Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$E_2 - E_1 = hf$ $-2{\cdot}976\times10^{-18} - \left(-3{\cdot}290\times10^{-18}\right)$ **(1)** $=6{\cdot}63\times10^{-34}\times f$ $\left(f = 4{\cdot}736048265\times10^{14}\ Hz\right)$ $v = f\lambda$ **(1)** (**for both relationships** anywhere) $3{\cdot}00\times10^{8} = 4{\cdot}736048265\times10^{14}\times\lambda$ **(1)** $\lambda = 6{\cdot}33\times10^{-7}$ m **(1)**	**4**	Accept: $6{\cdot}3, 6{\cdot}334, 6{\cdot}3344$ Accept: $(\Delta)E = hf$ with $v = f\lambda$ **OR** $E_5 - E_3 = hf$ with $v = f\lambda$ for relationship mark anywhere Note: $\Delta E = 3{\cdot}14\times10^{-19}\ (\text{J})$ Accept: $3{\cdot}290\times10^{-18} - 2{\cdot}976\times10^{-18}$ $= 6{\cdot}63\times10^{-34}\times f$ for energy substitution mark If $2{\cdot}976\times10^{-18} - 3{\cdot}290\times10^{-18}$ is shown for ΔE, maximum (**1 mark)** for **both relationships**. Alternative method: $E_2 - E_1 = \frac{hc}{\lambda}$ **OR** $(\Delta)E = \frac{hc}{\lambda}$ Combined relationship **(1)** Substitution for h and ΔE **(1)** Substitution for c **(1)** Final answer **(1)**
		(ii)	$A = \pi r^2$ $= \pi\times(4{\cdot}00\times10^{-4})^2$ **(1)** $I = \frac{P}{A}$ **(1)** $9950 = \frac{P}{\pi\times(4{\cdot}00\times10^{-4})^2}$ **(1)** $P = 5{\cdot}00\times10^{-3}$ W **(1)**	**4**	Accept a range of 1 to 5 significant figures for **this question**. The use of $3{\cdot}14$ for π is acceptable. $I = \frac{P}{A}$ anywhere - **(1)** If no attempt to calculate area, maximum **(1 mark)** for relationship.

Question			Expected response	Max mark	Additional guidance
9.	(b)		Obtain values of irradiance for different distances **(1)** Plot graph of I against $1/d^2$ **(1)** Graph of I against $1/d^2$ is a straight line <u>through the origin</u> (then this verifies the inverse square law of light) **(1)**	**3**	Look for this statement or equivalent first – if incorrect or missing then **(0 marks)**. Alternative method: Obtain values of irradiance for different distances **(1)** Determine $I \times d^2$ **(1)** Values of Id^2 are a constant (then this verifies the inverse square law of light) **(1)**