GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
PHYSICS – COMPONENT 3
A420U30-1

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INTRODUCTION

This marking scheme was used by WJEC for the 2020 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.

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GCE A LEVEL PHYSICS COMPONENT 3

LIGHT, NUCLEI AND OPTIONS

AUTUMN 2020 MARK SCHEME

GENERAL INSTRUCTIONS

The mark scheme should be applied precisely and no departure made from it.

Recording of marks

Examiners must mark in red ink.

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

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.

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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

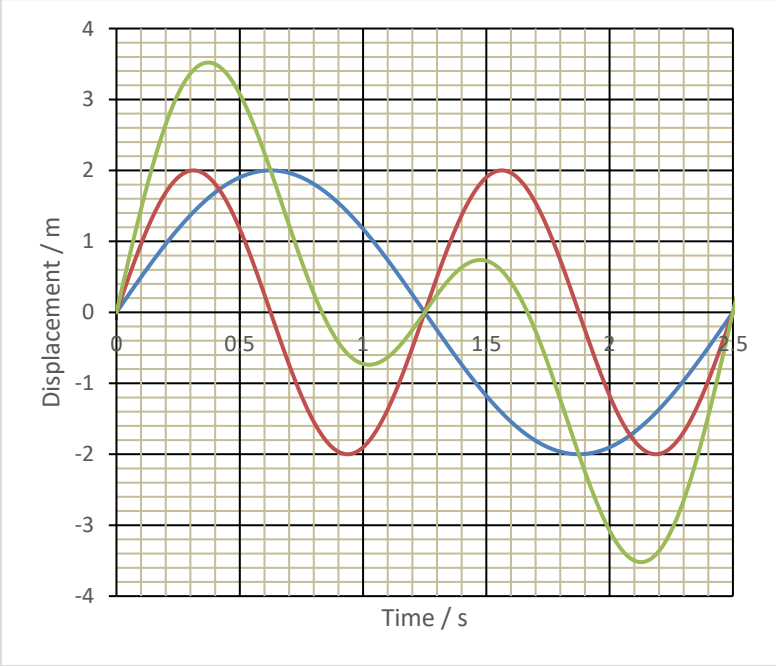
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1.	(a)		Matter also transferred / no vibrations involved (1) So wrong (1) Accept de Broglie wavelength argument for 1 mark			2	2		
	(b)	(i)	Holes far smaller than wavelength of micro (1) So nothing passes (1) Light wavelength far smaller than 2 mm (so little or no diffraction) (1)	1 1	1		3		
		(ii)	1.6-3.3 eV or 2.56-5.28 $\times$ 10^{-19}J (or calculation leading to said numbers)	1			1		
		(iii)	Smaller because f smaller or lambda longer		1		1		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Evidence of application of superposition e.g. 0 s (1) 0.4 and 2.1 s correct i.e. 3.4/3.6 and -3.4/-3.6 (1) 1 s and 1.5 s i.e. -0.7 and +0.7 (1) Smoothish curve through points (1) 		4		4	2	
			Question 1 total	**3**	**6**	**2**	**11**	**2**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2.	(a)		Substitution into $p = \frac{h}{\lambda}$ (1)	1					
			Use of KE = 2 200 e (1)		1				
			Answer = 2.62×10^{-11} [m] (1)		1		3	3	
	(b)		Incident on thin crystal/graphite accept reflected off crystal (1)	1					
			Pattern/concentric rings viewed on screen (1)	1					
			Pattern closer due to smaller wavelength (1)		1		3		3
			Question 2 total	**3**	**3**	**0**	**6**	**3**	**3**

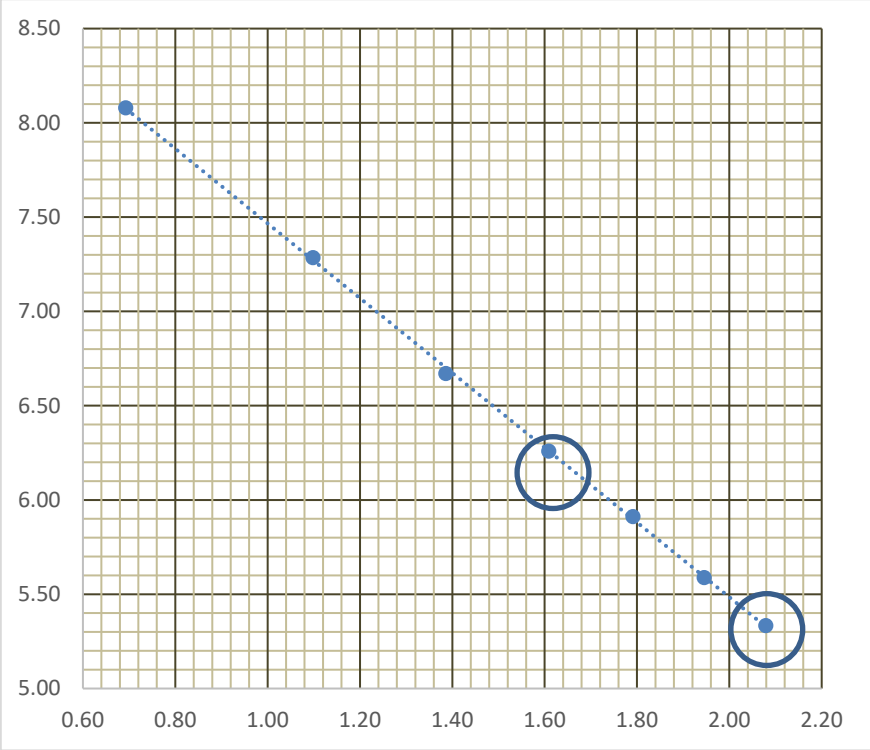
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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3.	(a)	(i)	Use tan to find sin e.g. 10.23° or 0.1776 seen (1) can be implied Correct conversion of d i.e. $d = \frac{1}{300\,000}$ (1) Substitution in diffraction grating equation for n = 1 e.g. $\lambda = \frac{0.178}{300}$ Leading clearly to correct answer (1)		3		3	2	3
		(ii)	A correct percentage uncertainty i.e. 0.10 or 0.13 **OR** 0.28 or 0.3(1) Correct percentage uncertainty for tanθ (0.28 or 0.3) (1) Adding percentage uncertainties (0.38) or 0.4 or 0.41 (1) $\frac{592 \text{ x } 0.38}{100}$ or similar seen (1) NOTE: accept fractional uncertainty throughout instead of %		4		4	4	4
	(b)		Value is inside uncertainty (of both values) OR overlap region is 593-594 nm (1) Hence agreement (1)			2	2		2
	(c)		Smaller distance (same uncertainty) (1) Larger percentage/fractional uncertainty (1) Accept converse argument **if referring to n = 2 data**			2	2		2
			Question 3 total	**0**	**7**	**4**	**11**	**6**	**11**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4.	(a)		Electron drops giving 2 photons (1) (Stimulated by) incoming photon of correct energy / wavelength (1)	2			2		
	(b)		Short lifetime (1) Above ground level **OR** level above is metastable / long T (1)	2			2		
	(c)		1 % lost each round trip (due to transmission) (1) Equilibrium requires 1 % gain or WTTE (1) Which is 0.5 % each length & Victoria is correct (or similar) (1) **Award a maximum of 2 marks -** David is correct because large amplification (1) must counteract other losses (1)			3	3		
			Question 4 total	**4**	**0**	**3**	**7**	**0**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5.	(a)		1.61 and 2.08 for ln distance (1) 600 × 0.4 seen (or 240 counts or implied) (1) ln(corrected) answers = 6.26 and 5.33 (implies previous) (1)		3		3	2	3
	(b)		 One mark each for the circled points plotted correctly		1		1	1	1

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Line of best fit as shown above (1) Correct method for gradient (1) Gradient = -1.98 (allow ± 0.05) (1)		3		3	3	3
	(d)		Taking logs correctly e.g. $\log C = \log k - 2 \times \log d$ (1) Comparison with $y = mx + c$ **OR** gradient clearly identified (1)		2		2	2	2
	(e)		Gradient agrees well with inverse square law (1) Points are close to line of best fit (1) Line of best fit is straight (1)			3	3		3
	(f)		Absorbs other radiation	1			1		1
	(g)		Ionising (1) Kills cells / causes cancer / DNA damage / causes cataracts etc. (1) Hence unethical & linked to risk (1)			3	3		
			Question 5 total	**1**	**9**	**6**	**16**	**8**	**13**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6.			**Indicative content:** 1. Names - electron, positron (anti-electron), neutron, anti-proton, pion/pi meson 2. Fundamental/composite - electron&positron fundamental others not 3. Leptons - electron & positron (anti-lepton) OR lepton numbers 4. Hadrons - neutron, anti-proton & pion 5. Baryons & mesons - neutron (B), anti-proton (anti-baryon), pion - meson OR baryon numbers 6. Quarks - neutron - 3 quarks, anti-proton - 3 anti-quarks, pion - quark + anti-quark 7. Strong force - felt by hadrons or quarks only 8. Weak force - felt by all particles OR accept leptons 9. E-M force - felt by all charged particles 10. Make-up - udd, $\mathbf{\overline{uud}}$, $\mathbf{\bar{u}d}$ 11. Charge - -1, +1, 0, -1, -1 12. Anti-particles - positron for electron and anti-proton mentioned	6			6		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks 7-12 points – all particles considered There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** 3-6 points – majority of particles considered There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** 1-2 points – a few particles considered 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 6 total	**6**	**0**	**0**	**6**	**0**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7.	(a)		4,2 for helium (1) 205, 81 for thalium (1)	1	1		2		
	(b)		**Binding energy method:** BE of Bi = 7.87 × 209 (=1 644.83) (1) Correct method for working out mass defect of He or Tl (1) Conversion of mass defect to energy i.e. ×931 **or** $E = mc^2$ (1) Values correct for BE 28.40 and 1 620.03 (1) Final answer = 3.6 MeV (1) **Alternative:** Calculating mass of 83p and 126n (=210.7021 u) (1) BE of Bi = 7.87 × 209 (=1 644.83) (1) Subtracting mass defect for Bi mass (=208.9354 u) (1) LHS mass - RHS mass (=0.0039 u) (1) Final answer = 3.63 MeV (1)			5	5	4	
	(c)	(i)	Sub into half-life = $\frac{0.693}{\lambda}$ (gives 1.16 × 10^{-27}) (1) Number of mol = $\frac{1}{209}$ **OR** mass of 1 atom = 209 × 1.66 × 10^{-27} (1) Number of nuclei/atoms = 2.88 × 10^{21} (1) Answer = 3.3 × 10^{-6} Bq (1) **unit mark**	1	1 1 1		4	4	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	3.3×10^{-6} **ecf** $\times 5 \times 365 \times 24 \times 3\,600$ OR $N = N_0 e^{-\lambda t}$ used (1) Answer = 525 (1)		2		2	2	
			Question 7 total	**2**	**6**	**5**	**13**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8.	(a)		$\frac{1}{2}mv^2 = eV$ applied (1) $d = vt$ used (1) $s = \frac{1}{2}at^2$ used for vertical motion (1) $a = \frac{Vq}{md}$ (1) Substitutions & ok algebra (1)	1	1 1 1 1		5	5	
	(b)		Both are -ve charges **OR** move same direction (1) Independent of m and q, hence, yes (1)			2	2		
			Question 8 total	**1**	**4**	**2**	**7**	**5**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
9.	(a)		2.1 eV required to free electron **OR** subbing into Einstein's (1) Remainder (8.2 eV) can become KE (1) 8.2 V corresponds to 8.2 eV (for electrons) (1) +ve will stop electrons from escaping (or attractive force) (1) Hence, +8.2 V is just enough to stop any electrons escaping (or any greater and the electrons can't escape etc.) (1)	1 1	 1 1 1		5		
	(b)		$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ quoted **OR** used **OR** implied (1) Hence, $E = \frac{V}{r}$ **OR** Q obtained using V equation (59.3 pC) (1) Answer = 126 [V m^{-1}] **OR** 1.26 if [V cm^{-1}] (1)	1	 1 1		3	2	
			Question 9 total	**3**	**5**	**0**	**8**	**2**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
10.	(a)	(i)	Answer = 57.3 m[T]	1			1	1	
		(ii)	Shape correct (minimum 3 lines) (1) Direction correct (no contradicting arrows) (1)	2			2		
		(iii)	Iron core	1			1		
	(b)	(i)	Change in flux (1) Complete circuit **OR** low resistance (1) Large rate of change of flux **OR** large flux & small t (1)		3		3		
		(ii)	Use FRHR **OR** use FLHR on electrons **OR** RH grip (1) on bottom part **OR** in bottom part **OR** induced field opposes (1)	1	1		2		
		(iii)	Faraday's law used e.g. 2.18 V **OR** $\frac{BA}{t}$ seen (1) $I = \frac{V}{R}$ used (1) Answer = 323 [A] (1)	1 1	 1		3	2	
		(iv)	Use of $F = BIL$ **ecf** (1) Answer = 205 [N] (1) Opposes motion (1)			3	3	2	
			Question 10 total	**7**	**5**	**3**	**15**	**5**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
11.	(a)		Correct phasor diagram, labelled Explanation of subtracting reactances Pythagoras or similar for final step 	3			3		
	(b)	(i)	Substitution into $X_L=\omega L$ (1) Substitution into $X_C=(\omega C)^{-1}$ (1) 511-91 = 420 [Ω] (1)	1 1	1		3	1	
		(ii)	420√2 or similar seen for impedance e.g.$\sqrt{R+R}$ (1) Use of $I=\frac{V}{Z}$ (1) Answer = 7.58 m[A] (1)		3		3	3	
		(iii)	45°		1		1	1	
		(iv)	Shape correct (1) Max current = 10.7 m[A] (approx., by eye) (1) Explanation or horizontal line right from 4 150 Hz point (1)	1	1 1		3	1	
		(v)	Either X_L = 511 or X_C = 91 used **OR** quadratic equation set up (1) Answer = 23 250 [Hz] (1)		2		2	1	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Period = 0.333 m[s](1) So 1 cycle is 3.33 [cm] (1) Peak pd is 0.85 [V] (1) i.e. 4 and a bit squares (1) Conclusion: Time scale OK, volts/div not quite (1)			5	5	3	
			Question 11 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
12.	(a)	(i)	Curve identical to the original (including the line spectrum in the same place) but all the curve above the original with the minimum wavelength below original but not at (0,0)		1		1		
		(ii)	Use of $eV = \frac{hc}{\lambda}$ (1) $\lambda = 4.125 \times 10^{-11}$ [m] (1)	1	1		2	2	
		(iii)	Power = $120 \times 10^{-3} \times 30\,000$ (1) Heat production = $(0.9955 \times 3\,600) = 3\,583.8$ or 3 584 [W] (1)	1	1		2	2	
		(iv)	[No] for λ to be zero the voltage must be infinite (all other parts of the expression are constants) / It would require an infinite amount of energy		1		1		
	(b)	(i)	A high freq changing / alternating [electrical] voltage (1) causes the piezoelectric [crystal] to oscillate [producing ultrasound] (1)	2			2		
		(ii)	Time from scale 4.5 ± 0.5 [μs] (1) Distance = $4.5 \times 10^{-6} \times 1\,640 = 7.4 \times 10^{-3}$ [m] (1) Thickness = 3.7×10^{-3} [m] **ecf** (1)		3		3	3	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	CT scan (1) Gives a 3D image (1) In real time/only seconds of delay time (1) **Alternative for last 2 marks** A scan will only measure distance **and** tracers will not detect leaks (1) X-rays 2D **and** not in real time (1) (also poor quality for brain)			3	3		
		(ii)	Radioactive tracer (1) Taken up by the thyroid /detected using a gamma camera (1) **Alternative for the last mark** X-ray, CT and A scan will (only) detect the gland (1)			2	2		
	(d)		At centre B = $\frac{(0.80 + 1.40)}{2}$ **OR** 1.10 [T] (1) $f = 42.6 \times 10^6 \times 1.1 = 46.86 \times 10^6$ [Hz] (1) allow **ecf** $\lambda = \frac{3 \times 10^8}{46.86 \times 10^6}$ = 6.4 m with units (1) allow **ecf** Radio waves (1)	1 1	 1 1 		4	3	
			Question 12 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
13.	(a)	(i)	Moment of inertia of a body about a given axis is defined as $I = \Sigma mr^2$ for all points in the body (1) where m is the mass and r is the distance of each point from the axis (1) accept radius of cricket ball	2			2		
		(ii)	Rotational Kinetic energy $= \frac{1}{2}I\omega^2$ (1) Angular velocity = $(30 \times 2\pi)$ (1) Moment of inertia = 8.3×10^{-5} [kg m^2] (1)	1	1 1		3	2	
	(b)	(i)	Vertical component = 12.5 [m s^{-1}] and horizontal component = 21.7 [m s^{-1}] (1) Time taken for ball to travel 5.6 m = 0.25 s ($\frac{5.6}{21.7}$) (1) Correct substitution of values into $x = ut + \frac{1}{2}at^2$ to determine height after 0.25 s (**ecf**) **OR** calculating times at which height is 2.4 m (1) Height = 2.8 [m] **OR** time is around 0.21 [s] (1) So ball cannot be caught by fielder (1)			5	5	4	
		(ii)	Moving hand in direction of ball will <u>increase time</u> of contact **OR** distance of contact (1) According to $F = \frac{mv-mu}{t}$; **OR** $F = \frac{Wd}{x}$ this will reduce force (1)		2		2		
		(iii)	Re-arranging to determine bounce height as e^2H (1) Bounce height = 0.32 [m] (1)		2		2	2	

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Forces of drag and weight drawn or discussed (1) Lift or Magnus force shown or discussed (1) Resultant of these forces decides motion (1)	3			3		
		(ii)	Effective area of sphere = πr^2 = 4.07 × 10^{-3} m^2 (1) Substituting values into $F_D = \frac{1}{2}\rho v^2 A C_D$ (1) Drag force = 1.19 [N] (1)		3		3	2	
			Question 13 total	**6**	**9**	**5**	**20**	**10**	**0**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
14.	(a)	(i)	$I = \frac{P}{A} = \frac{\mathbf{3.8\times10^{26}}}{\mathbf{4\pi(1.5\times10^{11})^2}}$ = 1 344 [W m^{-2}] (1) Solar constant (1)	1	1		2	1	
		(ii)	Use of $P = \sigma AT^4$ (1) Manip and sub to give $\boldsymbol{T = \sqrt[4]{\frac{P}{\sigma A}} = \sqrt[4]{\frac{1.2\times10^{17}}{5.67\times10^{-8}\times4\pi\times(6.4\times10^{6})^2}}}$ (1) 253 [K] (answer seen) (1)		3		3	3	
		(iii)	Atmosphere and the greenhouse effect (1) Burning fossils fuels/increased livestock farming increase CO_2/methane (1) More IR absorbed (1)		3		3		
	(b)	(i)	High enough temperatures to overcome coulomb repulsion (1) High enough particle density to allow high enough collision rate (1) Long enough confinement time [for more output/reactions] (1)	3			3		
		(ii)	$3.5 \times 10^{28} = \frac{2.4\times10^{22}}{70} \times T \times 0.9$ (1) T = 1.13 $\times$ 10^8 [K] (1)		2		2	2	
	(c)	(i)	[Rate of flow of heat is] 0.030 J s^{-1} (or W) through an area of 1 m^2 (1) when the temperature gradient is 1 K m^{-1}(1) **Alternative:** (Rate of heat flow is) 0.030 J s^{-1} (or W) per unit cross-sectional area (1) per unit temperature gradient (1)	2			2		

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	Gradients calculated: A = [-]0.25 and B = [-]0.5 [°C/mm] (1) Heat flow per unit area same through both materials so temperature gradient $\boldsymbol{\alpha}\ \frac{\mathbf{1}}{\boldsymbol{K}}$ or $\mathrm{K} \times$ temp gradient = constant (1) Material A has 2× thermal conductivity of material B ∴ suggestion is incorrect (1) Use of B's gradient to find $\frac{P}{A} = 0.030 \times 0.5\ \times 10^3 = 15$ W m^{-2} and $U = \frac{P}{A\Delta\theta} = \frac{15}{17}$ or use of thermal resistance (1) = 0.88 W m^{-2} K^{-1} ∴ suggestion is correct or too high as there is no consideration of stationary air layers (1)			5	5	4	
			Question 14 total	**6**	**9**	**5**	**20**	**10**	**0**

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GCE A LEVEL COMPONENT 3: LIGHT, NUCLEI AND OPTIONS

SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	3	6	2	11	2	0
2	3	3	0	6	3	3
3	0	7	4	11	6	11
4	4	0	3	7	0	0
5	1	9	6	16	8	13
6	6	0	0	6	0	0
7	2	6	5	13	10	0
8	1	4	2	7	5	0
9	3	5	0	8	2	0
10	7	5	3	15	5	0
11	6	9	5	20	10	0
12	6	9	5	20	10	0
13	6	9	5	20	10	0
14	6	9	5	20	10	0
TOTAL	**36**	**54**	**30**	**120**	**51**	**27**

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