$$eV_0 = h\nu - \phi_0 = \frac{hc}{\lambda} - \phi_0$$

or, $\lambda = hc/(eV_0 + \phi_0)$

$$= \frac{(6.63\times10^{-34}\,\text{J s})\times(3\times10^{8}\,\text{m/s})}{(0.60\,\text{eV}+2.14\,\text{eV})}$$

$$= \frac{19.89\times10^{-26}\,\text{J m}}{(2.74\,\text{eV})}$$

$$\lambda = \frac{19.89\times10^{-26}\,\text{J m}}{2.74\times1.6\times10^{-19}\,\text{J}} = 454\ \text{nm}$$

EXAMPLE 11.2

Example 11.3 The wavelength of light in the visible region is about 390 nm for violet colour, about 550 nm (average wavelength) for yellow-green colour and about 760 nm for red colour.

(a) What are the energies of photons in (eV) at the (i) violet end, (ii) average wavelength, yellow-green colour, and (iii) red end of the visible spectrum? (Take $h = 6.63\times10^{-34}$ J s and 1 eV = 1.6×10^{-19}J.)

(b) From which of the photosensitive materials with work functions listed in Table 11.1 and using the results of (i), (ii) and (iii) of (a), can you build a photoelectric device that operates with visible light?

Solution

(a) Energy of the incident photon, $E = h\nu = hc/\lambda$

$E = (6.63\times10^{-34}\,\text{J s})\,(3\times10^{8}\,\text{m/s})/\lambda$

$$= \frac{1.989\times10^{-25}\,\text{J m}}{\lambda}$$

(i) For violet light, λ_1 = 390 nm (lower wavelength end)

Incident photon energy, $E_1 = \dfrac{1.989\times10^{-25}\,\text{J m}}{390\times10^{-9}\,\text{m}}$

$= 5.10\times10^{-19}$J

$$= \frac{5.10\times10^{-19}\,\text{J}}{1.6\times10^{-19}\,\text{J/eV}}$$

$= 3.19$ eV

(ii) For yellow-green light, λ_2 = 550 nm (average wavelength)

Incident photon energy, $E_2 = \dfrac{1.989\times10^{-25}\,\text{J m}}{550\times10^{-9}\,\text{m}}$

$= 3.62\times10^{-19}$ J = 2.26 eV

(iii) For red light, λ_3 = 760 nm (higher wavelength end)

Incident photon energy, $E_3 = \dfrac{1.989\times10^{-25}\,\text{J m}}{760\times10^{-9}\,\text{m}}$

$= 2.62\times10^{-19}$ J = 1.64 eV

(b) For a photoelectric device to operate, we require incident light energy E to be equal to or greater than the work function ϕ_0 of the material. Thus, the photoelectric device will operate with violet light (with E = 3.19 eV) photosensitive material Na (with ϕ_0 = 2.75 eV), K (with ϕ_0 = 2.30 eV) and Cs (with ϕ_0 = 2.14 eV). It will also operate with yellow-green light (with E = 2.26 eV) for Cs (with ϕ_0 = 2.14 eV) only. However, it will not operate with red light (with E = 1.64 eV) for any of these photosensitive materials.

EXAMPLE 11.3