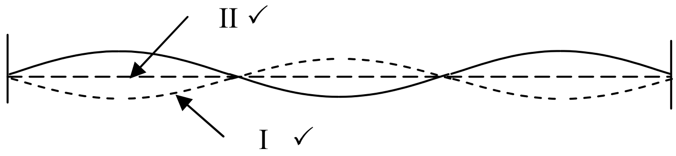
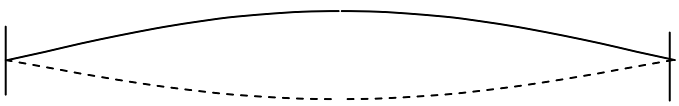
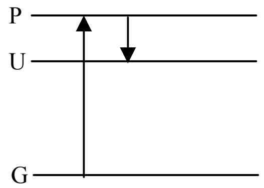
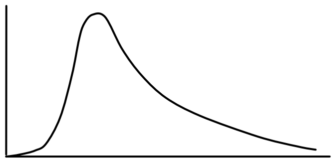
PH2

Question			Marking details	Marks Available
1	(a)	(i)		2
		(ii)	Either λ = 1.16 [m] (1) f = 50 [Hz] (1) v = 58 [m s^{-1}](1) Or λ = 1.16 [m] (1) $v = \frac{\lambda}{T}$ **or** $v = \frac{1.16}{0.02}$ (1) v = 58 [m s^{-1}](1) [1 mark only if either 1.2m used or 1.74/0.03 used]	3
		(iii)	All 4 nodes labelled	1
		(iv)	Any crosses placed in first **and** last loops	1
	(b)	(i)	 Either line drawn ✓	1
		(ii)	f = 17 Hz (1) UNIT mark New wavelength = 3.48 m **or** 3 × previous λ **or** appeal to $f = [n]\frac{v}{2L}$ (1) (Allow 1 mark only if f = 34 Hz) Allow e.c.f. from (b)(i)	2
	(c)	(i)	The displacement at any point is the [vector] sum of the displacements of the individual waves.	1
		(ii)	t = 1.0 s: horizontal line shown (1) t = 2.0 s: inversion of t = 0 shown (1)	2
			Question 1 total	**[13]**

Question			Marking details	Marks Available
2	(a)	(i)	I. Vibrations / oscillations / displacements [accept particle displacements] are perpendicular / at right angles / 90° to the propagation directions [or equiv.]	1
			II. Vibrations / oscillations / displacements [accept particle displacements] are in one direction [accept in one plane]	1
		(ii)	Alternates [gradually] between light and dark (1) 2 extinctions / dark places in 360°/ or equivalent (1) [Accept an answer which assumes initially bright or initially dark]	2
	(b)	(i)	I. Light spreads out [round edge of each slit] [or equiv.]	1
			II. So light from the two slits overlaps [or equiv.]	1
		(ii)	I. $\lambda = \dfrac{2.0\text{ mm} \times 0.50\text{ mm}}{1.5\text{ m}}$ (1) $= 670$ n[m] (1) [667 nm, accept 700 nm]	2
			II. Fringe separation increased (1); [bright] fringes dimmer (1)	2
	(c)		$3\lambda = d \sin 77°$ [or by impl.] (1) $d = \dfrac{1}{5.00 \times 10^5}$ m [$= 2.00 \times 10^{-6}$ m] [or by impl.] (1) $\lambda = 650$ n[m] (1)	3
			Question 2 total	**[13]**

Question			Marking details	Marks Available
3	(a)	(i)	Smooth curve drawn through all the points	1
		(ii)	46° [or as appropriate from drawn line]	1
		(iii)	Reflected ray drawn with angle of reflection equal to θ_P **by eye**.	1
		(iv)	Any of: $\frac{\sin 14^\circ}{\sin 10^\circ}$ ✓ 1.39 [±0.05]✓ or by implication $\frac{\sin 28.5^\circ}{\sin 20^\circ}$ 1.40[±0.05] $\frac{\sin 44^\circ}{\sin 30^\circ}$ 1.40[±0.05] $\frac{\sin 64^\circ}{\sin 40^\circ}$ 1.40[±0.05] $\frac{\sin 82^\circ}{\sin 45^\circ}$ 1.40[±0.05]	2
		(v)	I. Any 2 × (1) from • Straight ✓ • Through the origin ✓ • Gradient > 1 ✓	2
			II. [*n* is the] gradient	1
	(b)	(i)	1.530 sin *c* = 1.520 [sin 90°] (1) [or by impl.] *c* = 83° (1)	2
		(ii)	θ = 7° [accept 6.5°] e.c.f. from (b)(i)	1
		(iii)	Smaller <u>differences</u> in distances travelled or times taken [by light travelling different paths] (1), so less blurring / smearing / overlap of data / pulses (1) [**or** data can be transmitted at a greater rate] Less multimode dispersion only award 2nd mark	2
			Question 3 Total	**[13]**
4	(a)		$f_{\text{Thresh}} = \frac{\phi}{h}$ (1) [or by impl.] = 5.1[3] × 10^{14} [Hz] (1)	2
	(b)	(i)	Photon E = 6.63 × 10^{-34} × 7.4 × 10^{14} [= 4.91 × 10^{-19}J][or by impl.](1) $E_{\text{k max}}$ [= 4.91 × 10^{-19} – 3.4 × 10^{-19}] = 1.5 × 10^{-19} [J] (1)	2
		(ii)	[A single] photon gives its energy to an electron (1) Some of the energy used to escape from the metal (1).	2
	(c)	(i)	Points plotted at (5.1 × 10^{14}Hz, 0) and (7.4 × 10^{14} Hz, 1.5 × 10^{-19} J) (1) Allow e.c.f. from (a) and (b)(i) Straight line drawn through points (1) (One correct point only and a positive slope line = 1 mark)	2
		(ii)	*h* / the Planck constant	1
		(iii)	Straight line drawn with same gradient as (i) and to the right	1
			Question 4 Total	**[10]**

Question			Marking details	Marks Available
5	(a)		$E = \dfrac{hc}{\lambda}$ [or equiv. eg. $E = hf$ and $\lambda = \dfrac{c}{f}$ or by impl] (1) $\lambda_{UG} = 6.95 \times 10^{-7}$ [m] (1)	2
	(b)	(i)	More electrons in level U than in level G	1
		(ii)	They / the photons would be absorbed [accept 'disappear'] (1). The energy would be used to excite ions [accept atoms] / raise electrons from G to U [or equiv.] (1)	2
		(iii)	 **Both** transitions shown	1
		(iv)	Any 2 x (1) from • Passing / incident photon ✓ • Excited ion ✓ • Electron drops to lower level ✓ • The incident photon must have wavelength = λ_{UG} [or 695 nm] **or** must have energy 2.86×10^{-19} J ✓ 3^{rd} mark • 2 photons where there was one previously. Accept by implication e.g. in phase with the incident photon.	3
	(c)		Any 2 $\rightarrow$ (1); any third $\rightarrow$(2) from • [plane] polarised ✓ • Coherent✓ • Monochromatic✓ • Parallel beam✓	2
			Question 5 Total	**[11]**

Question			Marking details	Marks Available
6	(a)	(i)	$\lambda_{\text{Peak}} = \dfrac{2.90\times10^{-3}\text{ K m}}{2.5\times10^{7}\text{ K}}$ (1) = 1.16×10^{-10} [m] (1)	2
		(ii)	X-ray / γ-ray	1
		(iii)		1
		(iv)	Spectral intensity low <u>in high λ 'tail'</u> but not zero.	1
	(b)		$P = \sigma A \times (2.5 \times 10^7\text{ K})^4$ [or by impl.] (1) $A = 4\pi \times 11000^2$ [or by impl.] (1) [= $1.52 \times 10^9\text{ m}^2$] $P = 3.4 \times 10^{31}$ W (1) UNIT mark	3
	(c)		$A_2T_2^4 = A_1T_1^4$ (1) or $T_2^4 = \dfrac{3.4\times10^{31}}{5.67\times10^{-8}\times3.04\times10^{9}}\text{K}^4$ e.c.f from (b) $T_2 = 2.1 \times 10^7$ K (1)	2
			Question 6 Total	**[10]**
7	(a)	(i)	Any 3 × (1) from • d have $^1/_3$ electronic charge / $-^1/_3e$ charge✓ • ds have greater mass than e s✓ • ds feel strong force [or interact with gluons]; e don't✓ • ds cannot be isolated; e can [**or** d can only be found in specific groupings; e can be by itself] ✓ • ds have lepton number 0, es have lepton number 1 ✓	3
		(ii)	[$3 \times (-^1/_3e)$] = $-e$ [accept e or -1 or 1.6×10^{-19} C with some justification]	1
	(b)		Any 2 × (1) from • Very short decay time ✓ • Individual quark flavours conserved ✓ • Accept: no neutrino [and no γ] emission	2
	(c)	(i)	x is an electron (1) y is an antineutrino (1) clear logical reasoning based on the laws of conservation of charge and of lepton number (1)	3
		(ii)	Weak	1
			Question 7 Total	**[10]**