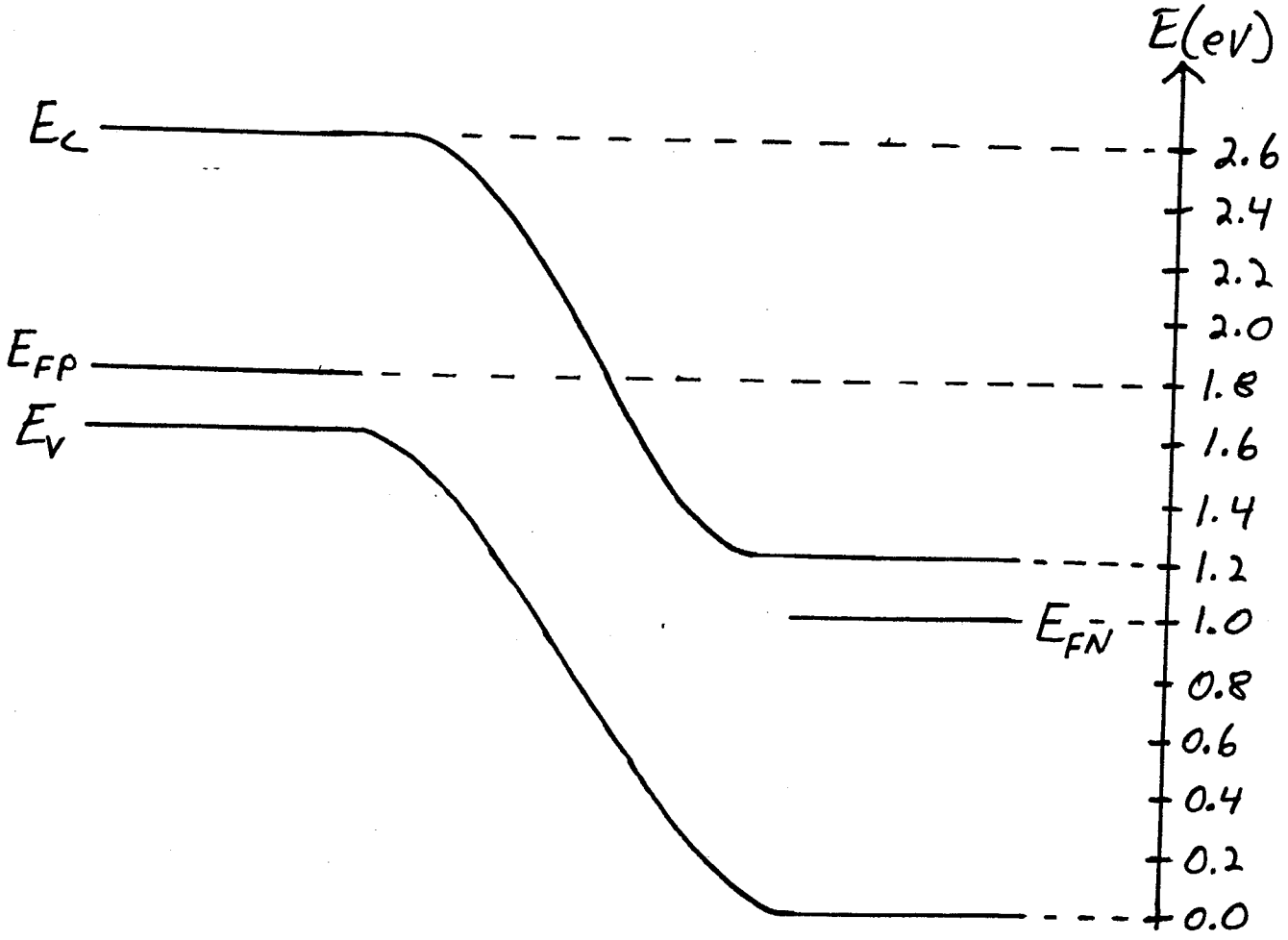
Course:	**Semiconductor Device Fundamentals**
Level:	**Undergraduate**
Module:	**B**
Test:	**B12**
Type:	**Closed Book, Closed Notes**
Note:	**Available Info/Equation Sheets**

Problem Weighting is noted adjacent to each problem.

Score _____

(10 pts) 1. Given the following energy band diagram for a pn junction,



(2 pts) A) Is the diode forward or reverse biased?

(3 pts) B) What is the magnitude of the bias?

(5 pts) C) What is the built-in potential, V_{bi}, of the junction?

(5 pts) 2. Which of the following statements are true concerning reverse bias breakdown of a pn junction.

A) Zener breakdown only occurs for reverse bias of large magnitude ($V_{BR} > 7$ volts for a silicon diode).

B) The breakdown voltage in an asymmetric diode due to avalanching is primarily controlled by the doping of the lighter doped side.

C) Avalanche breakdown is destructive to a pn junction while zener breakdown is not.

D) None of the above.

(5 pts) 3. An abrupt p^+n diode has a zero bias capacitance of 90 pf and a built-in potential of 1.0 volts. If a reverse bias of 8 volts is applied to the diode the resulting depletion capacitance would be

A) 90 pf

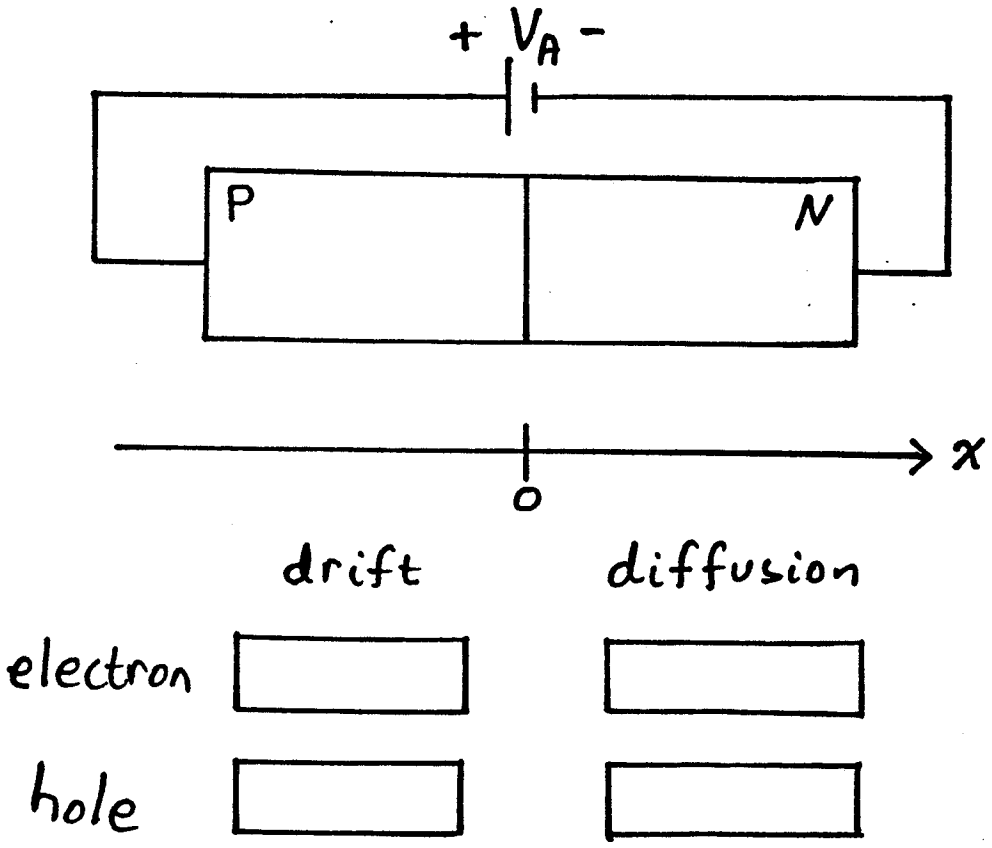
B) 30 pf

C) 10 pf

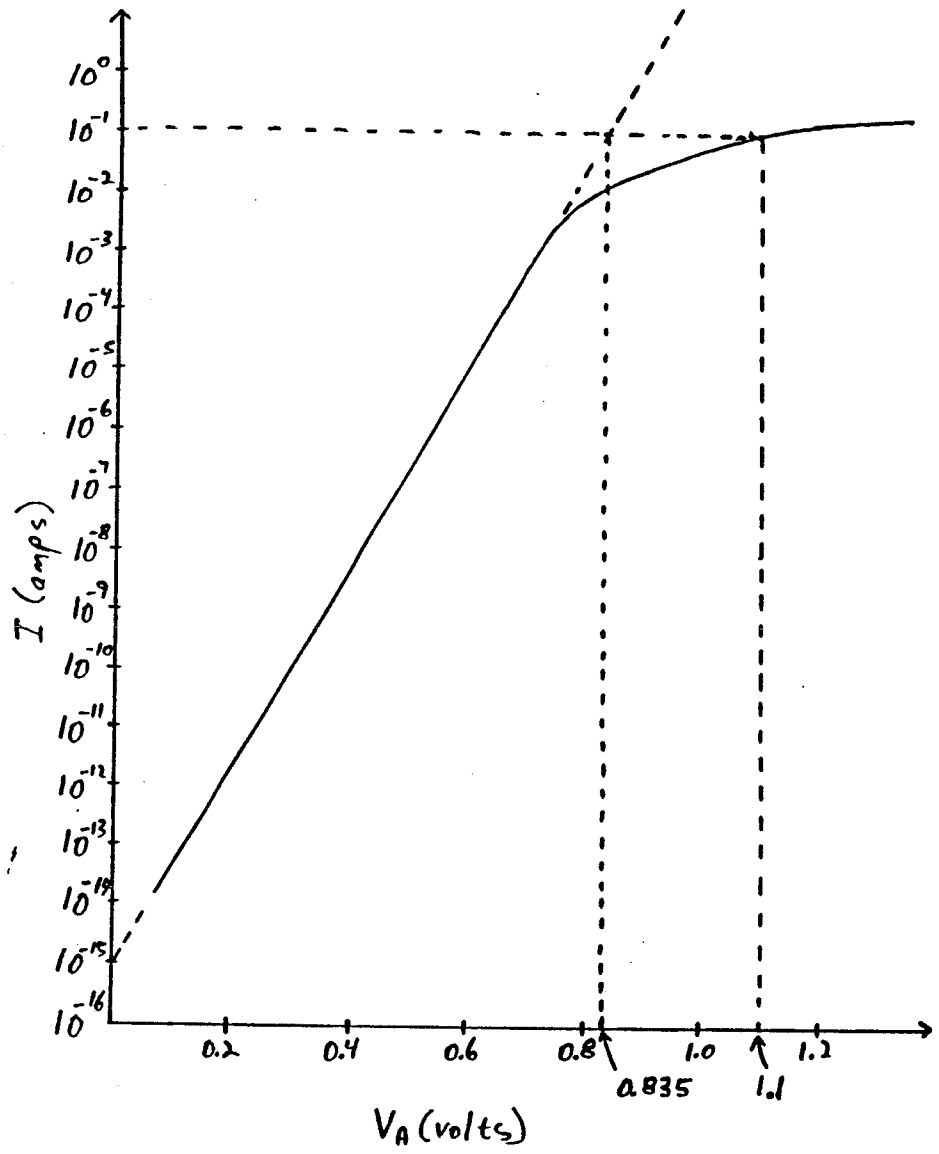
D) 0 pf

E) None of the above.

(8 pts) 4. Place arrows in the boxes to depict the direction of *current flow* due to electron and hole drift and diffusion at x=0 for the pn junction shown biased at $V_A = 0$ volts. Place a zero in the box if a given current component is equal to zero.



(10 pts) 5. A pn junction diode exhibits an ideal forward bias characteristic until series resistance effects set in at high bias as shown below.



(5 pts) 5A. If you were to reverse bias this diode at −5V, what would be the magnitude of the reverse current that would flow?

A) 0 A because there is no generation in the depletion region of an ideal pn junction.

B) 10^{-15} A

C) 10^{-15} A/cm^2

D) Cannot be determined from the information given.

E) 10^{-100} A

(5 pts) 5B. What is the series resistance of the diode?

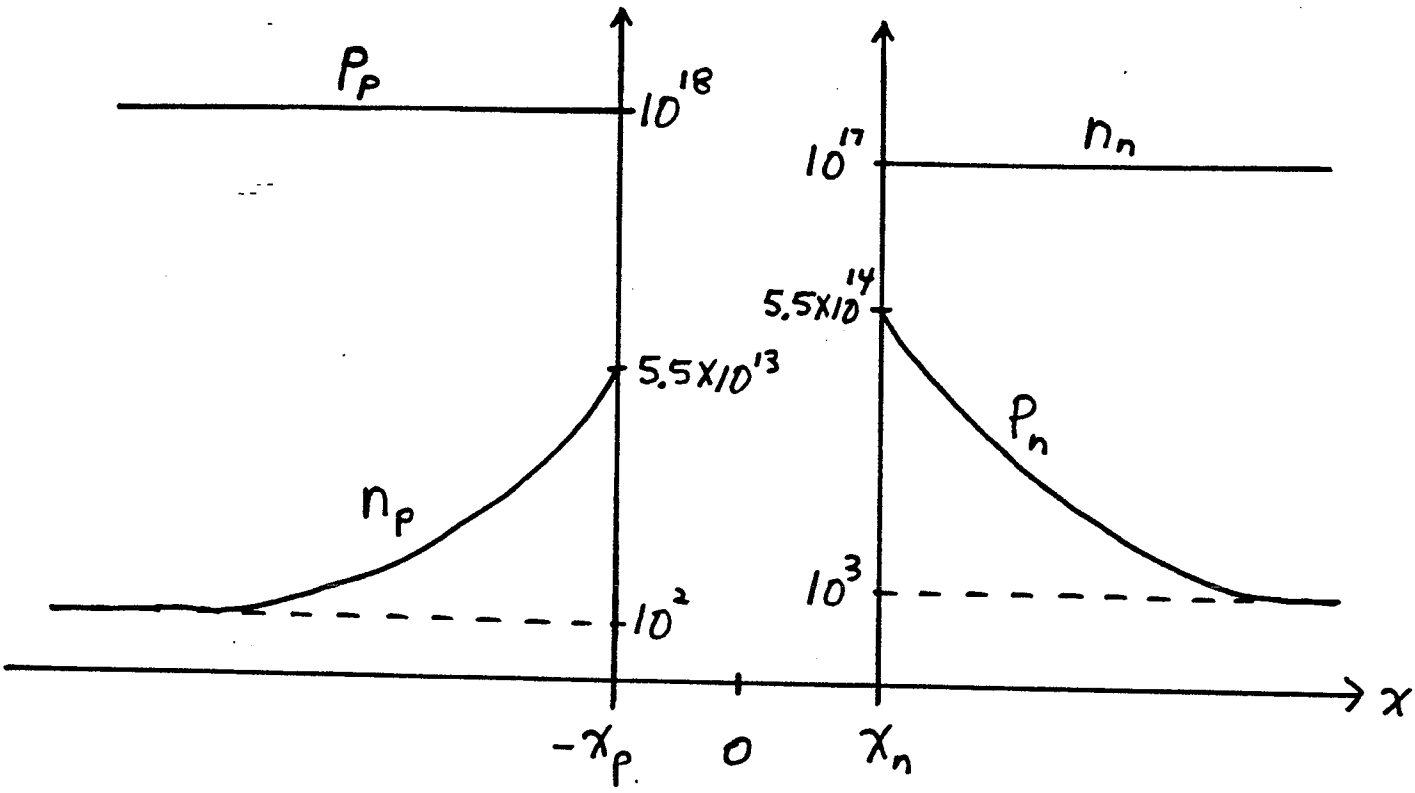
A) 2.65 Ω

B) 0 Ω

C) 11 Ω

D) None of the above.

(17 pts) 6. A bias, V_A, is placed across a pn junction. Shown below is the resulting carrier concentrations in the neutral regions. (Note: T = 300K)



(2 pts) A) Is the diode forward or reverse biased?

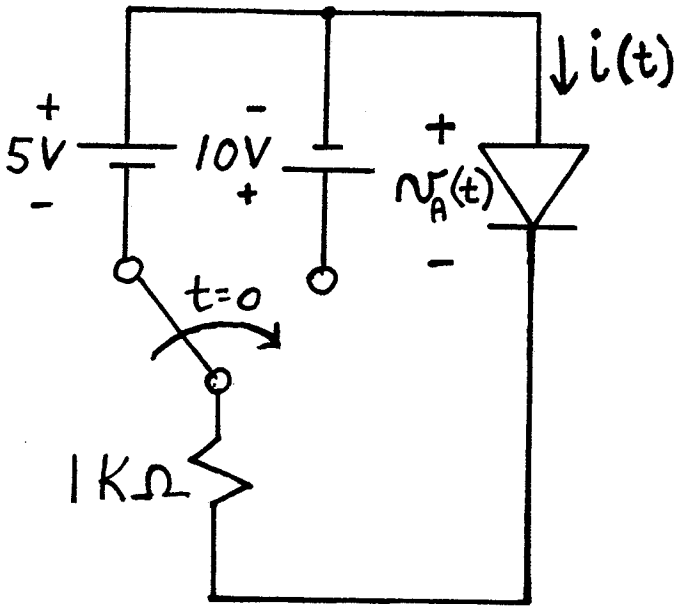
(3 pts) B) What is the doping on the p-side?

(3 pts) C) What is the doping on the n-side?

(5 pts) D) What is the applied voltage, V_A?

(4 pts) E) What is the intrinsic carrier concentration?

(5 pts) 7. A p^+n Silicon diode is biased as shown for times $t < 0$. The silicon diode exhibits ideal behavior with $I_0 = 1.6 \times 10^{-18}$A and $\tau_p = \tau_n = 1\,\mu$sec. At time $t = 0$ the switch is thrown so that the diode becomes reverse biased as shown. At time $t = 0^+$, that is times much less than 1 μsec, the current $i(0^+)$ flowing through the diode is approximately,



A) -10 mA

B) $+10$ mA

C) -1.6×10^{-18}A

D) $+1.6 \times 10^{-18}$A

E) -93.8 mA

F) $+93.8$ mA

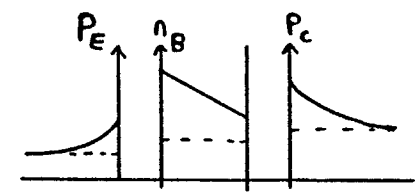
(8 pts) 8. From the carrier concentrations shown below for an npn bipolar transistor, indicate the mode of operation. Select your answers from the choices below and place the appropriate letter in the boxes.

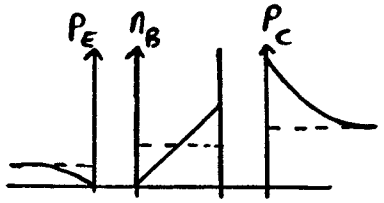
A - forward active

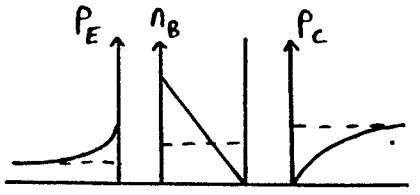
B - cutoff

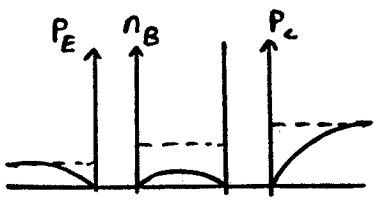
C - saturation

D - inverted active

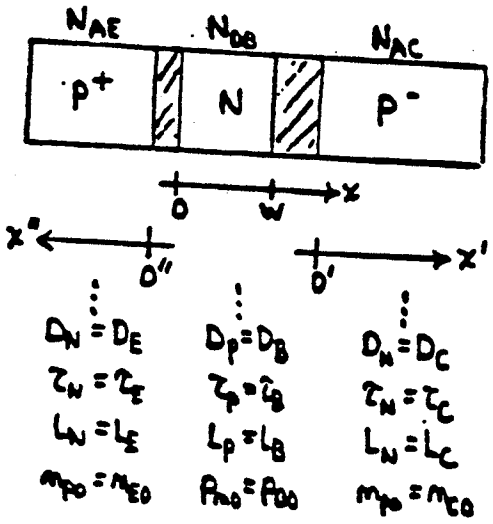








(20 pts) 9. You are given the p^+np silicon bipolar junction transistor shown. Fill in the table with raise, lower, or no effect, to describe how the change in the left hand column affects the emitter injection efficiency γ and the base transport factor α_T for the transistor operated in the forward active mode.



	γ	α_T
increase D_E		
lower W		
decrease τ_B		
increase N_{AE}		
lower L_C		

(8 pts) 10. In class we derived ideal parameters for a pnp transistor by ignoring recombination in the base-emitter depletion region. How will the following parameters be influenced by the consideration of recombination in the base-emitter depletion region?

(4 pts) I) β

A) decreased at low collector current levels

B) decreased at high collector current levels

C) increased at low collector current levels

D) increased at high collector current levels

E) unchanged

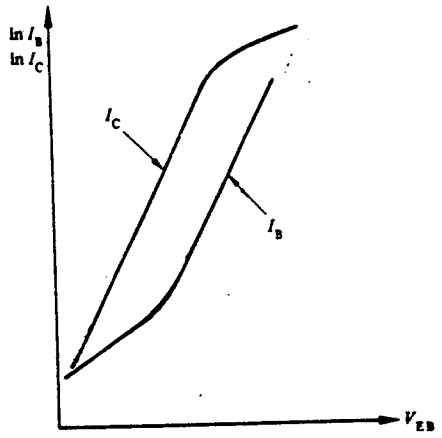
(4 pts) II) α_T

A) increased

B) decreased

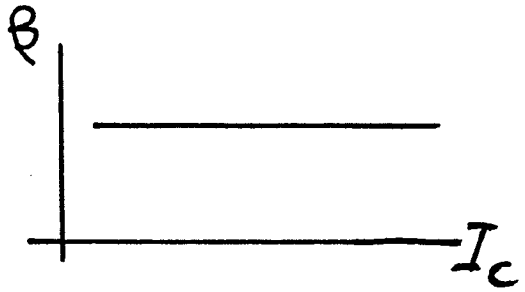
C) unchanged

11. Shown is the natural logarithm of the base and collector currents as a function of emitter base bias for a pnp BJT whose collector-base junction is kept at a constant reverse bias.

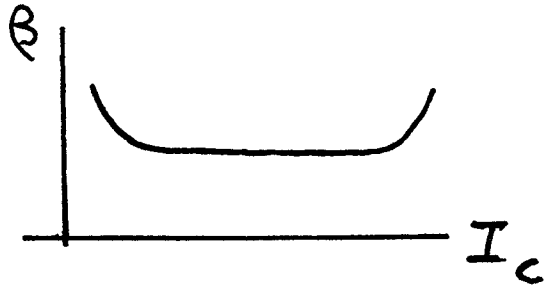


(4 pts) For this transistor, which of the following curves represents the base-collector current gain, β, as a function of collector current?

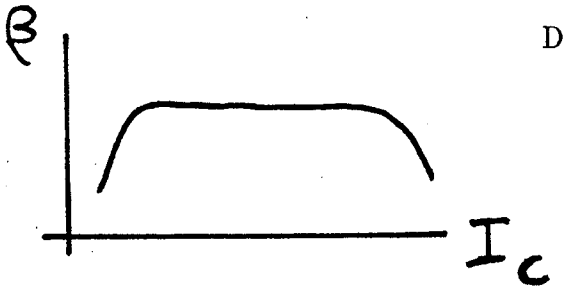
A)



B)



C)



D)