① a) $C = \frac{\epsilon}{W}$ small signal diode capacitance (F/cm^2)

Leftmost diode

$$W = \sqrt{\frac{2\epsilon}{q}(V_{bi} - V_a)\frac{N_a + N_d}{N_a N_d}} \quad *$$

$$W \sim 8.0\ \mu m$$

Middle diode

$$W \sim 2.6\ \mu m$$

Rightmost Diode

$$W > 3\ \mu m$$

∴ <u>Middle diode</u> has smallest depletion width and thus highest capacitance.

---

* Since $N_a = 10^{19}\ cm^{-3}$ is a degenerate doping, this equation is not precisely accurate, but still gives relative widths.

b.) The dominant reverse bias current for real diodes is generation current from depletion region.

$$I_{Gen} = -\frac{q n_i}{2\tau_0} W A$$

$n_i = 1.1 \times 10^{10}\ cm^{-3}$

$\tau_0 = 10^{-6}\ sec$

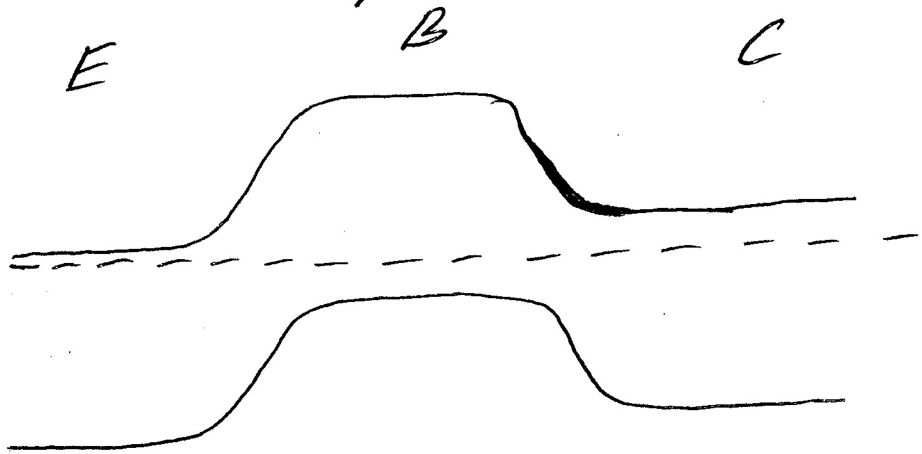
$A = 1mm^2 = .01 cm^2$

$W \approx 2.6\ \mu m$ at $V_a = -5V$

$q = 1.6 \times 10^{-19}$ coul

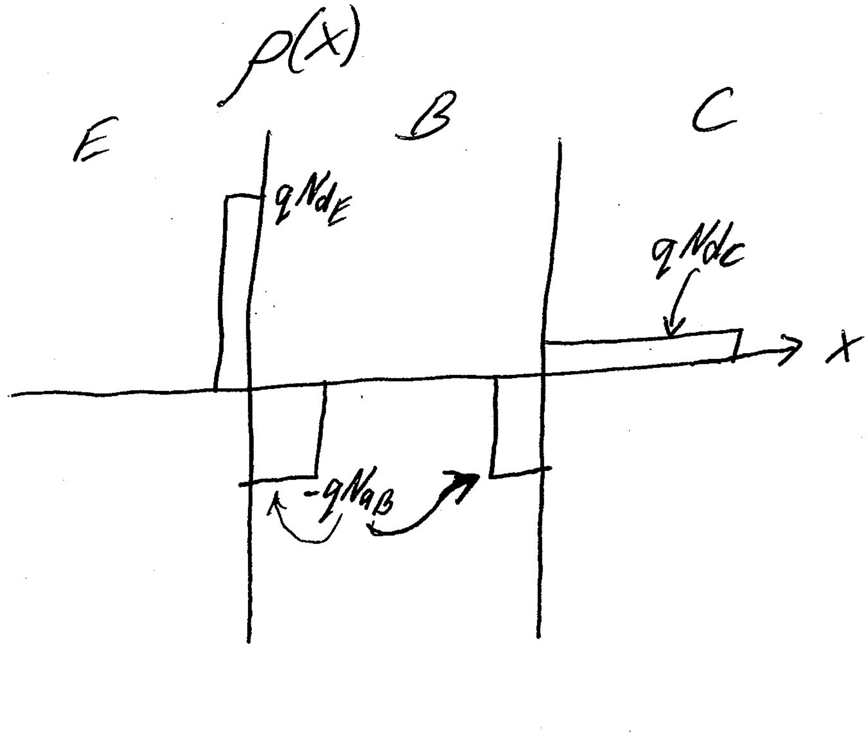
$$\boxed{I_{gen} = 2.3\ nA}$$

(2.) a.) Thermal equilibrium



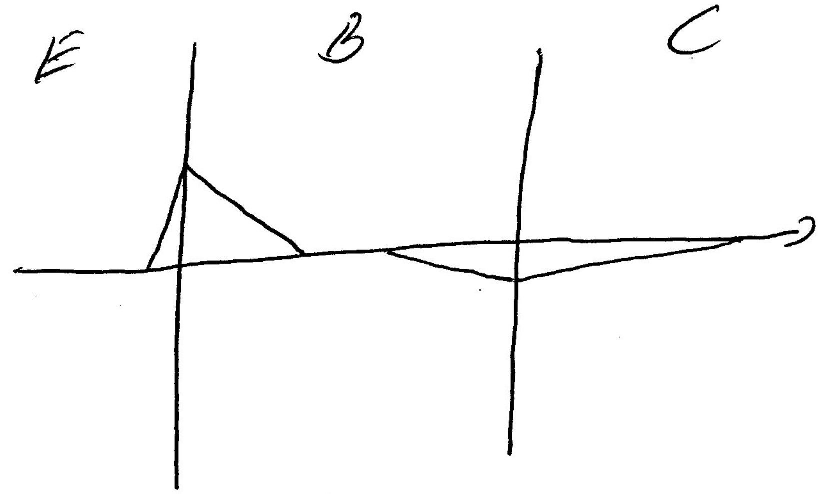
$(E_c - E_f)$ for n+ material in emitter is smaller than $(E_c - E_f)$ for material in collector

b.)

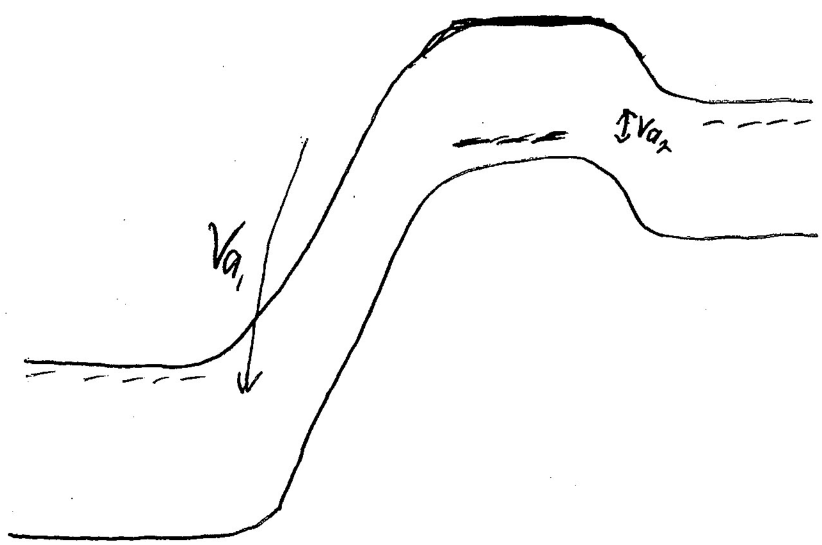


C.)

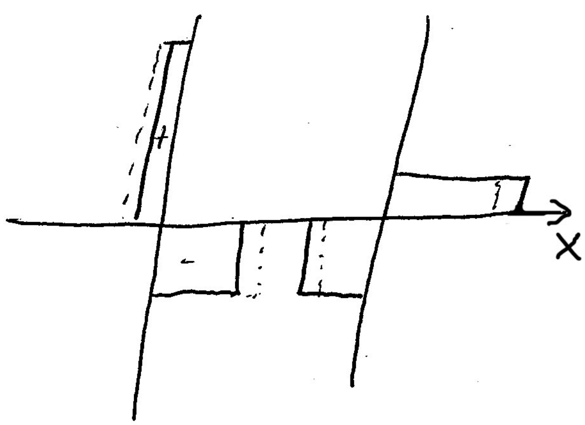
$\mathcal{E}(x)$



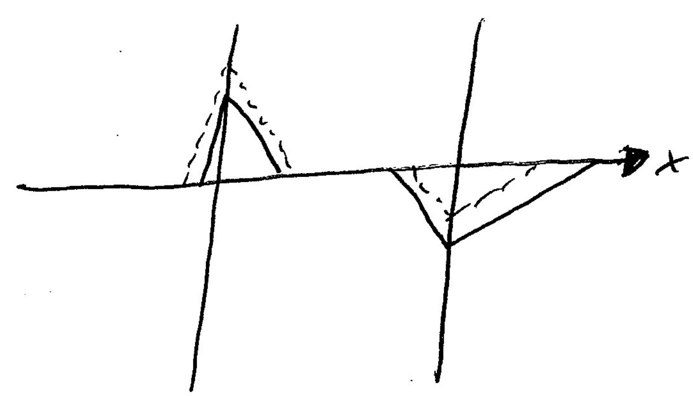
Inverse Active



$\rho(x)$



$\mathcal{E}(x)$



d) β for forward active $\gg$ β for inverse active

A small amount of base current in forward active will leverage a very large amount of emitter current due to the large ratio of $\left(\frac{\text{electrons injected to base}}{\text{holes injected to emitter}} \right)$

for an $n+p$ diode.

In ~~reverse~~ inverse active, the ratio is much smaller, and a large base current is necessary to leverage the same "emitter" current.