wjec cbac

eduqas Part of WJEC

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

<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)	(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)	R circuit $= \frac{6.0}{18.2 \times 10^{-3}}$ (1) = 330 [Ω] (1) **Alternative**: R (of e.g. P) = $\frac{3}{9.1 \times 10^{-3}}$ (1) = 330 [Ω] (1) **Alternative:** R of two buzzers in series considered (1) (= $\frac{6}{9.1 \times 10^{-3}}$ = 660 Ω) and value halved (1) ($\frac{660}{2}$ = 330 [Ω])	1	1		2	1	

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
		(ii)	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) For 3rd mark, either: • 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) **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)			3	3	2	

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

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>2</td><td>(a)</td><td></td><td>Indicative content:

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.
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.
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.

5-6 marks
Comprehensive description and explanation
There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

3-4 marks
Outline description with reference to particle movement
There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.</td><td>6</td><td></td><td></td><td>6</td><td></td><td></td></tr>
</table>

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			1-2 marks Limited description. Little if any reference to particle 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.						
	(b)	(i)	Appropriate line of best fit (1) Intercept, E = 1.45 [± 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 [± 0.02] [Ω] (1)			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 $C = \frac{\varepsilon_0 A}{d}$ **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 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 [m^2], hence l = 20.9 [cm] confirmed.			3	3	2	
		(ii)	Use dielectric [between the plates]. Accept insulator	1			1		
	(b)		Capacitance of parallel combination = 4 μ[F] (1) Total capacitance = 2.67 μ[F] (1) no ecf $Q = C_{\text{tot}}$ **ecf** × 6 [=16 μC] = Q_3 stated (1) Hence, $Q_1 = Q_2 = ½\, Q_3$ (**ecf**) [=8 μC] (1) $V_3 = \frac{Q_3}{C_3}$ [= 2 V] **OR** using pd ratios: $\frac{V_3}{V_{\text{parallel}}} = \frac{C_{\text{parallel}}}{C_3} = ½$ (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 [V] (1) V_1 and V_2 = 4 [V] (1) $Q_3 = 8 \times 10^{-6} \times 2$ (**ecf**) = 16 μ[C] (1) $Q_1 = 2 \times 10^{-6} \times 4$ (**ecf**) = 8 μ[C] (1) $Q_2 = 2 \times 10^{-6} \times 4$ (**ecf**) = 8 μ[C] (1) Correctly calculated values gain all marks. Deduct 1 mark for power of 10 error e.g. μF → 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)		Ductile: Can be drawn into wires / showing plastic deformation / can be re-shaped [without breaking] (1) Don't accept can be stretched Addition of carbon inhibits movement of dislocations (1) Don't accept planes of atoms flowing over each other	2			2		
	(b)	(i)	$e_{\text{copper}} = \frac{Fl}{2AE_{\text{copper}}}$ **or** $e_{\text{steel}} = \frac{Fl}{2AE_{\text{steel}}}$ seen (1) Attempt at $e_{\text{brass}} + e_{\text{iron}}$ (1) Correct manipulation / algebra (1)	1	1 1		3	3	
		(ii)	Substitution: $W = \frac{45^2 \text{ x } 3.8}{4 \text{ x } 0.6 \text{ x } 10^{-6}} \text{ x} \left(\frac{1}{120 \text{ x } 10^9} + \frac{1}{180 \text{ x } 10^9} \right)$ (1) W = 0.044[5] J **unit mark** (1) Subtract 1 for errors of 10 e.g. GPa → 10^6	1	1		2	1	
		(iii)	Use of $W = \frac{1}{2} F\Delta x$ (1) To show either W or F or Δx **consistent** with b(ii) (1)			2	2	1	
	(c)	(i)	CSA = 8.0[42] × 10^{-8} [m^2] (1) % unc in CSA = $\frac{2 \text{ x } 0.01}{0.32}$ = 6.25 [%] (1) % unc length (0.2 %) **and** tension (1.3 %) **and** extension (11.1 %) (1) Total % unc = 18.9 [%] (1) (**ecf** from all uncertainties). Accept length and mass uncertainties ignored only if stated / explained E calculated (substitution and answer) = 1.52 × 10^{11} [Pa] (1) Absolute unc = 0.28[8] × 10^{11} [Pa] **ecf** [Look for e.g. (1.5 ± 0.3) × 10^{11} Pa or (150 ± 30) GPa or (152 ± 29) GPa] **Unit mark** (1) Don't accept the absolute uncertainty expressed to 3 or more sig fig		6		6	5	6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Alternative: Maximum - minimum approach: CSA = 8.0[42] × 10^{-8} [m^2] (1) Maximum possible E = 1.85 × 10^{11} [Pa] (**ecf** if A incorrect) (1) Minimum possible E = 1.27 × 10^{11} [Pa] (**ecf** if A incorrect) (1) Uncertainty: $\frac{\text{max - min}}{2}$ = 29 G[Pa] (**ecf**) (1) E calculated (1) E given with uncertainty (**ecf**) to appropriate sig figs with **unit mark** (1)						
		(ii)	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			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 μ[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 [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 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	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
		(iii)	Substitution: $6 \times 10^6 = \dfrac{V}{3.2 \times 10^{-3} \times 20 \times 10^{-3}}$ (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)		**Peak** wavelength referenced or identified on graph (1) Accept wavelength at maximum intensity, but **not** maximum wavelength Peak wavelength inversely proportional to T or $\lambda_{\text{peak}} = \frac{W}{T}$ seen (1)	2			2		
	(b)	(i)	Substitution into $P = A\sigma T^4$ (1) P = 3.7 × 10^{31} [W] (1) Substitution into $I = \frac{P}{4\pi d^2}$ e.g. $d^2 = \frac{(3.7 \text{ x } 10^{31})\textbf{ecf}}{4\pi \text{ x } (5.2 \text{ x } 10^{-7})}$ (1) d = 2.4 × 10^{18} [m] (1)	1	1 1 1		4	3	
		(ii)	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)			2	2	1	
	(c)		**Any 2 × (1) from:** • 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) $v = 1.08 \times 10^8$ [m s^{-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) $v = 4.7 \times 10^4$ [m s^{-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 × 10^{22} k[g] seen (1)	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	1		2	1	
		(ii)	**Either:** $v = (2 \times 1.62 \times (1.74 \times 10^6))^{\frac{1}{2}}$ (1) v = 2 374 [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 = 2 374 [m s^{-1}] (1) (or 2 317 m s^{-1} if 7 × 10^{22} kg used from (a) **or** 2 382 m s^{-1} if 7.4 × 10^{22} kg used) No ecf from (a) as value for M given		2		2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	Recall $E_{\text{k mean}} = \frac{3}{2}kT$ **or** $kT = \frac{1}{3}m\overline{c^2}$ (1) $m = \frac{32 \times 10^{-3}}{6.02 \times 10^{23}}$ (= 5.3×10^{-26}) **or** $32 \times 1.667 \times 10^{-27}$(1) Substitution and rearrange e.g. $\langle c^2 \rangle = \frac{(3 \times 1.38 \times 10^{-23}) \times 400}{5.3 \times 10^{-26}}$ **ecf** on m (1) c_{rms} = 559 [m s^{-1}] (1) **Alternative:** For n mole, $\frac{1}{3}m\overline{c^2} = nRT$ (1) For 1 mole, $M = 32 \times 10^{-3}$ kg (1) Substitution: e.g $\overline{c^2} = \frac{3 \times 8.31 \times 400}{32 \times 10^{-3}}$ (1) c_{rms} = 558 [m s^{-1}] (1)	1	1 1 1		4	3	
		(ii)	Distribution indicates proportion / some/ small number of molecules with speeds > than 2 km s^{-1} / very high / > than escape speed (1) Therefore, [over time] proportion of molecules will [continuously] escape (1) **Example:** [rms] speed of some of the particles is greater than the escape speed (approx. 2 km s^{-1}) (1) So particles will leave the surface over a period of time (1) 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.			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**