



Questions

Q1.

The mean intensity of solar radiation arriving at the Earth is 1.37 kW m^{-2} .

(a) The distance of the Earth from the Sun is $1.50 \times 10^{11} \text{ m}$.

Show that the luminosity of the Sun is about $4 \times 10^{26} \text{ W}$.

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(b) The energy radiated from the Sun results in a decrease in the mass of the Sun.

Calculate the decrease in the mass of the Sun due to this radiation over a period of 1 year.

1 year = $3.15 \times 10^7 \text{ s}$

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Decrease in mass = www.RocketRevise.com

(Total for question = 4 marks)

Q2.



Alnilam and Mintaka are stars in the constellation Orion.

The table gives some information about these stars.

Star	Surface temperature / K	Luminosity / L_{Sun}	Distance from the Earth / m
Alnilam	2.75×10^4	5.37×10^5	1.90×10^{19}
Mintaka	3.00×10^4	9.00×10^4	8.70×10^{18}

$$L_{\text{Sun}} = 3.85 \times 10^{26} \text{ W}$$

(a) State where these stars would be located on a Hertzsprung-Russell diagram.

(1)

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(b) Calculate the wavelength at which peak radiation power occurs for Mintaka.

(2)

Wavelength =

(c) Calculate the radius of Alnilam.

(2)

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Radius of Alnilam =

(d) Deduce which of these stars gives the lower intensity of radiation at the Earth.

(3)



(Total for question = 8 marks)

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Q3.

A massive planet orbits the red dwarf star Gliese 876. The planet was discovered after wavelength shifts in spectral lines were seen in the light received from the star.

(a) Explain how a massive planet orbiting a star can cause a change in the wavelength of light received from the star.

(3)

(b) The maximum shift in a spectral line of wavelength 4.35×10^{-7} m in the light received from Gliese 876 is 3.19×10^{-13} m.

Calculate the maximum velocity of Gliese 876 away from the Earth.

(2)



Maximum velocity =

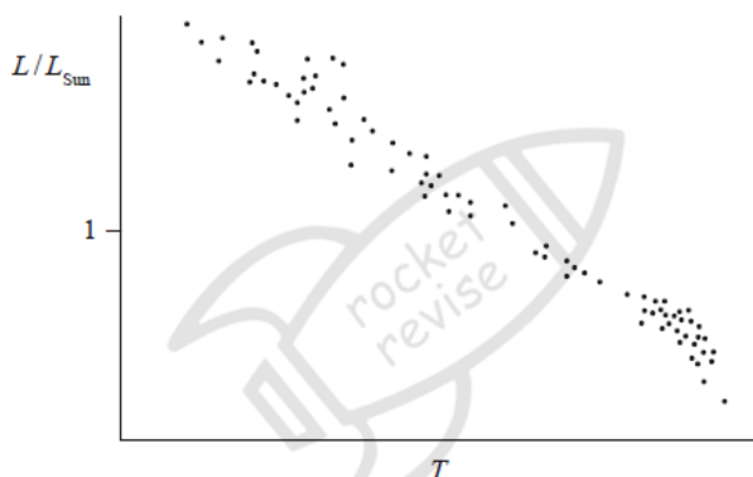
(Total for question = 5 marks)

Q4.

(a) The Hertzsprung-Russell (HR) diagram shows the relationship between luminosity L and surface temperature T for a range of stars.

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The HR diagram below is for a young star cluster.



(i) Mark on the diagram the position of a star similar to the Sun.

(1)

* (ii) The appearance of the HR diagram changes as stars in the cluster evolve.

Explain the changes in the appearance of the HR diagram as the star cluster gets older.

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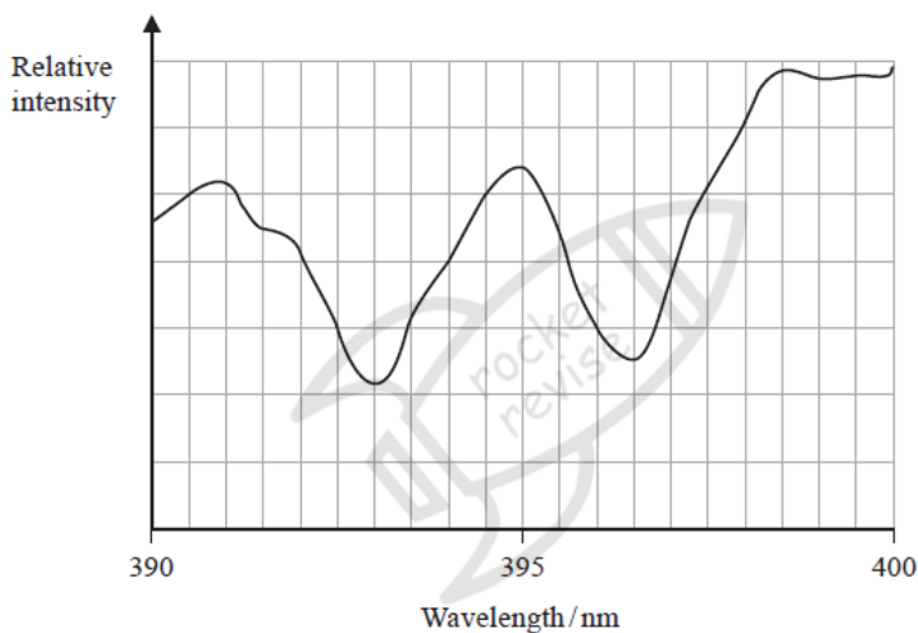
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(b) One hundred years ago the Andromeda Galaxy was thought to be a group of stars within our own galaxy. In 1923, Edwin Hubble made observations on a standard candle within this group of stars. He concluded from these observations that Andromeda must be outside our own galaxy.

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(i) The graph shows part of the spectrum of radiation received from Andromeda.



(Source: © Nasa)

The two intensity minima represent lines in the absorption spectrum of calcium. In the laboratory these two lines have a wavelength of 393.4 nm and 396.9 nm.

Determine the velocity of Andromeda relative to the Earth.

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Velocity of Andromeda relative to the Earth =

(ii) Dust in space around a star may affect how bright the star appears to be.

It is claimed that dust around a standard candle would lead to the conclusion that the standard candle is a greater distance from Earth than the actual distance.

Assess the validity of this claim.

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(Total for question = 14 marks)

Q5.

In the 18th century, Herschel discovered an irregular-shaped galaxy. This galaxy, now known as NGC 6052, is shown in the photograph.



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(Source: dcf21-www@dcford.org.uk)

(a) Light from NGC 6052 has a red-shift z equal to 0.0158



(i) Explain what is meant by redshift.

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(ii) Calculate the distance of NGC 6052 from Earth.

$$H_0 = 1.62 \times 10^{-18} \text{ s}^{-1}$$

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Distance of NGC 6052 from Earth =

(b) Recent photographs from the Hubble Space Telescope show that NGC 6052 actually consists of two galaxies that are colliding.

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(Source: © Nasa)



The galaxies are accelerating towards each other.

Explain why the acceleration increases as time passes.

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(Total for question = 7 marks)

Q6.

Astronomers use a variety of techniques to determine the distances to astronomical objects outside our solar system.

(a) Describe how trigonometric parallax can be used to determine the distance to a nearby star.

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(b) Explain how a knowledge of the distances to distant galaxies has enabled astronomers to determine a value for the age of the universe.

(4)

(Total for question = 7 marks)

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 ☐.

- ☐ **A** a star of known distance
- ☐ **B** a star of known intensity
- ☐ **C** a star of known luminosity
- ☐ **D** a star of known mass

(Total for question = 1 mark)



Q8.

In recent years, astronomers have discovered sources of fast radio bursts (FRBs) in other galaxies. Studies suggest that these sources may be a type of standard candle.

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

(1)

(b) An FRB source emits intense bursts of radio waves, each burst lasting for a fraction of a second. The closest FRB

source is in a massive spiral galaxy 4.60×10^{24} m from the Earth.

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A detector of area $1.00 \times 10^{-4} \text{ m}^2$ on the surface of the Earth received bursts of radio waves. In one burst, $9.40 \times 10^{-23} \text{ J}$ of energy was received in a time of 1.15 ms.

(i) Show that the luminosity of the source is about $2 \times 10^{35} \text{ W}$.

(4)

(ii) When FRB sources were first discovered, some observers suggested that the bursts might be alien communications.

Suggest why this is unlikely.

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luminosity of the Sun = $3.8 \times 10^{26} \text{ W}$

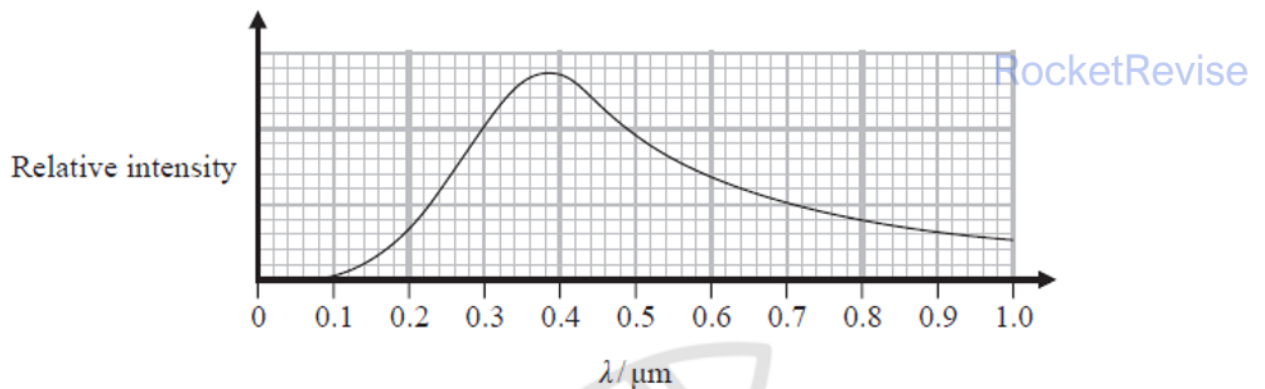
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(Total for question = 7 marks)

Q9.

A graph of relative intensity against wavelength for a star is shown.



(a) Determine the surface temperature of the star.

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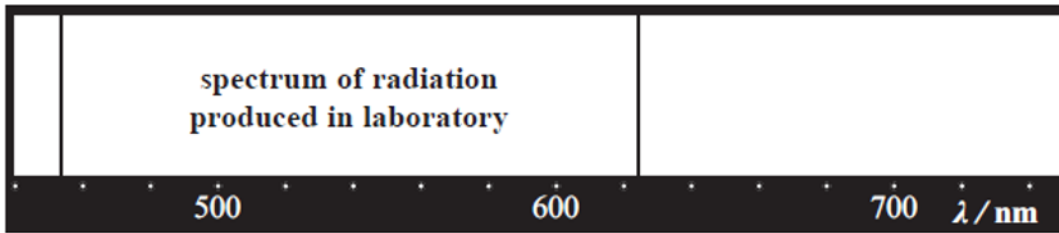
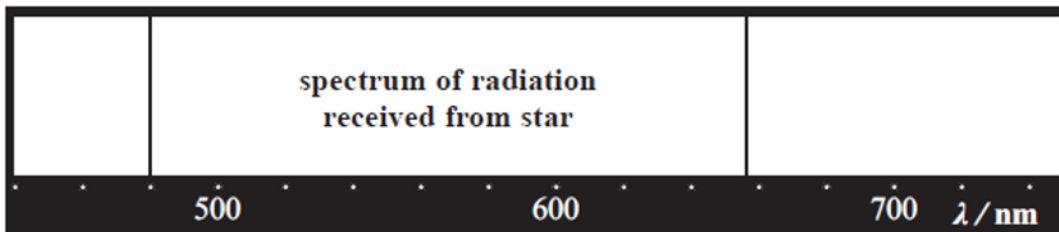
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Surface temperature of star =

(b) Radiation from the star is analysed. The radiation from the star has spectral lines at different wavelengths from the same spectral lines produced by a source in the laboratory, as shown.



Explain what can be concluded about the star from these results.
Your answer should include a calculation.

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(Total for question = 8 marks)

Q10.

The Sun is a main sequence star.



(a) State what is meant by a main sequence star.

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(b) The Sun will eventually leave the main sequence and become a red giant star.

luminosity of Sun = 3.83×10^{26} W

(i) Show that the current radius of the Sun is about 7.0×10^8 m.

surface temperature of Sun = 5780 K

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(ii) As a red giant star, the radius of the Sun will be about 150 times its current radius. Its luminosity will be about 1600 times its current luminosity.

λ_{max} is the wavelength at which peak power radiation occurs.

Show that when the Sun is in its red giant stage, λ_{max} is about 1×10^{-6} m.

current radius of Sun = 7.0×10^8 m

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(iii) At this stage of its evolution the Sun will be classified as a red giant star.

The wavelength of red light is between 6.2×10^{-7} m and 7.8×10^{-7} m.

Comment on the value for λ_{max} and this classification of the Sun.



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(c) As the Sun continues its evolution, its mass will decrease. It is estimated that at its largest radius, the mass of the Sun will have decreased significantly. RocketRevise

Explain how the orbital period of a planet would change as the mass of the Sun decreases.

Assume that the radius of the planet's orbit about the Sun does not change.

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(Total for question = 12 marks)

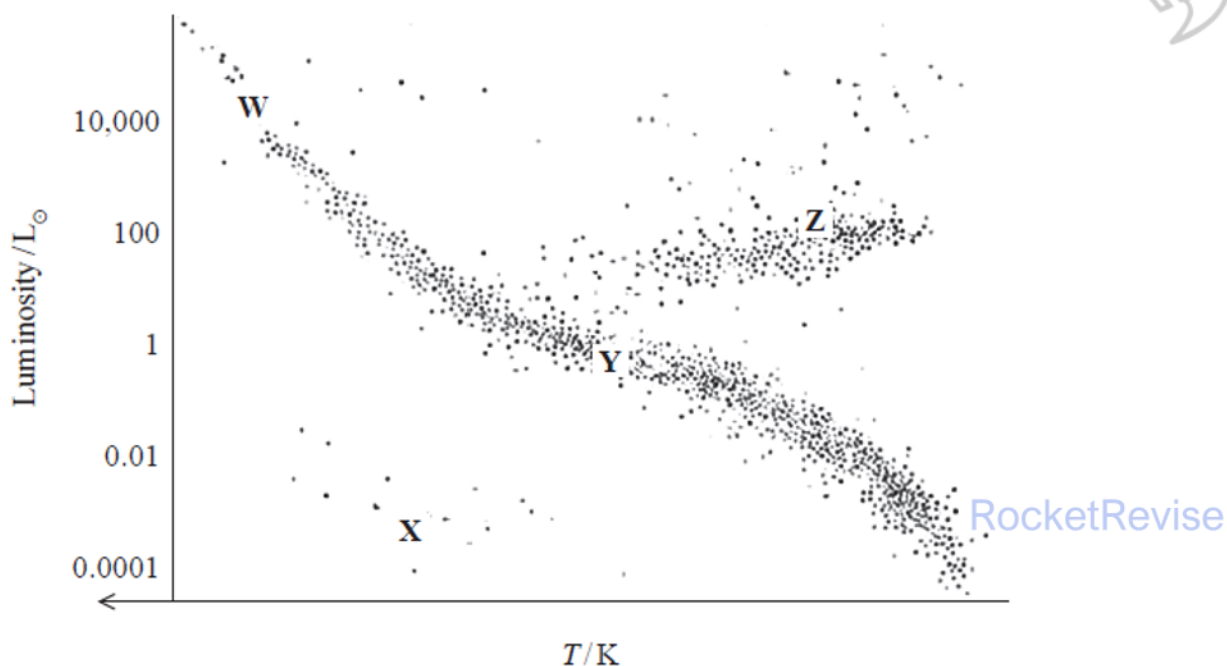
Q11.

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 ☐.

This question relates to the Hertzsprung-Russell diagram shown below.



The letters W, X, Y and Z represent stars at these positions on the diagram.



Which of the following is part of a possible evolutionary path of a star?

- ☐ **A** W → Y
- ☐ **B** X → Y
- ☐ **C** Y → W
- ☐ **D** Y → Z



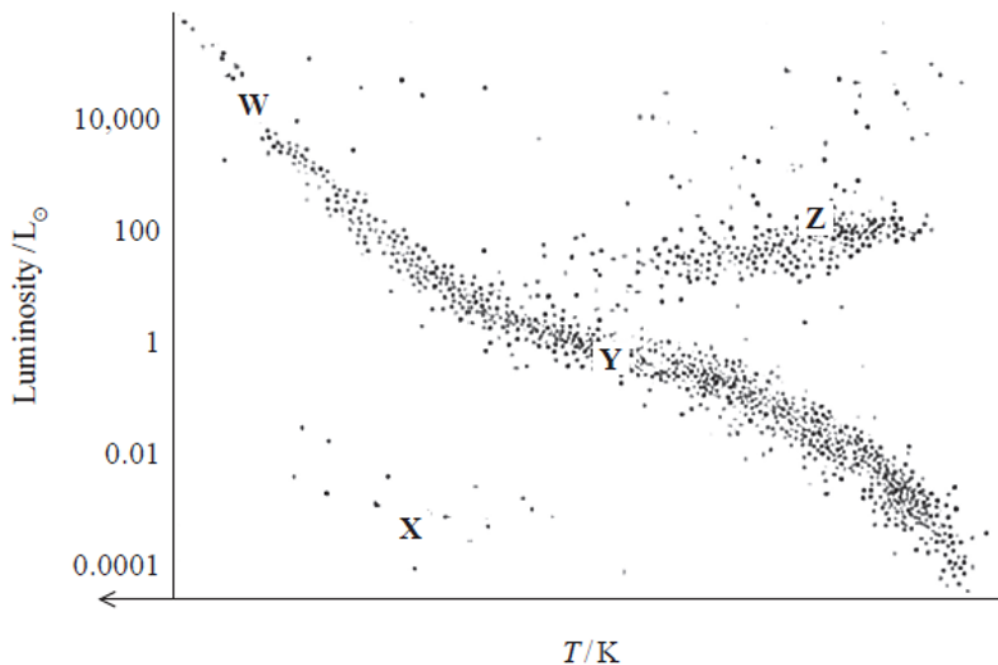
(Total for question = 1 mark)

Q12.

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 ☐.

This question relates to the Hertzsprung-Russell diagram shown below.

The letters W, X, Y and Z represent stars at these positions on the diagram.



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Which of the following statements about stars in positions W, X, Y and Z is correct?

- ☐ **A** W and Y have the same mass.
- ☐ **B** W has a lower surface temperature than Z.
- ☐ **C** Y is more massive than W.
- ☐ **D** Y has a lower surface temperature than X.

(Total for question = 1 mark)

Q13.

The star Vega has a luminosity 5 times the luminosity of the star Altair. The distance of Vega from the Earth is 1.5 times the distance of Altair from the Earth.

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The intensity of radiation received on Earth from Vega is I_V .
The intensity of radiation received on Earth from Altair is I_A .

The ratio I_V / I_A is about

- ☐ **A** 0.5
- ☐ **B** 1.5
- ☐ **C** 2
- ☐ **D** 5



(Total for question = 1 mark)

Q14.

Two stars, X and Y, have the same surface temperature. X has a radius 25% larger than the radius of Y.

The luminosity of X is L_X . The luminosity of Y is L_Y .

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Which of the following is the ratio L_X / L_Y ?

- ☐ **A** 1.0
- ☐ **B** 1.3
- ☐ **C** 1.6
- ☐ **D** 2.0



(Total for question = 1 mark)

Q15.

Scientists believe that some of the mass of our universe consists of "dark matter".

Which of the following is true of dark matter?

- ☐ **A** It absorbs all electromagnetic radiation.
- ☐ **B** It emits no electromagnetic radiation.
- ☐ **C** It exerts no gravitational force.
- ☐ **D** It is a form of anti-matter.

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(Total for question = 1 mark)



Q16.

A metal bar is heated, then allowed to cool. The wavelength λ_{max} at which peak radiation emission occurs is determined.

Which of the following statements is correct?

- ☐ **A** λ_{max} decreases as the metal bar cools.
- ☐ **B** λ_{max} increases as the metal bar cools.
- ☐ **C** λ_{max} increases as the metal bar is heated.
- ☐ **D** λ_{max} stays constant as the metal bar is heated.

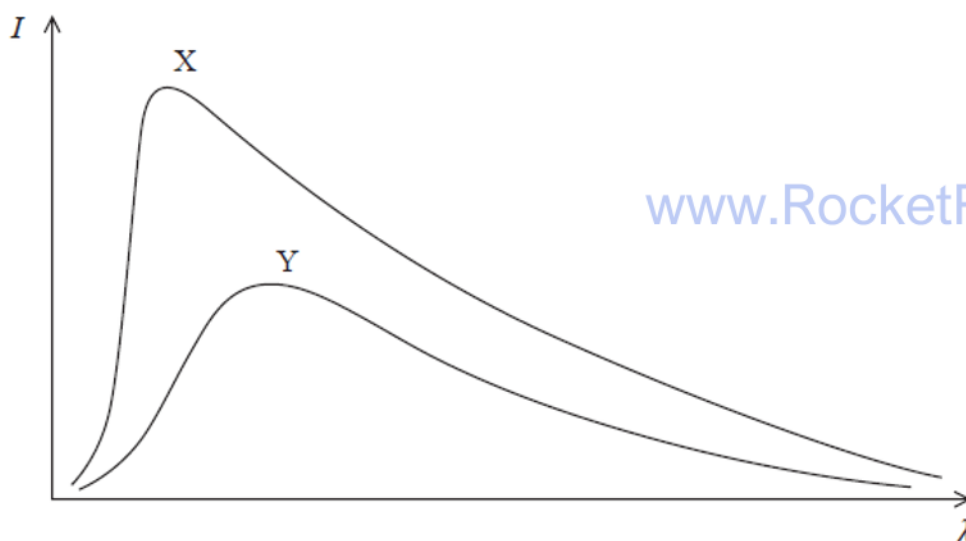
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(Total for question = 1 mark)

Q17.

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 ☐.

Two stars, X and Y, behave as black body radiators. The graphs show how the intensity I of radiation emitted varies with wavelength λ for the two stars.



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The stars are both viewed from the same distance.

Which of the following statements can be deduced from the two graphs?



- ☐ **A** Star X is brighter and has a higher surface temperature than star Y.
- ☐ **B** Star X is brighter and has a lower surface temperature than star Y.
- ☐ **C** Star X is dimmer and has a higher surface temperature than star Y.
- ☐ **D** Star X is dimmer and has a lower surface temperature than star Y.

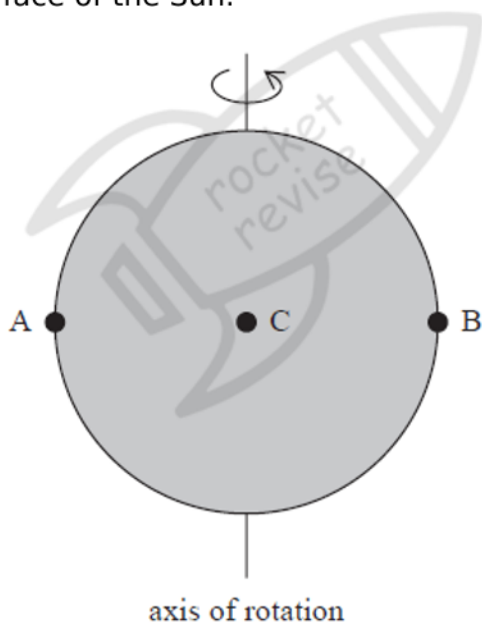
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Q18.

The diagram shows the Sun rotating about its axis as viewed from the Earth.

A, B and C are points on the surface of the Sun.



Light from points A, B and C is analysed. The wavelength λ_{α} of the alpha line in the hydrogen spectrum is determined for the light from each point.

(a) Complete the table with the letters A, B and C to indicate the point corresponding to each wavelength.

(1)



$\lambda_{\alpha} / \text{nm}$	Point
656.2837	
656.2797	
656.2757	

(b) Explain why there is a variation in the wavelength of the light from different points on the Sun.

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(c) In the laboratory, the wavelength of the alpha line in the hydrogen spectrum is 656.2797 nm.

Assess whether this is consistent with the Sun having a period of rotation approximately equal to 28 days.

radius of the Sun = $7.0 \times 10^8 \text{ m}$

1 day = 86 400 s

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(Total for question = 7 marks)



Q19.

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 ☐.

Two stars, P and Q, have approximately the same radius. The surface temperature of star P is twice the surface temperature of star Q.

Star P has a luminosity L_P and star Q has a luminosity L_Q .

The ratio $\frac{L_P}{L_Q}$ is approximately

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- ☐ **A** 2
- ☐ **B** 4
- ☐ **C** 8
- ☐ **D** 16

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

Q20.

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 ☐.

Tau Ceti is one of the closest stars to the Sun. Tau Ceti has a surface temperature of 5300 K and a luminosity of $0.55 L_{\text{Sun}}$, where L_{Sun} is the luminosity of the Sun.

Which of the following is the correct description of Tau Ceti?

- ☐ **A** main sequence star
- ☐ **B** red dwarf star
- ☐ **C** red giant star
- ☐ **D** white dwarf star

(Total for question = 1 mark)



Q21.

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 ☒.

The initial value determined by astronomers for the Hubble constant was smaller than the currently accepted value.

Which of the following statements is correct?

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- ☐ **A** The universe is bigger than astronomers initially thought.
- ☐ **B** The universe is not as old as astronomers initially thought.
- ☐ **C** The universe is older than astronomers initially thought.
- ☐ **D** The universe is smaller than astronomers initially thought.

(Total for question = 1 mark)

Q22.

Sirius is the brightest star in the night sky. The intensity of Sirius is measured to be $1.09 \times 10^{-7} \text{ W m}^{-2}$.

Calculate the distance of Sirius from the Earth.

luminosity of Sirius = $8.94 \times 10^{27} \text{ W}$

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Distance of Sirius from the Earth =



Q23.

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 ☐.

A graph of red shift against distance in metres was plotted for a range of nearby galaxies. The value of the gradient of the graph was 5.4×10^{-27}

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Which of the following expressions gives a value for the Hubble constant in s^{-1} ?

- ☒ A 5.4×10^{-27}
- ☐ B $\frac{3 \times 10^8}{5.4 \times 10^{-27}}$
- ☐ C $\frac{1}{3 \times 10^8 \times 5.4 \times 10^{-27}}$
- ☐ D $3 \times 10^8 \times 5.4 \times 10^{-27}$



(Total for question = 1 mark)

Q24.

Astronomers often use the unit megaparsec (Mpc) for astronomical distances. In a textbook a value for the Hubble constant is given as $72 \text{ km s}^{-1} \text{ Mpc}^{-1}$.

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(a)(i) Show that $72 \text{ km s}^{-1} \text{ Mpc}^{-1}$ is equivalent to a Hubble constant of about $2.3 \times 10^{-18} \text{ s}^{-1}$.

$$1 \text{ Mpc} = 3.09 \times 10^{22} \text{ m}$$

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(ii) Determine a value for the age of the universe in years.

$$1 \text{ year} = 3.16 \times 10^7 \text{ s}$$

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Age of universe = years

(b) In the 1950s, astronomers realised that they had made an error in their determination of distances to galaxies. Galaxies are twice as far away as astronomers had previously thought.

Explain how this changed the age of the universe as calculated by astronomers.

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(Total for question = 6 marks)

Q25.

The astronomer Hertzsprung used parallax to determine the distances to some of the variable stars known as Cepheids.

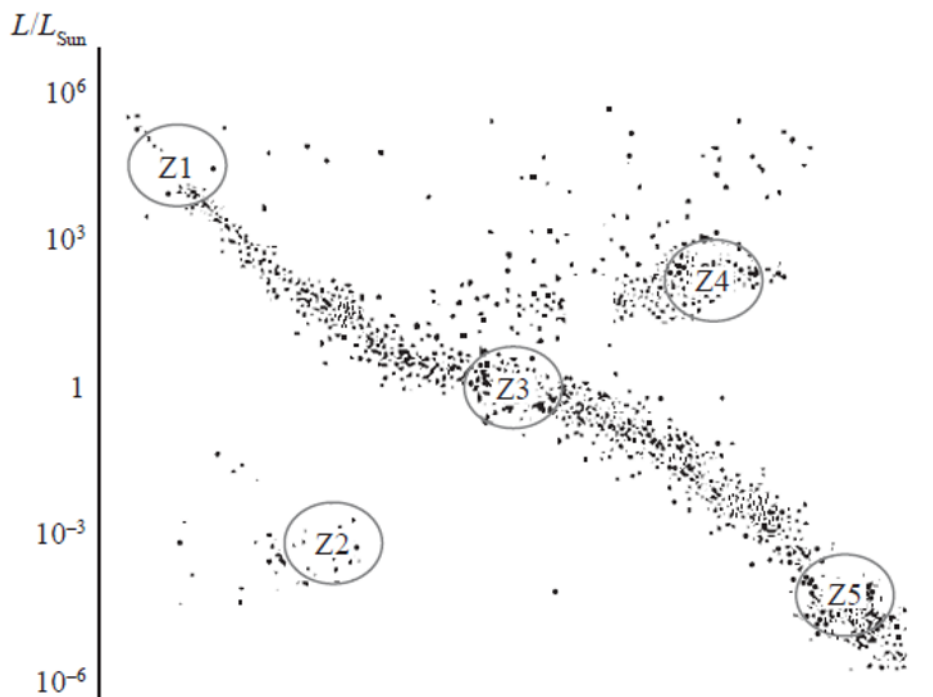
(a) Using parallax measurements, astronomers can determine distances to all stars with a parallax angle larger than 2.4×10^{-7} rad.

The variable star Alpha Cephei is 4.6×10^{17} m from the Earth.

Deduce whether the distance to Alpha Cephei could be determined from parallax measurements.

$$\text{distance from Earth to Sun} = 1.5 \times 10^{11} \text{ m}$$

(3)



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(i) Label the x-axis of the HR diagram. You should include approximate values.

(3)

(ii) There are five zones, Z1, Z2, Z3, Z4 and Z5, identified on the HR diagram.

Complete the following table. You should match one zone with each description.

(3)

Description	Zone
High mass hot stars	
Low mass cool stars	
Low mass hot stars	

*(iii) The position of a star on the HR diagram changes as the star evolves.

Explain how a star like the Sun evolves as it progresses from zone Z3 to its final position on the HR diagram.

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(Total for question = 18 marks)

The spectrum of light emitted by the star Chi Lupi provides evidence of mercury atoms in the outer layers of the star. The light emitted from the star is compared with light emitted from a mercury lamp on Earth.

Calculate the mean kinetic energy of the mercury atoms.

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(b) One line in the spectrum of light from Chi Lupi has a wavelength of 576.933 nm.

The equivalent line in a mercury spectrum produced on Earth is 576.959 nm.

A student concluded from this data that Chi Lupi is moving towards the Earth, and that the relative velocity of Chi Lupi is about 1400 m s^{-1} .

Deduce whether the student's conclusions are correct.

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(c) The surface temperature of Chi Lupi is twice the surface temperature of the Sun.

The radius of Chi Lupi is three times the radius of the Sun.

State where Chi Lupi would be located on the Hertzsprung-Russell diagram.

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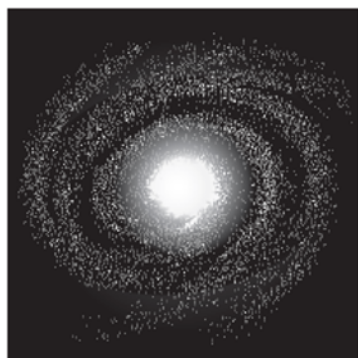
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(Total for question = 8 marks)

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Q27.

The image shown is a representation of our galaxy, the Milky Way.



(Source: © daulon/Shutterstock)

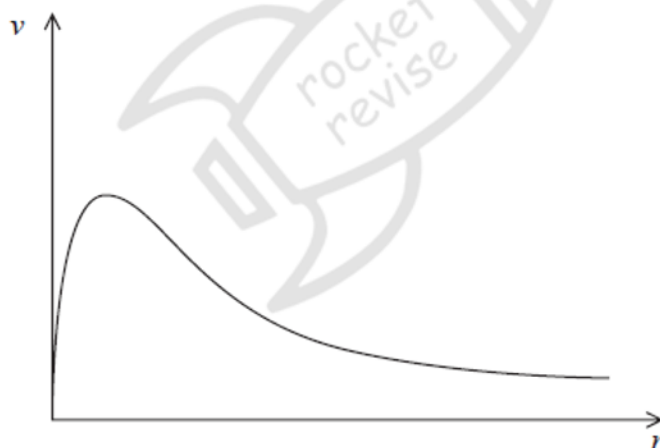
(a) Astronomers think that there is a very large concentration of stars in the central region of the galaxy. Outside this central region the concentration of stars is very much less. All stars in the galaxy are rotating about its centre.

It can be shown that the velocity v of a star a distance r from the centre of the galaxy is given by the expression

$$v = \sqrt{\frac{GM}{r}}$$

where M is the mass of the galaxy contained in a sphere of radius r .

(i) The graph shows how astronomers expect v to vary with r .

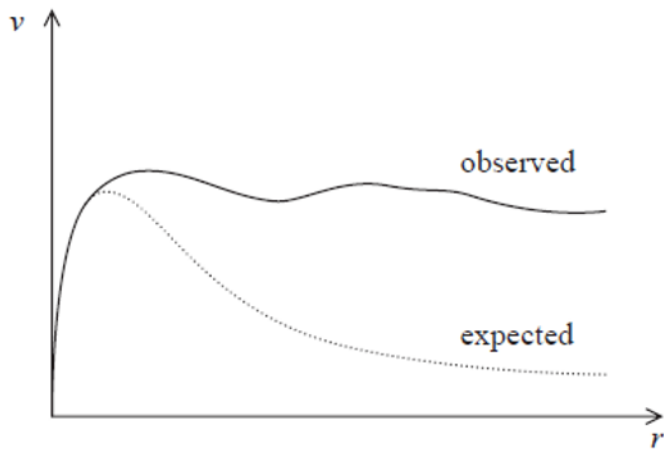


Explain how the expression gives the variation of v with r shown in the graph.

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(ii) The observed variation of v with r has been added to produce the graph below.



Suggest why the 'observed' velocity varies as shown.

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(b) The ultimate fate of the universe may be a closed universe, but astronomers cannot be sure what their current models predict.

Explain why astronomers cannot be sure that the universe is closed.

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(Total for question = 7 marks)

Q28.

Wolf 359 is a red dwarf star. The distance of the star from Earth was first determined from parallax measurements made by the astronomer Max Wolf.



(a)(i) The parallax angle was 2.01×10^{-6} rad.

Calculate the distance, in metres, of Wolf 359 from Earth.

mean distance from Earth to Sun = 1.50×10^{11} m

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Distance of Wolf 359 from Earth = m

(ii) Explain why parallax measurements can only be used to determine the distances to a relatively small number of stars.

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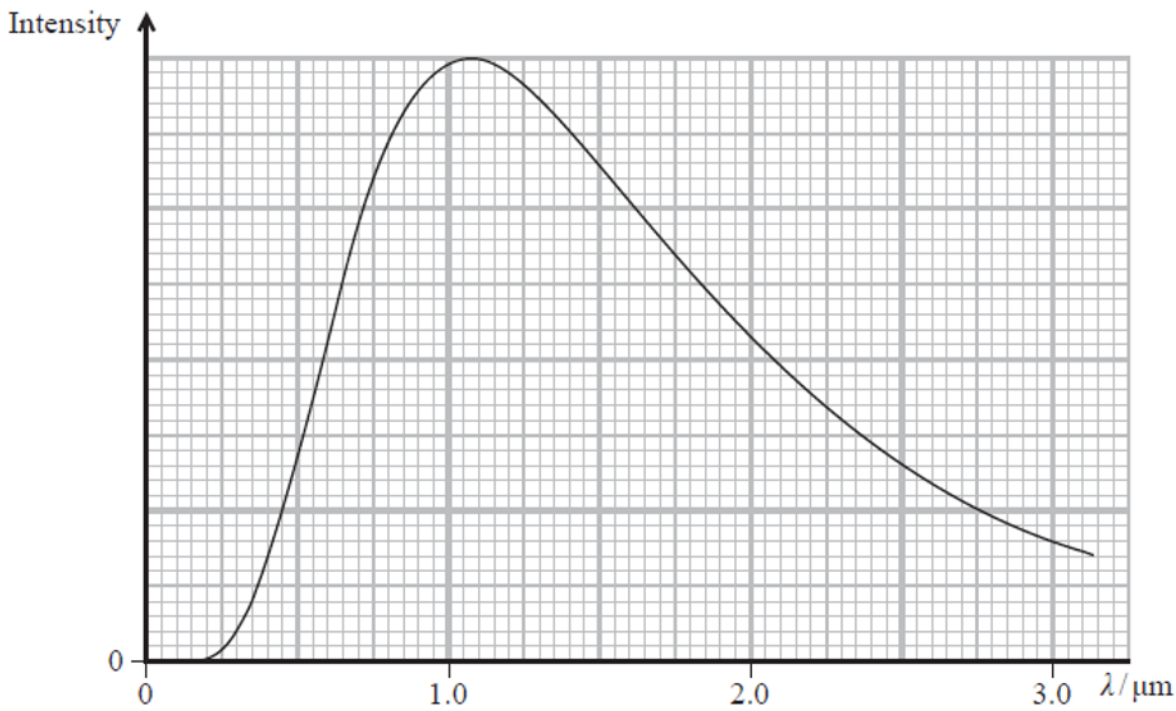
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(b) The graph shows how the intensity of radiation from the star Wolf 359 varies with wavelength.



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(i) Show that the surface temperature of Wolf 359 is about 2700 K.

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(ii) The radius of the Sun is R_{Sun} . The radius of Wolf 359 is $0.16 R_{\text{Sun}}$.

It is claimed that the luminosity of Wolf 359 is less than 0.1% of the luminosity of the Sun, L_{Sun} .

Deduce whether this claim is correct.

$$R_{\text{Sun}} = 6.96 \times 10^8 \text{ m}$$

$$L_{\text{Sun}} = 3.83 \times 10^{26} \text{ W}$$

$$T = 2700 \text{ K}$$

(3)

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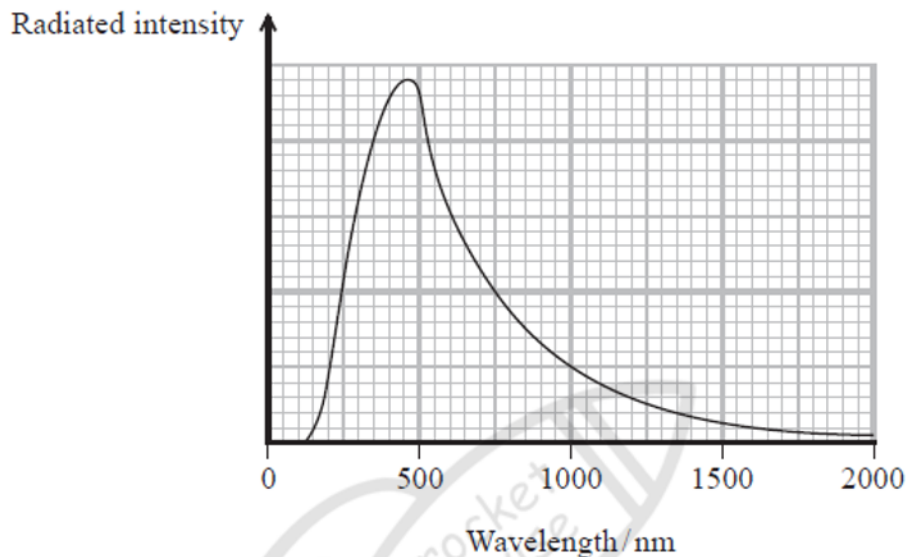
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Q29.

Procyon is the brightest star in the constellation Canis Minor. The graph shows how the radiated intensity from Procyon varies with wavelength.



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A website states that Procyon has twice the diameter of the Sun.

Assess the accuracy of this statement.

luminosity of Procyon = 2.65×10^{27} W

diameter of Sun = 6.96×10^8 m

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Q30.

A standard candle in the galaxy M81 has a luminosity 14 800 times the luminosity of the Sun. The intensity of radiation received from the standard candle, measured at the top of the Earth's atmosphere, is $3.64 \times 10^{-17} \text{ W m}^{-2}$.

$$L_{\text{Sun}} = 3.83 \times 10^{26} \text{ W}$$

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Distance of M81 from Earth =

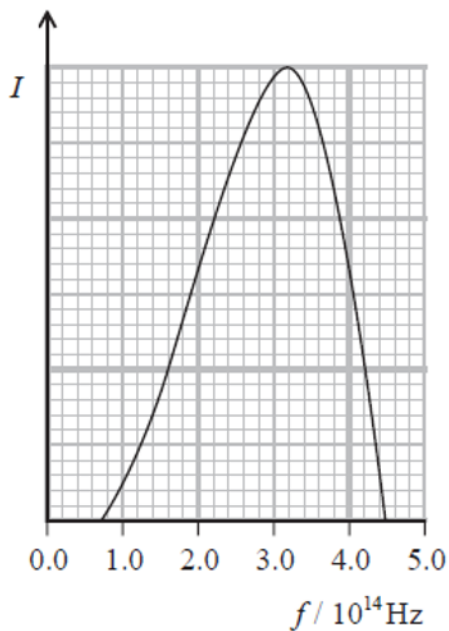
(Total for question = 3 marks)

Q31.

Gliese-876 is a main sequence star in the constellation Aquarius.

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The graph shows how the intensity I of radiation emitted from Gliese-876 depends upon frequency f .



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(a) Show that the surface temperature of Gliese-876 is about 3000 K.

(4)

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(b) As a red dwarf star, the luminosity of Gliese-876 should be less than 10% of the luminosity of the Sun.

Evaluate whether the surface temperature of Gliese-876 supports this statement.

radius of Gliese-876 = 2.62×10^8 m

luminosity of Sun = 3.83×10^{26} W

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(4)

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Q32.

* The average distance between galaxies is many times greater than the size of our galaxy. Astronomers use standard candles to determine the distances to other galaxies.

Describe how astronomers determine the luminosity of a standard candle and can use this to determine the distance to a nearby galaxy.

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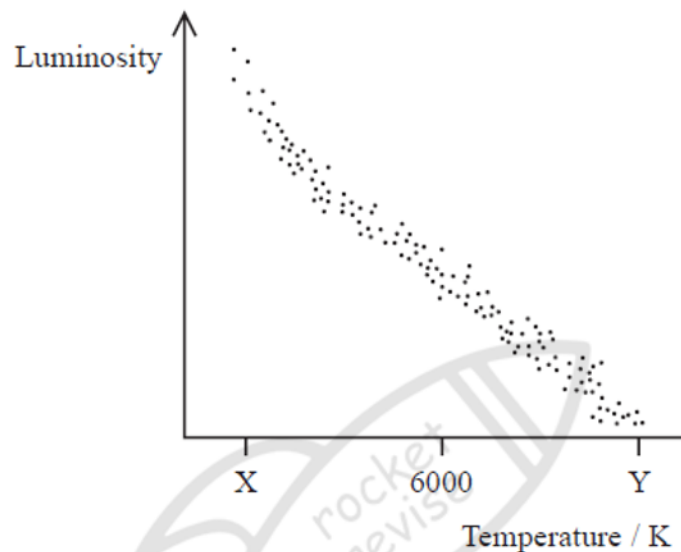
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Q33.

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 ☐.

The Hertzsprung-Russell diagram below has an incomplete temperature scale.



Which row of the table gives possible values for X and Y?

	X	Y
☐ A	3000	9000
☐ B	3000	12 000
☐ C	9000	3000
☐ D	12 000	3000

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(Total for question = 1 mark)

Q34.

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 ☐.



Which of the following does **not** have the base unit s^{-1} ?

- ☐ **A** angular velocity
- ☐ **B** frequency
- ☐ **C** redshift
- ☐ **D** rate of decay

(Total for question = 1 mark)

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Q35.

Select one answer from A to D and put a cross in the box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The spectrum of electromagnetic radiation from a galaxy is observed to have a redshift.

Which of the following is a correct statement about lines in this spectrum?

- ☐ **A** All the lines are in the red part of the spectrum.
- ☐ **B** All the lines are observed to have longer wavelengths than expected.
- ☐ **C** Lines with wavelengths at the red end of the spectrum are the most intense.
- ☐ **D** Light for all the lines was emitted with longer wavelengths than expected.

(Total for question = 1 mark)

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Q36.

Select one answer from A to D and put a cross in the box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Sirius and α -Centauri are two of our closest stars. Sirius has a luminosity about 16 times greater than the luminosity of α -Centauri. Sirius is twice as far away from the Earth as α -Centauri.



The intensity of light from Sirius is I_s and the intensity of light from α -Centauri is I_α .

Which of the following is the value of $\frac{I_s}{I_\alpha}$?

- ☐ A $\frac{1}{4}$
- ☐ B 4
- ☐ C 8
- ☐ D 16

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(Total for question = 1 mark)

Q37.

Select one answer from A to D and put a cross in the box ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

Current theory suggests that the universe is expanding.

Which of the following is evidence to support this theory?

- ☐ A All galaxies appear to be rotating in space.
- ☐ B Dark matter has been detected in the universe.
- ☐ C All distant stars are observed to be increasing in size.
- ☐ D The further a galaxy is from the Earth, the faster it recedes.

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(Total for question = 1 mark)

Q38.

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 ☒.

The luminosity axis of a Hertzsprung-Russell diagram has a logarithmic scale.

Which of the following is the reason for this?

- ☐ **A** Stars all have very large luminosities.
- ☐ **B** The range of luminosities of stars is very large.
- ☐ **C** The range of distances to stars is very large.
- ☐ **D** The temperature axis has a logarithmic scale.

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(Total for question = 1 mark)

Q39.

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 ☒.

Canopus and Sirius are two stars.

Radiation from Sirius has 3 times the intensity of radiation from Canopus.
The distance of Canopus from Earth is 36 times the distance of Sirius from Earth.

Canopus has a luminosity L_C and Sirius has a luminosity L_S .

Which of the following is equal to the ratio $\frac{L_C}{L_S}$?

- ☐ **A** $\frac{1}{3} \times \left(\frac{1}{36}\right)^2$
- ☐ **B** $3 \times \left(\frac{1}{36}\right)^2$
- ☐ **C** $\frac{1}{3} \times (36)^2$
- ☐ **D** $3 \times (36)^2$

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(Total for question = 1 mark)



Q40.

GN-z11 is one of the most distant observed galaxies in the universe. A red shift z of 10.96 has been detected by the Hubble Space Telescope (HST) for radiation from this galaxy.

(a) Radiation with a wavelength of 134 nm was emitted from GN-z11.

Calculate the wavelength λ_o of this radiation when it is detected at the HST.

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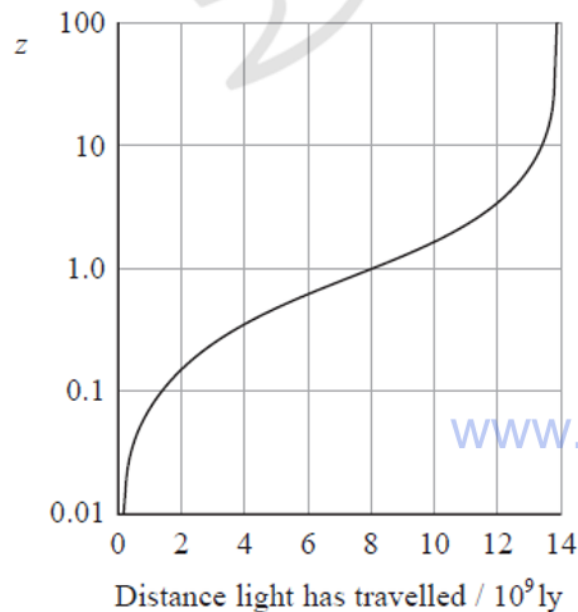
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$\lambda_o =$

(b) The graph shows how z , for light emitted from a galaxy, varies with the distance the light has travelled in reaching the Earth.

A light year (ly) is the distance travelled by light in 1 year.



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Determine the distance light from GN-z11 has travelled in reaching the Earth, in metres.

1 year = 3.15×10^7 s

(3)

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Distance the light has travelled = m

(c) The recently launched James Webb Space Telescope is designed to operate in the infrared region of the spectrum.

Explain why this will be helpful for studying very distant galaxies.

(2)

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(Total for question = 7 marks)

Q41.

A recent theory suggests that, during the Big Bang, an 'anti-universe' was created alongside our universe.

This theory suggests that dark matter is a new type of neutrino particle.

(a) Describe what is meant by dark matter.

(2)

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(b) The theory suggests that the mass of the new type of neutrino particle is $4.8 \times 10^{-31} \text{ kg}$.

Calculate the mass of this particle in GeV/c^2 .

(3)



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Mass of particle = kg

(c) The ultimate fate of our universe is uncertain.

Explain how the existence of dark matter contributes to this uncertainty.

RocketRevise
(2)

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(Total for question = 7 marks)

Q42.

The planet Kapteyn-b orbits Kapteyn's Star. Scientists think the conditions on Kapteyn-b could enable the long-term survival of humans.

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(a) The spectrum of radiation emitted by Kapteyn's Star has a peak of intensity at a wavelength λ_{max} of 8.12×10^{-7} m.

(i) Show that the surface temperature of Kapteyn's Star is about 3600 K.

(2)

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(ii) The distance from Kapteyn's Star to the planet Kapteyn-b is 2.55×10^{10} m.

The intensity I_E of light received at the Earth from the Sun is 1380 W m^{-2} .

Show that the intensity of radiation received at Kapteyn-b from Kapteyn's Star is about $0.4 I_E$.

radius of Kapteyn's Star = 2.03×10^8 m

(4)

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(b) Humans would not be able to survive on a planet with a gravitational field strength 4 times greater than the gravitational field strength at the surface of the Earth.

Deduce whether humans could survive the gravitational field strength at the surface of Kapteyn-b.

radius of Kapteyn-b = 1.02×10^7 m

density of Kapteyn-b = $6.44 \times 10^3 \text{ kg m}^{-3}$

(5)

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(4)

(1)



(b) Tycho Brahe was one of the first astronomers to observe a supernova. Supernovas are used as a type of standard candle.

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

(1)

(ii) Describe how standard candles can be used to determine the distance to nearby galaxies.

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(Total for question = 9 marks)

Q44.

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The following statement appears on a website:

Messier 87 (M87) is 55 million light-years from Earth.

The spectrum of light from M87 includes an absorption line at a wavelength of 394.5 nm. The same line produced by a source on Earth has a wavelength of 393.4 nm.

A light-year is the distance travelled in a year by light in a vacuum.

Assess the accuracy of the statement made on the website.

$$1 \text{ year} = 3.15 \times 10^7 \text{ s}$$



$$H_0 = 1.62 \times 10^{-18} \text{ s}^{-1}$$

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**(Total for question = 5 marks)**

Q45.

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 ☐.

A star is moving away from the Earth.

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The wavelengths of spectral lines in the light received from the star are measured. These wavelengths are not the same as the wavelengths of the same lines measured from a source in the laboratory.

Which of the following explains the difference in the wavelengths?

- ☐ **A** The star emits light with a shorter wavelength.
- ☐ **B** The star emits light with a longer wavelength.
- ☐ **C** The light arrives at the Earth with a shorter wavelength.
- ☐

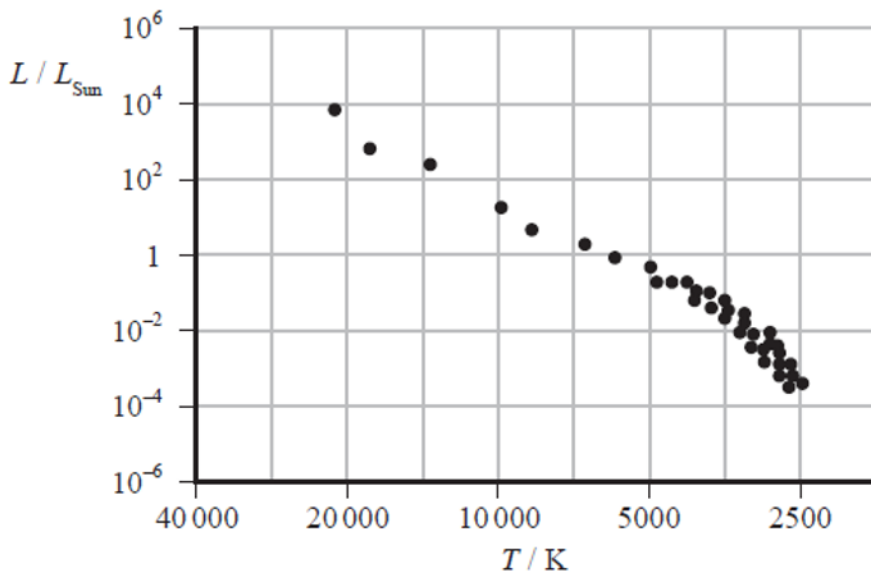
- (Total for question = 1 mark)**

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- (4)

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- (2)



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(iii) State what is meant by a main sequence star.

(1)

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(b) The final stage of evolution for a massive star may be a rotating neutron star.

One neutron star rotates with a period of 33.5 ms.

As this star rotates, one side of the star moves towards the Earth while the other side of the star moves away from the Earth. This causes a range of wavelengths to be received by an observer.

Ultraviolet radiation of wavelength 91.2 nm is emitted by the star.

Calculate the maximum and minimum wavelengths observed.

diameter of star = 20.5 km

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Maximum wavelength observed =

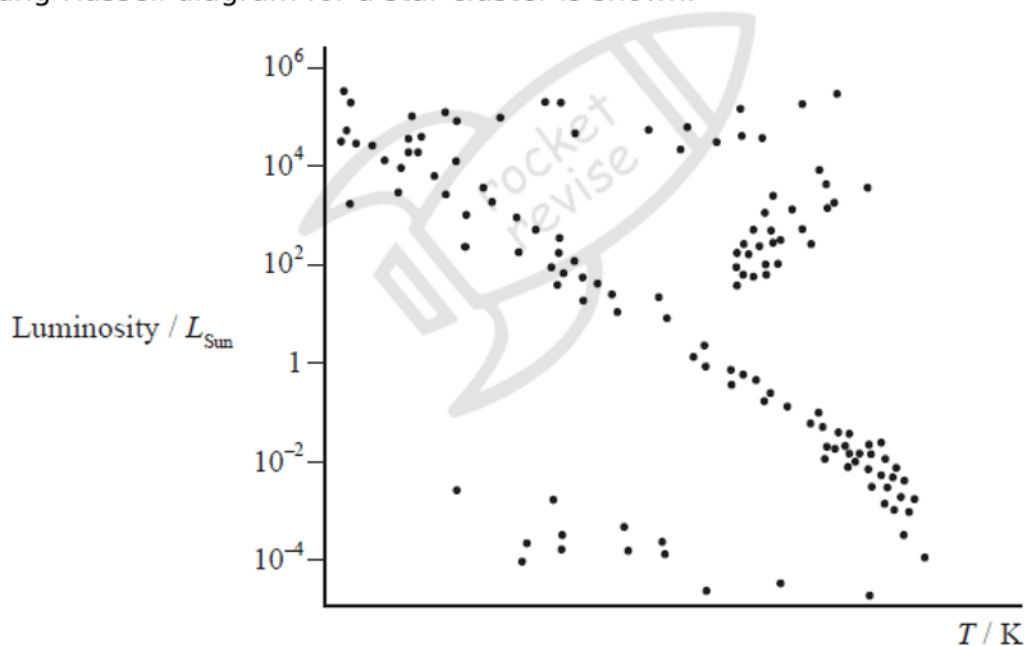
Minimum wavelength observed =

(Total for question = 13 marks)

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Q47.

The Hertzsprung-Russell diagram for a star cluster is shown.



(a) Add a scale to the horizontal axis.

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(b) Explain how this Hertzsprung-Russell diagram shows that the star cluster is not a young star cluster.

You should refer to groups of stars and their positions on this diagram.

(3)

(c) In the early 20th century, Edwin Hubble observed the Andromeda Nebula. He saw stars similar to the stars in our galaxy.

One star he saw was a standard candle known as V1.



Describe how measurements of this standard candle could demonstrate that the Andromeda Nebula is **not** a nearby star cluster.

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(Total for question = 9 marks)

Q48.

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 ☐.

A hydrogen source on Earth emits a spectral line with a wavelength of 410 nm.

An observer determines the wavelength of the same line in the spectrum of a star. The star is moving away from the Earth at 2.5% of the speed of light.

What is the wavelength of the line as determined by the observer?

- ☐ **A** 400 nm
- ☐ **B** 410 nm
- ☐ **C** 420 nm
- ☐ **D** 430 nm



(Total for question = 1 mark)

Q49.

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 ☐.

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The distances to stars can be determined using trigonometric parallax.

Star X has twice the parallax angle of Star Y.

Which of the following statements is correct?

- ☐ **A** The distance of Star X from Earth is twice the distance of Star Y from Earth.
- ☐ **B** The distance of Star X from Earth is four times the distance of Star Y from Earth.
- ☐ **C** The distance of Star Y from Earth is twice the distance of Star X from Earth.
- ☐ **D** The distance of Star Y from Earth is four times the distance of Star X from Earth.

(Total for question = 1 mark)

Q50.

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 ☐.

Measurements related to a distant galaxy may be used to determine the value of the Hubble constant.

Which two measurements related to a distant galaxy must be used?

- ☐ **A** distance from the Earth and mass
- ☐ **B** distance from the Earth and recession velocity
- ☐ **C** luminosity and mass



- ☐ **D** luminosity and recession velocity

(Total for question = 1 mark)

Q51.

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 ☐.

The ultimate fate of the universe is uncertain.

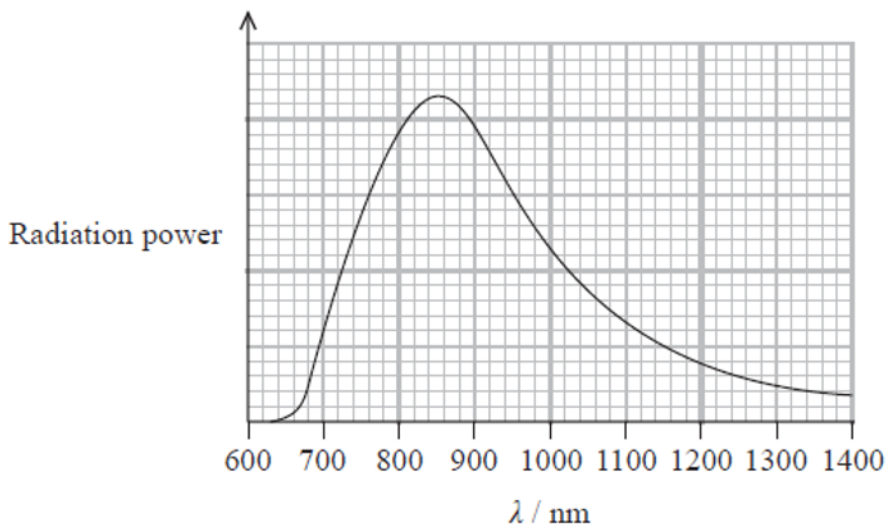
Which of the following would result in an open universe?

- ☐ **A** The average density of the universe is equal to the critical density of the universe.
- ☐ **B** The average density of the universe is less than the critical density of the universe.
- ☐ **C** The mass of the universe is equal to the critical mass of the universe.
- ☐ **D** The mass of the universe is greater than the critical mass of the universe.

(Total for question = 1 mark)

Q52.

Ross-154 is one of the closest stars to the Sun. The graph shows how the power radiated from Ross-154 depends upon wavelength λ .



(a) (i) Show that the surface temperature of Ross-154 is about 3000 K.

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(3)

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(ii) A website states that the luminosity of Ross-154 is less than 0.5% of the luminosity of the Sun, L_{Sun} .

Evaluate whether this statement is correct.

$$\text{radius of Ross-154} = 1.18 \times 10^8 \text{ m}$$

$$L_{\text{Sun}} = 3.83 \times 10^{26} \text{ W}$$

(5)

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(b) Scientists have observed an Earth-type planet in orbit around Ross-154. The radius of the orbit is 0.096 AU.

Calculate the time for this planet to make one orbit of Ross-154.

$$1 \text{ AU} = 1.50 \times 10^{11} \text{ m}$$

$$\text{mass of Ross-154} = 3.38 \times 10^{29} \text{ kg}$$

(3)

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Time for one orbit =

(Total for question = 11 marks)

Q53.

At the beginning of the 20th century, astronomers identified that a number of galaxies were moving away from the Earth.

(a) State how astronomers knew that galaxies were moving away from the Earth.

(1)

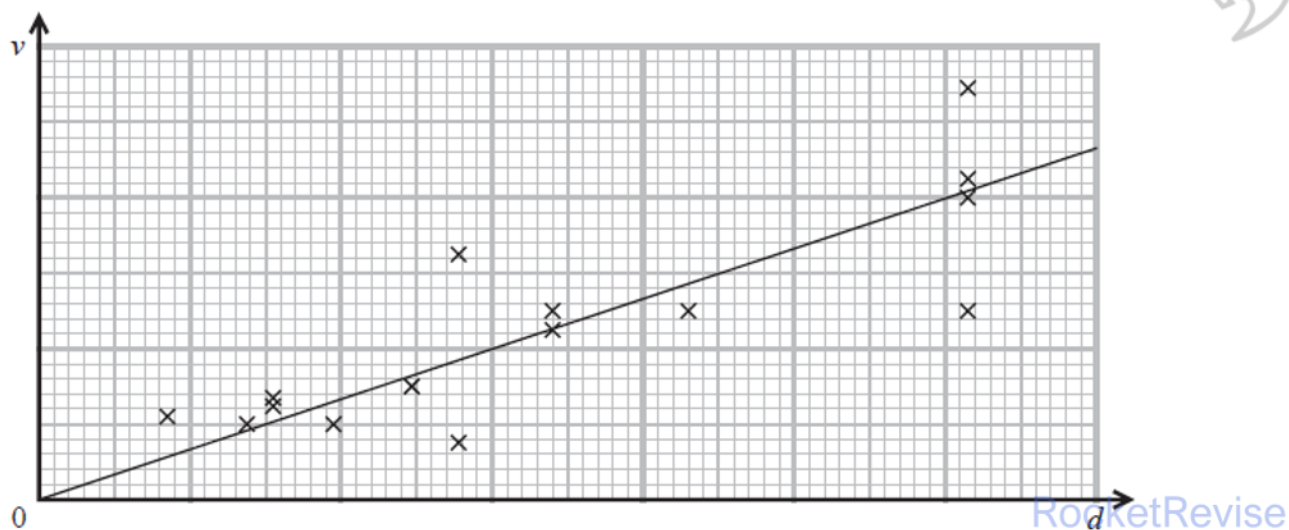
(b) Hubble suggested that the recessional velocity v of a galaxy was related to the distance d of the galaxy from the Earth by the expression

$$v = H_0 d$$

where H_0 is a constant.



The graph shows some of Hubble's data.



Assess the validity of Hubble's expression based on the data shown.

(3)

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(Total for question = 4 marks)

Q54.

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 ☒.

Astronomers use stellar parallax to determine the distances to nearby stars.

Which of the following must be known to use stellar parallax?

- ☒ **A** distance between the Earth and the Sun
- ☒ **B** intensity of radiation received from the star



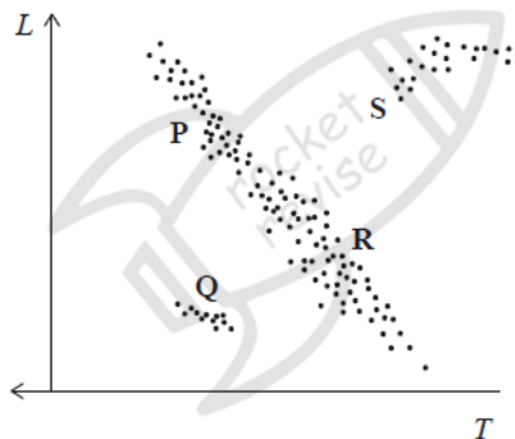
- ☐ **C** luminosity of the Sun
- ☐ **D** value of the Hubble constant

(Total for question = 1 mark)

Q55.

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 ☐.

The Hertzsprung-Russell diagram shows four areas **P**, **Q**, **R** and **S**, where different types of stars are located.



Which of the following is a possible evolutionary path for stars initially in area **P**?

- ☐ **A** $P \rightarrow Q \rightarrow S$
- ☐ **B** $P \rightarrow S \rightarrow Q$
- ☐ **C** $P \rightarrow R \rightarrow S$
- ☐ **D** $P \rightarrow S \rightarrow R$

(Total for question = 1 mark)

Q56.

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 ☐.

The Hertzsprung-Russell diagrams W, X, Y and Z below show a star cluster at various times when the star cluster is in different stages of evolution.

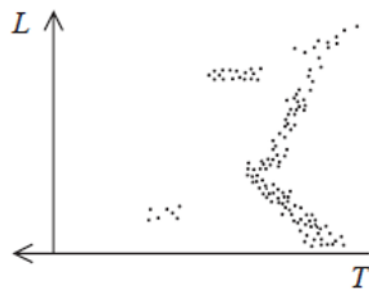


Diagram W

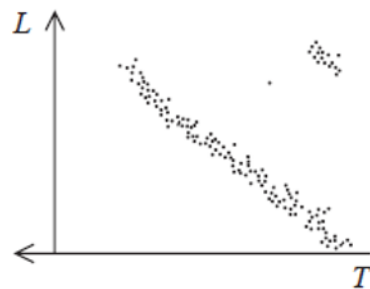


Diagram X

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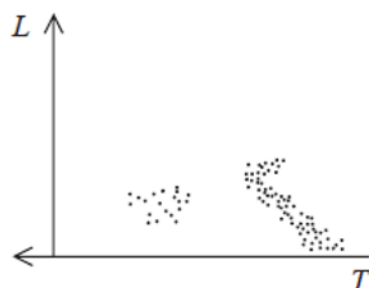


Diagram Y

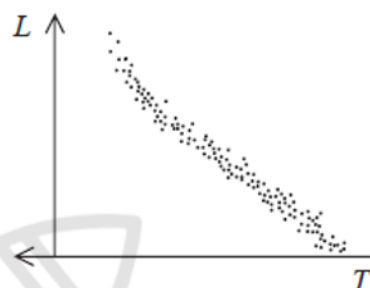


Diagram Z

Which of the diagrams represents the cluster in the final stage of evolution?

- ☒ **A** W, as there are white dwarf stars and red giants in the cluster.
- ☒ **B** X, as there are red giants and no white dwarf stars in the cluster.
- ☒ **C** Y, as there are white dwarf stars but no red giants in the cluster.
- ☒ **D** Z, as all the stars in the cluster are in the main sequence.

(Total for question = 1 mark)

Q57.

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 ☐.

Absorption lines in the spectrum of light from a star are shifted to higher frequencies than the same lines viewed from a source on Earth.



Which of the following can be concluded from this?

- ☐ **A** The star is accelerating away from the Earth.
- ☐ **B** The star is accelerating towards the Earth.
- ☐ **C** The star is moving away from the Earth.
- ☐ **D** The star is moving towards the Earth.

(Total for question = 1 mark)

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