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GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
PHYSICS - COMPONENT 2
A420U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2017 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.

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)*		Electrical energy (or work) transferred [to other forms] per unit [accept coulomb] of charge [passing between the two points]	1			1		
	(b)		**Either:** I in circuit = $\frac{2.4}{160}$ (1) [= 15.0 mA] $R_{\text{Thermistor}} = \frac{(12.0-2.4)(1)}{15.0 \times 10^{-3}}$ [**ecf** on I] = 640 [Ω] (1) **Or:** $R_T = \frac{9.6(1)}{2.4} \times 160$ (1) **or** $2.4 = \frac{12 \times 160}{160 + R_T}$ (2) = 640 [Ω] (1)	1	1 1		3	3	
	(c)	(i)	[Resistance of thermistor decreases as temp increases] pd across thermistor decreases (1) So pd across fixed resistor increases **because**: **Either** - ratio of pds across potential divider changes **Or** - total pd must = 12.0 V (or equivalent) (1) **Alternative:** [Resistance of thermistor decreases as temp increases] so circuit current increases (1) So pd across fixed resistor increases **because** $V = IR$ and R is constant or $V \propto I$ (1)		2		2		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $V_{\text{cooling system}} = \frac{160}{(480+160)} \times 12.0$ (1) [**ecf** on $R_{\text{Thermistor}}$] = 3.0 [V] (1) **Alternative:** $2.8 = \frac{160}{(R_{\text{Thermistor}}+160)} \times 12.0$ (1) $R_{\text{Thermistor}}$ = 526 [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_{\text{R}} = \frac{2.8}{160}$ = 0.0175 [A] (1) $R_{\text{T}} = \frac{9.2}{0.0175}$ = 526 [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_{\text{R}} = \frac{2.8}{160}$ = 0.0175 [A] (1) At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $I_{\text{T}} = \frac{9.2}{480}$ = 0.0192 [A] (1) **Alternative:** At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $I = \frac{V}{R} = \frac{12}{(480+160)}$ =0.01875 [A] (1) $V = IR$ = 0.01875 × 160 = 3 [V] (1) **Final mark for all methods - Valid conclusion consistent with answer:** i.e. Claim incorrect - system activated at $\theta < 30$ °C (1)			4	4	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		More effective at 0 °C – 10 °C (no mark) Because: Steeper gradient / larger change in resistance (1) Greater sensitivity in this range / greater [fractional] change in R <u>per °C</u> change in temperature or over the same temperature range) (1)			2	2		2
			Question 1 total	**2**	**4**	**6**	**12**	**6**	**2**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	For Left Hand Combination: $\frac{1}{R_{\text{parallel}}} = \frac{1}{2R} + \frac{1}{R} + \frac{1}{2R}$ (RHS seen in any correct form e.g. $\frac{4}{2R}$)(1) = $\frac{R}{2}$ (1) Total R = $\frac{R}{2}$ + R or $\frac{3R}{2}$ seen (1) **Alternative solutions possible** e.g. Sum of top and bottom branch = R (1) Then parallel branch = $\frac{R}{2}$ (1) Total R = $\frac{R}{2}$ + R (1)		3		3	3	
		(ii)	Right hand resistor circled (1) Greatest current / greatest voltage (1)		2		2		
	(b)		Correct substitution into $l = \frac{RA}{\rho}$ i.e. $\frac{2.0 \times 10^{3} \times 250 \times 10^{-9} \times 0.25 \times 10^{-3}}{1.20 \times 10^{-6}}$ (1) l = 0.10 [m] (1) (**ecf** on slip in powers of 10)	1	1		2	2	

<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></td><td>(c)</td><td>(i)</td><td>n- <u>free</u> electron density. Accept- number of <u>free</u> electrons per unit volume or per m^3 (or equivalent)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>
<table>
<tr><th>Ratio</th><th>Value</th><th>Explanation</th></tr>
<tr><td>$\frac{n_X}{n_Y}$</td><td>1</td><td>Wires made of the same material</td></tr>
<tr><td>$\frac{I_X}{I_Y}$</td><td>1</td><td>Wires in series</td></tr>
<tr><td>$\frac{v_X}{v_Y}$</td><td>0.25</td><td>Correct explanation based on $A_x v_x = A_y v_y$
e.g $(d)^2 v_x = \left(\frac{d}{2}\right)^2 v_y$</td></tr>
</table>
Award 1 mark for each correct row</td><td>1
1</td><td>1</td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>$R = \frac{\rho l}{A}$ substituted into $P = I^2 R$ i.e. $P = \frac{I^2 \rho l}{A}$ (1)
$P_x = \frac{I^2 \rho_x l_x}{A_x}$ and $P_z = \frac{I^2 \rho_z l_z}{A_z}$ (or equivalent) - can award 1st mark from one of these expressions
$A_x = 4A_z$ and $l_x = \frac{l_z}{2}$ and $\rho_x = 2\rho_z$ to show: (1)
$\frac{P_z}{P_x} = 4$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Question 2 total</td><td>4</td><td>10</td><td>0</td><td>14</td><td>8</td><td>0</td></tr>
</table>

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
3	*(a)*		Electrons (or negative charges) are deposited on Z [and this plate becomes negatively charged] (1) Electrons (or negative charges) are removed from Y [and this plate becomes positively charged] (1)		2		2		2
	(b)	(i)	Initial pd across capacitor = pd of cell (by implication) **and** correct application to show R or I		1		1		1
		(ii)	Reference to **resolution of voltmeter** (1) which is **too small to be plotted** (1) (on given scale)			2	2		2
		(iii)	Error bars [are ±1 s]		1		1		1
		(iv)	Appropriate (corresponding) values from graph e.g. V_0 = 6 V, V = 4 V, t = 13 s (1) Correct algebra [$V = V_0 e^{-\frac{t}{CR}}$] to show t = 32 [s] (1) **Alternative:** Time constant = 0.37 V_0 stated or implied or V = 2.2[2] V (1) Time constant = 32 [s] (1) **Alternative:** $T_{½}$= 0.69RC (1) RC = 31 [s] (1) **Alternative:** Initial gradient = $-\frac{V_0}{RC} = -\frac{6}{33}$ (tangent at t = 0 intercepts time axis at t = 33 s) (1) $RC = \frac{6 \text{ x } 33}{6}$ = 33 [s] (1)		2		2	2	2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(v)	Application of time constant = CR (1) $C = \frac{32}{68\,000}$ = 471 μF (**ecf** in t or candidate value used) (1) % uncertainty calculated as 3% + 3.2% = 6.2% (1) Absolute uncertainty = ± 30 μF So: 470 ± 30 μF (or 0.47 ± 0.03 mF) (1) consistency of sig figs	1	1 1 1		4	4	4
		(vi)	Correct substitution into $V = V_0 e^{-\frac{t}{CR}}$ (1) V shown = 1.1 [V] (1) Reference to continued graph line going through this point (1)			3	3	2	3
			Question 3 total	**1**	**9**	**5**	**15**	**8**	**15**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Horizontal line[s] with direction indicated from X to Y	1			1		
	(b)	(i)	Substitution into $F = \frac{Ve}{d}$ shown: $\frac{1800 \times 1.6 \times 10^{-19}}{3.2 \times 10^{-3}}$ (1) $F = 9.0 \times 10^{-14}$ [N] (1)	1	1		2	2	
		(ii)	[Gain in E_k = Work done by field] Gain in $E_k = 9.0 \times 10^{-14} \times 3.2 \times 10^{-3}$ (1) (**ecf** on F) Gain in $E_k = 2.88 \times 10^{-16}$ J **unit mark** (1) **Alternative:** $W = 1.6 \times 10^{-19} \times 1\,800$ (1) $W = 2.88 \times 10^{-16}$ J **unit mark** (1) [Accept 1 800 eV **unit mark**]	1	1		2	2	
		(iii)	$x = ut + ½ at^2$ and $u = 0$ (all possible by implication) (1) $a = \frac{F}{m}$ **and** substitution step: **ecf** on F e.g. $t^2 = \frac{2 \times 3.2 \times 10^{-3} \times 9.11 \times 10^{-31}}{9.0 \times 10^{-14}}$ (1) $t = 2.54 \times 10^{-10}$ [s] (1) **Alternative:** $½ mv^2 = 2.88 \times 10^{-16}$ to calculate v (1) Application of $x = \frac{(u+v)t}{2}$ (1) **ecf** on v $t = 2.54 \times 10^{-10}$ [s] (1)	1	1 1		3	3	
	(c)		F doubled (explained from $\frac{Ve}{\frac{1}{2}d}$) (1) $W = 2F \times \frac{d}{2}$ so no change (1) **Accept:** $W = QV$ and Q stated to be constant (1) so W remains unchanged (1)			2	2		
			Question 4 total	**4**	**4**	**2**	**10**	**7**	**0**

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<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>5</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th></th><th>Advantage</th><th>Disadvantage</th></tr>
<tr><td>Ben (ruler)</td><td>Easy to use/convenient / quicker</td><td>Inaccurate [only to ± 1 mm] / reference to parallax errors / difficulty in supporting ruler / may touch spheres</td></tr>
<tr><td>Sarah (rod)</td><td>Diameter measured accurately / greater accuracy</td><td>Diameter/radius of spheres need to be known beforehand / difficult to judge one complete rotation / difficult to measure angle [of rotation] / difficult to set-up / thread overlapping</td></tr>
</table>
4 × 1 mark - one response required from each cell.</td><td></td><td>4</td><td></td><td>4</td><td></td><td>4</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Any ×(1) from:
• Pins/markers on ruler
• Marker on cylinder
• Measure diameter of spheres
• Mark point at centre of each sphere and use a travelling microscope to measure the separation
• Fix the ruler close to spheres
• Smaller diameter rod
• Use of Vernier calipers (for Ben)
Don't accept repeat readings</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
</table>

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
	(b)	(i)	F = 9.81 × 10^{-5} N (1) Use of $F = \frac{9 \times 10^9 Q_1 Q_2}{r^2}$ (1) Q_1Q_2 = 4.36 × 10^{-18} [C^2] (1)	1	1 1		3	3	3
		(ii)	$Q = (4.36 \times 10^{-18})^{1/2}$ determined (or use of 4.4 × 10^{-18}) = 2.09 × 10^{-9} C (1) Area under graph calculated: 3.2 × 10^{-6} × 0.65 × 10^{-3} = 2.08 × 10^{-9} C (1) **Alternative:** Area, Q = 2.08 × 10^{-9} (1) So $QQ = (2.08 \times 10^{-9})^2$ = 4.3 × 10^{-18} C^2 (1)			2	2	2	2
		(iii)	$n = \frac{2.09 \times 10^{-9}}{1.6 \times 10^{-19}}$ = 1.31 × 10^{10} electrons **ecf** on Q		1		1	1	1
			Question 5 total	**1**	**7**	**3**	**11**	**6**	**11**

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
6	(a)		Line drawn from Sun to planet..... (1) ......will sweep out equal areas reference to $A_1 = A_2 = A_3$ (1) ......in equal time intervals / 6 months (1)	3			3		
	(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	3	
	(c)	(i)	1.45 years = 4.573×10^7 [s] (1) Substitution into $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ i.e. $\frac{0.052}{486.14} = \frac{v}{3.0 \times 10^8}$ (1) $v = 3.209 \times 10^4$ [m s^{-1}] (1) $r = \frac{vT}{2\pi} = \frac{3.209 \times 10^4 \times 4.573 \times 10^7}{2\pi}$ $= 2.34 \times 10^{11}$ [m] (1) **Alternative** for 4.573×10^7 see $1.45 \times 86\,400 \times 365$	1	1 1 1		4	4	
		(ii)	Assumption CoM at/near centre of neutron star or M_1 much greater than M_2 (1) **Either**: $M = \frac{v^2 r}{G}$ (1) $M = \frac{(3.209 \times 10^4)^2 \times 2.34 \times 10^{11}}{6.67 \times 10^{-11}}$ (substitution) (1) **ecf** on v $M = 3.6 \times 10^{30}$ [kg] **and** valid conclusion (1)						

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	**Alternative:** $M = \frac{4\pi^2 r^3}{GT^2}$ (1) $M = \frac{4\pi^2 \text{x}(2.34 \text{ x } 10^{11})^3}{6.67 \text{ x } 10^{-11} \text{x}(4.573 \text{ x } 10^7)^2}$ (substitution) (1) **ecf** on T M = 3.6 × 10^{30} [kg] **and** valid conclusion (1)			4	4	4	
			Question 6 total	**6**	**4**	**4**	**14**	**11**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)		Potential at infinity = 0 (1) <u>Work done</u> on object to get to infinity, [therefore initial energy must be negative] (or equivalent) (1)	2			2		
		(ii)	I	Zero (1) No change in potential (or on same 'equipotential'). Do not accept r unchanged unless reference made to potential unchanged (1)	2			2		
			II	ΔV = (-1.79) – (-1.31) (1) Change in gravitational E_p = [-]144 M[J] (1)		2		2	2	
		(iii)		V at Moon surface calculated = -2.82 M[J] per kg (1) Loss in E_p = $m \times$ 0.63 MJ (ignore –ve sign) (1) **ecf** on V at Moon surface $\frac{1}{2} mv^2 = m \times 0.63 \times 10^6$ (1) $v = (1.26 \times 10^6)^{1/2}$ [m s^{-1}] = 1.12×10^3 [m s^{-1}] (1) **Alternative:** E_p at Moon = -846 M[J] Total energy at D = -657 M[J] (1) Loss in E_p (gain in E_k) = 189 M[J] (1) $v = 1.12 \times 10^3$ [m s^{-1}] (1)	 1	1 1 1		4	4	

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Benefits - Any × (1) from:** • Easier for humans to survive on Moon if water present • Help understand origin of Earth/Moon system • To advance science • Generate interest in science/space exploration • Develop new technologies • Create jobs **Costs - Any × (1) from:** • Funding could have been used to address Earth based issues • Little current impact on society • Pollution of Moon			2	2		
				Question 7 total	**5**	**5**	**2**	**12**	**6**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*		**Plastic Deformation:** P1 - Reference to dislocations or incomplete planes of atoms P2 - Applied forces break bonds near to dislocations P3 - Dislocations slip P4 - Original bonds permanently broken and do not reform or crystal does not return to original form when force removed **Increasing Strength:** S1- Foreign atom S2- Reduce grain size or increase number of grain boundaries S3- Further dislocations S4- Reason - how they work - inhibit dislocation movement **5-6 marks** Comprehensive description including both plastic deformation and increasing strength typically 6 or more points covered. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either plastic deformation or increasing strength or brief description of both plastic deformation and increasing strength typically 4 - 5 points covered. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Brief description of either plastic deformation or increasing strength 1 - 3 points covered. *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.*	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)	CSA = $\pi \times (0.16 \times 10^{-3})^2$ = [8.0×10^{-8}] (1) Gradient from graph = 4 375 or use of a point from the straight portion (1) Young Modulus = grad $\times \frac{l}{A}$ shown to be 1.2×10^{11} Pa (1)			3	3	3	3
		(ii)	0.2% strain corresponds to an extension of 4.4 mm (1) Area under graph calculated = $\frac{1}{2} \times 4.4 \times 10^{-3} \times 18.5$ (1) [W = 0.04 J]		2		2	2	2
		(iii)	Straight line from end of graph (between 6 – 8 mm) parallel to original line to x-axis. Tolerance: x-axis intercept between 0.4 - 4.0 mm.	1			1		1
			Question 8 total	**7**	**2**	**3**	**12**	**5**	**6**

A LEVEL COMPONENT 2: ELECTRICITY AND THE UNIVERSE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	4	6	12	6	2
2	4	10	0	14	8	0
3	1	9	5	15	8	15
4	4	4	2	10	7	0
5	1	7	3	11	6	11
6	6	4	4	14	11	0
7	5	5	2	12	6	0
8	7	2	3	12	5	6
TOTAL	**30**	**45**	**25**	**100**	**57**	**34**