



**DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY**

**UNIVERSITY EXAMINATIONS 2021/2022**

**SECOND YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF  
BACHELOR OF SCIENCE IN MECHATRONIC ENGINEERING**

**EEE 3101 ANALOGUE ELECTRONICS**

**DATE: DECEMBER 2021**

**TIME: 2 HOURS**

**INSTRUCTIONS**

This paper contains THREE printed pages with FIVE Questions.

Answer QUESTION ONE (COMPULSORY) and ANY OTHER TWO Questions

**QUESTION ONE [COMPULSORY – 30 MARKS]**

- a) What is a *hole* and how does it contribute to conduction? [2 Marks]
- b) In the three regions of operation, how are the BJT junctions biased? Illustrate the following three regions of operation of a Bipolar Junction Transistor (BJT) on Common Emitter (CE) configuration output (collector) characteristics. [6 Marks]
  - i. Active region
  - ii. Saturation region
  - iii. Cut off region
- c) Explain the operation of a zener diode and sketch its symbol. [2 Marks]
- d) What is meant by diffusion of charge carriers? How is it different from drift? [2 Marks]
- e) The Opamp circuit in Fig. Q1(e) is that of an inverting amplifier. Determine the output voltage  $V_0$ . [3 Marks]

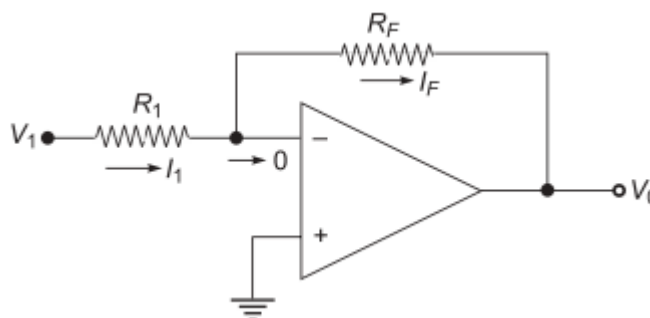


Fig. Q1(e)

- f) With the aid of a well-labeled diagram, explain the formation of a depletion region in a PN-junction diode? [5 Marks]
- g) For the diode circuit of Fig. Q1(g), determine the currents  $I_1$ ,  $I_2$  and  $I_{D2}$ . [6 Marks]

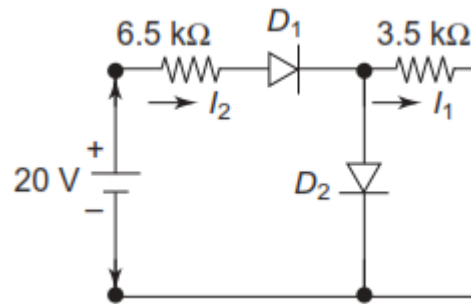


Fig. Q1(g)

- h) A Silicon diode has a reverse saturation current  $I_s = 10 \text{ nA}$ , operating at  $25^\circ\text{C}$ . Calculate the diode current  $I_D$  for a forward bias voltage of  $0.6 \text{ V}$ . [3 Marks]
- i) State ONE difference between a Field Effect Transistor (FET) and a Bipolar Junction Transistor (BJT)? [1 Mark]

### **QUESTION TWO [20 MARKS]**

- a) Show the two-dimensional picture of a silicon crystal containing:
- Donor impurity atoms
  - Acceptor impurity atoms.
- [6 Marks]
- b) The collector current  $I_C$  in a *NPN* Bipolar Junction Transistor (BJT) is given by  $I_C = \alpha I_E + I_{CBO}$ , where  $\alpha$  is the common-base forward-current gain,  $I_E$  is the emitter current and  $I_{CBO}$  is the reverse saturation current. Show that the collector current can also be given by;

$$I_C = \beta I_B + (1 + \beta)I_{CBO}$$

where  $\beta$  is the common-emitter forward-current gain and  $I_B$  is the base current. [5 Marks]

- c) With the aid of diagrams, discuss the THREE types of configurations in which a Bipolar Junction Transistor (BJT) can be connected in a circuit operation. [9 Marks]

### **QUESTION THREE [20 MARKS]**

- a) Sketch the frequency response of an op-amp open-loop mode. [5 Marks]
- b) Sketch the *IV* characteristics of a silicon *PN*- junction diode and describe the shapes of the characteristics drawn. [5 marks]
- c) For the fixed-bias configuration shown in Fig. Q3(a), determine  $R_B$ ,  $R_C$ ,  $I_C$  and  $V_{CE}$ , given that  $\beta = 100$  [10 Marks]

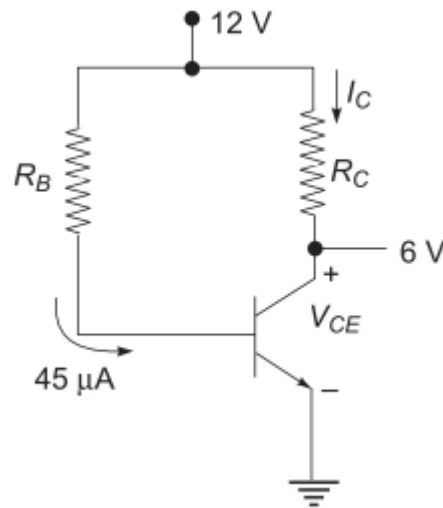


Fig. Q3(c)

**QUESTION FOUR [20 MARKS]**

- a) Sketch an  $n$ -channel JFET. Explain how the pinch off takes place for  $V_{GS} = 0$ . What is meant by  $I_{DSS}$ . [8 Marks]
- b) Define the following terms as used in Electronics. [4 Marks]
  - i. Recombination
  - ii. Threshold voltage
  - iii. Slew rate
  - iv. Common Mode Rejection Ratio (CMRR)
- c) Given  $\alpha_{dc} = 0.997$ , determine; [8 Marks]
  - i.  $I_c$  if  $I_E = 5 \text{ mA}$
  - ii.  $\alpha_{dc}$  if  $I_E = 2.8 \text{ mA}$  and  $20 \mu\text{A}$
  - iii.  $I_E$  if  $I_B = 40 \mu\text{A}$  and  $\alpha_{dc} = 0.98$

**QUESTION FIVE [20 MARKS]**

- a) What is a tunnel diode? With the aid of a sketch, explain the  $IV$  characteristics of a tunnel diode. [5 Marks]
- b) With the aid of a well labeled diagram, describe the flow of carriers (holes and electrons) in a  $NPN$  transistor. [7 Marks]
- c) For the diode circuit of Fig. Q5(c), determine  $I$ ,  $V_1$ ,  $V_2$  and  $V_0$ . [8 Marks]

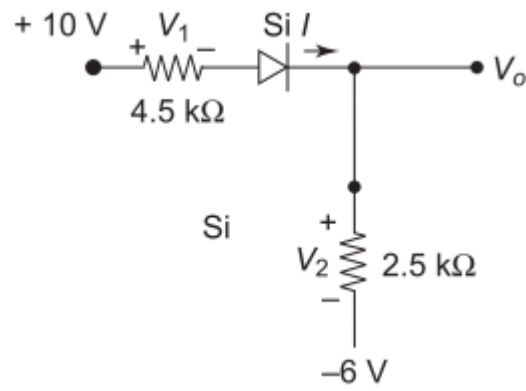


Fig. Q5(c)