Calculations of Energy, wavelength, and frequency

In Unit 2, Section C we discussed the electromagnetic spectrum. We also mentioned that different wavelengths of light have different energies and the electromagnetic spectrum is sectioned into ranges such as infrared, ultraviolet and visible. How do we actually calculate the energies? Let’s see below.

The product of the wavelength of radiation (λ)and the frequency of the radiation (ν) is equal to the speed of light (c) which is 3.0 x 108 m/s.

Since the speed of light is constant, if you know either the frequency or the wavelength of radiation you can calculate the other – see the 2 equations below:

$$λν=c$$

$$λ=\frac{c}{ν}$$

$$ν=\frac{c}{λ}$$

Thus, frequency and wavelength are inverses of each other.

German physicist Max Planck showed that energy (E) is directly proportional to the frequency of the radiation. Thus E = constant x ν; the constant was determined to be 6.626 x 10-34 J·s and is called Planck’s constant (h).

Thus our equation relating frequency and wavelength is:

$$E=hν$$

This energy is known as the quantized energy of the radiation.

If we do not know the frequency but know the wavelength we can still calculate the energy using the following equation.

$$E=\frac{hc}{λ}$$

Finally, this leads us to Einstein’s famous equation: E=mc2

The energy can be related to the mass of the radiation (quantized particle) and the speed of light. This allows us to perform more calculations and discuss the wave-particle duality later.