ELECTRONIC DEVICES
(ECE2205)

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) The majority carriers in an n-type semiconductor have an average drift velocity **v** in a direction perpendicular to a uniform magnetic field **B**. The electric field **E** induced due to Hall Effect acts in the direction
(a) **v** x **B** (b) **B** x **v**
(c) along **v** (d) opposite to **v**

(ii) Electron transition in indirect bandgap semiconductor involves
(a) a change of momentum of electron only
(b) a change of potential energy of electron only
(c) change of both the momentum & potential energy of electron
(d) none of these

(iii) A Zener diode in breakdown region 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

(iv) In a uniformly doped abrupt p-n junction, the doping level of the n-side is 4 times the doping level of the p-side. The ratio of the depletion layer width of n-side versus p-side is
(a) 0.25 (b) 0.5
(c) 1.0 (d) 2.0

(v) 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

(vi) In which one of the following modes of operation the E_F of base region remains lower than the E_F of both the emitter and collector regions for an npn BJT?
(a) saturation mode
(b) cut-off mode
(c) forward active mode
(d) reverse active mode

(vii) Which one of the following is a small signal model for BJT?
(a) Ebers-Moll model
(b) Gummel-Poon model
(c) Hybird-Pi model
(d) none of these

(viii) 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

(ix) At threshold inversion point in a MOS structure, the relation between surface potential $\phi_s(inv)$ and Fermi potential ϕ_F of the semiconductor body is
(a) $\phi_s(inv) = (\phi_F)^2$
(b) $\phi_s(inv) = \phi_F/2$
(c) $\phi_s(inv) = \phi_F$
(d) $\phi_s(inv) = 2\phi_F$

(x) In an n-channel enhancement type MOSFET what happens when $V_{GS}<V_T$?
(a) The MOSFET conducts maximum current.
(b) The MOSFET is in the cut-off mode.
(c) The MOSFET is in the saturation mode.
(d) The MOSFET is in the triode region.

Fill in the blanks with the correct word

(xi) Effective mass of electron is _____ inside valence band.

(xii) The dc current gain of BJT is 50. Assuming that the emitter injection efficiency is 0.995, the base transport factor is _____.

(xiii) A MOSFET can be used as an amplifier in _____ region of operation.

(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) For n-channel MOSFET device we always choose _____-type substrate.

Group - B

2. (a) Define density of states and plot it as a function of energy for both the conduction and valance bands. *[(CO2)(Understand/LOCQ)]*

(b) Discuss the effects of doping & temperature on Fermi energy level in semiconductor with proper plots. *[(CO2)(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. *[(CO2)(Apply/IOCQ)]*

4 + 4 + 4 = 12

3. (a) Explain the concept degeneracy in p-type doped semiconductor with proper energy band diagram. *[(CO2)(Understand/LOCQ)]*

(b) Derive the expression for drift current density due to electrons in a semiconductor. *[(CO2)(Apply/IOCQ)]*

(c) Can effective mass of electron be negative? Explain. *[(CO2)(Analyze/IOCQ)]*

(d) A silicon sample A is doped with 10^{18} atoms/cm^3 of Boron. Another sample B of identical dimension is doped with 10^{17} atoms/cm^3 of Phosphorous. The ratio of electron to hole mobility is 3. Find the ratio of conductivity of the sample A to B. *[(CO2)(Evaluate/HOCQ)]*

3 + 3 + 3 + 3 = 12

Group - C

4. (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. *[(CO3)(Create/HOCQ)]*

(c) Explain the formation of 2-D electron gas in hetero-junction with proper example and band diagram. *[(CO3)(Create/HOCQ)]*

5 + 4 + 3 = 12

5. (a) Explain the formation of a semiconducting hetero-structure of rectifying nature with proper energy band diagram. *[(CO3)(Create/HOCQ)]*

(b) Define maximum power efficiency and fill factor for Solar cell. *[(CO4)(Understand/LOCQ)]*

(c) Derive the expression of diffusion capacitance for a p-n junction and plot it against biasing voltage. *[(CO4)(Apply/IOCQ)]*

4 + 4 + 4 =12

Group - D

6. (a) Explain the Eber's Moll Model of BJT and write the current equations. *[(CO4)(Analyse/IOCQ)]*

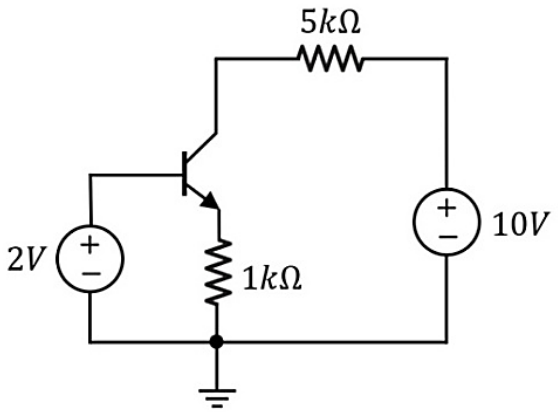
(b) Explain punch through in BJT with proper energy band diagram. *[(CO4)(Understand/LOCQ)]*

(c) An n-p-n transistor at room temperature has its emitter open circuited. A voltage of 5V is applied between collector and base with collector positive and a current of 0.2 μA flows. When the base is open circuited and the same voltage is applied between collector and emitter, the current is found to be 20 μA. Find α, I_E and I_B, when collector current is 1mA. *[(CO5)(Apply/IOCQ)]*

6 + 3 + 3 = 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}. *[(CO5)(Apply/IOCQ)]*



7 + 5 = 12

Group - E

8. (a) Explain the operation of an n-channel enhancement type MOSFET along with V-I characteristics. *[(CO6)(Understand/LOCQ)]*

(b) Write voltage-current relations for n-channel MOSFET under linear and saturation modes. *[(CO4)(Remember/LOCQ)]*

(c) What is channel length modulation? How does it affect the voltage-current relation of n-channel MOSFET devices? *[(CO4)(Analyze/IOCQ)]*

5 + 4 + 3 = 12

9. (a) Explain the formation of accumulation layer in a MOS structure with p-type substrate using proper energy band diagram. Can this layer be used as channel? –explain. *[(CO6)(Analyze/IOCQ)]*

(b) Define flat band voltage and threshold voltage for MOS devices. *[(CO6)(Understand/LOCQ)]*

(c) Consider an ideal n-channel MOSFET with channel length L=1.25μm, μ_n= 650cm^2/V-s, C_{ox}=6.9 × 10^{-8} F/cm^2 and V_T= 0.65V. If the saturation drain current I_D (sat)= 4mA for V_{GS}= 5V, evaluate the channel width W. *[(CO4)(Evaluate/HOCQ)]*

(3 + 2) + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	41.67	25.00