



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, $e = 1.6 \times 10^{-19} \text{ C}$

Boltzmann's constant, $k_B = 8.62 \times 10^{-5} \text{ eV/K}$

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°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, $I_{DSS} = 9 \text{ mA}$ and $V_P = -3 \text{ V}$. Find the value of R_L for setting the value of V_{DS} at 7 V. Given: $V_{GS} = -2 \text{ V}$, $I_G = 0$ (3 marks)

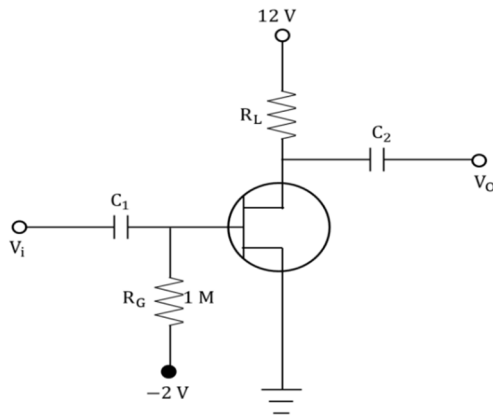


Figure 1

- f) The resistivity of an intrinsic silicon semiconductor at 27°C is $2.3 \times 10^5 \Omega\text{-cm}$. Calculate the intrinsic concentration of silicon at 127°C . (5 marks)
- Given: $\mu_n = 0.14 \text{ m}^2/\text{V-s}$ (At 27°C)
 $\mu_p = 0.05 \text{ m}^2/\text{V-s}$ (At 27°C)
 $E_{G0} = 1.21 \text{ eV}$
- 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 $V_{CE} = 5 \text{ V}$ and $I_C = 5 \text{ mA}$. 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:
- the collector-emitter voltage (2 marks)
 - 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
- Conduction band (2 marks)
 - Valence band (2 marks)
 - 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 $2.5 \times 10^{-4} \text{ m}^2$. The electron density is $1.5 \times 10^{16} / \text{m}^3$. Current through the bar is 1.2 mA when 9 V is applied across it, how long is the bar?
- d) Given that $\mu_n = 0.14 \text{ m}^2/\text{V-s}$ and $\mu_p = 0.05 \text{ m}^2/\text{V-s}$. (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)

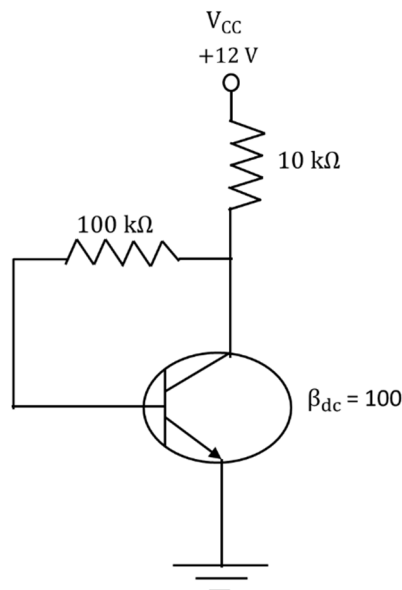


Figure 2

QUESTION FOUR (20 MARKS)

- a) What do you understand by the following terms as used in semiconductor devices,
- Recombination (2 marks)
 - Load line (3 marks)
 - Quiescent point (3 marks)
- b) Explain the formation of the following semiconductors and explain how conduction takes place in each.
- An N-type semiconductor. (3 marks)
 - A P-type semiconductor. (3 marks)
- c) Find the DC load line for common emitter circuit shown in Figure 3, assuming $V_{BE} = 0.7 \text{ V}$. (6 marks)

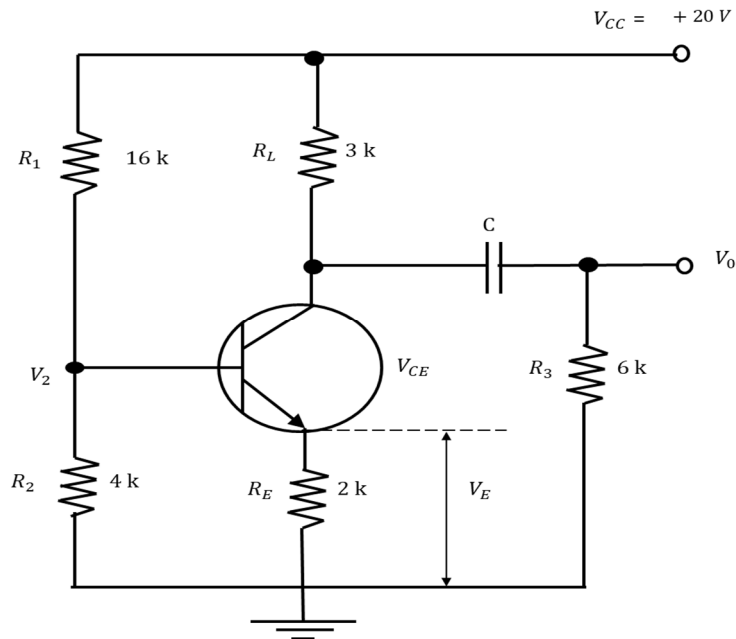


Figure 3

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 $+6\text{ V}$. (4 marks)