

TASK 15.2

$$4(i) \cdot E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{633 \times 10^9} = 3.13 \times 10^{-19} \text{ J} = 1.96 \text{ eV} \quad [3]$$

$$(ii) I_{\text{I}} = I_{\text{R}} + I_{\text{A}} \rightarrow I_{\text{A}} = 0.6 I_{\text{I}} = 0.6 \times 10^{-3} \text{ W}$$

$$g = \frac{I_{\text{A}}}{E} = \frac{0.6 \times 10^{-3}}{3.13 \times 10^{-19}} = 1.92 \times 10^{15} \text{ s}^{-1} \quad [5]$$

$$(iii) |v_{\text{d}}| = \frac{eE\tau}{m^*} \quad E = 500 \text{ V m}^{-1} \quad \tau = 2 \times 10^{-10} \text{ s}$$

$$m_e^* = 0.05 m_e \quad m_h^* = 0.3 m_e$$

$$v_{\text{d}}^- = \frac{-1.6 \times 10^{-19} \times 500 \times 2 \times 10^{-10}}{0.05 \times 9.1 \times 10^{-31}} = -3.5 \times 10^5 \text{ ms}^{-1}$$

$$v_{\text{d}}^+ = \frac{1.6 \times 10^{-19} \times 500 \times 2 \times 10^{-10}}{0.3 \times 9.1 \times 10^{-31}} = 5.8 \times 10^4 \text{ ms}^{-1} \quad [1]$$

$$(iv) \frac{dN}{dt} = g - \frac{N}{\tau} \quad \text{Steady state} \Rightarrow \frac{dN}{dt} = 0$$

$$N_0 = g\tau \quad [8]$$

$$p = n = \frac{N_0}{V} \quad V = 10^{-11} \text{ m}^3 \quad A = 5 \times 10^{-9} \text{ m}^2 \quad N_0 = 1.92 \times 10^{15} \times 2 \times 10^{-10} = 3.84 \times 10^5$$

$$I = -n A v_{\text{d}}^- e + p A v_{\text{d}}^+ e$$

$$= \frac{3.84 \times 10^5 \times 5 \times 10^{-9} \times 1.6 \times 10^{-19}}{10^{11}} (+3.5 \times 10^5 + 5.8 \times 10^4)$$

$$= 1.25 \times 10^{-5} \text{ A} \quad [8]$$

TASK 15.3

The collision time, τ_c , is obtained from:

$$\tau_c = \frac{\mu_e m_e^*}{e} = \frac{0.39 \times 0.55 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}} = 1.2 \text{ ps}$$

The mean free path, l , equals:

$$l = v \tau_c = 10^7 \times 10^{-2} \times 1.2 \times 10^{-12} = 120 \text{ nm}$$

TASK 15.4

The resistivity of the silicon equals:

$$\rho = \frac{1}{qn\mu_e} = \frac{1}{1.6 \times 10^{-19} \times 10^{15} \times 1350} = 4.6 \text{ } \Omega \text{ cm}$$

The resistance then equals:

$$R = \rho \frac{L}{Wt} = 4.6 \times 10^{-2} \times \frac{75 \times 10^{-3}}{8 \times 10^{-3} \times 0.8 \times 10^{-3}} = 540 \text{ } \Omega$$