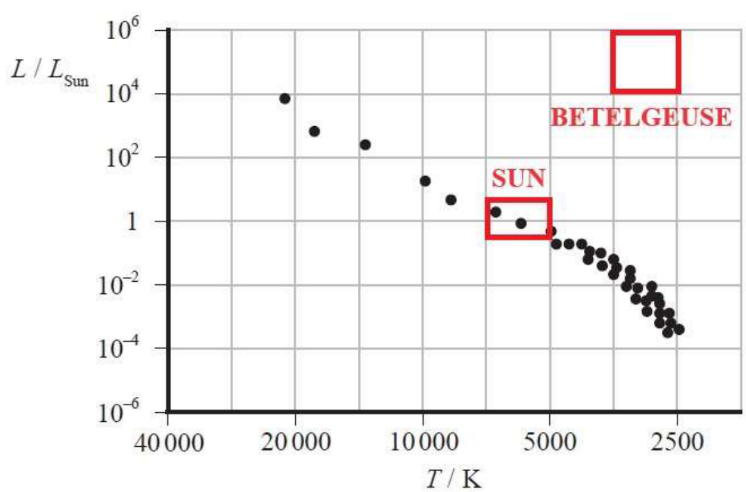
Question Number	Answer		Mark
21(a)(i)	Use of $\lambda_{max}T = 2.898 \times 10^{-3}$	(1)	
	Use of $L = \sigma AT^4$ **and** $A = 4\pi r^2$ **Or** Use of $L = \sigma AT^4$ to calculate A **and** $A \propto r^2$	(1)	
	$\frac{r_B}{r_S} = 990$ [Probable values for *r*: $r_B = 6.831 \times 10^{11}$m and $r_S = 6.892 \times 10^8$m Watch out for variation due to rounding, particularly for *T*]	(1)	
	$\frac{r_B}{r_S}$ is approximately equal to 1000, so claim is accurate **Or** $\frac{r_B}{r_S}$ is less than 1000, so claim is inaccurate **Or** $\frac{r_B}{r_S}$ is not equal to 1000, so claim is inaccurate (Allow use of calculated ratio with consistent conclusion)	(1)	4
	<u>Example of calculation</u> $T = \frac{2.898 \times 10^{-3}\text{ m K}}{850 \times 10^{-9}\text{ m}} = 3410\text{ K}$ $\frac{L_B}{L_S} = \frac{4\pi\sigma r_B^2 T_B^4}{4\pi\sigma r_S^2 T_S^4}$ $\frac{r_B}{r_S} = \sqrt{\frac{L_B}{L_S} \times \frac{T_S^4}{T_B^4}} = \sqrt{\frac{4.49 \times 10^{31}\text{ W}}{3.83 \times 10^{26}\text{ W}} \times \left(\frac{5800\text{ K}}{3410\text{ K}}\right)^4} = 991$		
21(a)(ii)	Sun in correct position Betelgeuse in correct position 	(1) (1)	2
21(a)(iii)	A main sequence star is a star that is fusing <u>hydrogen</u> in its <u>core</u> [Accept "burning" for "fusing"]	(1)	1

21(b)	Use of $\omega = \frac{2\pi}{T}$ Use of $v = r\omega$ Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ Determines range by taking 91.2 nm ± Δλ [Δλ is their calculated value] [This may be awarded by seeing two substitutions into the Doppler equation. Once with Δλ = (91.2 − λ) **and** once with Δλ = (λ − 91.2)] Maximum wavelength = 91.8 (nm) Minimum wavelength = 90.6 (nm) <u>Example of calculation</u> $\omega = \frac{2\pi}{T} = \frac{2\pi \text{ rad}}{33.5 \times 10^{-3} \text{s}} = 187.6 \text{ rad s}^{-1}$ $v = 10.25 \times 10^3 \text{ m} \times 187.6 \text{ rad s}^{-1} = 1.922 \times 10^6 \text{ m s}^{-1}$ $\frac{\Delta\lambda}{91.2 \times 10^{-9} \text{ m}} = \frac{1.922 \times 10^6 \text{ m s}^{-1}}{3.00 \times 10^8 \text{ m s}^{-1}}$ $\therefore \Delta\lambda = 6.408 \times 10^{-3} \times 91.2 \times 10^{-9} \text{ m} = 5.84 \times 10^{-10} \text{ m}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
	Total for question 21		**13**