MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 206: SEMICONDUCTOR PHYSICS

DATE: 30/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS TO CANDIDATES

Answer **Question One** and **any other two** questions in this paper.

IMPORTANT CONSTANTS

Charge on an electron, $e = 1.6 \times 10^{-19}$ C
Boltzmann's constant, $k_B = 8.62 \times 10^{-5}$ eV/K

QUESTION ONE (30 MARKS)

a) Briefly describe the following materials using energy band diagrams clearly showing the forbidden gap,

i. A semiconductor (2 marks)

ii. A metal (2 marks)

iii. An insulator (2 marks)

b) State the values of forbidden energy gap for silicon and germanium at a room temperature of $27\,^0$C. (2 marks)

c) Explain the following.

i. The operation of a field effect transistor (FET). (4 marks)

ii. The difference in operation between a zener diode and a light emitting diode. (3 marks)

d) State two differences between a FET and bipolar junction transistor (BJT). (2 marks)

e) For the JFET circuit of Figure 1, $I_{DSS} = 9$ mA and $V_P = -3$ V. Find the value of R_L for setting the value of V_{DS} at 7 V. Given: $V_{GS} = -2$ V, $I_G = 0$ (3 marks)

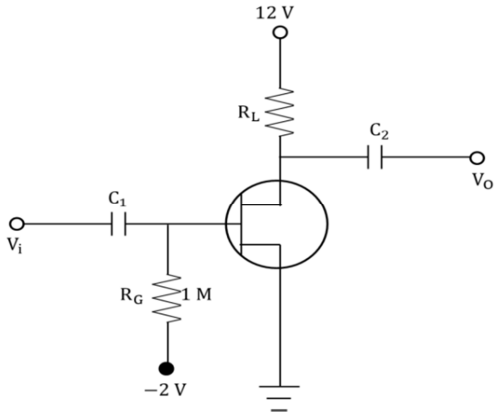

Figure 1

f) The resistivity of an intrinsic silicon semiconductor at $27\ ^0$C is 2.3×10^5 Ω-cm. Calculate the intrinsic concentration of silicon at $127\ ^0$C. (5 marks)

Given: $\mu_n = 0.14\ \text{m}^2/\text{V-s}$ (At $27\ ^0$C)

$\mu_p = 0.05\ \text{m}^2/\text{V-s}$ (At $27\ ^0$C

$E_{G0} = 1.21$ eV

g) Design a fixed biased circuit using a silicon transistor having β value of 100. V_{CC} is 10 V and dc bias conditions are to be $V_{CE} = 5$ V and $I_C = 5$ mA. Label your circuit with all correct values. (5 marks)

QUESTION TWO (20 MARKS)

a) Draw and explain the V-I characteristic of a PN junction diode. (4 marks)

b) Explain the action of a PNP transistor accounting for all the currents. (4 marks)

c) A transistor is connected in a common-emitter (CE) configuration in which the collector supply is 8 V and the voltage drop across resistance R_C connected in the collector circuit is 0.5 V. The value of $R_C = 800\ \Omega$ if $\alpha = 0.96$, determine:

i. the collector-emitter voltage (2 marks)

ii. the base current. (4 marks)

iii. What would be the emitter current I_E if the transistor β was 50? (3 marks)

d) What is Fermi-Dirac probability function? State its significance. (3 marks)

QUESTION THREE (20 MARKS)

a) With the help of energy band theory, define the following terms

i. Conduction band (2 marks)

ii. Valence band (2 marks)

iii. Forbidden energy gap (2 marks)

b) Explain the mechanism of conduction in an intrinsic semiconductor, by free electrons and holes. (3 marks)

c) A bar of intrinsic silicon semiconductor has a cross-sectional area of 2.5×10^{-4} m^2. The electron density is 1.5×10^{16} /m^3. Current through the bar is 1.2 mA when 9 V is applied across it, how long is the bar?

d) Given that $\mu_n = 0.14$ m^2/V-s and $\mu_p = 0.05$ m^2/V-s. (5 marks)

e) Calculate the Q - point values (I_C and V_{CE}) for the circuit in Figure 2 hence show the point on the dc load line. (6 marks)

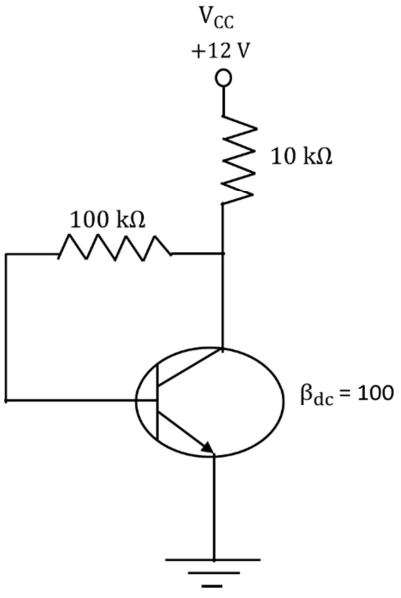

Figure 2

QUESTION FOUR (20 MARKS)

a) What do you understand by the following terms as used in semiconductor devices,

i. Recombination (2 marks)

ii. Load line (3 marks)

iii. Quiescent point (3 marks)

b) Explain the formation of the following semiconductors and explain how conduction takes place in each.

i. An N-type semiconductor. (3 marks)

ii. A P-type semiconductor. (3 marks)

c) Find the DC load line for common emitter circuit shown in Figure 3, assuming $V_{BE} = 0.7$ V. (6 marks)

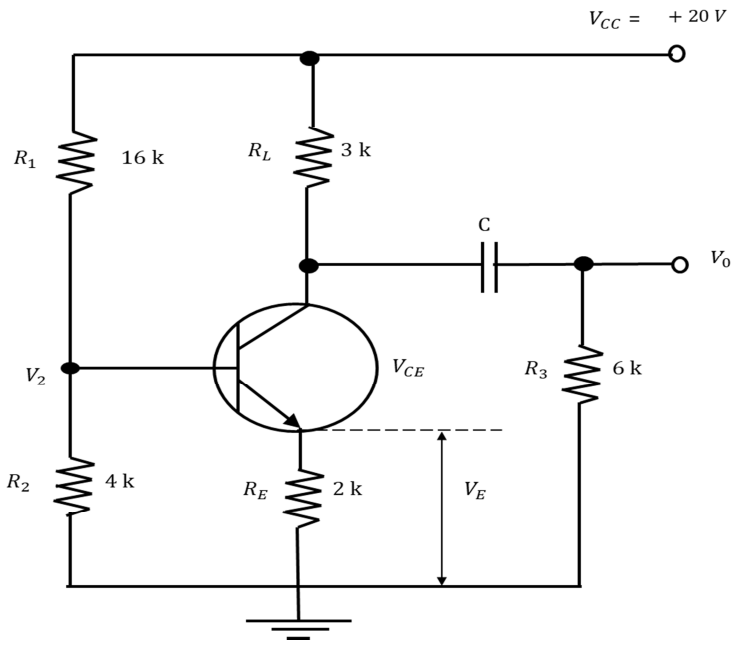

Figure 3

QUESTION FIVE (20 MARKS)

a) Explain with aid of diagrams the meaning of the following terms

i. Pinch off voltage (3 marks)

ii. Cut off voltage (3 marks)

b) Describe with the aid of a diagram how a combination of an LED and a photodiode can be used as raindrop sensor for automobile windscreen. (6 marks)

c) The collector current of a transistor is found to be 9.9 mA for an emitter current of 10 mA in the common base mode. Calculate the transistor parameters and the base current. (4 marks)

d) The pinch off voltage of a depletion layer type MOSFET is -4 V and the drain current at zero gate voltage is 10 mA . Find the mutual conductance when the gate voltage is $+6\,V$. (4 marks)