EECS 2077 Test #2, Winter 2015 Name:____

#1 ____/25 pts **Allowed materials: 2 pages of 1-sided equation sheets, writing utensil, calculator.**
#2 ____/25 pts **Remember – we use cgs units! Centimeter/gram/second.**
#3 ____/24 pts kT = 0.026 eV (300K) ε_0=8.854x10^{-14} F/cm ε_r(Si)=11.8
#4 ____/26 pts q= 1.6x10^{-19} C n_i(Si)=1.5x10^{10} / cm^3

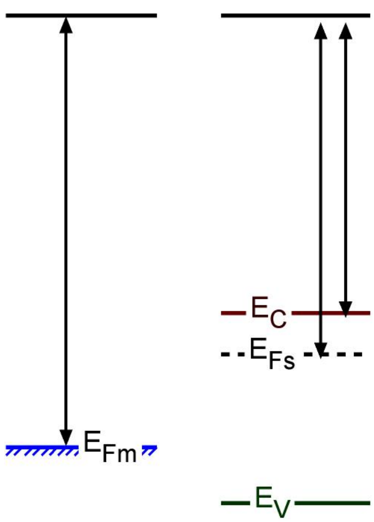
Prof. Heikenfeld will be out of town, so please read all problems carefully right away and he will try to be available to answer questions via his cell phone – 513-884-4094 - during the 1st 30 min of the test (until 4 PM). His availability is not guaranteed, but he will do his best to answer any confusion/questions.

1.) [25 pts] A metal-semiconductor diode! Again! As I noted, I tend to reintroduce problems that folks may have struggled with on previous tests.

(a) [9 pts] draw the resulting band diagram after the materials are contacted. Make sure you label the contact potential on your band diagram.

(b) [8 pts] redraw the diagram for <u>reverse bias</u>, and draw with an arrow where the current is coming from.

(c) [8 pts] challenge problem :) Draw the E-field plot for this device for both the cases of no-voltage and reverse-bias voltage (make sure you label which is which!).



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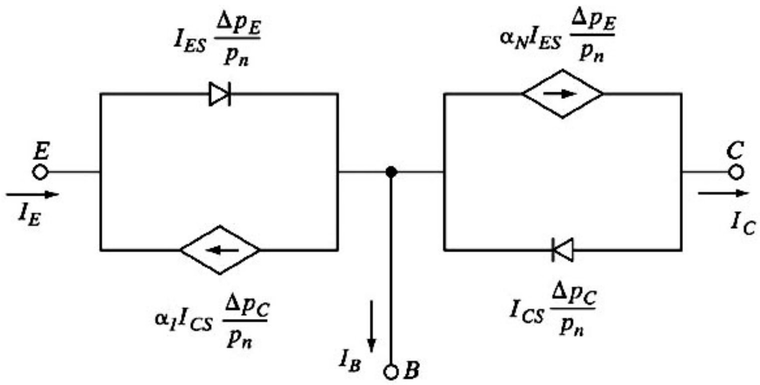
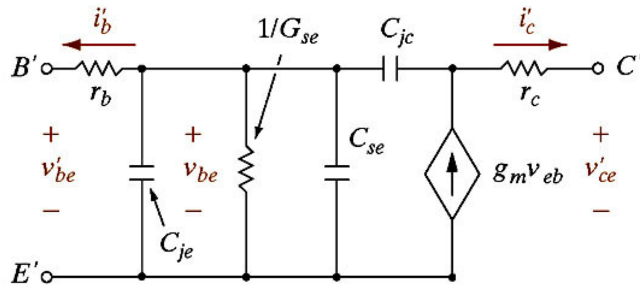
2) [25 pts] Two models are shown below, one on the left, and one on the right. I will generally refer to them that way.

$$\Delta p_E = p_n\left(e^{qV_{EB}/kT} - 1\right)$$





(a) [10 pts] Draw a diagram, only one diagram, and mark/annotated it, to explain why for the model at left the current sources are exponential with voltage and why in the model at right the current sources are linear with voltage.

(b) [15 pts] Redraw the model on the left for a NPN BJT. Just draw the circuit components and label the terminals and label current directions (you do NOT need to label the terms and equations).

3.) 24 points Some true/false for BJTs. (4 pts. each).

TRUE / FALSE If you widen the base of a BJT too much, it basically becomes more like two back-to-back diodes.

TRUE / FALSE For a PNP BJT, hole injection across the emitter-base dominates over electrons, at least in part, because the emitter is more heavily doped than the base.

TRUE / FALSE For a PNP BJT, hole injection across the emitter-base dominates over electrons, at least in part, because the base is narrower than an electron diffusion length.

TRUE / FALSE Assume a BJT is in normal forward active mode. As you increase V_{BC} (base-collector reverse bias) the collector current will increase slightly due to narrowing base width.

TRUE / FALSE Current transport across the base of a BJT is dominantly due to diffusion.

TRUE / FALSE In the base of a BJT, at any given time, the number of excess holes has to be equal to the number of excess electrons.

4.) [26 pts.] Some calculations…. consider a Symmetrical p+-n-p+ BJT, and some starting assumptions. Use the values given to simplify your calculations, don't calculate everything from scratch!

$I_B = 10\ \mu A$
$I_C = 10\ mA$
$V_{EC} = 10\ V$
$V_{EB} = 0.25\ V$
$p_n = 1\times10^5/cc$

$$qA\frac{D_p}{L_p}p_n = 0.2\,pA$$

$$I_{Ep} \approx qA\frac{D_p}{L_p}\Delta p_E \ \text{ctnh}\frac{W_b}{L_p}$$

$$I_C \approx qA\frac{D_p}{L_p}\Delta p_E \ \text{csch}\frac{W_b}{L_p}$$

$$I_B \approx qA\frac{D_p}{L_p}\Delta p_E \tanh\frac{W_b}{2L_p}$$

(a) [10 pts] Calculate the excess of holes in the base at the edge of the EB depletion region.

(b) [6 pts] Calculate the emitter current.

(c) [10 pts] Assuming this BJT is in a circuit with NO external resistors (just external voltage sources), calculate the power consumption which is occurring across the emitter-base region <u>and</u> across the base-collector region (provide two answers, one for each region).

EXTRA SPACE