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.

Question				Marking details	Marks Available
1	*(a)*	(i)		$y = \frac{532 \text{ x } 10^{-9} \text{ x } 1.5}{0.0004}$ even if slips in powers of 10 (1) y = 2.0 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** $\lambda_{red} > \lambda_{green}$	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 [nm] sin 44° [or 46° or even 45°] = 2λ or equivalent (1) λ_{min} = 521 [nm] (1) λ_{max} = 540 [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)	λ = 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)	λ = 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)	**Method 1** AC= 27 mm [± 1 mm] BD = 42 mm [± 1 mm] (1) $v_{\text{plastic}} = \frac{\text{AC}}{\text{BD}} \times 3.00 \times 10^8$ m s^{-1} or equivalent (1) $v_{\text{plastic}} = 1.9 \times 10^8$ m s^{-1} **ecf** on lengths (1) **Method 2** AC= 27 mm [± 1 mm] AD = 59.5 mm [± 1 mm]; (1) $\sin\theta = \frac{\text{AC}}{\text{AD}}$ =[0.453] so $v_{\text{plastic}} = 3.00 \times 10^8$ m s^{-1} $\times \frac{\frac{\text{AC}}{\text{BD}}}{\sin 45^{\circ}}$ (1) $v_{\text{plastic}} = 1.9 \times 10^8$ m s^{-1} **ecf** on lengths (1)	3
		(ii)	$\sin\theta = \frac{\sin 45^{\circ}}{\frac{\text{BD}}{\text{AC}}}$ **or** equivalent (1) $\theta = 27°$ [± 2°] **ecf** on lengths and arithmetical slips (1)	2
	(b)	(i)	$v = \frac{360}{1.86 \times 10^{-6}}$ [= 1.94 × 10^8 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) $\phi = 77°$ (1)	2
		(iii)	[ϕ 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 [*accept* 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) $E_{k\ \mathrm{max}} = 1.26 \times 10^{-19}$ [J] (1)	2
		(ii)	$E_{k\ \mathrm{max}} = 1.26 \times 10^{-19}$ [J] **ecf or** same as for violet alone **or** equivalent	1
		(iii)	No emission because photon 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) $E_{k\ \mathrm{max}} = e \times$ 'cut-off voltage' accept $E_{k\ \mathrm{max}}$ in eV = cut-off voltage (1)	2
			Question 4 Total	**[9]**

Question			Marking details	Marks Available
5	*(a)*	(i)	ΔE = 1.51 × 10^{-19} [J] [**or** $hf = \Delta E$ **and** $\lambda = \frac{c}{f}$ **or** $\lambda = \frac{hc}{\Delta E}$ **or** by imp] (1) λ = 1.32 μ[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:** • **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 = 3 625 K, T_Y = 8 056 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 λs, 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 × 10^8 [m] **or** 9.4 × 10^8 [m] **or** 1.1 × 10^9 [m] **ecf** on (iii) (1) **Alternative:** P_X = 6.92 × 10^{25} [W] or equivalent (1) 9.0 P_X = σA_Y × 8056^4 or equivalent (1) d_Y = 9.2 × 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)	${}^{3}_{2}\mathrm{He}$ lost, ${}^{4}_{2}\mathrm{He}$ gained [**or** ${}^{3}_{2}\mathrm{He}$ changed to ${}^{4}_{2}\mathrm{He}$]	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]**