SOLID STATE DEVICES
(ECEN 2204)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Electron effective mass depends on
(a) Temperature (b) Doping concentration
(c) Band gap (d) Curvature of band.

(ii) The band gap of silicon at room temperature is
(a) 1.4ev (b) 1.1eV (c) 1.3eV (d) 0.7eV.

(iii) The substrate bias effect in MOSFET results in
(a) change in the value of threshold voltage
(b) increase in the value of transconductance
(c) increase in the value of output resistance
(d) decrease in the value of transconductance

(iv) The channel length modulation effect in MOSFET is observed in
(a) cut-off mode (b) linear mode
(c) saturation mode (d) both (b) and (c).

(v) Which of the following has a negative resistance region?
(a) Zener diode (b) Photodiode (c) Tunnel diode (d) LED.

(vi) At 0K, the acceptor energy level
(a) is filled with electrons
(b) is empty
(c) accepts electrons from the valence band due to overlapping
(d) excites electrons to the conduction band.

(vii) An infra-red LED is usually fabricated from
(a) Ge (b) Si (c) GaAsP (d) None of the above.

(viii) The depletion capacitance C_j of an abrupt p-n junction with constant doping on either side varies with reverse bias V_R as,

(a) $C_j \alpha V_R$ (b) $C_j \alpha V_R^{-1}$

(c) $C_j \alpha V_R^{-1/2}$ (d) $C_j \alpha V_R^{-1/3}$

(ix) When BJT operates in the forward active mode

(a) Emitter-base junction forward biased, collector-base junction reverse biased
(b) Emitter-base junction reverse biased, collector-base junction reverse biased
(c) Emitter-base junction forward biased, collector-base junction forward biased
(d) None of the above.

(x) Piezoelectricity is exhibited by

(a) Silicon (b) Quartz (c) Germanium (d) GaAs.

Group – B

2. (a) Explain the concepts of direct and indirect band-gap materials with proper *E-k* diagrams.

(b) Define density-of-states and plot it for bulk semiconductors. Show the effective mass of electron is negative in the valence band. Explain the concept of negative and positive effective mass.

4 + (2 + 3 + 3) = 12

3. (a) Define Hall effect and how it can be used to identify unknown semiconductor type.

(b) Explain the concept of Quasi-Fermi energy level for the *p-n* junction. Explain the effects of doping and temperature on the Fermi energy level with proper plots.

5 + (4 + 3) = 12

Group – C

4. (a) Briefly describe the principle of operation of the Tunnel diode using proper energy band diagram and draw its *I-V* characteristics.

(b) Explain the principle of operation of solar cell. Draw its I-V characteristics and define Fill Factor.

7 + 5 = 12

5. (a) Derive the expression of built-in potential across a p-n junction with constant donor and acceptor concentrations. Also draw the charge density and electric field profile.

(b) Draw the energy band diagram of forward biased *p-n* junction with proper references. Explain the formation of 2D electron gas in a heterostructure with proper energy bad diagram.

6 + (3 + 3) = 12

Group – D

6. (a) Draw and explain the energy band diagram of the *n-p-n* transistor under zero bias and forward active mode.

   (b) Draw and explain the current components in the *n-p-n* transistor. Explain early effect with proper diagram.

4 + (5 + 3) = 12

7. (a) Draw and explain the minority carrier concentration profile in the BJT.

   (b) Describe the Hybrid-Pi model of *n-p-n BJT* in *CE* mode and draw the equivalent circuit.

5 + (5 + 2) = 12

Group – E

8. (a) Distinguish between the transfer and drain characteristics of *n*-channel depletion type and enhancement type MOSFET. Write down the conditions and linear & saturation mode expressions of current for *n*-channel enhancement type MOSFET.

   (b) Which type of MOSFET is suitable for switching applications – depletion or enhancement type? Justify your answer.

(6 + 3) + 3 = 12

9. (a) Explain the formation of inversion layer in a MOSFET with *p*-type substrate.

   (b) Draw and explain the small-signal equivalent model of an *n*-channel enhancement type MOSFET and simplify it for low frequency case.

5 + (5 + 2) = 12

Department & Section	Submission Link
ECE	https://classroom.google.com/w/Mzc0MjgxMjA3Mzkw/tc/Mzc0MjgxMjA3NDQ3