EECS 2077 Test #1, Fall 2016 Name:____

#1 ____/25 pts **Allowed materials: 1 page of a 1-sided equations sheet, writing utensil, calculator.**
#2 ____/25 pts **Remember – we use cgs units! Centimeter/gram/second.**
#3 ____/25 pts kT = 0.026 eV (300K) ε_o=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

1) [25 pts.] An ideal p+n junction at 300K, made out of an unknown material (is not Si) has the following parameters (you might not need them all).

p-side:	n-side:	General parameters
Na=10^{18}/cm^3	Nd=10^{15}/cm^3	ε_r=10
Dn=40 cm^2/sec	Dp=80 cm^2/sec	n_i=10^{10} / cm^3
Ln=10^{-3} cm	Lp=10^{-2} cm	A = 50 μm^2

a) [10 pts] What are the DRIFT and DIFFUSION current densities (A/cm^2) across the junction at an applied reverse bias of -6V?

Calculations:

Answer for DRIFT: ___________

Answer for DIFFUSION: _________

b) [10 pts] What are the DRIFT AND DIFFUSION current density (A/cm^2) across the junction at a forward bias of 0.7? V?

Calculations:

Answer for DRIFT: ___________

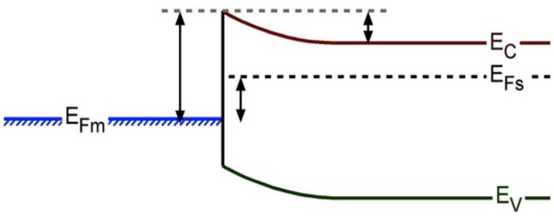
Answer for DIFFUSION: _________

c) [5 pts] Under forward bias, what type of carrier dominates the current flow?

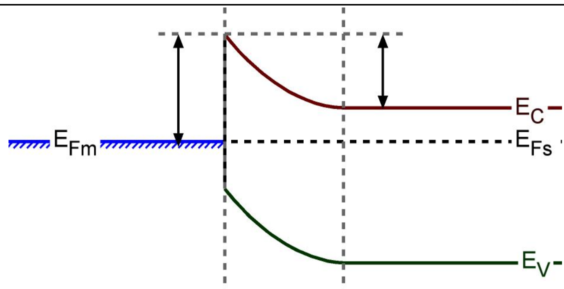
Circle one: electrons / holes / neither

2.) Metal-semiconductor Diodes!

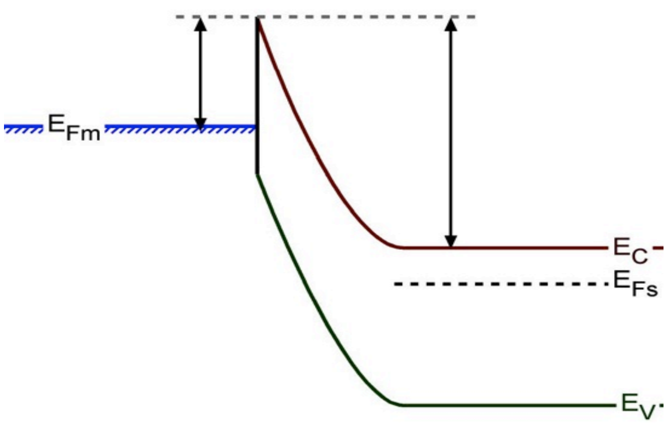
(a) [18 points] For each device state shown below, circle from each list which carrier type dominates (electrons, holes, neither) and the relative magnitude of the current (large, small, zero)



electrons holes neither / large small zero

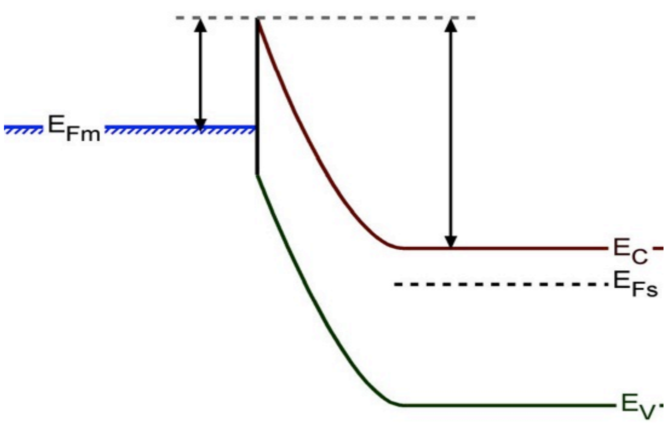


electrons holes neither / large small zero



electrons holes neither / large small zero

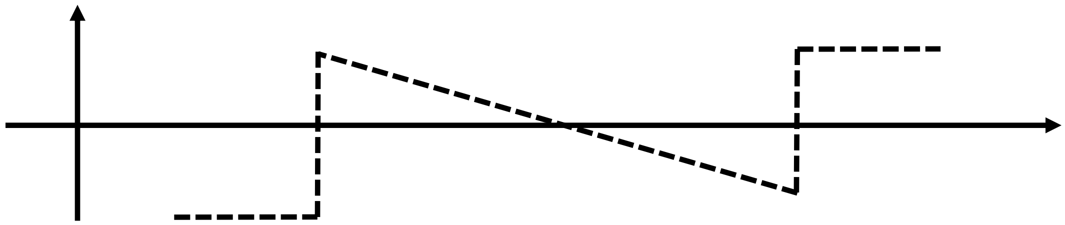
(b) [7 points] For the device state shown below, if more negative voltage is applied to the metal (assume the semiconductor is grounded), how will the electrical capacitance of the device change? Circle the right answer.



increase decrease stay the same

3) 25 pts - Some mish-mash questions…

a) [8 pts] Draw the band-diagram (just conduction and valance bands) for the following E-field profile. Draw the band-diagram directly below the E-field profile so I can match them up. (The dotted line is the E-field for the band-diagram, Y-axis is E-field with positive E-field above the X-axis, X-axis is positive distance).



b) [7 pts] List the from the words provided below, the complete steps for an electron or hole starting from when it is ‘created’ to when it ‘goes away’ as part of <u>reverse saturation current</u>. There are a few correct answers for this (I will accept any correct answer, but only give ONE set of words as an answer). Just choose and list the words in order.

Words to choose from: drift / diffusion / recombination / thermal generation

Your answer:

c) [10 pts] A Si bar is 0.1 cm long and 100 μm^2 in cross-sectional area, and is doped with $8x10^{16}$ phosphorus, resulting a mobility for electrons of 1000 (cm/s)/(V/cm) and a mobility for holes of 500 (cm/s)/(V/cm). What is the DRIFT <u>current density</u> with 2 V applied? *If you find this problem variation confusing at first, then simply first think practically about what will make up most of the current.*

4) 25 pts - Some more mish-mash questions…!

a) [5 pts] If we increase doping for a diode on both sides or on either side, the which is true for the resulting diode currents (check all that apply):

___ total drift current decreases
___ total diffusion current decreases
___ total drift current increases
___ total diffusion current increases

b) [5 pts] What aspect of semiconductors causes a forward biased diode to be mathematically exponential? I am looking for only one simple answer (not an explanation, the answer is a single thing/term).

Answer: ________________________________

c) [5 pts] A hole starts with no energy and is accelerated through 0.5V applied across a slab of undoped Si, and does not give up any energy as it accelerates (does not lose any of its gained energy). How much energy in eV does the hole obtain?

d) [10 pts] For the case described in (c), diagram a representative band-diagram and note the starting position and final position for the hole. Remember, Si has a bandgap that is approximately 1 eV, so the hole positions diagrammed should be roughly correct in energy relative to the band-diagram.

<u>Optional Feedback</u>

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

Extra Space