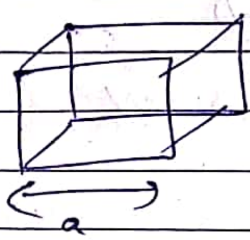
Semiconductor - Fundamentals "EE 1140"
"Final - Exam"

MCQ

Ans 6.



body diagonal $= (a\sqrt{3})$

$4r = a\sqrt{3}$

$r = \left(\frac{a\sqrt{3}}{4}\right)$ ans

Section - 4

Ans 18. intrinsic conc. $(n_i) = 2.5 \times 10^{19}\ m^{-3}$ at 300K

$p \leftarrow$ acceptor density $= 10^{20}$ atoms m^{-3}

∴ from mass action law.

$$p \cdot n = (n_i)^2$$

$$\Rightarrow n = \frac{n_i^2}{p} = \frac{2.5 \times 2.5 \times \cancel{10^{19}} \times \cancel{10^{19}}^{\,10^{18}}}{\cancel{10^{20}}_{\,10}}\ m^{-3}$$

$$= 6.25 \times 10^{18}\ m^{-3} \quad \text{ans}$$

Ans 19. $\mu_n = 0.36\ m^2/Vs$
$\mu_p = 0.17\ m^2/Vs$

e^- density = hole density
$n = p = 2.5 \times 10^{19}\ m^{-3}$

conductivity $(\sigma) = q(n\mu_n + p\mu_p)$

$= e(n\mu_n + p\mu_p)$

$= (1.6 \times 10^{-19}) \cdot \left[2.5 \times 10^{19} \times 0.36 + 2.5 \times 10^{19} \times 0.17\right]\ \Omega^{-1} m^{-1}$

$= \frac{16}{10} \times \cancel{10^{-19}} \times \frac{25}{10} \times \cancel{10^{19}}\ [0.53]$

$= 4 \times 0.53 = (2.12)\ \Omega^{-1} m^{-1}$ ans

akshar
Date
Page
Note Book

Ans 20. for a ~~ ~~ Bohr atom :

$$E_{\text{ground state}} = E_1 = (-13.6\ eV)$$

$$E_{1^{st}\ \text{excited state}} = E_2 = -3.4\ eV$$

$$\therefore\ hc/\lambda_{\text{absorbed}} = E_2 - E_1 = -3.4 + 13.6$$
$$= \underline{10.2\ eV}$$

$\therefore$

~~$h = 6.626 \times 10^{-34}$ J sec~~

~~$\lambda = \frac{10.2 \times 1.6 \times 10^{-19}}{6.626 \times 10^{-34}}$~~

$$\frac{hc}{\lambda} = 10.2\ eV.$$

$$\therefore\ \lambda = \frac{hc}{10.2} = \frac{1240}{10.2}\ nm$$

$$(hc \approx 1240\ eV.nm)$$

$$\therefore\ \lambda = \frac{1240 \times 10}{102} = \underline{121.56\ nm}\ \ \text{as}$$

Ans 21. Si at T = 300K,

$$\boxed{J_n^{\text{diff}} = q D_n \left(\frac{dn}{dx}\right)}$$

here $\frac{dn}{dx}$ e^- conc. varies linearly.

Scanned with CamScanner

$$\therefore \frac{dn}{dx} = \frac{\Delta n}{\Delta x} = \frac{(10^{16} - 10^{12})\ cm^{-3}}{3 \times 10^{-6} \times 10^{2}\ cm}$$

$$\frac{\Delta n}{\Delta x} = \frac{10^{16} - 10^{12}}{3 \times 10^{-4}}\ cm^{-4}$$

$$= \frac{10^{12} \cdot [10^{4} - 1]}{3 \times 10^{-4}}$$

10000

$$= \frac{10^{16}}{\cancel{3}} \cdot \left[\cancel{9999}^{3333}\right] = 3333 \times 10^{16}\ cm^{-4}$$

$$\therefore J_n^{diff} = (1.6 \times 10^{-19}) \cdot (35) \cdot (3333 \times 10^{16})\ C \cdot \frac{cm^2}{sec}\ cm^{-4}$$

$$J_n^{diff} = 186648 \times 10^{-3}\ C\ cm^{-2}\ sec^{-1}$$

$$\boxed{J_n^{diff} = 186.648\ A/cm^2}$$ ans

Ans 22. thickness = 0.5mm $\Delta V = 100mV$

$$E = \frac{\Delta V}{d} = \frac{100 \times \cancel{10^{-3}}}{0.5 \times \cancel{10^{-3}}} \left(\frac{V}{m}\right)$$

(a) $\mu = 0.2\ m^2/Vs$

$$= 200\ V/m$$

$\therefore$ e^- drift velocity $(V_d) = \mu E$

$$V_d = 0.2 \times 200\ m/sec$$

$$\boxed{V_d = 40 m/sec}$$ ans

Scanned with CamScanner

Ans 22. (b) Let time be t.

$\therefore V_d \cdot t$ = thickness

$\Rightarrow (40) \cdot [t] = 0.6 \times 10^{-3}$ meters.

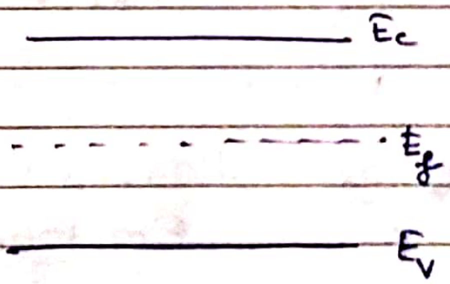
$$t = \frac{0.5}{40} \times 10^{-3}$$

$$= \frac{5}{4} \times 10^{-5} \text{ sec}$$

$$\boxed{t = t_{required} = 1.25 \times 10^{-5} \text{ sec}}$$ ans

Ans 24. $E_g = 1.12\,eV$ Silicon at $T = 300K$

From the class notes we know that.



$$P(E) = \frac{1}{1 + \underbrace{\exp\left[\frac{(E-E_F)}{K_B T}\right]}_{\alpha}}$$

$$\therefore \alpha = \exp\left[\frac{E-E_F}{K_B T}\right]$$

now if $E = E_c + KT$

$$\therefore \alpha = \exp\left[\frac{E_c + KT - \cancel{E_F}}{K_B T}\right] = \exp\left[\frac{KT + \left(\frac{E_c - E_v}{2}\right)}{KT}\right]$$

$\left(\frac{E_c + E_v}{2}\right)$

$$\alpha = \exp\left[\frac{KT + \frac{E_g}{2}}{KT}\right]$$

$$\alpha = \exp\left[\frac{0.0259 + 0.56}{0.0259}\right]$$

$$\alpha = \exp[+22.6].$$

$$\therefore \quad P(E = E_c + KT) = \frac{1}{1 + \exp(22.6)} \simeq \exp(-22.6)$$

$$\simeq 1.53 \times 10^{-10} \quad \text{ans}$$

(b). if $E_f = E_c$.

$$\therefore P(E_c + KT) = \frac{1}{1 + \exp\left[\frac{\cancel{E_c} + KT - \cancel{E_c}}{KT}\right]}$$

$$= \frac{1}{1 + \exp[1]} \simeq 0.2689 \quad \text{ans}$$

Ans 25. $\boxed{n_i = \sqrt{N_c N_v} \; e^{-E_g/2KT}}$

$N_c \propto T^{3/2}$

$N_v \propto T^{3/2}$

$$n_i^2 = N_c N_v \; e^{-E_g/KT}$$

$N_c N_v \propto T^3$

$$E_g = 1.17 - 4.73\times10^{-4} \frac{T^2}{T+636}$$

$$\therefore \frac{(n_i)^2_{T=300K}}{(n_i)^2_{T=77K}} = \frac{n_1^2}{n_2^2} \text{ (let)} = \frac{(300)^3}{(77)^3} \cdot \frac{e^{-\frac{E_{g_1}}{K(300)}}}{e^{-\frac{E_{g_2}}{K(77)}}}$$

$$= \frac{(300)^3}{(77)^3} \cdot \left[e^{\frac{E_{g_2}}{77K} - \frac{E_{g_1}}{300K}} \right]$$

$$E_{g_1} = 1.17 - 4.73\times10^{-4} \times \frac{(300\times300)}{(300+636)} \quad 936$$

$$E_{g_1} = 1.17 - 0.045 \simeq 1.124$$

$$E_{g_2} = 1.17 - 4.73\times10^{-4} \times \frac{77\times77}{713}$$

$$E_{g_2} = 1.1660$$

$$\therefore \frac{n_1^2}{n_2^2} = \frac{(300)^3}{(77)^3} \cdot \exp\left[\frac{\frac{1.166}{77} - \frac{1.124}{300}}{K} \right]$$

0.01514 0.0034

$$= \frac{(300)^3}{(77)^3} \exp\left[\frac{0.01174}{8.617\times10^{-5}} \right]$$

$$\frac{n_1^2}{n_2^2} = \frac{(300)^3}{(77)^3} \cdot \exp(136.24)$$

$$\therefore \quad n_2 = \sqrt{\frac{n_1^2 \times (77)^3}{(300)^3 \times \exp(136.24)}} \quad \text{ans}$$

$$n_2 = \sqrt{\frac{1.05 \times 1.05 \times \cancel{10^{20}}^{10^{10}} \times 77 \times 77 \times 77}{27 \times \cancel{10^{6}} \times \cancel{10^{4}} \times 1.47 \times \cancel{10^{59}}\, 10^{49}}}$$

$$n_2 = \sqrt{\frac{1.26 \times 10^{8}}{10^{44}\; 10^{41}}}$$

$$n_2 = \sqrt{12.6 \times 10^{-42}}$$

$$n_2 = 3.54 \times 10^{-21}\ \text{cm}^{-3} \quad \text{ans}$$

$$\underline{n_2 \simeq 7.5932 \times 10^{8}\ \text{cm}^{-3}} \quad \text{ans}$$

Akshar Note Book — Date ______ Page ______

Ans 26.

$$J_n^{diff} = q D_n \frac{dn}{dx}$$

$$\frac{dn}{dx} = \frac{6\times 10^{6} - 10^{17}}{2\times 10^{-4}}$$

$$= -2\times 10^{20}\ cm^{-4}$$

$$\therefore \left| J_n^{diff} \right| = \frac{1.6\times 10^{-19} \times 35 \times 2\times 10^{20}}{1}$$

$$= 32\times 35 = \boxed{1120\ A/cm^2}$$

ans

Ans 23.

$$\frac{1}{1+e^{\left(\frac{E-E_F}{KT}\right)}} = 0.05$$

$$\therefore 1+e^{\left(\frac{E-E_F}{KT}\right)} = 20$$

$$\therefore \frac{E-E_F}{KT} = \ln(19)$$

$$\therefore E-E_F = KT(\ln 19) = \underline{2.94\ KT}$$ ans