ECE 320 - Quiz #3 - Name _____

Diodes, Ideal Diodes, LEDs - Spring 2020

1a) What do the terms "n-type silicon" and "p-type silicon" mean?

n-type: doped with phosphorus

$\#e^- \gg \#$holes

almost all charge carriers are electrons

p-type: doped with boron

$\#$holes $\gg \#e^-$

almost all charge carriers are holes

1b) Why can current flow p to n but not n to p for a pn-juction (i.e. a diode)?

p→n uses majority carriers (low R)

n→p uses minority carriers (high R)

$V_{pn} > 0.7V$ squeezes the depletion zone to zero & current flows

2) Determine the doping level required (n_p) to create a piece of p-type silicon with a resistance of 100 Ohms. Assume

- $L = 1\text{cm}$
- $A = 0.01\text{cm}^2$
- $\mu_p = 500$ (mobility of holes)
- $q = 1.6 \cdot 10^{-19}$
- $R = \left(\frac{\rho L}{A}\right)$
- $\sigma = \frac{1}{\rho} = n_p \cdot q \cdot \mu_p$

$$100\Omega = \frac{\rho \cdot 1\text{cm}}{.01\text{cm}^2}$$

$$\rho = 1\ \Omega \cdot \text{cm}$$

$$\sigma = 1\ \frac{1}{\Omega\text{cm}} = n_p \cdot 1.6 \cdot 10^{-19} \cdot 500$$

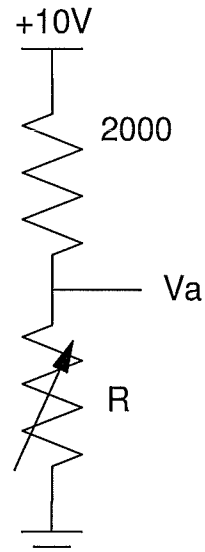
$$\boxed{n_p = 1.25 \cdot 10^{16}\ /\text{cc}}$$

3) Assume the resistance - temerature relationship for a thermistor is

$$R = 1000 \cdot \exp\left(\frac{3905}{T} - \frac{3905}{298}\right)\ \Omega$$

where T is the temperature in degrees Kelvin. If the voltage Va = 3.5V, determine R and the temperature

R (Ohms)	T (degrees K)
1076	296.3°K



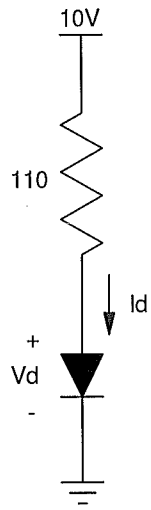
$$Va = 3.5 = \left(\frac{R}{R+2000}\right) 10V$$

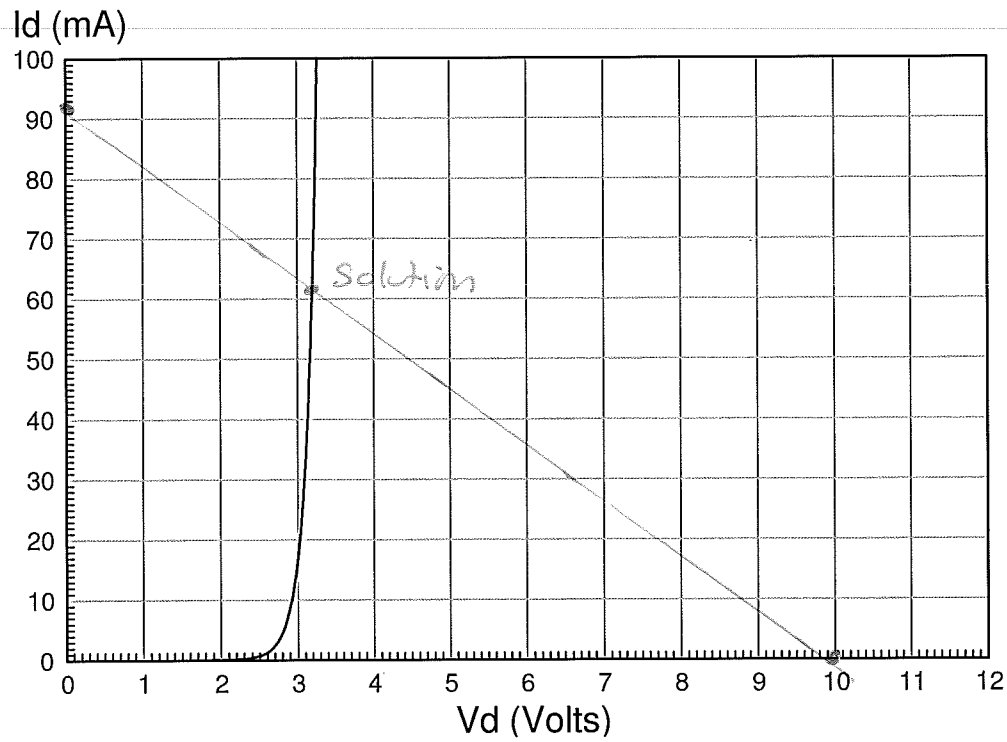
$$R = \left(\frac{3.5}{10-3.5}\right) 2000 = 1076\Omega$$

$$T = 296.3°K$$

4) Load Line: The VI characteristics for a diode are shown below. Draw the load line for the circuit shown below and determine the operating point (Vd, Id)

Load Line	Vd	Id
show on graph	3.2V	6mA



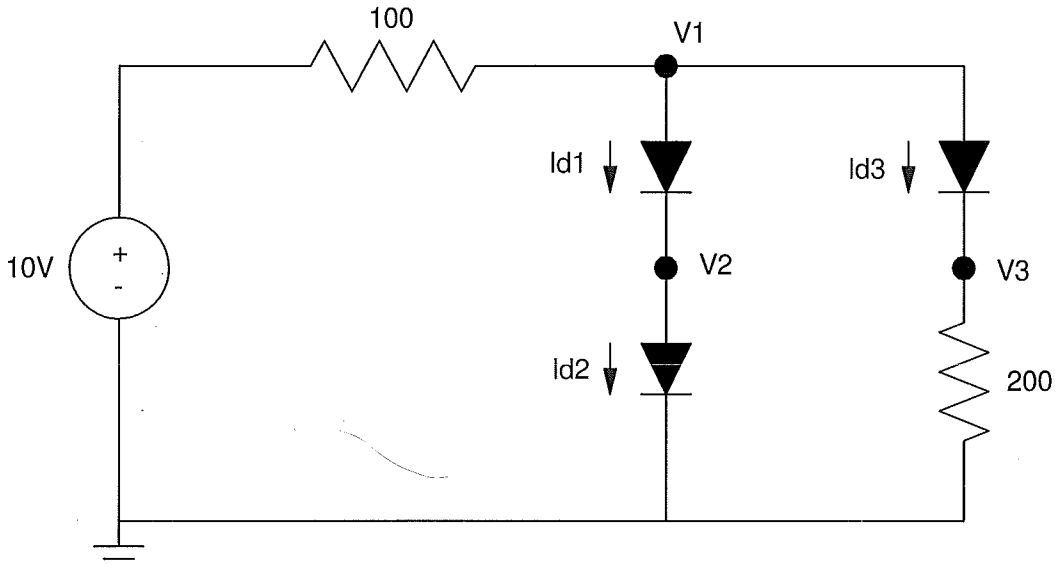


$\frac{10V}{110\Omega} = 91mA$

5) The VI characteristics for a diode are

$$V_d = 0.052 \ln(10^8 I_d + 1) \qquad I_d = 10^{-8}\left(\exp\left(\frac{V_d}{0.052}\right) - 1\right)$$

Write N equations to solve for N unknowns for the following circuit (V1, V2, V2, Id1, Id2, Id3)

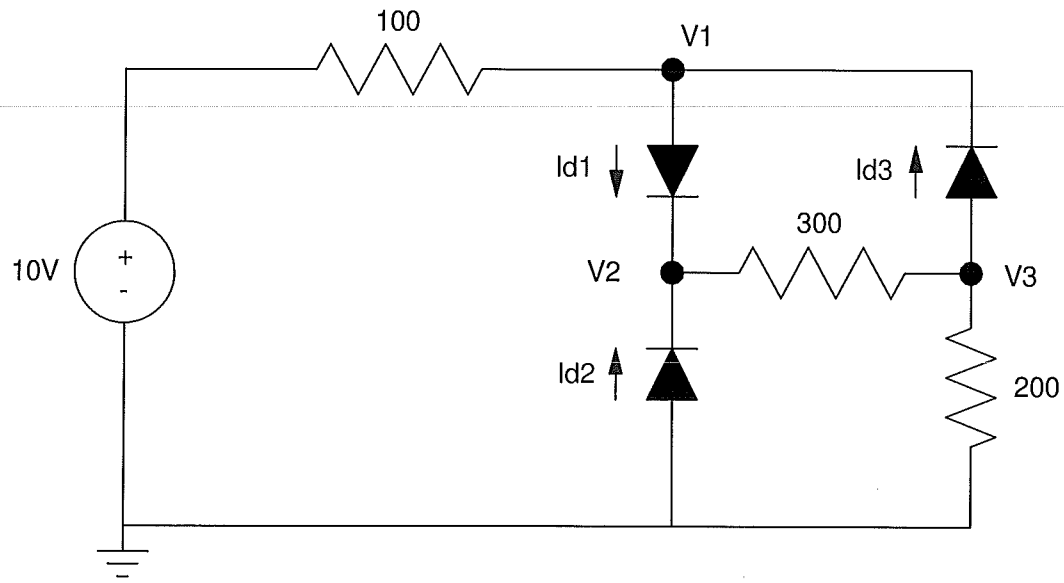


$I_{d1} = 10^{-8}\left(\exp\left(\frac{V_1 - V_2}{.052}\right) - 1\right)$
$I_{d2} = 10^{-8}\left(\exp\left(\frac{V_2}{.052}\right) - 1\right)$
$I_{d3} = 10^{-8}\left(\exp\left(\frac{V_1 - V_3}{.052}\right) - 1\right)$
$\frac{V_1 - 10}{100} + I_{d1} + I_{d3} = 0$
$-I_{d1} + I_{d2} = 0$
$-I_{d3} + \frac{V_3}{200} = 0$

6) The VI characteristics for a diode are

$$V_d = 0.052 \ln(10^8 I_d + 1) \qquad I_d = 10^{-8}\left(\exp\left(\frac{V_d}{0.052}\right) - 1\right)$$

Write N equations to solve for N unknowns for the following circuit (V1, V2, V2, Id1, Id2, Id3)



$I_{d1} = 10^{-8}\left(\exp\left(\frac{V_1 - V_2}{.052}\right) - 1\right)$
$I_{d2} = 10^{-8}\left(\exp\left(\frac{0 - V_2}{.052}\right) - 1\right)$
$I_{d3} = 10^{-8}\left(\exp\left(\frac{V_3 - V_1}{.052}\right) - 1\right)$
$\frac{V_1 - 10}{100} + I_{d1} - I_{d3} = 0$
$-I_{d1} - I_{d2} + \frac{V_2 - V_3}{300} = 0$
$I_{d3} + \frac{V_3 - V_2}{300} + \frac{V_3}{200} = 0$

Bernie Sanders Bonus!!! Three of the following types of cheese, the other three are legal terms used in things like impeachment trials. Which ones are cheese?

Amicus curiae - Chura kampo - De novo - Kesong puti - Le Wavreumont - Voir dire

friend of the court

the new

prelim exam of a witness