MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

EC-302

SOLID STATE DEVICE

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. 10×1 = 10

(i) When a positive voltage is applied to a p-n junction structure the barrier potential

(A) increases (B) decreases (C) remains same (D) none of these

(ii) Electron transition in in-direct band gap semiconductor involves

(A) a change of momentum of electron
(B) dependence on band gap
(C) no change of momentum of electron
(D) none of these

(iii) Effective electron mass depends on

(A) curvature of band (B) band gap
(C) doping concentration (D) temperature

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(iv) Intrinsic carrier concentration of a given semiconductor depends on

(A) bandgap (B) temperature
(C) bandgap and temperature (D) none of these

(v) Metal *n*-type semiconductor form ohmic contact if

(A) $\varphi_m > \varphi_{sn}$ (B) $\varphi_m = \varphi_{sn}$ (C) $\varphi_m < \varphi_{sn}$ (D) none of these

(vi) In Schottky barrier diode, the current mechanism is due to

(A) minority carrier (B) majority carrier
(C) both (A) and (B) (D) none of these

(vii) When a transistor is used as switch its operation is confined to

(A) Cut-off region (B) Saturation region
(C) Active region (D) Both (A) and (B)

(viii) Above pinch off voltage in a JFET the drain current

(A) decreases (B) increases sharply
(C) remains constant (D) both (A) and (B)

(ix) If V is the voltage applied to the metal with respect to p-type semiconductor in a MOS capacitor then V < 0 corresponds to

(A) accumulation (B) depletion
(C) inversion (D) strong inversion

(x) Capacitance of varactor diode can be changed by varying

(A) doping (B) biasing
(C) size of the diode (D) all of these

(xi) A transistor connected in CB configuration has

(A) high input resistance and low output resistance
(B) low input resistance and high output resistance
(C) low input resistance and low output resistance
(D) high input resistance and high output resistance

(xii) Quadrant of I-V plot relevant to operation of solar cell is

(A) 1st (B) 2nd (C) 3rd (D) 4th

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GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. Compare 'drift' and 'diffusion' transport in a semiconductor. Derive the Einstein Relation. 2+3

3. What is a hetero-junction? How many types of hetero-junctions are possible? Draw the band diagrams of each types of hetero-junction, considering straddling. 1+1+3

4. What is photovoltaic effect? Write down the operating principle of solar cell. 2+3

5. Sketch the cross section view of p-channel Depletion MOSFET and explain with neat sketch the output characteristics and transfer characteristics. 5

6. What is power transistor? What are the special features of power transistor? Compare with small signal BJT? 1+3+1

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

7. (a) What is Hall field? Why Hall Effect is important in semiconductor physics? How can we calculate mobility of electron in p type semiconductor using Hall Effect? 3+2+4

   (b) In a Hall experiment length of semiconductor specimen $L = 10^{-1}$ cm, width $W = 10^{-2}$ cm and depth $d = 10^{-3}$ cm and current through semiconductor substrate $I_x = 1.0$ mA, applied voltage $V_x = 12.5$ V, magnetic flux density $B_z = 500$ gauss, Hall voltage $V_H = -625$ mV. What type of majority carrier is there in semiconductor substrate? Calculate majority carrier concentration and mobility. 1+2

   (c) What is quasi-Fermi level? 3

8. (a) Derive expressions for Built-in potential. 5

   (b) Define the diffusion capacitance of p-n junction diode and derive its expression. 5

   (c) For a silicon one-sided abrupt junction with $N_A = 2 \times 10^{19}cm^{-3}$ and $N_D = 8 \times 10^{15}cm^{-3}$, calculate the junction capacitance at zero bias and reversed bias of 4V (T=300K). 5

9. (a) Explain working principle of Schottky Diode. 4

   (b) Describe punch-through effect in BJT. 2

   (c) For an ideal p-n-p transistor, the current components are given by $I_{Ep} = 3$ *mA*, $I_{En} = 0.01$ *mA*, $I_{Cp} = 2.99$ *mA*, and $I_{Cn} = 0.001$ *mA*, Determine (i) the emitter efficiency γ, (ii) the base transport factor α_T, (iii) the common-base current gain α_o and (iv) I_{CBO}. 4

   (d) Explain working principle of PNPN transistor. 5

10. (a) What is flat band voltage in case of ideal MOSFET? 3

    (b) How and why threshold voltage V_T in case of real MOSFET depends on semiconductor doping, oxide charge and oxide thickness? 5

    (c) An ideal p-channel MOSFET has following parameters: $W = 15\mu m$, $\mu_p = 300cm^2/V\text{-}s$, $L = 1.5\mu m$, $t_{ox} = 350Å$ and $V_{TP} = -0.80V$. If transistor is operating in non-saturation region at $V_{DS} = 0.5$ V, then calculate value of Transconductance g_m? 4

    (d) What is the effect of reduction in channel length as drain voltage is increased in MOSFET characteristics? 3

11. Write short notes on any *three* of the following: 3×5

    (a) Tunnel diode

    (b) MOS capacitance

    (c) Effective mass

    (d) Ebres-Moll Model

    (e) Photo transistor.