GCE A LEVEL MARKING SCHEME

SUMMER 2019

A LEVEL
PHYSICS - COMPONENT 2
A420U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2019 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.

A LEVEL COMPONENT 2 – ELECTRICITY AND THE UNIVERSE

MARK SCHEME

GENERAL INSTRUCTIONS

<u>Recording of marks</u>

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.

<u>Marking rules</u>

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.

<u>Extended response question</u>

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)*		V- Energy (per coulomb or unit charge) used in external resistor/circuit [1] E- Energy (per coulomb/unit charge) transferred by source [or from chemical energy or from other forms] or used in **whole** circuit [1] Ir – energy (per coulomb/unit charge) wasted/lost in source or due to internal resistance [1] Use of 'per coulomb' or 'unit charge' at least once [1]	4			4		
	(b)	(i)	Circuit current = $\frac{1050\times10^{-3}}{2.5}$ = 0.42 [A] [1] Total internal resistance = $\frac{0.5}{0.42}$ = 1.2 [Ω] **ecf** on I [1] r_{cell} = 0.6 [Ω] [1]		3		3	2	
		(ii)	Substitution into I^2rt i.e. $(0.42)^2 \times 0.6 \times 60$ (**ecf** on I, r) [1] **Alternative:** Substitution into $\frac{V^2t}{r}$ i.e. $\frac{(0.25)^2\times60}{0.6}$ (**ecf** on V, r) **Alternative:** Substitution into IVt i.e. $0.42 \times 0.25 \times 60$ (**ecf** on I, V) Energy dissipated = 6.3 [J] [N.B. Alternative → 6.4 J] [1]	1	1		2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Either**: Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] **ecf** [1] New current in circuit = $\frac{3}{4.175}$ = 0.72 [A] [1] **For the 4th mark:** Rate of energy dissipation in each cell = $(0.72)^2 \times 0.6$ = 0.31 [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute = $(0.72)^2 \times 0.6 \times 60$ = 18.6 [J] so Kiera correct (or ratio calculated to be approx. 3) [1] **Alternative:** Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] **ecf** [1] New current = 0.72 [A] and pd drop across internal resistance = 0.72×1.2 = 0.86 [V] [1] Rate of energy dissipation in each cell **For the 4th mark:** = $\frac{(0.43)^2}{0.6}$ = 0.31 [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute = $\frac{(0.43)^2 \times 60}{0.6}$ = 18.6 [J] so Kiera correct (or ratio calculated to be approx. 3) [1]			4	4		
			Question 1 total	**5**	**4**	**4**	**13**	**3**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		Varies value of variable resistor			1	1		1
	(b)		Correct attempt e.g. $\ln R = \ln\left(kV^n\right)$ **or** $\ln R = \ln k + \ln V^n$ [or using $\log_e$ or using $\log_{10}$] [1] Correct expression $\ln R = n \ln V + \ln k$ [or using $\log_e$ or using $\log_{10}$] [1]		2		2	2	2

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(c)		(see below)		3		3	3	3

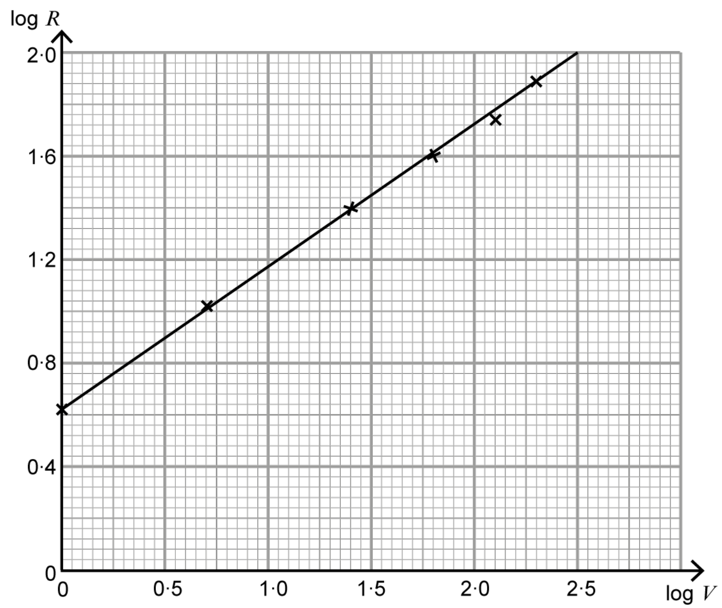
V / V	I / A	R / Ω	ln(V/V)	ln(R/Ω)
1.00	0.52	**1.9(2)**	**0.00**	**0.65**
2.00	0.72	**2.78 or 2.8**	**0.69**	**1.02**
4.00	0.98	**4.08 or 4.1**	**1.39**	**1.41**
6.00	1.20	**5.00**	**1.79**	**1.61**
8.00	1.40	**5.7(1)**	**2.08**	**1.74**
10.00	1.54	**6.49 or 6.5**	**2.30**	**1.87**

$\ln V$ values correct **or** accept $\log_{10} V$ values [1]

Use of $R = \frac{V}{I}$ **and** all R and $\ln R$ values correct **or** accept $\log_{10} R$ values [1]

Log$_{10}$(V/V)	**Log$_{10}$(R/Ω)**
0.00	0.28
0.30	0.45
0.60	0.61
0.78	0.70
0.90	0.76
1.00	0.81

Accept 2 or 3 sig figs in all cases. Accept 4 sig. Figs for $\ln V$ at 10.00 V (= 2.302) [1]

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		Axes labelled **either** with no units i.e. $\ln R$ (or $\log_{10}R$) on y-axis and $\ln V$ (or $\log_{10}V$) on x-axis, **or** with $\ln\left(R/\Omega\right)$ and $\ln\left(V/\text{V}\right)$ respectively (or equivalent using) [1] Suitable scale e.g. large block – 0.2 on y-axis and 0.4 on x-axis for $\ln$ values and 0.2 on x-axis and 0.1 on y-axis on both axes for $\log_{10}$ values. [Linear, scales, with points occupying ≥ half available space] [1] All points plotted correctly within ±< small square division [2] 5 points plotted correctly within ±< small square division [1] 4 or less points plotted correctly within ±< small square division [0] Straight line of best fit drawn [1] e.g. for $\ln$ graph: 		5		5	4	5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)	Attempt at taking gradient [1] $n = \frac{(2.0 - 0.65)}{2.5}$ = 0.5[4] [1] [answer gains both marks] $\ln k = 0.65$ **or** $k = e^{0.65}$ [1] k = 1.9[2] [1] [answer gains both marks] **N.B. ecf from graph for both values.** Mark scheme to be applied as above for candidates using $\log_{10}$ values.	1 1	1 1		4	3	4
		(ii)	R = 1.9 $V^{0.5}$ (**ecf** on n and k)	1			1	1	1
	(f)		**Required statement:** Results lie close to line of best fit suggests good quality **Accept:** results fit with the expected theory **Don't accept** it's a straight line or reference to measuring instruments			1	1		1
			Question 2 total	**3**	**12**	**2**	**17**	**13**	**17**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		Plates of X are closer together (than plates of Y) or vice-versa [1] X contains dielectric (or space between plates of X contains material of higher permittivity) or vice-versa [1] **Accept:** Overlap of plates in X > overlap of plates in Y	2			2		
	(b)	(i)	Series combination: Substitution - $\frac{1}{C_{\text{series}}} = \frac{1}{20\,[\mu\text{F}]} + \frac{1}{30\,[\mu\text{F}]}$ **or** $C_{\text{series}} = \frac{20 \times 30}{20 + 30}$ [μF] [1] C_{series} = 12 μ[F] [1] Total capacitance = 52 μ[F] [1]	1 1	1		3	2	
		(ii)	Idea that Q is same on both capacitors, either stated **or** e.g. $C \propto \frac{1}{V}$ [1] 20 [$\times$ 10^{-6}] $\times$ pd across C_2 = 30 [$\times$ 10^{-6}] $\times$ pd across C_3 [1] [Both marks can be awarded if this seen]	1	1		2	1	
		(iii)	40 [V]		1		1	1	
		(iv)	C_1 stores the greatest charge with explanation: Largest capacitance **and** greatest pd across it [1] Q = 40 $\times$ 10^{-6} $\times$ 100 = 0.004 [C] [1]	1	1		2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Substitution: $E = ½ \times 1.6 \times 10^{-3} \times (300)^2$ [1] E = 72 [J] [1] Energy gained by Al block = $mc\Delta\theta$ **or** substitution seen i.e. $E = 0.1 \times 910 \times 0.6$ [1] E = 54.6 [J] [1] Efficiency (%) = $\frac{54.6\text{ecf} \times 100}{72\text{ecf}}$ = 75.8 % $\therefore$ Not justified / criteria not met [1]			5	5	3	
			Question 3 total	**6**	**4**	**5**	**15**	**8**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		**Indicative content:** **Description:** **D1**: At very low temperatures resistance of superconductor is zero ohms **D2**: Reference to transition temperature or critical temperature...... **D3**: .....where resistance suddenly drops to zero as temperature drops (or jumps up from zero as temperature rises) **D4**: Above transition temperature resistance increases with temperature **D5**: This increase in resistance with temperature is [approximately] linear **[Sketch graph can show some of these points]** **Explanation:** **No explanation required for superconducting state.** **Above transition temperature:** **E1:** As temperature increases, the ions in the metal lattice vibrate more quickly **E2:** Which makes it more likely that an electron will interact (accept collide) with the ion.... **E3**: So electrons lose kinetic energy and the drift velocity decreases **E4:** ....and collisions will cause ions to gain kinetic energy making further collisions more likely	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Comprehensive description and explanation provided. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description or explanation provided or limited attempt at both description and explanation. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited attempt at description or explanation. *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			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)		**One** benefit **to society** given for each application: **Particle accelerator 1 × (1) from:** • Improve understanding of the nature of particles, • Skilled workforce opportunities • Have led to more powerful computing • Particle discoveries used in everyday applications e.g. TV sets • Well-reasoned economic benefits **MRI scanner 1 × (1) from:** • Improved diagnoses and treatment of many ailments • Skilled workforce opportunities • Benefits more people Reasoned choice of application [1]			3	3		
			Question 4 total	**6**	**0**	**3**	**9**	**0**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)	$\Delta x_{\text{total}} = \Delta x_A + \Delta x_{3A}$ (or by implication) [1] $\Delta x_{\text{total}} = \frac{FL_0}{AE} + \frac{FL_0}{3AE}$ [1] Convincing algebra e.g. $\frac{3FL_0}{3AE} + \frac{FL_0}{3AE}$ seen [1]		3		3	2	
		(ii)	Straight line from origin to (400 N, 4.0×10^{-6} m)		1		1		

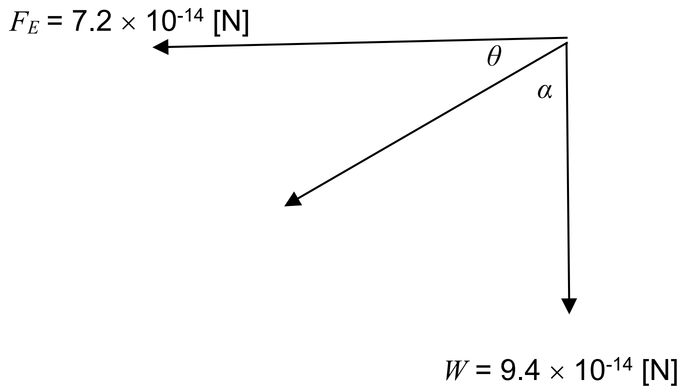
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	**Using combination:** $Y = \dfrac{4FL_0}{3A\Delta x_{\text{total}}}$ and Δx_{total} = 16 × 10^{-6} [m] [1] Substitution - $E = \dfrac{4 \times 400 \times 1.2}{3 \times 2 \times 10^{-4} \times 16 \times 10^{-6}}$ [1] (gains first and second marks) E = 2 × 10^{11} N m^{-2} or Pa **unit mark** [1] **Using bar of CSA A:** $E = \dfrac{FL_0}{A\Delta x_A}$ and Δx_A = 12 × 10^{-6} [m] [1] Substitution – $E = \dfrac{400 \times 1.2}{2 \times 10^{-4} \times 12 \times 10^{-6}}$ [1](gains first and second marks) Y = 2 × 10^{11} N m^{-2} or Pa **unit mark** [1] **Using bar of CSA 3A: - ecf** $E = \dfrac{FL_0}{3A\Delta x_{3A}}$ and Δx_{3A} = 4 × 10^{-6} [m] [1] Substitution – $E = \dfrac{400 \times 1.2}{3 \times 2 \times 10^{-4} \times 4 \times 10^{-6}}$ [1](gains first and second marks) E = 2 × 10^{11} N m^{-2} or Pa **unit mark** [1]		3		3	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iv)	$E_{\text{elastic}} = \frac{1}{2}Fx_{\text{total}}$ and substitution: $E = \frac{1}{2} \times 400 \times 16 \times 10^{-6}$ [1] E = 3.2 m[J] [1] **Alternative:** $E_{\text{elastic}} = \frac{2F^2L_0}{3AE}$ used with substitution: $E_{\text{elastic}} = \frac{2 \times (400^2) \times 1.2}{3 \times 2 \times 10^{-4} \times 2 \times 10^{11}}$ [1] E_{elastic} = 3.2 m[J] [1] **Alternative: Area under graphs - ecf** ½ × 4 × 10^{-6} × 400 + ½ × 12 × 10^{-6} × 400 [1] E_{elastic} = 3.2 m[J] [1]	1	1		2	2	
	(b)	(i)	From graph, stress = 2.2 × 10^9 Pa [1] F = 2.2 × 10^9 × π × (0.1 × 10^{-3})^2 = 69 [N] [1] **ecf** for 2.1 × 10^9 Pa Mass = $\frac{69}{9.81}$ = 7.0 k[g] [1]		3		3	2	
		(ii)	**Crack propagation** [around surface imperfection] - no details in terms of breaking bonds needed [1] **Thinner fibre contains fewer surface imperfections** [1] (mention of ‘surface’ required only once)	2			2		
			Question 5 total	**3**	**11**	**0**	**14**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*		$V \propto \frac{1}{r}$ **or** equivalent or $\frac{-0.72\times10^{6}}{3}$ seen (accept 0.73) [1] V shown as – 0.24×10^{6} [J kg^{-1}] [1] Accept answers based on determination of			2	2	1	
	(b)	(i)	Substitution: $E_P = 600 \times [-]\ 0.72 \times 10^{6}$ [1] $E_P = [-]\ 4.3 \times 10^{8}$ [J] [1]	1	1		2	1	
		(ii)	Concept: $E_k = -E_P$ **or** equivalent [1] Substitution: 4.3×10^{8} **ecf** = ½ × 600 × v^2 **or** $v = \sqrt{2 \times 0.72 \times 10^{6}}$ [1] v = 1.2 k[m s^{-1}] [1]		3		3	2	
	(c)		Equation used to show that g at $2r$ should be ¼ of surface value **or** determined i.e. g at $2r$ = 0.15(5) N kg^{-1} **or** $gr^2 = k$ **or** equation used to calculate mass of Pluto [1] Good tangent [1] Gradient calculated e.g. $\frac{0.56\times10^{6}}{3\times1.18\times10^{6}}$ = 0.15[8] (approx.) [1] Appropriate comment **or** analysis to show that $g \propto \frac{1}{r^2}$ [1]			4	4	3	
			Question 6 total	**1**	**4**	**6**	**11**	**7**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Substitution: $T = 2\pi\sqrt{\dfrac{(5.2\times10^{9})^{3}}{6.67\times10^{-11}\times6.2\times10^{28}}}$ [or mass on bottom line = ($6.0 \times 10^{28} + 2.0 \times 10^{27}$)] [1] $T = 1.16 \times 10^{6}$ [s] [1] If mass of planet ignored → $T = 1.18 \times 10^{6}$ [s] award 1 mark	1	1		2	1	
		(ii)	Substitution: $r = \dfrac{2\times10^{27}\times5.2\times10^{9}}{6.2\times10^{28}}$ [1] $r = 1.68 \times 10^{8}$ [m] accept 1.7×10^{8} [m] [1]	1	1		2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)		Use of (a)(i) and (ii) **ecf** - $v_{\text{star}} = \dfrac{2\pi \times 1.68 \times 10^8}{1.16 \times 10^6}$ [1] v_{star} = 910 [m s^{-1}] [1] Use of Doppler shift: **Either:** $\Delta\lambda = \dfrac{910 \times 656.3 \times 10^{-9}}{3 \times 10^8}$ [m] or $\Delta\lambda = \dfrac{910 \times 656.3}{3 \times 10^8}$ n[m] [1] $\Delta\lambda \approx$ 1.99 p[m] seen $\therefore$ consistent [1] **Or:** $v_{\text{star}} = \dfrac{2 \times 10^{-12} \times 3 \times 10^8}{656.3 \times 10^{-9}}$ [1] v_{star} = 914 [m s^{-1}] $\therefore$ consistent [1]			4	4	3	
	(c)		Planet moves in front of star			1	1		
			Question 7 total	**2**	**2**	**5**	**9**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*		**Similarity**: Both are vectors **or** both obey inverse square law **or** both have infinite range [1] **Difference:** Gravitational fields are attractive only, whereas electric fields can be attractive or repulsive. **Or** gravitational fields act on masses, electric fields act on charges. Accept, gravitational field is much weaker than electric field [1]	2			2		
	(b)	(i)	Substitution and answer $W = mg$ = 9.4 × 10^{-14} [N] [1] Substitution $E = \frac{V}{d} = \frac{150}{5.0\times10^{-2}}$ [1] Substitution and answer $F_E = Eq$ = 7.2 × 10^{-14} [N] [1]	1	1 1		3	2	
		(ii)	 F_E and W vectors correctly drawn and labelled (including directions) [1] Resultant direction of movement shown - no precision required and **ecf** if F_E vector drawn to the right [1] θ = 52.5° or α = 37.5° calculated and shown on diagram (or equivalent, e.g. bearing 217.5° stated) [1] Accept scale drawings	1	1 1		3	3	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		$F_{\text{res}} = \sqrt{(9.4\times10^{-14})^2 + (7.2\times10^{-14})^2}$ **or** F_{res} = 1.18 × 10^{-13} [N] seen or in (b)(ii) [1] $a\left[=\frac{F}{m}\right] = \frac{1.18\times10^{-13}}{9.6\times10^{-15}}$ **or** a = 12.3 [m s^{-2}] seen [1] Substitution and rearrangement of $x = ½at^2$ i.e. $t^2 = \frac{0.04}{12.3}$ [1] t = 0.06 [s] Accept 0.057 [s] [1]		4		4	3	
			Question 8 total	**4**	**8**	**0**	**12**	**8**	**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	5	4	4	13	3	0
2	3	12	2	17	13	17
3	6	4	5	15	8	0
4	6	0	3	9	0	0
5	3	11	0	14	9	0
6	1	4	6	11	7	0
7	2	2	5	9	5	0
8	4	8	0	12	8	0
TOTAL	**30**	**45**	**25**	**100**	**53**	**17**