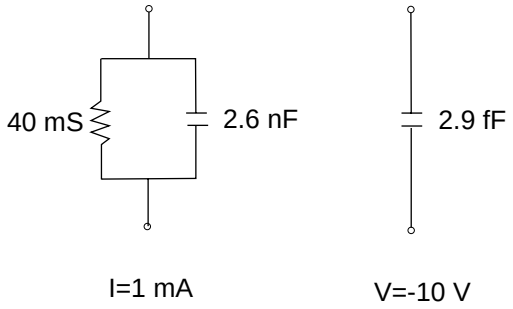
## Homework #5 - April 20, 2001

Due: April 27, 2001 at recitation
*(late homework will not be accepted)*

**Please write your recitation session time on your problem set solution.**

**1.** *[30 points]* The equivalent circuit of a $p^+$-n diode that you are trying to reverse engineer is measured at room temperature for two different bias points, one forward ($I = 1\ mA$) and another one reverse ($V = -10\ V$). The results are sketched below:




Based on your understanding of the technology that has been used, you are pretty sure that you can assume that the diode is very abrupt (that is $N_a \gg N_d$) and that all minority carrier behavior is dominated by the lowly-doped side. On the microscope, you measure the area of the diode and you find it to be 10 $\mu m^2$.

**a)** Estimate the doping level on the n side, $N_d$.

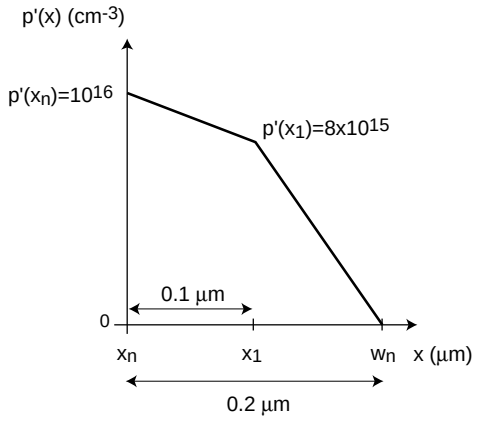
**b)** Estimate the thickness of the n region, $W_n$.

**c)** Verify whatever assumptions you needed to make.

**2.** *[40 points]* Consider an abrupt asymmetric $p^+$-n junction diode with a junction area of 25 $\mu m^2$. All the action in this device is dominated by the lowly-doped n-type region.

Due to processing reasons, the diffusion coefficient of holes across the quasi-neutral n-type region is not uniform. It suddenly changes half way down the n-QNR at location $x_1$. As a

result, at a current level of 10 $\mu A$, the excess minority concentration in the quasi-neutral n-type region has a distribution as sketched below:




At this bias point:

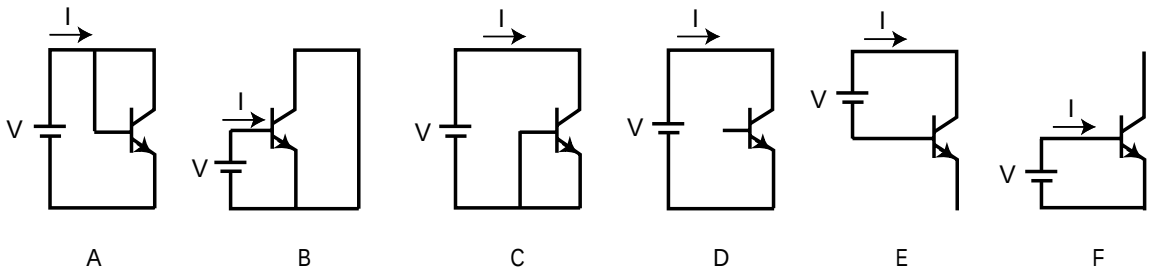
**a)** Estimate the hole diffusion coefficient in both portions of the quasi-neutral region.

**b)** Estimate the total amount of excess minority carrier charge in the diode.

**c)** Estimate the diffusion capacitance of the diode.

**d)** Estimate the hole diffusion velocity at $x_1^-$ and $x_1^+$.

**3.** *[30 points]* The figure below shows six possible ways of connecting an npn bipolar transistor that may yield a diode-like behavior. Using the ideal *Non-Linear Hybrid-π Model*, calculate the I-V characteristics of the two-terminal device in each configuration. Express your result as a function of $I_S$, $\beta_F$, and $\beta_R$.




Which of these configurations exhibit diode-like I-V characteristics?