Mark Scheme

Q1.

Question Number	Answer	Mark
	A	1

Q2.

Question Number	Answer	Mark
	B	1

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	D	1

Q5.

Question Number	Answer	Mark
	D	1

Q6.

Question Number	Acceptable answers	Additional guidance	Mark
	B		**1**

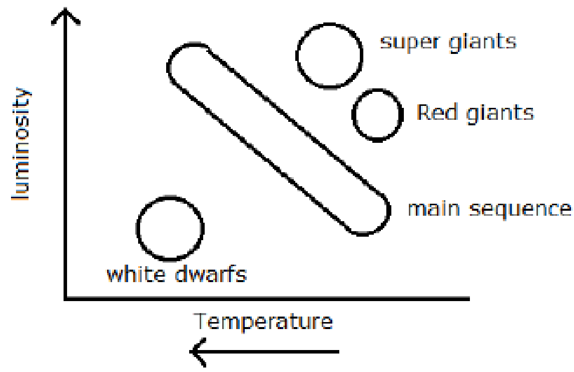
Q7.

Question Number	Answer	Mark
	B – (point on graph with luminosity ≠ $L_\odot$)	**1**
	Incorrect Answers: A – luminosity ≠ $L_\odot$ C – luminosity ≠ $L_\odot$ D – luminosity ≠ $L_\odot$	

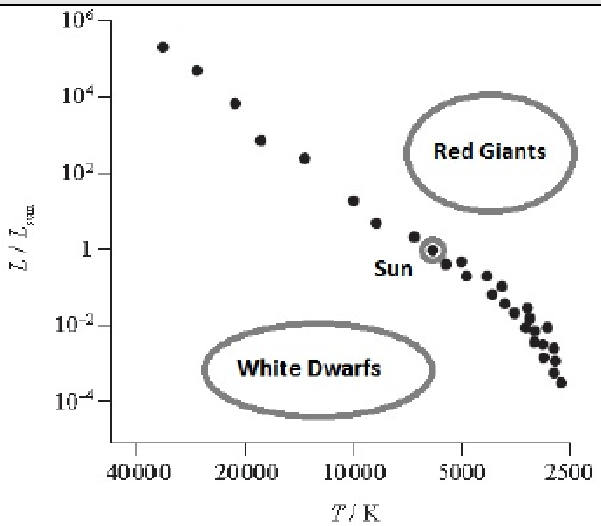
Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	A description that makes reference to the following: • (main sequence) stars are (primarily) converting hydrogen to helium in their core (1) • stars on main sequence maintain a constant luminosity (for most of their lifetime) (1)		**(2)**

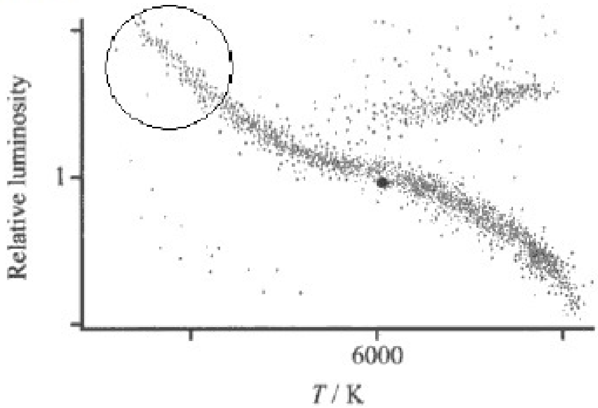
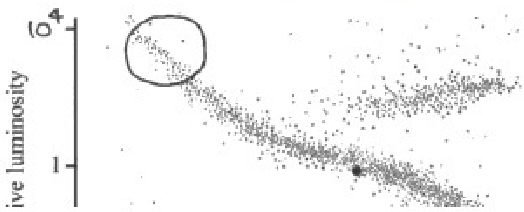
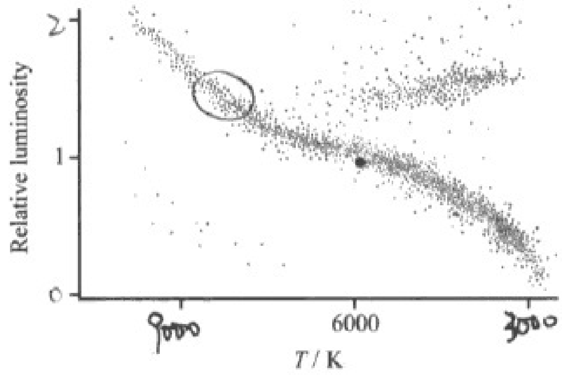
Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	• *y* axis: luminosity (/ luminosity of Sun) (1) • *x* axis: (surface) temperature, with indication of decreasing temperature (1) • 2 or 3 correct regions (1) • 4 correct regions (1)	Example of graph:  	**(4)**

Q10.

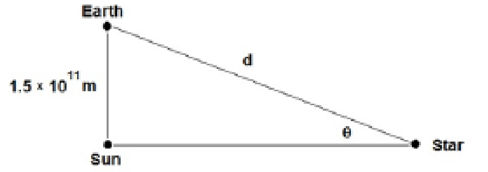
Question Number	Answer		Mark
	 		
(i)	Sun's position identified [single point identified]	(1)	
(ii)	White dwarf region Red giant region	(1) (1)	3
*(iii)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) White dwarf stars have: high temperature T (because λ_{max} is small) low luminosity L $L = \sigma A T^4$ linked to a determination of the surface area	 (1) (1) (1)	3

Q11.

Question Number	Answer		Mark
(a)	Luminosity scale: Log scale [$10^3 \rightarrow 10^6$ (top) and $10^{-3} \rightarrow 10^{-6}$ (bottom)]	**(1)**	
	Temperature scale: reverse log/power scale [e.g. 12,000 (left) and 3000 (right)]	**(1)**	**2**
(b)(i)	(Fusion of) hydrogen into helium [accept symbols]	**(1)**	**1**
(b)(ii)	Circle around stars top left of main sequence [included in the area indicated below] 	**(1)**	
	Max 2 They have the highest temperatures **Or** they are the most luminous [accept brightest]	**(1)**	
	(Because) they fuse H (into He) at the highest/higher rate (Because) they have the largest/larger gravitational forces	**(1)** **(1)**	**3**
	[Max 1 mark if no comparative]		
	 Both scale marks and correct area identified		
	 Neither scale mark and area too low		

	Total for question	**6**

Q12.

Question Number	Answer	Mark
(a)	**Max 6** The young star cluster consists (mainly) of main sequence stars **(1)** The old star cluster has a truncated main sequence **(1)** The old star cluster has lost its heaviest main sequence stars **(1)** The old star cluster has (many) red giant stars **(1)** The old star cluster has (some) white dwarf stars **(1)** Massive main sequence stars are the first stars (to deplete sufficient hydrogen in their core) to evolve into red giant stars. **(1)** Some red giant stars have evolved into white dwarf stars in the old cluster **(1)**	**6**
(b)(i)	Star A is closer to Earth than Star B **(1)**	**1**
(b)(ii)	 Use of appropriate trigonometric relationship **(1)** $d = 4.0 \times 10^{16}$ m **(1)** <u>Example of calculation:</u> $\sin\theta = \dfrac{1.5 \times 10^{11}\text{ m}}{d}$ $d = 4.01 \times 10^{16}$ m	**2**

(c)	$\lambda_{max} = 1.0 \times 10^{-6}$ m **(1)** Use of $\lambda_{max} T = 2.9 \times 10^{-3}$ **(1)** $T = 2900$ K **(1)** <u>Example of calculation:</u> $T = 2.9 \times 10^{-3}$ m K/1.0 × 10^{-6} m = 2900 K	**3**
	Total for question	**12**

Q13.

Question Number	Answer		Mark
(a)(i)	Reverse direction for temperature [at least 2 values seen] Logarithmic/power temperature variation [at least 3 realistic values seen increasing by the same factor]	(1) (1)	**2**
(a)(ii)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Area 1: Max 2** The Sun is fusing/burning hydrogen (into helium in its core) When (hydrogen) fusion/burning ceases the core of the Sun cools [accept radiation pressure drops when fusion/burning ceases in the core] The core collapses/contracts (under gravitational forces) **Area 2: Max 2** The Sun expands and becomes a red giant The core becomes hot enough for helium fusion/burning to begin (in the core) Helium begins to run out and the core collapses again (under gravitational forces) **Area 3: Max 2** Idea that outer layers of Sun are ejected into space The temperature doesn't rise enough for further fusion to begin The core/Sun becomes a (white) dwarf star	 (1) (1) (1) (1) (1) (1) (1) (1) (1)	**6**

(b)(i)	Idea of a very high temperature [accept value of about 10^7 K] To overcome repulsive/electrostatic forces between protons/nuclei **Or** so that protons/nuclei get close enough together for the strong (nuclear) force to act **Or** so that protons/nuclei get close enough to fuse Idea of a very high density [accept pressure] to give a sufficient collision rate	(1) (1) (1)	**3**
(b)(ii)	Attempt at calculation of mass deficit Use of $\Delta E = c^2 \Delta m$ Attempt at conversion from J to (M)eV $\Delta E = 12.9$ (MeV) [If correct mass defect in kg is converted into u and then 1u = 931 Mev used, then full marks may be awarded] Example of calculation $\Delta m = ((5.008238 \times 2) - 6.646483 - (1.673534 \times 2)) \times 10^{-27}\,\text{kg}$	(1) (1) (1) (1)	**4**

	$\Delta m = 2.2925 \times 10^{-29}$ kg $\Delta E = \left(3.00 \times 10^{8}\,\text{ms}^{-1}\right)^2 \times 2.2925 \times 10^{-29}\,\text{kg} = 2.063 \times 10^{-12}\,\text{J}$ $\Delta E = \dfrac{2.063 \times 10^{-12}\,\text{J}}{1.60 \times 10^{-13}\,\text{J MeV}^{-1}} = 12.9\,\text{MeV}$	
	Total for question	**15**