A Level · OCR · Physics

22 mins 3 questions

Structured Questions

Stellar Evolution

Definitions of Astronomical Objects / Star Formation / Evolution of a Low-Mass Star / White Dwarfs & the Chandrasekhar Limit / Evolution of a Massive Star / Neutron Stars & Black Holes / The Hertzsprung - Russell (HR) Diagram

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Total Marks **/22**

1 (a) In 2017, an ultra-cool star TRAPPIST-1 was discovered with at least five of its own orbiting planets. Astronomers are interested about the possibility of finding life on some of the planets orbiting TRAPPIST-1.

The table below shows some data.

	TRAPPIST-1	**Sun**
Luminosity *L*/W	2.0×10^{23}	3.8×10^{26}
Surface temperature *T*/K	2500	5800
Radius of star/m	R	7.0×10^{8}
Distance between Earth and Sun/m		1.5×10^{11}
Distance between planets and TRAPPIST-1/m	1.6×10^{9} to 9.0×10^{9}	

The temperature T in kelvin of a planet, its distance d from the star and the luminosity L of the star are related by the expression

$$\frac{T^4 d^2}{L} = \text{constant}$$

- The average temperature of the Earth is about 290K. Explain how life may be possible on some of the planets orbiting TRAPPIST-1.
- Use your knowledge of luminosity to show that the radius R of TRAPPIST-1 is smaller than the Sun.
- Support your answers by calculations.

[6]

(6 marks)

(b) Kepler's third law can be applied to a satellite in a geostationary orbit around the Earth.

i) Complete the equation for Kepler's third law below. You do not need to define any of the terms.

$$\text{.....} = \frac{4\pi^2}{GM} \text{.....}$$

[1]

ii) The mass of Earth is 6.0×10^{24} kg. Calculate the radius of the circular path of a satellite in a geostationary orbit around the Earth.

radius = ... m **[2]**

(3 marks)

2 (a) Our Sun will eventually become a red giant.

Describe and explain the next stages of evolution of our Sun.

[4]

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(4 marks)

(b) Rigel is a blue giant star in the constellation of Orion.

The table below shows some data about Rigel and about our Sun.

	Rigel	**Sun**
Surface temperature / K		5.8×10^3
Luminosity / W	4.62×10^{31}	3.85×10^{26}
Wavelength of emitted light at peak intensity / nm	240	500

i) Show that the surface temperature of Rigel is 12 000 K.

[2]

ii) Calculate the radius of Rigel.

radius = ... m **[2]**

(4 marks)

(c) An astronomer claims to have discovered a white dwarf with a mass twice that of our Sun.

Suggest why this claim must be incorrect.

[1]

(1 mark)

3 (a) Fig. 19 is an incomplete Hertzsprung-Russell (HR) diagram of stars in our galaxy.

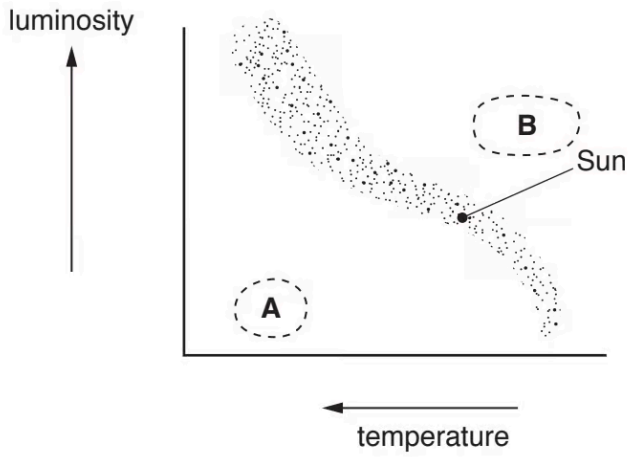

Fig. 19

The position of the Sun on the HR diagram is shown in Fig. 19.

State the type of stars found in regions **A** and **B**.

A .....

B .....

[1]

.....

(1 mark)

(b) The Sun is a main sequence star. Its surface temperature is 5800 K. The wavelength of the emitted light at maximum intensity is 550 nm.

Beta Pictoris is also a main sequence star. The wavelength of the emitted light at maximum intensity from this star is 370 nm.

i) Calculate the surface temperature of Beta Pictoris.

temperature = ... K **[2]**

ii) On Fig. 19, mark the likely position of Beta Pictoris with a letter **P**.

[1]

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(3 marks)