GCE AS MARKING SCHEME

SUMMER 2016

PHYSICS AS - Unit 2
2420U20/01

INTRODUCTION

This marking scheme was used by WJEC for the 2016 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.

AS UNIT 2 – ELECTRICITY AND LIGHT

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 1			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)	Conversion of eV to J i.e. any 1 of: 0.820 eV = 1.312×10^{-19} J 0.051 eV = 0.082×10^{-19} J 0.769 eV = 1.23×10^{-19} J or by implication (1) Photon energy = $= 0.82\ \text{eV} - 0.05\ \text{eV}$ **or** $1.312 \times 10^{-19}\ \text{J} - 0.082 \times 10^{-19}\ \text{J} = [1.230 \times 10^{-19}\text{J}]$ **or** by implication (1) $\lambda = 1\,617\ [\text{nm}]$ (1) [1 516 nm arises from wrong photon energy – 1 mark] Arithmetic slip lose 1 mark	1	1 1		3	3	
		(ii)	A photon of this wavelength or energy or 1.23×10^{-19} J or 0.769 eV or 1 617 nm (**ecf**) (accept "correct energy, specific energy") passing an electron in <u>the U state</u> (1) accept "colliding with" ... triggers release of another photon (1) don't accept "photon absorbed and emits two" The photons are in phase **or** of the same wavelength **or** energy **or** frequency **or** identical **or** travelling in the same direction (1) don't accept coherent	3			3		
	(b)		Level L self-emptying or short-lived or short time or fall immediately or equivalent (1) Population inversion easier to achieve (accept better or equivalent) **or** lower pumping [rate] needed (1) don't accept more efficient only	2			2		
			Question 1 total	**6**	**2**	**0**	**8**	**3**	**0**

Question				Marking details		Marks available				
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)		[Minimum] energy needed to eject an electron [from a material **or** surface **or** metal **not atom**]	1			1		
		(ii)	I	Brighter light of same frequency means more photons [per second] but individual photons unchanged (accept hf unchanged) (1) [so] ejection rate increased (1) accept more electrons emitted but maximum KE unchanged (1)	3			3		
			II	Photon energy for frequency 7.4×10^{14} Hz is 4.9×10^{-19} J or by implication (1) $\phi = 3.7 \times 10^{-19}$ [J] (1) Photon energy for frequency 5.1×10^{14} Hz is 3.4×10^{-19} [J] **or** threshold frequency = 5.59×10^{14} Hz (1) or by implication **ecf** on arithmetic slip on ϕ Photon energy < work function **or** photon frequency < threshold frequency so no emission or equivalent (1) no **ecf** Statement that KE is negative treat as neutral			4	4	3	
	(b)	(i)		Photon energy expressed as $E = \frac{hc}{\lambda}$ or by implication (1) Number per second = $\frac{P\lambda}{hc}$ (1) Accept $P \div (\frac{hc}{\lambda})$ or equivalent		2		2	2	
		(ii)		Use of $p = \frac{h}{\lambda}$ seen in momentum change per sec = $N \times \frac{h}{\lambda}$ **ecf** (1) Simplified to $\frac{P}{c}$ **ecf** from (i) but not if left in terms of N (1) **First mark available even if no answer to (b)(i)**		2		2	2	
		(iii)		Force	1			1		
				Question 2 total	**5**	**4**	**4**	**13**	**7**	**0**

Question			Marking details		Marks available				
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	$n = \frac{\sin 50.0}{\sin 29.0}$ [= 1.58] **or** $\frac{v_{\text{air}}}{v_{\text{plastic}}} = \frac{\sin 50.0}{\sin 29.0}$ [or by implication] (1) $v = 1.90 \times 10^8$ [m s^{-1}] (1)	1	1		2	2	
		(ii)	39.3° Accept 39.2° and 39° e**cf**	1			1	1	
	(b)	(i)	$n_{\text{clad}}[\sin 90°] = 1.530 \sin 81°$ Give this first mark even if 9° instead of 81° (1) $n_{\text{clad}} = 1.51$ (1)		2		2	2	
		(ii)	$\frac{1}{\cos 9°}$ **or** $\frac{1}{\sin 81°}$		1		1	1	
		(iii)	**Either** starting from $\Delta t = 7.5$ ns $t_{\text{axial}} = \frac{\Delta t}{0.0125}$ [= 600 ns] or by implication (1) $d = \frac{ct_{\text{axial}}}{n}$ used (1) d = 118 m, so 150 m is too long. [Accept d = 180 m so 150 m not too long, arising from omission of n – already penalised] (1) **or** if starting from d = 150 m, $t_{\text{axial}} = \frac{nd}{c}$ [= 765 ns] **or** t_{zigzag} = 775 ns or by implication (1) $\Delta t = 0.0125\ t_{\text{axial}}$ or equivalent used (1) $\Delta t = 9.6$ ns, (accept 10 ns) so 150 m is too long. [Accept $\Delta t = 6.25$ ns so 150 m not too long, arising from omission of n, already penalised.] (1)			3	3	3	
			Question 3 total	**2**	**4**	**3**	**9**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Diagram showing relevant right-angled triangle with d and θ labelled (1) $d \sin\theta$ stated to be path difference [between light from adjacent slits] (1) $d \sin\theta = n\lambda$ is condition for constructive interference [or for light to 'arrive' in phase (1) mention of constructive interference only don't award the mark	3			3	1	
	(b)	(i)	Scales correctly chosen (more than ½ used) and orientated and axes clearly labelled (1) $\sin\theta$ plotted correctly, whether or not tabulated - allow ± ½ small square tolerance (1) Best straight line through origin or by eye (1) **If θ plotted:** don't award the scales mark, plotting of points correctly mark can be awarded and best fit curve or straight line can be awarded		3		3	3	3
		(ii)	Gradient = $\frac{\lambda}{d}$ **or** single point on graph taken by implication (1) Gradient = 0.285 [± 0.005] (1) λ = 510 [± 15] nm (1) **unit mark** **If θ plotted:** If λ determined correctly award a maximum of 2 marks			3	3	3	3
			Question 4 total	**3**	**3**	**3**	**9**	**7**	**6**

Question			Marking details]	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		Work / charge **or** energy / charge **or** energy / coulomb (1) Don't accept joules / coulomb Context i.e. energy transferred [or converted] from electrical [potential] / work done……. [between the points] not a freestanding mark (1)	2			2		
	(b)	(i)	1.62 [V] **or** emf	1			1		
		(ii)	$I = \frac{1.38}{1.50}$ [=0.92 A] **or** by implication if answer correct to 2 sf (1) $V_r = 1.62\ \text{V} - 1.38\ \text{V} = [0.24\ \text{V}]$ **or** $R + r = \frac{1.62\ \text{V}}{0.92\ \text{A}} = [1.76\ \Omega]$(1) $r = 0.26\ [\Omega]$ (1)		3		3	3	
		(iii)	$t = \frac{750\ \text{J}}{EI}$ (1) or by implication **ecf** $t = 500\ \text{s}$ [503 s] (1) [590 s indicates wrong pd used so award 1 mark only]		2		2	2	
		(iv)	Total circuit resistance = 0.26 Ω **ecf** + 0.75 Ω or by implication (1) $V_R = 1.20$ [V] (1) or 0.3 Ω + 0.75 Ω gives $V_R = 1.16$ [V]		2		2	2	
	(c)	(i)	$I = \frac{6.0\ \text{V}}{200\ \Omega + 850\ \Omega)}$ [= 5.71 mA] **or** $V_{200} = \frac{200}{200+850}\ 6.0\ \text{V}$ (1) $V_{200} = 1.14$ [V] (1)V_{LDR} = 4.86 [V] but V_{200} not given award 1 mark		2		2	2	
		(ii)	**No credit** for 'Resistance decreases' Current increases **or** *total* circuit resistance decreases **or** any relevant resistance ratio (e.g. $\frac{V_{200}}{V_{\text{LDR}}}$) stated to increase or decrease as appropriate to the ratio (1) V_{200} goes up, but award mark only if argument presented so that this conclusion follows (1) **no ecf** from (c)(i)		2		2		
			Question 5 total	**3**	**11**	**0**	**14**	**9**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)	Waves from source interfere (accept superpose) with waves <u>reflected</u> [from plate] (1) Waves in phase **or** constructively interfere at [each] antinode (1)		2		2		
		(ii)	Antinodes $\frac{\lambda}{2}$ apart or λ = 32 mm (1) 8 mm = ¼ λ or equivalent, so node at P (1) If correct answer and valid argument without any reference to λ award 1 mark. Alternative for 1 mark only – phase change of 180° <u>on reflection</u> therefore node at P		1	1	2		
	(b)	(i)	In antiphase. Accept exactly**, or** π**, or** <u>180° out of phase</u> or half a cycle (1) don't accept phases expressed in terms of λ Longest λ is 0.60 m [because 0.30 m = $\frac{\lambda}{2}$] (1) Second longest is 0.20 m [because 0.30 m = $\frac{3\lambda}{2}$] (1)	1	1 1		3		
		(ii)	f = 20 [Hz] **or** T = 0.050 s if <u>used</u> in $v = \frac{\lambda}{T}$ (1) If λ = 0.60 m, then $v = 20 \times 0.6 = 12$ [m s^{-1}] (1) **ecf** on both λ This is in range; λ = 0.20 [m] is out of range (1) **Alternative method for last two marks** 10 m s^{-1} at 20 Hz corresponds to λ = 0.50 m, **and** 15 m s^{-1} at 20 Hz corresponds to λ = 0.75 m (1) So λ = 0.60 m (1) **ecf** on (i) extending to conclusion (also rewards strategy)		3		3	2	
			Question 6 total	**1**	**8**	**1**	**10**	**2**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Circuit sends current that can be varied through lamp (1) Accept series variable resistor correctly drawn, variable potential divider, or any recognisable symbol for variable (dc) power supply. Ammeter and voltmeter correctly connected and shown by correct symbols (1)	2			2		2
		(ii)	Choose 200 mA as better resolution (accept precision, accuracy) Accept 0.16 A is closer to maximum of range for that meter		1		1		1
		(iii)	More points needed [for lower voltages] (1) accept smaller intervals or more readings pd range needs <u>extending</u> [beyond 2 V (to 3 V)] (1) Don't accept take evenly spaced readings or take repeat readings or equivalent			2	2		2
	(b)	(i)	5.0 [Ω] **or** $\frac{0.50}{0.10}$ [Ω] **or** by implication (1) 13.8 [Ω] **or** $\frac{2.00}{0.145}$ [Ω] **or** by implication (1) 2.8 (1) Accept correct answer expressed as a fraction 14.2 [Ω] or 14.3 [Ω] are from graph mis-readings deduct 1 mark only		3		3	3	
		(ii)	**Marking points** **M1** [Free] electrons make collisions **M2** …..with ions **or** atoms **or** lattice (accept particles) **M3** Increasing the pd increases the current / drift velocity / energy of electrons **M4** Electrons hit ions harder or transfer more energy [**or** equivalent] when I [or V] larger **M5** Increased vibration [amplitude] [of ions/atoms] **M6** Therefore temperature increases **M7** Collisions more frequent **or** more probable [when T larger] **M8** Smaller current / drift velocity [for a given pd] **M9** Resistance increases in context						

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks 7 – 9 of M1 – M9 are present *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** 4 - 6 of M1 – M9 are present *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1 - 3 of M1 – M9 are present *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		
	(c)		No marks for unsupported 'Spend' or 'Don't spend'. Worth following up because: Any 2 × (1) from: - **Use of superconductors** avoids energy wastage (accept reduced resistance to zero) or equivalent or specific example pointing out advantage - **Room temperature superconductivity** means no cooling costs or makes systems simpler or cheaper or equivalent - **Advancing scientific knowledge** **But** original claim very likely to be wrong, so hard to defend spending more (1)			3	3		
			Question 7 total	**8**	**4**	**5**	**17**	**3**	**5**

AS UNIT 2: ELECTRICITY AND LIGHT

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	2	0	8	3	0
2	5	4	4	13	7	0
3	2	4	3	9	9	0
4	3	3	3	9	7	6
5	3	11	0	14	9	0
6	1	8	1	10	2	0
7	8	4	5	17	3	5
TOTAL	**28**	**36**	**16**	**80**	**40**	**11**