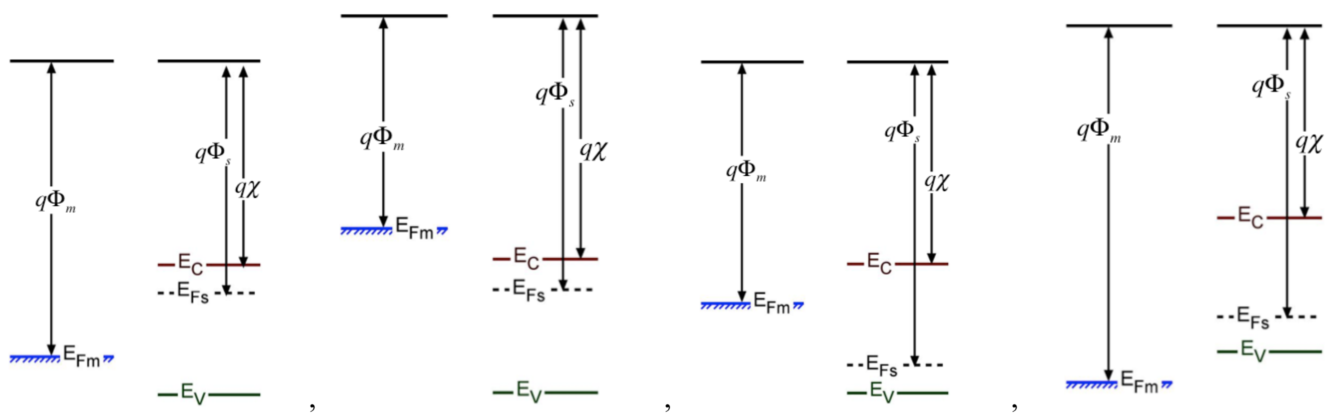
EECS 2077 Test #2, Fall 2014 Name:____

#1 ____/20 pts **Allowed materials: 2 pages of 1-sided equation sheets, writing utensil, calculator.**
#2 ____/30 pts **Remember – we use cgs units! Centimeter/gram/second.**
#3 ____/25 pts kT = 0.026 eV (300K) ε_0=8.854x10^{-14} F/cm ε_r(Si)=11.8
#4 ____/25 pts q= 1.6x10^{-19} C n_i(Si)=1.5x10^{10} / cm^3

Optional Feedback
Rate the length of this test: ***short*** ☐ ***long*** ☐ ***OK*** ☐
Rate the difficulty of this test: ***easy*** ☐ ***hard*** ☐ ***OK*** ☐

1.) As I have noted to you before, I quickly grade and return tests so you can learn from your mistakes… lets toss out a few problems folks struggled with on the last test… both are a bit changed but touch on things you struggled with.

a) [10 pts] Which of the following metal-semiconductor contacts can be used to construct a MESFET gate?



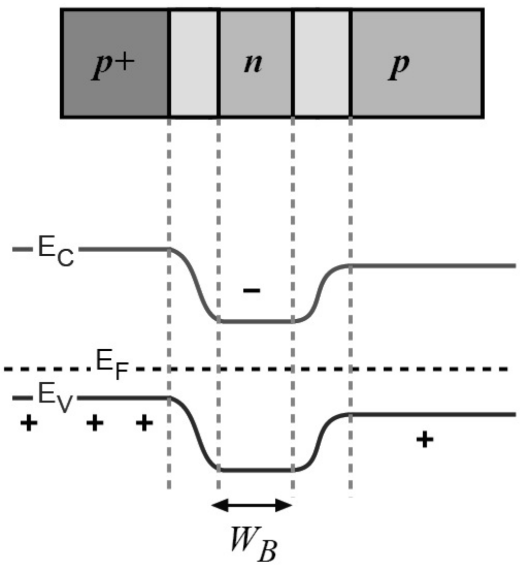
b) [10 pts] An <u>ideal</u> Si pn+ junction at 300K has the following parameters. Using ONLY the information have provided below, give your best calculation/estimate for the magnitude of the amount of reverse saturation current that is due to electron drift. I understand you are missing some other variables to get the exact answer, but my goal is to see if you really understand how reverse bias diodes work. *Careful! I modified this problem from last time, think through it before you do a quick calculation!*

p-side:	n-side:	General parameters
Na=10^{15}/cm^3	Nd=10^{18}/cm^3	I_0= 1x10^{-15}A

2.) [30 pts] Consider a PNP BJT setup for normal amplification, assume an amplification factor of 100.

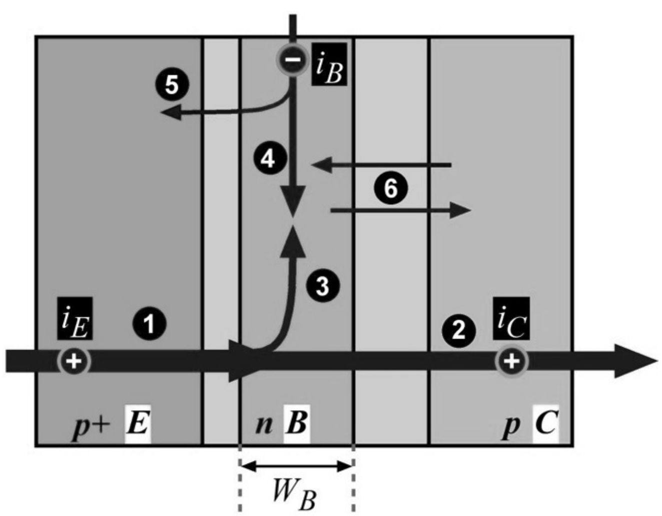
(a) [5 pts] If we add 5 electrons to the base, then how many holes are emitted? Answer: __________

(b) [15 pts] Redraw the band diagram for normal forward active mode, including placement and labeling of Fermi levels, conductive and valence bands, and four arrows for current in appropriate locations, labeled drift, diffusion, or recombination.



(c) [10 pts] For the diagram below, label the currents in order from LARGEST in magnitude to SMALLEST in magnitude. Just list them as numbers, such as 1,6,4,5,3,2. If two currents are equal, you may note that by circling both of them in your answer. For component 6, count both electron and hole current as both being part of 6.

Answer: ____, ____, ____, ____, ____, ____,

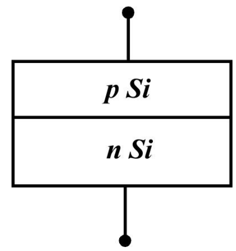


3.) 25 pts. A JFET is constructed from two **ideal** Si pn+ junctions at 300K (assume p-side is the JFET channel with n-type gates on either side), and which has the following parameters (you may or may not need them all, carefully look to see what parameters I already gave you).

p-side:
$Na=10^{15}/cm^3$

n-side:
$Nd=10^{17}/cm^3$

General parameters
$\varepsilon_{Si}\varepsilon_0=1x10^{-12}$ F/cm (11.8 x ε_0 F/cm)
reverse sat. current per junction $I_0 = 4.5x10^{-14}$ A
contact potential $V_0 = 0.7$ V
depletion width at 0V: W =9.4 x10^{-5} cm



(a) [5 pts] If you used these exact PN junction materials to make a JFET, how far apart the gate regions have to be (channel width) to have a conducting channel that is 2 µm wide with no voltage applied to the gates, source, or drain electrodes.

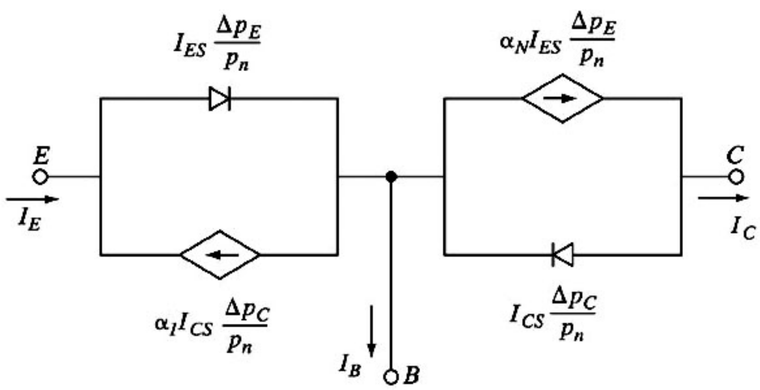
(b) [5 pts] The gate voltage needed to turn the JFET off is (circle one): positive / negative .

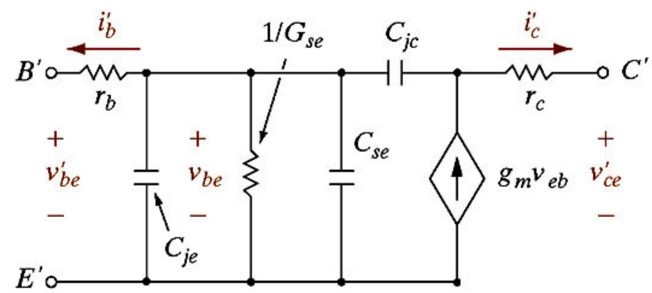
(c) [5 pts] Calculate the amount of current required to turn the JFET off (to deplete the conducting channel completely).

(d) [10 pts] If you were to accidently bias the gates with 0.4 V in the incorrect direction for turning the JFET off, and the source and drain were grounded, calculate the current consumed by the gates. You may assume ideal diode behavior.

4) [25 pts] Two BJT models are shown below, one on the left, and one on the right. I will generally refer to them that way. So here are some tougher questions to see who really knows their stuff!

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





(a) [5 pts] Which of the following is correct, check ALL answers that are true (could be one, or more):

___ the model on the left is accurate for high-frequency AC , the model on the right is accurate for DC operation

___ either of the can be used accurately for high-frequency AC or DC operation

___ the model on the right is accurate for high-frequency AC , the model on the left is accurate for DC operation

___ the reason we have these models is that they are easier when you need to bring the semiconductor world into modeling or prediction of the performance of a device in an electronic circuit

(b) [10 pts] for the model on the left, if it is run in inverted mode, and the emitter output current is 10 mA and V_{CE} is 10V, then clearly mark on the circuit what and where the voltage drop would be if the emitter output resistance was 600 ohms (you only need to mark the portion of voltage that is not across the emitter output resistance).

(c) [10 pts] Tough question (not really, if you really understand the model). For the model on the right, if the transconductance was 1 mA/V, and current out the collector was found to be 0.5 mA, how much of the incoming 0.8 V AC applied to the emitter-base terminals is lost across r_b due to RC time-constant/charging effects? You don't need R or C to determine this, or the frequency….

EXTRA SPACE