Astrophysics - Questions by Topic

Q1.

Scientists believe that the universe is expanding and that there is a critical density ρ_c which will determine the ultimate fate of the universe.

Choose the row of the table that correctly identifies the ultimate fate of the universe for different average densities.

	Average density of the universe > ρ_c	Average density of the universe = ρ_c
☐ **A**	closed	flat
☐ **B**	flat	closed
☐ **C**	closed	open
☐ **D**	open	flat

(Total for question = 1 mark)

Q2.

At the top of the Earth's atmosphere the measured radiation flux of the Sun is 1.36 kW m^{-2}.

(a) (i) Show that the luminosity of the Sun is about 4×10^{26} W.

distance from Earth to the Sun = 1.50×10^{8} km

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(ii) The luminosity of a star depends on its surface area and temperature.

Calculate the radius of a star that has a surface temperature of 4000 K and luminosity 100 times that of the Sun.

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Radius of star = ...

(b) B030D is a supergiant star in the Andromeda galaxy. Through a telescope this star is observed to be a yellow star.

(i) When the spectrum of light from B030D is analysed a line, identified as the hydrogen α line, occurs at a wavelength 654.58 nm. The wavelength of this line in the laboratory is 656.29 nm.

State what conclusion can be made about B030D from this data. Your answer should include a calculation.

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(ii) A student states that blue stars are cooler than yellow stars. Use Wien's law to comment on the accuracy of this statement.

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(Total for question = 9 marks)

Q3.

When compared to the Sun, red giant stars are

☐ **A** cooler and brighter.

☐ **B** cooler and dimmer.

☐ **C** hotter and brighter.

☐ **D** hotter and dimmer.

(Total for question = 1 mark)

Q4.

The properties of a young group of stars are compared with those of an old group of stars. Both groups contain a similar number of stars.

In the young group there will be more

☐ **A** high mass main sequence stars.

☐ **B** low mass main sequence stars.

☐ **C** red giant stars.

☐ **D** white dwarf stars.

(Total for question = 1 mark)

Q5.

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 standard candle is a stellar object of known

☐ **A** distance.

☐ **B** luminosity.

☐ **C** radiation flux.

☐ **D** surface temperature.

(Total for question = 1 mark)

Q6.

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 Hubble constant has been determined to be 2.2×10^{-18} s^{-1}, although there is a large uncertainty in this value. Astronomers have used this value to calculate the age of the universe.

Previous data gave a value for the Hubble constant of 2.0×10^{-18} s^{-1}.
The age of the universe calculated from this value would be

☐ **A** 20% smaller.

☐ **B** 10% smaller.

☐ **C** 10% bigger.

☐ **D** 20% bigger.

(Total for question = 1 mark)

Q7.

In an incandescent light bulb a metal filament is heated to a high temperature by passing an electric current through it until the filament glows. The wavelength λ_{max} at which peak energy emission occurs and the rate at which radiation energy is emitted *P* both depend upon the filament temperature.

What happens to λ_{max} and *P* when the current through the filament is increased?

☐ **A** λ_{max} and *P* both decrease

☐ **B** λ_{max} and *P* both increase

☐ **C** λ_{max} decreases and *P* increases

☐ **D** λ_{max} increases and *P* decreases

(Total for question = 1 mark)

Q8.

Scientists believe that a significant proportion of the universe consists of dark matter.

Dark matter is

☐ **A** antimatter.

☐ **B** black dwarf stars.

☐ **C** undetectable.

☐ **D** invisible.

(Total for question = 1 mark)

Q9.

A Hertzsprung-Russell (H-R) diagram is a plot of luminosity against temperature for a range of stars. One group on the H-R diagram is the main sequence.

Select the row of the table that could describe a main sequence star.

	Temperature	Luminosity	Mass
☒ **A**	low	low	low
☒ **B**	low	high	high
☒ **C**	high	low	high
☒ **D**	high	high	low

(Total for question = 1 mark)

Q10.

A series of observations are made of nearby stars over a number of years. The stars are seen to undergo a very small oscillatory motion, appearing to "wobble" against the background of more distant stars.

Describe how astronomers use this "wobble" to calculate the distance to a nearby star.

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(Total for question = 3 marks)

Q11.

The distances to two stars are being determined using trigonometric parallax.
The radiation flux from star P is greater than that from star Q, and the parallax angle for star P is greater than that of star Q.

Which of the following is a correct deduction about the stars?

☐ **A** Star P has a greater luminosity than star Q.

☐ **B** Star P has the same luminosity as star Q.

☐ **C** Star P is closer than star Q.

☐ **D** Star P is the same distance from the Earth as star Q.

(Total for question = 1 mark)

Q12.

In the early 20th century Edwin Hubble carried out research on objects known as extra–galactic nebulae. The light spectra emitted by these nebulae were found to be shifted from the wavelengths measured for corresponding sources in the laboratory. We now recognise that these nebulae are galaxies and that the wavelength shifts are evidence for an expanding universe.

(a) Hubble used standard candles to determine the distances to these nebulae.

(i) Explain how a standard candle can be used to determine distance.

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(ii) Suggest why some standard candles can only be used to determine distances to relatively close galaxies.

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*(b) Once the distances to the nebulae had been determined, Hubble used the values of the wavelength shifts to conclude that there was a roughly linear relationship between velocities and distances for these nebulae.

Describe how Hubble was able to determine the velocities of the nebulae and explain how his conclusion provides evidence for an expanding universe.

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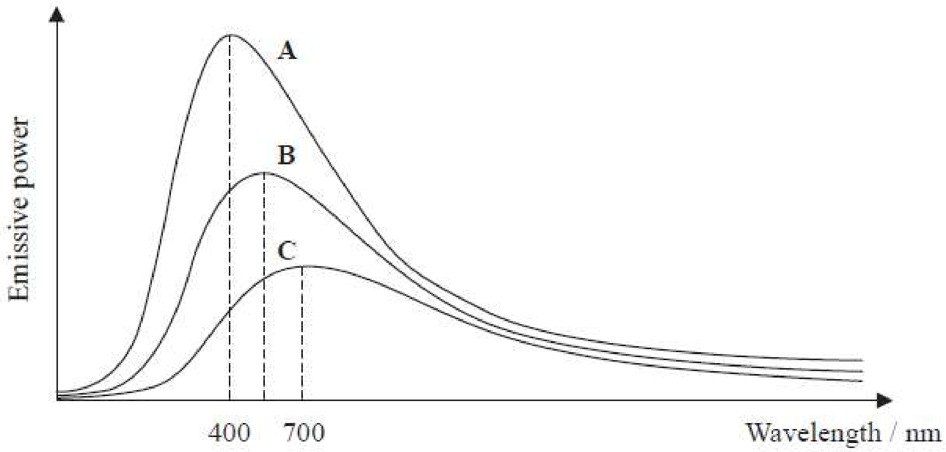
(Total for question = 8 marks)

Q13.

Curves A, B and C show the radiation spectra of stars with three different surface temperatures.



(a) (i) Curve B represents radiation from the Sun. State what evidence from the graphs suggests that this might be so.

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(ii) State with a reason which curve represents a star with a greater surface temperature than the Sun.

(1)

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(iii) Use the graphs to explain how the radiation from the star identified in (ii) differs from the radiation from the Sun.

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(b) Stars other than the Sun are too far away from the Earth for us to make a direct measurement of their diameter.
Explain how we can deduce that some are giant stars and some are dwarf stars.

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(c) For stars which are relatively close to the Earth, describe how parallax measurements can be used to determine their distances from the Earth.

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(Total for question = 11 marks)

Q14.

Observations of supernovae were made in the 1990s by the Hubble Space Telescope. Measurements taken from these observations gave a value for the Hubble constant of $2.365 \times 10^{-18}\ s^{-1}$.

In 2013, data from the Planck satellite gave a value for the Hubble constant of $2.171 \times 10^{-18}\ s^{-1}$.

(a) State, with a reason, a conclusion about the age of the universe that can be drawn from the change in the value of the Hubble constant.

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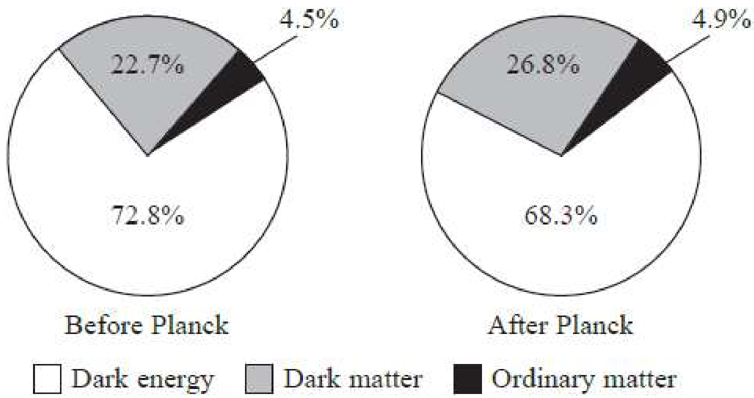
(b) The universe is believed to consist of dark energy, dark matter and ordinary matter.

The relative amounts of dark energy, dark matter and ordinary matter believed to exist in the universe have changed as a result of data from the Planck satellite.



(i) Explain what is meant by dark matter.

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(ii) Suggest how data from the Planck satellite, concerning dark matter, might change our ideas on the future of the universe.

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(Total for question = 6 marks)

Q15.

(a) Stars are formed from gas clouds within galaxies. As the gas cloud contracts, an extremely dense core at a very high temperature is formed. Within the core the hydrogen begins to fuse into helium.

(i) Explain why the core must be extremely dense and at a very high temperature for fusion to take place.

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(ii) As the gas cloud contracts the internal energy of the system increases.

Explain how energy conservation applies to the system during this period of contraction.

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(iii) Explain how the fusion of hydrogen into helium in the core enables large amounts of energy to be released.

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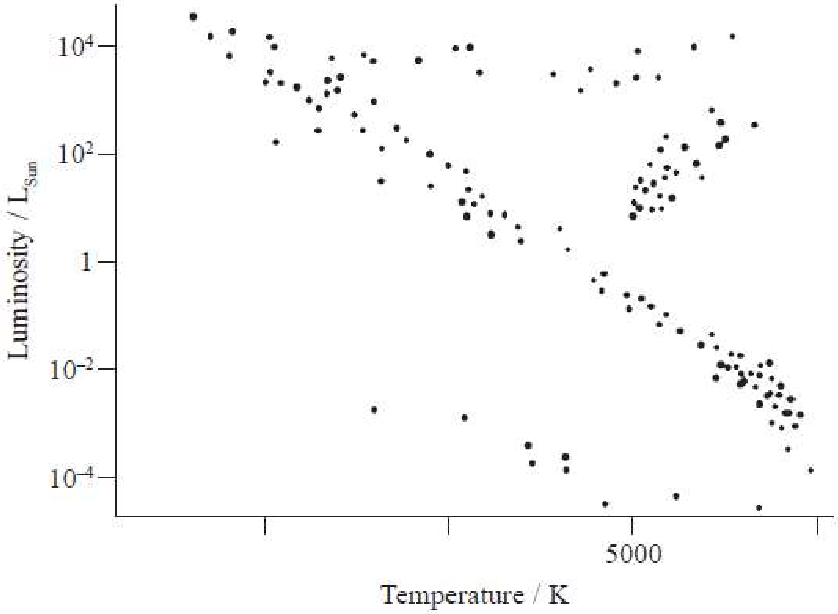
(b) The Hertzsprung-Russell diagram is used by astronomers to show the relationship between luminosity and temperature for stars.

(i) Complete the temperature scale on the Hertzsprung-Russell diagram.

(2)



(ii) The table shows the luminosity and temperature of a range of stars.

Star	Luminosity / L_{Sun}	Temperature / K	Star type
A	0.001	8 000	
B	0.1	4 400	main sequence
C	160	3 600	red giant
D	160	13 600	

Complete the table.

(2)

(iii) On the Hertzsprung-Russell diagram indicate where each of the stars A, B, C, and D is located.

(2)

(c) Polaris is the nearest variable star to the Earth and is an example of a standard candle.

(i) State what astronomers mean by a standard candle.

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*(ii) Recent measurements indicate that Polaris may be significantly closer to the Earth than previously thought.

Explain why this would have a significant impact on our estimation of the age of the universe.

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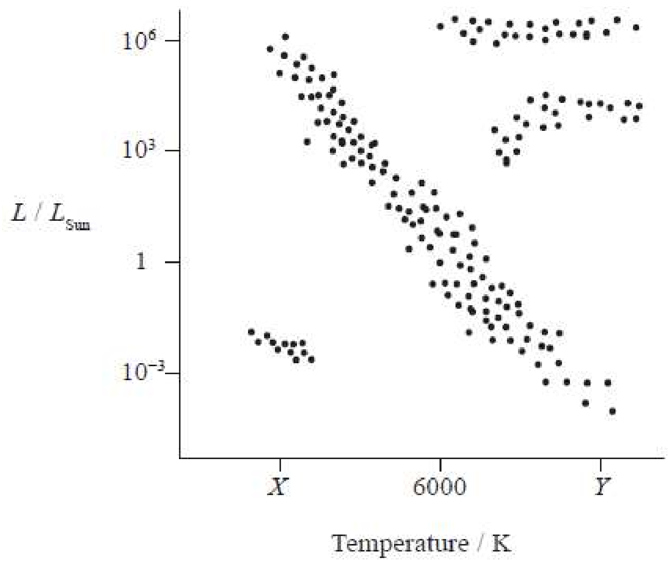
(Total for question = 18 marks)

Q16.

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 (☒). If you change your mind about an answer, put a line through the box and then mark your new answer with a cross (☒).

On the Hertzsprung-Russell diagram shown, the temperature scale is incomplete.



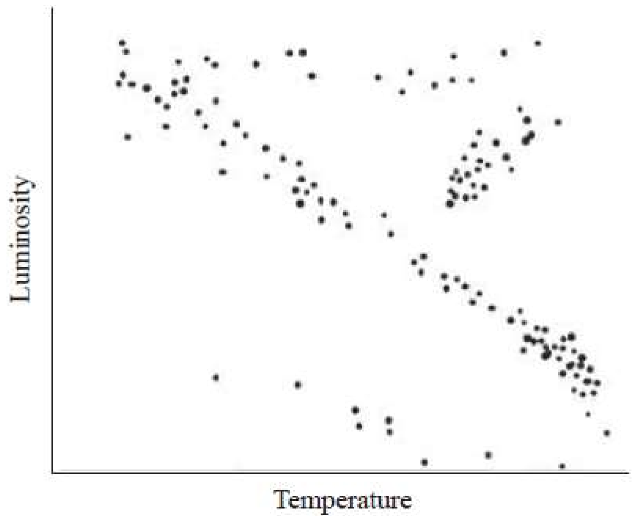
Select the row in the table with possible values for *X* and *Y*.

	X / K	*Y* / K
☐ **A**	2000	10 000
☐ **B**	3000	12 000
☐ **C**	12 000	3000
☐ **D**	10 000	2000

(Total for question = 1 mark)

Q17.

The Hertzsprung-Russell diagram is a scatter graph of luminosity against temperature for stars.



A star is located near to the top end of the main sequence.

Select the row in the table that correctly compares the mass and temperature of the star to those of the Sun.

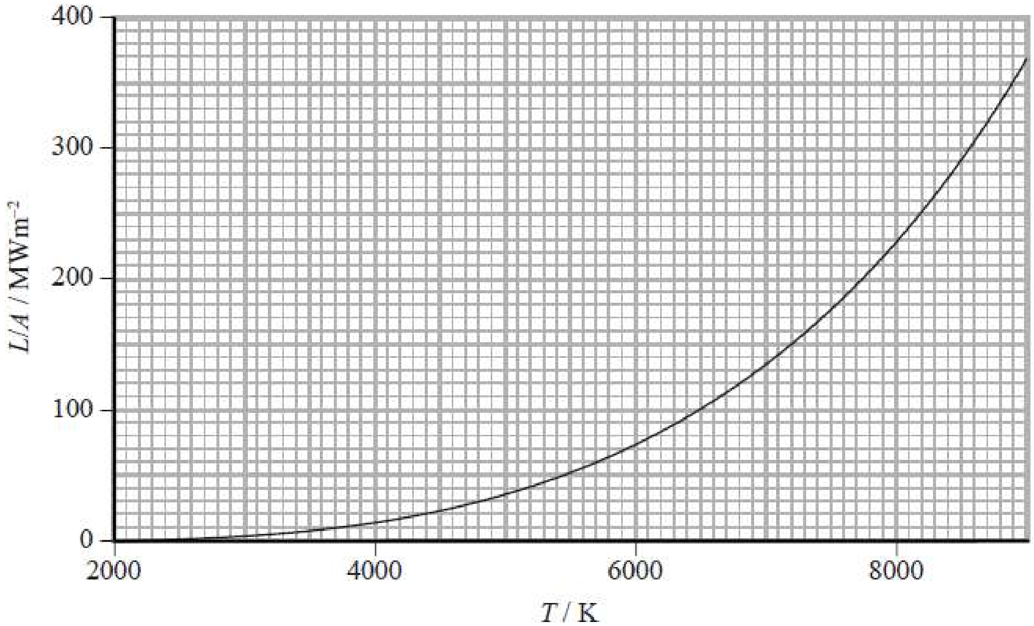
(1)

		Mass	Temperature
☒	**A**	larger	higher
☒	**B**	larger	lower
☒	**C**	smaller	higher
☒	**D**	smaller	lower

(Total for question = 1 mark)

Q18.

A black body of surface area *A* has luminosity *L*. The graph shows how the radiated flux *L*/*A* varies with temperature *T*.



(a) (i) Using data from the graph show that the luminosity of the Sun is about 4×10^{26} W.

surface temperature of the Sun = 5900 K
radius of the Sun = 6.96×10^{8} m

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(ii) Calculate the radiation flux *F* from the Sun at the top of the Earth's atmosphere.

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

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F =

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(iii) Suggest why the total rate at which energy from the Sun arrives at the top of the Earth's atmosphere is much less than $F \times A$, where A is the area of the spherical surface representing the top of the atmosphere.

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(b) The Sun is often referred to as a yellow star.

(i) Show that the wavelength λ_{max} at which peak energy emission occurs for the Sun is about 5×10^{-7} m.

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(ii) The visible region of the electromagnetic spectrum extends from a wavelength of about 400 nm to a wavelength of about 700 nm.

Suggest why light from the Sun is white rather than yellow.

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(Total for question = 11 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 ☒.

Star X has a luminosity L and is a distance x from the Earth. The radiation flux received from this star is F.

Star Y has a luminosity $3L$ and is a distance $2x$ from the Earth.

What is the radiation flux received from star Y?

☐ **A** $3F/4$

☐ **B** $2F/3$

☐ **C** $4F/3$

☐ **D** $3F/2$

(Total for question = 1 mark)

Q20.

The image below of a healthy man was taken with an infrared camera. Darker areas on the image represent areas of higher temperature.

From the image it was estimated that the average skin temperature of the man was 307 K.

(a) Calculate the peak emission wavelength λ_{max} of the thermal radiation emitted by the man.

Treat the man as a black body radiator.

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λ_{max} = ...

(b) Calculate the rate P at which thermal energy is radiated from the man. Treat the man as a black body radiator.

surface area of man = 1.20 m^2

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P = ...

(c) In practice, the net rate of energy loss by thermal radiation is different from that

given by the calculation in part (b). One reason is that the man is not a perfect black body radiator. Suggest two other reasons.

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(Total for question = 6 marks)

Q21.

A pan contains water at a temperature of 300 K. The water temperature is increased to 330 K. Assuming that the pan behaves like a black body, the rate at which energy is emitted as radiation from the pan changes by a factor of

☐ **A** 0.9

☐ **B** 1.1

☐ **C** 1.2

☐ **D** 1.5

(Total for question = 1 mark)

Q22.

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 (☒).

Stellar parallax can be used to determine the distances to stars which are relatively close to the Earth.

Why is this method unsuitable for more distant stars?

☐ **A** The radiation flux from these stars is too low.

☐ **B** The luminosity of these stars is too low.

☐ **C** The parallax angle is too large.

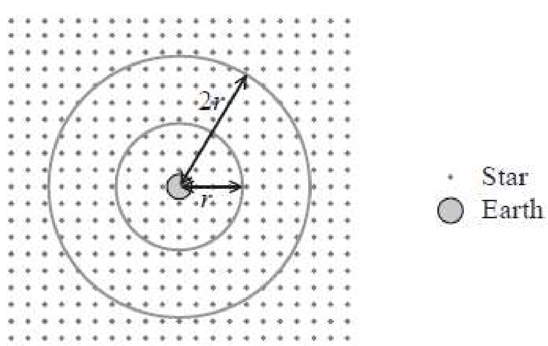
☐ **D** The parallax angle is too small.

(Total for question = 1 mark)

Q23.

In the early 19th century, Heinrich Olbers asked the question, "Why is the night sky dark?" He reasoned that in an infinite universe light from very distant stars should make the whole of the visible sky bright.

To see how much distant stars contribute to light reaching the Earth, the universe can be modelled as a uniform distribution of identical stars. If this universe is divided into a series of thin concentric 'shells' centred on Earth, there will be a certain number of stars on each shell.



The diagram shows two shells of equal thickness at distances r and $2r$ from the centre of the Earth.
There are four times as many stars on the shell at $2r$ than on the shell at r.

(a) Explain why the total radiation flux received at the Earth from the stars on each shell is the same.

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(b) One explanation proposed for why the night sky is not bright was that there is too much dust in space for distant stars to be seen. However, such dust would absorb radiation and heat up.

(i) Space is estimated to be at a temperature of 2.7 K. Use this value to calculate the radiant power emitted per m^2 of a body at this temperature.

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Radiant power emitted per m^2 = ... $W\ m^{-2}$

(ii) Calculate the value of λ_{max} for the radiation emitted by a black body at a temperature of 2.7 K, and sketch a graph of the radiation spectrum.

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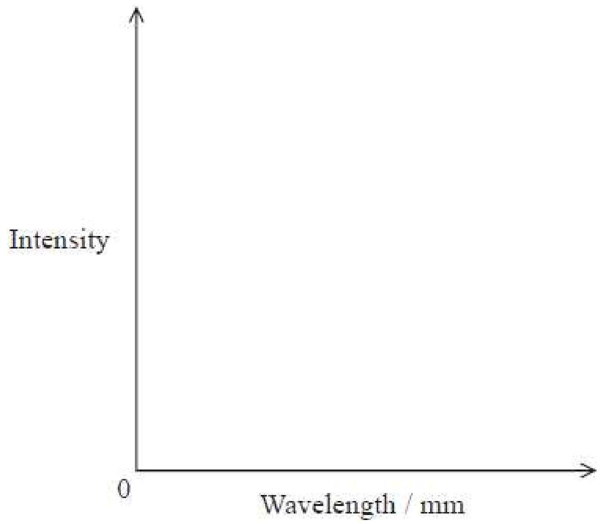
λ_{max} = ...



(iii) State how your graph would change if the black body were at a higher temperature.

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(c) The commonly accepted solution to Olbers' question is that the universe is expanding and has a finite age.

Suggest why some stars may be unobservable in a universe of finite age.

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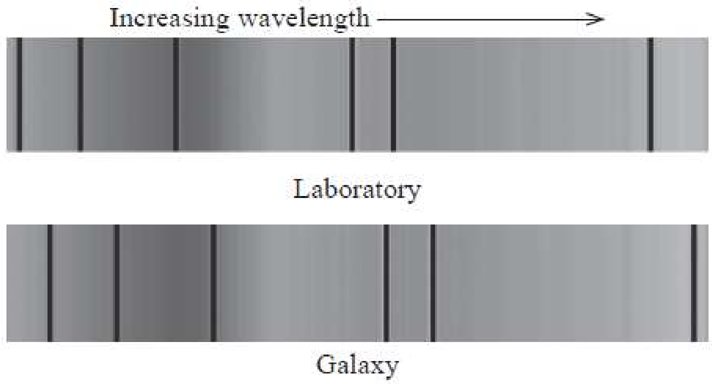
(Total for question = 11 marks)

Q24.

The diagram shows the line spectrum produced by a source in the laboratory and by light from a distant galaxy.



A correct deduction is that the galaxy is

☐ **A** accelerating away from the Earth.

☐ **B** accelerating towards the Earth.

☐ **C** moving away from the Earth.

☐ **D** moving towards the Earth.

(Total for question = 1 mark)