PH2

Question				Marking details	Marks Available
1	(a)			0.40 [m]	1
	(b)			$v = \frac{0.050}{0.10}, \frac{0.450}{0.10}$ etc **or** $\left(\frac{1}{0.8}\right) \times 0.4$ or by implication (1) v = 0.50, 4.5 etc [m s^{-1}] (1)	2
	(c)			1.25 Hz **UNIT MARK** [**ecf** on v and λ and T]	1
	(d)			same	1
	(e)			**B** lags **A** (1) by ¼ cycle / 90° / $\frac{\pi}{2}$ accept $\frac{T}{4}$ or $\frac{\lambda}{4}$ (1)	2
				Question 1 total	**[7]**
2	(a)			Direction of wave [or energy] travel and direction of [particle] displacements [or oscillations] are the same [or parallel].	1
	(b)	(i)		diffraction	1
		(ii)		No zeros (or waves spread right round) so $\lambda \geq 0.3$ m (1) λ = 0.9 m for 375 Hz or λ = 0.09 m for 3 750 Hz or if λ = 0.3 m then f = 1 100 Hz (1) 375 Hz more likely with some supporting argument, e.g. the above, or even just "Longer wavelengths [or lower frequencies] spread more."] (1)	3
	(c)			λ = 140 [mm] (1) Any 2 x (1): Interference occurs between [accept superposition of] waves travelling in opposite directions [accept waves from speaker and reflected waves] Board acts as reflector Stationary wave set up	3
				Question 2 total	**[8]**

Question				Marking details	Marks Available
3	(a)	(i)		Same point in cycle at same time **or** equivalent	1
		(ii)		$S_2P - S_1P$ **or** equivalent. [Accept $S_1P - S_2P$]	1
		(iii)	(I)	Path difference = 36 mm (1) which is 3λ, so constructive. (1) Award 1 mark only for : $S_1Q = 28\lambda$, $S_2Q = 25\lambda$ therefore arrive in phase so constructive interference	2
			(II)	[Path difference doesn't change], so always constructive (1) but signal strength will decrease as we move further from sources. (1)	2
		(iv)		$y = \frac{12x360}{36}$ even if units inhomogeneous (1) y = 120 mm **UNIT** (1)	2
	(b)			correct insertion of 12 [mm] and 30 [mm] into grating equation or by implication (1) 24° (1) 53° (1) award 1 mark if both angles wrong because of arithmetic error Either 0° **or** ± 24°**and** ± 53° **or** equivalent. (1)	4
				Question 3 total	**[12]**
4	(a)	(i)		incident ray **and** angle c marked **and** grazing refracted ray	1
		(ii)		$n_1 \sin c = n_2 \sin 90°$ (1) $\sin 90° = 1$ **or** $n_1 \sin c = n_2$ (1)	2
	(b)	(i)		$\sin c = \frac{x}{s}$ **and** c marked on diagram (1) convincing algebra (1)	2
		(ii)		$v = 2.0 \times 10^8$ m s^{-1} [**or** by implication] (1) t = 6.00 μ[s] [**or** t = 4.00 μs, in which case first mark not gained] (1)	2
		(iii)		time via zigzag = 6.00 μs x $\frac{1.500}{1.485}$ [= 6.06 μs] or $\frac{1212}{2x10^8}$ (1) [**ecf** on t = 6.00 μs **or** by implication] Δt = 0.06 μ[s] [ecf on 6.00 μs] (1)	2
		(iv)		$[\frac{1}{6.00x10^{-6}}] = 17 \times 10^6$ [s^{-1}] [Accept $(18 \pm 2) \times 10^6$] (1) assumes negligible pulse duration [**or** assumes angles of incidence range from 0 to c or longest path is 1 212 m] (1)	2
				Question 4 Total	**[11]**

Question				Marking details	Marks Available
5	(a)	(i)		[minimum] energy needed to eject an electron from the metal [**or** surface **or** solid **not** atom]	1
		(ii)		6.9×10^{14} [Hz]	1
		(iii)		Photon energy not high enough [< work function] (1) Electrons can't escape (1)	2
	(b)			$f = \frac{(E_{k\max} + \phi)}{h}$ **or** correct transposition at any stage **or** by implic(1) $= 1.0 \times 10^{15}$ [Hz] (1)	2
	(c)	(i)		3.2×10^{-19} [J] (1) This uses the higher energy [**or** the higher frequency] photons, or produces the higher energy electrons, **or** photons don't co-operate **or** equivalent (1)	2
		(ii)		2.0 [V] **ecf**	1
				Question 5 Total	**[9]**
6	(a)	(i)		$\lambda = \frac{hc}{\Delta E}$ **or** [$\lambda = \frac{c}{f}$ **and** $E = hf$] or $f = 2.8 \times 10^{14}$ [Hz] (1) $\lambda = 1.06 \times 10^{-6}$ [m] (1)	2
		(ii)		*up* arrow from L to U (1) Photon's energy given to atom **or** electron (1)	2
		(iii)	(I)	[Incident] photon causes electron to drop from U to L. (1) Incident photon must have energy $E_U - E_L$ or equivalent (1) Photon emitted so now 2 photons present; accept by implic from emitted photon in phase.(1)	3
			(II)	Need more electrons in U than L. *Accept*: need pop'n inversion (1) Electrons pumped to P and drop to U (1) Electrons drop from L to ground [helping to keep L depopulated].(1)	3
	(b)			Any 2 x (1): monochromatic [or equivalent e.g. long wave-trains] photons in phase (don't accept waves in phase) light in phase (or wavefronts continuous) across width of beam	2
				Question 6 Total	**[12]**

Question				Marking details	Mark Available
7	(a)	(i)		λ_{peak} = 430 n[m] [± 10 nm] (1) T = 6 700 [K] **ecf** on λ_{peak}, provided it's not 1 200 nm (1)	2
		(ii)		T = 5 400 [K] [± 250 K]	1
		(iii)		bluer or whiter at maximum T **or** redder at minimum T	1
	(b)			$A = \frac{P}{\sigma T^4}$ (transposition at any stage) **or** by implication (1) $A = \frac{1.46\text{x}10^{30}}{5.76\text{x}10^{-8}\text{x}6700^4}$ [= 1.3 x 10^{22}m^2] **ecf** on T (1) use of $A = 4\pi r^2$ **or** $A = \pi d^2$ (1) d = 6.4 x 10^{10} [m] **ecf** on T if value from *(a)*(i) used (1) Slips of factors of 2 or 10 lose 1 mark each.	4
	(c)			$\left(\frac{P_{min}}{P_{max}}\right) = \left(\frac{T_{min}}{T_{max}}\right)^4$ **or** P_{min} = 6.2 x 10^{29} W **ecf** (1) $\frac{P_{min}}{P_{max}} = 0.42$ **ecf** **or** $P_{max} - P_{min}$ = 8.4 x 10^{29} W **ecf** (1) $\left(\frac{P_{max} - P_{min}}{P_{max}}\right) = 0.58$ [accept] = 58% (1)	3
				Question 7 Total	**[11]**
8	*(a)*			+2, 0 (1) ūd, –1, 0 (1) [blank], 0, 1 [Accept 'none' instead of cell left blank.] (1)	3
	(b)	(i)		Sun **or** stars	1
		(ii)		e-m **and** γ **or** photon involvement	1
		(iii)		In stage 1: 0 + 0 goes to 0 – 1 + 1 [or equivalent] (1) In stages 2 and 3, zeros throughout or equivalent (1)	2
		(iv)	(I)	uud + uud goes to uud + udd accept d: 2→3, u: 4→3 (1) A u is lost and a d is gained [or a u changes to a d]. (1)	2
			(II)	Neither involves weak force or equivalent e.g. only strong [and em] force involved.	1
				Question 8 Total	**[10]**