

## 2.3.2 Photons

Electromagnetic radiation comes in small packets called photons. A photon has a certain amount of energy related to its frequency:

$$E = hf$$

where  $h$  is the Planck constant ( $=6.63 \times 10^{-34}\text{s}$ )



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(1) ✎ What is the energy of a photon with a frequency  $f = 5 \times 10^{14}\text{Hz}$ ?

All photons travel at the speed of light. In a vacuum, this is  $3.00 \times 10^8\text{ms}^{-1}$ .

The wave equation is given by:

$$c = f\lambda$$

where  $c$ =the speed of light,  $f$ =frequency (in hertz),  $\lambda$ =wavelength (in metres)

(2) ✎ Rearrange this equation to find an expression for frequency.

(3) ✎ Substitute for  $f$  in the equation  $E=hf$ .

(4) ✎ What is the energy of a photon with a wavelength of  $500\text{nm}$  ( $500 \times 10^{-9}\text{m}$ )?

### The particle nature of light

A light source will emit photons of light. The total energy of the light emitted will depend on the number  $n$  of photons released:

$$E_{total} = nhf = nh \frac{c}{\lambda}$$

The power (in watts) of the light source will be the energy released per second.

$$P = \frac{nhf}{t} = \left(\frac{n}{t}\right) hf$$

where  $t$  is the time

(5) ✎ Work out the number of photons emitted per second  $\left(\frac{n}{t}\right)$  for a  $100\text{W}$  light bulb, assuming that it is emitting photons with wavelength of  $550\text{nm}$  (and  $100\%$  efficient!).