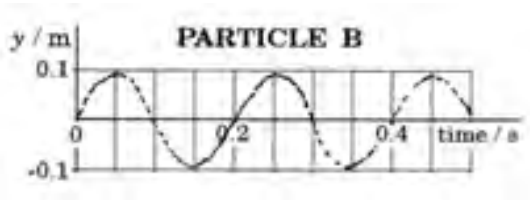
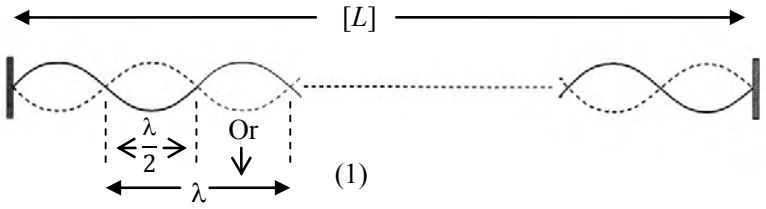
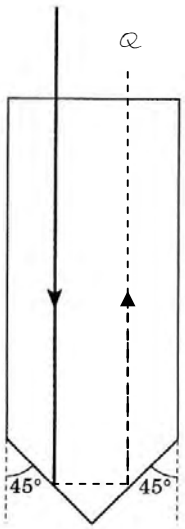
PH2

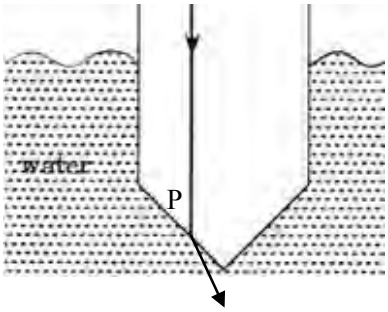
Question			Marking details	Marks Available
1	*(a)*	(i)	I. 2.0 [m] / 2.5 or <u>clear</u> equivalent	1
			II. The same	1
		(ii)	I. 5.0 Hz / s^{-1} **UNIT**	1
			II.  Same *f* and *A* (1) Delayed by $\frac{1}{4}$ cycle (1)	2
		(iii)	4.0 [m s^{-1}] **ecf**	1
	(b)		Statement that *f* doesn't change (1), or working based on this principle (e.g. *v* = 5.0 [Hz] x 0.60 [m]) *v* = 3.0 [m s^{-1}] (1) **ecf**	2
			Question 1 total	**[8]**

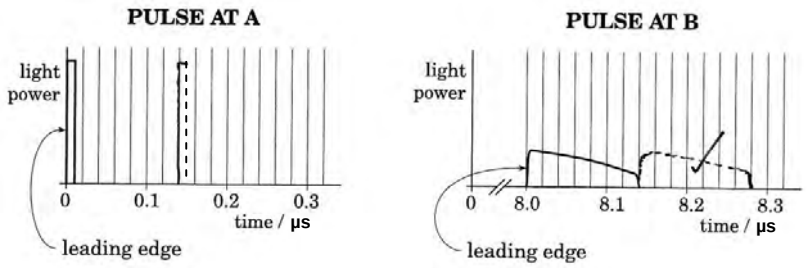
Question			Marking details	Marks Available
2	*(a)*		Waves arrive in phase at P. (1) Accept twin graphs: displacement along paths or displacement versus time at P.	
			This occurs if path difference = [0], λ, 2λ …… (1) Accept $n\lambda$	2
	(b)	(i)	Insertion of *a*, *D* and *y* into $\lambda = \frac{ay}{D}$, <u>even if powers of 10 incorrect</u>. (1)	
			λ = 600 n[m] (1)	2
		(ii)	Beams (fringes, orders) :	
			brighter / sharper or more defined or narrower / further apart / slit separation more accurately known (Any 2 x (1))	2
			Question 2 total	**[6]**

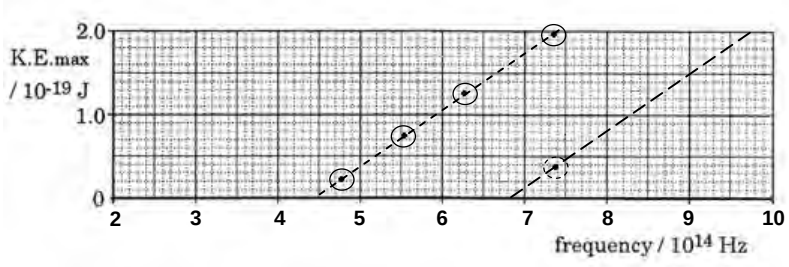
Question			Marking details	Marks Available
3	*(a)*		 (1)	
			Convincing algebra, e.g. $n\ \frac{\lambda}{2} = L$ (1)	2
	(b)	(i)	When λ = 820.0 nm, $\frac{2L}{\lambda} = 500$ (1)	
			When λ = 821.0 nm, $\frac{2L}{\lambda} = 499.4$ (1) (Give 1 mark if same arithmetical error in both)	2
		(ii)	n = 499.00 (1) **ecf** [or by implication]	
			λ = 821.60 [nm] (1) No mark if previous mark not given.	2
	(c)		Less amplitude [or fewer photons…] reflected back from [partially reflecting] mirror than arrive at it. (1) + (1) of the following: • Mirror not a proper node • Amplitudes of progressive waves travelling in opposite directions not equal. (Except near fully reflecting mirror).	2
			Question 3 total	**[8]**

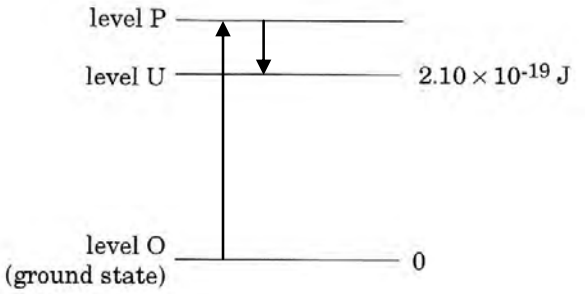
Question			Marking details	Marks Available
4	*(a)*	(i)	$1.55 \sin c = 1.00 \sin 90°$ (1) [or equivalent, or by implication]	
			$c = 40°$ (1)	2
		(ii)	First reflection (1) **No ecf**	2
			Rest of path (1)	
	(b)	(i)	$1.55 \sin 45° = 1.33 \sin w$ (1) [or equivalent, or by implication]	
			$w = 56°$ (1)	2
		(ii)	Bends as shown	1
		(iii)	[Sensor at] Q receives more light when water level drops and exposes lower end of rod to the air. No ecf if paths badly wrong.	1
			Question 4 Total	**[8]**





Question			Marking details	Marks Available
5	*(a)*	(i)	$d = v \times t$ (1) [Attempt to use, or by implication]	
			$v = \frac{3.00 \times 10^8}{1.50}$ [m s^{-1}] (1)	
			d = 1600 [m] (1) [Omission of n (giving 2400 [m]) loses 1] Arithmetical error loses 1 mark.	3
		(ii)	Zig-zag routes [take] longer than straight. (1)	
			(1) For one of the following: • Good diagram (angles equal by eye) • A continuous range of zig-zag routes, all of different lengths	2
	(b)	(i)	0.14 [μs] [± 0.02μs]	1
		(ii)	 1 mark for the correct pulse on each graph. **ecf from (b)(i)**	2
			Question 5 Total	**[8]**

Question			Marking details	Marks Available
6	*(a)*	(i)	Maximum k.e. of <u>emitted / photo electrons</u>	1
		(ii)	Energy of a photon[s]	1
		(iii)	[Minimum] energy needed to remove electron [from surface]. Don't accept from an atom	1
	(b)	(i)	I. Gradient calculation attempted (1) – no penalty for wrong powers of 10. $6.6\ [\pm 0.3] \times 10^{-34}$ [J s] (1) <u>agreeing with working</u>	2
			II. $f_{thresh} = 4.4 \times 10^{14}$ Hz (1) $[\pm 0.1 \times 10^{14}$ Hz] <u>or</u> valid algebraic method $\phi = 2.9 \times 10^{-19}$ J **UNIT** (1) **ecf**	2
		(ii)	I.  Correct point (1), parallel line (1)	2
			II. Ultraviolet [or UV]	1
			III. Lithium has higher work function / needs more energy to remove an electron	1
			Question 6 Total	**[11]**

Question			Marking details	Marks Available
7	*(a)*	(i)	P and U : zero or very low and / or O : 100%	1
		(ii)	Absorption (accept excitation) (1) : electron promoted from O to U (1)	2
	(b)	(i)	More electrons in U than O or more electrons in higher level	1
		(ii)		1
		(iii)	Incident (or by implication) photons (1) causes an electron to drop (1). Emitting photon: so two photons where one previously (or by implication) (1). (1) For one of the following: • Atom / electron drops [from U] to O. • Incident photon energy must be 2.10 x 10^{-19} J or equivalent • Process happens repeatedly as photons traverse cavity to and fro • Stimulated photon in phase with incident photon	4
		(iv)	$\lambda = \frac{hc}{\Delta E}$ or $\lambda = \frac{c}{f}$ and $f = \frac{\Delta E}{h}$ or equivalent or by implication (1) λ = 950 n[m] (1)	2
	(c)		Electrons in lower level drop [spontaneously] to ground state (1) (accept de-excite) Making population inversion easier to maintain or lowering number of electrons in lower level or making photon absorption less likely. (1) [**or equivalent**]	2
			Question 7 Total	**[13]**

Question			Marking details	Marks Available
8	*(a)*	(i)	= 5.4 [± 0.2] [day] (1)	
			P = 0.70 [± 0.1] x10^{30} [W] (1) **ecf**	2
		(ii)	$I = \frac{P}{4\pi r^2}$ (1) [or equivalent, or by implication]	
			r = 2.6x10^{20} [m] (1) **ecf**	2
			[1 mark only lost if factor of 4 omitted]	
	(b)	(i)	λ_{peak} = 450 n[m] (1) [±10 nm]	
			T = 6400 [K] (1) [ecf on λ_{peak}]	2
		(ii)	$A = \frac{P}{\alpha T^4}$ (1) [transposition at any stage]	
			= 10 x 10^{21} [m^2] (1) [or by implication] **ecf on *T***	
			$r = \sqrt{\frac{A}{4\pi}}$ (1) [= 2.8 x 10^{10} [m]] [or by implication]	
			d = 5.6 x 10^{10} [m] (1) **ecf** (missing factor of 4 loses 1 mark)	4
			Question 8 Total	**[10]**

Question			Marking details	Marks Available
9	*(a)*	(i)	e^- : +1 e^+ : -1 (1) γ : 0 (1)	2
		(ii)	electromagnetic : γ involvement (1) both	1
	(b)		π^- (1) because either charge of x = -e [accept -1] and x must be a hadron / can't be a lepton Or u number = 0 - 1 = -1, d number = 0- (-1) = 1 or equivalent (1)	2
	(c)	(i)	e^+ or positron	1
		(ii)	Weak	1
	(d)		π^- [accept μ or $\bar{u}d$] → $e^- + \bar{\nu}_e$ (accept $+ \bar{\nu}$) [In fact, π^- → $\mu^- + \bar{\nu}_\mu$ much more likely]	1
			Question 8 Total	**[8]**