EE130 Midterm I
Spring2006

Problem 1:

Consider a P type semiconductor material. Fill in the blank cells in the table, using the following symbols: ↑for increase, ↓ for decrease, and → for no change. If the cell has already been provided with an X it means that you are not responsible for filling that cell out. When moving along a row consider only the change brought on due to the parameter specified in the first cell of that row

	p	**n**	**μ p**	**D_n**	**Jp (When an electric field is applied)**
Na ↑					
Shine light (light intensity ↑)			**X**	**X**	
Temperature ↑	→		Assume phonon scattering dominates	Assume phonon scattering dominates	

Problem 2:

a) Does $E_c - E_f$ increase or decrease when the doping density of an N-type Silicon sample is raised?

b) Express diffusion length in terms of τ and D.

c) Given $J_{n,diffusion} = bx$, what is n(x) in terms of b and any common parameters and constants

d) Does the resistivity of a semiconductor increase or decrease when it is exposed to light?

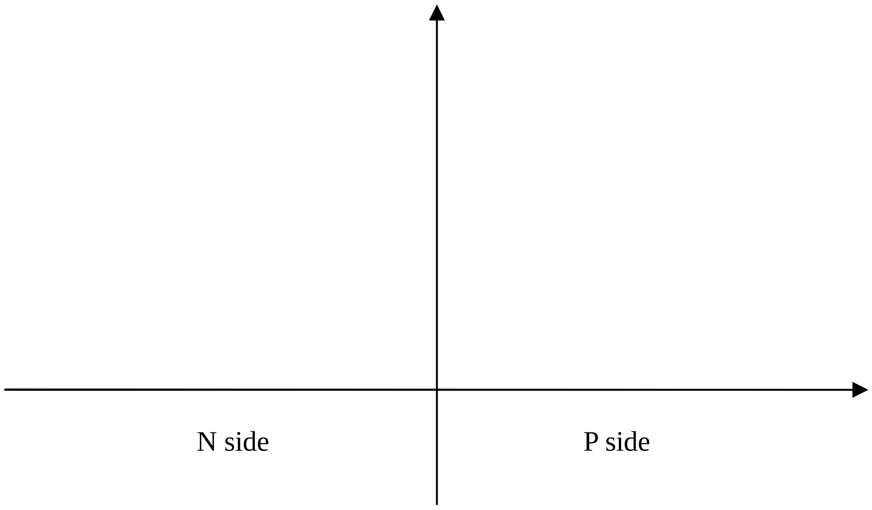
e) Answer the following in one phrase. After the light in part d is suddenly switched off, what determines the time left for the resisitivity to settle back to the dark value?

Problem 3:

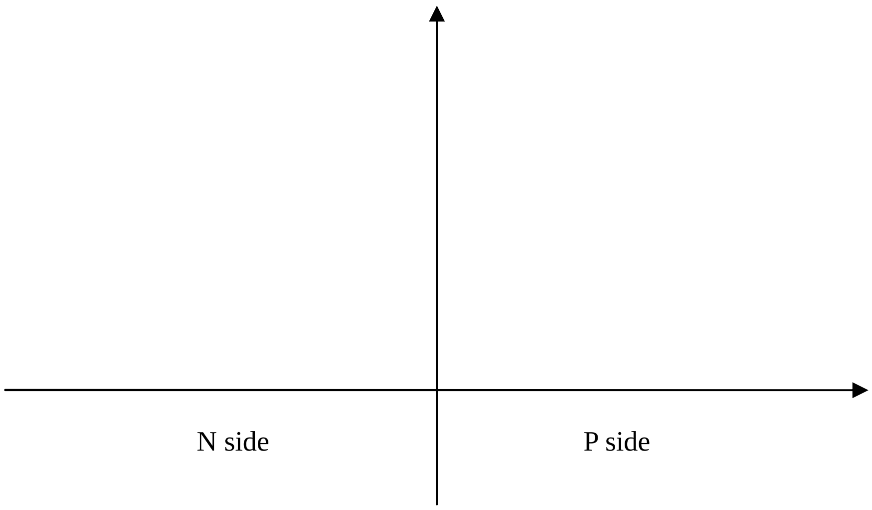
A silicon PN diode has the following specifications. On the N side $N_d = 5 \times 10^{17} cm^{-3}$, τ =1us. ON the P side $N_a = 10^{17} cm^{-3}$, τ =1us. For questions which ask for curves, pay attention to the relative vertical magnitude of the curves on the two sides. There is no need to indicate the relative magnitude of diffusion lengths.

a) On which side is the diffusion length shorter – the P side or the N side

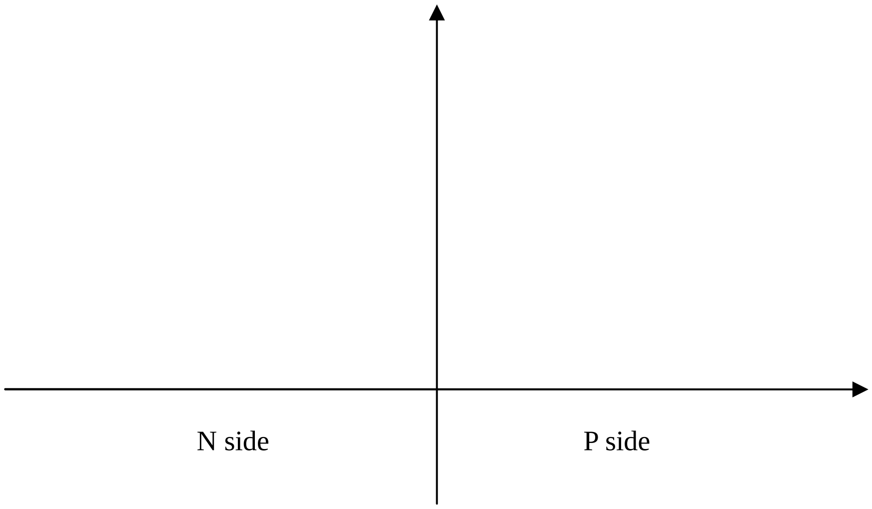
b) Sketch the excess minority carrier concentration on both sides under forward bias.



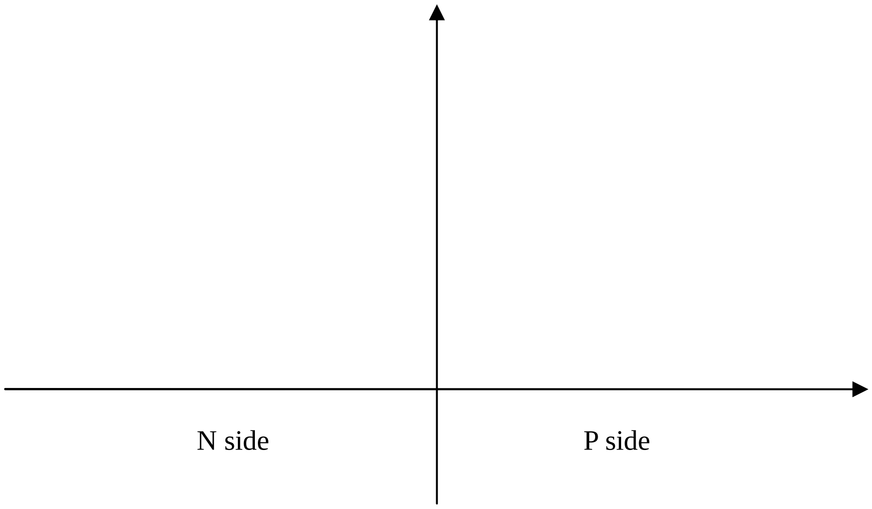
c) Sketch the excess majority carrier concentration on both sides.



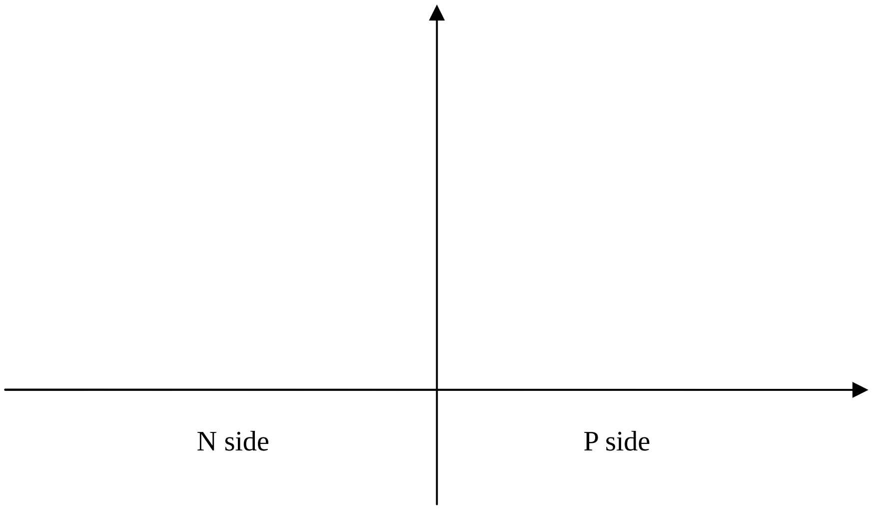
d) Sketch the minority current density and the total current density on both sides.



e) Sketch the majority current density on both sides.



f) Sketch the minority current density in a semilog plot, i.e. log(minority current density) versus x for both the P side and N side.



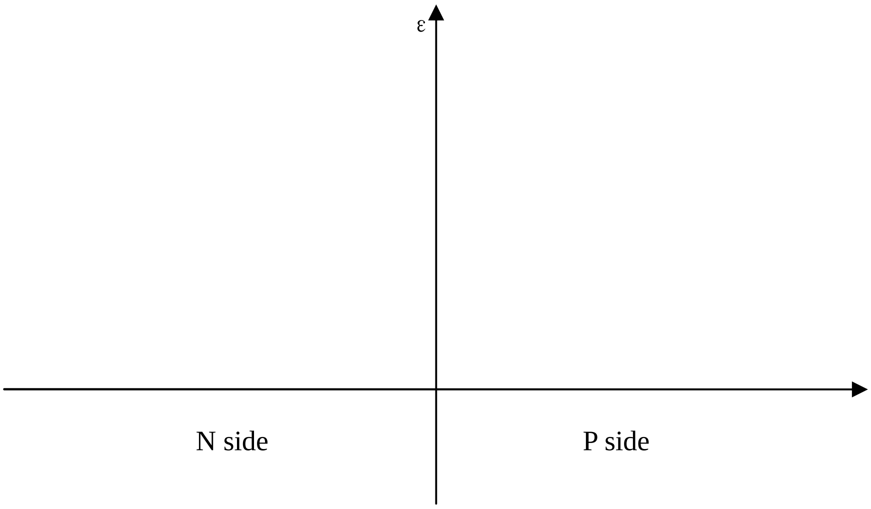
g) What is the numerical ratio of the minority carrier charge (Q_s) stored in the N side to that stored in the P side.

Problem 4:

a) Given the critical field for breakdown is 5 x 10^5V/cm, what doping concentration should be used on the P side of N^+P diode in order to make the breakdown voltage equal to 40V. (Hint: for simplifying the math you may consider that 40V is much larger than the built-in potential (Φbi) of the diode).

b) How wide is the depletion layer ($W_{dep,BD}$) at the breakdown voltage? Assume that 40V is much larger than the built-in potential (Φbi) of the diode).

c) Sketch ε versus x. Assume an ideal one sided N^+P junction



d) Express the breakdown voltage as a simple function of ε_{crit} and $W_{dep,BD}$

e) Sketch V(x) for this ideal one-sided junction with no voltage applied across the diode. Assume an ideal one sided N^+P junction. Pay attention to the shape of the profile. There is no need to calculate the numerical quantities.