GCE A LEVEL MARKING SCHEME

SUMMER 2018

A LEVEL
PHYSICS - COMPONENT 2
A420U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2018 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

Eduqas A LEVEL COMPONENT 2 – Electricity and the Universe

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response question).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao	=	correct answer only
ecf	=	error carried forward
bod	=	benefit of doubt

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)	Resistance of LDR / circuit increases [as light intensity decreases] (1) [Hence] current decreases (1)	2			2		2
		(ii)	**Either:** Current in LDR $= \frac{4.0}{2.4 \times 10^{-3}}$ = [1.67×10^{-3} A] (1) $R = \frac{5.0}{1.67 \times 10^{-3}}$ (1) R = 3.0 kΩ (1) **Alternative:** 4.0 = $\frac{2.4 \times 10^3 \times 9.0}{(2.4 \times 10^3 + R)}$ (1) [substitution into potential divider equation] Correct algebra (1) R = 3.0 kΩ (1) **Alternative:** $\frac{4}{5}$ (1) $= \frac{2.4}{R}$ (1) R = 3.0 kΩ (1)	1	1 1		3	2	3
	(b)		Light from lamp will decrease [LDR resistance and hence] V across lamp low so lamp not activated (1) Hence reason for on/off, e.g. lamp off → LDR in dark → V_{out} high → lamp on		2		2		2
			Question 1 total	**3**	**4**	**0**	**7**	**2**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	Rate of charge flow Accept $I = \frac{\Delta Q}{\Delta t}$ only if ΔQ and Δt defined [accept Q and t]	1			1		
		(ii)	J C^{-1} **and** C s^{-1} **as units of *V* and *I*** respectively clearly shown (1) Correct division seen i.e. $\frac{\text{JC}^{-1}}{\text{Cs}^{-1}}$ seen (1) Or from alternative correct expression, e.g. $R = \frac{V^2}{P}$ Or equivalent in terms of quantities.	1	1		2	1	
	(b)	(i)	I through R_P = 1.2 A **and** I through R_T = 0.8 A (1) $\frac{V_\text{P}}{V_\text{T}} = \frac{1.2R_\text{P}}{0.8R_\text{T}}$ (=1.5) seen (1) **Or** Parallel combination calculated as $\frac{2}{3}R$ (1) Potential divider: $\frac{R}{R+\frac{2}{3}R} \times 9 = 1.5$ (1)		2		2	1	

		(ii)	$2.5V_T = 9.0$ **or** $\frac{5V_P}{3} = 9.0$ (1) $V_T = 3.6$ V or $V_P = 5.4$ V (1) Award 2 marks for **either** V_P **or** V_T calculated correctly. $R_T = \frac{3.6}{0.8} = 4.5\ \Omega$ **or** $R_P = \frac{5.4}{1.2} = 4.5\ \Omega$ or $\frac{1.8}{0.4} = 4.5\ \Omega$(1) **Alternative:** Total circuit $R = \frac{9.0}{1.2} = 7.5\ \Omega$ (1) Parallel and series combination shown to be = $\frac{5R}{3}$ (1) $\frac{5R}{3} = 7.5$ and $R = 4.5\ \Omega$ (1) **Alternative:** Understanding that $V_p + V_T = 9$ (1) $1.2R_p + 0.8R_T = 9$ (1) (award 2 marks for this only) $R_p = R_T = R$ and $R = \frac{9}{2} = 4.5\ \Omega$ clearly shown (1) Accept reverse argument.		3		3	3	

	(c)		P (circuit) = 10.8 W (1) (either $\frac{81}{7.5}$ or $(1.2)^2 \times 7.5$ or 1.2×9) P in $R_Q = (0.4)^2 \times 4.5 = 0.72$ W (1) $\frac{10.8}{0.72} = 15$ seen (1) **Alternative:** $P_s = P_Q$ since $I_s = I_Q$ $P_T = 4 \times P_Q$ since $I_T = 2 \times I_Q$ $P_P = 9 \times P_Q$ since $I_P = 3 \times I_Q$ Hence total circuit power = $P_Q + P_Q + 4P_Q + 9P_Q$ $= 15P_Q$ Award (1) for correct individual power analysis Award (1) for correct reason linked to currents Award (1) for showing correct total P		3		3	2	
	(d)		Circuit resistance increases, leading to total current decreasing. Power dissipated in circuit decreases (1) V across R_Q has increased (from 1.8 V to 3.0 V), so P_Q increases / I through R_Q has increased (from 0.4 A to 0.67 A) so P_Q increases (1) Hence ratio decreases (1) [only award from correct explanation] Accept numerical explanation: e.g. Circuit resistance is now 13.5 Ω **and** circuit current = 0.67 A (1) circuit power shown to be 6 W **and** P_Q shown to be 2 W (1) Hence ratio decreases or is now 3 (1) **Alternative:** With T removed, I through all remaining resistors is the same or V across each is the same (1) Use of VI or I^2R or V^2/R **or** power **/** energy dissipated in all three resistors equal (1) So total $P = 3 \times P_Q$ **or** which is less than $15P_Q$ (1)		3		3		
			Question 2 total	**2**	**12**	**0**	**14**	**7**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*			Test wire and reference wire made from the same material (or identical) (1) Do not accept reference to common support. [Change in] temperature will affect both **equally** (1)			2	2		2
	(b)			$A = \pi\,(0.08 \times 10^{-3})^2$ and conversion to m^2 $A = 2.01 \times 10^{-8}$ [m^2] (1) % Uncertainty = $\frac{(0.01)\times 100}{0.16}$ (1) (= 6.25%) $\times$ 2 [doubling ecf] (= **12.5% / 13%**) (1) [accept 3 s.f.] (award 2 marks if 12.5% or 13% seen)		3		3	3	3
	(c)			Correct reference to uncertainty taken as ruler resolution i.e. 1 mm (or 1×10^{-3} m) (1) ecf on same mistake in resolution as *(b)* Calculation of % uncertainty: 0.059% (or 0.06%) (1) Answer gains both marks	1	1		2	1	2
	(d)	i	I	Error bars correctly included for all points ± 2 small divisions on extension axis		1		1	1	1
			II	Lines for steepest and least steep gradients drawn appropriately (1) [do not accept lines through the origin] Steepest gradient calculated: [1.5 to 1.6 N mm^{-1}] (1) Least steep gradient calculated: [1.3 to 1.4 N mm^{-1}] (1)		3		3	3	3

(d)(ii) MAX GRADIENT $= \frac{8.9}{5.7} = 1.561\ \text{Nmm}^{-1}$ ✓

MIN GRADIENT $= \frac{8.3}{6.1} = 1.361\ \text{Nmm}^{-1}$ ✓

d(iii) MEAN GRADIENT $= \frac{1.561 + 1.361}{2} = 1.461$ ✓

$\%\ \text{uncertainty} = \left(\left(\frac{1.561 - 1.361}{2}\right) \div 1.461\right) \times 100$ ✓

$= 6.8\%$

d(iv) $E = \text{gradient} \times \frac{l}{A}$ ✓

$E = \frac{1.461 \times 10^{3} \times 1.68}{2.01 \times 10^{-8}}$

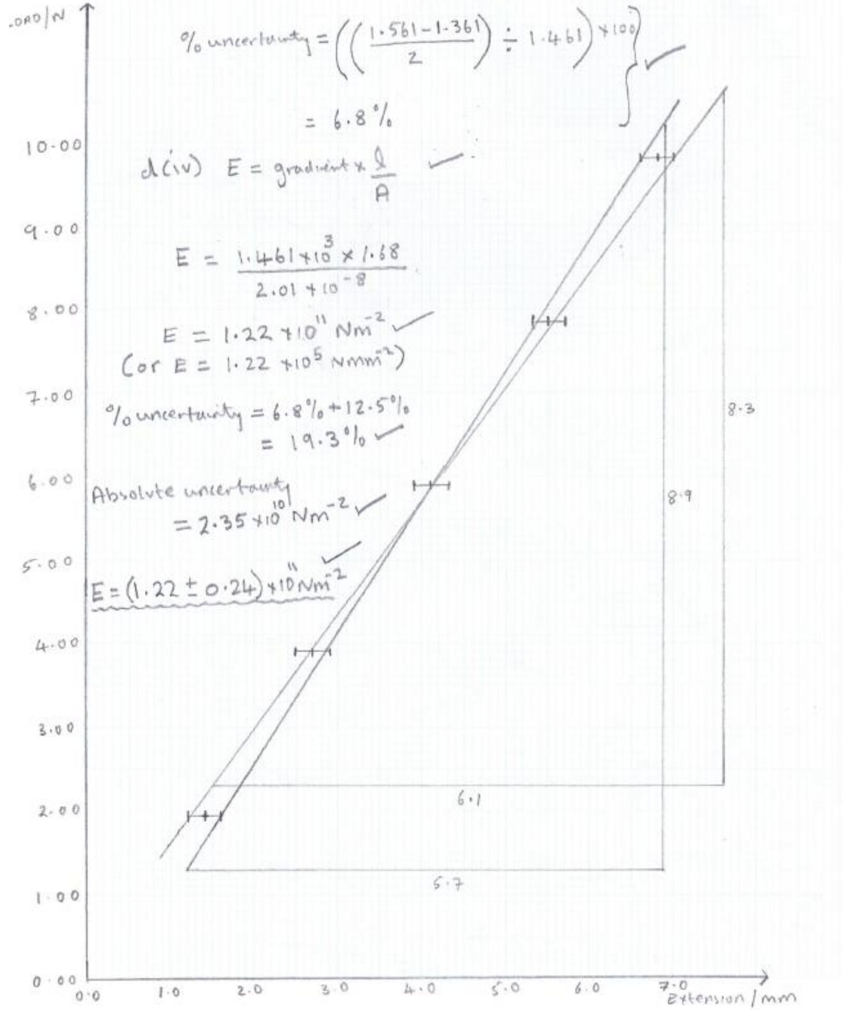
$E = 1.22 \times 10^{11}\ \text{Nm}^{-2}$ ✓

(or $E = 1.22 \times 10^{5}\ \text{Nmm}^{-2}$)

$\%\ \text{uncertainty} = 6.8\% + 12.5\%$
$= 19.3\%$ ✓

Absolute uncertainty
$= 2.35 \times 10^{10}\ \text{Nm}^{-2}$ ✓

$E = (1.22 \pm 0.24) \times 10^{11}\ \text{Nm}^{-2}$ ✓



			(ii)	Mean gradient calculated correctly using answers to d(i): expect 1.4 to 1.5 N mm^{-1} (1) ecf % uncertainty in mean calculated: expect 6%-10% (1) ecf		2		2	2	2
	(e)			Understanding shown that E = gradient $\times \frac{l}{A}$ (1) [or by implication] [not awarded for use of data point rather than line] Substitution and value of E found to any sig fig and using any unit (does not need to be given).e.g. $E = 1.22 \times 10^{11}\ \text{N m}^{-2}$ (1) ecf on *A*. Total % uncertainty calculated from (b) [+ (c)] + (d)(ii) e.g. 7% + 12.5% = 19.5% (1) ecf Absolute uncertainty calculated: e.g. $2.38 \times 10^{10}\ \text{N m}^{-2}$ (1) Answer and uncertainty to appropriate sig figs with correct unit: e.g. $E = (1.22 \pm 0.24) \times 10^{11}\ \text{N m}^{-2}$ or $(1.2 \pm 0.2) \times 10^{11}\ \text{N m}^{-2}$ (1)			5	5	4	5
	(f)			Diameter (1) Use 'thicker' wire or more accurate measuring instrument (or instrument with higher/greater resolution) (1) Apply ecf if candidate's gradient uncertainty greater than candidate's calculation of uncertainty in area: Extension (1); use a micrometer for extension			2	2		2
				Question 3 total	**1**	**10**	**9**	**20**	**13**	**20**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)	Some context e.g. Consider matter within [shell of] radius R (assuming homogenous universe) [credit from diagram] Mass within shell = $\frac{4}{3}\pi R^3 \times \rho$ (1) $\frac{1}{2} mv^2 - \frac{GMm}{R}$ = 0 (or equivalent) (1) Substitution of $v = H_0 R$ (or equivalent, e.g. $H_0 D$) (1) Convincing algebra (1)	4			4	3	
		(ii)	Correct substitution of H_0 and G leading to $\rho_c = 8.7 \times 10^{-27}$ kg m^{-3} (1) $\frac{8.7 \times 10^{-27}}{1.66 \times 10^{-27}}$ = 5.2 (m^{-3}) (approx. 5 atoms of hydrogen m^{-3}) (1) Alternative for 2nd mark Calculation of mass of 5H m^{-3} using 5×molar mass / $N_A \rightarrow 5.3 \times 10^{-27}$ kg m^{-3} (1) **Alternative** Density of 5 H atoms m^{-3} = $5 \times 1.66 \times 10^{-27}$ = 8.3×10^{-27} kg m^{-3} (1) Correct substitution of H_0 and G leading to $\rho_c = 8.7 \times 10^{-27}$ kg m^{-3} + comment [e.g. similar] (1)		2		2	1	
	(b)	(i)	Due to expansion of universe [or space-time] / cosmological red shift or galaxy is moving away from earth or Doppler shifted (1) 'Red shift' only is not enough	1			1		
		(ii)	Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ where $\frac{\Delta\lambda}{\lambda}$ = 0.16 (1) $0.16 \times 3.00 \times 10^8 = 4.8 \times 10^7$ m s^{-1} (1) $D = \frac{4.8 \times 10^7}{2.20 \times 10^{-18}} = 2.18 \times 10^{25}$ m (1)	1	1 1		3	2	

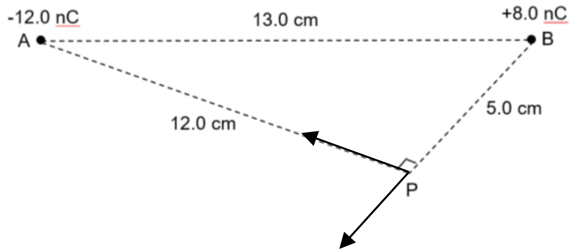
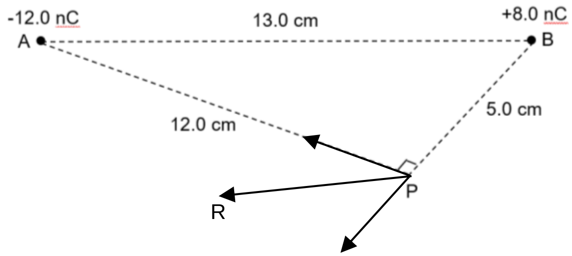
	(c)		Assuming constant recession speeds / universe expands at a constant rate / H_0 constant (since Big Bang) (1) Age of Universe ≈ $\frac{1}{H_0}$ ≈ 4.5[5] × 10^{17} s (1) = 1.4[4] × 10^{10} [years] (1)	1	1 1		3	2	
			Question 4 total	**7**	**6**	**0**	**13**	**8**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5			Indicative content: 1. Reference to $\frac{mv^2}{R} = \frac{GMm}{R^2}$ or equivalent e.g. $v = \left(\frac{GM}{R}\right)^{1/2}$ 2. For small R theory agrees with observation 3. $v^2 \propto$ observed M 4. Observations of [baryonic /ordinary matter show a concentration of mass at the centre leading to …. 5. … For large R theory predicts: $v \propto R^{-1/2}$ [shown by dotted line] [based on observed baryonic matter] 6. Observed line shows v constant or greater than expected. 7. Indicates $M \propto R$ or M greater than expected [or accept even distribution of matter] 8. M is not observed however, indicating missing mass/ dark matter. [possible link to Higgs boson] 9. All stars [matter] orbit centre of galaxy 10. Curves extend beyond visible disc 11. Orbital speeds [of stars and gas clouds] measured using Doppler effect.	6			6		

			5-6 marks **At least 5/6 clear points made** *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** **At least 3/4 clear points made.** *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** **At least 2 clear points made.** *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*						
			Question 5 total	**6**	**0**	**0**	**6**	**0**	**0**

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th></th><th></th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td>capacitance = $\frac{\text{charge (on either plate)}}{\text{pd (between the plates)}}$
Accept charge per unit pd / voltage [between plates] (1)
Accept $C = \frac{Q}{V}$ if Q and V defined</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Q = - 75 nC,
R = + 75 nC,
S = - 75 nC
All numerical values stated as 75 [nC] (1)
Correct signs and unit, i.e. nC (1)
One of: (1)
• Capacitors in series carry equal charges when joined to common pd
• Conservation of charge applies for series circuit [hence if +75 μC moves from A to plate P, the same moves from Q $\rightarrow$ R etc]
• Opposite charge to P (accept R), since connected to negative potential [Accept: battery transfers electrons from P to Q]</td><td>3</td><td></td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Total capacitance = 7.5 nF (1)
$V = \frac{75 \text{ x } 10^{-9}}{7.5 \text{ x} 10^{-9}}$ (ecf on total C)
V = 10 V (1)
Alternative:
Application and substitution into $\frac{Q}{C_1} + \frac{Q}{C_2}$
i.e. $\frac{75 \text{ x } 10^{-9}}{30 \text{ x} 10^{-9}} + \frac{75 \text{ x } 10^{-9}}{10 \text{ x} 10^{-9}}$ (1)
V = 10 V (1)</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
</table>

		(iii)	**Either:** Q same on both capacitors (1) $\frac{1}{2}\frac{Q^2}{C}$ is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis) **Or:** $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ CV^2 bigger across smaller capacitor (V^2 factor) (1) (Award 2 marks for correct numerical analysis) **Or** Q same on both capacitors and $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ QV is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis			2	2		
	(c)		New C = 0.47 pF (1) New $d = 3.0 \times 10^{-3}$ m (1) $\Delta d = 5.2 \times 10^{-3} - 3.0 \times 10^{-3} = 2.2 \times 10^{-3}$ m (1) (**ecf** from new d) Application of $F = k\Delta d$ ecf $k = 91\ \text{N m}^{-1}$ so spring of $k = 90\ \text{N m}^{-1}$ suitable [conclusion consistent with value of F](1) **Alternative 'Trial and Error' :** Application of $x = \frac{F}{k}$ for each spring constant, showing that for: $k = 120\ \text{N m}^{-1}$, $x = 1.67 \times 10^{-3}$ m $k = 150\ \text{N m}^{-1}$, $x = 1.33 \times 10^{-3}$ m $k = 90\ \text{N m}^{-1}$, $x = 2.22 \times 10^{-3}$ m (All required for1) New C = 0.47 pF (1) Application of $C = \frac{\varepsilon_0 A}{d}$ for each value of x above to show that, for $x = 2.22 \times 10^{-3}$ m, $C = 0.475 \times 10^{-12}$ F, so $k = 90\ \text{N m}^{-1}$ suitable. (1)			4	4	3	
			Question 6 total	**4**	**2**	**6**	**12**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		Electric field strength, E, is the force per unit charge [on a small positive test charge placed at the point]. (1) Electric potential, V, [at a point] is the work done per unit charge [in bringing the charge] from infinity [to that point]. (1) E- vector **and** V- scalar (both needed) (1)	3			3		
	(b)	(i)	 Both arrows seen. Ignore length of arrows. [Must be along dotted lines]	1			1		
		(ii)	 R correctly drawn and labelled [ecf]. Ignore length of arrow.		1		1		
		(iii)	E at P due to A (–12.0 nC) = 7 500 N C^{-1} (1) E at P due to B (+8.0 nC) = 28 800 N C^{-1} (1) (Deduct 1 mark for powers of 10 error) Resultant field strength at P = $(7\,500^2 + 28\,800^2)^{1/2}$ = 29 760 N C^{-1} (1) (**ecf** on both values of E) [or using horizontal and vertical components] Correct trigonometric relationship applied e.g. between R and A: $\theta = \cos^{-1}\left(\dfrac{7500}{29760}\right)$ = 75.4° (or 14.6° between R and B) [accept 2 sf and different ways of expressing directions] (1)		4		4	4	

	(c)	(i)	V_P due to A (–12.0 nC) =[–] 900 V V_P due to B (+ 8.0 nC) = [+] 1 440 V **Both potentials regardless of signs** (1) Correct sign convention [and addition clearly shown] (= + 540 V) (1) **Alternative** $\therefore V_P = \frac{1}{4\pi\varepsilon}\left\{\frac{-12\times10^{-9}}{12\times10^{-2}} + \frac{8\times10^{-9}}{5\times10^{-2}}\right\}$ values(1) and signs (1)		2		2	2	
		(ii)	Correct substitution into $W = q\Delta V$ i.e -1.6 × 10^{-19} (+540 – 0) (1) **Or** W = - 8.64 × 10^{-17} J seen (accept 540 eV converted into J) Hence gain in E_k = (+) 8.64 × 10^{-17} J (1) (+) can be awarded by implication	1	1		2	1	
	(d)		de Broglie $\lambda = \frac{h}{p}$ (1) Electron accelerates (or velocity or E_k increases) towards point P, **so** momentum increases (need to explain why momentum increases here) (1) So λ decreases (1) Ecf from (c) on marks 2 and 3: If ΔE_k < 0 then opposite answer required.	1	1 1		3		
			Question 7 total	**6**	**10**	**0**	**16**	**7**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	(i)	Reference to expected relationship: i.e. $I \alpha \frac{1}{R^2}$ (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 $P = 4\pi R^2_{\text{sun}}\sigma T^4$ (**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. $R_{\text{sun}} = 7.0 \times 10^8$ m (1) **Or:** Luminosity from *(a)*(ii) (**ecf**) and radius substituted into $P = 4\pi R^2_{\text{sun}}\sigma T^4$ (1) T calculated [expect 5830 K] (1) λ_{peak} calculated from Wien's law [5830 K $\rightarrow$ 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**

A LEVEL COMPONENT 2: Electricity and the Universe

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	3	4	0	7	2	7
2	2	12	0	14	7	0
3	1	10	9	20	13	20
4	7	6	0	13	8	0
5	6	0	0	6	0	0
6	4	2	6	12	5	0
7	6	10	0	16	7	0
8	1	1	10	12	7	0
TOTAL	**30**	**45**	**25**	**100**	**49**	**27**