GCE AS MARKING SCHEME

SUMMER 2022

AS
PHYSICS – UNIT 2
2420U20-1

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 AS PHYSICS

AS UNIT 2 – ELECTRICITY AND LIGHT

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.

<u>Marking abbreviations</u>

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)		<u>1.5J</u> [of energy] transferred [from chemical] to electrical [potential] (1) per coulomb / per unit charge [of charge flowing through the source] (1)	2			2		
	(b)	(i)	Straight line **or** negative gradient (1) Positive intercept on pd axis **or** points close to best fit line (1)			2	2	1	2
		(ii)	Gradient calculated to be - 0.54 ± 0.02 (1) r = 0.54 Ω **ecf** (1) **unit mark**		2		2	2	2
		(iii)	y-intercept = E = 1.45 [V] so claim incorrect / correct plus valid comment e.g. correct as close to 1.50 Accept calculated value of E from gradient **ecf** in (ii) with comment			1	1	1	1
	(c)	(i)	2.7 [A] Accept 2.65 [A]		1		1	1	1
		(ii)	Zero		1		1		1
			Question 1 total	**2**	**4**	**3**	**9**	**5**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)	Number of [free] <u>electrons</u> per unit volume Accept electron density	1			1		
		(ii)	Volume = vtA or lA (1) can be obtained from clear diagram No. of [free] electrons = $vtAn$ or lAn (1) Total charge = $vtAne$ or $lAne$ (1) $$\text{Current} = \frac{vtAne}{t} \text{ or } \frac{lAne}{t} \text{ (1)}$$ Accept alternatives e.g. in 1 second or per second	4			4	1	
		(iii)	Substitution and rearrangement: i.e. $v = \frac{I}{nAe} = \frac{1.8}{9.0 \times 10^{28} \times 2.8 \times 10^{-8} \times 1.6 \times 10^{-19}}$ (1) allow errors in powers and use of diameter for radius for first mark Answer = 4.4×10^{-3} [m s^{-1}] (1)		2		2	2	
	(b)	(i)	Same pd across $12\,\Omega$ and $24\,\Omega$ **or** 2.4 V across both $12\,\Omega$ and $24\,\Omega$ (1) I through $24\,\Omega$ is ½ that through $12\,\Omega$ **or** 0.1 A through $24\,\Omega$ (1) Parallel branch currents add to 0.3 A **or** 0.2 A + 0.1 A = 0.3 A (1)		3		3		
		(ii)	$\frac{1}{R_P} = \frac{1}{12} + \frac{1}{24}$ to give $R_P = 8$ [Ω] (1) 40 + 8 **ecf** = 48 [Ω] (1) $V = IR = 0.3 \times 48$ **ecf** = 14.4 [V] (1) **Alternatively:** pd across $40\,\Omega = IR = 0.3 \times 40 = 12$ [V] (1) pd across parallel branch = 2.4 [V] (1) Total pd = 12 + 2.4 = 14.4 [V] **ecf** (1)		3		3	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	For 40 Ω, power [= I^2R= 0.3² × 40] = 3.6 [W] (1) Power from parallel arrangement = [I^2R= 0.3² × 8] = 0.72 [W] (1) **Alternative for the first 2 marks** Correct use of IV **or** $\dfrac{V^2}{R}$ **Third mark:** $\dfrac{3.6}{0.72}$ [= 5] or $\dfrac{0.72}{3.6}=[\dfrac{1}{5}]$ (1) **Alternative:** $\dfrac{2.4}{12}$ or $\dfrac{8}{40}$ (1) = $\dfrac{1}{5}$ (1) Because current is the same or equivalent (1)		3		3	3	
			Question 2 total	**5**	**11**	**0**	**16**	**8**	**0**

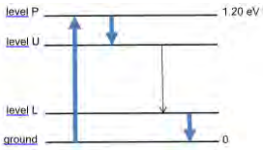| Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3			**Indicative content:** *Nature of a progressive wave* • (Particle) displacements or vibrations or oscillations... • passed on through medium or through a distance • without matter being transported • Carries / transports energy • Phase lag steadily increases with distance from source • Amplitude constant or falls with distance from source *Difference and example* Longitudinal: particle vibrations parallel to direction of [wave or energy] travel. *Accept clear diagram* *Example* sound **or** [compression] wave **or** seismic P Transverse: particle vibrations at right angles to direction of [wave or energy] travel. *Accept clear diagram* *Example* light (or e-m wave) **or** [transverse!] wave in a wire, string or rope **or** seismic S or any other correct example. **5-6 marks** *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* A comprehensive account. [Expect two or three (bulleted) points on the nature of a progressive wave, **and** l and t waves distinguished with *clear reference to relevant directions*, **plus** correct examples.] **3-4 marks** *There is a line of reasoning that is partially coherent, largely relevant, supported by some evidence and with some structure.* A less than comprehensive account. [Expect one or two points on the nature of a progressive wave, **and** an understandable attempt to distinguish l and t waves, **plus** correct examples.]	6			6		

Question			Marking details	Marks available					
				AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
			1-2 marks *A basic line of reasoning that is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* A poor account. [Expect one or two correct remarks about progressive waves and / or longitudinal / transverse waves.] **0 marks** No attempt made or no response worthy of credit.						
			Question 3 total	**6**	**0**	**0**	**6**	**0**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4	(a)	(i)		$\Delta y = 1.6$ m[m] or by implication (1)		1				
				Correct use of $\lambda = \frac{a\,\Delta y}{D}$ ignoring slips of 10^n. **ecf** on Δy (1)	1					
				$\lambda = 533$ n[m] [**ecf** on Δy if between 1.0 and 2.0 mm] (1)		1		3	2	3
		(ii)		*Diffraction* mentioned (1) For each slit, intensity falls off with angle from normal **or** doesn't spread round through 180° **or** equivalent (1)		2		2		2
		(iii)	I.	$\lambda_{i-r} > \lambda_{vis}$ **or** $\lambda_{i-r} > 700$ mm **or** $\lambda_{i-r} > 533$ mm (1) Accept wavelength has increased **or** infra-red has a longer wavelength $\Delta y \propto \lambda$ **or** equivalent e.g. Δy increases because a and D are constant [so student is right] (1)		2		2		2
			II.	Increase D **or** decrease a		1		1	1	1
	(b)			Light is a wave / wave-like (1) Repetition of experiment by other scientist(s) (1) Other experiments completed to check on the nature of light (1)			3	3		
				Question 4 total	**1**	**7**	**3**	**11**	**3**	**8**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)		T = 40 ms **or** f = 25 Hz **or** by implication with correct use of $v = \frac{\lambda}{T}$ **or** $v = f\lambda$, ignoring slips of 10^n (1) v = 0.50 m s^{-1} **unit mark** No ecf (1)		2		2	2	
		(ii)	I.	Same as printed graph. Accept poor shape.		1		1	1	
			II.	Same as printed graph but amplitude 2 mm. Accept poor shape. No ecf.		1		1	1	
		(iii)		$S_1Q - S_2Q = \frac{\lambda}{2}$ or equivalent (1) Waves (arrive) in antiphase / <u>exactly</u> out of phase (1) Displacements [due to S_1 and S_2] cancel [or partly cancel] **or** there is destructive interference, [so she is correct] (1)			3	3		
	(b)	(i)		Substitution and rearrangement: $\sin\theta = \frac{3 \times 590}{2000}$ accepting slips in powers of 10 (1) $\theta = 62[.25\ °]$ (1)		2		2	2	
		(ii)		3λ **or** 1 770 nm Accept 1.77 × 10^{-6} m or 1.8 × 10^{-6} m		1		1		
				Question 5 total	**0**	**7**	**3**	**10**	**6**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		This is the energy needed to eject an electron (1) from the surface **or** the metal **or** rubidium (**not** the atom) (1)	2			2		
	(b)		Any electron ejected is ejected by a single photon or equivalent (1)	1					
			Photon energy [or hf] must be [at least] equal to ϕ (1)	1					
			So $hf > \phi$ [for emission] (1)		1		3		
	(c)	(i)	Mean = 0.377 [V] Accept 0.376 [V] **or** 0.3765 [V] **or** 0.38 (V) (1) ± 0.011 [V] **or** 0.0110 [V] **or** 0.01 [V] (1) Answer + uncertainty expressed to an appropriate number of sig figs i.e. 0.377 (or 0.376) V ± 0.011 V or 0.38 ± 0.01 [V] (1) Must use earlier calculations		3			3	3
		(ii)	$E_{k\,max}$ calculated for **one** stopping pd i.e. 0.366 V → 5.86 × 10⁻²⁰ J, **or** 0.388 V → 6.21 × 10⁻²⁰ J **or** (0.377 V → 6.03 × 10⁻²⁰ J) (1) Einstein's equation used correctly, either with hf and **one** $E_{k\,max}$ value including mean to give ϕ, **or** with hf and $\phi = 3.62 × 10^{-19}$ J to give $E_{k\,max}$ e.g. $\phi = 6.63 × 10^{-34} × 6.34 × 10^{14} − 5.86 × 10^{-20}$ (1) $= 3.62 × 10^{-19}$ [J] (1) **or** $\phi = 6.63 × 10^{-34} × 6.34 × 10^{14} − 6.21 × 10^{-20}$ (1) $= 3.58 × 10^{-19}$ [J] (1) **or** $E_{k\,max} = 6.63 × 10^{-34} × 6.34 × 10^{14} − 3.62 × 10^{-19}$ (1) $= 5.83 × 10^{-20}$ [J] (1)						

Question			Marking details	Marks available					
				AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
			Conclusion: the ϕ of Rb, $(3.62 \times 10^{-19}$ J $)$ just fits in the range 3.58×10^{-19} J to 3.62×10^{-19} J so Rb is a possibility **or** $E_{k\,max} = 5.83 \times 10^{-20}$ J and lies just outside the range 5.86×10^{-20} J to 6.21×10^{-20} J) so possibly Rb or can't be Rb (1) **Variation on this method for the 1st and 4th marks:** 5.83×10^{-20} J correspond to a stopping pd of $0.364\,V$ (1) which lies just outside the range given, so possibly / probably not Rb (1)			4	4	2	4
			Question 6 total	**4**	**4**	**4**	**12**	**5**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)	More electrons occupy Level U than Level L Accept more electrons in higher state than lower state.	1			1		
		(ii)	All 3 arrows correct.		1		1		
		(iii)	Greater probability of stimulated emission [of photon] ... (1) ...than absorption [of photon] (1) So extra photon produced (1)	3			3		
	(b)		Calculation of 1.92×10^{-19} J (1) Use of $E = hf$ **or** $E = \dfrac{hc}{\lambda}$ (1) $f < 2.9 \times 10^{14}$ Hz **ecf** or $\lambda > 1.0 \times 10^{-6}$ m **ecf** so visible light not produced (1) **Alternative:** Use of $\dfrac{hc}{e\lambda}$ (1) eV values calculated at 400 nm and 700 nm i.e. 3.1 eV and 1.78 eV (1) Lasing transition less than 1.20 eV so visible light not produced (1) **Alternative:** Lasing transition <1.20 eV (1) Red photon is $\approx$2 eV (1) Therefore infra-red photon produced (1)			3	3	2	
			Question 7 total	**4**	**1**	**3**	**8**	**2**	**0**

Question			Marking details	Marks available					
				AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
8	(a)	(i)	Light travels different distances **or** by different routes **or** different paths (1) [Same pulse] takes different times **or** spreads out over time **or** equivalent (1)	2			2		
		(ii)	Core only a few wavelengths diameter. *Accept* thinner <u>core</u>. Accept light can only take one path. Don't accept smaller core.	1			1		
	(b)	(i)	1.574 sin C = 1.550 [sin 90°] **or** equivalent **or** by implication (1) C = 80° or by implication (1) θ = 10° **ecf** on C (1)		3		3	2	
		(ii)	Refraction (1) Accept TIR won't happen Also some reflection **or** intensity rapidly falls [with successive reflections] **or** light escapes from the core **or** light goes into the cladding (1)	2			2		
			Question 8 total	**5**	**3**	**0**	**8**	**2**	**0**

AS UNIT 2 – ELECTRICITY AND LIGHT

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	4	3	9	5	7
2	5	11	0	16	8	0
3	6	0	0	6	0	0
4	1	7	3	11	3	8
5	0	7	3	10	6	0
6	4	4	4	12	5	7
7	5	0	3	8	2	0
8	5	3	0	8	2	0
TOTAL	28	36	16	80	31	22