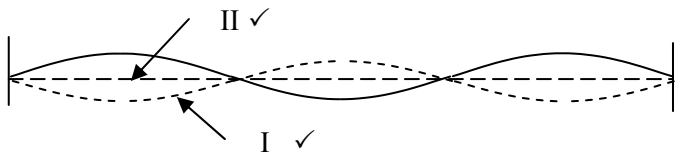
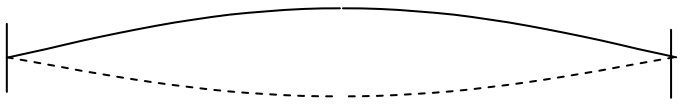
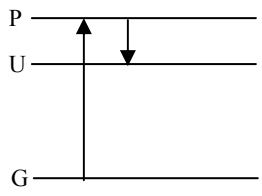
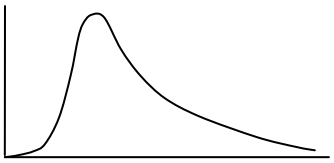
# PH2

| Question | | | Marking details | Marks Available |
|---|---|---|---|---|
| 1 | (a) | (i) |  | 2 |
| | | (ii) | Either<br>$\lambda = 1.16$ [m] (1)<br>$f = 50$ [Hz] (1)<br>$v = 58$ [m s$^{-1}$](1)<br><br>Or<br>$\lambda = 1.16$ [m] (1)<br>$v = \frac{\lambda}{T}$ **or** $v = \frac{1.16}{0.02}$ (1)<br>$v = 58$ [m s$^{-1}$](1)<br><br>[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) |  <br>Either line drawn ✓ | 1 |
| | | (ii) | $f = 17$ Hz (1) UNIT mark<br>New wavelength = 3.48 m **or** 3 × previous $\lambda$<br>**or** appeal to $f = [n]\frac{v}{2L}$ (1)<br>(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)<br>$t = 2.0$ 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)<br>2 extinctions / dark places in 360°/ or equivalent (1)<br>[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. $\lambda = \frac{2.0\text{ mm} \times 0.50\text{ mm}}{1.5\text{ m}}$ (1)<br>= 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)<br>$d = \frac{1}{5.00 \times 10^5}$ m [= $2.00 \times 10^{-6}$ m] [or by impl.] (1)<br>$\lambda$ = 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 $\theta_P$ **by eye**. | 1 |
| | | (iv) | Any of:<br>$\frac{\sin 14^\circ}{\sin 10^\circ}$ ✓ 1.39 [±0.05]✓ or by implication<br>$\frac{\sin 28.5^\circ}{\sin 20^\circ}$ 1.40[±0.05]<br>$\frac{\sin 44^\circ}{\sin 30^\circ}$ 1.40[±0.05]<br>$\frac{\sin 64^\circ}{\sin 40^\circ}$ 1.40[±0.05]<br>$\frac{\sin 82^\circ}{\sin 45^\circ}$ 1.40[±0.05] | 2 |
| | | (v) | I. Any 2 × (1) from<br>• Straight ✓<br>• Through the origin ✓<br>• Gradient > 1 ✓ | 2 |
| | | | II. [$n$ is the] gradient | 1 |
| | (b) | (i) | 1.530 sin $c$ = 1.520 [sin 90°] (1) [or by impl.]<br>$c$ = 83° (1) | 2 |
| | | (ii) | $\theta$ = 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]<br>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)<br>$E_{\text{k max}}$ [= 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)<br>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)<br>Allow e.c.f. from (a) and (b)(i)<br>Straight line drawn through points (1)<br>(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) | | $E = \frac{hc}{\lambda}$ [or equiv. eg. $E = hf$ and $\lambda = \frac{c}{f}$ or by impl] (1)<br>$\lambda_{UG} = 6.95 \times 10^{-7}$ [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<br>• Passing / incident photon ✓<br>• Excited ion ✓<br>• Electron drops to lower level ✓<br>• The incident photon must have wavelength = $\lambda_{UG}$ [or 695 nm] **or** must have energy 2.86 x $10^{-19}$ J ✓<br>3rd mark<br>• 2 photons where there was one previously. Accept by implication e.g. in phase with the incident photon. | 3 |
| | (c) | | Any 2 → (1); any third →(2) from<br>• [plane] polarised ✓<br>• Coherent✓<br>• Monochromatic✓<br>• Parallel beam✓ | 2 |
| | | | **Question 5 Total** | **[11]** |

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