GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
PHYSICS – COMPONENT 2
A420U20-1

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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 2

ELECTRICTY AND THE UNIVERSE

AUTUMN 2020 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.

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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)			**Before pd applied**: [Free] electrons move randomly/no overall velocity/mean velocity zero/vector average velocity zero [1] **After pd applied:** [Free] electrons accelerated by pd/drift velocity/overall velocity due to pd [1] **Reference to speed either before or after pd applied:** [1] **e.g. either** • [Free] electrons move very quickly/magnitude approx. 10^6 m s^{-1} before pd is applied **or** • Drift velocity is small/magnitude approx. 10^{-3} or 10^{-4} m s^{-1} after pd is applied.	3			3		
	(b)	(i)		Volume = vtA or lA [1] can be obtained from diagram No of free electrons = $vtAn$ or lAn [1] Total charge = $vtAne$ or $lAne$ [1] Current = $\frac{vtAne}{t}$ or $\frac{lAne}{t}$ [1]	4			4	1	
		(ii)		$I_P = I_Q$ seen or implied- e.g. $n_P A_P v_P = n_Q A_Q v_Q$ [1] Substitution e.g. $6.4 \times A \times v_P = 2.0 \times 4A \times v_Q$ [1] Algebra to show $\frac{v_Q}{v_P} = \frac{6.4}{8}$ (or $\frac{4}{5}$ or 0.8) [1]	1	1 1		3	3	
				Question 1 total	**8**	**2**	**0**	**10**	**4**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		Statement that length of error bar = largest reading (of U) – smallest reading (of U) [1] Accept reference from mean point to max or min if clearly stated. Data from one plot to show this e.g. for 6.8 μF capacitor, length of error bar calculated as = 14×10^{-4} - 13.2×10^{-4} [1] [award 1st mark by implication if 2nd mark awarded]		2		2	1	2
		(ii)		Length of horizontal error bar for one data point taken and divided by 2. e.g. for 6.8 μF, (0.65 to 0.70 seen) [1] % tolerance calculated: 10% (Accept 6% to 12%) e.g. $0.68 \times \frac{100}{6.8}$ [1]		2		2	1	2
	(b)	(i)		$U = ½\ CV^2$ used and V shown (by implication possibly) to = (2 × gradient)$^{1/2}$ [1] V_{max} = 22.4 [V] [1] V_{min} = 18.0 [V] [1]		3		3	3	3
		(ii)		Mean $V = \frac{(22.4+18.0)}{2}$ = 20.2 [V] (any sig fig.) [1] Uncertainty = $\frac{(22.4-18.0)}{2}$ = 2.2 [V] (any sig fig) [1] or candidate answers to (i) used correctly (**ecf**) 2 or 3 sig figs seen for mean V and 1or 2 sig figs for uncertainty [1]		3		3	3	3
	(c)			Substitution into $V = V_0 e^{-\frac{t}{CR}}$ [1] Algebra to show either V = 8 V or V_0 = 20 V or t = 35 s or CR value [1] Relevant statement: e.g. value confirmed [1]			3	3	2	3
				Question 2 total	**0**	**10**	**3**	**13**	**10**	**13**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			**Methodology** • Take readings of diameter at more than one point and determine mean diameter. • Tape the wire to the ruler (or move wire close to the ruler) • Ensure wire is taut (kink free) • Obtain values for R for at least 5 different values for l • Most/all of the length of the wire used to take readings from. • Obtain value for resistance of crocodile clips and subtract from each reading of R. **Analysis** • Calculate CSA from $\frac{\pi d_{\text{mean}}{}^2}{4}$ • Plot graph of R against l • Determine gradient of graph • ρ =gradient $\times A$ **Uncertainties** • Check zero error for micrometer (or state that 'any' zero error should be subtracted from each reading of diameter). Or close callipers and press 'zero' button. • Plot uncertainties on R-axis from repeat readings of R **Other possible answers** {Uncertainty in $\frac{R}{l}$ obtained from graph (no details)} {Total % uncertainty in ρ calculated from % unc in gradient + % unc in A.}	4		2	6		6

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks At least 7 clear points made, but must include at least one statement from each of methodology, analysis and uncertainties *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** At least 5 clear points made and must include at least one statement from each of methodology and analysis. *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 3 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.*						

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			$R_{total} = \frac{V^2}{P} = \frac{14.3^2}{45}$ = 4.5[44 Ω] [1] R of each strip = 4 × 4.5[44] = 18[.176 Ω] [1] A calculated = $\frac{\rho l}{R} = \frac{6.0 \times 10^{-6} \times 1.2}{18}$ = 4.0 × 10^{-7} [m^2] [1] (**ecf** on R, even if total R used) A = 3.96 × 10^{-7} if 18.176 Ω used. Thickness = $\frac{4.0 \times 10^{-7}}{2.0 \times 10^{-3}}$ = 2.0 × 10^{-4} [m] (0.2 mm) and appropriate statement e.g. can be achieved [1] (Thickness = 0.198 mm if A = 3.96 × 10^{-7} used) **Alternative:** Find power used for thickness of 0.2 mm: A = 2 × 10^{-3} × 0.2 × 10^{-3} = 4.0 × 10^{-7} [m^2][1] $R = \frac{\rho l}{A}$ = 18 [Ω] [1] Total R = 4.5 [Ω] [1] $P = \frac{14.3^2}{4.5}$ = 45.4 [W] and appropriate statement [1] **Or alternative for final two marks above:** $P = \frac{14.3^2}{18}$ = 11.4 [W] for each strip [1] Total P = 11.4 × 4 = 45.4 [W] and appropriate statement [1]			4	4	4	
				Question 3 total	**4**	**0**	**6**	**10**	**4**	**6**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			**Description and appropriate example given for each [3 × 1]** **Crystalline**- long range, regular (unit cell repeated) Accept 'lattice'. **Amorphous** - no order (accept: short range, irregular) **Polymeric** - long chain molecules (no order between, only within molecules)	3			3		
	(b)	(i)		At (A) molecules unravel (accept untangle) under the action of a force. [Accept – C-C bond rotates] [1] At (B) molecules fully stretched/ strong forces between atoms within molecule / stretching bonds (covalent) [1] Either: Small force (or stress) produces large extension (or strain) at A [hence shallow gradient] Or: Large force (or stress) produces small extension (or strain) at B [hence steep gradient] [1]	1 1	1		3		3
		(ii)	I	Hysteresis [1] Explanation: e.g. area between curves represents energy 'lost' in the cycle or energy is transferred to internal energy in the rubber and then lost as heat [1]	2			2		
			II	Correctly drawn curve, of the same shape but 'below' the extension curve at all points. Can return to origin or shown as small 'permanent set'	1			1		
				Question 4 total	**8**	**1**	**0**	**9**	**0**	**3**

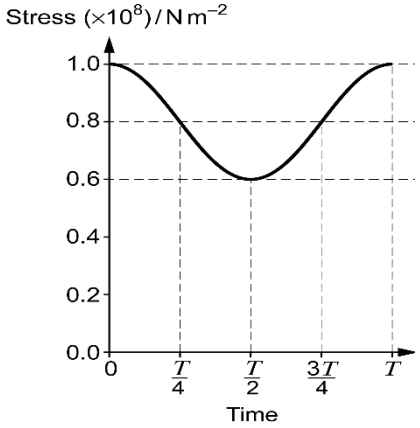
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)		Substitution and re-arrange e.g. $\Delta x_{max} = \frac{(1.0 \times 10^{8} \times 2.5)}{2.0 \times 10^{11}}$ [1] Δx_{max} = 1.25 × 10^{-3} m or 1.25 mm [1] Accept use of 1.25 mm to show E_{steel} = 2.0 × 10^{11} [N m^{-2}]		2		2	2	
		(ii)		Stress required to reach elastic limit will remain constant irrespective of radius e.g. If radius is doubled the tension is increased by factor 4 [1] Δx_{max} (of this wire) will be the same (depends only on stress) [1] Δx_{max} does not depend on the radius, Natalie correct (or Simon incorrect) [1]			3	3		
	(b)	(i)		Re-arrangement and substitute: $F = \frac{EA\Delta x}{l}$ i.e. $F = \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-6} \Delta x}{2.5}$ [1] $F = k\Delta x$ seen or implied [1] Correct algebra to show k = 8 × 10^{4} [N m^{-1}] [1] **Alternative:** At elastic limit $k = \frac{100}{1.25 \times 10^{-3}}$ (= 80 kN m^{-2}) - award 3 marks		3		3	3	
		(ii)		$mg = k\Delta x$ seen or implied [1] $m = \frac{8.0 \times 10^{4} \times 1 \times 10^{-3}}{9.81}$ m = 8.2 k[g] [1]		2		2	1	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		Substitution into $T = 2\pi\sqrt{\frac{m}{k}}$ [1] (**ecf** on m) T = 0.06[3 s] [1]	1	 1		2	2	
		(ii)		Elastic limit must not be exceeded, so max possible displacement = 1.25 mm – 1.0 mm = 0.25 [mm] [1] Substitution into $v_{max} = A\omega$ or equivalent: e.g. v_{max} = 0.25 × 10^{-3} × $\frac{2\pi}{0.06}$ [1] (**ecf** on T and Δx_{max}) v_{max} = 0.026 [m s^{-1}] [1]	 1	1 1		3	2	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		Stress in equilibrium position calculated or seen on graph i.e. $= \frac{2.0 \times 10^{11} \times 1.0 \times 10^{-3}}{2.5}$ ($= 0.8 \times 10^8$ N m^{-2}) [1] Appropriate stress scale e.g. as shown or in steps of 0.2×10^8 N m^{-2} [1] Correct general shape with no reference to time/ stress scales [1] Correct shape and stress and timings [1]  		4		4	2	
				Question 5 total	**2**	**14**	**3**	**19**	**12**	**0**

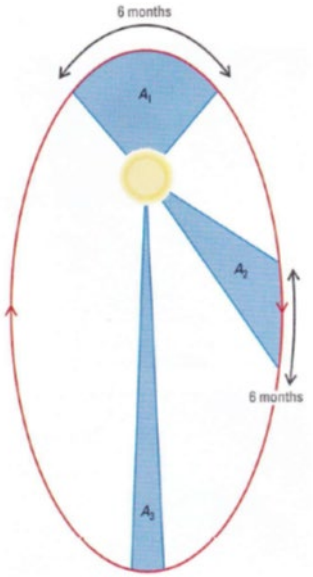
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			**Description**: Continuous spectrum **and** [superimposed] line [absorption] spectrum / dark lines [1] **Cause:** [Continuous] due to radiation of all wavelengths **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)		1				
				$A = 1.12 \times 10^{22}$ m^2 [1]						
				$4\pi R^2 = 1.12 \times 10^{22}$ $R = 2.98 \times 10^{10}$ [m] (**ecf** on A) [1]		1		5	5	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(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 6 total	**3**	**4**	**6**	**13**	**5**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Areas and time periods shown correctly or described [1] $A_1 = A_2$ $(= A_3)$ indicated [1]  6 months	2			2		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			$\frac{mv^2}{r} = \frac{GMm}{r^2}$ [1] $v = \frac{2\pi r}{T}$ [1] Substitution and clear algebra step shown [1] **Or** $mr\omega^2 = \frac{GMm}{r^2}$ [1] $\omega = \frac{2\pi}{T}$ [1] Substitution and clear algebra step shown [1]	1	1 1		3	2	
	(c)	(i)		$\omega = \frac{2\pi}{(7.7 \times 3\,600)}$ or 2.26(7) × 10^{-4} rads^{-1} seen [1] $M = \frac{(2.27 \times 10^{-4})^2 \times (9.4 \times 10^6)^3}{6.67 \times 10^{-11}}$ substitution and re-arrangement [1] M = 6.39[8] × 10^{23} k[g] [1]		3		3	3	
		(ii)	I	Substitution into $V_g = -\frac{GM}{R}$ i.e. $V_g = -\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{9.4 \times 10^6}$ [1] V_g = - 4.5(4) × 10^6 [J kg^{-1}] [1]	1	1		2	2	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
			II	V_g at orbit of Deimos = $= -\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{2.35 \times 10^{7}}$ = - 1.8(2) $\times$ 10^6 J kg^{-1}[1] ΔV = - 1.82 + 4.54 = 2.72 M[J kg^{-1}] [1] Energy available per kg of fuel = 0.6 $\times$ 4.4 = 2.64 M[J kg^{-1}] [1] Scientists should not attempt manoeuvre [1] [**ecf** based on calculations]			4	4	3	
		(iii)		One of: • g is not constant [over the distance between orbits] • g decreases as height increases • work done per metre decreases as height increases • field is not uniform		1		1		
				Question 7 total	**4**	**7**	**4**	**15**	**10**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			Substitution i.e. $\rho = \frac{3(2.20 \times 10^{-18})^2}{8\pi(6.67 \times 10^{-11})}$ [1] ρ = 8.66 × 10^{-27} kg m^{-3} **(unit mark)** [1]	1	1		2	2	
	(b)			Increase in distance = $(2 \times 10^9 \times 365 \times 24 \times 3\,600 \times 2.2 \times 10^{-18})R$ (= $0.14R$) [1] R increased by 14 % [1] Nearly 15 %, justified [1] **Alternative:** $D\alpha \frac{1}{H_0}$ or $D = \frac{k}{H_0}$ [1] Appropriate algebra e.g. $D_1 = \frac{k}{1.44 \times 10^{10}}$ [years] and $D_2 = \frac{k}{2 \times 10^9 \times 1.44 \times 10^{10}}$ and/or $k = \frac{D_2}{D_1} = \frac{1.64}{1.44}$ [= 1.14] [1] Hence k approx. = 14 % shown (approx. 15 %) [1]			3	3	2	
	(c)	(i)		$\frac{\Delta\lambda}{410}$ calculated or shown: i.e. $\frac{65}{410}$ or 0.16 seen [1] v calculated = 0.16 × 3 × 10^8 = 4.8 × 10^7 [m s^{-1}] [1]		2		2	2	
		(ii)		Substitution and re-arrangement: Distance = $\frac{4.8\,x\,10^7}{2.2\,x\,10^{-18}}$ (**ecf** on v) [1] Distance = 2.18 × 10^{25} [m] [1]		2		2	2	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		Use of $E_k = \frac{3}{2}kT$ E_k = 1.47 × 10^{-19} [J] [1] = 0.9[2 eV] [1]		2		2	1	
				Question 8 total	**1**	**7**	**3**	**11**	**9**	**0**

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SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	8	2	0	10	4	0
2	0	10	3	13	10	13
3	4	0	6	10	4	6
4	8	1	0	9	0	3
5	2	14	3	19	12	0
6	3	4	6	13	5	0
7	4	7	4	15	10	0
8	1	7	3	11	9	0
TOTAL	**30**	**45**	**25**	**100**	**54**	**22**

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