Test 2

EE315 Fall 2017—Dr. B

NAME Solution Key

53 took exam in class 10/24

DO ALL YOUR WORK ON THIS EXAM. USE THE BACK SIDES of EXAM PAPER IF NECESSARY BUT POINT ME WHERE YOU DID THAT.

- ***Your Equation sheet must be turned in with the Exam.***
- ***NO Cell PHONE Calculators allowed. Other calculators ok.***
- ***Closed books/closed lecture notes.***
- ***<u>Each Problem worth 18 points.</u>***

Wise sayings heard where I've worked:

- **"You make a really good technical point. I wish I hadn't heard it". DR B, March 1987, Pentagon meeting.**
- **"We'll burn that bridge when we get to it", Col. Rob Barry, Feb 2009**
- **"The flow just may take you where you want to go, unless you're sewage". Dr. B, Dec, 2009**
- **"Sorry I'm late for the project meeting. A plate of chicken wings just came by me and I got the tingles and jingles. I'm good now". Chad Z, new UAH graduate engineering employee, Mar 27, 2014**
- **"Prediction is difficult, especially about the future". Yogi Berra**

FALL

EE315 ~~SPRING~~ TERM 2017

24 OCT

TEST 2 ~~MAKEUP~~- ~~29 MARCH~~ 2017

NAME ______________________________

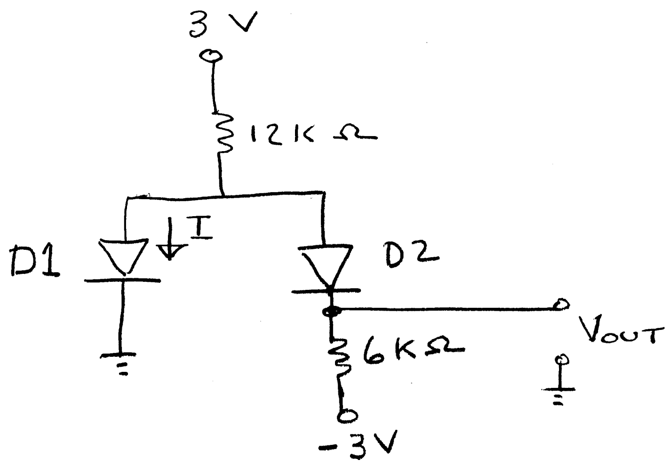
CIRCLE TRUE OR FALSE (1 point each)

1. (T/F) Thermal voltage for a semiconductor diode depends on temperature (in Kelvin degrees), Boltzmann's Constant, and internal resistance of the diode. $V_T = \frac{kT}{q}$ Nope
2. (T/F) An intrinsic semiconductor does not have any doping to change the conductivity of the material.
3. (T/F) A semiconductor diode has only two states; either forward biased or politically biased.
4. (T/F) At room temperature, thermal voltage for silicon is approximately 26 milliamps. millivolts
5. (T/F) A depletion region in a semiconductor diode is a region free of charge carriers.
6. (T/F) A semiconductor diode is formed by a p-n junction.
7. (T/F) A Zener diode must be forward biased in order to perform and operate as a Zener diode. Reversed
8. (T/F) A "hole" is the empty space where an electron was but the space has no effective mass or electrical charge.
9. (T/F) A reversed biased semiconductor diode is, ideally, an open circuit.
10. (T/F) A "p region" in a semiconductor diode is a region where an excess of positive charges are available for conduction.

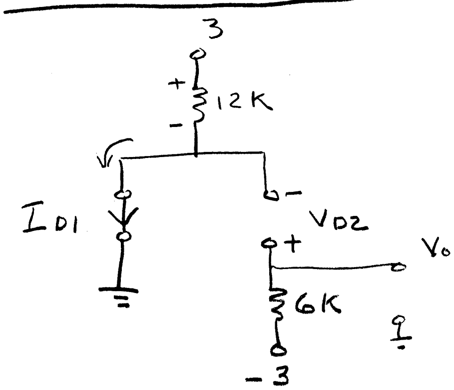
2. In the circuit below, diodes D1 and D2 ARE NEVER BOTH FORWARD BIASED AND NEVER REVERSED BIASED AT THE SAME TIME.

(9) **(a) Determine what state diodes D1 and D2 are in. (That is, which diode is forward biased and which diode is reversed biased)**

(9) **(b) Find Vout and I, voltage polarity and current direction as shown, for the correct state for diodes D1 and D2.**



Assume D1/FB, D2/RB



No Voltage on 6K,
No Current Through it.

KVL $12K\, I_{D1} - 3 = 0$

$I_{D1} = 3/12K = 2.5 \times 10^{-4}$ Amp

KVL $-3 - V_{D2} + 12K(2.5\times10^{-4}) - 3 = 0$

$-3 - V_{D2} + 3 - 3 = 0$

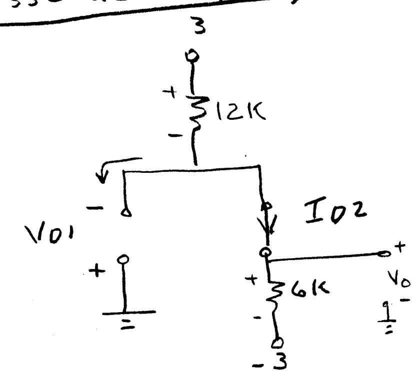
$-V_{D2} = 3$

$V_{D2} = -3$

Not plausable

(a) Correct

Assume D1/RB, D2/FB



KVL $-3 + 6K\, I_{D2} + 12K\, I_{D2} - 3 = 0$

$18K\, I_{D2} = 6$

$I_{D2} = 6/18K = 3.33\times10^{-4}$

D2: ok on current, FB

KVL $-V_{D1} + 12K\, I_{D2} - 3 = 0$

$-V_{D1} + 4 - 3 = 0$

$-V_{D1} = -1$

$V_{D1} = 1$ Says D1 is RB!

Then $-3 + 6K\, I_{D2} - V_o = 0$

$-3 + 4 - V_o = 0$

(b) $\boxed{V_o = -1\ V}$

$\boxed{I = 0}$

3. A particular "ideal semiconductor diode" is found to conduct 1.2 milliamps with a voltage of 0.68 volts across it at a temperature of 350 degrees Kelvin.

(9) **(a) What is the thermal voltage?**

(9) **(b) What is the reverse saturation current?**

(a) $V_T = \frac{kT}{q} = \frac{\left[1.38 \times 10^{-23} \frac{\text{Joules}}{{}^\circ K}\right]\left[350\ {}^\circ K\right]}{1.6 \times 10^{-19}} = 30.18\ \text{mV}$

(b) $I_D = I_S\left[e^{V_D/V_T} + 1\right]$ forget +1

$I_S = \frac{I_D}{e^{V_D/V_T}} = \frac{1.2 \times 10^{-3}}{e^{.68/30.18 \times 10^{-3}}} = \frac{1.2 \times 10^{-3}}{e^{22.53}}$

$= \frac{1.2 \times 10^{-3}}{6.099 \times 10^{9}} = \boxed{1.97 \times 10^{-13}\ \text{Amps} = I_S}$

Given:

Charge on electron= 1.6 x 10 to -19 coulombs

Boltzmann's constant= 1.38 x10 to -23 joules/~~coulomb~~ °K

1 volt= 1 joule/coulomb

4. **Consider an ideal transformer designed to be a STEP UP TRANSFORMER.**

(6) **(a) Given the primary voltage is 120 volts a-c and the secondary voltage is 600 volts a-c. <u>Determine the turns ratio for the transformer.</u>**

(6) **(b) If the primary current is 5 amps, what is the secondary current?**

(6) **(c) If the total impedance Z on the secondary side is 10 ohms, what is the total impedance on the primary side?**

$$N = \frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S}$$

Solutions

(a) $N = \frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{120}{600} = \boxed{\frac{1}{5} = N = 0.2}$

(b) $N = \frac{V_P}{V_S} = \frac{I_S}{I_P}$ $\quad \frac{V_P}{V_S} = \frac{120}{600} = \frac{I_S}{5}$ $\quad \boxed{I_S = 1 \text{ Amp}}$

(c) $Z_P = \frac{1}{N^2} Z_S = \frac{1}{(0.2)^2}(10) = \left(\frac{1}{.04}\right)10 = \boxed{250\ \Omega}$

NOT GRADED

Did not work problem in class as example!

EQUATIONS

$N = \frac{N_P}{N_S}$ $\quad V_P I_P = V_S I_S$

STEP UP XFMR: [MORE turns on secondary side than primary]

① $N V_P = V_S$

② $I_P = N I_S$ (if voltage steps up, current steps down)

divide ① by ② $\quad N Z_P = \frac{1}{N} Z_S$

$$\boxed{Z_P = \frac{1}{N^2} Z_S}$$

MOSTLY GRADED LIKE No PC!

5. A 9.1 volt Zener diode has a test current of Iz=20 milliamps and rz =10 ohms.

(6) **(a) Compute Vzo**

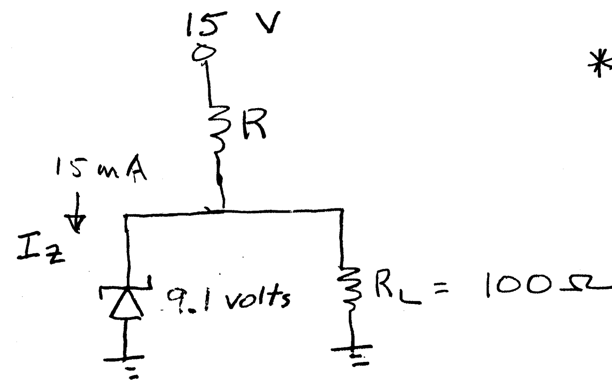
(6) **(b) Compute Vz at Iz=10milliamps**

(6) **(c) In the shunt regulator circuit below, compute the value of R needed.**

* Ignore (Forget) r_z in this case!

* Let $I_z = 15$ milliAmps

$V_z = 12$ volts



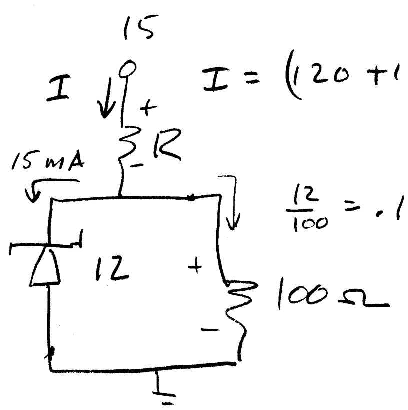
(a) $V_z = V_{zo} + r_z I_z$

$9.1 = V_{zo} + 10(.020) = V_{zo} + .2$

$9.1 - .2 = \boxed{V_{zo} = 8.9 \text{ V}}$

(b) $V_z = 8.9 + (.01)(10) = 8.9 + .1 = \boxed{9 \text{ volts} = V_z|_{10\,mA}}$

(c)



$I = (120 + 15)$ mA $= 135$ mA

$\frac{12}{100} = .12 = 120$ mA

KVL

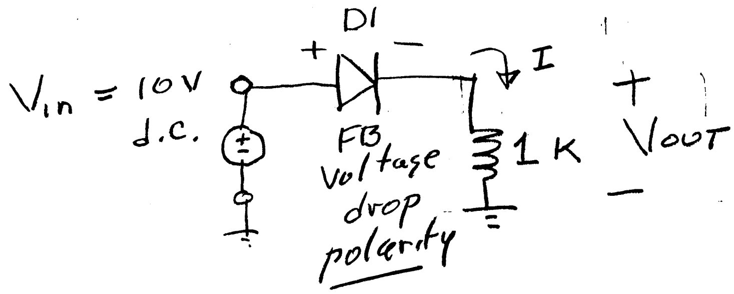
$12 + R(.135) - 15 = 0$

$R(.135) = 3$

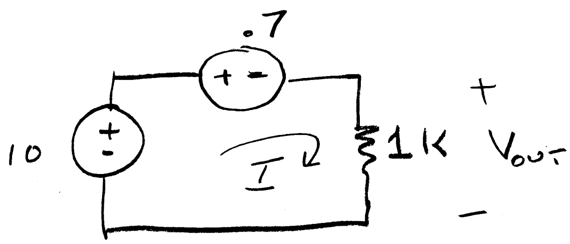
$\boxed{R = 22.22\,\Omega}$

6. For the circuit below, and using the constant voltage drop model for the semiconductor diode, compute Vout if Vin = 10 volts. (18) AND Compute I through the 1KΩ.

$\boxed{\text{A GIFT Problem}}$



OK to use .6 or .7 volts



$10 - .7 - 1K\,I = 0$

$9.3 = 1K\,I$

$I = 9.3\ mA$

$\boxed{V_o = 1K\,(9.3\ mA) = 9.3\ \text{volts}}$

OR KVL $10 - .7 - V_{OUT} = 0$

$V_{OUT} = 9.3$ Volts