PH2 Mark scheme – January 2011

Question			Marking details	Marks Available
1	*(a)*	(i)	0.20 m	1
		(ii)	I. 10 m s^{-1} [e.c.f.]	1
			II. 0.02 s	1
			III. Displaced wave drawn with same amp and wavelength (1) As 1st marking point with displacement 0.05 m to right (1)	2
		(iii)	Direction of [particle] oscillation [accept particle movement] and direction of travel [or direction of energy propagation] (1) at right angles (1).	2
	(b)	(i)	Progressive waves transfer energy through medium; stationary waves do not.	1
		(ii)	For progressive waves the amplitude doesn't change [or falls gradually] (1) For stationary waves the amplitude increases, decreases and increases (1) [or drops to zero at equally spaced points / nodes]	2
				[10]
2.	*(a)*	(i)	Spreads out [or equiv. but not just "bends"]	1
		(ii)	constant phase relationship (1) [between light from slits / sources]	1
	(b)		re-arrangement of formula at any stage (1) [or by impl.] answer correct except, perhaps, for powers of 10 (1) 1.9 m (1)	3
	(c)		Dark fringes caused by destructive interference (1). With one slit closed, light from the other slit not cancelled [or equiv.](1)	2
				[7]

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3	*(a)*	(i)	Formula correctly transposed at any stage (1). $n = 2$ (1); $d = 2.2$ μm (1)	3
		(ii)	Uncertainty [accept error] in measuring angle makes lower uncertainty [accept error] in d.	1
	(b)	(i)	$2\lambda = 2.2 \times 10^{-6} \sin 35.1°$ [e.c.f.] (1) [or by impl.] $\lambda = 633$ nm (1)	2
		(ii)	**Either** $\frac{d}{\lambda} = 3.5$ [or < 4] **or** $\frac{3\lambda}{d}$ and $\frac{4\lambda}{d}$ evaluated [in an attempt to find $\sin\theta$]. (1) [e.c.f. on d or λ] 3rd order deduced by valid reasoning (1).	2
				[8]
4.	*(a)*		$n_{clad} \sin 90° = 1.540 \sin 77°$ **or** $n_{clad} = 1.540 \sin 77°$ [or by impl.] (1) $n_{clad} = 1.50[1]$ [accept 1.5] (1)	2
	(b)	(i)	speed = $\frac{3.00 \times 10^8}{1.54}$ (1) time = $\frac{\text{distance}}{\text{speed}}$ (1) [transposed at any stage] $= 1.027 \times 10^{-5}$ s (1) [omission of 1.54 loses just 1 mark]	3
		(ii)	I. AB = $\frac{AC}{\sin 77°}$ **or** AB = $\frac{AC}{\cos 13°}$ **or** equiv. (1) II. Zigzag time = $1.027 \times 10^{-5} \times 1.026$ s (1) [**or** Extra time = $1.027 \times 10^{-5} \times 0.026$ or by impl.] Extra time = 2.7×10^{-7} s [e.c.f. on speed] (1)	1 2
		(iii)	Bit of data arrives spread out over a period of time [accept: data smeared or multimode dispersion] (1). Data bits could overlap on arrival / can't distinguish (1)	2
				[10]

Question			Marking details	Marks Available
5.	*(a)*		[minimum] energy needed to eject an electron [from surface]	1
	(b)	(i)	$hf_{min} = \phi$ [or equiv. or by impl.] (1) $f_{min} = 5.7\ 10^{14}$ Hz (1)	2
		(ii)	$E_{k\,max} = 6.63 \times 10^{-34} \times 7.0 \times 10^{14} - 3.8 \times 10^{-19}$ [or equiv or by impl.] (1) $= 8.4 \times 10^{-20}$ J (1)	2
	(c)	(i)	Increasing intensity increases number of photons per second [or "photons cannot co-operate"]. (1) But individual photon energy unchanged [or "frequency unchanged"] (1).	2
		(ii)	No. of emitted electrons per second [accept current].	1
	(d)		Increase p.d. from zero (1) until ammeter reads zero (1). Take voltmeter reading, V. (1) Evaluate eV. (1)	4
				[12]
6	*(a)*	(i)	$\lambda = \frac{hc}{E}$ [any orientation] [**or** $E = hf$ **and** $f = \frac{c}{\lambda}$] (1) $\lambda = 6.33 \times 10^{-7}$ m ((**unit**))(1)	2
		(ii)	Red or orange.	1
		(iii)	Arrow shown from top energy level to middle level	1
	(b)	(i)	[Incident or passing] photon (1) of energy 3.14×10^{-19} J [or equiv. but not just "of the right energy"] (1)	2
		(ii)	Any 2 × 1 of: • coherent ✓ • beam nearly parallel ✓ • [almost] monochromatic [or same frequency] ✓ • polarised ✓	2
	(c)	(i)	[photons reflected by M_2 per second =] 6.3×10^{-15} [s^{-1}] **and** [photons transmitted per second =] 0.7×10^{15} [s^{-1}]	1
		(ii)	$0.7 \times 10^{15}\ s^{-1} \times 3.14 \times 10^{-19}$ J [or by impl.] (1) = 0.22 mW ((**unit**))(1) [1 mark lost if wrong number of photons used]	2
		(iii)	Stimulated emission event gives 2 photons out for 1 photon in. (1) Many such events as photons traverse amplifying medium [twice] (1) [**or** other true **and** relevant observation]	2
				[13]

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7.	*(a)*	(i)	LHS: lepton number [= 0 + 0] = 0 (1) RHS: lepton number = [0] – 1 + 1 (1) [= 0]	2
		(ii)	I. $4 \rightarrow 3$ II. $2 \rightarrow 3$	1 1
	(b)		weak (1) because of neutrino involvement [**or** change in quark flavour] (1)	2
	(c)		takes place in the Sun (1) first stage in fusion chain [**or** ultimately leads to sunshine] (1) **Alternatively:** <u>has</u> taken place in stars (✓) leading to the formation of heavy elements (✓)	2
	(d)		electro-magnetic	1
				[9]
8	*(a)*	(i)	Power = intensity × $4\pi r^2$ (1) = 3.8[5] × 10^{26} W (1) [1 mark lost for factors of 2, 3 or 10^n adrift]	2
		(ii)	absorption by atmosphere.	1
	(b)	(i)	$A = \frac{3.85\times10^{26}}{5.67\times10^{-8}\times5780^4}$ m^2 [e.c.f.] (1) = 6.1 × 10^{18} m^2 (1) [6.08 × 10^{18} m^2]	2
		(ii)	***Either*** $d = 2\sqrt{\frac{A}{4\pi}}$ [or equiv.] (1) = 1.39 × 10^9 m (1) **Or** $A = 4\pi\left[\frac{d}{2}\right]^2$ (1) = 6.15 × 10^{18} m^2 (1)	2
	(c)		$\lambda_{\text{I max}} = \frac{W}{T} = \frac{2.90\times10^{-3}\text{ mK}}{5780\text{ K}}$ (1) = 500 nm [which is in the visible] (1) Sketch graph of correct general shape (1) with peak at 500 nm [e.c.f.] (1)	4
				[11]