Example 4.1 Ultraviolet light of wavelengths 800 Å and 700 Å when allowed to fall on hydrogen atoms in their ground states is found to liberate electrons with kinetic energies 1.8 eV and 4.0 eV, respectively. Find the value of Planck's constant. **(IIT-JEE, 1973)**

Sol. The energy of incident photon = (hc/λ)

If W_i is the ionization energy and E_k the kinetic energy of the emitted electrons, then we have

$$\frac{hc}{\lambda_1} = W_i + E_{K_1}$$

For incident photon of wavelength $\lambda_1 = 800$ Å $= 8 \times 10^{-8}$ m,

$$\frac{hc}{\lambda_1} = W_\text{i} + E_{K_1} \qquad \text{(i)}$$

And for incident photon of wavelength $\lambda_2 = 700$ Å $= 7 \times 10^{-8}$ m,

$$\frac{hc}{\lambda_2} = W_\text{i} + E_{K_2} \qquad \text{(ii)}$$

Subtracting Eq. (i) from Eq. (ii), we get $\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) = E_{K_2} - E_{K_1}$

or $$h = \frac{(E_{K_2} - E_{K_1})\lambda_1\lambda_2}{c(\lambda_1 - \lambda_2)}$$

Here, $E_{K_1} = 1.8\text{eV} = 1.8 \times 1.6 \times 10^{-19}$ J

and $E_{K_2} = 4.0 \text{ eV} = 4.0 \times 1.6 \times 10^{-19}$ J

Substituting the given values, we get

$$h = \frac{(4.8 - 1.8) \times 1.6 \times 10^{-19} \times 8 \times 10^{-8} \times 7 \times 10^{-8}}{3 \times 10^8 (8 \times 10^{-8} - 7 \times 10^{-8})}$$

$$= 6.57 \times 10^{-34} \text{ J-s}$$