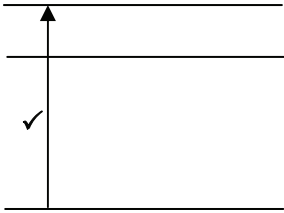


PH2 Mark Scheme – January 2010

Question		Marking details	Marks Available
1	(a)	(i) I. 2 arrows drawn upwards at right angles to wave fronts	1
		II. The waves travel more slowly in the shallow water (1) as the propagation direction bends towards the normal (or equiv) (1)	2
		(ii) I. Wavelength = 8 [±1] mm	1
		II. $f = \frac{0.33 \text{ m s}^{-1}}{0.008 \text{ m}}$ (1) [or by impl.] (e.c.f. on λ) = 40 or 41 Hz (1)	2
		[-1 on wrong power of 10]	
	III. Attempt clearly based upon unchanged f <u>or</u> $\frac{v_s}{v_d} = \frac{\lambda_s}{\lambda_d}$ (1) [or by impl.]	2	
	$v = 0.21$ [±0.02 m s ⁻¹] (e.c.f. on f) (1)		
	(b)	(i) Total internal reflection	1
		(ii) $1.58 \sin 72^\circ = n_{\text{clad}} \sin 90^\circ$ [or by impl.] (1)	3
		$n_{\text{clad}} = 1.58 \sin 72^\circ$ <u>or</u> $\sin 90^\circ = 1$ <u>or</u> by impl. (1)	
	$n_{\text{clad}} = 1.50$ (1)		
	[Angles transposed, leading to $n = 1.64$, or other transposition errors → 1 mark only]		
	(iii) Light takes longer by zigzag paths [accept ‘multimode dispersion’] [Accept – different paths give different times] (1)	2	
	A piece of data will be ‘smeared out’ over time on arrival <u>or</u> may overlap other pieces of data (1) [Accept ‘pulse broadening’ only if first mark gained by reference to zigzag paths, i.e. not ‘multimode dispersion’ + ‘pulse broadening’ only (2)]		
			[14]

Question			Marking details	Marks Available	
2.	(a)	(i)	At [centres of] bright fringes: <ul style="list-style-type: none"> • Path lengths from slits differ by $0, \lambda, 2\lambda...$ [if sources in phase] • Waves arrive in phase or sketch graphs of in-phase waves • Waves interfere constructively <u>or</u> displacements add to make larger displacement. • Assume slits act as coherent sources or waves diffract at slits 	any 4 × (1)	4
		(ii)	Separation of centres of fringes = $\frac{4.0}{3}$ mm / 1.3 mm / 1.33 mm [or equiv, or by impl.] (1) Correct data substitution into $\lambda = \frac{ay}{D}$ ignoring factors of 10 [e.c.f.] (1) $\lambda = 6.3 \times 10^{-7}$ m (1)		3
	(b)	(i)	$2[.00] \times 10^{-6}$ m		1
		(ii)	Attempt to use $n\lambda = d \sin \theta$ with $d = 2.00 \times 10^{-6}$ m [e.c.f.] (1) $\theta = 72^\circ$ (1) $n = 3$ (1) $\lambda = 6.3 \times 10^{-7}$ m (1) [e.c.f. only on d from (b)(i)]		4
	(c)		More uncertainty with Young's method (1)... because..... either fringe separation is small and difficult to measure [whereas grating beams are well spaced] or fringes are not sharp compared to the beams (1) [accept: d can be measured more accurately for grating [because there are more slits]]		2
				[14]	

Question		Marking details	Marks Available
3	(a)	(i) ... in phase (1) ... in antiphase [accept <u>completely</u> or 180° or π out of phase] (1)	2
		(ii) Use stroboscope (1) and adjust flash frequency for slow motion / expect to see A moving up as C moves down etc. (1) [Or: Use a video camera and replay in slow motion / expect to see A moving up as C moves down etc.]	2
	(b)	(i) Either: <u>Amplitude</u> constant [or falls off] for progressive wave (1) as we go through the medium; goes up and down [regularly] form stationary wave (1) Or: <u>Phase</u> changes steadily with distance for progressive waves (1); reverses at nodes [otherwise constant] form stationary waves (1) [“Stationary waves have nodes, progressive waves don’t” → 1]	2
		(ii) Reflections give rise to waves propagating in both directions (1); interference between these [progressive] waves gives stationary wave (1)	2
	(c)	(i) 0.6 m	1
(ii) 30 m s ⁻¹ ((unit))	1		
			[10]
4.	(a)	(i) <u>Photon</u> energy	1
		(ii) $E_{k \max}$ is the maximum KE of emitted electron (1) ϕ is the minimum energy for an electron to escape (1). What is left over of the photon’s energy after the escape is its kinetic energy. (1)	3
	(b)	(i) Graph: Points [±0.2 divisions] (1); line [not necessarily extrapolated] (1)	2
		(ii) I. $3.8 [\pm 0.2] \times 10^{-19} \text{ J}$ II. $\frac{(4.04 - 0.79) \times 10^{-19} \text{ J}}{(11.8 - 6.9) \times 10^{14} \text{ Hz}} \left[\text{or } \frac{\Delta y}{\Delta x} \text{ from graph} \right] (1)$ $= 6.6 [\pm 0.4] \times 10^{-34} \text{ Js}$ (1) NB. Must be value from working.	2
(iii) Graph line drawn with same slope (1) and to left of / above that for sodium (1)	2		
			[11]

Question		Marking details	Marks Available
5	(a)	$\Delta E = \frac{hc}{\lambda}$ [or $\Delta E = hf$ and $c = f\lambda$] [or by impl.] (1) $\lambda = 6.95 \times 10^{-7} \text{ m (1)}$	2
	(b)	(i) Absorption [accept excitation]	1
		(ii) Increases atom's [accept electron's]energy [accept 'excites atom' unless excitation credited in part (i)](1)	1
	(c)	(i) <u>Stimulated</u> emission	1
		(ii) Any 2 × 1 of: frequency [or wavelength or energy] / phase / propagation direction / polarisation	2
(d)	(i) More electrons in the higher (middle) level than the lower [or ground]	1	
	(ii) Arrow shown on Process B from lowest level to top level.	1	
			
(iii) Shorter time at top level (1) to maintain population of middle level (1)...	2		
[11]			
6	(a)	Charge = $\frac{2}{3} [e] + -\frac{1}{3} [e] + -\frac{1}{3} [e] = 0$ [or equiv.] [or No other combination of 3 u and d quarks gives zero charge]	1
	(b)	(i) $\pi^-: -\frac{1}{3} [e] + -\frac{2}{3} [e]$ [or equiv.] = $-e$ [or -1] (1) $\Delta^-: 3 \times -\frac{1}{3} [e] = -e$ [or -1] (1)	2
		(ii) A meson is a quark-antiquark (1) pairing. A baryon is a triplet of quarks [accept antiquarks] (1)	2
	(c)	(i) I. $0 \rightarrow 1 + (-1)$ or equiv. II. $3 \rightarrow 2 + 1$ or equiv.	2
		(ii) u and d individually conserved or lifetime too short [accept no ν_e involvement]	1
	(d)	(i) uuu	1
		(ii) π must be $u\bar{d}$ [because charge must be conserved or because u and d numbers are individually conserved].	1
	[9]		

Question		Marking details	Marks Available
7	(a)	$\lambda_{\max} = 950 [\pm 50] \text{ nm}$ [or by impl.] (1) $T = \frac{2.90 \times 10^{-3} \text{ m K}}{950 \times 10^{-9} \text{ m}}$ (1) [ecf on λ_{\max}] $= 3050 \text{ K}$ (1)	3
	(b)	(i) Spectral intensity [far] greater at 700 nm [than at 400 nm].	1
		(ii) Infrared	1
		(iii) I. peak / around 900 – 950 nm II. $\lambda_{\max} = 550 \text{ nm}$ [accept 500 – 600 nm](1) $T = 5300 \text{ K}$ (1) [e.c.f. from λ_{\max} but only if λ_{\max} between 400 and 700 nm]	1 2
(c)	knowledge of meaning of symbols in $P = \sigma AT^4$ demonstrated (1) $A = 4\pi \times (1.01 \times 10^8 \text{ m})^2 [=1.28 \times 10^{17} \text{ m}^2]$ (1) $P = 6.3 \times 10^{23} \text{ W}$ ((unit))(1) [e.c.f. on T from (a)] [1 mark lost if answer adrift by a factor of π or 2^n , or if the answer to (b)(iii)II used instead of 3000 K]	3	
			[11]