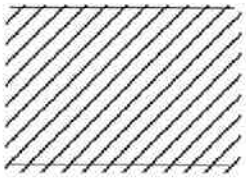
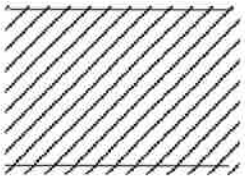
PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
PhD PRELIMINARY EXAMS - MICROELECTRONICS
FALL 2015

Name:_____

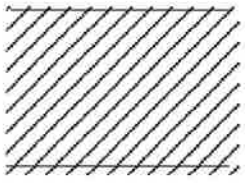
Problem 1 (12 points) The following four band diagrams describe four different doping configurations of a semiconductor - intrinsic, extrinsic and compensated. Write, under each diagram, the appropriate description.



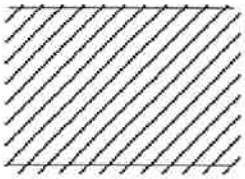
Ans:



Ans:

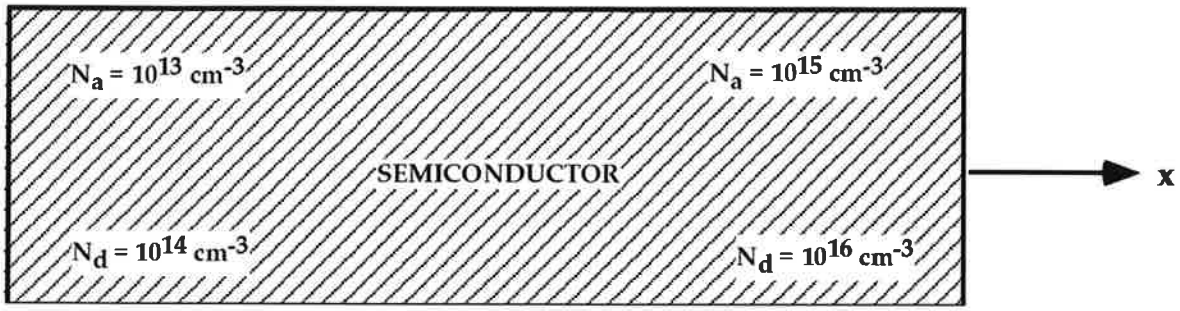


Ans:



Ans:

Problem 2 (12 points) Consider the following figure. Shown are the concentrations of holes and electrons on either side. Indicate the correct directions (+x or -x) of transport for each question below.



(a) hole diffusion?

(b) electron diffusion?

(c) hole current?

(d) electron current?

Problem 3 (16 points) A Si step p-n junction has a doping of $N_a = 5x10^{15}$ cm^{-3}, $N_d = 10^{15}$ cm^{-3} and a cross-sectional area (A) of 10^{-4} cm^2. The intrinsic carrier concentration n_i is $1.5x10^{10}$ cm^{-3} and the temperature is 300K.

(a) Compute V_{bi}; (b) Compute x_n and x_p

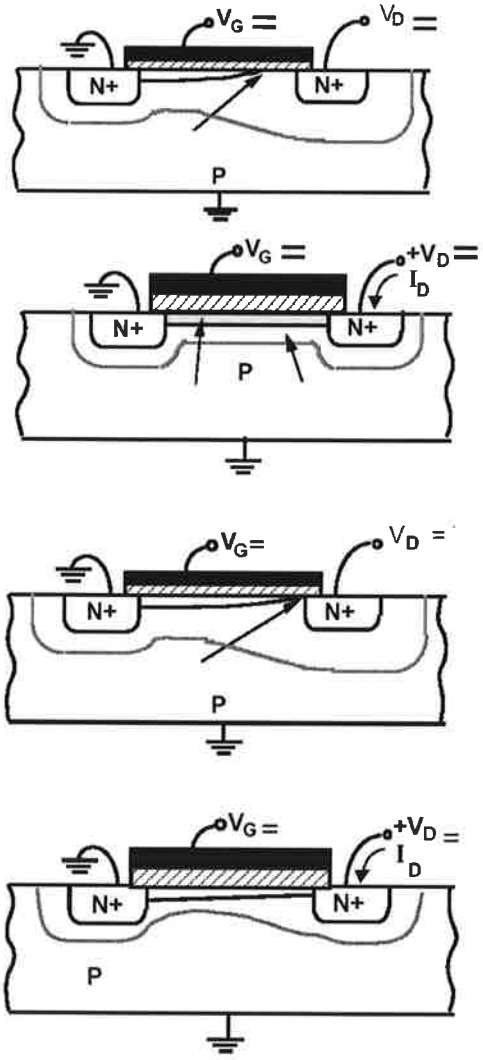
(c) Hence compute the total depletion width $W = x_n + x_p$. (d) What is the total positive ion charge?

(e) Which of the following statements is true for this junction? Why?

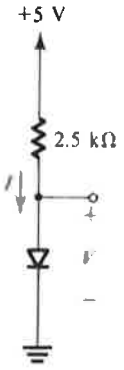
(i) $x_n = x_p$ (ii) $x_n = 5\,x_p$ (iii) $x_n = 0.2\,x_p$

$\phi = V_t \ln \frac{N_d N_a}{n_i^2}$	$x_n = \sqrt{\frac{2\varepsilon_s}{q}\frac{N_a}{N_d}\frac{1}{N_a + N_d}(\phi - V_a)}$
$x_p = \sqrt{\frac{2\varepsilon_s}{q}\frac{N_d}{N_a}\frac{1}{N_a + N_d}(\phi - V_a)}$	

Problem 4 (10 points) Shown are four stages of a MOS capacitor for four different operating values of the gate voltage and the drain voltage. In the order the stages occur – accumulation, flat band, inversion and strong inversion – label the four figures appropriately. In particular, show the signs and relative magnitudes of voltages.



Problem 5 (8 points) 1. For diode shown in the figure below, assuming that the voltage across a forward-biased conducting diode is 0.7 volts, Find the voltage V and I



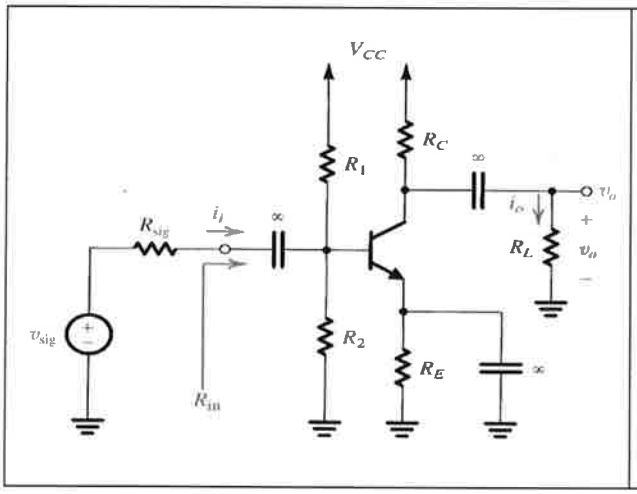
V = _____ I = _____

Problem 6 (12 points) The terminal voltages of various npn transistors were measured during operation of their respective circuits with the following results. Calculate the voltages V_{BE} and V_{BC} and indicate the mode of operation of the transistor.

Case	Emitter Voltage (V)	Base Voltage (V)	Collector Voltage (V)	Voltage V_{BE}	Voltage V_{BC}	Mode (indicate the mode of operation)
1	2.4	2.1	2.3			
2	3.3	4.0	5			
3	2.3	3.0	2.4			

Problem 8. (14 points) For the common-emitter amplifier shown below, V_{CC} is unknown, $R_1 = 60\ K\Omega$, $R_2 = 30\ K\Omega$, $R_E = 2.0\ K\Omega$, $R_C = 5.0\ K\Omega$, $R_{sig} = 0.5\ K\Omega$, and $R_L = 5\ K\Omega$. The transistor β is 100, r_O is almost infinite and $r_\pi = 1.5\ K\Omega$.

(a) Draw the small-signal equivalent circuit



Draw the small signal equivalent circuit here.

(b) Find the input resistance, R_{in},

(c) Determine voltage gain, $\frac{v_o}{v_{sig}}$.