ELECTRONIC DEVICES
ASSIGNMENT 2

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Exercise 1.
Consider a silicon PN step junction at equilibrium with

$$\begin{aligned} N_A &= 10^{18}\text{cm}^{-3} \\ N_D &= 10^{17}\text{cm}^{-3} \end{aligned}$$

maintained at 300 K.

(1) Calculate the builtin potential, V_{BI}, and the depletion layer width W.
(2) Sketch the following as functions of position x across the device.
  (a) Energy band diagram
  (b) Charge density
  (c) Electric field
  (d) Potential
  Be sure to include units, and also to indicate on the energy band diagram all relevant energy levels.

Solution 1.
(1) The builtin voltage is

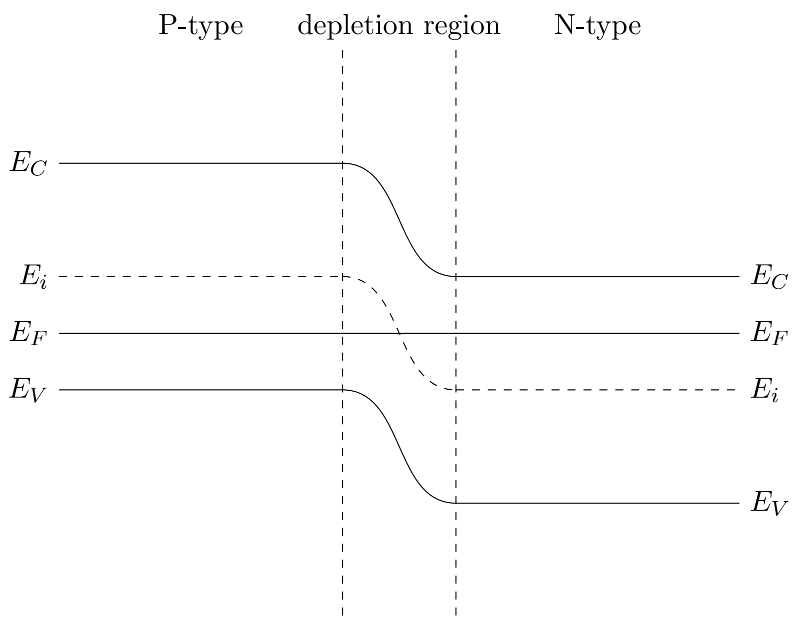
$$\begin{aligned} V_{\text{BI}} &= \frac{kT}{q} \ln\left(\frac{N_A N_D}{{n_i}^2}\right) \\ &= \left(2585.1 \times 10^{-5}\,\text{V}\right) \ln\left(\frac{10^{18}10^{17}}{10^{20}}\right) \\ &= \left(2585.1 \times 10^{-5}\,\text{V}\right) \ln\left(10^{15}\right) \\ &= \left(2585.1 \times 10^{-5}\,\text{V}\right) (34.539) \\ &= 89286.768 \times 10^{-5}\,\text{V} \\ &= 0.89286768\,\text{V} \end{aligned}$$

Date: Thursday 17$^{\text{th}}$ March, 2016.

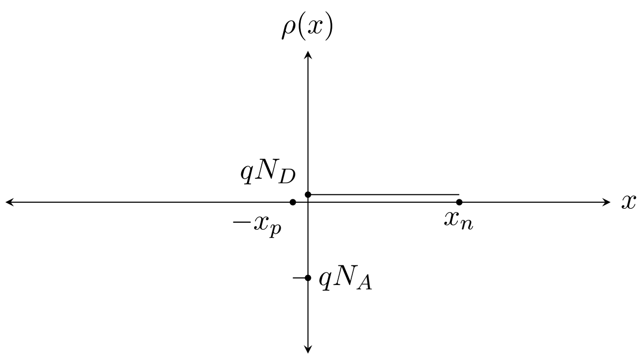
Therefore,

$$
\begin{aligned}
W &= \sqrt{\frac{2\varepsilon\varepsilon_0 V_{\mathrm{BI}}}{q}\left(\frac{N_A+N_D}{N_A N_D}\right)} \\
&= \sqrt{\frac{(2)(11.8)\left(8.85\times10^{-14}\mathrm{F\,cm^{-1}}\right)(0.893\,\mathrm{V})}{1.6\times10^{-19}\,\mathrm{C}}\left(\frac{10^{18}+10^{17}}{10^{18}\cdot10^{17}}\mathrm{cm}^3\right)} \\
&= \sqrt{\left(116.5699875\times10^{5}\right)\left(\frac{11\times10^{17}}{10^{35}}\right)\mathrm{cm}} \\
&= \sqrt{1282.2698625\times10^{-13}\mathrm{cm}} \\
&= \sqrt{128.22698625}\times10^{-6}\mathrm{cm} \\
&= 1.132373553\times10^{-6}\mathrm{cm} \\
&= 11.32373553\mathrm{nm}
\end{aligned}
$$

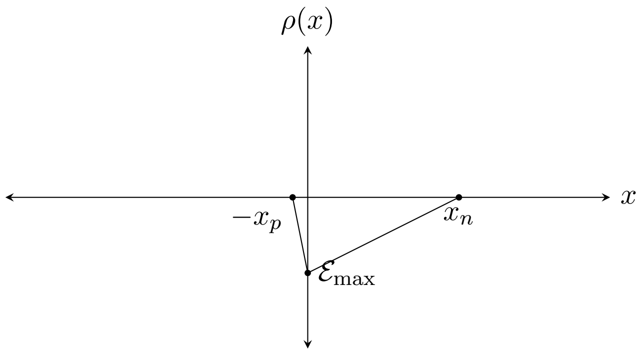
(2) (a)



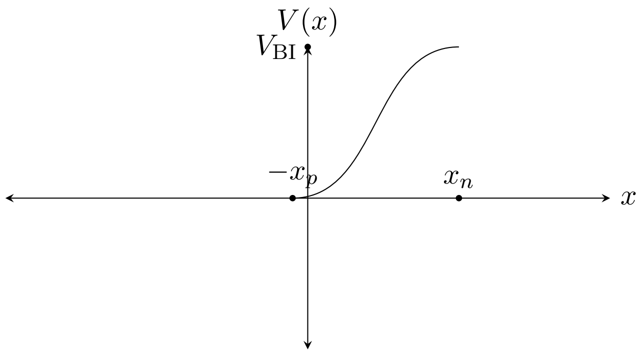
(b)



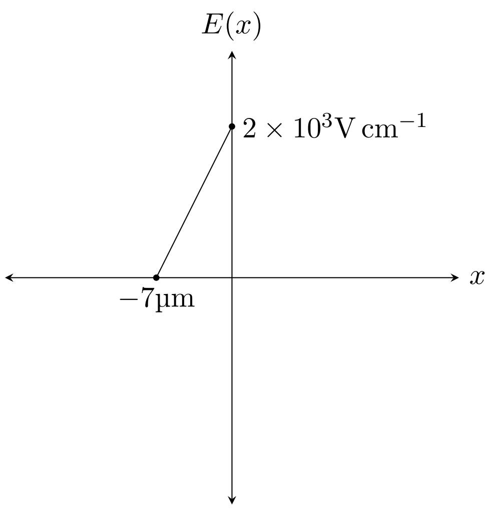
(c)



(d)



Exercise 2.
Consider a one-sided silicon PN junction at equilibrium and room temperature, with electric field profile as shown.



(1) What is the doping on the left side of the junction? Is it P-type or N-type?

(2) What is the doping on the right side of the junction? Is it P-type or N-type?

Solution 2.

(1) As the field is zero at −7µm, and as the field is positive between 0 and −7µm, the doping on the left side of the junction is N-type.

$$\begin{aligned}\mathcal{E}_{max} &= \frac{qN_D x_n}{\varepsilon\varepsilon_0}\\ \therefore 2\times 10^3 &= \frac{\left(1.6\times 10^{-19}\right)\left(N_D\right)\left(7\times 10^{-4}\right)}{\left(11.8\right)\left(8.85\times 10^{-14}\right)}\\ \therefore N_D &= 1.8648\times 10^{13}\text{cm}^{-3}\end{aligned}$$

(2) The right side is P-type, with doping much greater than that on the left side.