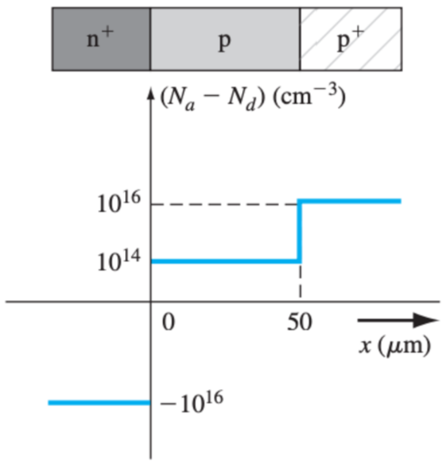
# VE320 Homework Six

**Due: 2021/7/2 23:59**

1. A silicon pn junction in thermal equilibrium at $T = 300$ K is doped such that $E_F - E_{Fi} = 0.365\text{eV}$ in the n region and $E_{Fi} - E_F = 0.330\text{eV}$ in the p region.
(a) **Sketch** the energy-band diagram for the pn junction.
(b) Find the impurity doping concentration in each region.
(c) Determine $V_{bi}$

2. A particular type of junction is an n region adjacent to an intrinsic region. This junction can be modeled as an n-type region to a lightly doped p-type region. Assume the doping concentrations in silicon at $T = 300$ K are $N_d = 10^{16}$ cm$^{-3}$ and $N_a = 10^{12}$ cm$^{-3}$. For zero applied bias, determine $(a) V_{bi}, (b) x_n, (c) x_p$, and $(d) |\mathrm{E}_{\max}|$. **Sketch** the electric field versus distance through the junction.

3. Consider a silicon pn junction with the doping profile shown in the figure below. $T = 300$ K.
(a) Calculate the applied reverse-biased voltage required so that the space charge region extends entirely through the p region.
$(b)$ Determine the space charge width into the $\mathrm{n}^+$ region with the reverse-biased voltage calculated in part $(a)$.
$(c)$ Calculate the peak electric field for this applied voltage.




4. A silicon $\mathrm{p^+n}$ junction has doping concentrations of $N_a = 2 \times 10^{17}$ cm$^{-3}$ and $N_d = 2 \times 10^{15}$ cm$^{-3}$. The cross-sectional area is $10^{-5}$ cm$^2$. *(This problem is the same with the quiz, don't worry too much)*
Calculate $(a)$ $V_{bi}$ and $(b)$ the junction capacitance at $(i) V_R = 1$ V, $(ii) V_R = 3$ V, and $(iii) V_R = 5$ V.
$(c)$ **Plot** $1/C^2$ versus $V_R$ and show that the slope can be used to find $N_d$ and the intercept at the voltage axis yields $V_{bi}$

5. (a) The doping concentrations in a silicon pn junction are $N_d = 5 \times 10^{15}$ cm$^{-3}$ and $N_a = 5 \times 10^{16}$ cm$^{-3}$. The minority carrier concentration at either space charge edge is to be no larger than 10 percent of the respective majority carrier concentration.

(i) Determine the maximum forward-bias voltage that can be applied to the junction and still meet the required specifications.

(ii) Is the n-region or p-region concentration the factor that limits the forward-bias voltage?

$(b)$ Repeat part $(a)$ if the doping concentrations are $N_d = 3 \times 10^{16}\ \mathrm{cm}^{-3}$ and $N_a = 7 \times 10^{15}\ \mathrm{cm}^{-3}$