Space

Question Paper 1

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Physics from Creation to Collaps
Sub Topic	Space
Booklet	Question Paper 1

Time Allowed: **62 minutes**

Score: **/51**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Light from a distant galaxy is analysed. The line spectrum obtained is compared with similar radiation from the Sun.

When compared with the light from the Sun, a line in the spectrum of light from the distant galaxy has a

☒ **A** higher frequency and a greater photon energy.

☒ **B** higher frequency and a smaller photon energy.

☒ **C** lower frequency and a greater photon energy.

☒ **D** lower frequency and a smaller photon energy.

(Total for Question 1 = 1 mark)

2 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 2 = 1 mark)

3 In the early 20th century, Hubble determined the distances to a range of nearby galaxies.

Which of the following methods would have allowed him to do this?

☒ **A** measuring trigonometric parallax

☒ **B** observing Cepheid variables

☒ **C** using radio waves

☒ **D** using the formula $v = H_0 d$

(Total for Question 3 = 1 mark)

4 The brightness of a star depends upon its luminosity and

☒ **A** core temperature.

☒ **B** distance from the observer.

☒ **C** initial mass.

☒ **D** surface temperature.

(Total for Question 4 = 1 mark)

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5 The average density of the universe is unknown. Scientists believe that there is a critical value for this density.

If the density of the universe is less than this critical density the universe will

☒ **A** eventually reach a maximum size.

☒ **B** keep expanding forever.

☒ **C** maintain its present size.

☒ **D** reach a maximum size and then contract.

(Total for Question 5 = 1 mark)

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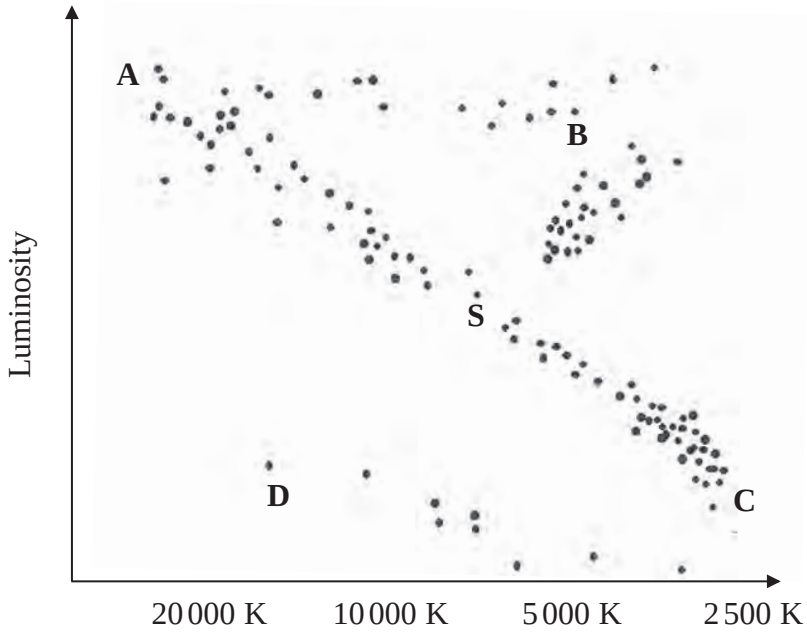
6 The figure shows our Sun, S, plotted on a Hertzsprung-Russell diagram.



Once hydrogen fusion has ceased in its core the Sun will move to a new position on the diagram.

The new position of the Sun will be

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 1 mark)

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7 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 7 = 1 mark)

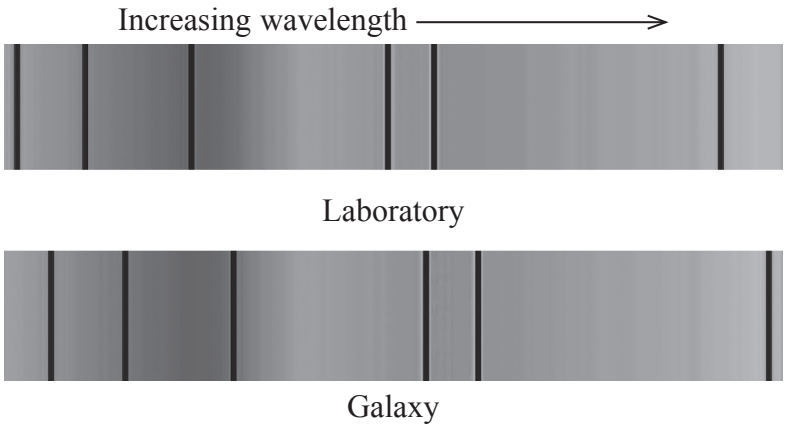
8 Scientists believe that the universe is expanding and that there is a critical density ρ_c which will determine the ultimate fate of the universe.

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 8 = 1 mark)

9 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 9 = 1 mark)

10 There is uncertainty in the value of the Hubble constant determined by astronomers because

☒ **A** detailed observations have only been possible recently.

☒ **B** distances to distant galaxies are uncertain.

☒ **C** the age of the universe is uncertain.

☒ **D** the Big Bang is only a theory.

(Total for Question 10 = 1 mark)

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11 Recent observations have led scientists to propose the existence of dark matter.

Dark matter

☒ **A** is a perfect black body radiator.

☒ **B** is at a temperature very close to absolute zero.

☒ **C** may account for most of the matter in the universe.

☒ **D** will be discovered in high energy particle accelerators.

(Total for Question 11 = 1 mark)

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12 Which of the following is **not** a source of background radiation?

☒ **A** coffee beans

☒ **B** granite rock

☒ **C** microwave ovens

☒ **D** people

(Total for Question 12 = 1 mark)

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13 When viewed from the Earth, light from a distant galaxy is observed to be red-shifted.

This is evidence that

☒ **A** the distant galaxy is moving away from the Earth.

☒ **B** the Earth is rotating about the Sun.

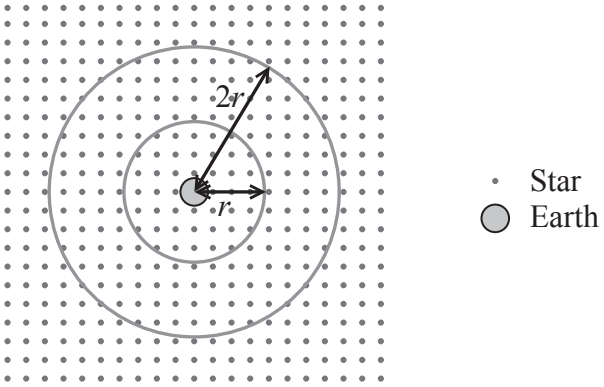
☒ **C** the Earth is rotating on its axis.

☒ **D** the universe is expanding uniformly.

(Total for Question 13 = 1 mark)

14 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.

(2)

(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.

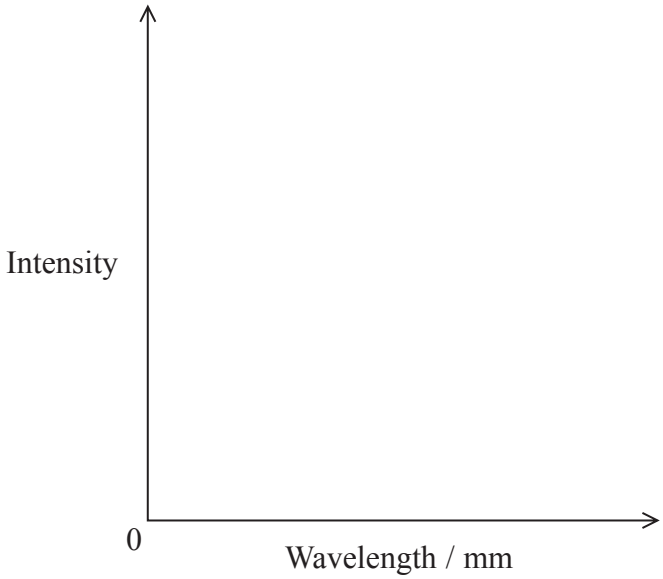
(2)

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.

(4)

λ_{max} = ...



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

(2)

(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.

(1)

(Total for Question 14 = 11 marks)

15 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.

(3)

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

(1)

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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.

(4)

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(Total for Question 15 = 8 marks)

16 Light from either end of the Sun's diameter is analysed and compared to light from the centre of the Sun. A hydrogen line in light from the centre of wavelength 490 nm is shifted in wavelength by 3.4×10^{-3} nm compared with light from the centre.

Calculate a value for the angular velocity of the Sun.

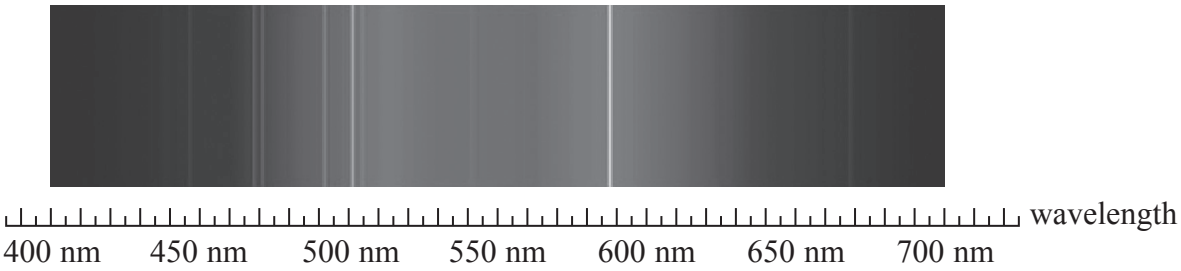
diameter of Sun = 1.4×10^{9} m

(3)

Angular velocity of Sun = ...

(Total for Question 16 = 3 marks)

17 The yellow line emitted by a helium discharge tube in the laboratory has a wavelength of 587.5 nm.



The same line in the helium spectrum of a star has a measured wavelength of 595.6 nm.

Calculate the speed of the star relative to the Earth.

(2)

Speed = ...

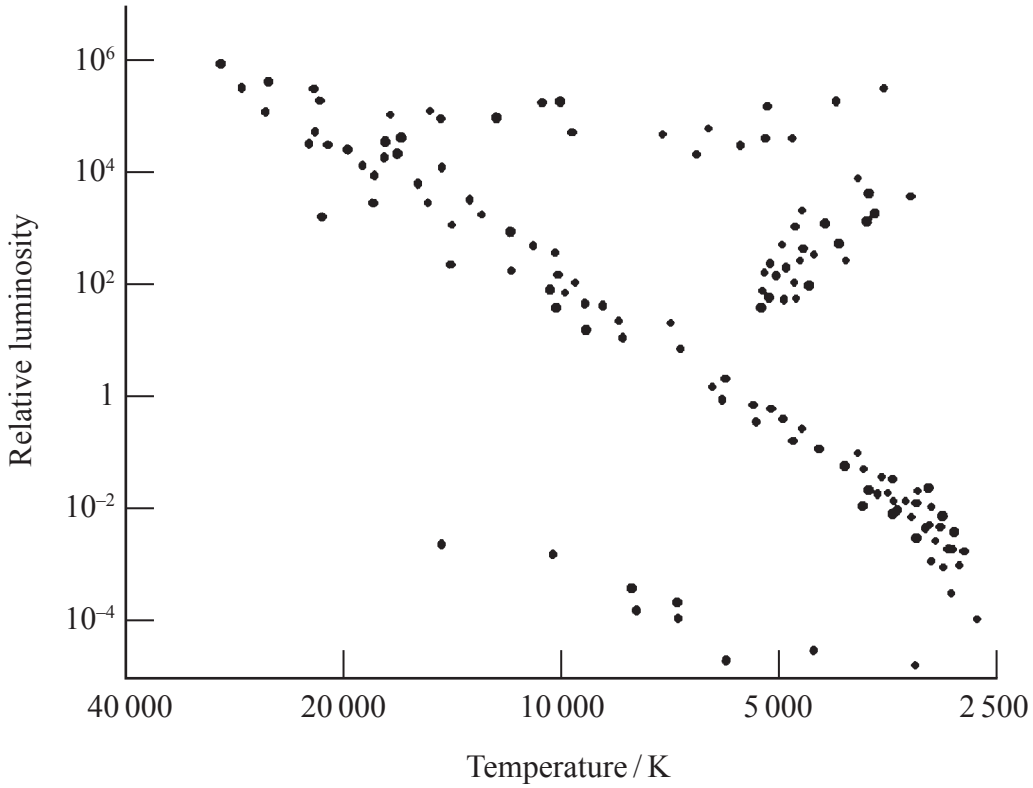
(Total for Question 17 = 2 marks)

18 Astronomers have been watching an old star suddenly stir back into new activity.

(a) They are studying a star known as "Sakurai's Object", an old white dwarf that has run out of hydrogen fuel for nuclear fusion reactions in its core. Astronomers now believe that some such stars can undergo a final burst of fusion.

Computer simulations indicate that convection would bring hydrogen in from the star's outer regions, causing a brief flash of new nuclear fusion. This produces a sudden increase in the size and brightness of the star.

The diagram below is a Hertzsprung-Russell diagram.



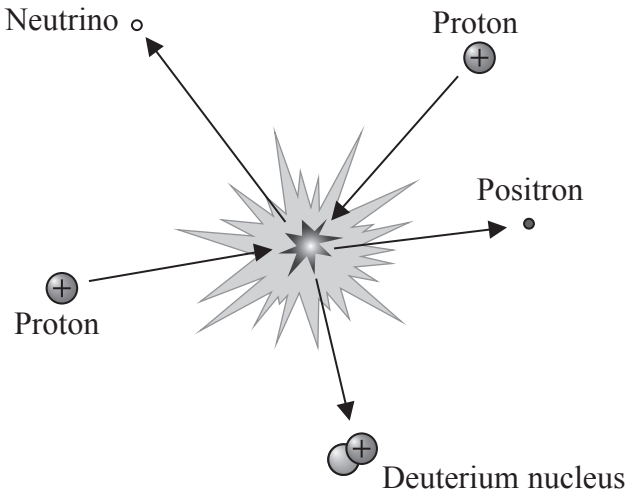
(i) On the diagram, mark a likely position for Sakurai's Object before the final burst of fusion took place. Label this X.

(1)

(ii) On the diagram, mark a likely position for Sakurai's Object during the final burst of fusion. Label this Y.

(1)

(b) During the hydrogen fusion process the first stage is the fusion of two protons to form a deuterium nucleus.



Particle	Mass / MeV/c^2
Deuterium nucleus	1875.62
Electron	0.51
Proton	938.27

(i) Complete the nuclear equation to represent the fusion of two protons to form a deuterium nucleus.

(1)

$$ {}_{1}^{1}\mathrm{p} + {}_{1}^{1}\mathrm{p} \rightarrow $$

(ii) Calculate the energy, in joules, emitted in this first stage.

(3)

Energy emitted = ... J

(c) For fusion to take place in the core of a star there must be a very high density of hydrogen at an extremely high temperature.

Explain why.

(3)

*(d) The quest for a practical nuclear fusion reactor to contribute to our electrical power demands is hindered by the extreme conditions necessary. Nuclear fission already supplies a large fraction of this demand.

Discuss the potential advantages of nuclear fusion, compared with nuclear fission, as a means of supplying our power demands.

(5)

(Total for Question 18 = 14 marks)