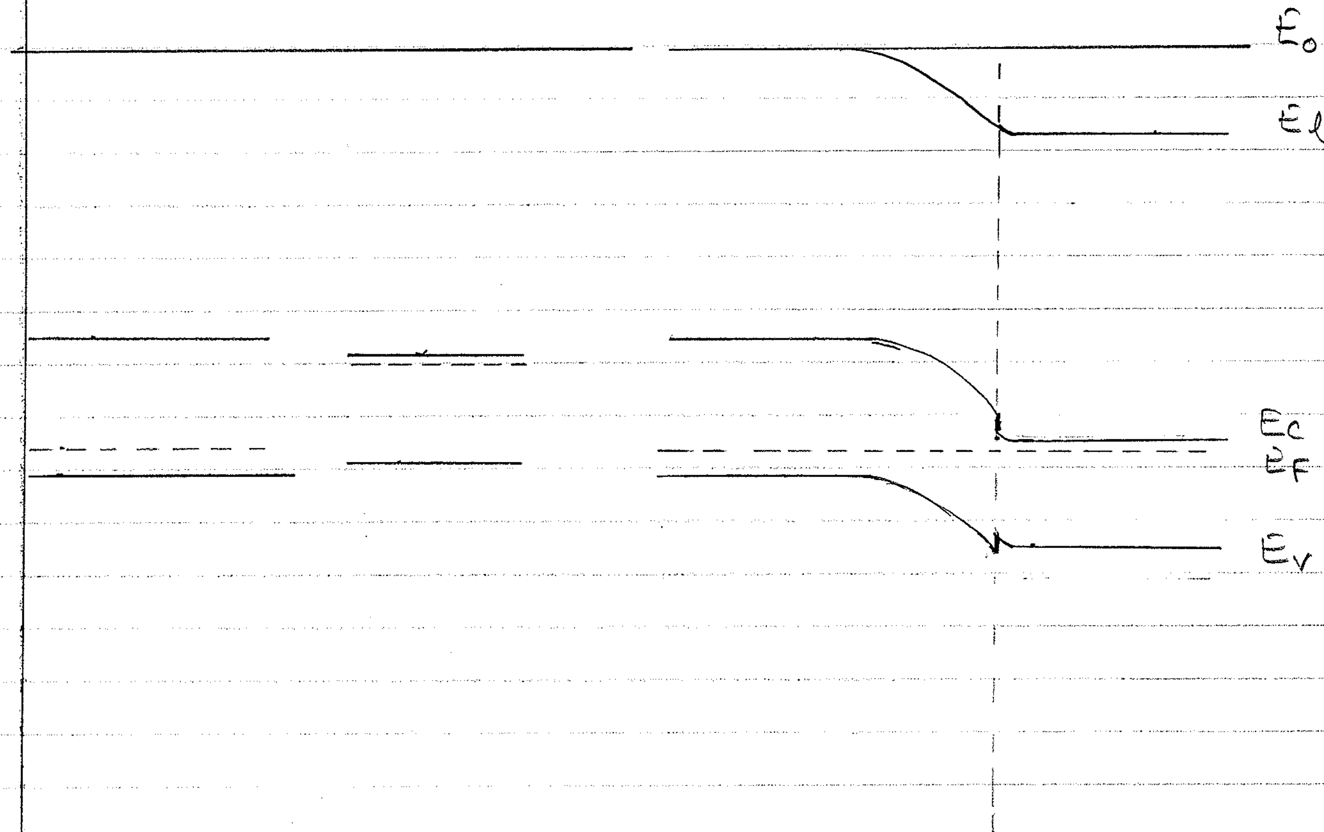
EECE 480 MID-TERM October 23, 2008

1

$$E_g(x) = 1.424 + 1.247x \xrightarrow{x=0.3} E_g = 1.80\text{ eV}$$
$$\chi(x) = 4.07 - 0.79x \longrightarrow \chi = 3.83\text{ eV}$$

$$\Delta E_c = \Delta\chi = 0.24\text{ eV}$$
$$\Delta E_v = \Delta E_g - \Delta E_c = 0.37 - 0.24 = 0.13\text{ eV}$$

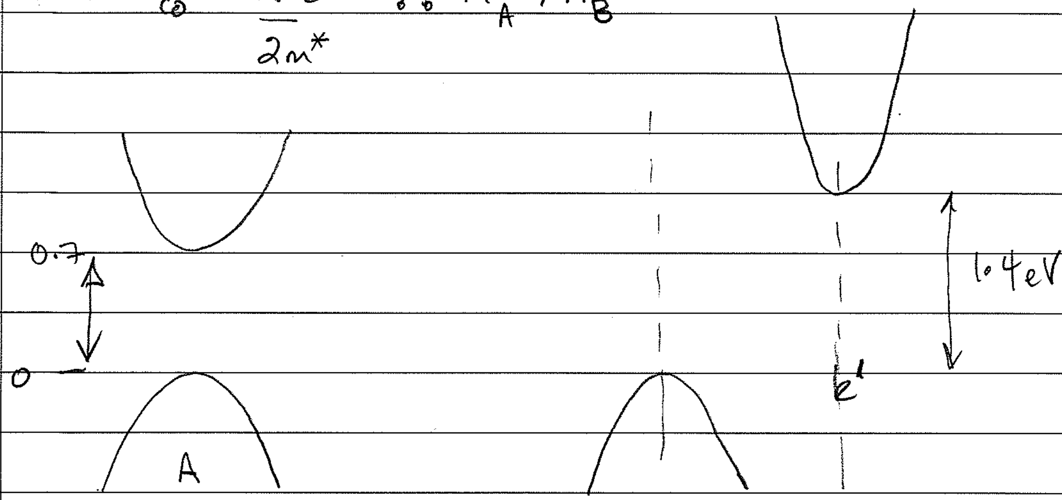


MARKING	SCHEME	
1	5	
2	5	
3	3	
4	3	(1+2)
5	5	(2+1+2)
6	4	

Note: Above values from (8.6)

Procedure for drawing band diagrams from section 6.1.1.

2. $E - E_{c0} = \frac{\hbar^2 k^2}{2m^*}$ $\therefore m_A^* > m_B^*$



a) $n_i \propto e^{-E_g/2kT}$ $\therefore n_i^A > n_i^B$

b) $J_{drift} \propto \mu$, $\mu \propto \frac{1}{m^*}$ $\therefore J_{drift}^A < J_{drift}^B$

c) For solar cell η peaks @ 1.4eV $\therefore$ B is better (See Fig. 7.11)

d) For LED need direct bandgap $\therefore$ A is better.

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3. From Assignment 3 & 7.6, one cell goes into FB.

$\therefore$ At low V_L, the other cell goes into RB, i.e. it absorbs power.

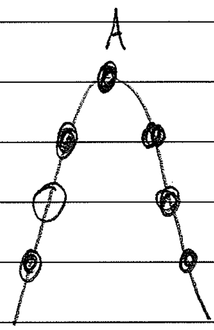
To emphasize: $I_L < 0$ and $V_{RB} < 0$ $\therefore P > 0$

4(a) $\psi_k(x) = u_k(x)e^{ikx}$

$\psi_k(x)\psi_k^*(x) = u_k(x)^2 = |\psi_k(x)|^2$

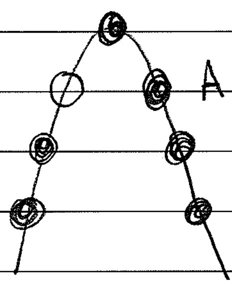
$u_k(x) = u_k(x+a)$, so $|\psi_k(x)|^2$ is periodic

4(b)



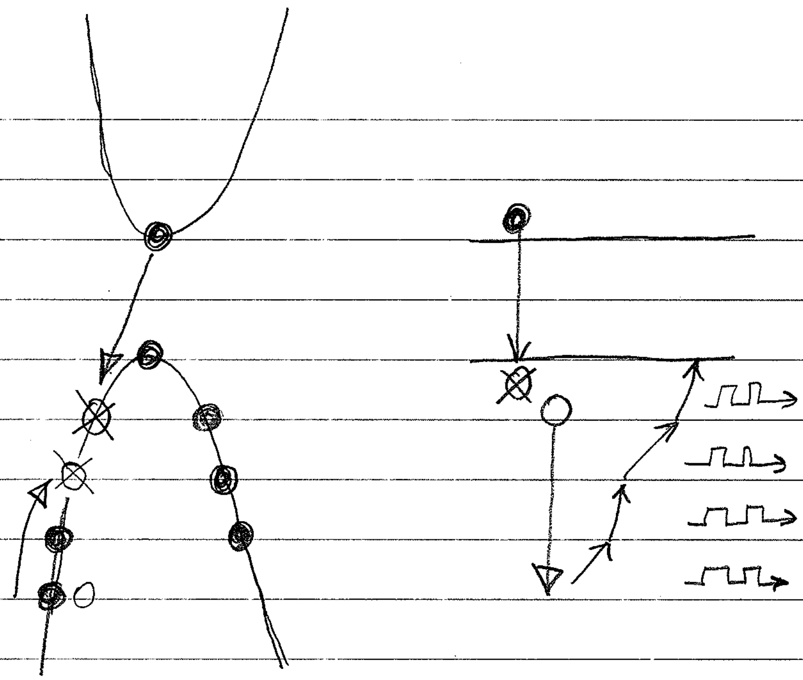
$F = \hbar \frac{dk}{dt} = -(-q)\mathcal{E}_x$ for electron in VB

-ve mass



OR, remember the result from Assignment 2 for the movement of the hole and realize that the electrons must move the same way. If they moved the other way a state would be skipped

5(a)



(b) $np - n_0 p_0 = (n_0 + \Delta n)(p_0 + \Delta n) - n_0 p_0$

(c) $\Delta n = 10^{15}\ cm^{-3}$ is appropriate for LLI

$$\eta_{rad} = \frac{\tau_e}{\tau_{rad}} \qquad \tau_e = \left[\frac{1}{\tau_{erad}} + \frac{1}{\tau_{eA}}\right]^{-1}$$

$$= \left[Bp_0 + A\right]^{-1}$$

$$\therefore \eta_{rad} = \frac{Bp_0}{Bp_0 + A} = \frac{1}{1 + \frac{A}{Bp_0}} = \frac{1}{1 + \frac{10^{-3}}{7\times10^{-10}\times10^{16}}}$$

$$\approx 1$$

Actual value is ≈ 0.01

Try $A_e = 10^{+9}$ $\quad \eta_{rad} = \frac{1}{1 + \frac{10^9}{7\times10^6}} = 0.0069$

6 For Si $\tau_{e,h} \simeq \dfrac{10^{-7}}{1+\dfrac{N}{5\times10^{16}}}$ $\rightarrow \tau_{e,BASE} \approx \dfrac{10^{-7}}{1+\dfrac{1.5\times10^{16}}{5\times10^{16}}}$ 0.769×10^{-7}s

From (3.21)

$\tau_{h,EMITTER} = \dfrac{10^{-7}}{1+\dfrac{5\times10^{19}}{5\times10^{16}}} = 10^{-10}$s.

From (5.27)

$L = \sqrt{D\tau}$ $\therefore$ $\mu_{h\ EMITTER} = 60 \rightarrow D = 15.6\ cm^2/s \rightarrow L_h = 395$ nm

From (6.30)

$\mu_{e\ BASE} = 1220 \rightarrow D\ \ 31.6\ cm^2/s \rightarrow L_e = 15.6\ \mu m$

$\therefore$ $L_e \ll W_B$ $\therefore$ Back surface probably makes no difference

$L_h > W_E$ $\therefore$ a blocking contact would help.

Don't forget, these S's are for minority carriers in this instance. Obviously, if S=0 at one contact for both carriers, then there would be no current.