Solved selected problems of An Introduction to Quantum Theory by Keith Hannabuss

Franco Zacco

Chapter 1 - Introduction

Solution. 1.1

(i) A frequency of $200kHz$ corresponds to an energy of

$$E = \hbar\omega = 1.0546 \times 10^{-34} \cdot 2\pi \cdot 2 \times 10^{5} = 1.3252 \times 10^{-28} \ J$$

(ii) A frequency of $4.95 \times 10^{14} Hz$ corresponds to an energy of

$$E = \hbar\omega = 1.0546 \times 10^{-34} \cdot 2\pi \cdot 4.95 \times 10^{14} = 3.2799 \times 10^{-19} \ J$$

(iii) A frequency of $10^{20} Hz$ corresponds to an energy of

$$E = \hbar\omega = 1.0546 \times 10^{-34} \cdot 2\pi \cdot 10^{20} = 6.62624 \times 10^{-14} \ J$$

(iv) A frequency of $10^{23} Hz$ corresponds to an energy of

$$E = \hbar\omega = 1.0546 \times 10^{-34} \cdot 2\pi \cdot 10^{23} = 6.62624 \times 10^{-11} \ J$$

$\square$

Solution. 1.2 Let a radio station broadcast on a frequency of 200 kHz then each photon generated has an energy of

$$E = 1.0546 \times 10^{-34} \cdot 2\pi \cdot 2 \times 10^5 = 1.3252 \times 10^{-28}\ J$$

So a 200 $kW = 200\ kJ/s$ transmitter generates

$$\frac{200 \times 10^3}{1.3252 \times 10^{-28}} = 1.5092 \times 10^{33}$$

photons per second.

Let us assume the radio station broadcasts photons in every direction then the radio station broadcasts the following number of photons per meter squared per second

$$\frac{1.5092 \times 10^{33}}{4\pi \cdot (1 \times 10^6\ m)^2} = 1.2009 \times 10^{20}$$

Finally if the aerial were on a space probe at a distance of 3000 millon km of the earth the number of photons per meter squared per second will be

$$\frac{1.5092 \times 10^{33}}{4\pi \cdot (3 \times 10^{12}\ m)^2} = 1.3344 \times 10^7$$

□