Homework 11 (<u>optional</u> extra credit) EE 362 Electronic, Magnetic, & Optical Properties of Materials (Spring 2025) Wednesday, April 30, 2025

1) 12.4

- 2) 12.5c
- 3) 12.9ab
- 4) At 300 K, a silicon npn bipolar junction transistor (BJT), with each region uniformly doped, has the following parameters:

$N_E = 2 \times 10^{18} \text{ cm}^{-3}$	$N_B = 4 \times 10^{16} \text{ cm}^{-3}$	$N_C = 3 \times 10^{15} \text{ cm}^{-3}$
$D_E = 7.4 \text{ cm}^2/\text{sec}$	$D_B = 14 \text{ cm}^2/\text{sec}$	$D_C = 11.2 \text{ cm}^2/\text{sec}$
$\tau_{E0} = 9 \text{ ns}$	$\tau_{B0} = 46 \text{ ns}$	$\tau_{C0} = 88 \text{ ns}$
$x_E = 1 \ \mu m$	$x_B = 0.8 \ \mu m$	$x_C = 100 \ \mu m$

Also, $A_{BE} = 4 \times 10^{-3} \text{ cm}^2$, $x_{BE} = 7.8 \text{ nm}$, $V_{BE} = 0.63 \text{ V}$ and $V_{CE} = 5.1 \text{ V}$. Then:

- a) Determine the thermal equilibrium minority carrier concentrations p_{E0} , n_{B0} , and p_{C0} .
- b) Calculate the diffusion length and fractional length (e.g., x_C/L_C) of each region.
- c) Find the current densities J_{nE} and J_{pE} as well as the emitter current I_E (mA). What fraction of I_E is due to electrons?
- d) Find the current density constants J_{s0} and J_{r0} . [Hint: see (8.39) for τ_0]
- e) Find the approximate base transport factor α_T and emitter injection efficiency γ as well as the recombination factor δ .
- f) Find the approximate common-base α and common-emitter β current gains.
- g) Find the collector I_C (mA) and base I_B (mA) currents.

Due Wednesday, May 7, 2025 at my office or mail box by 2 pm.

Notes:

- If completed, this extra credit opportunity will replace your *lowest counting* HW or quiz grade (as best advantages your overall grade).
- > There will be at least one question dealing with this material on the final exam.
- ➢ Read Note on page 560.
- Carry *at least* 6 significant figures on constants/parameters in calculations. Give answers with 4-5 significant figures.
- > If a solution requires the use of a graph, include the graph with work shown.