

## 1.3 The measurement of light — photometry

### 1.3.1 Luminous flux

The most fundamental measure of the electromagnetic radiation emitted by a source is its radiant flux. This is the rate of flow of energy emitted and is measured in watts. The most fundamental quantity used to measure light is luminous flux. Luminous flux is radiant flux multiplied, wavelength by wavelength, by the relative spectral sensitivity of the human visual system, over the wavelength range 380 nm to 780 nm (Figure 1.3). This process can be represented by the equation:

$$\Phi = K_m \sum \Psi_\lambda V_\lambda \Delta\lambda$$

where:  $\Phi$  = luminous flux (lumens)

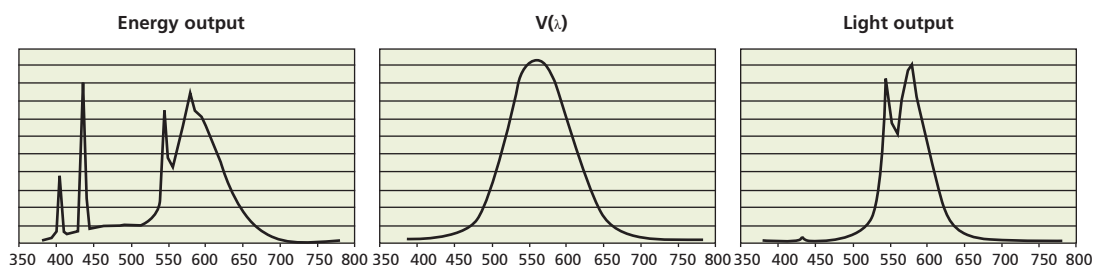
$\Psi_\lambda$  = radiant flux in a small wavelength interval  $\Delta\lambda$  (watts)

$V_\lambda$  = the relative luminous efficiency function for the conditions

$K_m$  = constant (lumens/watt)

$\Delta\lambda$  = wavelength interval

In System Internationale (SI) units, the radiant flux is measured in watts (W) and the luminous flux in lumens (lm). The values of  $K_m$  are 683 lm/W for the CIE Standard and Modified Photopic Observers and 1699 lm/W for the CIE Standard Scotopic Observer. It is always important to identify which of the CIE Standard Observers is being used in any particular measurement or calculation. The CIE recommends that whenever the Standard Scotopic Observer is being used, the word scotopic should precede the measured quantity, i.e. scotopic luminous flux. Luminous flux is used to quantify the total light output of a light source in all directions.



**Figure 1.3** The process for converting from radiometric to photometric quantities. The lefthand figure shows the spectral power distribution of a light source in radiometric quantities (watts/wavelength interval). The centre figure shows the CIE Standard Photopic Observer. Multiplying the spectral power at each wavelength by the luminous efficiency at the same wavelength given by the CIE Standard Photopic Observer, the right hand figure is produced. The right hand figure is the spectral luminous flux distribution in photometric quantities (lumens/wavelength interval).

### 1.3.2 Luminous intensity

Luminous intensity is the luminous flux emitted/unit solid angle, in a specified direction. Solid angle is given by area divided by the square of the distance and is measured in steradians. An area of 1 square metre at a distance of 1 metre from the origin subtends one steradian. The unit of measurement of luminous intensity is the candela, which is equivalent to one lumen/steradian. Luminous intensity is used to quantify the distribution of light from a luminaire.