# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

## FACULTY OF ENGINEERING

## DEPARTMENT OF ELECTRONIC ENGINEERING

ELECTRONIC ENGINEERING CIRCUITS AND DEVICES
**EEE 1203/EEE 1213**

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### FINAL EXAMINATION PAPER
### JULY 2024

This paper consists of 7 printed pages.

| | | |
|---|---|---|
| EXAMINATION DURATION | : | **3 HOURS** |
| TOTAL MARKS | : | **100** |
| SPECIAL REQUIREMENTS | : | **None** |
| EXAMINER'S NAME | : | **FUNANI. J** |

### INSTRUCTIONS TO CANDIDATES

i.    Answer **ALL** questions in **Section A** and **any THREE** from **Section B**

ii.    Each question in **Section B** carries **20 marks.**

iii.    Show any calculations and assumptions clearly.

iv.    Start each question on a fresh page.

$Boltman\ constant = 1.381\ X\ 10^{-23}\ J/K$

$eV = 1.602\ X\ 10^{-19}\ J$

## SECTION A

Answer Multiple Choice Questions 1 – 10 on the same page.

1. **The concentration of current carriers in an intrinsic semiconductor:**
   A. Is constant over a large temperature range
   B. Decreases exponentially with increase in temperature
   C. The current carriers' concentration depends on the type of semiconductor material only
   D. Increases exponentially with increase in temperature

2. **An N- type semiconductor is obtained by:**
   A. Inserting atoms of elements of valence III between semiconductor atoms
   B. Adding elements of valence III to an intrinsic semiconductor
   C. Converting the bonds between the atoms from covalent to ionic bonds
   D. Replacing some of the semiconductor atoms with atoms of an element of valence IV

3. **At room temperature, the current in an intrinsic semiconductor is due to**
   A. Holes and electrons
   B. Electrons
   C. Ions
   D. Holes

4. **Which of the following inserts a DC level in a waveform?**
   A. Clipper
   B. Clamper
   C. Amplifier
   D. Limiter

5. **In a Zener diode large reverse current is due to**
   A. Collision
   B. Presence of impurities
   C. Rapture of bonds
   D. Lower resistance in reverse biased region

6. **Which of the following diodes is operated in reverse bias mode?**
   A. P-N junction
   B. Zener
   C. Tunnel
   D. Schottky

7. **Which of the following components adds or restores a DC level to an electric signal?**
   A. Clamper
   B. Clipper
   C. Diode
   D. Transistor

8. **The equation that gives the relationship between the currents in a bipolar junction transistor (BJT) is**
   A. $IC = I_E + I_B$
   B. $IB = I_E + I_C$
   C. $IE = I_B - I_C$
   D. $IE = I_C + I_B$

9. **A Bipolar Junction Transistor (BJT) mode of operation when both the Emitter junction (EJ) and the Collector junction (CJ) are reverse biased:**
   A. Is called the 'saturation mode'

    B. A BJT does not allow both (EJ) and (CJ) to be reverse biased.

    C. Is called the 'cut-off' mode of operation

    D. Is called 'inverse active' mode of operation

10. **In common collector (cc) configuration the input and output parameters are:**

    A. Input: $I_B$ and $V_{CE}$; Output: $I_E$ and $V_{CE}$

    B. Input: $I_E$ and $V_{BE}$; Output: IB and $V_{CE}$

    C. Input: $I_B$ and $V_{CB}$; Output: IC and $V_{CB}$

    D. Input: $I_C$ and $V_{CB}$; Output; IB and $V_{CB}$

11. **Draw the output waveform produced by the circuit below** [3]



$$V_z = 5.6 \text{ V} \qquad V_z = 5.6 \text{ V}$$
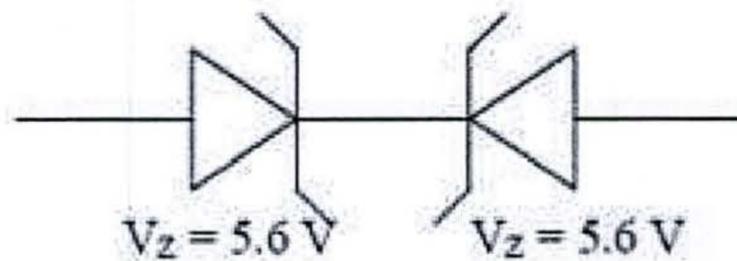
12. **Differentiate between drift current and diffusion current with respect to semiconductor materials** [2]

13. **With the aid of an energy band diagram, explain the difference between a metal, semiconductor and insulator in terms of the energy band diagram.** [6]

14. **Explain with suitable diagrams the formation of PN junction** [2]

15. **Explain the behavior of a P junction when forward biased** [4]

16. **Explain the behavior of a PN junction when reverse biased** [3]

## SECTION B

B111    For the circuit shown below, determine the current through and the voltage across the resistor R and the voltage across the diode. Assume Si diode.    [4]
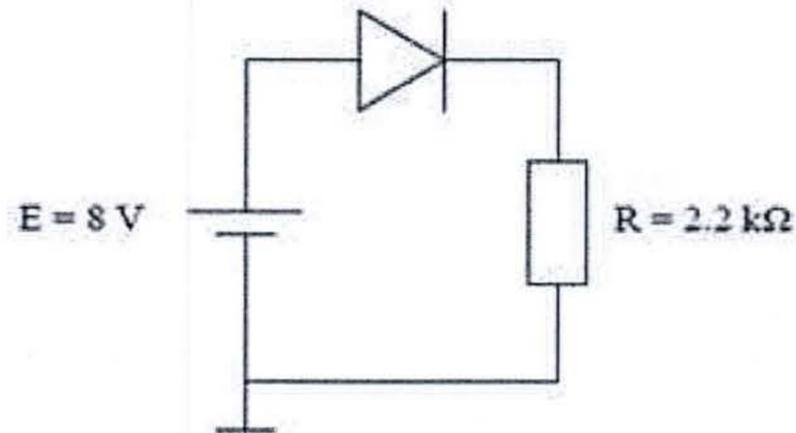


B112    With reference to BJT transistor operating regions, complete the following table with relevant information    [10]

|  | Bias mode | Emitter Junction (EJ) | Collector Junction (CJ) |
|---|---|---|---|
| Cutoff |  |  | Reverse |
|  |  | Forward | Reverse |
| Inverted |  | Reverse |  |
|  |  | Forward | Forward |

B113    A transistor has the following currents: IE = 15mA, IB = 60μA, calculate:    [6]
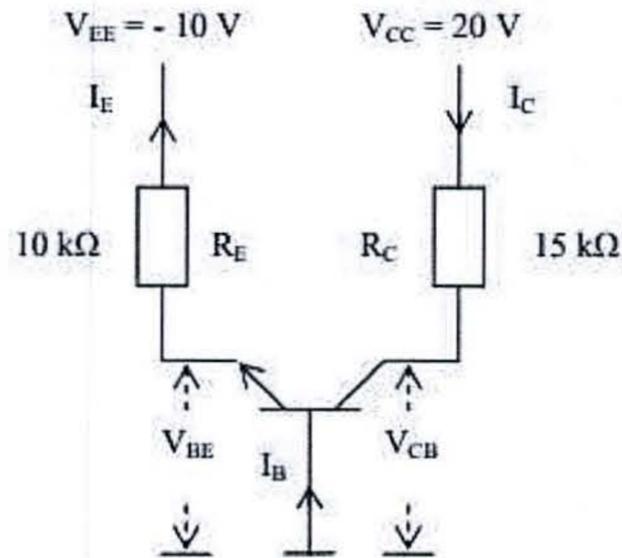
   i.    $\alpha_{dc}$

   ii.    $\beta_{dc}$

B211    Determine the current through the Resistor r for the circuit below    [4]
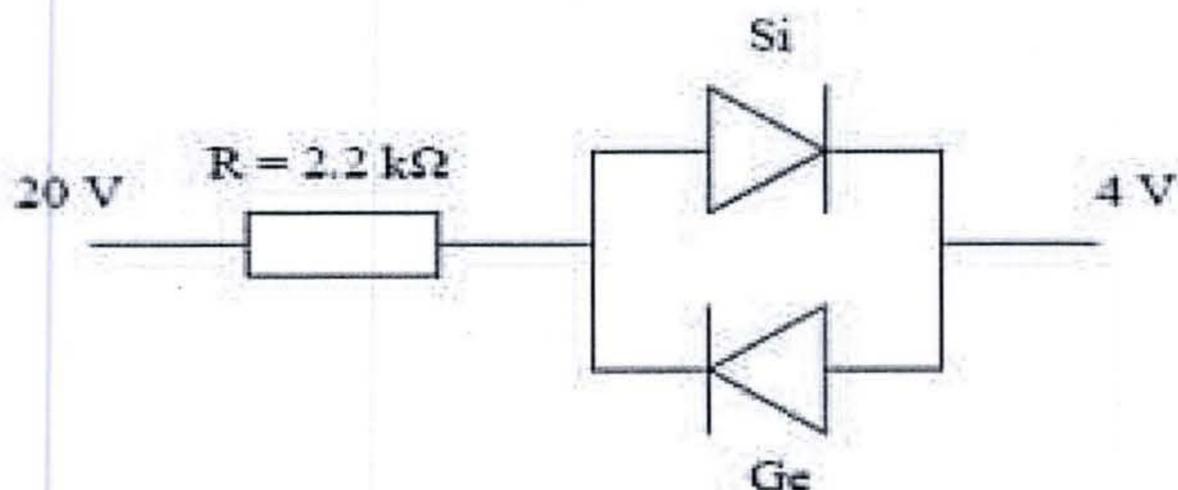
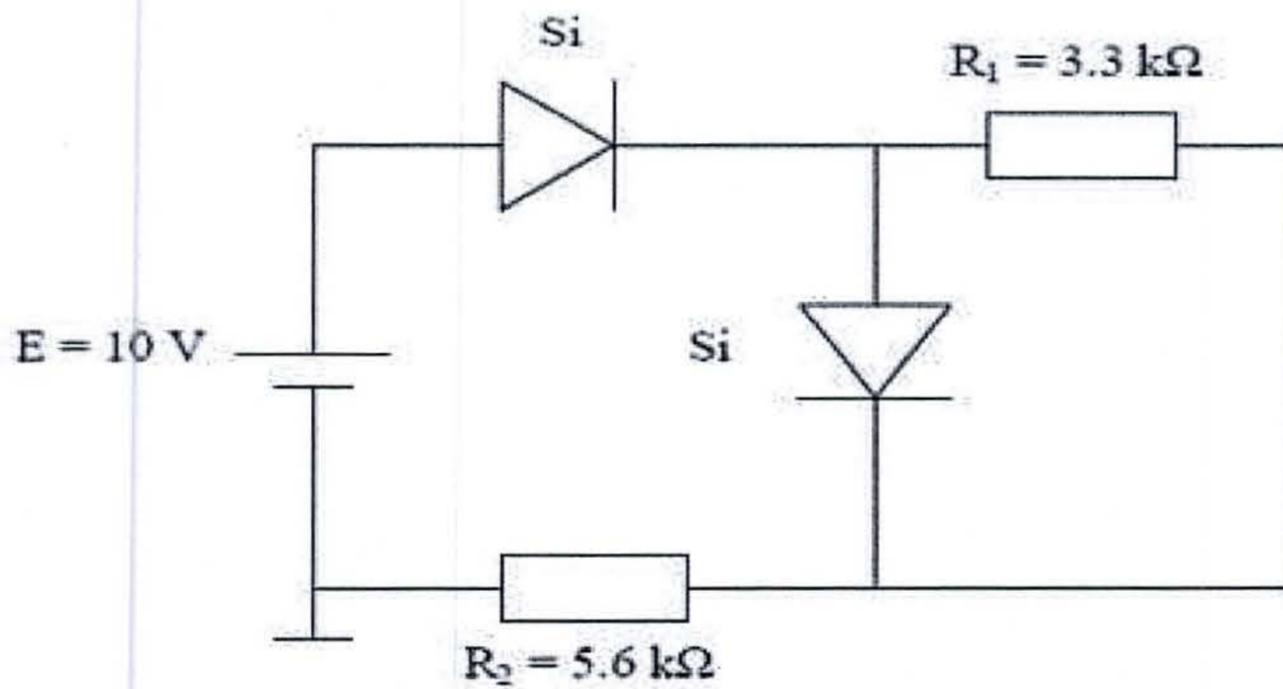B212    Given the NPN transistor in CB configuration mode, with $\beta = 100$ shown below, calculate                                                                    [8]
   i.    $I_E$
   ii.   $I_C$
   iii.  $V_{CB}$
   iv.   $I_B$



B213    Determine the current through and the voltage across each component for the circuit below                                                                       [8]
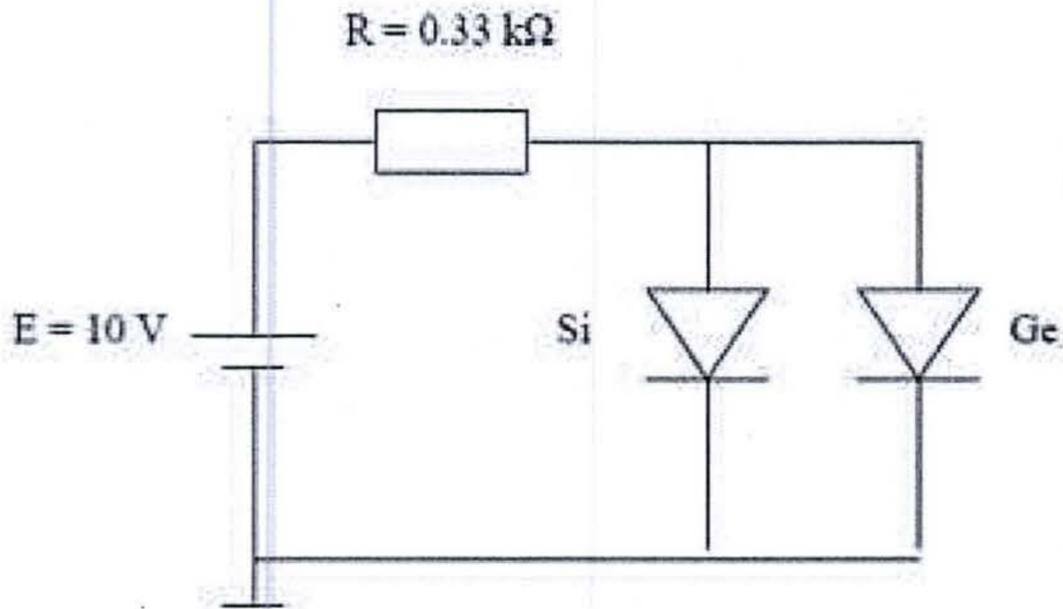
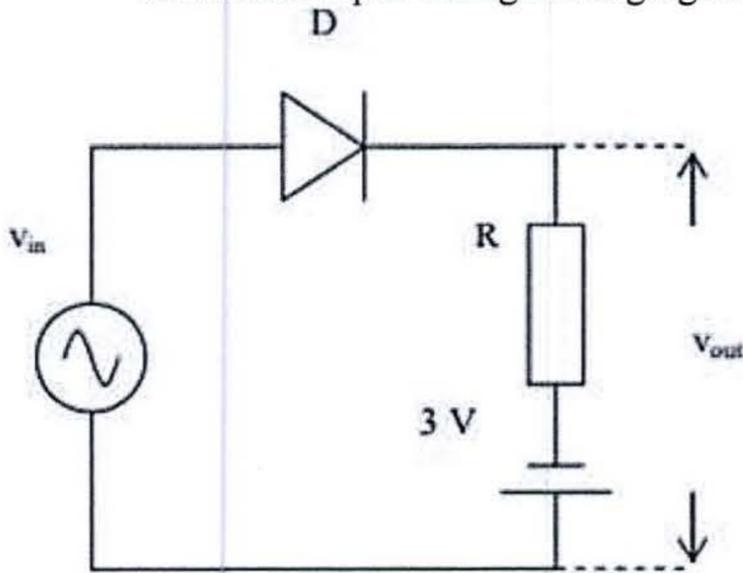

B311    For the circuit below, calculate                                                            [6]
   i.    The total current and the currents through the Si and the Ge diodes.
   ii.   The total current through the diodes if all the diodes were Si

$$R = 0.33 \text{ k}\Omega$$



B312    Given a Si diode with a reverse current ($I_R$) of 35nA at 25°C, calculate its reverse current at 100°C.                                                                          [4]
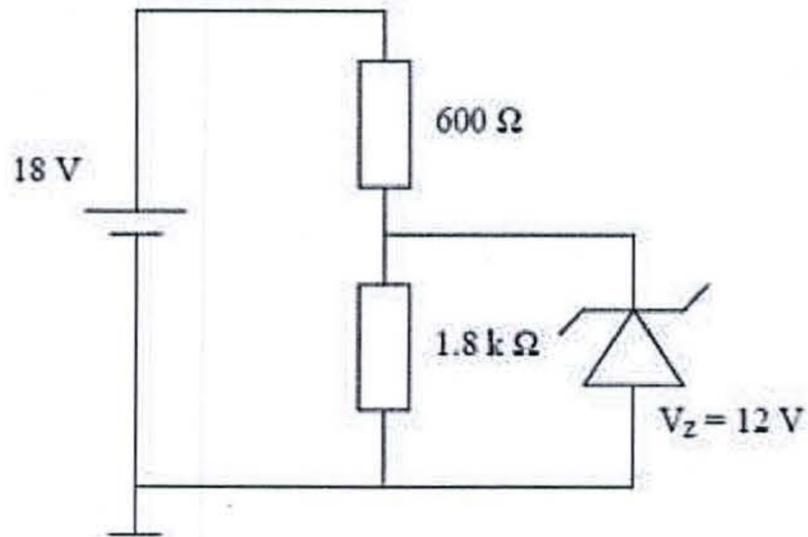
B313    For the clipper circuit below
   i.    Identify the name of the clipper
   ii.   Explain how the circuit works and draw the output waveform considering a sinusoidal input voltage swinging from -10 to +10 and an ideal diode          [10]



B411    Identify the circuit diagram below and hence produce its output waveform          [6]
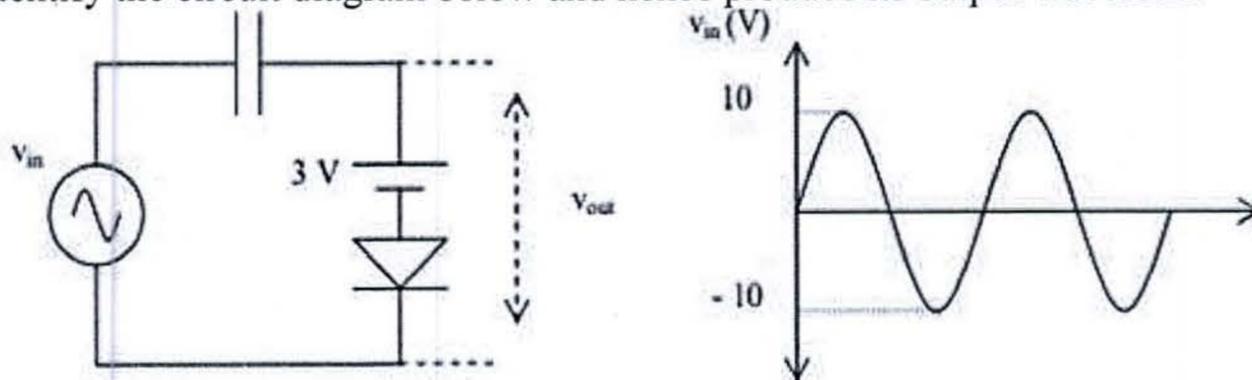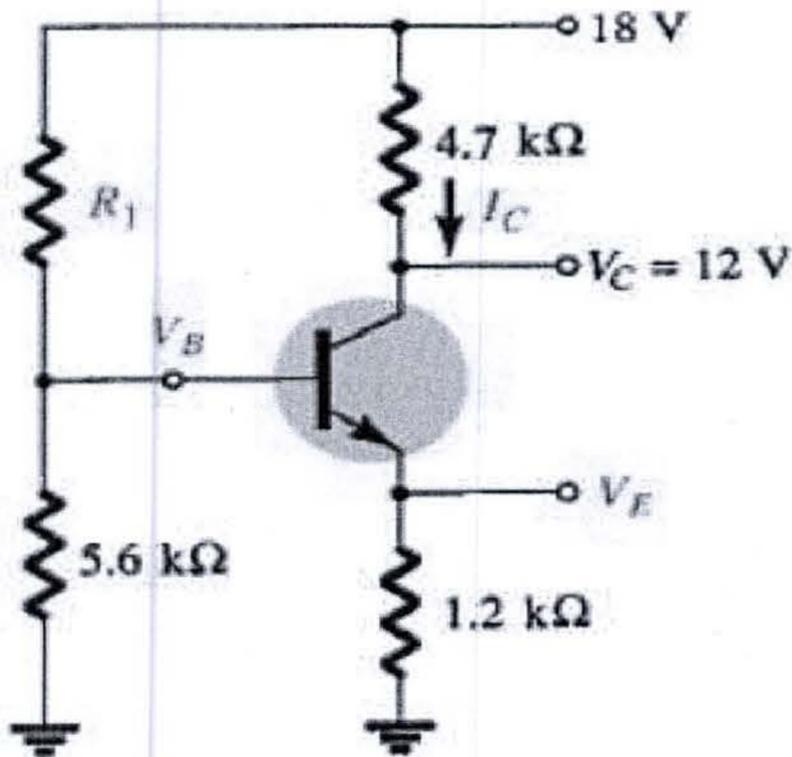


B412    Calculate the current through each resistor and zener diode                         [6]

B413    Draw the block diagram of a power supply and explain each block          [8]

B511    For the voltage divider bias configuration shown below, determine:          [10]
   i.    $I_C$
   ii.    $V_E$
   iii.    $V_B$
   iv.    $R_1$
   v.    $I_{C(sat)}$



B512    Define a rectifier          [1]

B513    Draw a full wave bridge rectifier circuit, explain its operation and draw its output waveform.          [9]