Final Assessment Test – April 2019

Course: ECE1002 - Semiconductor Devices and Circuits

Class NBR(s): 1225 / 1227 / 1231 / 1233 / 1235 / 1239/ 1247

Slot: C1+TC1

Time: Three Hours

Max. Marks: 100

General instruction: *Important constants:* $k=1.38\times10^{-23}$ J/K, $h=6.625\times10^{-34}$ J-s, $m_0=9.11\times10^{-31}$ kg, $\varepsilon_0=8.85\times10^{-14}$ F/cm, $q = 1.6\times10^{-19}$C, For Si: $E_g = 1.12$ eV, n_i (300 K) $= 10^{10}$/cm^3, $\varepsilon_s = 11.7\varepsilon_0$

Answer ALL Questions
(10 X 10 = 100 Marks)

1\. a) I) A thin film of silicon layer was grown using chemical vapour deposition. It was found that the doping concentrations $N_A = 5\times10^{17}$ cm^{-3} and $N_D = 3\times10^{17}$ cm^{-3} at 300 K. Find the following:

I. Type of semiconductor
II. Position of Femi-level from valance band at equilibrium.
III. Minority carrier concentration

II) A Si bar was doped with boron at 10^{16} cm^{-3}. A short pulse of light was exposed and found the electron-hole pair generation rate as 10^{20}/s·cm^3 and recombination lifetime as 10 µs. Determine the following:

I. Majority and minority carrier concentrations
II. Excess charge carriers produced after illumination of light

[OR]

1\. b) In a 5.4 mm long n-type silicon bar with rectangular cross section 50 µm × 100 µm, the measured drift current at 300 K was 2.8 µA. It was found that the electron mobility is 1500 cm^2/V-s for the donor concentration is 5×10^{14} /cm^3. Assume $\mu_p = 450$ cm^2/V·s. Calculate:

I. Electron and hole concentrations
II. Resistivity of the sample.
III. Average electric field across the sample

Applied voltage across the sample.

2\. A p-n junction has a built-in potential of 0.65V and the donor concentration on the N-side is 5 times the acceptor concentration on the P-side. If the intrinsic carrier concentration is 10^{11} cm^{-3} at 100°C, find the doping concentration on the P-side, width of the depletion region and the distance it extends in the P-side and in the N-side of the junction. Also, find the value of the depletion capacitance when a reverse bias of 2 V is applied across it for a cross sectional area of 0.5 cm^2. Assume the relative dielectric constant is 10.

3\. a) With the help of band diagrams explain the operation and V-I characteristics of tunnel diodes. [5

b) Explain the differences between Avalanche and Zener breakdown mechanisms. [5

4\. Analyze the circuit (by determining V_D & v_o). Assume circuit and diode parameters of $V_{PS} = 5$ V, $R = 5$ kΩ, $V_\gamma = 0.6$ V & $v_i = 0.1 \sin \omega t$.

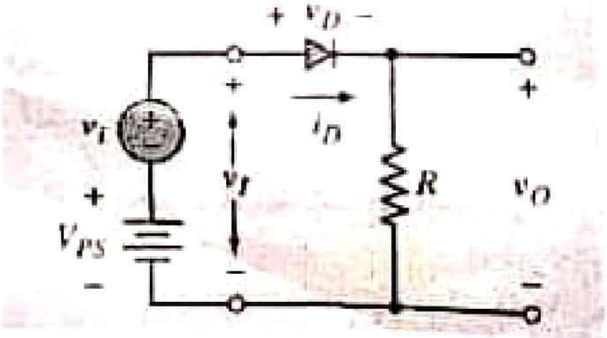

Fig.1

JOIN
VIT QUESTION PAPERS
ON TELEGRAM

5. a) Determine the output waveform of the given circuit.

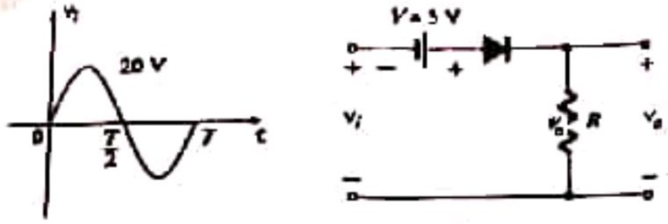

Fig.2

b) (i) Sketch the output v_o and determine the dc level of the output for the network, Fig.3

(ii) Repeat part (a) if the ideal diode is replaced by a silicon diode.

(iii) Repeat parts (a) and (b) if V_m is increased to 200 V and compare solutions.

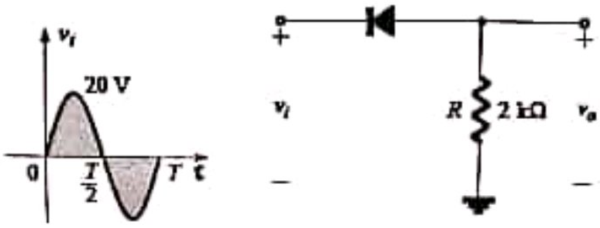

Fig.3

6. a) Determine the V_o for the circuit. (Fig.4)

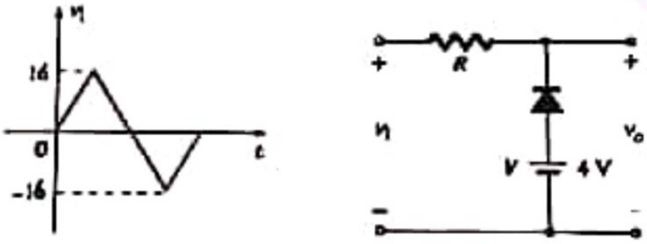

Fig.4

b) Determine the output waveform for the network and calculate the output dc level and the required PIV of each diode.

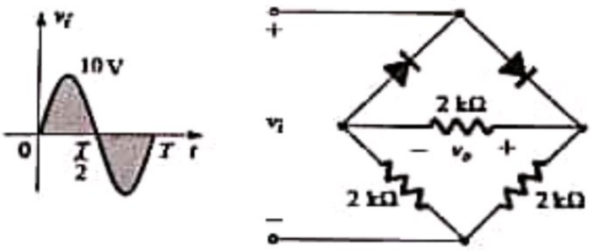

Fig.5

Scanned by CamScanner

Determine Q point, I_C and I_B. Assume β_{dc} = 200 and [illegible]

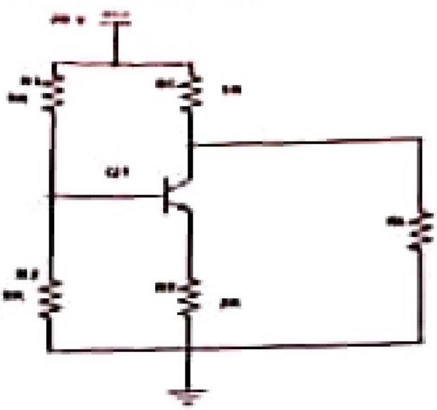

Fig.6

Find the values of voltages at emitter, collector and base terminal and the current flowing through each terminal. Use $\beta = 30$ and $V_{BE} = 0.7V$.

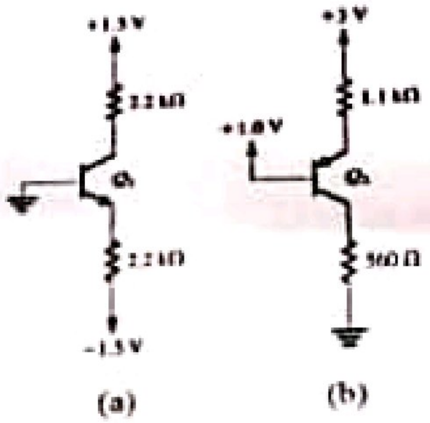

Fig.7

9. a) i) Calculate the total charge in the channel of NMOS Transistor which has:

$C_{ox} = 9\frac{fF}{\mu m^2}$; $L = 0.36\ \mu m$; $W = 3.6\ \mu m$; $V_{ov} = 0.2\ V$ and $V_{DS} = 0\ V$.

ii) Refer to the Fig. 8 the MOSFET has $V_t = 0.7\ V$; $\mu_n C_{ox} = 100\ \mu A/V^2$; $L = 1\ \mu m$ and $W = 32\ \mu m$. Design the circuit to have a drain current of 0.4 mA with $V_D = +0.5$ V, calculate the values of R_S and R_D.

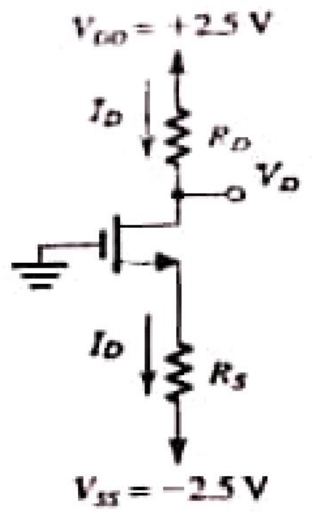

Fig.8

[illegible]

9. The NMOS and PMOS transistors in the circuit in Fig 9 are matched with $k_n'(W_n/L_n) = k_p'(W_p/L_p) = 1\ mA/V^2$ and $V_{tn} = -V_{tp} = 1V$. Assuming λ = 0 for both the devices, find the drain currents i_{DN} and i_{DP} and the voltage v_O for v_I = 0 V, +2.5 V and −2.5 V

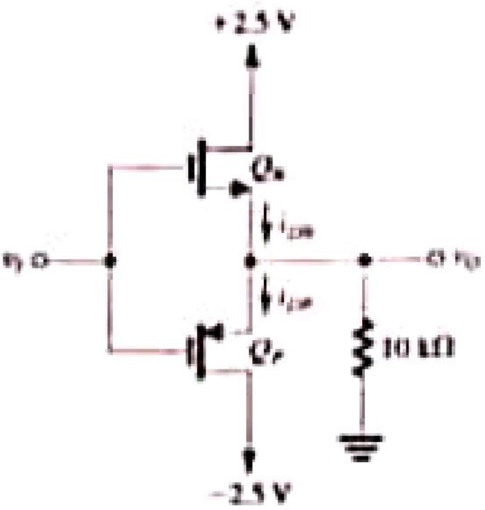

Fig 9

10. Determine the dc transistor currents and voltages in a circuit 9 Fig 10 containing an enhancement load device. The transistors in the circuit (shown in Figure) have parameters $V_{TND} = V_{TNL} = 1V$, $K_{nD} = 50\ \mu A/V^2$, and $K_{nL} = 10\ \mu A/V_2$. Also assume $\lambda_{nD} = \lambda_{nL} = 0$. (The subscript D applies to the driver transistor and the subscript L applies to the load transistor.) Determine V_O for $V_I = 5V$ and $V_I = 1.5V$

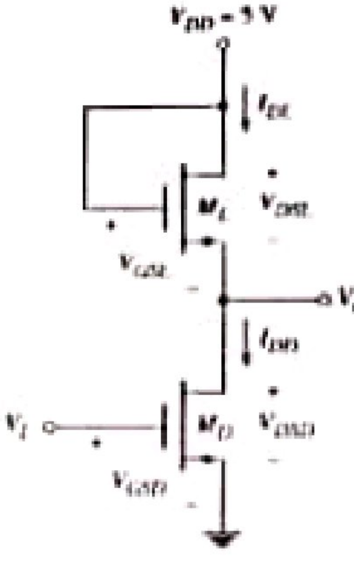

Fig 10

<><><>

Scanned by CamScanner