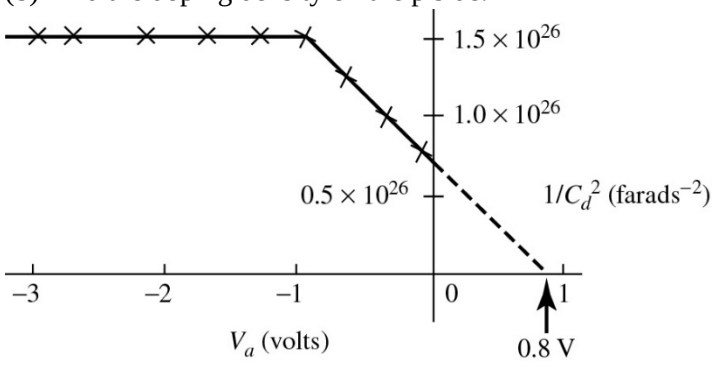
**Problem 1: C-V characteristics for reverse biased p-n junction (20 points)**

The capacitance $C_d$ of a pn junction diode with area $10^{-5}$ cm$^2$ is measured. A plot of $(1/C_d^2)$ vs. the applied voltage $V_a$, is shown in the figure below.

(a) If the p side of the diode is heavily doped, find the doping level on the n side (use the slope of the curve).

(b) Find the doping density on the p side.




**Problem 2: pn Junction Diode Current Components (40 points)**

Consider an ideal, long-base, silicon abrupt pn-junction diode with uniform cross section and constant doping on either side of the junction. The diode is made from p-type and n-type materials in which the doping concentrations are, $N_a$=1.5 x $10^{16}$ cm$^{-3}$ and $N_d$=3x$10^{16}$ cm$^{-3}$, minority carrier mobility are, $\mu_n$=1150 cm$^2$/Vs and $\mu_p$=400 cm$^2$/Vs, and minority-carrier lifetimes are, $\tau_n$= $10^{-6}$ s and $\tau_p$ = $10^{-8}$ s, respectively.

(a) What is the value of the built-in voltage?

(b) Calculate the density of the minority carriers at the edge of the space-charge region when the applied volt age is 0.589 V (which is 23 kT /q).

(c) Sketch the majority- and minority-carrier currents as functions of distance from the junction on both sides of the junction, under the applied bias voltage of part b.

(d) Calculate the location(s) of the plane or planes at which the minority-carrier and majority-carrier currents are equal in magnitude for the applied bias voltage of part b.

**Problem 3: Work function of Si (20 points)**

For silicon in which the doping changes abruptly from 5 x $10^{18}$ donors cm$^{-3}$ to 8 x $10^{15}$ donors cm$^{-3}$.

(a) What are the work functions associated with the two regions of the crystal?

(b) What is the potential difference between the two regions of silicon?

**Problem 4: conditions for the formation of Schottly contacts (20 points).**

Both Schottky-barrier diodes and ohmic contacts are to be formed by depositing a metal on a Silicon-integrated circuit. The metal has a work function of 4.5 eV. For ideal Schottky behavior, find the allowable doping range for each type of contact. Consider both p- and n-doped regions.