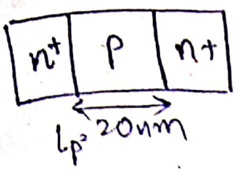
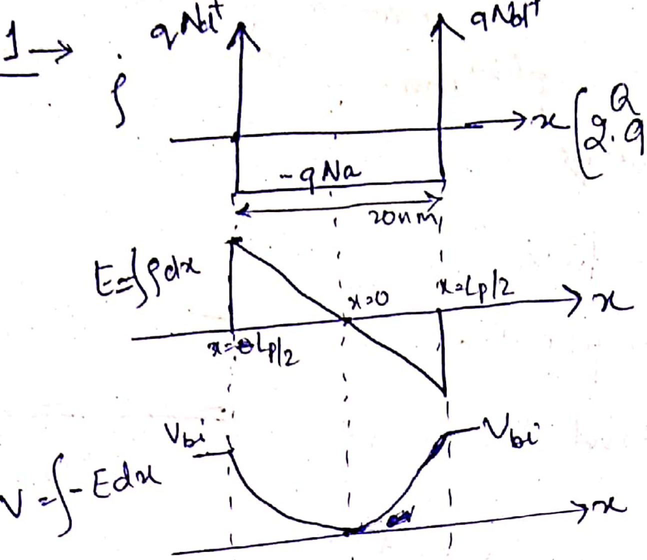
Q4.

a) Step 1. Assume a charge profile (ρ) wrt x & corresponding Electric field & potential profiles (from poisson eq^n)

Guess 1 →





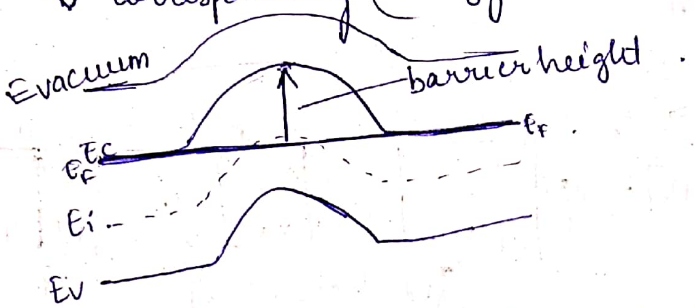
$$Q = q N_d x_n = -q N_A \omega \quad (x_n \approx 0)$$

$$N_d x_n = -N_A w/2$$

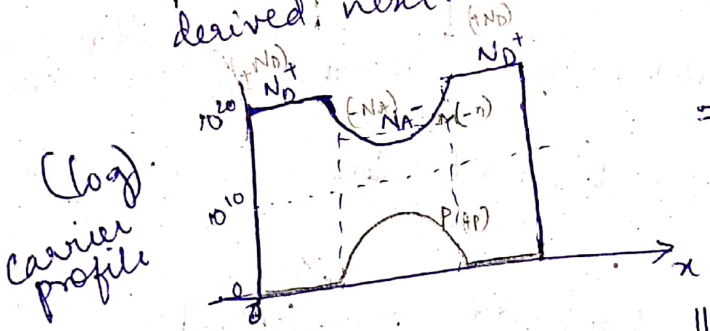
$$E = \frac{q N_d x}{\epsilon}$$

V_{max} = Area under the E curve – $\frac{1}{2} \times E_{max} \times \frac{L_p}{2} = \frac{E_{max} L_p}{4}$

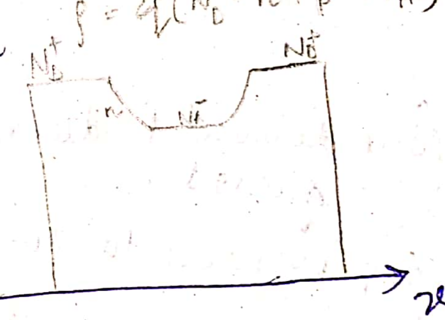
⇓ corresponding (Energy Band – flipped V profile)



Step 2 – from this Energy Band diagram, now find the charge profile & see if the guess was consistent with the one derived next:

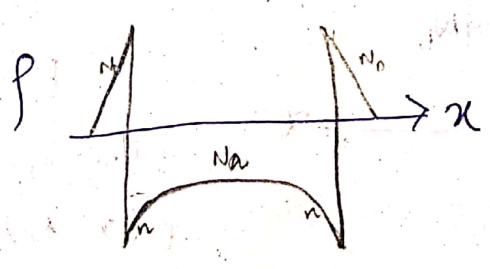


⇒ overall carrier profile (log)



⇓

$$\rho = q(N_D - N_A + p - n)$$



The derived charge profile is approximately similar so, we can say that the guess was approximately matching.

a) · Calculate doping to get $V_{bi} = 0.6V$ at zero bias.

$N_d^+ = 10^{20}/cc$ (given)

$N_a = 10^{18}/cc$ $\quad$ $n_i = 10^{10}/cc$ (Set)

We have,

with given values $V_{bi} = \frac{KT}{q}\ln\left(\frac{N_a N_d^+}{n_i^2}\right) = 1.0729\ V.$

We need to reduce V_{bi} to 0.6V.

and $W_{dep} = \sqrt{\frac{2\epsilon_{si} V_{bi}}{qN_a}} = 3.774\times10^{-6}\ cm \simeq \underline{37\ nm}.$

$L_p = 20nm$, $W_{dep} = 37nm$. , $L_p < W_{dep}$

⇒ all p region is depleted.

Vmax - from previous analysis = $\frac{E_{max}\cdot L_p/2}{2}$

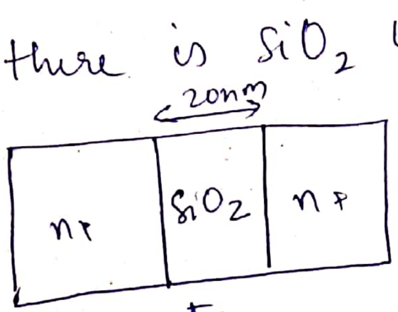
$|E_{max}|_{x=L_p/2} = \frac{qN_d(L_p/2)}{\epsilon_{si}}$ ⇒ $V_{max} = \frac{qN_D(L_p/2)^2}{2\epsilon_{si}}$

(max. barrier height at Lp/2 assumed)

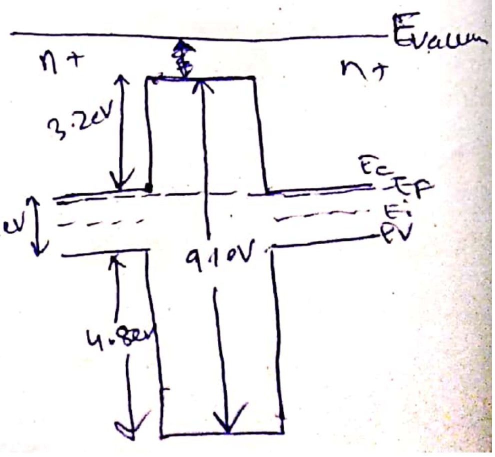
$V_{max} = V_{bi} = 0.6 = \frac{qN_D(L_p/2)^2}{2\epsilon_{si}}$

$\underline{N_D = 7.96\times10^{18}/cc}$

If there is SiO_2 in between 2 n+ layers



→ Band diagram would look like (at equil^m)



Physical property

SiO_2 → insulator (large bandgap)

→ no Oxide charges or traps.