parallax angle for star A is 3.74×10^{-6} rad and that for star B is 1.84×10^{-7} rad.

(i) Without calculation, state what can be deduced from this data about the relative distances of the two stars.

(1)

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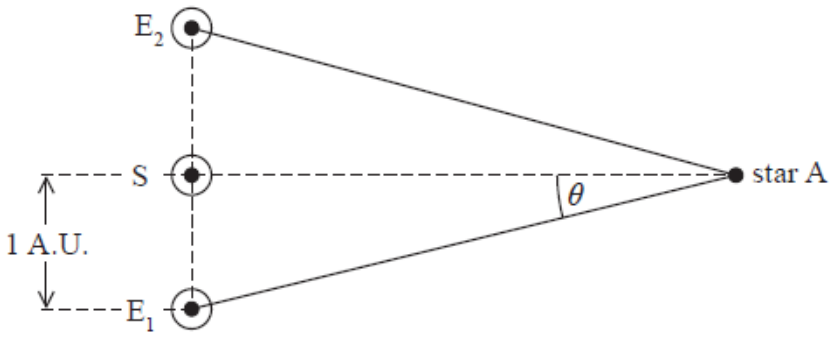
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(ii) The diagram shows the parallax angle for star A.

Calculate the distance of star A from the Earth.

1 A.U. is 1.50×10^{11} m

(2)



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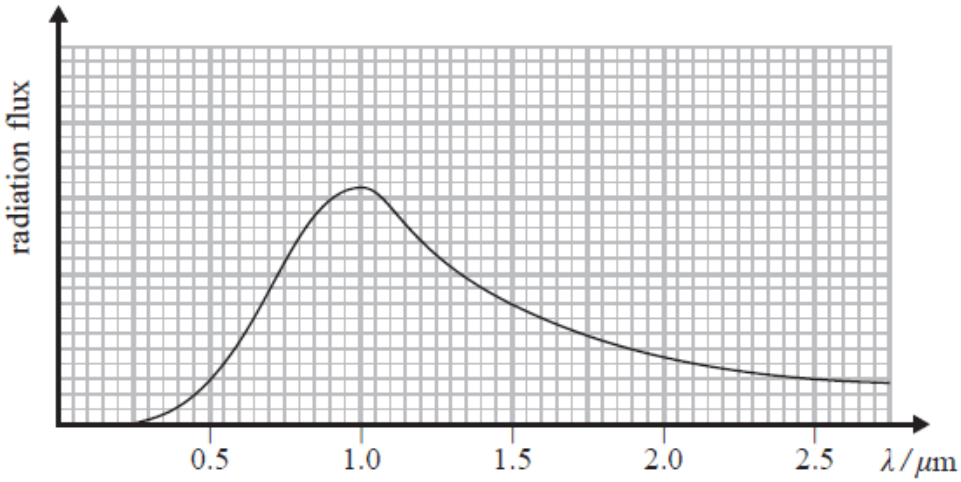
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Distance = ...

(c) In addition to finding the distances to stars astronomers are interested in determining the temperatures of stars.

The spectrum of star A is shown below.



Use data from the graph to determine the surface temperature of star A.

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Temperature = ...

(Total for question = 12 marks)

Q3.

A sample of gas is contained within a sealed tube with a moveable piston at one end.
The gas occupies a volume V at pressure p and temperature T.

The temperature of the gas is increased to $2T$ and the volume of the cylinder changes.
The pressure decreases to $p/2$.

What will the new volume be?

☒ **A** $V/2$

☒ **B** V

☒ **C** $2V$

☒ **D** $4V$

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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)

Q5.

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)

Q6.

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.

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(Total for question = 6 marks)

Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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.

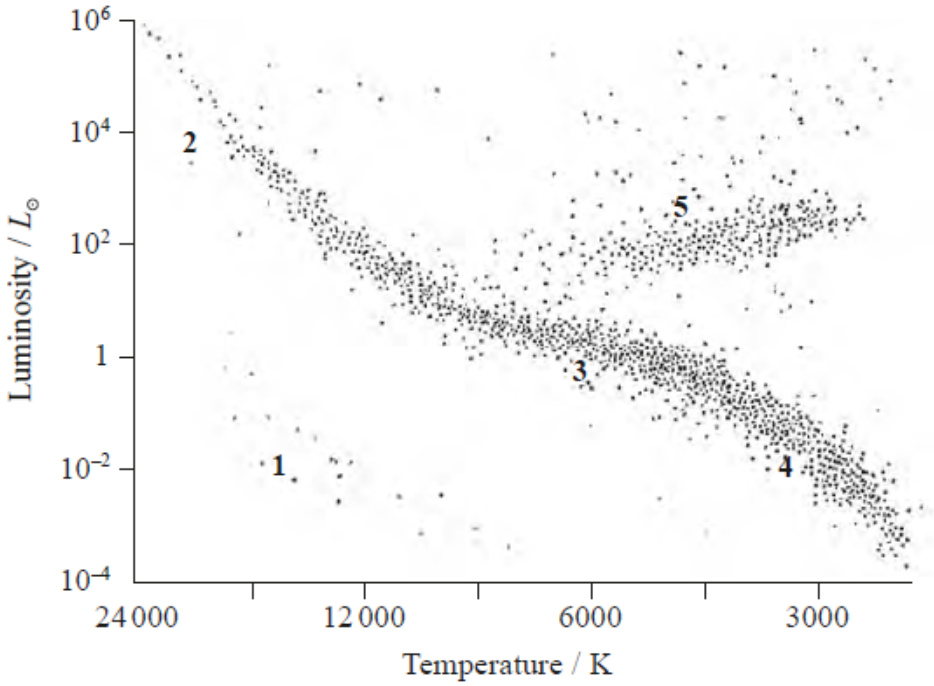
Which row in the table shows a correct comparison of the surface temperature and surface area of Betelgeuse with those of the Sun?

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

(Total for question = 1 mark)

Q2.

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)

Q3.

A simple model of the hydrogen atom consists of an electron moving in a circular path around a proton.

(i) In this simple model it is the electrostatic force, rather than the gravitational force, that is responsible for keeping the electron in a circular path.

By means of calculations justify this statement.

radius r of the hydrogen atom = 5.3×10^{-11} m

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(ii) Ignoring the gravitational force, calculate the velocity of the electron in this simple model of the hydrogen atom.

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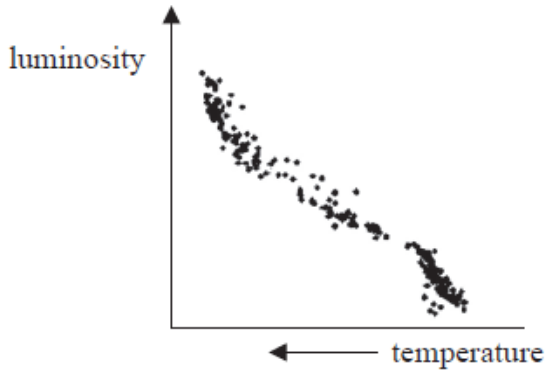
Velocity = ...

(Total for question = 7 marks)

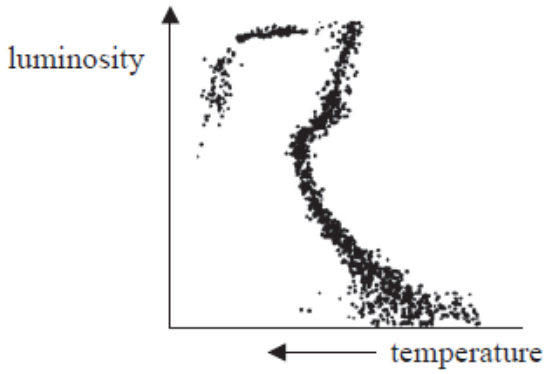
Q4.

(a) The Herzsprung-Russell (H-R) diagram is one of the most important tools in the study of stellar evolution.

The H-R diagrams below are for a young star cluster and an old star cluster.



Young star cluster



Old star cluster

Use the diagrams to describe and explain how the old star cluster is different from the young star cluster.

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(b) Trigonometric parallax is one way in which stellar distances can be measured.

Astronomers measure the parallax angle for two nearby stars. The parallax angle for star A is 3.74×10^{-6} rad and that for star B is 1.84×10^{-7} rad.

(i) Without calculation, state what can be deduced from this data about the relative distances of the two stars.

(1)

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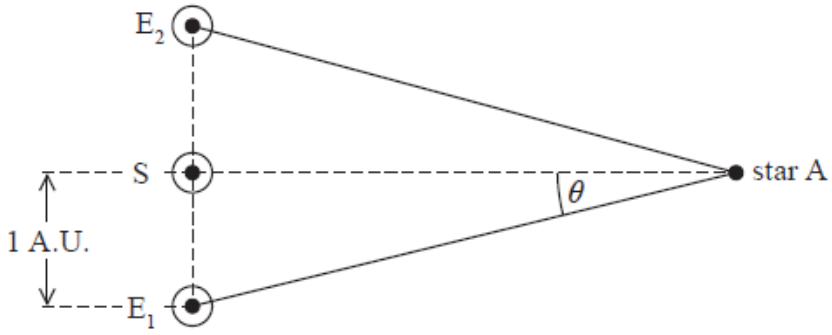
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(ii) The diagram shows the parallax angle for star A.

Calculate the distance of star A from the Earth.

1 A.U. is 1.50×10^{11} m

(2)



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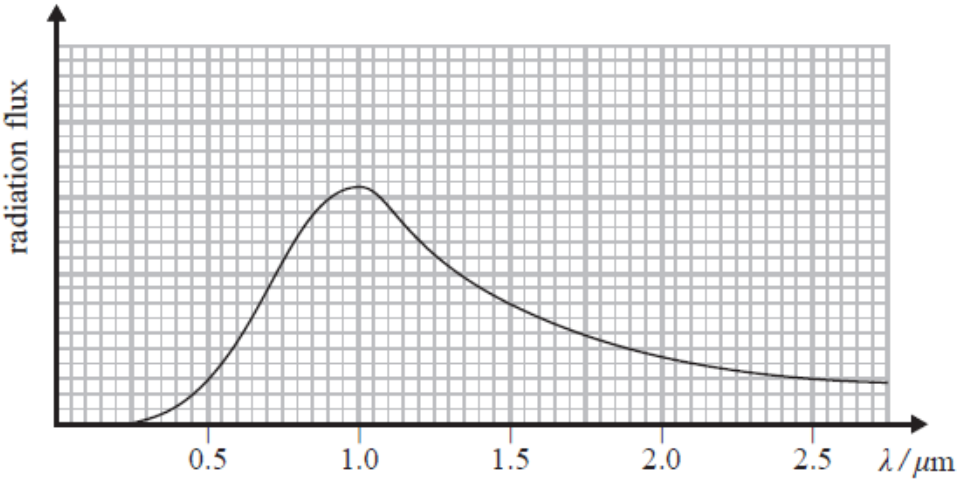
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Distance = ...

(c) In addition to finding the distances to stars astronomers are interested in determining the temperatures of stars.

The spectrum of star A is shown below.



Use data from the graph to determine the surface temperature of star A.

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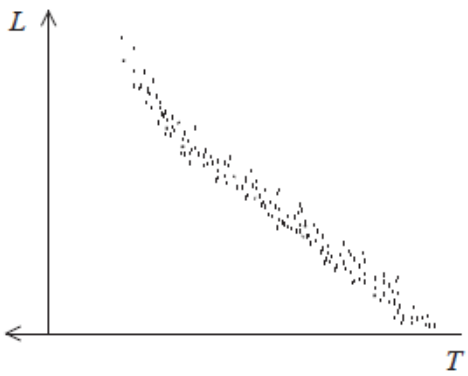
Temperature = ...

(Total for question = 12 marks)

Q5.

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.

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

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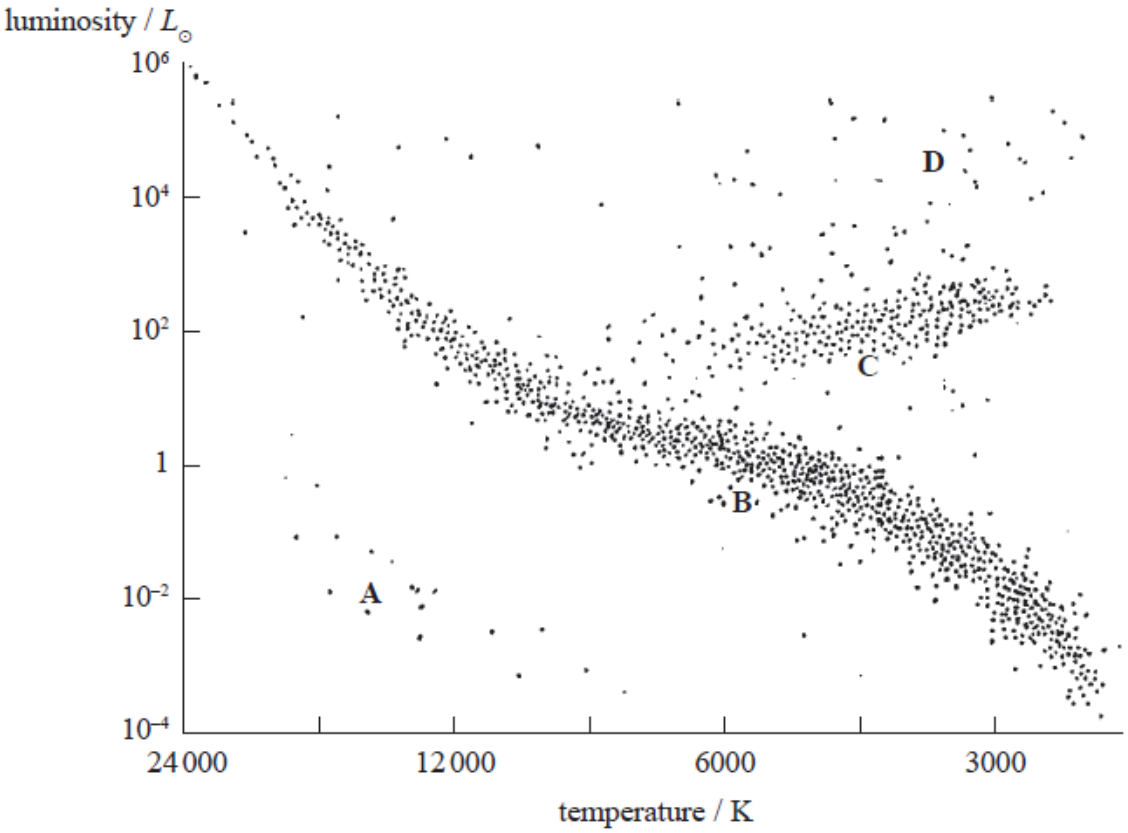
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(Total for question = 6 marks)

Q6.

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)

Q7.

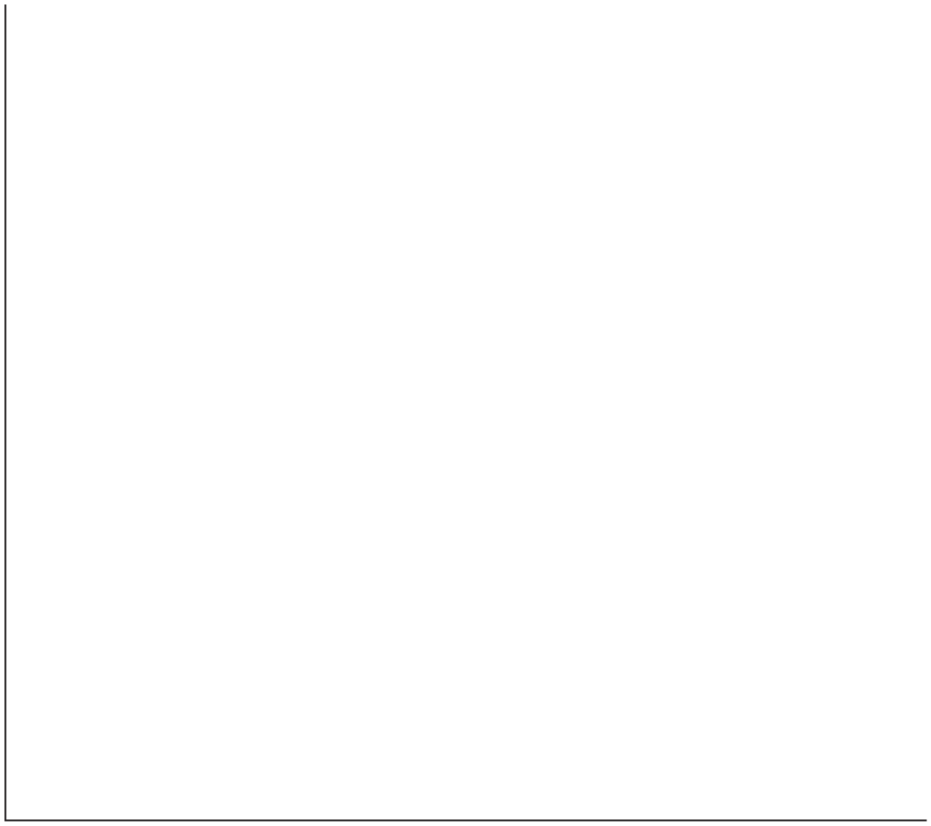
The Hertzsprung-Russell diagram is a diagram used by astronomers to illustrate the properties of stars.

Label the axes below 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

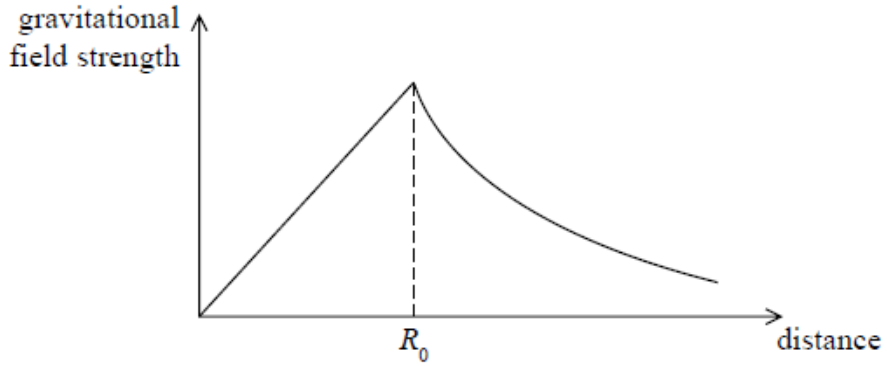
- supergiants
- white dwarfs

(4)



Q8.

The graph shows the variation of the gravitational field strength with distance from the centre of the Earth. R_0 is the radius of the Earth.



A scientist suggests that the period of oscillation for a body dropped through the tunnel would be the same as the orbital period for a body orbiting just above the surface of the Earth. Its radius of orbit is assumed to be R_0.

(i) Derive an expression for the period of oscillation of the body dropped through the tunnel.

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(ii) Derive an expression for the orbital period for a body that is orbiting the Earth with radius R_0.

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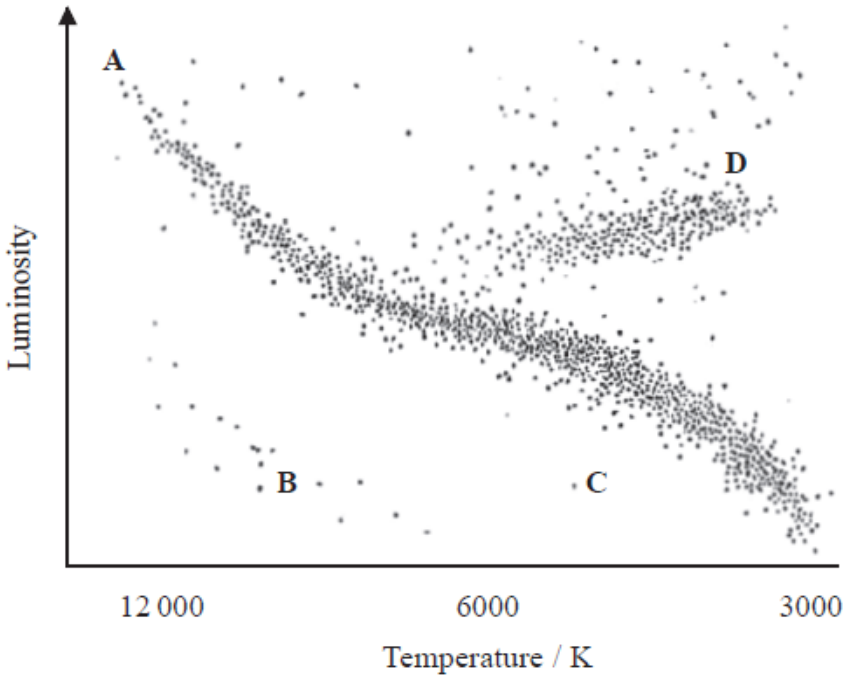
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(Total for question = 7 marks)

Q9.

This question refers to the Hertzsprung-Russell diagram below.



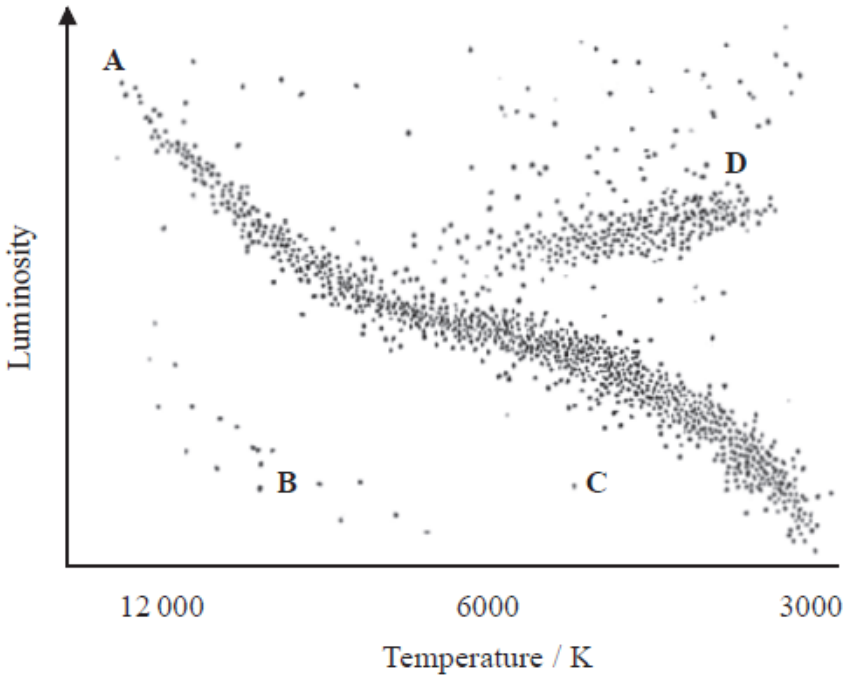
Which letter, **A**, **B**, **C** or **D**, indicates the region where a white dwarf star would be shown?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 mark)

Q10.

This question refers to the Hertzsprung-Russell diagram below.



Which letter, **A**, **B**, **C** or **D**, indicates the region where a blue giant star would be shown?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 mark)

Q1.

* Cepheid variable stars have long been seen as examples of standard candles. Recent measurements have indicated that the movement of the star through the interstellar material might result in the formation of a layer of dust around the star. This affects how bright the star appears.

Explain how standard candles are used in astronomy, and suggest how the existence of a layer of dust around a Cepheid variable star might affect the conclusions drawn by astronomers.

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(Total for question = 6 marks)

Q2.

Rigel A in the constellation of Orion is one of the brightest stars in the sky. It is a massive blue variable star with an intensity peak at a wavelength λ_{max} of 0.25 μm.

RR Lyrae stars are also variable stars. They are used by astronomers as standard candles, although none of them are close enough for trigonometric parallax to be useful.

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

(1)

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*(ii) Describe how astronomers use standard candles.

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(iii) Explain why stars have to be within a certain distance from the Earth for trigonometric parallax to be useful.

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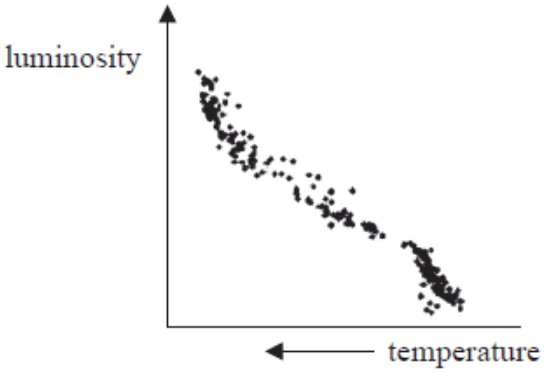
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(Total for question = 12 marks)

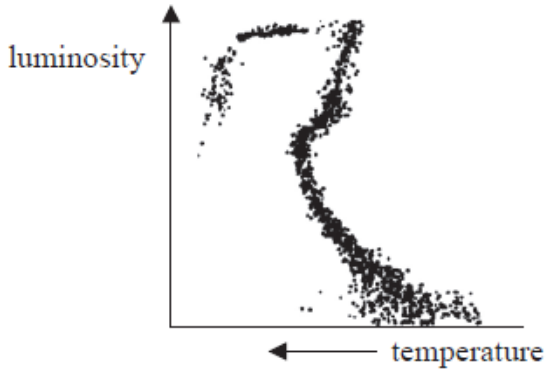
Q3.

(a) The Herzsprung-Russell (H-R) diagram is one of the most important tools in the study of stellar evolution.

The H-R diagrams below are for a young star cluster and an old star cluster.



Young star cluster



Old star cluster

Use the diagrams to describe and explain how the old star cluster is different from the young star cluster.

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(b) Trigonometric parallax is one way in which stellar distances can be measured.

Astronomers measure the parallax angle for two nearby stars. The parallax angle for star A is 3.74×10^{-6} rad and that for star B is 1.84×10^{-7} rad.

(i) Without calculation, state what can be deduced from this data about the relative distances of the two stars.

(1)

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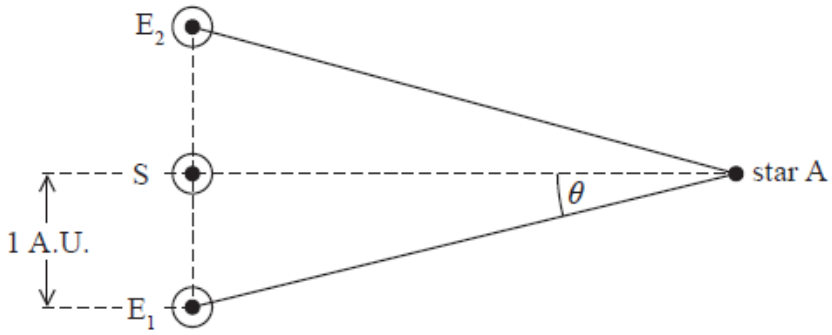
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(ii) The diagram shows the parallax angle for star A.

Calculate the distance of star A from the Earth.

1 A.U. is 1.50×10^{11} m

(2)



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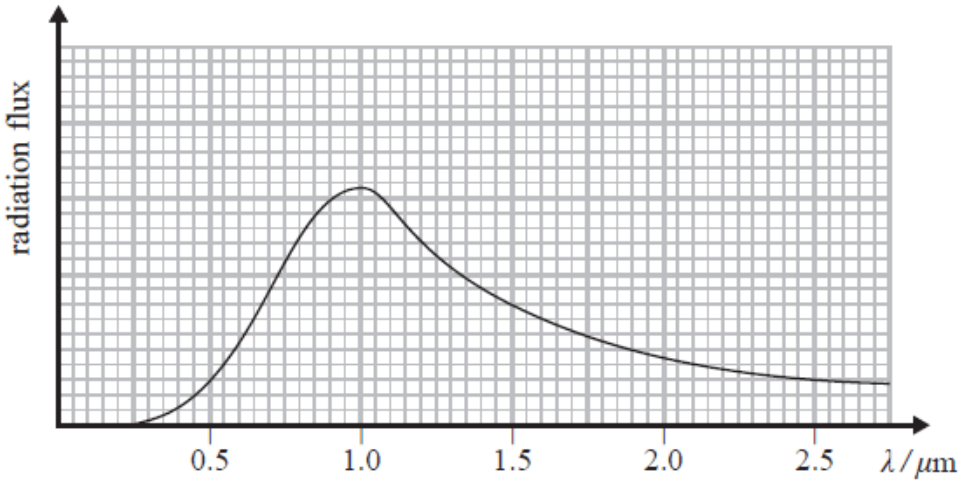
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Distance = ...

(c) In addition to finding the distances to stars astronomers are interested in determining the temperatures of stars.

The spectrum of star A is shown below.



Use data from the graph to determine the surface temperature of star A.

(3)

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Temperature = ...

(Total for question = 12 marks)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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)

Q5.

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)

Q6. * Parallax measurements are used to determine the distance to nearby stars, but this method is unsuitable for more distant objects.

Outline how parallax measurements are used to determine the distance to nearby stars and explain how the use of a standard candle enables the distance to more distant objects to be determined.

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(Total for Question = 6 marks)

Q7.

Almost a century ago Edwin Hubble was investigating the light spectra emitted from a large number of galaxies. He used redshift values obtained from these spectra to determine the velocity of the galaxies relative to the Earth. He also measured the distances to each galaxy using Cepheid variable stars, which are a type of standard candle. From these measurements Hubble was able to formulate a law linking the velocity of distant galaxies to their distance from the Earth.

(a) (i) Explain what is meant by redshift.

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*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

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

(1)

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(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

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(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

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(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

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(Total for question = 13 marks)

Q8.

According to astronomers in Denmark and Australia a common type of active galactic nucleus (AGN) could be used as an accurate "standard candle" for measuring cosmic distances. The technique has been used to measure distances corresponding to redshifts significantly larger than was previously possible.

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

(1)

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(ii) Explain how a standard candle is used to measure cosmic distances.

(2)

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(b) (i) State what is meant by redshift.

(1)

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(ii) Calculate the distance to a galaxy with a redshift $z = 0.12$

$H_0 = 2.1 \times 10^{-18}\ s^{-1}$

(2)

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Distance to galaxy = ...

*(c) Discuss how astronomers were led to propose the existence of dark matter and the consequences of its existence for the ultimate fate of the universe.

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(d) Explain why the observable universe has a finite size.

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(Total for Question = 11 marks)

Q9.

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.

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(Total for question = 6 marks)

Q1.

Describe the characteristics of a main sequence star.

(2)

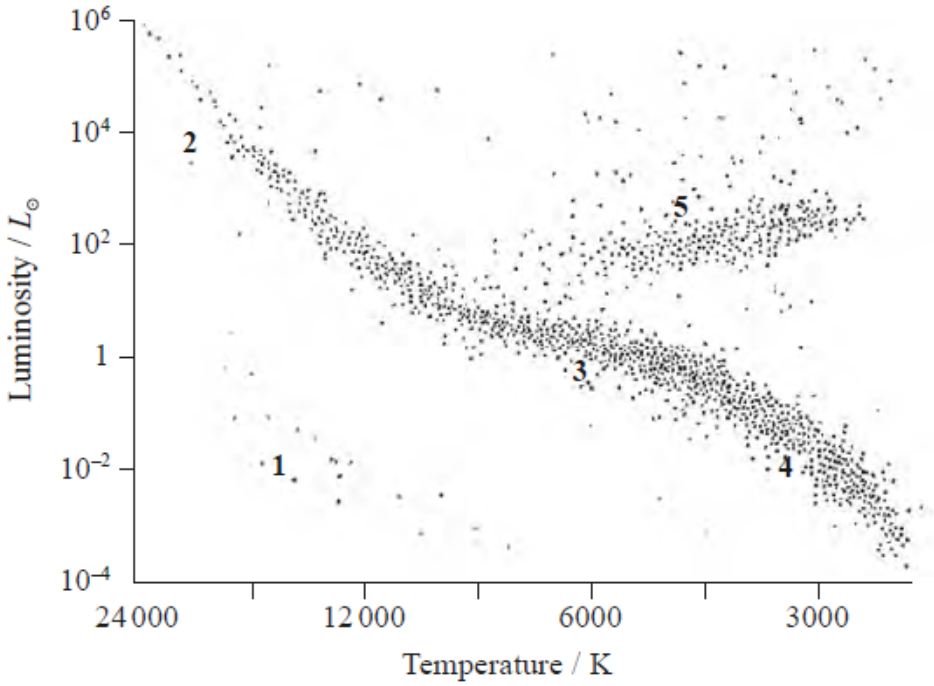
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Q2.

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)

Q3.

A simple model of the hydrogen atom consists of an electron moving in a circular path around a proton.

(i) In this simple model it is the electrostatic force, rather than the gravitational force, that is responsible for keeping the electron in a circular path.

By means of calculations justify this statement.

radius r of the hydrogen atom = 5.3×10^{-11} m

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(ii) Ignoring the gravitational force, calculate the velocity of the electron in this simple model of the hydrogen atom.

(3)

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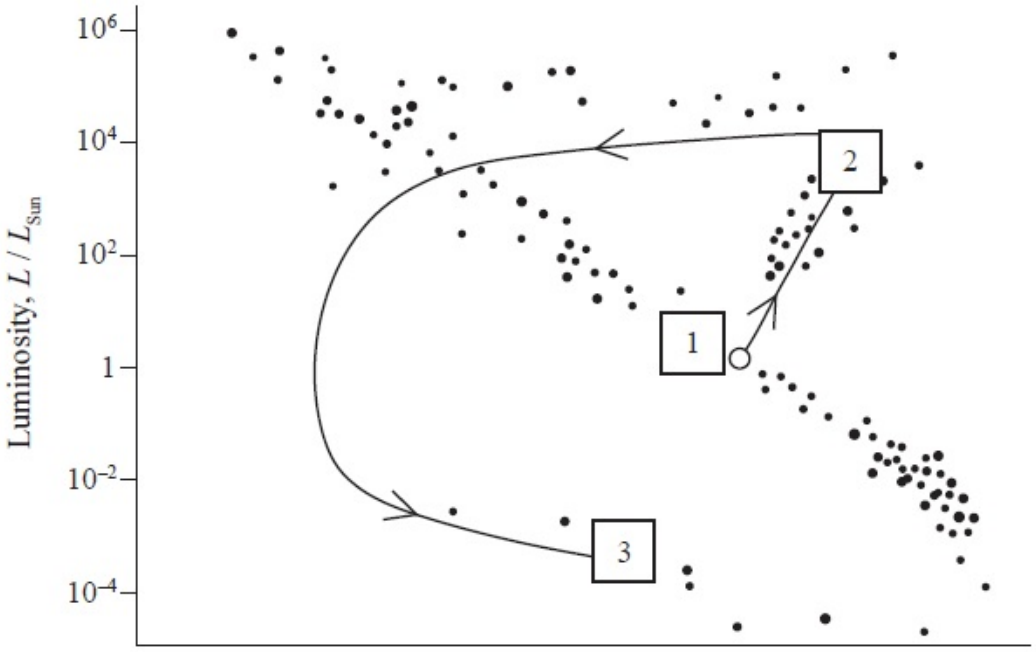
Velocity = ...

(Total for question = 7 marks)

Q4. The Sun has a surface temperature of 5800 K and is approximately 4.5 billion years old.

The Hertzsprung-Russell diagram maps the future evolution of the Sun, from its current position

in area 1 of the diagram, through to its final position in area 3 of the diagram.



(a) (i) Complete a suitable temperature scale on the x-axis.

(2)

*(ii) Use the diagram to describe the lifecycle of the Sun starting from its present position in area 1 and concluding in area 3.

(6)

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(b) The energy source for the Sun is the fusion of light nuclei to heavy nuclei. In its present stage of evolution hydrogen is being converted into helium in the core of the Sun.

(i) State and explain the conditions necessary for fusion to occur in a star.

(3)

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(ii) In a star the fusion of hydrogen into helium takes place in a number of stages. The final stage is:

$$^{3}_{2}\mathrm{He} + {}^{3}_{2}\mathrm{He} \rightarrow {}^{4}_{2}\mathrm{He} + 2 \times {}^{1}_{1}\mathrm{H}$$

Calculate the energy released in MeV when one nucleus of the normal isotope of helium is produced.

(4)

Isotope	Mass / 10^{-27} kg
^{3}He	5.008238
^{4}He	6.646483
^{1}H	1.673534

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Energy released = ... MeV

(Total for Question = 15 marks)

Q5.

A star is estimated to have approximately the same surface temperature as the Sun, but less than 1% of the Sun's luminosity.

The star is best classified as a

☒ **A** main sequence star.

☒ **B** red dwarf star.

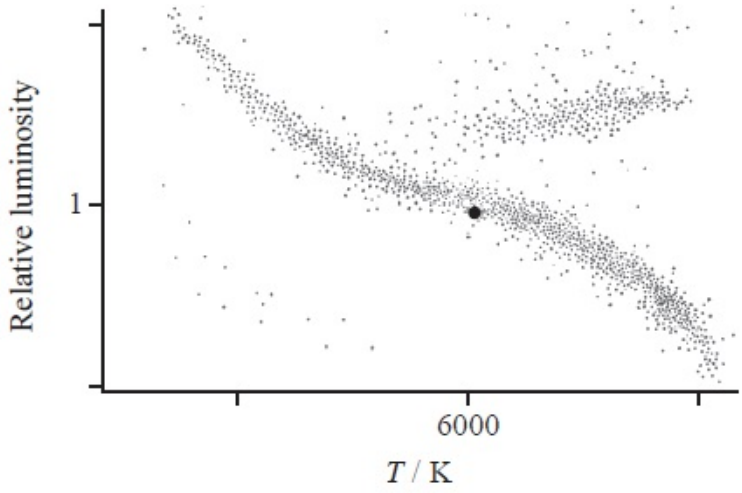
☒ **C** red giant star.

☒ **D** white dwarf star.

(Total for Question = 1 mark)

Q6.

This Hertzsprung-Russell diagram is a plot of relative luminosity against temperature for a large number of stars.



The position of the Sun, at a surface temperature of about 6000 K and a relative luminosity of 1, is marked on the diagram.

(a) Complete the temperature and relative luminosity scales by adding values at the positions shown.

(2)

(b) The Sun is an example of a main sequence star.

(i) State the fusion process taking place in the core of all main sequence stars.

(1)

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(ii) Draw a circle where the most massive main sequence stars are located on the diagram and explain why they are found in this position.

(3)

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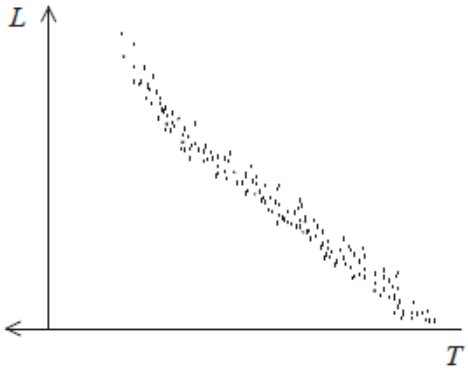
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(Total for Question = 6 marks)

Q7.

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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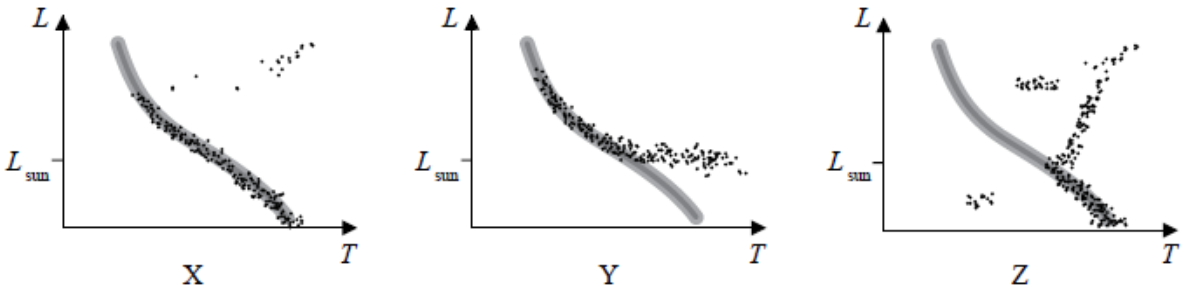
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(Total for question = 6 marks)

Q8.

Hertzsprung-Russell diagrams are shown for three star clusters.



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

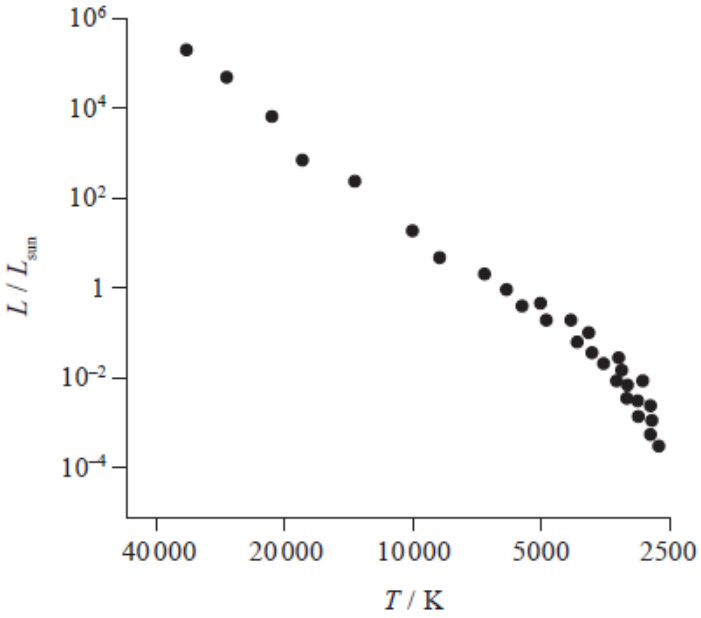
	Youngest ⟶		Oldest
☒ A	X	Z	Y
☒ B	Y	X	Z
☒ C	Y	Z	X
☒ D	Z	X	Y

(Total for question = 1 mark)

Q9.

The Hertzsprung-Russell (H-R) diagram is a plot of luminosity against temperature for a range of stars.

The H-R diagram below shows a number of main sequence stars.



(i) Label the position of our Sun on the diagram.

(1)

(ii) Label on the diagram the regions in which white dwarf and red giant stars would be located.

(2)

*(iii) Stars known as white dwarf stars have small surface areas. Explain how astronomers have deduced this.

(3)

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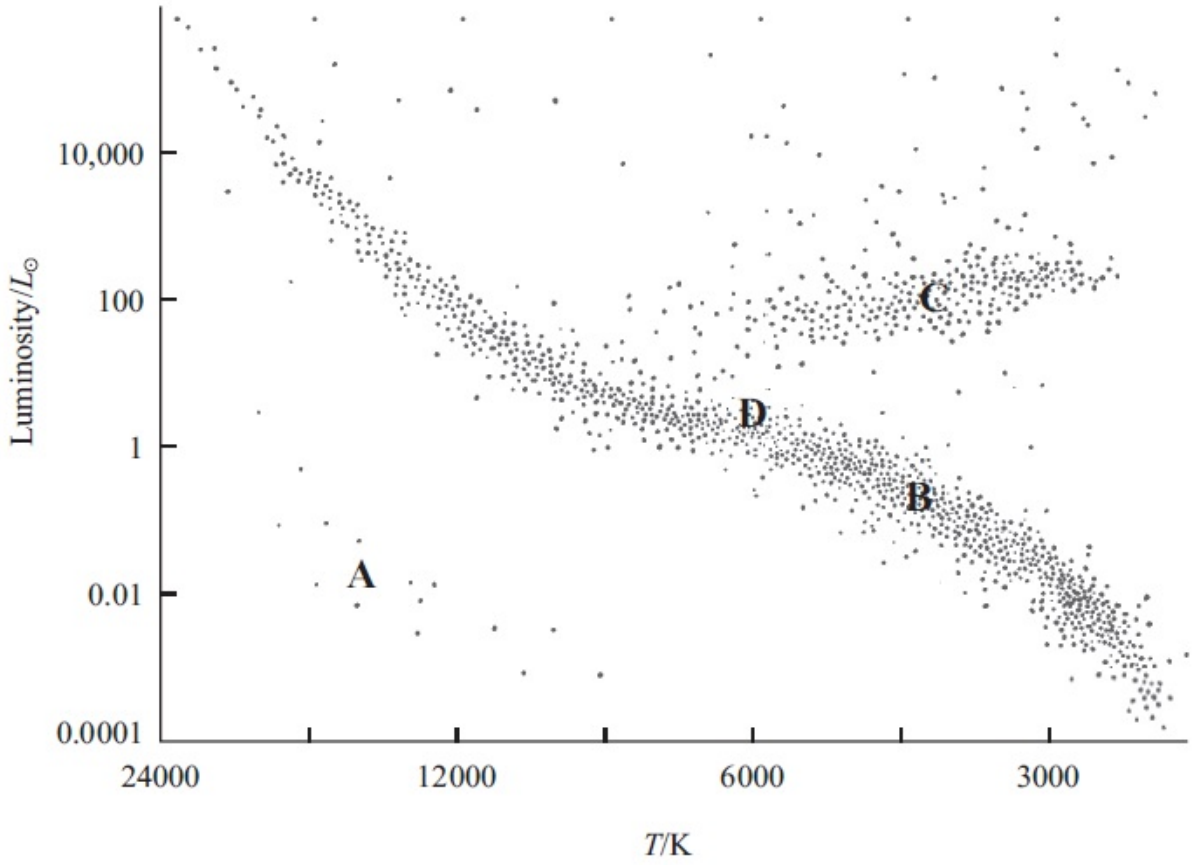
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(Total for question = 6 marks)

Q10.



Which letter A, B, C or D represents the region on the diagram where our Sun would be shown?

☒ **A**

☒ **B**

☒ **C**