GCE A LEVEL MARKING SCHEME

AUTUMN 2021

A LEVEL
PHYSICS – COMPONENT 2
A420U20-1

© WJEC CBAC Ltd.

INTRODUCTION

This marking scheme was used by WJEC for the 2021 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.

© WJEC CBAC Ltd.

GCE A LEVEL COMPONENT 2 – ELECTRICITY AND THE UNIVERSE

AUTUMN 2021 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.

© WJEC CBAC Ltd.

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

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*		Thermistor A **and** wider / greater / larger variation of resistance [between 20 °C and 60 °C]		1		1		
	(b)	(i)	As temperature falls R of thermistor increases (1) Thermistor resistance is a larger fraction of total R (1) Since V increases as R increases, V_{out} must increase (1) Accept **alternative** based on current. Accept reference to formulae.	1	1 1		3		
		(ii)	Correct use of potential divider equation for A and B (1) Correct reading from graph at 10 °C for both A and B (1) Correct conclusion - A possible, B not possible (1) **Thermistor A: Either:** Apply potential divider equation to determine minimum value of variable resistor for V_{out} = 2 [V] i.e. $2 = \frac{9 \times 10}{(10 + R)}$ R = 35 k[Ω] which is within range for the variable resistor, so possible **Or:** Determine max possible V_{out} at 10 °C i.e. $V_{out} = \frac{9 \times 10}{(10 + 20)}$ V_{out} = 3 [V], which is above requirement, so possible.			3	3	2	

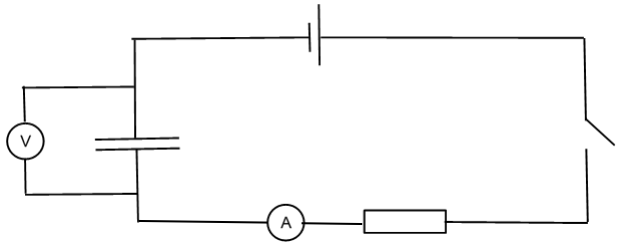
© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Thermistor B: Either: Apply potential divider equation to determine minimum value of variable resistor for V_{out} = 2 V i.e. $2 = \frac{9 \times 5}{(5 + R)}$ R = 17.5 k[Ω], which is below min of range for the variable resistor, so not possible **Or:** Determine max possible V_{out} at 10 °C i.e. $V_{out} = \frac{9 \times 5}{(5 + 20)}$ V_{out} = 1.8 [V], which is below requirement, so not possible. **Alternative approach:** Ratio of pds = $\frac{2}{7}$ (1) Both values of R of thermistor at 10 °C from graph i.e.10 kΩ and 5 kΩ (1) Equate ratios to show thermistor A is possible and thermistor B is not e.g. For A: $\frac{2}{7} = \frac{10}{R_{variable}}$ and for B: $\frac{2}{7} = \frac{5}{R_{variable}}$ (1) **Or:** use $\frac{2}{7}$ (1) ratio to determine allowable range of resistance - 5.7 kΩ and 14.3 kΩ (1) Conclusion (1)						

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Alternative approach: Calculate V_{out} for both 20 k and 50 k, which will yield 3 V and 1.5 V for thermistor A (1) For thermistor B, the corresponding voltages will be 1.8 V and 0.82 V (1) Conclusion (1)						
		(iii)	**First mark for either:** Determination of V across variable resistor (7 V) and R across variable resistor (35 kΩ) (possible **ecf**) if using $P = \frac{V^2}{R}$ **Or:** Determination of I (2×10^{-4} A) and R across variable resistor (35 kΩ) (possible **ecf**) (if using $P = I^2R$) **Or:** Determination of I (2×10^{-4} A) and V across variable resistor (7 V) if using $P = IV$ P = 1.4 m[W] (1)		2		2	2	
		(iv)	Small power output will have negligible effect on thermistor so OK			1	1		
			Question 1 total	**1**	**5**	**4**	**10**	**4**	**0**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		Ω shown as $V A^{-1}$ **and** Farad shown as $C V^{-1}$ (1) C shown as A s [or equivalent] (1) Convincing algebra (1) **Alternative:** Ω shown as $J s(C^2)^{-1}$ (1) Farad shown as $C^2 J^{-1}$ (1) Convincing algebra (1)	1	1 1		3	1	
	(b)	(i)	 Circuit showing all components other than ammeter and voltmeter (1) Correctly positioned voltmeter and ammeter (1)	2			2		2
		(ii)	Q_0 = [2 200 $\times$ 10^{-6} $\times$ 6] = 0.0132 [C] (1) RC = 97 [s] (1) Substitution: $Q = 0.0132\mathbf{ecf}\left(1-e^{-\frac{20}{97}}\right)$ (1) Q = 2.46 m[C] (1)	1	1 1 1		4	3	4

© WJEC CBAC Ltd.

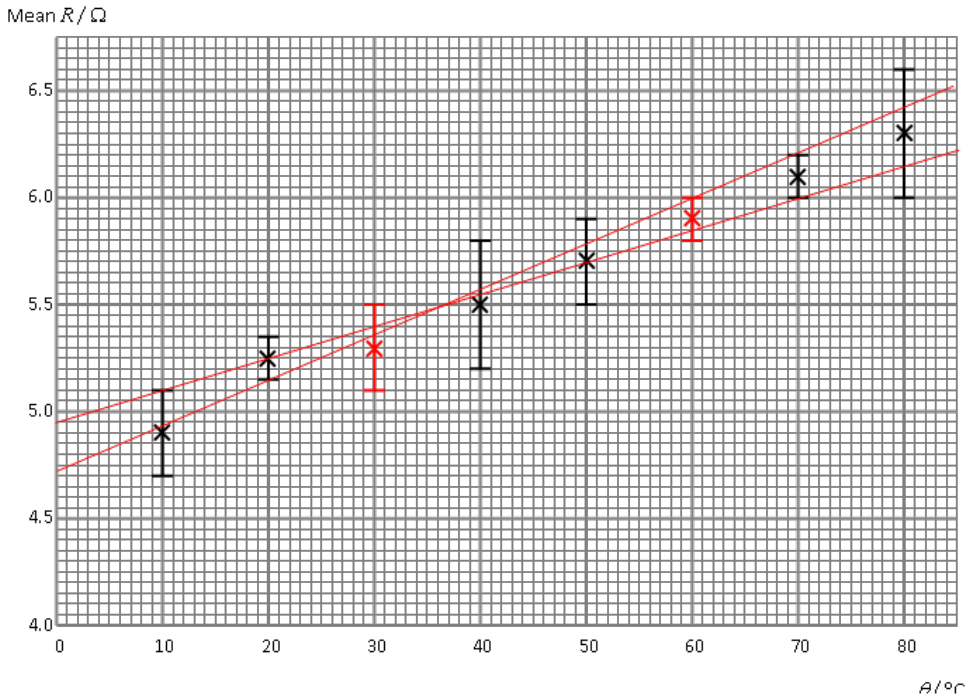
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Substitution: $V = 6\left(1 - e^{-\frac{20}{97}}\right)$ (1) V = 1.1[2 V] Yes, consistent (1) **Alternative:** $V = \frac{Q}{C} = \frac{2.46 \times 10^{-3}}{2\,200 \times 10^{-6}}$ (1) V = 1.1[2] m[V] Yes, consistent (1) (**ecf** on Q, and corresponding conclusion) A variation on this approach would be using the 1.1 V given in the question, calculate the charge as 2.42 mC (1) and comment on how close this is to the 2.46 mC calculated in (ii) (1)			2	2	1	2
	(c)		n = 8.25 × 10^{16} (**ecf** on Q_0)		1		1	1	1
			Question 2 total	**4**	**6**	**2**	**12**	**6**	**9**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	Small uncertainty compared to uncertainty in R / small error bars / ± 0.1 °C			1	1		1
		(ii)	Point plotted at 5.3 Ω (30 °C) and error bars from 5.1 to 5.5 Ω (1) Point plotted at 5.9 Ω with error bar from 5.8 to 6.0 Ω (1)		2		2	2	2
		(iii)	Acceptable lines of max and min gradients (1) Max gradient = 0.022 [Ω °C^{-1}] (1) (**ecf** from incorrect gradients) Min gradient = 0.015 [Ω °C^{-1}] (1)		3		3	2	3
		(iv)	Mean gradient = 0.0185 [Ω °C^{-1}] (**ecf**) (1) % uncertainty calculated as approximately 19 % (1)		2		2	2	2
	(b)	(i)	Gradient = $R_0\alpha$ (1) Description in terms of $y = mx + c$ (1)			2	2	1	2
		(ii)	Mean R_0 = 4.775 Ω (1) % unc in R_0 = 4 % (approx.) (1) $\alpha = \frac{0.0185}{4.775}$ (**ecf** on both values) = 0.00387 °C^{-1} (1) % unc in α = 19 % + 4 % = 23 % (Accept answer based on previous calculations **and** unc = 0.000876 (1) α = (3.9 ± 0.9) × 10^{-3} °C^{-1} sig figs required. Ignore units (1)			5	5	4	5

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Temperature of wire different to temp at thermometer (1) **Any ×(1) from:** - Add stirrer or reference to stirring to equalize the temperature. - Time required for temperature to equalize. - Comment based on cooling taking more time and thus easier to read.			2	2		2
			Question 3 total	**0**	**7**	**10**	**17**	**11**	**17**



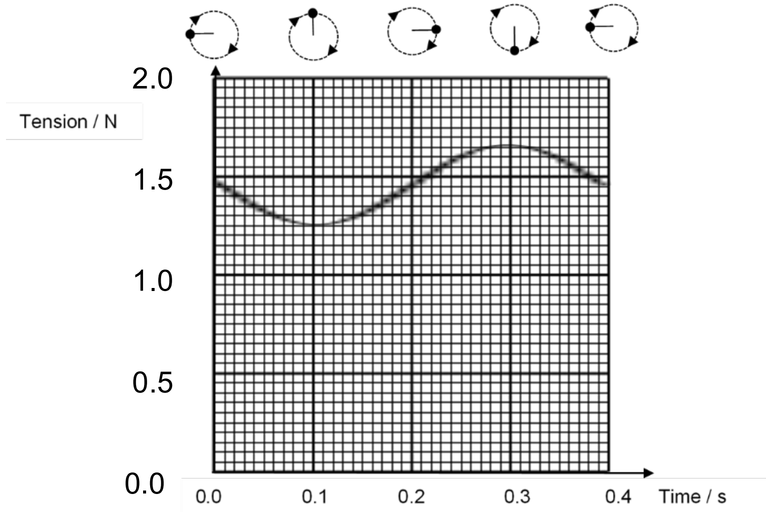
© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)	Surface cracks / imperfections / scratch (1) propagates through sample when under tension (1) **Accept answer** based on breaking bonds e.g. bonds break (1) and explanation of stress passing on to next bond etc (1)	2			2		
		(ii)	Outside surface will need to be put under greater tension (1) for cracks to propagate or bonds to break (1) **Or vice-versa:** Surface cracks closed under cooling (1) Outside under compression and cracks do not propagate (1)	2			2		
	(b)	(i)	CSA calculated as 2.01×10^{-8} [m^2] (1) can be awarded by implication from final answer $\Delta x = \frac{(20 \times 10^{-3} \times 9.81 \times 0.30)}{(2.01 \times 10^{-8} \times 2 \times 10^{9})}$ substitute and re-arrange (1) Δx = 1.46×10^{-3} [m] (1)	1	1 1		3	2	
		(ii)	F = $9.00 \times 10^{7} \times 2.01 \times 10^{-8}$ substitution and re-arrange, **ecf** on CSA (1) F = 1.81 [N] (1)		2		2	1	

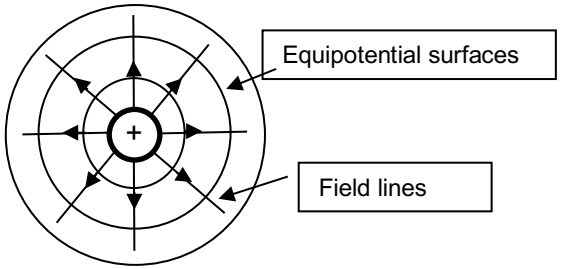
© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	**Either:** Determine max tension when T = 0.4 [s] i.e. max tension = $m\omega^2 r + mg$ (1) Substitution: max tension = $(20 \times 10^{-3} \times 246.7 \times 0.3) + (20 \times 10^{-3} \times 9.81)$ (1) Max tension = 1.68 [N], so OK (1) **Or:** Determine min period for F breaking ≥ 1.81 N Max tension = $m\omega^2 r + mg$ **and** $\omega = \frac{2\pi}{T}$ (1) Substitution: $1.81 = \frac{(20 \times 10^{-3} \times 4\pi^2 \times 0.3)}{(T + 20 \times 10^{-3} \times 9.81)}$ (1) T = 0.15 [s], so OK (1) [Award 1 mark for correct consideration of centripetal force only]			3	3	2	

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	 Tension horizontal = 1.48 N (1) Min tension = 1.28 N (1) Scale (1) Plot (1)	 1	1 1 1		4	3	
			Question 4 total	**6**	**7**	**3**	**16**	**8**	**0**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i) (ii)	 Correct diagram. At least three circles and 4 or more roughly symmetrical lines (1) Correct arrows and labels (1)	2			2		
	(b)	(i)	Substitution: $F = \frac{(9 \times 10^{9} \times 3 \times 10^{-9} \times [-6] \times 10^{-9})}{(4 \times 10^{-3})^{2}}$ (1) F = [-] 0.01 [N] (1) To the right or towards B (1)	1	1 1		3	2	
		(ii)	Same as (i), but to the left or towards A or '+' if '-' used in (i) (1) Newton's third law (1)	2			2		
	(c)	(i)	Electric potential at a point is the work done in bringing a unit positive charge from infinity to that point.	1			1		

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	Potential difference = $9 \times 10^{9} \times 3 \times 10^{-9} \left(\frac{1}{0.006} - \frac{1}{0.004} \right)$ (1) pd = -2 250 [V] (1) Substitution: $W = QV$ = - $6 \times 10^{-9} \times$ – 2 250 (1) W = 1.35×10^{-5} J **(unit mark)** (1)	1	1 1 1		4	2	
	(d)		No work done when moving along equipotential (1) Pathway shown between inner and outer equipotential is equal in length to previous pathway..... (1) …. as distance between charges does not change or as change in potential is the same. (1)	3			3		
			Question 5 total	**10**	**5**	**0**	**15**	**4**	**0**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6			**Indicative content:** • Analysis of absorption spectrum will identify elements in star. • Wavelength at peak intensity and Wien's law to determine surface temperature of star. • Luminosity / power can be determined from inverse square law. • Surface area determined using Stefan's law, knowing luminosity and temperature. • Diameter/radius determined from surface area. • Motion of star determined from red/blue shift. Link to Hubble. **5-6 marks** Complete coverage using **5 or more** bullet points and relevant formulae to support points**.** *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured* **3-4 marks** Either coverage of **5 or more** bullet points without supporting formulae or **3 or 4** bullet points covered with some supporting formulae. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** **One or two** bullet points covered with or without supporting formulae. *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 6 total	**6**	**0**	**0**	**6**	**0**	**0**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Mean radial velocity = 20 km s^{-1} **unit mark**		1		1	1	
		(ii)	Correct readings from graph for A and B i.e. peak speed A = 60 km s^{-1} **and** B = 30 km s^{-1} (1) Orbiting speed of A = 40 km s^{-1} **and** B = 10 km s^{-1} (1)		2		2	2	
		(iii)	$R_A = \frac{vT}{2\pi}$ (1) $R_A = \frac{40 \text{ x } 14(1) \text{ x } 24 \text{ x } 3\,600}{2\pi}$ **ecf** for orbiting speed R_A = 7.70 $\times 10^6$ k[m] (1)		3		3	2	
		(iv)	R_B same method (or ¼ of R_A) = 1.93 $\times$ 10^6 k[m] (1) Separation = 9.63 $\times$ 10^6 k[m] (1)		2		2	1	
	(b)	(i)	Re-arrange to give $M_{total} = \frac{4\pi^2 d^3}{GT^2}$ (1) Substitution: $M_{total} = \frac{4\pi^2 \text{x } (9.63 \text{ x } 10^9)^3}{6.67 \text{ x } 10^{-11} \text{x } 1.46 \text{ x } 10^{12}}$ **ecf** on T (if same error as in (iii) (1) M_{total} = 3.6 $\times$ 10^{29} k[g] (1)	1	1 1		3	2	

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	**For first mark either:** $M_A v_A = M_B v_B$ Therefore $\frac{M_A}{M_B} = \frac{v_B}{v_A}$ = 1:4 **Or** $M_A R_A = M_B R_B$ Therefore $\frac{M_A}{M_B} = \frac{R_B}{R_A}$= 1:4 (1) (Ratio explained) **ecf** from (b)(i) M_A = 7.2 × 10^{28} kg **and** M_B = 2.9 × 10^{29} kg (1) **Alternative:** Correct use of $r_1 = \frac{M_2 d}{(M_1 + M_2)}$from formulae sheet		2		2	1	
			Question 7 total	**1**	**12**	**0**	**13**	**9**	**0**

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*		Use of $t = \frac{1}{H}$ to determine H in seconds^{-1} (2.26×10^{-18} s^{-1}) (1) Substitution: $\rho_c = \frac{3 \text{ x } (2.26 \text{ x } 10^{-18})^2}{8\pi \text{ x } 6.67 \text{ x } 10^{-11}}$ **ecf** on calculated value of H_0 (1) $\rho_c = 9.2 \times 10^{-27}$ (approx. 10^{-26}) (1) Or alternative approaches possible. Award 1 mark only if H_0 from data sheet used.			3	3	2	
	(b)	(i)	Galaxy is receding (1) Red shift / wavelength extended (1)	2			2		
		(ii)	$\Delta\lambda$ calculated = 2.6 n[m] (1) can be awarded from correct v by implication Substitution and re-arrangement: $v = \frac{\Delta\lambda c}{\lambda}$, so $v = 1.97 \times 10^6$ [m s^{-1}] (1) Substitution and re-arrangement: $D = \frac{v}{H_0}$, so $D = 8.9 \times 10^{23}$ [m] (1)		3		3	2	

© WJEC CBAC Ltd.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Data does not agree with Hubble's law **or** v not proportional to D **or** data provides two different values for H_0 (or calculated: 2.52×10^{-19} and 1.75×10^{-18}) (1) **Any 2 × (1) from:** - Measurements may be incorrect / large uncertainty in measured quantities - Wikipedia may be incorrect - Not a good sample - need to measure data from many more galaxies at various distances - More data needed to confirm Hubble - Relevant comment(s) if two values for H_0 calculated. - Motion affected by gravitational field of cluster/ cluster effect on motion should be considered.			3	3		
			Question 8 total	**2**	**3**	**6**	**11**	**4**	**0**

© WJEC CBAC Ltd.

A LEVEL COMPONENT 2: ELECTRICITY AND THE UNIVERSE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	1	5	4	10	4	0
2	4	6	2	12	6	9
3	0	7	10	17	11	17
4	6	7	3	16	8	0
5	10	5	0	15	4	0
6	6	0	0	6	0	0
7	1	12	0	13	9	0
8	2	3	6	11	4	0
TOTAL	**30**	**45**	**25**	**100**	**46**	**26**

© WJEC CBAC Ltd.