1811061 Dinesh Beniwal Ass - 2

Q(1) $E = \frac{hc}{\lambda}$; $\lambda_{visible} = 400 - 700 nm$

$\because$ 1 eV corresponds to 1240.669 nm

$\therefore$

	$\boxed{E_g}$	$\boxed{\lambda (nm)}$	$\boxed{\text{result}}$
Si	1.12	1107.74	Opaque
Ge	0.66	1879.80	Opaque
GaAs	1.42	873.713	"
GaP	2.26	548.968	semi trasparent
GaN	3.44	360.59	Trasparent

Logic behind is if it absorb in the visible range it will be Transparent

$\lambda > 700 nm$ opaque as they will absorb all the ~~[illegible]~~ above it

$400 < \lambda < 700 nm$ semi- transpert

$\lambda < 400 nm$ Transpert

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Q ① $\because E_g = 1.17\,ev - 4.73 \times 10^{-4} \dfrac{T^2}{T+630}$

& $n_i^2 = N_c N_v \exp(-E_g/kT) \sim T^3 \exp(-E_g/kT)$

$$n_i(T_2) = n_i(T_1)\left(\frac{T_2}{T_1}\right)^{3/2} \exp\left(\frac{-E_g(T_2)}{2kT_2} + \frac{E_g(T_1)}{2kT_1}\right) \quad (1)$$

$E_g(T_1)$ (when $T_1 = 77k$ & $T_2 = 300k$) $= 1.17 - 4.73 \times 10^{-4} \left(\frac{77^2}{77+630}\right)$

$$\boxed{E_g(T_1) = 1.166034}$$

$E_g(T_2 = 300k) = 1.17 - 4.73 \times 10^{-4} \left(\frac{300^2}{930}\right)$

$= 1.12423$

for eq ① $n_i(300) = n_i(77)\left(\frac{300}{77}\right)^{3/2} \exp\left(\frac{-1.12423}{2 \times k \times 300} + \frac{1.66034}{2 \times k \times 77}\right)$

$\because \downarrow$
1.05×10^{10}

after solving

$\Rightarrow \boxed{n_i(77) = 2.61 \times 10^{-20}\ cm^{-3}}$

Similarly for $T_2 = 400k$ & $T_1 = 300k$

$E_g(400) = 1.0965$

$E_g(300) = 1.124$

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Again from eq ① $n_i(400) = n_i(300)\left(\ \right)\exp\left(\ \right)$

$$\boxed{\Rightarrow n_i(400) = 5.548 \times 10^{12}\ cm^{-3}}$$

- At lower temp. it acts more like an insulator due to unavaibility of e^-s, whereas @ higher temp. the covalat bond breaks and the e^-s can move around freely thus increasing the conductivity.

Q ③ $\because$ $D_p = \frac{k_B T}{q} \mu_p$

$$= \frac{1.38 \times 10^{-23} \times 300 \times 1500 \times 10^{-4}}{1.6022 \times 10^{-19}}$$

$$= 3.88\ cm^2/s$$

$$\boxed{D_p = 3.88 \times 10^{-3}\ m^2/s}$$

The diffusion length $L_D = \sqrt{D\tau}$

$$\Rightarrow \tau = \frac{L_D^2}{D} = \frac{1 \times 10^{-12}}{3.88 \times 10^{-3}} = 2.577 \times 10^{-10}\ sec$$

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Q (4) $V_t = \sqrt{\dfrac{8kT}{\pi m^*}}$

$$V_t^{e^-} = \sqrt{\frac{8 \times 1.38 \times 10^{-23} \times 77}{3.142 \times 0.063 \times 9.1 \times 10^{-31}}}$$

$V_t^{e^-} = \underline{2.17 \times 10^5 \ m/s}$ @ 77 k

Similarly following the same calculations

$V_t^{e^-}$ (@ 300k) $= 4.29 \times 10^5$ m/s

$V_t^{e^-}$ (@ 400k) $= 4.95 \times 10^5$ m/s

Now $V_t^h = \sqrt{\dfrac{8 \times 1.38 \times 10^{-23} \times 77}{3.142 \times 0.53 \times 9.1 \times 10^{-31}}}$

$\boxed{V_t^h = 7.49 \times 10^4 \ m/s}$ @ 77K

Similarly V_t^h (@ 300k) $= 1.48 \times 10^5$ m/s

V_t^h (@ 400k) $= 1.71 \times 10^5$ m/s

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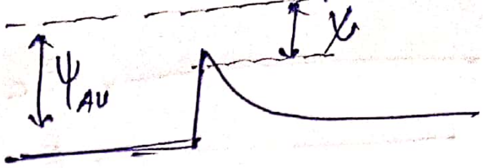
Q(6) $\phi = \psi_{AU} - \chi_{he}$



$= 5.1\,eV - 4.0\,eV$

$= 1.1\,eV$

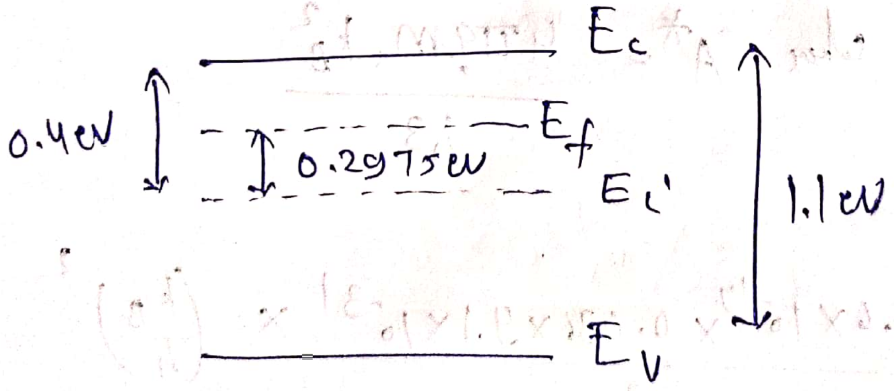
Q(5) (a) $E_f - E_i = k_B T \ln\left(\frac{N_D}{n_i}\right)$ @ 300k

$$= \frac{1.38\times10^{-23}\times 300}{1.602\times10^{-19}} \ln\left(\frac{10^{15}}{10^{10}}\right)$$

$E_f - E_i = 0.2975\,eV$

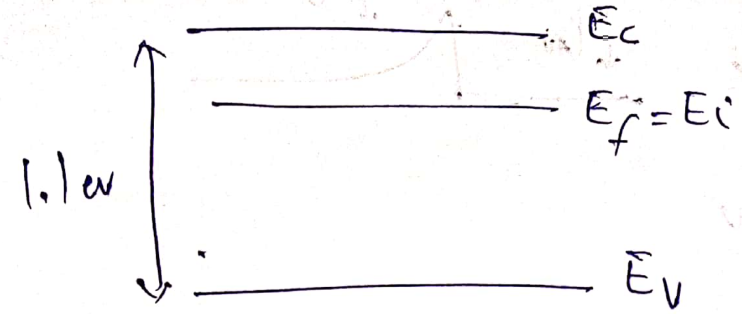
here the donor level is conductor level

$E_c - E_i = 0.4\,eV$



(b) $E_f - E_i = k_B T \ln\left(\frac{N_D}{N_i}\right) = k_B T \ln\left(\frac{10^{15}}{10^{15}}\right) = 0$ (@ 600k)

$\Rightarrow E_f = E_i$



At the equilibrium when $N_v = N_c$ the fermi level coincides with intrinsic fermi-level.

~~Where for doping~~ The fermi level for extrinsic semiconductor shifts towards valence on conduction ~~bo~~ band based on the type of semiconductor / doping.

Q 7 Saturation current $J = A^* T^2 \exp\left(\frac{-\phi_B}{k_B T}\right)$

where $A^* = \frac{4\pi q m_n k_B^2}{h^3}$

~~after subs~~

$$\Rightarrow A^* = \frac{4 \times \pi \times 1.6 \times 10^{-19} \times 0.036 \times 9.1 \times 10^{-31}}{6.62 \times 10^{-34}} \times \left(\frac{k_B}{h}\right)^2$$

$$\Rightarrow J_0 = 9.92 \times 10^{-17} \times \left(\frac{1.38 \times 10^{-23}}{6.62 \times 10^{-34}}\right) \times \exp\left(\frac{-0.25}{0.026}\right) \times (300)^2$$

$$\boxed{J_0 = 2.584 \times 10^5 \, A/m^2}$$

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Q 8

(a) @ 1V ~~the~~ LED will be in Low injection regime,

So $\tau_r = \frac{\Delta n}{R} = \frac{\Delta n}{r(n_0+p_0+\Delta n)\Delta n} = \frac{1}{r(n_0+p_0+\Delta n)}$

for low-level injection, $n_0+p_0 \gg \Delta n$

$$\tau_r = \frac{1}{r(n_0+p_0)} = \frac{1}{r N_A}$$

(b) @ 10V LED will be in high injection regime

$\Rightarrow \Delta n \gg n_0+p_0$

$$\Rightarrow \tau_r = \frac{\Delta n}{r(n_0+p_0+\Delta n)\Delta n} = \frac{1}{r(n_0+p_0+\Delta n)} = \boxed{\frac{1}{r\Delta n}}$$

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