GCE AS MARKING SCHEME

SUMMER 2023

AS
PHYSICS – UNIT 2
2420U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2023 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 AS PHYSICS

UNIT 2 – ELECTRICITY AND LIGHT

SUMMER 2023 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)	0.4 [Ω] (1) Contact resistance / resistance of connecting wires and or crocodile clips (1) Don't accept internal resistance / natural resistance		1	1	2	1	2
		(ii)	**Any 3 × (1) from:** • Straight line • Positive gradient / as length increases, resistance increases • Points close to line of best fit / little scatter in the points • Positive intercept so doesn't agree / if 0.4 subtracted line would go through origin so agreement • Graph neither confirms nor denies dependency on ρ or A but is consistent with constancy of $\frac{\rho}{A}$ Award no marks for directly proportional			3	3		3
		(iii)	[Digital] callipers / micrometer (1) Accept screw gauge 0.01 mm **unit mark** (1)	2			2		2
		(iv)	Gradient determined to be 11.6 ± 0.1 or 0.116 ± 0.001 (1) Gradient = $\frac{\rho}{A}$ (can be implied) (1) Area = $\pi(0.115 \times 10^{-3})^2 = 4.2 \times 10^{-8}$ [m^2] (1) $\rho = 4.9 \times 10^{-7}$ Ω m **ecf** on gradient and area (1) **unit mark** -1 mark for arithmetical slips of power of 10 / factor of 2 slip **Alternative for first and second marking points:** Use of point from line to give R value with 0.4 Ω subtracted and corresponding l value (1) Substituted into $\rho = \frac{RA}{l}$ (1)			4	4	4	4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(b)		Avoids heating [the wire] / small current (1) So resistance does not change / does not increase / is not affected (1) Accept reverse argument. Don't accept any reference to burning or fire risk			2	2		2
			Question 1 total	**2**	**1**	**10**	**13**	**5**	**13**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Energy transferred from {some form / chemical} to electrical [potential] (1) {per coulomb / unit charge} [passing through the cell] (1)	2			2		
	(b)	(i)	Use of $R = \frac{V}{I}$ i.e. $\frac{5.4}{0.3}$	1			1	1	
		(ii)	Substitution into $V = E - Ir$ i.e. $5.4 = 6 - 0.3r$ (1) to give $r = 2[\Omega]$ (1) $\div 4 = 0.5[\Omega]$ **ecf** on r (1) **OR** Total resistance of circuit = $\frac{E}{I}$ = 20 [Ω] (1) $20 - 18$ (1) $\div 4 = 0.5$ [Ω] **ecf** on r (1) **OR** Lost volts $= 6 - 5.4 = 0.6$ [V] (1) $\frac{0.6}{0.3} = 2$ [Ω] (1) $\div 4 = 0.5[\Omega]$ **ecf** on r (1)	1	1 1		3	3	
		(iii)	Correct substitution into a power equation using appropriate values e.g. $P = I^2R$ so $0.3^2 \times 2$ (1) = 0.18 [W] (1) **ecf from ii**	1	1		2	2	
		(iv)	$6 = I(9 + 2) \therefore I = 0.55$ [A] (1) $0.55^2 \times 2 = 0.60$ [W] (1) $\frac{0.60}{0.18} = 3.3$ or 0.60 is more than 2 $\times$ 0.18 owtte hence incorrect (1) Accept 0.58 [W] or 0.59 [W] or 0.61 [W]			3	3	3	
			Question 2 total	**5**	**3**	**3**	**11**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)	[A particle's] maximum displacement [from the equilibrium position] Accept distance from {crest / trough} to {midpoint / rest / equilibrium point} Don't accept maximum height of wave if unqualified	1			1		
		(ii)	$f = 50$ [Hz] **or** $T = 0.02$ [s] (1) Use of $v = f\lambda$ **or** $v = \frac{\lambda}{T}$ (1) = 7.5 m s^{-1} or 750 cm s^{-1} **unit mark** (1)	1	1 1		3	3	
		(iii)	Sinusoidal wave with same A and T as original (1) Starting at (0,6) i.e. cos function drawn (1) Minimum of 1 wave drawn		2		2	2	
	(b)		**Indicative content:** ***Formation of stationary wave*:** • two [progressive] waves travelling in opposite directions • same frequency / wavelength / amplitude • reference to pulley / fixed point to act as reflector • interference / superposition • nodes and antinodes ***Stationary / progressive comparison:*** • Stationary waves have the same frequency or wavelength as the progressive waves which created them • Particles oscillate in both • ENERGY: not transferred (S) / transferred (P) • PHASE: neighbouring particles [in same loop] in phase (S) / neighbouring particles not in phase / continuous change of phase along the wave (P)	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			• WAVELENGTH: $\lambda = 2 \times$ internodal distance (S) / $\lambda =$ distance between 2 consecutive points in phase (P) • AMPLITUDE: Neighbouring particles have different amplitudes or amplitude is zero at nodal points (S) / Amplitude the same for all particles on the wave (P) • FREQUENCY: all particles vibrate at same frequency except at the nodes (S) / all particles vibrate at same frequency (P) **5-6 marks** A comprehensive description is provided on both the *formation of a stationary wave* **and** *comparison given*. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** A comprehensive description is provided on either the *formation of a stationary wave* **or** *comparison* or a limited description is provided of both. *There is a line of reasoning that is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** A limited description is provided on either the *formation of a stationary wave* **or** *comparison*. *A basic line of reasoning that 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 3 total	**8**	**4**	**0**	**12**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		[The sources have] constant phase {difference / relationship} Don't accept in phase	1			1		
	(b)	(i)	The difference in the distance that the two waves travel [to reach the same point] (1) Accept S_1B - S_2B At <u>first</u> maxima wave from S_1 to B has travelled λ metres further (1)	1	1		2		
		(ii)	**Any 2 ×(1) from:** 0.3 [m] / 0.9 [m] / 1.5 [m] / ….. Award 1 mark for $\frac{\lambda}{2}$ **and** $\frac{3\lambda}{2}$ or equivalent stated with no values given		2		2		
	(c)	(i)	If waves [from two sources] {overlap / cross / interfere} then the total displacement [at any one point] (1) is the [vector] sum of their individual displacements [at that point] (1)	2			2		
		(ii)	@ A and B: Resultant amplitude / total max displacement is less or algebraic / numerical argument i.e. $A_{S1} + A_{S2\,\text{fault}} < A_{S1} + A_{S2\,\text{orig}}$ (1) @ C: Resultant amplitude / total max displacement is greater or algebraic / numerical argument i.e. $A_{S1} - A_{S2\,\text{fault}} > A_{S1} - A_{S2\,\text{orig}}$ (1) Accept: Total destructive interference becomes partial destructive interference as waves no longer cancel out. {Waves continue to arrive in phase **/** constructive interference} at A and B **OR** {waves continue to arrive in anti-phase / destructive interference} at C (1)		3		3		
			Question 4 total	**4**	**6**	**0**	**10**	**0**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		$\frac{\text{speed of light in a vacuum}}{\text{speed of light in the material}}$ Do not accept $n = \frac{c}{v}$ unless letters are clearly defined. Accept answer based on ratio of sines if surrounding material stated as vacuum / n = 1 / accept air for vacuum	1			1		
	(b)	(i)	Substitution into: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ i.e. $1.61 \sin 65 = n_2 \sin 80$ (1) $n_2 = 1.48$ (1)	1	1		2	2	
		(ii)	Distance travelled = $\frac{10}{\cos 80}$ = 58 [mm] (1) $\frac{3\times10^8}{1.48 \textbf{ ecf}} = 2.03 \times 10^8$ [m s^{-1}] (1) $\frac{58\times10^{-3}}{2.03\times10^8} = 2.86 \times 10^{-10}$ [s] (1)		3		3	3	
	(c)	(i)	$\sin C = \frac{1.31}{1.48 \textbf{ ecf}}$ (1) C = 62.3° (1) $< 80°$ ∴ TIR (1) **Accept** $n_1 \sin\theta_1 = n_2 \sin\theta_2$ with 80° (1) Reports error message (1) Hence no refraction therefore TIR (1)	1 1	1		3	2	
		(ii)	Light reflected at Y with angle i = angle r by eye		1		1		
			Question 5 total	**4**	**6**	**0**	**10**	**7**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		The [minimum] energy required to liberate an electron [from the metal's surface]	1			1		
	(b)		Zinc as {more energy / higher frequency / lower wavelength} required		1		1		
	(c)	(i)	$E_{\mathrm{k\,max}} = hf - \phi$ **and** use of $f = \frac{c}{\lambda}$ (1) @ threshold $E_{\mathrm{k\,max}} = 0$ **and** convincing algebra (1)	2			2	1	
		(ii)	$\lambda_{\max} = \frac{hc}{3.7\times10^{-19}} = 5.4 \times 10^{-7}$ [m] i.e. 540 n[m] (1) 650 nm (accept red) **and** 550 nm (accept green) (1) **Alternative:** Energy of green photon = $\frac{hc}{\lambda_g} = 3.6 \times 10^{-19}$J **AND** energy of blue photon = $\frac{hc}{\lambda_b} = 4.4 \times 10^{-19}$J [Energy of red photon = $\frac{hc}{\lambda_r} = 3.1 \times 10^{-19}$J] (1) 650 nm (accept red) **and** 550 nm (accept green) (1)		2		2	1	
		(iii)	Greater intensity is more photons [s^{-1}] (1) Intensity has no effect on photon energy (1) so max kinetic energy of electrons doesn't change **Conclusion must be present to award both marks**		2		2		
			Question 6 total	**3**	**5**	**0**	**8**	**2**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)	Mean = 1.87 [V] (1) $\frac{1.93-1.81}{2}$ = 0.06 (1) $\frac{0.06\ \mathbf{ecf}}{1.87\ \mathbf{ecf}} \times 100 = 3\ [\%]$ (1) No sig fig penalty		3		3	3	3
		(ii)	Substitution and rearrangement i.e. $\lambda = \frac{hc}{e \times 1.87\mathbf{ecf}}$ (1) $= 6.6[5] \times 10^{-7}\ [\mathrm{m}]$(1) Absolute uncertainty$= 0.2[0] \times 10^{-7}[\mathrm{m}]$ **ecf** (1) Uncertainty quoted to only 1 or 2 sig figs		3		3	3	3
	(b)		Use an ammeter [and record pd when current increases above 0 A or a few mA] / use a light meter Accept light sensor or light detector Don't accept use a camera			1	1		1
			Question 7 total	**0**	**6**	**1**	**7**	**6**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)		$E = \frac{hc}{1.06\times10^{-6}} = 1.88 \times 10^{-19}$ [J] (1) $\div e = 1.18$ [eV] (1) $1.43-1.18= 0.25$ [eV](1)		3		3	3	
	(b)		Level P is not metastable / electrons drop to level U which is metastable (1) Population inversion is {not between P and ground / between U and L} (1)		2		2		
	(c)		**Any two × (1) from:** • More efficient / require less energy / pumped electrically with lower voltage • Cheaper • Mass produced • Smaller / more compact Don't accept safer / more environmentally friendly / don't overheat	2			2		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		**Any two × (1) from:** • Toxic chemicals/Pb/Hg/Cd/Ba could get into ground water / contaminate soil / crops / livestock / wildlife • Toxic chemical / Br could be released into air (when warmed) • Landfill sites decreases value of surrounding land / lack of land for housebuilding • Landfill sites nearing capacity • Landfill sites create visual pollution • Replacement electrical devices contributing to CO_2 emissions • Provide opportunity for [recycling] jobs • Scarce resources e.g. tantalum wasted / rare metals not being reused • Wasted energy extracting new resources e.g. mining Accept any other valid points			2	2		
			Question 8 total	**2**	**5**	**2**	**9**	**3**	**0**

AS UNIT 2 – ELECTRICITY AND LIGHT

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	1	10	13	5	13
2	5	3	3	11	9	0
3	8	4	0	12	5	0
4	4	6	0	10	0	0
5	4	6	0	10	7	0
6	3	5	0	8	2	0
7	0	6	1	7	6	7
8	2	5	2	9	3	0
TOTAL	**28**	**36**	**16**	**80**	**37**	**20**