

**ELECTRONIC DEVICES
(ECEN 2204)**

Time Allotted: 2½ hrs

Full Marks: 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Effective masses of electron and hole in Valance band respectively are
 - (a) negative and positive
 - (b) positive and negative
 - (c) both are negative
 - (d) both are positive.
- (ii) Drift current in semiconductors depends upon
 - (a) only the electric field
 - (b) only the carrier concentration gradient
 - (c) both the electric field and the carrier concentration
 - (d) both the electric field and the carrier concentration gradient.
- (iii) Which one of the following devices can be used to generate microwave frequencies?
 - (a) Schottky diode
 - (b) Tunnel diode
 - (c) Photodiode
 - (d) None of these.
- (iv) The majority carriers in an n-type semiconductor have an average drift velocity $\mathbf{v}$ in a direction perpendicular to a uniform magnetic field $\mathbf{B}$. The electric field $\mathbf{E}$ induced due to Hall Effect acts in the direction
 - (a) $\mathbf{v} \times \mathbf{B}$
 - (b) $\mathbf{B} \times \mathbf{v}$
 - (c) along $\mathbf{v}$
 - (d) opposite to $\mathbf{v}$
- (v) A Zener diode works on the principle of
 - (a) tunnelling of charge carriers across the junction
 - (b) thermionic emission
 - (c) diffusion of charge carriers across the junction
 - (d) hopping of charge carriers across the junction.
- (vi) If the emitter base junction of a BJT is forward biased and collector base junction is reverse biased, then identify the operating mode of the BJT.
 - (a) Saturation mode
 - (b) Forward active mode
 - (c) Reverse active mode
 - (d) Cut off mode

- (vii) If V is the voltage applied to the metal with respect to the p-type semiconductor in a MOS capacitor, then $V < 0$ corresponds to
 (a) accumulation (b) depletion
 (c) inversion (d) strong inversion.
- (viii) Choose proper substitutes for X & Y to make the following statement correct. Tunnel diode and Avalanche photodiode are operated in X -bias and Y -bias respectively.
 (a) X : Reverse, Y : Reverse (b) X : Reverse, Y : Forward
 (c) X : Forward, Y : Reverse (d) X : Forward, Y : Forward
- (ix) The Early effect in a bipolar junction transistor caused by
 (a) fast turn-on
 (b) fast turn-off
 (c) increase in collector-base reverse bias
 (d) increase in emitter-base forward bias.
- (x) The channel length modulation effect of MOSFET is observed in
 (a) linear mode (b) saturation mode
 (c) cut-off mode (d) both linear & saturation modes.

Fill in the blanks with the correct word

- (xi) A Zener diode in its breakdown region is practically used for _____ regulation.
- (xii) When the collector junction and the emitter junction both are forward biased, the transistor is said to be in the _____ mode.
- (xiii) Reverse saturation current in a p-n junction is caused due the drifting of _____ carriers across the junction.
- (xiv) The threshold voltage of an n-type enhancement type MOSFET is 0.5V. When the device is biased at a gate voltage of 3V, pinch-off would occur at drain voltage of _____.
- (xv) A MOSFET can be used as an amplifier in _____ region of operation.

Group - B

- 2 (a) Describe the direct band gap semiconducting material with proper E-k diagram and mention its application in electronic devices. [[C02](Remember/LOCQ)]
- (b) Discuss the effects of doping & temperature on Fermi energy level in semiconductor. [[C02](Analyze/IOCQ)]
- (c) In a n-type semiconductor at $T=300K$, the electron concentration varies linearly from 2×10^{18} to 5×10^{17} per cc over a distance of 1.5mm and the diffusion current density is 360 A/cm^2 . Find the mobility of electrons. [[C01](Apply/IOCQ)]
- (d) Show that, the excess carrier recombination rate is directly proportional with the change in minority carrier concentration in a semiconducting specimen. [[C01](Understand/LOCQ)]

3 + 3 + 3 + 3 = 12

3. (a) Evaluate the electron concentration in conduction band of semiconductor under equilibrium. [[CO1](Evaluate/HOCQ)]
- (b) Under thermal equilibrium, show that, $n_o p_o = n_i^2$; is equal to a constant; where n_o , p_o and n_i are electron concentration in conduction band, hole concentration in valance band & intrinsic carrier concentration respectively under thermal equilibrium. [[CO1](Apply/IOCQ)]
- (c) Explain the concept of quasi-Fermi energy level with proper energy band diagrams. [[CO2](Understand/LOCQ)]

4 + 4 + 4 = 12

Group - C

4. (a) Derive the expression of junction capacitance per unit cross sectional area of an abrupt p-n junction. [[CO2](Apply/IOCQ)]
- (b) Describe the basic operation of a solar cell and draw the V-I characteristic. [[CO4](Remember/LOCQ)]
- (c) Distinguish between the Zener & avalanche breakdown mechanisms. [[CO2](Apply/IOCQ)]

4 + 5 + 3 = 12

5. (a) Explain the operating principle of a Tunnel diode along with V-I characteristic and proper energy band diagrams. [[CO5](Understand/LOCQ)]
- (b) Explain the formation of a metal semiconductor Schottky contact with proper energy band diagram. [[CO6](Create/HOCQ)]
- (c) Explain the formation of 2-D electron gas in hetero-junction with proper example and band diagram. [[CO6](Create/HOCQ)]

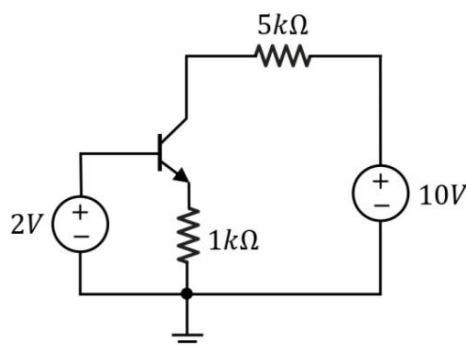
5 + 4 + 3 = 12

Group - D

6. (a) Describe all the current components in a pnp BJT with proper diagram. [[CO4](Understand/LOCQ)]
- (b) Draw and explain the minority carrier distribution profile for npn BJT operating in forward active mode. [[CO4](Apply/IOCQ)]
- (c) Explain the effects of Early Effect on the input & output characteristics of CE mode npn BJT. [[CO4](Analyze/IOCQ)]

4 + 4 + 4 = 12

7. (a) Develop Hybrid-Pi model for an npn BJT in CE configuration. [[CO4](Create/HOCQ)]
- (b) For the BJT circuit shown in the figure, assume that the β of the transistor is very large and $V_{BE} = 0.7V$. Find the operating mode of the given BJT. Also evaluate the values of collector current I_C and output voltage V_{CE} . [[CO4](Apply/IOCQ)]



7 + 5 = 12

Group - E

8. (a) Write voltage-current relations for n-channel MOSFET under linear and saturation modes. [[C04](Remember/LOCQ)]
(b) Draw and explain the small signal equivalent model of an n-channel MOSFET and simplify it for low frequency cases. [[C06](Analyze/IOCQ)]
4 + (6 + 2) = 12
9. (a) Explain the formation of inversion and depletion layers in a MOS structure with p-type substrate using proper energy band diagram. [[C05](Analyze/IOCQ)]
(b) Plot the drain and transfer characteristics of n-channel depletion type MOSFET under both enhancement and depletion modes. [[C02](Understand/LOCQ)]
(c) Design an inverter circuit using CMOS technology and explain its operation. [[C04](Create/HOCQ)]
4 + 4 + 4 = 12
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	43.75	22.92

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply the previous knowledge of basic electronics engineering to appreciate the contents of this paper.
2. Understand both the particle and wave natures of electrons in Solid State Devices.
3. Identify unknown extrinsic semiconductor type using Hall Effect.
4. Describe working principles of different devices using mathematical models and energy band diagrams.
5. Justify different operations of solid state devices using relative position of Fermi energy levels across p-n junctions in devices.
6. Evaluate performance of different hetero junctions in semiconductor devices.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*