Problem 1  pnp Bipolar Junction Transistor

Parameters for pnp BJT:

- $N_{ae} = 10^{18} \text{ cm}^{-3}$
- $N_{db} = 10^{16} \text{ cm}^{-3}$
- $N_{bc} = 10^{15} \text{ cm}^{-3}$
- $D_{ae} = 20 \text{ cm}^2/\text{s}$
- $D_{nc} = 30 \text{ cm}^2/\text{s}$
- $D_{pb} = 10 \text{ cm}^2/\text{s}$
- $A_E = 100 \mu \text{m}^2$
- $L_B = 1.0 \mu \text{m}$
- $L_E = 2.0 \mu \text{m}$
- $L_C = 3.0 \mu \text{m}$

- $L_E$ and $L_C$ are the distances between the contacts and the abrupt junctions. $L_B$ is the distance between the base-emitter and base-collector abrupt junctions. **Note that $L_B$, $L_B$ and $L_C$ are not widths of the quasi-neutral regions in the Emitter, Base and Collector.**
- Assume that recombination only occurs at the contacts and that there is no recombination in the quasi-neutral regions or the space charge regions.

a) What are the thermal equilibrium values of the potential barrier for the base-emitter ($\phi_{BE}$) and base-collector ($\phi_{BC}$) junctions?
b) What is the width of the quasi-neutral base region, $W_B$ at equilibrium?
c) What is $\beta_f$ (ignore the effect of the depletion region under forward bias for this calculation)?
6.012 Microelectronic Devices and Circuits
Spring 2009

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