



GCE MARKING SCHEME

SUMMER 2016

**PHYSICS PH2 - (LEGACY)
1322/01**

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.

**WJEC GCE PHYSICS PH2 - (LEGACY)
SUMMER 2016 MARK SCHEME**

Question			Marking details	Marks Available	
1	(a)	(i)	$y = \frac{532 \times 10^{-9} \times 1.5}{0.0004}$ even if slips in powers of 10 (1) $y = 2.0 \text{ mm}$ (1) unit mark	2	
		(ii)	Maxima on -4, -2, 0, 2, 4 mm; minima on -3, -1, 1, 3 mm ecf (1) Reasonable attempt at smooth variation (1) Maxima lower further from centre or evidence of single slit diffraction envelope (1)	3	
		(iii)	[Bright] fringes brighter (1) Fringes closer together (1) don't accept fringes are smaller	2	
		(iv)	I	• No credit for "Fringes red instead of green" Fringes further apart because $\lambda_{\text{red}} > \lambda_{\text{green}}$	1
			II	• Bright fringes dimmer and / or dark fringes brighter or uniform brightness. [Accept "fringes disappear" or "no fringes" or single [broad] peak] (1) because no [destructive or constructive] interference or because we now have single slit diffraction (1)	2
(b)		$1500 \text{ [nm]} \sin 44^\circ$ [or 46° or even 45°] = 2λ or equivalent (1) $\lambda_{\text{min}} = 521 \text{ [nm]}$ (1) $\lambda_{\text{max}} = 540 \text{ [nm]}$ or 539 [nm] (1)	3		
(c)		First experiment Observed: no change in brightness or equivalent (1) Explanation: oscillations in all directions [in plan of polariser] so equal absorption for all angles [of polaroid] (1) Accept equal absorption in all directions Second experiment Observed: Brightness changes as polaroid rotated (1) from bright to dark or vice versa every 90° or bright twice every revolution or any other correct quantitative remark (1) Explanation: extinctions [when absorbing axes of polaroids] are at right angles or crossed or equivalent (1)	5		
Question 1 Total				[18]	

Question			Marking details	Marks Available
2	(a)	(i)	$\lambda = 2.0$ [m] or equivalent (1) $f = 171$ [Hz] (ecf on wrong value of λ) (1)	2
		(ii)	Progressive waves travelling in opposite directions <u>interfere</u> (accept superpose). (1) Waves in opposite directions arise from <u>reflections</u> [at ends of pipe] (1)	2
	(b)	(i)	Graph shifted one division (0.1 m) to the right (1) Whole string shown, and amplitude roughly same as before (1)	2
		(ii)	$\lambda = 0.40$ [m] or $T = 0.080$ [s] or by implication (1) $f = 12.5$ Hz unit mark (1)	2
		(iii)	[From $\lambda = \frac{v}{f}$] λ decreases (1) assuming v unchanged (or tension unchanged) (1)	2
Question 2 total			[10]	

Question			Marking details	Marks Available
3	(a)	(i)	<p>Method 1 AC= 27 mm [± 1 mm] BD = 42 mm [± 1 mm] (1) $v_{\text{plastic}} = \frac{AC}{BD} \times 3.00 \times 10^8 \text{ m s}^{-1}$ or equivalent (1) $v_{\text{plastic}} = 1.9 \times 10^8 \text{ m s}^{-1}$ ecf on lengths (1)</p> <p>Method 2 AC= 27 mm [± 1 mm] AD = 59.5 mm [± 1 mm]; (1) $\sin \theta = \frac{AC}{AD} = [0.453]$ so $v_{\text{plastic}} = 3.00 \times 10^8 \text{ m s}^{-1} \times \frac{AC}{\sin 45^\circ}$ (1) $v_{\text{plastic}} = 1.9 \times 10^8 \text{ m s}^{-1}$ ecf on lengths (1)</p>	3
		(ii)	$\sin \theta = \frac{\sin 45^\circ}{\frac{BD}{AC}}$ or equivalent (1) $\theta = 27^\circ$ [$\pm 2^\circ$] ecf on lengths and arithmetical slips (1)	2
	(b)	(i)	$v = \frac{360}{1.86 \times 10^{-6}}$ [= $1.94 \times 10^8 \text{ m s}^{-1}$] or by implication (1) $n = 1.55$ (1) [1 mark for $n = 1.59$ from using zigzag time]	2
		(ii)	$\sin \phi = \frac{1.86}{1.91}$ [= 0.974] or equivalent or by implication (1) $\phi = 77^\circ$ (1)	2
		(iii)	$[\phi$ is for slowest route, so] ϕ is critical angle or equivalent (1) Slower paths would imply smaller angles of incidence, for which light would escape [into cladding] (1)	2
		(iv)	Pulses broadened [in time] or can overlap because of different possible routes [<i>accept</i> by multipath dispersion] (1) The shorter the fibre the less the broadening or the less chance of pulses overlapping [or equivalent] (1)	2
	Question 3 Total			[13]

Question			Marking details	Marks Available
4	(a)	(i)	Energy of photon [of frequency f]	1
		(ii)	[Minimum] energy needed to eject an electron [not "electrons"] from a surface [or a metal or a solid, not an atom].	1
	(b)	(i)	$hf = 7.40 \times 10^{14} \times 6.63 \times 10^{-34} - 3.65 \times 10^{-19}$ seen or by implic (1) $E_{k \max} = 1.26 \times 10^{-19}$ [J] (1)	2
		(ii)	$E_{k \max} = 1.26 \times 10^{-19}$ [J] ecf or same as for violet alone or equivalent	1
		(iii)	No emission because <u>photon</u> energy too small (1) $hf = 3.46 \times 10^{-19}$ J, which is less than ϕ , $hf - \phi = -1.9 \times 10^{-20}$ J with attention drawn to minus sign or equivalent (1)	2
	(c)	Increase voltage from zero until microammeter reads zero (accept until current is zero) or equivalent (1) $E_{k \max} = e \times$ 'cut-off voltage' accept $E_{k \max}$ in eV = cut-off voltage (1)	2	
	Question 4 Total			[9]

Question			Marking details	Marks Available
5	(a)	(i)	$\Delta E = 1.51 \times 10^{-19}$ [J] [or $hf = \Delta E$ and $\lambda = \frac{c}{f}$ or $\lambda = \frac{hc}{\Delta E}$ or by imp] (1) $\lambda = 1.32 \mu\text{[m]}$ (1) Infra-red (1)	3
		(ii)	Correct handling of efficiency output power 0.035 W or by implic (1) Division of power by photon energy (1.51×10^{-19} J) attempted (1) 2.3×10^{17} [s ⁻¹] photons per unit time [ecf on 2.29×10^{-19} J from (i)] (1)	3
	(b)	Electrons raised [or pumped] from ground to P and drop to U [or shown on diagram] (1) Electrons [spontaneously] drop from L to ground (accept L is self-emptying) (1) Any × 1 from: <ul style="list-style-type: none"> • P short-lived • U long-lived [metastable] • L short-lived • L not reliant on pumping to deplete 	3	
	(c)	Stimulated emission requires a [passing] photon [of energy $E_U - E_L$]; [spontaneous emission doesn't] (1) Two photons after stimulated emission event; one before (1)	2	
	Question 5 Total			[11]

Question		Marking details	Marks Available
6	(a)	An object [or surface] that absorbs all [e-m] radiation falling on it or that emits more radiation [per second per unit area at each wavelength] than any other object [or surface] at the same temperature	1
	(b)	(i) X peaks in infra-red or close to red or close to 700 nm or equivalent and is red [or yellow] (1) Y peaks in ultraviolet or close to blue or close to 400nm or equivalent and is blue [or white or violet] (1)	2
		(ii) X peaks at 800 nm [± 20 nm], Y at 360 nm [± 10 nm] or by implication (1) $T_X = 3625$ K, $T_Y = 8056$ K or $\frac{T_Y}{T_X} = \frac{800}{360}$ or equivalent or inverse proportionality between T and λ mentioned (1) $\frac{T_Y}{T_X} = 2.2$ must be to 2 sig figs [ecf on numerical slips including wrong peak λ s, but only if comment made if answer doesn't round to 2] (1)	3
		(iii) 24 or 23 [or 16 if $\frac{T_Y}{T_X}$ taken as 2] ecf	1
		(iv) $24 \frac{A_Y}{A_X} = 9.0$ [ecf on 24] or equivalent or by implication (1) $\frac{d_Y}{d_X} = \sqrt{\frac{9}{24}}$ or equivalent, ecf on $\frac{9}{24}$, or by implication (1) $d_Y = 9.2 \times 10^8$ [m] or 9.4×10^8 [m] or 1.1×10^9 [m] ecf on (iii) (1) Alternative: $P_X = 6.92 \times 10^{25}$ [W] or equivalent (1) $9.0 P_X = \sigma A_Y \times 8056^4$ or equivalent (1) $d_Y = 9.2 \times 10^8$ [m] or 9.4×10^8 [m] or 1.1×10^9 [m] ecf on (iii) (1)	3
Question 6 Total		[10]	

Question		Marking details	Marks Available
7	(a)	proton: uud, charge = $\frac{2}{3} + \frac{2}{3} + -\frac{1}{3} = 1.0$ [units of e] (1) neutron: udd, charge = $\frac{2}{3} + -\frac{1}{3} + -\frac{1}{3} = 0$ (1) [Accept alternative presentations in which quark constitutions of p and n are clear, and charges of u and d are clear.]	2
	(b)	(i) Charge LHS: 4p, 1e ⁻ [overall charge 3e]; RHS: 3p, ν_e has no charge [overall charge 3e] Accept 4-1 → 3+0(1) Lepton number LHS: e ⁻ : 1 Be: 0; RHS: ν_e :1 Li: 0 Accept 0+1 → 0+1 (1)	2
		(ii) Proton lost, neutron gained [or proton changes to neutron] (1) u lost, d gained [or u changes to d] (1)	2
		(iii) ${}^3_2\text{He}$ lost, ${}^4_2\text{He}$ gained [or ${}^3_2\text{He}$ changed to ${}^4_2\text{He}$]	1
		(iv) Fusion: [smaller or lighter] <u>nuclei</u> combine (1) E-m interaction: shown by γ or photon released (1)	2
Question 7 Total			[9]