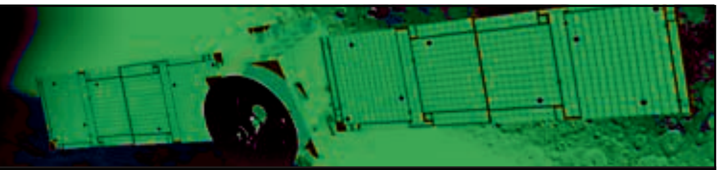
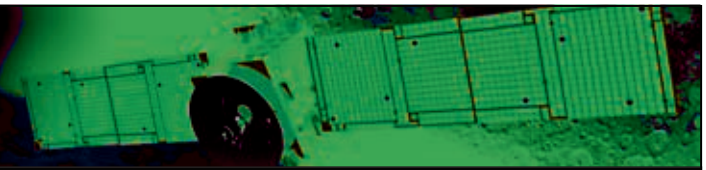


Particles, Waves and Quanta: Set 11

Set	Problem	Solution
11	1a	$f = \frac{E}{h} = \frac{2 \times 10^{-24} ms^{-1}}{6.63 \times 10^{-34} Js}$ f = 3.0 GHz
	1b	$\lambda = \frac{c}{f} = \frac{3 \times 10^{8} m\, s^{-1}}{3.0 \times 10^{9} Hz} = 0.1\text{m}$
	1c	In comparison with visible light, microwaves have lower energies, lower frequencies and longer wavelengths.
	2	For each colour; $frequency = \frac{c}{\lambda}$ and Energy = h f red: 4.41×10^{14} Hz; 2.92×10^{-19} J; orange: 5.17×10^{14} Hz; 3.43×10^{-19} J; green: 6.00×10^{14} Hz; 3.98×10^{-19} J
	3	E_{av} (X-rays) = 1×10^{4} eV E_{av} (γ-rays) = 1×10^{7} eV $\frac{E_{X-ray}}{E_{\gamma\ ray}} = \frac{h\, f_{X-ray}}{h\, f_{\gamma-ray}}$ $\frac{1 \times 10^{4} eV}{1 \times 10^{7} eV} = \frac{f_{x-ray}}{f_{\gamma-ray}}$ Ratio of frequencies 0.001:1 $\frac{c_{X-ray}}{c_{\gamma-ray}} = \frac{\lambda_{X-ray} f_{X-ray}}{\lambda_{\gamma-ray} f_{\gamma-ray}}$ $1 = \frac{\lambda_{x-ray}}{\lambda_{\gamma-ray}} \times 1 \times 10^{3}$ Ratio of wavelengths 1000:1
	4	red
	4b	$E = \frac{h\, c}{\lambda} = \frac{6.63 \times 10^{-34} J\, s \times 3 \times 10^{8}\, m\, s^{-1}}{694 \times 10^{-9} m}$ E = 2.87×10^{-19} J per photon
	4c	$I = \frac{P}{A} = \frac{1.0\, W}{10 \times 10^{-6} m^{2}}$ I = 1.00×10^{5} W m^{-2}
	4d	$\frac{I\,(laser)}{I\,(sunlight)} = \frac{1 \times 10^{5}}{1000}$ 100:1, the laser beam is 100 times more intense than sunlight
	5	750 W = 750 J s^{-1} $number\ of\ photons = \frac{750\, J}{1.0 \times 10^{-23} J}$ 7.5×10^{25} photons per second
	6	1.7×10^{-8} W = 1.7×10^{-8} J s^{-1} $photon\ energy = \frac{h\, c}{\lambda} = \frac{6.63 \times 10^{-34} J^{S} \times 3 \times 10^{8} m\, s^{-1}}{6.0 \times 10^{-7} m} = 3.3 \times 10^{-19} J$ $photons\ per\ second = \frac{energy\ per\ second}{energy\ per\ photon} = \frac{1.7 \times 10^{-8}}{3.3 \times 10^{-19}}$ 5.1×10^{10} photons per second
	7a	$\lambda = \frac{c}{f} = \frac{3.0 \times 10^{8} m\, s^{-1}}{720 \times 10^{3}\, Hz}$ λ = 420 m
	7b	1 day = 8.64×10^{4} s E = P × t = 50×10^{3} J s^{-1} × 8.64×10^{4} s E = 4.3 x 10^{9} J



Particles, Waves and Quanta: Set 11

Set	Problem	Solution
11	8	(a) Shows absorption of the short wavelengths (blue & violet) but transmission of the long wavelengths. This is a red filter. (b) Shows transmission of blue and red but absorption of middle frequencies, this is a purple filter. (c) Shows maximum transmission at 500nm – this is the wavelength of green light, this is agreen filter.
	9	Blueshift can occur in an expanding universe when an object is moving towards us, this may occur for example when observing spiral galaxies the side spinning towards us will be slightly blueshifted.