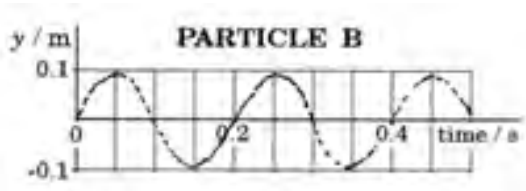
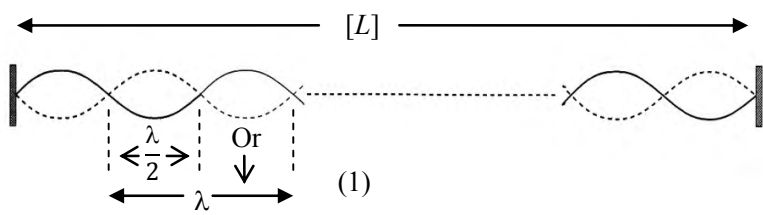
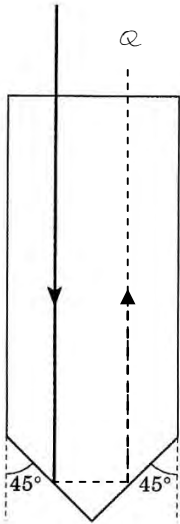
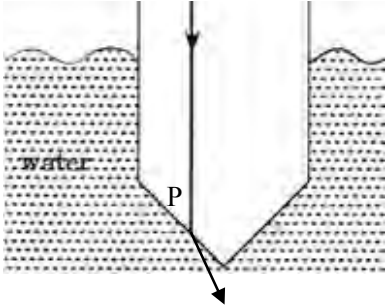


PH2

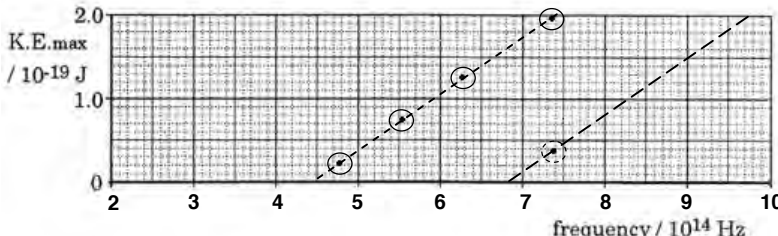
Question			Marking details	Marks Available
1	(a)	(i)	I. 2.0 [m] / 2.5 or <u>clear</u> equivalent	1
			II. The same	1
		(ii)	I. 5.0 Hz / s ⁻¹ UNIT	1
			II. 	2
		(iii)	4.0 [m s ⁻¹] ecf	1
	(b)	Statement that <i>f</i> doesn't change (1), or working based on this principle (e.g. $v = 5.0 \text{ [Hz]} \times 0.60 \text{ [m]}$) $v = 3.0 \text{ [m s}^{-1}\text{]}$ (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.		2
		This occurs if path difference = [0], λ , 2λ (1) Accept $n\lambda$		
	(b)	(i)	Insertion of a , D and y into $\lambda = \frac{ay}{D}$, <u>even if powers of 10 incorrect.</u> (1)	2
			$\lambda = 600 \text{ n[m]}$ (1)	
		(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	<p>(a)</p>  <p>Convincing algebra, e.g. $n \frac{\lambda}{2} = L$ (1)</p> <p>(b) (i) When $\lambda = 820.0 \text{ nm}$, $\frac{2L}{\lambda} = 500$ (1)</p> <p>When $\lambda = 821.0 \text{ nm}$, $\frac{2L}{\lambda} = 499.4$ (1) (Give 1 mark if same arithmetical error in both)</p> <p>(ii) $n = 499.00$ (1) ecf [or by implication]</p> <p>$\lambda = 821.60 \text{ [nm]}$ (1) No mark if previous mark not given.</p> <p>(c) Less amplitude [or fewer photons...] reflected back from [partially reflecting] mirror than arrive at it. (1)</p> <p>+ (1) of the following:</p> <ul style="list-style-type: none"> • Mirror not a proper node • Amplitudes of progressive waves travelling in opposite directions not equal. (Except near fully reflecting mirror). <p>Question 3 total</p>	<p>2</p> <p>2</p> <p>2</p> <p>2</p> <p>2</p> <p>[8]</p>

Question		Marking details	Marks Available
4	(a)	(i) $1.55 \sin c = 1.00 \sin 90^\circ$ (1) [or equivalent, or by implication] $c = 40^\circ$ (1)	2
		(ii) First reflection (1) No ecf Rest of path (1)	2
			
	(b)	(i) $1.55 \sin 45^\circ = 1.33 \sin w$ (1) [or equivalent, or by implication] $w = 56^\circ$ (1)	2
		(ii)	1
		Bends as shown	
			
(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)	<p>(i) $d = v \times t$ (1) [Attempt to use, or by implication]</p> <p>$v = \frac{3.00 \times 10^8}{1.50} \text{ [m s}^{-1}\text{]} (1)$</p> <p>$d = 1600 \text{ [m]} (1)$ [Omission of n (giving 2400 [m]) loses 1] Arithmetical error loses 1 mark.</p> <p>(ii) Zig-zag routes [take] longer than straight. (1)</p> <p>(1) For one of the following:</p> <ul style="list-style-type: none"> • <u>Good</u> diagram (angles equal by eye) • A continuous <u>range</u> of zig-zag routes, all of different lengths 	3
	(b)	<p>(i) 0.14 [μs] [$\pm 0.02\mu\text{s}$]</p> <p>(ii)</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>PULSE AT A</p> </div> <div style="text-align: center;"> <p>PULSE AT B</p> </div> </div> <p>1 mark for the correct pulse on each graph. ecf from (b)(i)</p> <p>Question 5 Total</p>	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 [± 0.3] $\times 10^{-34}$ [J s] (1) <u>agreeing with working</u>	2	
			II. $f_{\text{thresh}} = 4.4 \times 10^{14}$ 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.		2
			Correct point (1), parallel line (1)	1	
			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 <u>or</u> 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) <div style="text-align: center;"> <p>level P —————</p> <p>level U ————— $2.10 \times 10^{-19} \text{ J}$</p> <p>level O ————— 0 (ground state)</p> </div>	1
	(iii) Incident (or by implication) <u>photons</u> (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:		
	<ul style="list-style-type: none"> • Atom / electron drops [from U] to O. • Incident photon energy must be $2.10 \times 10^{-19} \text{ J}$ or equivalent • Process happens repeatedly as photons traverse cavity to and fro • Stimulated photon in phase with incident photon 	4	
	(iv) $\lambda = \frac{hc}{\Delta E}$ <u>or</u> $\lambda = \frac{c}{f}$ and $f = \frac{\Delta E}{h}$ <u>or</u> equivalent or by implication (1)		
	$\lambda = 950 \text{ n[m]}$ (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)	2	
	[or equivalent]		
	Question 7 Total	[13]	

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

Question		Marking details	Marks Available
9	(a)	(i) $e^- : +1 \quad e^+ : -1 \quad (1) \quad \gamma : 0 \quad (1)$	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 <u>Or</u> 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 $\bar{u}d$] $\rightarrow e^- + \bar{\nu}_e$ (accept $+\bar{\nu}$) [In fact, $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$ much more likely]	1	
Question 8 Total			[8]