Physics

Question	Maximum Mark	Mark Awarded
#1	8	
#2	9	
#3	10	
#4	11	
#5	12	
#6	13	
#7	20	
Total	83	

created with

eduqas Part of WJEC Question Bank

#1

4. *(a)* Stefan's law can be written as:

$$P = A\sigma T^4$$

Show that Stefan's constant, σ, has the base SI units of $\text{kg}\,\text{s}^{-3}\,\text{K}^{-4}$. [3]

....

....

....

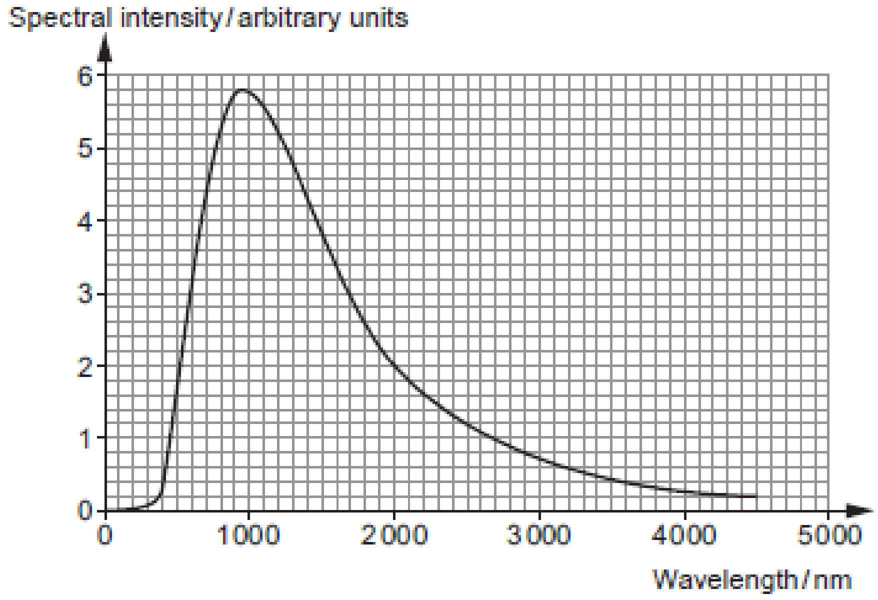
....

....

....

....

(b) Our nearest star is called Proxima Centauri. The following graph shows its spectrum.



(i) The total power output of electromagnetic radiation emitted from Proxima Centauri is 5.9×10^{23} W. Use this information and the graph opposite to calculate its effective diameter. [4]

....

....

....

....

....

....

....

(ii) State what colour you would expect Proxima Centauri to appear and name the region of the electromagnetic spectrum in which most of the star's power is radiated. [1]

....

....

Question taken from Eduqas examination paper 842001, June 2018

#2

4. (a) Define a black body. [1]

....

....

....

(b) A physics student, Tony, notices that the classroom is warmer when it has a number of students in it rather than when it is empty. Tony claims that each student will behave like a perfect black body and will emit about the same amount of heat as a 200 W light bulb. Assuming a typical human body has a surface area of 2 m^2. Evaluate whether or not Tony appears to be correct. Normal body temperature can be taken to be 37 °C. [3]

....

....

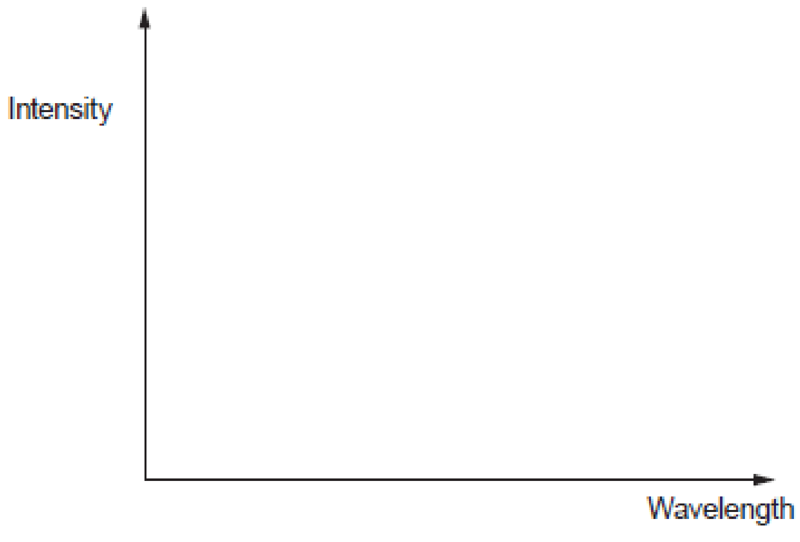
....

....

....

....

(c) (i) Some stars appear to be coloured to the naked eye. For two stars of similar diameter one appears red and the other appears blue. Sketch and label typical black body spectra for each star on the graph below. [3]



(ii) Suggest why it is that no stars appear to be green in colour. [2]

....

....

....

....

....

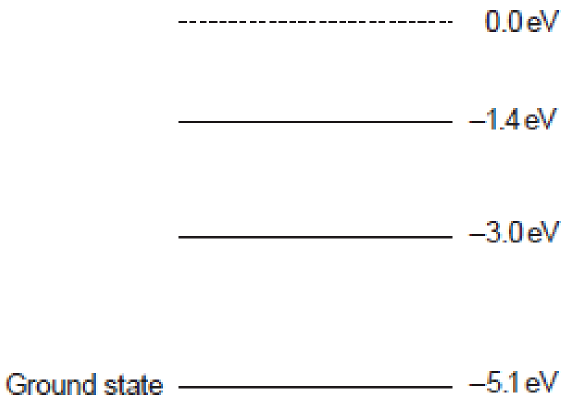
....

....

Question taken from Eduqas examination paper 842001, June 2019

#3

6. The diagram shows three energy levels of a sodium atom.



(a) State the ionisation energy of a sodium atom. [1]

....

(b) White light passes through a cloud of sodium atoms. The light which emerges is found to have the continuous spectrum of white light but with dark lines crossing the spectrum. State briefly how the dark lines are caused and what happens to the atoms in the process. [3]

....

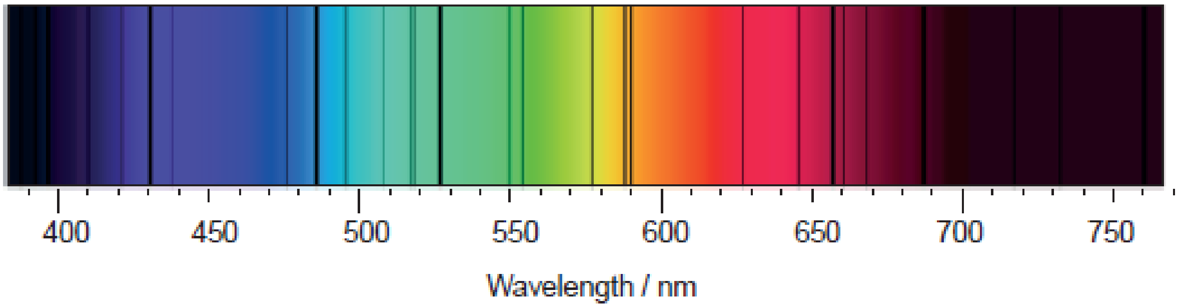
....

....

....

....

(c) (i) The spectrum of a star is shown below. The wavelength of one of the dark lines is 590 nm. Evaluate whether this is evidence for the presence of sodium in the star. [3]



....

....

....

....

....

....

(ii) The wavelength of peak emission of the star is 100 nm. Determine its surface temperature. [3]

....

....

....

....

....

....

Question taken from Eduqas examination paper 842002, June 2019

#4

In this question the Sun and the star Vega can be considered to be *black bodies*.

(a) (i) Define a *black body*. [1]

....

....

....

(ii) The surface temperature of the Sun is approximately 6 000 K and that of Vega approximately 10 000 K. Calculate the wavelength of peak spectral intensity for each star and name the region of the electromagnetic spectrum within which they lie. [3]

....

....

....

....

....

(iii) Sketch a black body spectrum for **each star** on the axis provided. [3]

(b) The radius of Vega is approximately 2.71 times that of the Sun. Determine the ratio:

$$\frac{\text{total power output of Vega}}{\text{total power output of Sun}}$$

[4]

....

....

....

....

....

....

....

....

Question taken from Eduqas examination paper 842001, June 2017

#5

8. (a) Diagram 1 shows how the intensity of electromagnetic radiation from the Sun varies with distance from its centre. Diagram 2 shows how the intensity of the radiation incident on the Earth from the Sun is distributed across the spectrum.

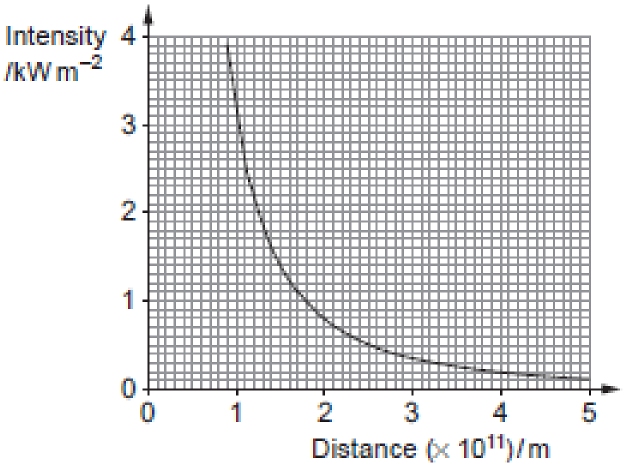


Diagram 1

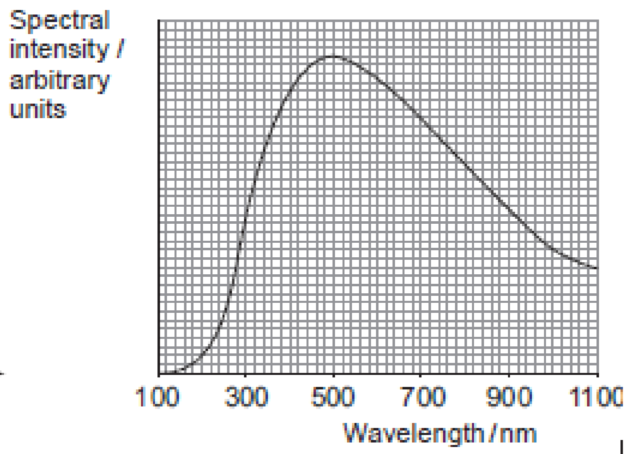


Diagram 2

(i) Confirm that Diagram 1 shows the expected relationship between intensity and distance. [3]

....

....

....

....

....

(ii) Use Diagram 1 to show that the Sun's luminosity is about 4×10^{26} W. [2]

....

....

....

(b) In 2006 scientists from the University of Hawaii used a solar telescope aboard NASA's Solar and Heliospheric Observatory satellite to measure the radius of the Sun with (they quote) "unprecedented accuracy". They measured it to be:

$$R_{\text{sun}} = 696\,342\,\text{km}$$

Use information from Diagram 2 along with your answer to *(a)*(ii) to evaluate whether the information from Diagrams 1 and 2 are consistent with the scientists' findings. [5]

....

....

....

....

....

....

....

....

(c) For centuries scientists have attempted to measure the Sun's diameter accurately. The following article is taken from a scientific paper written in 2004:

The solar diameter, and its possible variation, have been the subject of careful measurements for over 350 years, with ever increasing accuracy. Different techniques have been used, and the instrumentation has evolved in time. However, the long-term evolution of the Sun is still a controversial subject. Even for the short term, the results are inconsistent even with the most advanced instruments presently in use. These discrepancies probably have several origins.

[Past, present and future measurements of the solar diameter: Gerard Thuillier, Sabatino Sofia, Margit Haberreiter November 2004]

Suggest two reasons why it has been difficult for scientists to determine an accurate value for the Sun's diameter. [2]

....

....

....

....

Question taken from Eduqas examination paper 842102, June 2018

#6

(a) Describe the main features of the spectrum of a star **and** state where in the star they arise. [2]

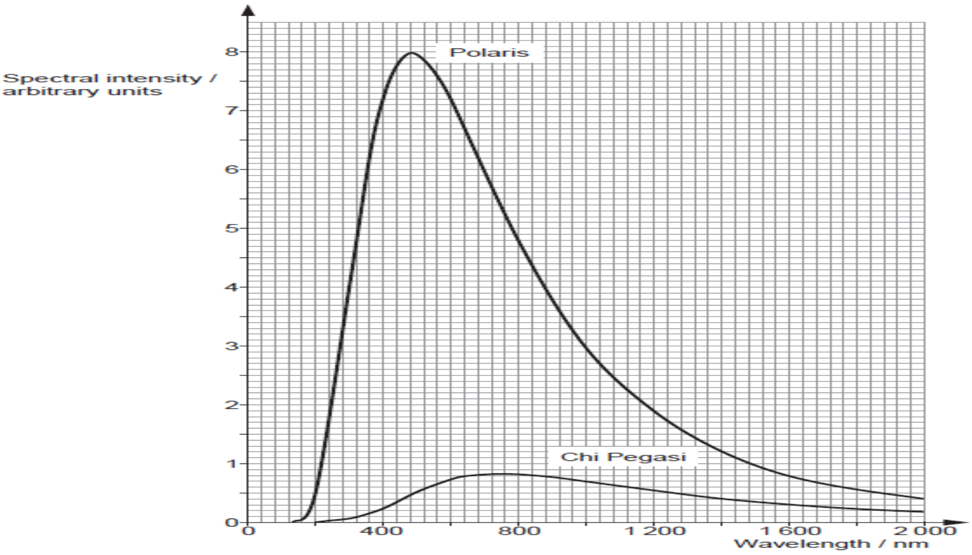
....

....

....

....

(b) The graph shows the black body radiation curves for the two stars **Polaris** (sometimes called the North Star) and **Chi Pegasi** (a red supergiant in the constellation Pegasus). **The stars are equidistant from Earth.**



(i) Suggest **three** differences between Polaris and Chi Pegasi. [3]

....

....

....

....

(ii) Polaris is 431 light years from Earth and the intensity of radiation received on Earth from it is $4.05 \times 10^{-9}\,\mathrm{W\,m^{-2}}$. Use this information and the graph to calculate the radius of Polaris. [1 light year = $9.46 \times 10^{15}\,\mathrm{m}$] [5]

....

....

....

....

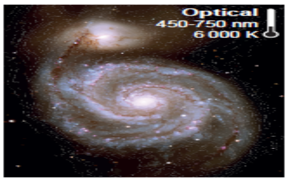
....

....

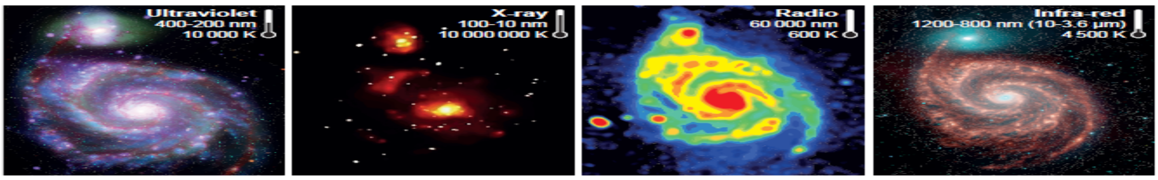
....

....

(c) The image below is of the whirlpool galaxy, M51 (or NGC 5194). This is one of the first images of the galaxy taken by astronomers.



Subsequent images of the **same galaxy** are shown below.



Describe how these developments in observational astronomy have advanced the study of the whirlpool galaxy. [3]

....

....

....

....

....

....

Question taken from Eduqas examination paper 842102, November 2020

#7

8. Read through the following article carefully. Paragraph

A little bit of information about stars by Ignasi Lluis Marxuach

Figure 1 shows the three different routes for the life cycle of different sized stars, from small stars, through medium (Sun-like) stars to explosive high mass stars. For some reason, exam boards tend to ignore the smallest category of stars (red dwarfs) because their cores never become hot enough to produce red giant stars. 1

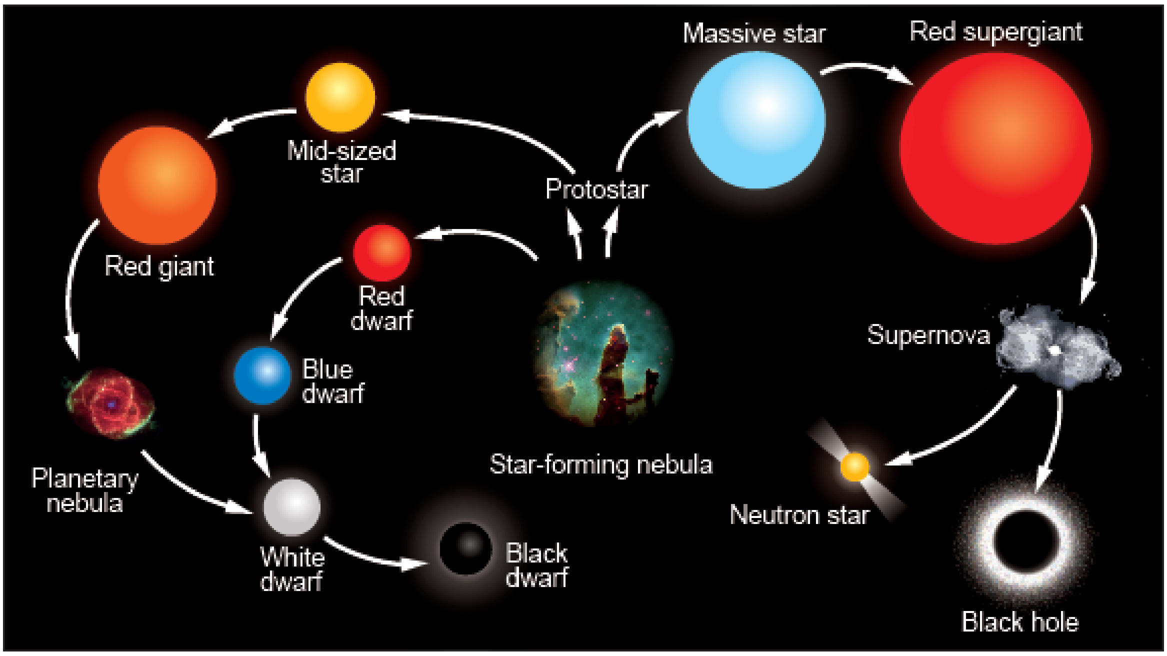


Figure 1

Stars are formed from the gravitational collapse of gas clouds called *nebulae*. Gravitational potential energy is converted to internal energy of hot gases which then emit radiation. This means that the search for new stars usually involves the use of infra-red telescopes in space. 2

The images on the next page show the same gas clouds but the image on the right (**Figure 3**) is taken with visible light while the image on the left (**Figure 2**) is taken with infra-red. Notice how the gas clouds are transparent to infra-red so that stars behind the gas clouds become visible at infra-red wavelengths. The areas where stars are forming are those areas of the gas cloud that appear to be emitting radiation at both infra-red and visible wavelengths. 3

Figure 2 (infra-red image)

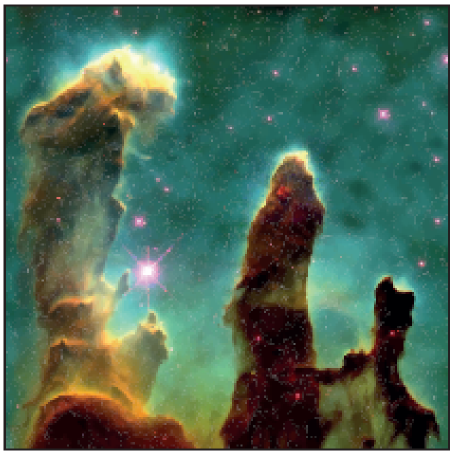
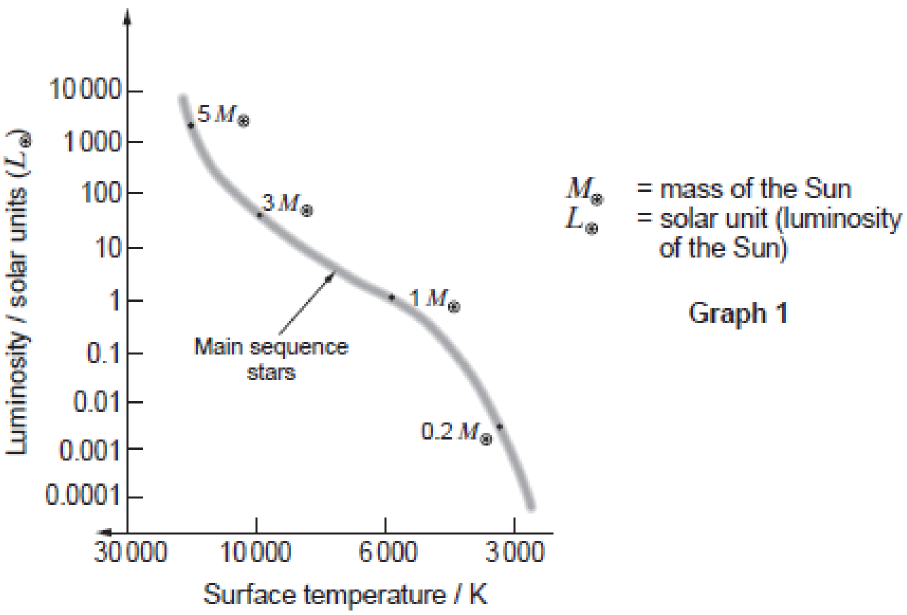


Figure 3 (visible light image)

Once the core of a young star is hot enough to initiate hydrogen fusion it is called a *main sequence star*. Such stars are stable, lasting for millions or billions of years and account for around 90% of all stars. They are stable because the outward pressures due to hot gases and electromagnetic radiation are balanced by the inward pressure due to gravity. 4
Larger main sequence stars have denser cores which means that the rate of fusion and the temperature are also greater. A graph of luminosity against temperature for main sequence stars is rather useful, although slightly less useful than it should be because astronomers, apparently, don't realise that values should increase going to the right on normal graphs.



Graph 1

Notice that nearly all main sequence stars have surface temperatures in the range 3000 K to 20000 K. This makes them suitable for analysing using visible light. 5

Paragraph

Another thing to note from the luminosity against surface temperature graph is that these factors seem to depend on the mass of the star. It turns out that there is only one factor that determines a star's position on the graph – its mass. The relationship between mass and luminosity for a star is quite complicated and comes in four parts. 6

$L = 0.23M^{2.3}$	for	$M < 0.43$	**Equation 1**
$L = M^4$	for	$0.43 < M < 2$	**Equation 2**
$L = 1.5M^{3.5}$	for	$2 < M < 20$	**Equation 3**
$L = 3200M$	for	$M > 20$	**Equation 4**

Note that these equations have been simplified by having the mass of the star (M) in units of the solar mass ($M_{\odot}$), and luminosity in units of the solar luminosity ($L_{\odot}$).

These relationships are rather useful and should explain why large mass stars can be found more easily using ultraviolet telescopes, but they can do so much more when combined with Einstein's equation. 7

$$E = \Delta mc^2 \qquad \textbf{Equation 5}$$

You might, in the first instance, be excused for thinking that a 10 $M_{\odot}$ star will burn 10 times longer than the Sun. This, however, could not be further from the truth. Use of Equation 3 should tell you that a 10 $M_{\odot}$ star will burn approximately 5000 times brighter. By using Einstein's equation and making a few simplifying assumptions, we find the expected lifetime of a 10 $M_{\odot}$ star to be, in fact, approximately 500 times less than that of the Sun. Some might say that a large star "burns the candle at both ends" but it's more accurate to say that it burns the candle at 5000 ends simultaneously. 8

It should be reasonably clear that there is a negative correlation between the mass of a star and its lifetime. Another two star variables that are (bizarrely) negatively correlated are the mass of a white dwarf and its radius. However, that is a completely different story which is beyond the remit of this 2019 Space Odyssey. 9

Answer the following questions in your own words. Extended quotes from the original article will not be awarded marks.

(a) Write down the complete life cycle of a mid-sized star (see **Figure 1**). [1]

Star-forming nebula →

(b) Suggest an advantage of placing telescopes *in space* to observe new stars (see Paragraph 2). [1]

....

....

....

(c) In **Figure 2** or 3 below, mark with an **X** one area where new stars are forming (see Paragraph 3 and **Figures 2** & 3). [1]

Figure 2 (infra-red image)

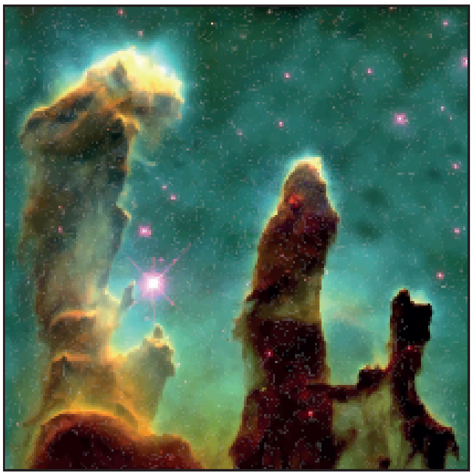


Figure 3 (visible light image)

(d) Explain, using Newton's 2nd law, how electromagnetic radiation exerts pressure inside a main sequence star (see Paragraph 4). [3]

...

(e) Explain why a more massive star has a higher density in its core and why this leads to a higher temperature (see Paragraph 4). [3]

...

(f) (i) Show that the wavelength of maximum emission for the hottest main sequence stars is approximately 150 nm (see Paragraph 5 or Graph 1). [2]

...

(ii) Discuss whether or not it is appropriate to analyse the hottest main sequence stars using visible light when their wavelength of maximum emission is 150 nm (see Paragraph 5). [2]

...

(g) Determine whether or not the star of mass $0.2\,M_{\odot}$ is plotted at approximately the correct luminosity in Graph 1 (see Equations 1–4 and Graph 1). [2]

....

....

....

....

....

(h) Explain why a $10\,M_{\odot}$ star has a lifetime that is 500 times shorter than that of the Sun, including any simplifying assumptions (see Paragraph 8 and Equations 1–5). [4]

....

....

....

....

....

....

....

....

(i) Explain **briefly** what the author means when he states that a white dwarf's mass and radius are negatively correlated (see Paragraph 9). [1]

....

....

....

Question taken from Eduqas examination paper 842101, June 2019