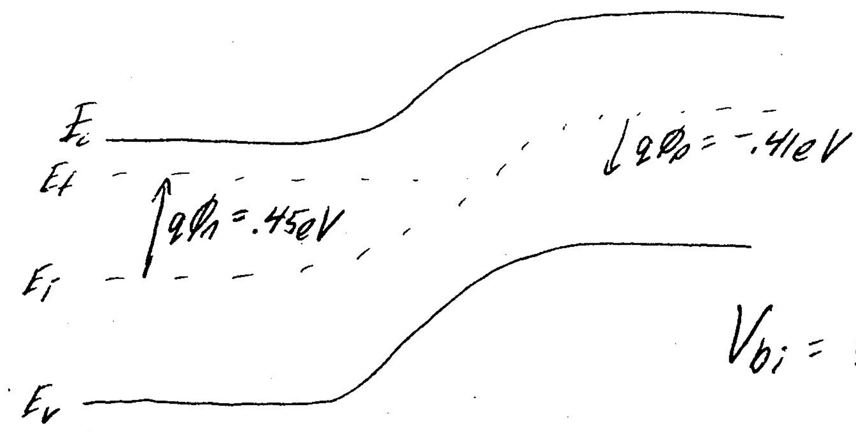
(1.) From previous handout, in thermal equilibrium:

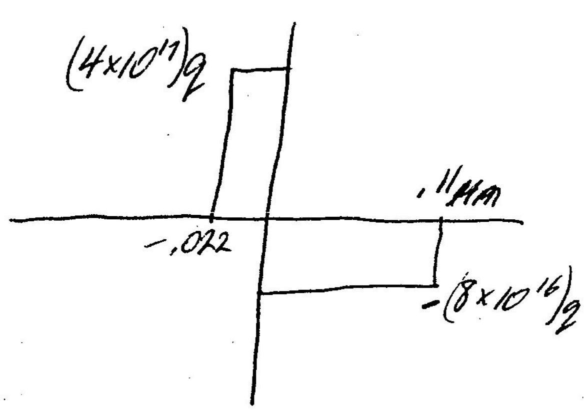


$$V_{bi} = \phi_n + \phi_p = .86\,V$$

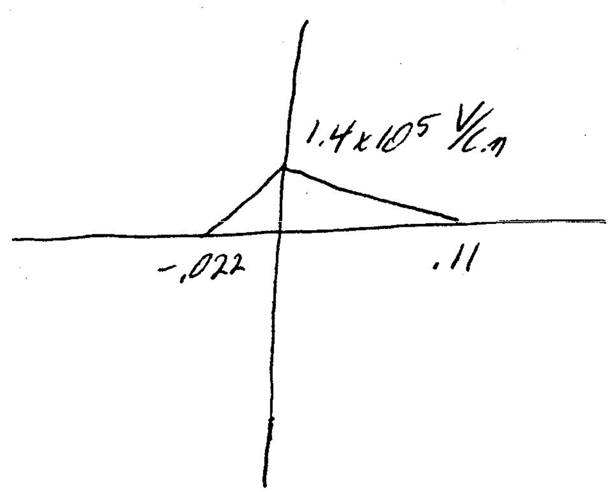
$$x_p = \sqrt{\frac{2\epsilon}{q} V_{bi} \frac{N_d}{N_a(N_a+N_d)}} = .11\,\mu m$$

$$x_n = \sqrt{\frac{2\epsilon}{q} V_{bi} \frac{N_a}{N_d(N_a+N_d)}} = .022\,\mu m$$

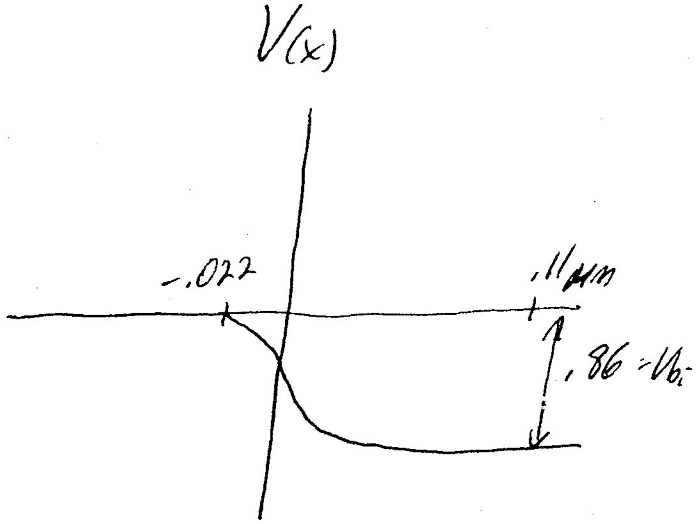
$\rho(x)$



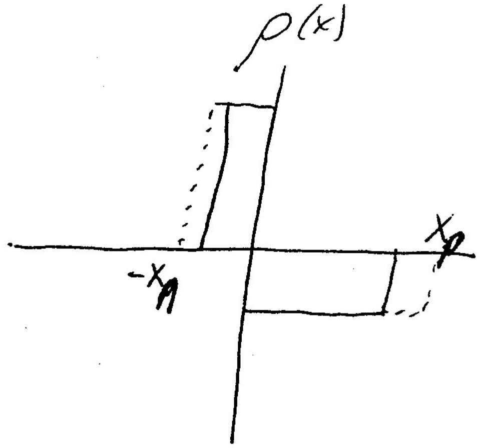
$\mathcal{E}(x)$



$$\mathcal{E}(0) = \frac{q N_a x_p}{\epsilon} = \frac{q N_d x_n}{\epsilon}$$



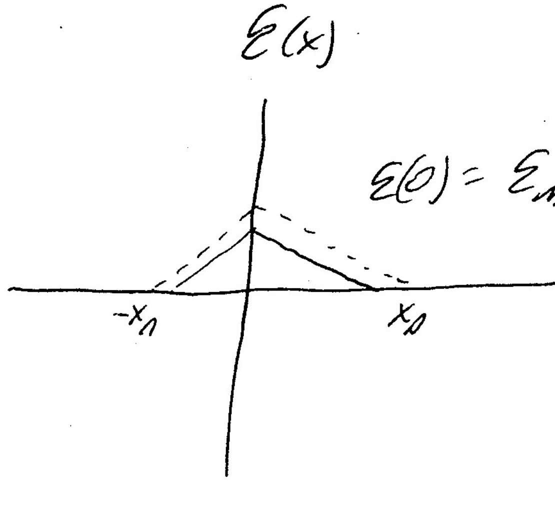
For Reverse bias ($V_a = -2V$)



$|X_p| + |X_n|$ have increased due to reverse bias voltage

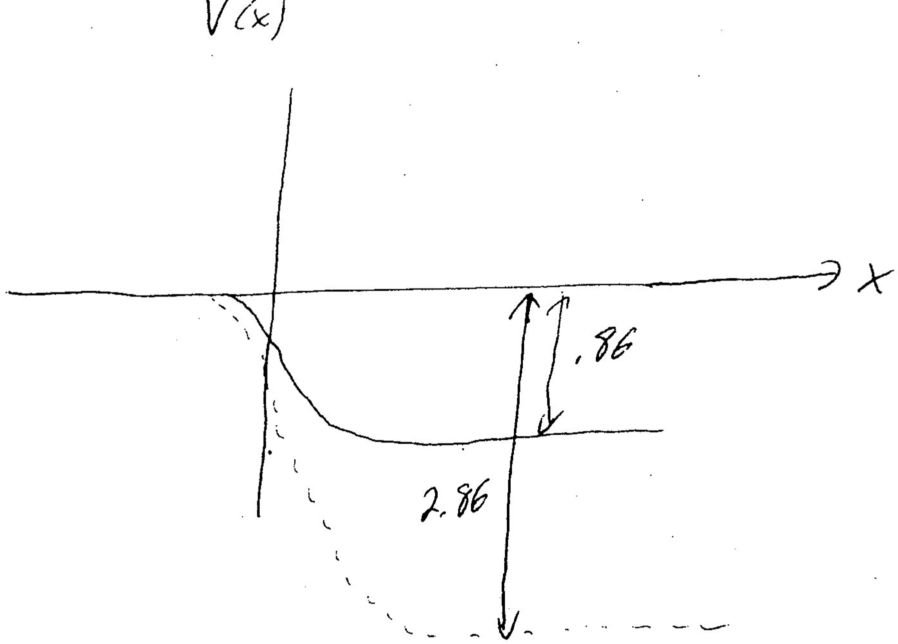
$$x_p = \sqrt{\frac{2\varepsilon}{q}(V_{bi} - V_a)\frac{N_d}{N_a(N_a+N_d)}} = .20\,\mu m$$

$$x_n = \sqrt{\frac{2\varepsilon}{q}(V_{bi} - V_a)\frac{N_a}{N_d(N_a+N_d)}} = .04\,\mu m$$

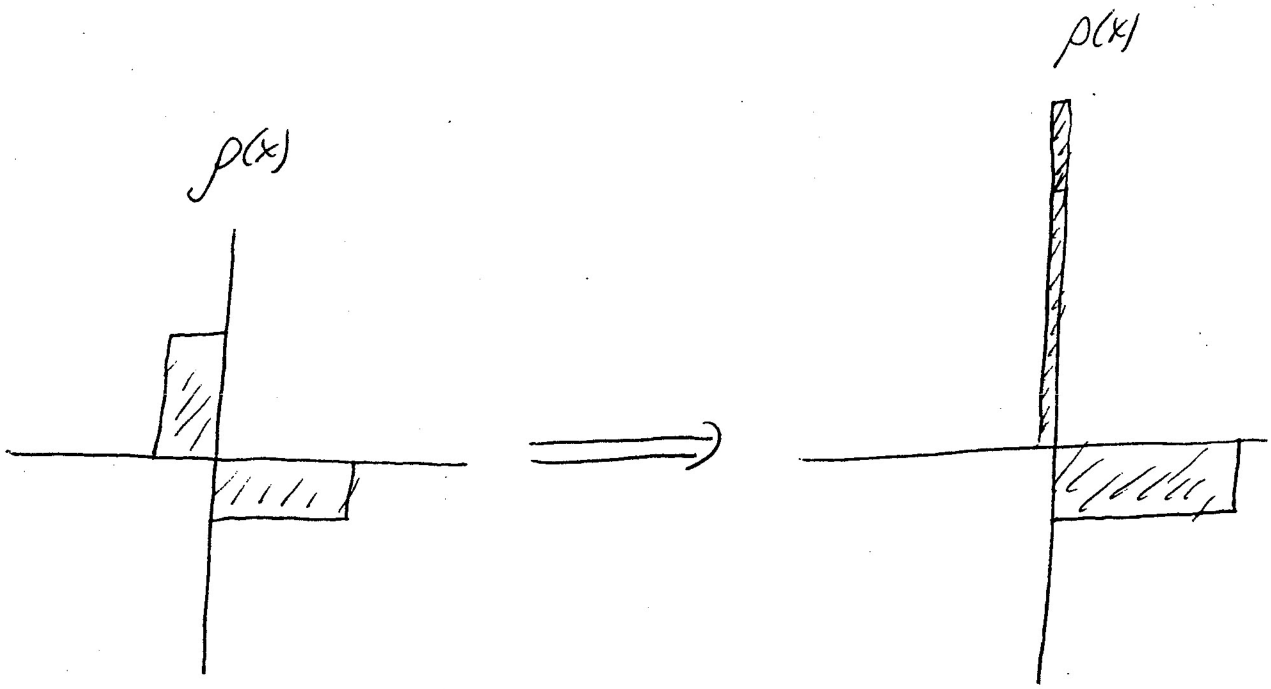


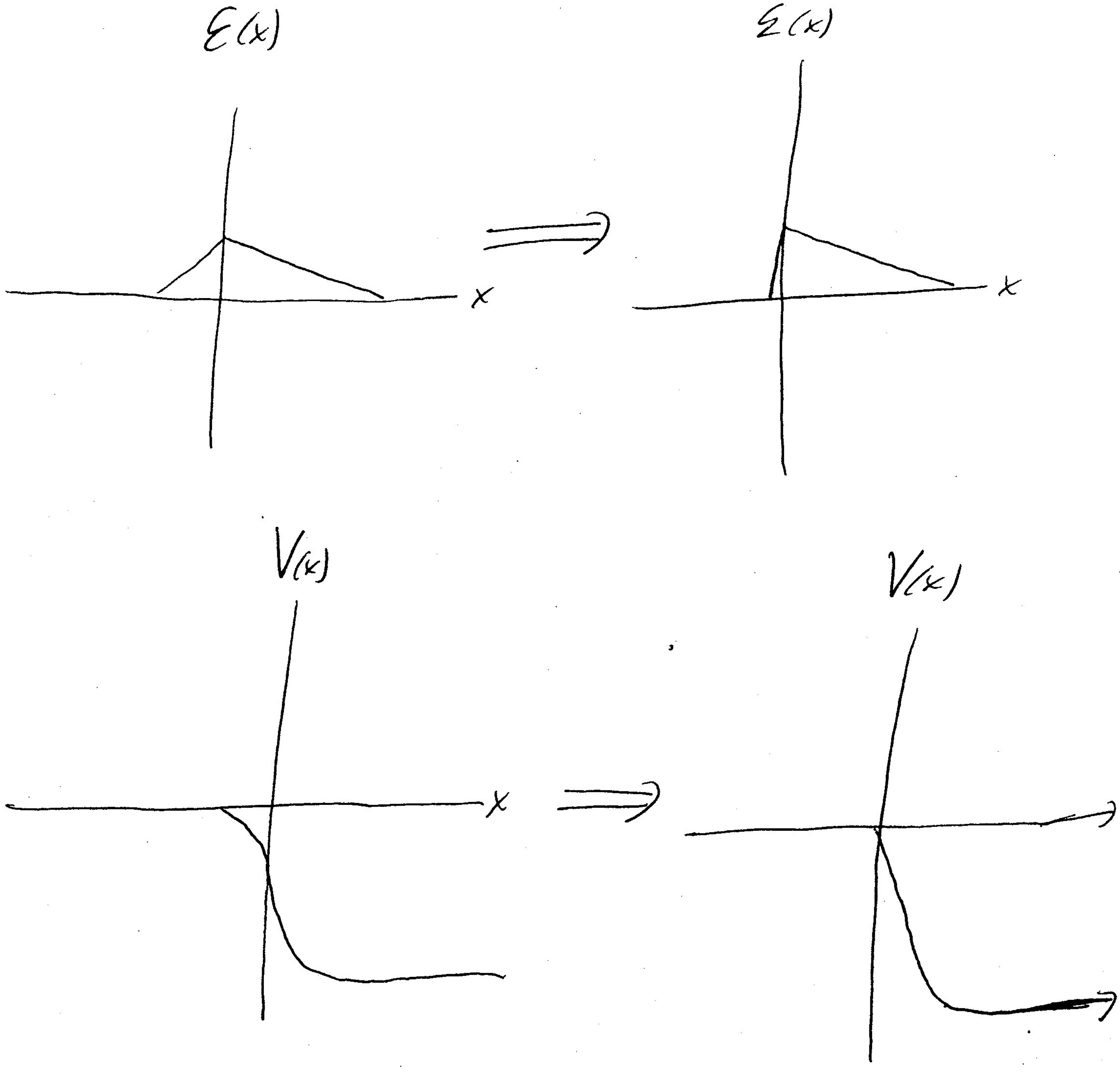
$$\mathcal{E}(0) = \mathcal{E}_{max} = \frac{q N_a x_p}{\varepsilon}$$

$$\boxed{\mathcal{E}_{max} = 2.5 \times 10^5 \frac{V}{cm}}$$



If the doping is increased in the n-region from 4×10^{17} to 10^{19} then the $\rho(x)$, $E(x)$, $V(x)$ curves will change.





ℰ(x)
x
ℰ(x)
x
V(x)
x
V(x)
x

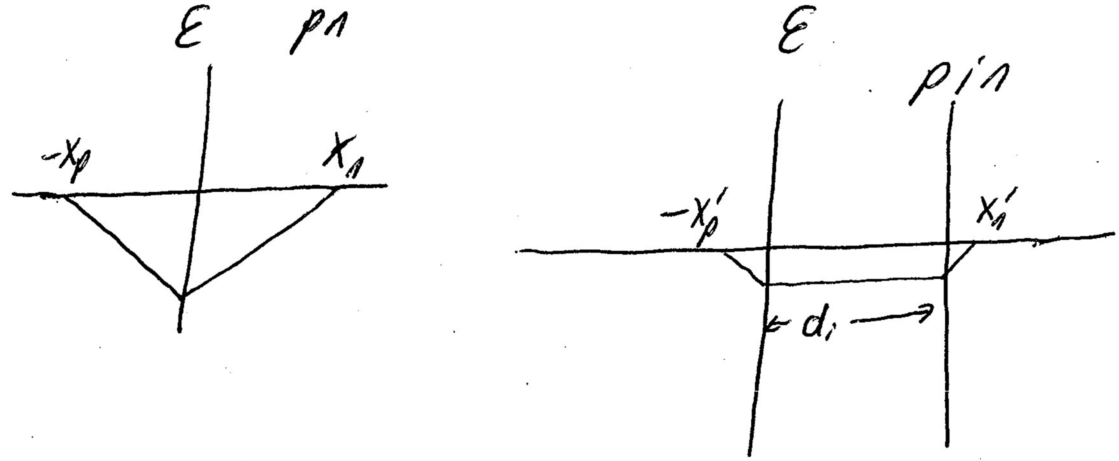
(2.) a.) V_{bi} is the same for both diodes because the intrinsic region only acts to extend the depletion region, not change the fermi levels of the p & n regions. These fermi levels are affected only by the free electron & hole concentrations (at room temp. and equilibrium)

$$V_{bi} = \frac{kT}{q} \ln \frac{N_a N_d}{n_i^2}$$

(N_a → free holes in p; N_d → free elec. in n)

$$\boxed{V_{bi} = .83\,V}$$

b.)



Since d_i is $\gg x_n', x_p'$ in the p-i-n diode and we know that the area of the ε-field curve = V_{bi} $\left(-\int \varepsilon\, dx = V_{bi}\right)$

then $(d_i)(\mathcal{E}_{max}) = V_{bi}$

$$\mathcal{E}_{max} = \frac{V_{bi}}{d_i}$$

$$\mathcal{E}_{max} = \frac{-.83V}{2\mu m}$$

$$\boxed{\mathcal{E}_{max} = -4.15 \times 10^3 \, V/cm}$$

The negative sign comes about because the $\mathcal{E}$-field points in the direction of p (negative charge)