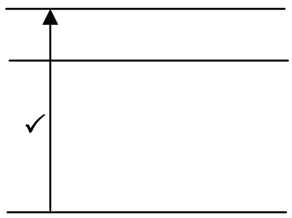
PH2 Mark Scheme – January 2010

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) [−1 on wrong power of 10]	2
			III. Attempt clearly based upon unchanged *f* <u>or</u> $\frac{v_s}{v_d} = \frac{\lambda_s}{\lambda_d}$ (1) [or by impl.] v = 0.21 [±0.02 m s^{-1}] (e.c.f. on *f*) (1)	2
	(b)	(i)	Total internal reflection	1
		(ii)	$1.58\sin 72^\circ = n_{clad}\sin 90^\circ$ [or by impl.] (1) $n_{clad} = 1.58\sin 72^\circ$ <u>or</u> $\sin 90^\circ = 1$ <u>or</u> by impl. (1) $n_{clad} = 1.50$ (1) [Angles transposed, leading to n = 1.64, or other transposition errors → 1 mark only]	3
		(iii)	Light takes longer by zigzag paths [accept 'multimode dispersion'] [Accept – different paths give different times] (1) 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)]	2
				[14]

Question			Marking details	Marks Available
2.	*(a)*	(i)	At [centres of] bright fringes: • Path lengths from slits differ by 0, λ, 2λ... [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] × 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) $\theta = 72°$ (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 completely 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:** Amplitude constant [or falls off] for progressive wave (1) as we go through the medium; goes up and down [regularly] form stationary wave (1) **Or:** Phase 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)	Photon 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 [± 0.2] × 10^{-19} J	1
			II. $\frac{(4.04-0.79)\times10^{-19}\,\text{J}}{(11.8-6.9)\times10^{14}\,\text{Hz}}\left[\text{or } \frac{\Delta y}{\Delta x} \text{ from graph}\right]$ (1) = 6.6 [± 0.4]× 10^{-34} 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) $\lambda = 6.95 \times 10^{-7}$ 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)	Stimulated 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)	π^-: $-\frac{1}{3}$ [e] + $-\frac{2}{3}$ [e] [or equiv.] = –e [or –1] (1) Δ^-: 3 × $-\frac{1}{3}$ [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 → 1 + (–1) or equiv. II. 3 → 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)*		λ_{max} = 950 [± 50] 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 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	1
			II. λ_{max} = 550 nm [accept 500 – 600 nm](1) T = 5300 K (1) [e.c.f. from λ_{max} but only if λ_{max} between 400 and 700 nm]	2
	(c)		knowledge of meaning of symbols in $P = \sigma A T^4$ demonstrated (1) $A = 4\pi \times (1.01 \times 10^8\ \text{m})^2$ [$=1.28 \times 10^{17}\ \text{m}^2$] (1) $P = 6.3 \times 10^{23}$ 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]