



GCE A LEVEL MARKING SCHEME

SUMMER 2022

**A LEVEL
PHYSICS – COMPONENT 2
A420U20-1**

INTRODUCTION

This marking scheme was used by WJEC for the 2022 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.

GCE A LEVEL PHYSICS
COMPONENT 2 – ELECTRICITY AND THE UNIVERSE
SUMMER 2022 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)	(i)	1.4 A and arrow away from P		1		1		
		(ii)	$\frac{0.8}{1.6 \times 10^{-19}} = 5 \times 10^{18}$		1		1	1	
	(b)	(i)	<p>$R_{\text{circuit}} = \frac{6.0}{18.2 \times 10^{-3}} \text{ (1)}$ $= 330 \text{ } [\Omega] \text{ (1)}$</p> <p>Alternative: $R \text{ (of e.g. P)} = \frac{3}{9.1 \times 10^{-3}} \text{ (1)}$ $= 330 \text{ } [\Omega] \text{ (1)}$</p> <p>Alternative: $R \text{ of two buzzers in series considered (1) } (= \frac{6}{9.1 \times 10^{-3}} = 660 \text{ } \Omega)$ and value halved (1) ($\frac{660}{2} = 330 \text{ } [\Omega]$)</p>	1	1		2	1	

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
	(ii)	<p>X only closed [3 buzzers on]: Circuit resistance calculated = 220 [Ω] ecf (1) X and Y closed [2 buzzers on]: Circuit resistance calculated = 165 [Ω] ecf (1)</p> <p>For 3rd mark, either:</p> <ul style="list-style-type: none"> Both currents calculated correctly (27 mA – 3 buzzers and 36 mA – 2 buzzers) and conclusion (Charlotte correct) One current calculated and logical comment for the other and Charlotte correct (e.g. 3 buzzers = 27 mA, for 2 buzzers current would be greater, so Charlotte correct) Logical comments only linked to calculated resistances and Charlotte correct. (e.g. When X is closed circuit resistance = 220 Ω therefore current will increase. When X and Y are closed, circuit resistance = 165 Ω so current will increase further, so Charlotte is correct) <p>Alternative: Closing the switch lowers the circuit resistance and both switches lower it more (1) Explanation in terms of series / parallel combination e.g. reducing series resistance reduces overall circuit resistance (1) Link increase in current to decrease in resistance so Charlotte is correct (1)</p>			3	3	2	

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
	(iii)	<p>X and Y open (4 buzzers): $P = (18.2 \times 10^{-3})^2 \times 330$ or $P = \frac{36}{330}$ or $18.2 \times 10^{-3} \times 330$ or by implication. Substitution (1) ecf on 330 Ω</p> <p>X and Y closed (2 buzzers): $P = (36.4 \times 10^{-3})^2 \times 165$ or $P = \frac{36}{165}$ (ecf) or $36.4 \times 10^{-3} \times 330$ (ecf) or by implication (1)</p> <p>P (4 buzzers) = 0.11 [W] and P (2 buzzers) = 0.22 [W] (1)</p> <p>Alternative: Accept clear algebraic solution e.g.</p> <p>For 4 buzzers $P = \frac{V^2}{R}$ (1)</p> <p>For 2 buzzers $P = \frac{2V^2}{R}$ (1)</p> <p>V same, so P for 2 buzzers = $2 \times P$ for 4 buzzers (1)</p>	1					
			1	1		3	2	
		Question 1 total	3	4	3	10	6	0

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
2	(a)	<p>Indicative content:</p> <p>1. Initially, at low voltages, the graph is straight i.e. R is constant or $\frac{V}{I}$ constant or $V \propto I$ or obeys Ohm's law as T remains constant. Then the ratio of $\frac{V}{I}$ increases (accept gradient decreases) as pd increases. This is because the resistance increases as the temperature of the filament increases.</p> <p>2. Electrons experience a force when a pd is applied across a conductor which accelerates them towards the positive of the pd. This is a non-random movement (called drift velocity) and is the basis of current. The drift continues until the electron collides with the vibrating lattice. These collisions provide a resistance to the mean drift movement of the electrons. The collisions cause the temperature of the wire to increase.</p> <p>3. As the temperature increases the lattice ions vibrate with a greater amplitude and the electrons travel faster, so decreasing the mean time between collisions. The mean drift velocity decreases and R therefore increases.</p> <p>5-6 marks Comprehensive description and explanation <i>There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.</i></p> <p>3-4 marks Outline description with reference to particle movement <i>There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.</i></p>	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			<p>1-2 marks Limited description. Little if any reference to particle explanation. <i>There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.</i></p> <p>0 marks No attempt made or no response worthy of credit.</p>						
	(b)	(i)	<p>Appropriate line of best fit (1) Intercept, $E = 1.45 [\pm 0.02]$ [V] (1) Gradient attempt or $r = \frac{(E-V)}{I}$ (by implication) (1) ecf from inappropriate line of best fit $r = 0.74 [\pm 0.02]$ [Ω] (1)</p>			4	4	4	4
		(ii)	To stop the cell from 'draining' / becoming 'flat' / stop emf from falling / or r from increasing (as cell temperature increases)			1	1		1
			Question 2 total	6	0	5	11	4	5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)	Use of $C = \frac{\epsilon_0 A}{d}$ and $C = \frac{Q}{V}$ (1) Substitution and re-arrangement (1) To confirm Q or C (3.9 nF) or A or d (1) e.g. (1) $Q = \frac{8 \times 8.85 \times 10^{-12} \times 0.0441}{0.0001} = 31.2 \text{ nC}$ confirmed e.g. (2) $\frac{31 \times 10^{-9}}{8} = \frac{8.85 \times 10^{-12} \times A}{0.1 \times 10^{-3}}$ $A = 0.044 \text{ [m}^2\text{]},$ hence $l = 20.9 \text{ [cm]}$ confirmed.			3	3	2	
		(ii)	Use dielectric [between the plates]. Accept insulator	1			1		
	(b)	Capacitance of parallel combination = $4 \mu\text{[F]}$ (1) Total capacitance = $2.67 \mu\text{[F]}$ (1) no ecf $Q = C_{\text{tot}} \text{ ecf} \times 6 \text{ [=16 } \mu\text{C]} = Q_3 \text{ stated}$ (1) Hence, $Q_1 = Q_2 = \frac{1}{2} Q_3$ (ecf) [=8 μC] (1) $V_3 = \frac{Q_3}{C_3}$ [= 2 V] OR using pd ratios: $\frac{V_3}{V_{\text{parallel}}} = \frac{C_{\text{parallel}}}{C_3} = \frac{1}{2}$ (1) $V_1 = V_2 = 2V_3$ (ecf) [= 4 V] (1) Alternative: Ratio of pds: e.g. $\frac{V_3}{V_{\text{parallel}}} = \frac{C_{\text{parallel}}}{C_3} = \frac{4}{8} = \frac{1}{2}$ (1) So $V_3 = 2 \text{ [V]}$ (1) V_1 and $V_2 = 4 \text{ [V]}$ (1) $Q_3 = 8 \times 10^{-6} \times 2$ (ecf) = $16 \mu\text{[C]}$ (1) $Q_1 = 2 \times 10^{-6} \times 4$ (ecf) = $8 \mu\text{[C]}$ (1) $Q_2 = 2 \times 10^{-6} \times 4$ (ecf) = $8 \mu\text{[C]}$ (1) Correctly calculated values gain all marks. Deduct 1 mark for power of 10 error e.g. $\mu\text{F} \rightarrow 10^9$	1	1 1 1 1 1		6	4		

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
	(c)	Decay equation for A e.g. $8 = 16e^{-\frac{t}{CR}}$ (1) Decay equation for B e.g. $2 = 16e^{-\frac{2T}{CR}}$ (1) Manipulation and answer (1) Alternative: Charge will halve through $\frac{R}{2}$ in half the time i.e. $\frac{t}{2}$ (1) 3 times 'halving' from 16 nC to 2 nC, each of equal time $(\frac{t}{2})$ (1) $3 \times \frac{t}{2} = \frac{3t}{2}$ (1)		3		3	2	
		Question 3 total	2	8	3	13	8	0

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
4	(a)	<p>Ductile: Can be drawn into wires / showing plastic deformation / can be re-shaped [without breaking] (1) Don't accept can be stretched</p> <p>Addition of carbon inhibits movement of dislocations (1) Don't accept planes of atoms flowing over each other</p>	2			2		
	(b) (i)	<p>$e_{\text{copper}} = \frac{Fl}{2AE_{\text{copper}}}$ or $e_{\text{steel}} = \frac{Fl}{2AE_{\text{steel}}}$ seen (1)</p> <p>Attempt at $e_{\text{brass}} + e_{\text{iron}}$ (1)</p> <p>Correct manipulation / algebra (1)</p>	1	1 1		3	3	
	(ii)	<p>Substitution: $W = \frac{45^2 \times 3.8}{4 \times 0.6 \times 10^{-6}} \times \left(\frac{1}{120 \times 10^9} + \frac{1}{180 \times 10^9} \right)$ (1)</p> <p>$W = 0.044$[5] J unit mark (1)</p> <p>Subtract 1 for errors of 10 e.g. GPa $\rightarrow 10^6$</p>	1	1		2	1	
	(iii)	<p>Use of $W = \frac{1}{2} F \Delta x$ (1)</p> <p>To show either W or F or Δx consistent with b(ii) (1)</p>			2	2	1	
	(c) (i)	<p>CSA = 8.0[42] $\times 10^{-8}$ [m²] (1)</p> <p>% unc in CSA = $\frac{2 \times 0.01}{0.32} = 6.25$ [%] (1)</p> <p>% unc length (0.2 %) and tension (1.3 %) and extension (11.1 %) (1)</p> <p>Total % unc = 18.9 [%] (1) (ecf from all uncertainties). Accept length and mass uncertainties ignored only if stated / explained</p> <p>E calculated (substitution and answer) = 1.52×10^{11} [Pa] (1)</p> <p>Absolute unc = 0.28[8] $\times 10^{11}$ [Pa] ecf [Look for e.g. $(1.5 \pm 0.3) \times 10^{11}$ Pa or (150 ± 30) GPa or (152 ± 29) GPa] Unit mark (1)</p> <p>Don't accept the absolute uncertainty expressed to 3 or more sig fig</p>		6		6	5	6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			<p>Alternative: Maximum - minimum approach: CSA = $8.0[42] \times 10^{-8} \text{ [m}^2\text{]}$ (1) Maximum possible $E = 1.85 \times 10^{11} \text{ [Pa]}$ (ecf if A incorrect) (1) Minimum possible $E = 1.27 \times 10^{11} \text{ [Pa]}$ (ecf if A incorrect) (1) Uncertainty: $\frac{\text{max} - \text{min}}{2} = 29 \text{ G[Pa]}$ (ecf) (1) E calculated (1) E given with uncertainty (ecf) to appropriate sig figs with unit mark (1)</p>						
		(ii)	<p>1.(%) unc in diameter (or CSA) will decrease (1) 2.Extension will decrease (mass and length not affected) (1) (%) unc in extension will increase (1) Reasonable comment related to points given e.g. decrease in (%) unc E if point 1 only given or no overall change in (%) unc in E or they will counteract each other if points 1 and 2 given (1) N.B. Credit only comments based on the uncertainty in E, not on the value itself</p>			4	4		4
			Question 4 total	4	9	6	19	10	10

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		Electric potential at a point is the work done in bringing a unit positive charge from infinity to that point	1			1		
	(b)	(i)	Values from graph e.g. 9 MV and 0.01 m or 3 MV and 0.03 m (1) Substitute e.g. $Q = \frac{9 \times 10^6 \times 0.01}{9 \times 10^9}$ (1) $Q = 10 \mu\text{[C]}$ (1)	1 1	1		3	2	
		(ii)	Correct values and substitution: $W = 4 \times 10^{-6} (4.5 - 1) \times 10^6$ (1) $W = 14 \text{ [J]}$ (1) ecf on power of 10 slips [-1 if negative answer given] Alternative for the 1st mark: $W = 9 \times 10^9 \times 1 \times 10^{-5} \left(\frac{1}{0.02} - \frac{1}{0.09} \right) \times 4 \times 10^{-6}$	1	1		2	1	
		(iii)	Appropriate tangent at 3.0 cm or values of V and r taken (1) Values $\frac{6 \text{ MV}}{0.06 \text{ m}} = 10^8$ (1) Use of $E = \frac{kQ}{r^2}$ with Q from b(i) and $r = 3.0 \text{ cm}$ gains 1 mark only			2	2	2	
	(c)	(i)	$F_B = Bqv$ (or Bev) upwards	1			1		
		(ii)	$E = \frac{V}{d}$ seen (1) Correct manipulation e.g. cancelling of q and re-arrangement (1)		2		2	1	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	Substitution: $6 \times 10^6 = \frac{V}{3.2 \times 10^{-3} \times 20 \times 10^{-3}}$ (1) $V = 384$ [V] (1)	1	1		2	1	
		(iv)	Resultant force downwards as $F_E > F_B$ or F_B reduced and F_E unchanged (1) Deflected downwards or towards negative plate (1)		2		2		
			Question 5 total	6	7	2	15	7	0

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
6	(a)	<p>Peak wavelength referenced or identified on graph (1) Accept wavelength at maximum intensity, but not maximum wavelength</p> <p>Peak wavelength inversely proportional to T or $\lambda_{\text{peak}} = \frac{W}{T}$ seen (1)</p>	2			2		
	(b)	(i) <p>Substitution into $P = A\sigma T^4$ (1) $P = 3.7 \times 10^{31}$ [W] (1)</p> <p>Substitution into $I = \frac{P}{4\pi d^2}$ e.g. $d^2 = \frac{(3.7 \times 10^{31})\text{ecf}}{4\pi \times (5.2 \times 10^{-7})}$ (1) $d = 2.4 \times 10^{18}$ [m] (1)</p>	1	1		4	3	
		(ii) <p>λ_{peak} calculated = 2.4×10^{-7} [m] (1) Relevant comment: λ_{peak} well below blue end of visible spectrum or in ultraviolet or blue = 400 nm. Highest intensities emitted in blue end of visible spectrum (1)</p>			2	2	1	
	(c)	<p>Any 2 × (1) from:</p> <ul style="list-style-type: none"> • Further independent investigation by other scientists • Peer review of both teams' findings • Comparison with historical data for Betelgeuse • Comparison with similar events for other stars • Continued observations in comparison with known models • Compare with theoretical research 			2	2		
Question 6 total			3	3	4	10	4	0

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)	Assumption: Constant rate of expansion or constant velocity (1) Substitution of $D = vT$ into Hubble's law and correct algebra (1)	1	1		2	1	
		(ii)	Substitution: $v = 0.36 \times 3.0 \times 10^8$ (1) $v = 1.08 \times 10^8$ [ms ⁻¹] (1) $\frac{1}{H_0}$ (or T) = $\frac{D}{v} = \frac{(9.46 \times 10^{15}) \times (4.6 \times 10^9)}{1.08 \times 10^8}$ (1) ecf on v $T = 4 \times 10^{17}$ s (or 1.3×10^{10} years) unit mark (1) Alternative to 2nd and 3rd marks: Calculate H_0 directly and then $T = \frac{1}{H_0}$		4		4	3	
	(b)	(i)	Use of $\frac{mv^2}{r} = \frac{GMm}{r^2}$ and rearrangement: e.g. $v = \left(\frac{(6.67 \times 10^{-11}) \times (4 \times 10^{40})}{1.2 \times 10^{21}} \right)^{\frac{1}{2}}$ (1) $v = 4.7 \times 10^4$ [ms ⁻¹] (1)		2		2	2	
		(ii)	[Increased velocity due to] additional galactic mass... (1) due to 'dark matter' or reference to undetected matter (1)	2			2		
Question 7 total				3	7	0	10	6	0

Question		Marking details		Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)		Substitution into $mg = \frac{GMm}{r^2}$ (1) Re-arrangement and $M = 7.35 \times 10^{22}$ k[g] seen (1)	1			2	1	
	(b)	(i)	$\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$ or equivalent (1) Correct signs required (subtract 1 mark for incorrect signs) Correct algebra to show either $v = (2gr)^{\frac{1}{2}}$ or $v = \left(\frac{2GM}{r}\right)^{\frac{1}{2}}$ (1)	1			2	1	
		(ii)	Either: $v = (2 \times 1.62 \times (1.74 \times 10^6))^{\frac{1}{2}}$ (1) $v = 2374$ [m s ⁻¹] (1) Or: $v = \left(\frac{2 \times (6.67 \times 10^{-11}) \times (7.35 \times 10^{22})}{(1.74 \times 10^6)}\right)^{\frac{1}{2}}$ (1) $v = 2374$ [m s ⁻¹] (1) (or 2 317 m s ⁻¹ if 7×10^{22} kg used from (a) or 2382 m s ⁻¹ if 7.4×10^{22} kg used) No ecf from (a) as value for M given				2	2	

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
(c)	(i)	<p>Recall $E_{k \text{ mean}} = \frac{3}{2} kT$ or $kT = \frac{1}{3} \overline{mc^2}$ (1)</p> $m = \frac{32 \times 10^{-3}}{6.02 \times 10^{23}} (= 5.3 \times 10^{-26}) \text{ or } 32 \times 1.667 \times 10^{-27} (1)$ <p>Substitution and rearrange e.g.</p> $\langle c^2 \rangle = \frac{(3 \times 1.38 \times 10^{-23}) \times 400}{5.3 \times 10^{-26}} \text{ ecf on } m (1)$ $c_{\text{rms}} = 559 \text{ [m s}^{-1}\text{]} (1)$ <p>Alternative:</p> <p>For n mole, $\frac{1}{3} \overline{mc^2} = nRT$ (1)</p> <p>For 1 mole, $M = 32 \times 10^{-3} \text{ kg}$ (1)</p> <p>Substitution:</p> <p>e.g. $c^2 = \frac{3 \times 8.31 \times 400}{32 \times 10^{-3}}$ (1)</p> $c_{\text{rms}} = 558 \text{ [m s}^{-1}\text{]} (1)$	1	1				
	(ii)	<p>Distribution indicates proportion / some/ small number of molecules with speeds > than 2 km s^{-1} / very high / > than escape speed (1)</p> <p>Therefore, [over time] proportion of molecules will [continuously] escape (1)</p> <p>Example:</p> <p>[rms] speed of some of the particles is greater than the escape speed (approx. 2 km s^{-1}) (1)</p> <p>So particles will leave the surface over a period of time (1)</p> <p>Accept the 400 K surface is constantly providing energy to nearby molecules, some of which will then have sufficient energy to escape for 2nd mark.</p>			2	2		
		Question 8 total	3	7	2	12	7	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	3	4	3	10	8	0
2	6	0	5	11	4	5
3	2	8	3	13	11	0
4	4	9	6	19	11	10
5	6	7	2	15	8	0
6	3	3	4	10	4	0
7	3	7	0	10	6	0
8	3	7	2	12	7	0
TOTAL	30	45	25	100	59	15