Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		Rearrangement $\sigma = \frac{P}{AT^4}$ and convincing algebra / cancellation of m^2 (1) P has units kg m^2 s^{-3} (1) A has units m^2 and T^4 units K^4 (1)	1 1	1		3	1	
	(b)	(i)	λ_p = 930 ± 20 nm (with units) (1) $T = \frac{2.9 \times 10^{-3}}{930 \times 10^{-9}}$ = 3 120 K (1) $A = 1.1 \times 10^{17}$ m^2 (1) $d = 1.87 \times 10^{8}$ m (1)	1	1 1 1		4	3	
		(ii)	Appears red and infra-red section			1	1		
			Question 4 total	**3**	**4**	**1**	**8**	**4**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		An object that absorbs all electromagnetic radiation [incident upon it]	1			1		
	(b)		Conversion of temperature 310 K (1) Use of $P = \sigma AT^4$ (1) P = 1047 [W] No he is incorrect / conclusion (1)			3	3	2	
	(c)	(i)	Reasonable attempt at two black body graphs skewed normal distribution curves (1) Curve labelled blue all above curve labelled red (1) λ_{max} blue to the left of λ_{max} red (1)	1	1 1		3		
		(ii)	For distribution to have a peak wavelength of green other colours are emitted / green is in the middle of the (light) spectrum (1) Star will appear white (1)			2	2		
			Question 4 total	**2**	**2**	**5**	**9**	**2**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		5.1 [eV]	1			1		
	(b)		Particular wavelengths of the light are absorbed (1) Atoms or electrons are raised to higher energy levels (1) Light re-radiated in all directions (1)	3			3		
	(c)	(i)	Energy ($= \frac{hc}{\lambda}$) = 3.4×10^{-19} [J] (1) Conversion to eV = 2.1 [eV] (1) Correct conclusion with justification – does correspond to energy difference in levels (1)			3	3	2	
		(ii)	Wien's Law $\lambda_{max} = \frac{W}{T}$ (1) $T = \frac{2.9 \times 10^{-3}}{\lambda_{max}}$ (1) Temperature = 29 000 [K] (1)	1	1 1		3	3	
			Question 6 total	**5**	**2**	**3**	**10**	**5**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	[A surface that] absorbs all em radiation falling on it / perfect absorber of em radiation	1			1		
		(ii)	Vega = 290 / 289 n[m] (1) Sun = 483 / 481 n[m] (1) Sun = visible (light) **and** Vega = ultraviolet (1)	1	1 1		3	2	
		(iii)	Shape of one correct with peak (1) Vega shown with a shorter peak wavelength (1) Graph of Vega always above graph of Sun (1)	3			3		
	(b)		Use of Stefan's law (1) $A = 4\pi r^2$ used (1) Ratios taken: $\frac{2.71^2 \times 10\,000^4}{6000^4}$ **or** $\frac{7.3 \times 10^{16}}{1.30 \times 10^{15}}$ (1) Answer = 56.7 (1)	1 1	1 1		4	4	
			Question total	**7**	**4**	**0**	**11**	**6**	**0**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)	Reference to expected relationship: i.e. $I \propto \frac{1}{R^2}$ (1) Valid strategy e.g. IR^2 = constant (1) [Award 2 marks for this] Data from graph used appropriately to confirm relationship: e.g. $(2 \times 10^{11})^2 \times 0.8 = 3.2 \times 10^{22}$ $(4 \times 10^{11})^2 \times 0.2 = 3.2 \times 10^{22}$ (1)			3	3	2	
		(ii)	Correct substitution of corresponding pairs of values into $I = \frac{P}{4\pi R^2}$ regardless of units used (1) Correct re-arrangement and correct unit conversions to show clearly that $P \approx 4 \times 10^{26}$ W e.g. $P = 1.4 \times 10^3 \times 4\pi \times (1.5 \times 10^{11})^2$ (1)	1	1		2	1	
	(b)		**Either:** λ_{peak} found from graph (= 500×10^{-9}) (1) Wien's law to find T_{sun} i.e. $\frac{2.9 \times 10^{-3}}{500 \times 10^{-9}}$ (= 5 800 K) (1) [(**ecf** on λ_{peak}]. Substitution into $P = 4\pi R^2_{sun}\sigma T^4$ (**ecf** on T) e.g. $4 \times 10^{26} = 4 \times \pi \times R^2_{sun} \times 5.67 \times 10^{-8} \times (5\,800)^4$ (1) [Allow A instead of $4 \times \pi \times R^2_{sun}$ but not $\pi \times R^2_{sun}$] **or** $A = 6.2 \times 10^{18}$ m^2. $R_{sun} = 7.0 \times 10^8$ m (1) **Or:** Luminosity from *(a)*(ii) (**ecf**) and radius substituted into $P = 4\pi R^2_{sun}\sigma T^4$ (1) T calculated [expect 5830 K] (1) λ_{peak} calculated from Wien's law [5830 K → 497 nm] (1) λ_{peak} found from graph (= 500 nm) (1) Appropriate comparison and comment: e.g. **Either** 700 000 km close to 696 342 km so reasonable comment. **Or** 700 000 km is '1000s' of km different, so unreasonable. **Or** λ_{peak} calculated in good agreement with graph (1)			5	5	4	
	(c)		**Any 2 ×(1) from:** • Inaccurate instruments • Atmospheric distortions (e.g. refraction) • Earth/sun distance uncertainty • Uncertainty regarding solar surface- defining edge of sun • Sun varies in size over time. • Shape of disc is non-spherical • Brightness of disc overwhelms eye / instruments			2	2		
			Question 8 total	**1**	**1**	**10**	**12**	**7**	**0**

#6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)			**Description**: Continuous spectrum **and** [superimposed] line [absorption] spectrum / dark lines [1] **Cause:** [Continuous] due to radiation of all wavelengths **emitted from surface** of star and [Line spectrum] (due to passage of radiation) **through atmosphere** (of star) [1]	2			2		
	(b)	(i)		Polaris [surface] temperature > Chi Pegasi [surface] temperature [1] [For all λs] intensity of radiation from Polaris > intensity of radiation from Chi Pegasi. Accept Polaris brighter than or more luminous than Chi Pegasi [1] Polaris 'appears' blue-white' and Chi Pegasi appears 'red-orange'. Do not accept they are different colours [1]			3	3		
		(ii)		Peak λ identified: 480 nm [1]	1					
				Re-arrange and substitute into Wien's law: $\frac{2.9 \times 10^{-3}}{480 \times 10^{-9}}$ = [6 042 K] [1] (**ecf** on λ)		1				
				Luminosity, $L = 4.05 \times 10^{-9} \times 4\pi \times (431 \times 9.46 \times 10^{15})^2$ $L = 8.46 \times 10^{29}$ [W] [1]		1				
				$A = \frac{8.46 \times 10^{29}}{(5.67 \times 10^{-8} \times 6042^4)}$ re-arrange and substitution (**ecf** on T and L) $A = 1.12 \times 10^{22}$ m^2 [1]		1				
				$4\pi R^2 = 1.12 \times 10^{22}$ $R = 2.98 \times 10^{10}$ [m] (**ecf** on A) [1]		1		5	5	
	(c)			Reference to the term multi-wavelength astronomy [1] Early photographs used visible wavelengths only [1]… … revealing few processes [1] **Or** (for last two marks) (subsequent) use of large range of e-m wavelengths [1]…. …. has revealed different processes. [accept specific examples] [1]			3	3		
				Question total	**3**	**4**	**6**	**13**	**5**	**0**

#7

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			Nebula, protostar, mid star, red giant, planetary nebula, white dwarf, black dwarf		1		1		
	(b)			Radiation/light not absorbed by atmosphere			1	1		
	(c)			Any one of these 4 marked [with a cross]. If more than one marked then follow the rule 1 right + 1 wrong = zero 		1		1		
	(d)			Photons collide with matter in star (or equivalent) [1] Force is rate of change of momentum [1] Light has momentum (or $p = \frac{h}{\lambda}$) [1]	1 1	1		3		
	(e)			More massive linked to greater gravitational force [hence density greater] [1] Greater density linked to increased [rate of] fusion [1] Reference to energy released <u>by fusion</u> e.g. more energy released [1]		3		3		
	(f)	(i)		$\lambda = \frac{0.0029}{T}$ used [1] Answer = 145 n[m] or $\frac{0.0029}{20\,000}$ seen (accept 17 000 K to 22 000 K from the graph) [1]	1	1		2	1	
		(ii)		Better to use UV or more radiation in UV or peak emission is not in visible range [1] [But] hot stars also emit visible light [more than colder stars] [1]			2	2		
	(g)			Choice of equation 1 e.g. $0.23 \times 0.2^{2.3}$ (=0.0057) [1] In (approximately) correct place (don't allow as a guess) [1]			2	2	2	
	(h)			Correct use of equation 3 e.g. $1.5 \times 10^{3.5}$ or 4 743 [1] Stated that luminosity or power or rate of use of fuel is 5 000× or 4 743× greater [1] Relevance of factor of 10 understood [1] Factor of 10 $M_\odot$ and 5 000 $L_\odot$ combined for a conclusion [1] e.g. $\frac{10}{5\,000}$ seen or $\frac{10}{4\,743}$ or worded answer e.g. although burning 5 000× faster, it has 10× more fuel so 500× less lifetime		4		4	2	
	(i)			As mass increases radius decreases or vice versa	1			1		
				Question 8 total	**4**	**11**	**5**	**20**	**5**	**0**