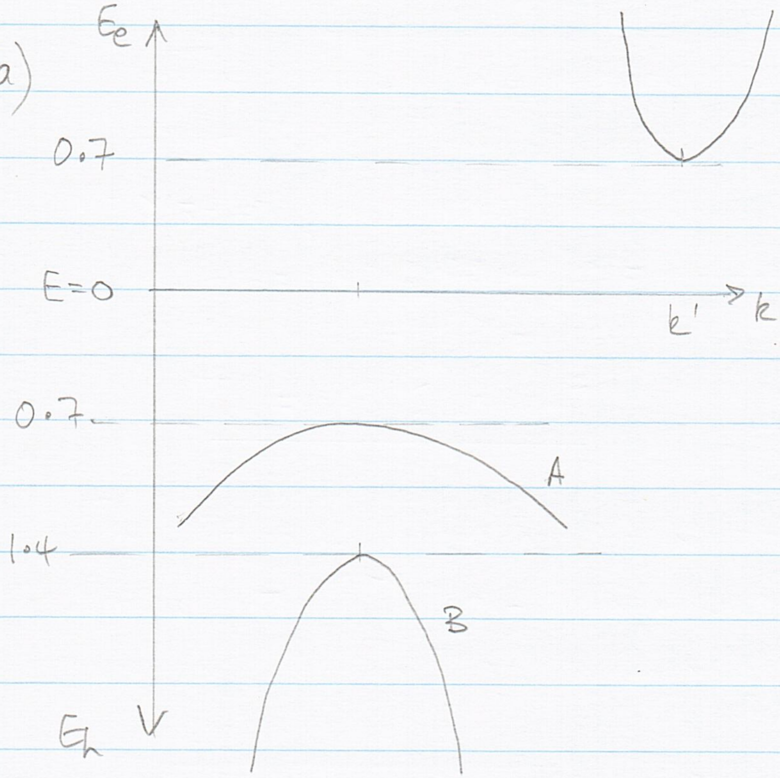
480 MT 2010

1 (a)



(b) For band diags need E_g, E_F, V_{bi}.

E_F approximate, but $(E_F - E_V)$ may be different.

1 $E_{gB} > E_{gA}$

$m^* \propto \frac{1}{d^2E/dk^2}$ $\therefore m^*_{hB} < m^*_{hA}$ $m^*_{hB} = 0.5\, m^*_{hA}$

$V_{bi} = V_{th} \ln \frac{N_A N_D}{n_i^2}$ $n_i^2 = N_c N_v e^{-E_g/k_BT}$

$N_V \propto m_h^{*\,3/2}$

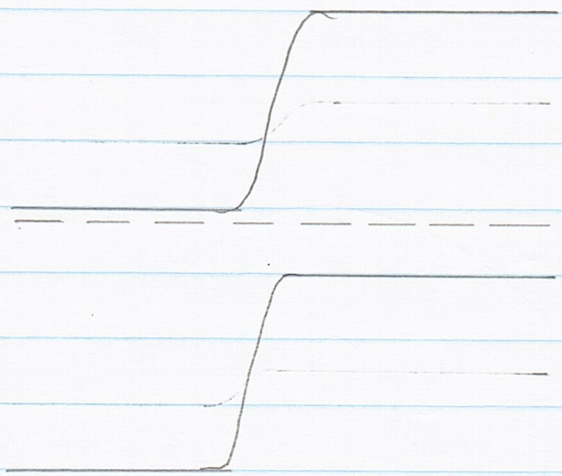
$\therefore E_g$ dominates in n_i^2 $\therefore n_{iA}^2 > n_{iB}^2$

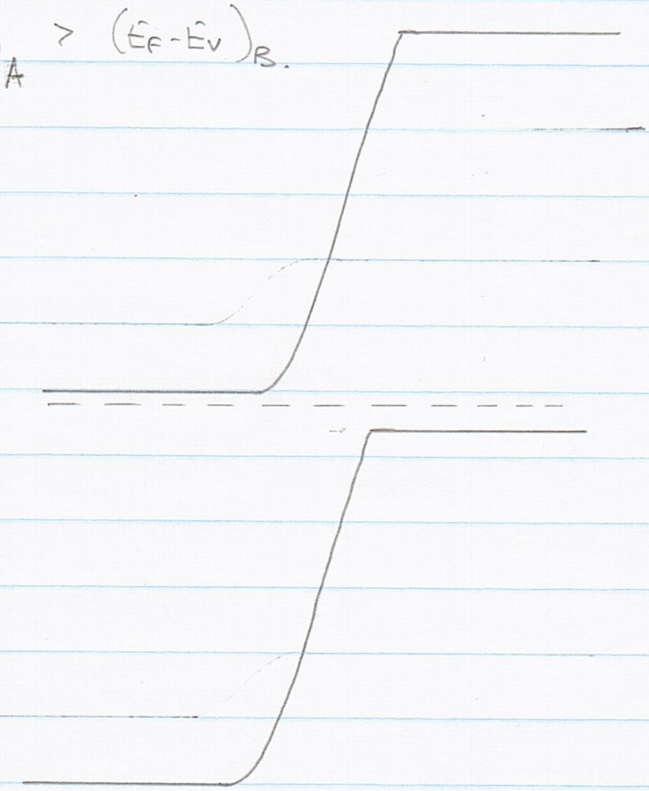
1 $\therefore V_{biA} < V_{biB}$

$p_0 \approx N_A = N_V \exp\left(\frac{E_V - E_F}{k_BT}\right)$ $\therefore E_V - E_F = k_BT \ln \frac{N_A}{N_V}$

1(b) cont. $E_F - E_V = k_B T \ln \frac{N_V}{N_A}$

1 $N_V^A > N_V^B \quad \therefore \quad (E_F - E_V)_A > (E_F - E_V)_B.$





1 (A) (B)

---

2. (a) $J_{diode} = (J_{oe} + J_{oh})(e^{-V_a/V_{th}} - 1)$

$\approx J_{oe}(e^{-V_a/V_{th}} - 1)$ for n^+p diode

$J_{oe} = -q D_e n_{oB} \coth W_B/L_e$

$\rightarrow -q D_e \frac{n_{oB}}{L_e}$ if $W_B \gg L_e$

$\rightarrow -q D_e \frac{n_{oB}}{W_B}$ if $W_B \ll L_e$

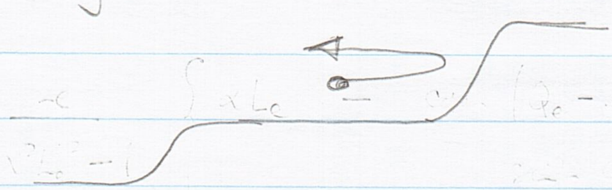
2(a) cont. For X, $W_B/L_e = 10/100$ i.e. $\ll 1$

For Y, $W_B/L_e = 10/1$ i.e. $\gg 1$

$$\therefore \quad J_{oe_X} = -q\frac{D_e n_{oB}}{W_B}, \qquad J_{oeY} = -q\frac{D_e n_{oB}}{L_{e,Y}} \quad \Bigg\} \quad \frac{J_{oeX}}{J_{oeY}} = \frac{L_{e,Y}}{W_B} = \frac{1}{10}$$

$\therefore$ <u>Y has larger current.</u>

2(b) Blocking base contact



Electrons diffusing to back contact would be reflected and collected as photocarriers. But need $L_e \gg W_B$

$\therefore$ <u>X would have higher photocurrent.</u>

3 InP, as its E_g is near the optimum (see Fig. 7.13).

As $E_g \uparrow$, photons not absorbed $\uparrow$, $\therefore J_{ph} \downarrow$

As $E_g \uparrow$, $n_i^2 \downarrow$, $n_{OB} \propto \frac{n_i^2}{N_A}$ $\therefore n_{oB} \downarrow$, $\therefore J_0 \downarrow$ & $V_{oc} \uparrow$

$\eta \propto V_{oc} J_{ph}$ $\therefore$ there is an optimum.

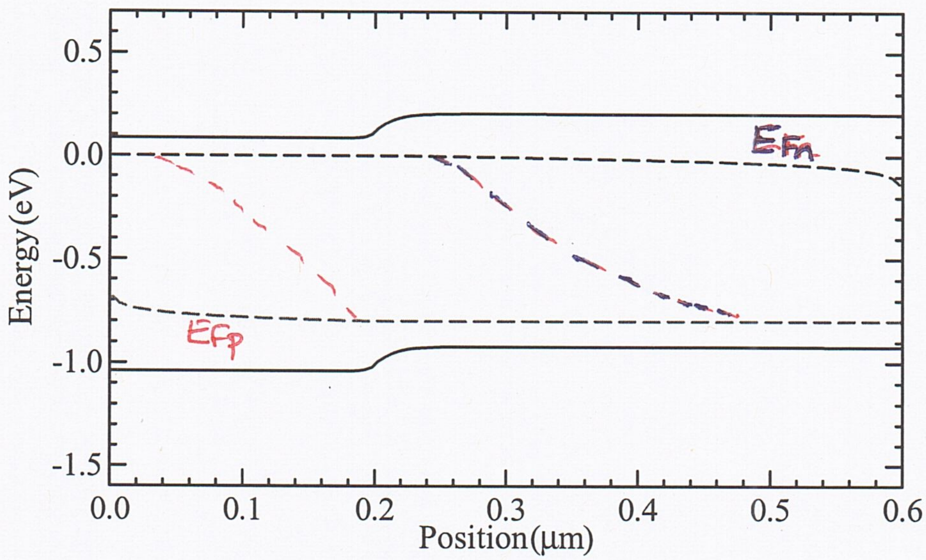


Figure 1: Energy band diagram (E_C, E_V, E_{Fn}, E_{Fp}) for a forward-biassed diode with no recombination.

Recombination causes minority carrier concentration to decrease, e.g., $(E_c - E_{Fn})$ increases.