Question	Answer	Marks
1	A	1
2	Energy of a photon of light of wavelength 400 nm $= \frac{6.6 \times 10^{-34}\ \text{J s} \times 3 \times 10^{8}\ \text{m s}^{-1}}{400 \times 10^{9}\ \text{m}}$ $= 4.95 \times 10^{-19}$ J Number of photons emitted per second = energy emitted per second/energy per photon = 18×10^{-3} J/ 4.95×10^{-19} J (1) = 3.6×10^{16} photons. Number of photons emitted per second = energy emitted per second/energy per photon $= \frac{18 \times 10^{-3}\ \text{J}}{4.95 \times 10^{-19}\ \text{J}}$ $= 3.6 \times 10^{16}$ photons	1 1 1 1 1
3	Momentum of electron = $\sqrt{2\,m\,E_k}$ $= (2 \times 9.11 \times 10^{-31}\ \text{kg} \times 1.6 \times 10^{3}\ \text{eV} \times 1.6 \times 10^{-19}\ \text{C})^{\frac{1}{2}}$ $= 2.159... \times 10^{-23}$ kg m s^{-1} De Broglie wavelength = $\frac{6.6 \times 10^{-34}\ \text{J s}}{2.159.. \times 10^{-23}\ \text{kg m s}^{-1}}$ $= 3.11 \times 10^{-11}$ m	1 1 1
4	Energy required to release electron in J = $3.7 \times 1.6 \times 10^{-19}$ J $k.e._{max} = \frac{6.6 \times 10^{-34}\ \text{J s} \times 3 \times 10^{8}\ \text{m s}^{-1}}{170 \times 10^{-9}\ \text{m}} - 3.7 \times 1.6 \times 10^{-19}$ J $= 5.7 \times 10^{-19}$ J	1 1 1
5	Momentum of electron = $\frac{6.6 \times 10^{-34}\ \text{J s}}{6.6 \times 10^{-10}\ \text{m}} = 1.0 \times 10^{-24}$ kg m s^{-1} Velocity of electron = $\frac{1.0 \times 10^{-24}\ \text{kg m s}^{-1}}{9.11 \times 10^{-31}\ \text{kg m s}^{-1}}$ $= 1.1 \times 10^{6}$ m s^{-1}	1 1 1
6 a	Phase difference of 2π radians corresponds to one wavelength path difference, therefore, a path difference of $\frac{\lambda}{3}$ will correspond to a phase difference of $\frac{2\pi}{3}$.	1
6 b	Resultant forms an equilateral triangle. Length of resultant = length of each individual phasor arrow	1 1
6 c	Length of resultant arrow at P_2 = 2 × length of individual phasor arrow. Ratio of lengths = 2	1 1
6 d	Ratio = $\frac{1^2}{2^2}$ = 0.25	1 1
6 e	Three phasors form equilateral triangle. No resultant phasor. This model gives a zero probability for a photon arriving at P_1 when the three slits are open.	1 1 1

7 a	When the intensity of the light incident on the surface is doubled the number of electrons released per second will also double; as twice as many photons are striking the surface each second. As the energy of each individual photon is unchanged, the ejected photoelectrons will have the same maximum kinetic energy.	1 1 1 1
7 b	0.2 eV = 4.5 × 10^{14} Hz × *h* – *Φ* 1.4 eV = 7.5 × 10^{14} Hz × *h* – *Φ* 4.5 × 10^{14} Hz × *h* – 0.2 eV = 7.5 × 10^{14} Hz × *h* – 1.2 eV 3.0 × 10^{14} Hz × *h* = 1.2 × 1.6 × 10^{-19} J *h* = 6.4 × 10^{-34} J s	 1 1 1 1
7 c	Using calculated value for *h*: Work function = 2.56 × 10^{-19} J Frequency = $\dfrac{2.56\times10^{-19}\text{ J}}{6.4\times10^{-34}\text{ J s}}$ = 4.0 × 10^{14} Hz (Using 6.6 × 10^{-34} gives the same value to 2 s.f.)	 1 1
8 a i	All in phase	1
8 a ii	3 A	1
8 b i	One phasor rotation corresponds to *λ*. 120° = 1/3 rotation for extra $\dfrac{\lambda}{3}$	1 1
8 b ii	(Arrows correctly drawn in circles; three arrows add tip-to-tail to give zero resultant.	1
8 b iii	$\sin\theta = \dfrac{\Delta x}{b/3 \times 1} = \dfrac{\lambda/3}{b/3} = \dfrac{\lambda}{b}$ so $\lambda = b\sin\theta$	1
8 c	$\sin\theta = \dfrac{\lambda}{b} = \dfrac{2.4\text{ cm}}{6.0\text{ cm}} = 0.40$ $\theta = 24°$ (2 s.f.)	1 1