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National Institute of Technology, Delhi

Name of the Examination: B. Tech (Make Up)

Branch	: ECE	**Semester**	: III
Title of the Course	: Solid State Devices	**Course Code**	: ECB 201

Time: 3 Hours **Maximum Marks: 50**

Note:

- **Questions are printed on BOTH sides. Answers should be CLEAR ANDTO THE POINT.**
- **All parts of a single question must be answered together. ELSE QUESTION SHALL NOT BE EVALUATED.**

Use following data if not given in a problem: ε_o = 8.85x10^{-14}F/cm, ε_r (SiO_2) = 3.9, ε_r (Si) = 11.8, At room temperature for Si [μ_n = 1350cm^2/V·S, μ_p = 480 cm^2/V·S, n_i = 1.5x10^{10}/cm^3, E_g = 1.12 eV], k = 8.62 x10^{-5}ev/K, $\tau_n = \tau_p$= 1μs, E_g(Ge) = 0.7 eV, n_i(Ge)= 2.5x10^{13}/cm^3.

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1. Comment on the following with brief and to the point logical explanation: [1+1+1+2]

   (a) Variation of band gap with doping.
   (b) Variation of band gap with temperature.
   (c) Variation of lattice controlled mobility with temp.
   (d) Variation of intrinsic carrier concentrations (n_i) with temp and band gap (E_g).

2. Write brief note on followings: [2 * 5 = 10]

   (a) Thermal Runway
   (b) Base narrowing effect and early effect
   (c) Enhancement mode MOSFET
   (d) p-i-n diode
   (e) Hall effect

3. A metal-semiconductor (MS) junction is made between a metal of work function $q\varphi_m$ = 4.6 eV and a p-type Si doped with 1.5x10^{14} /cm^3 at room temp. Sketch and label the energy band diagrams across the MS junction before contact and after contact. [$q\chi_{Si}$ = 4.05 eV]. [2.5 + 2.5]

4. Consider a Ge crystal at room temperature doped with 5x10^{17} /cm^3 As atoms. Find equilibrium electron, hole concentrations and position of the Fermi level w.r.t intrinsic energy level (E_i) and conduction energy band (E_c). Draw the energy band diagram also. [5]

5. For a Si bar having length 4 μm. doped n-type at 10^{17} /cm^3. Calculate the current for an applied voltage of 2 V having a cross sectional area of 0.01 cm^2. If the voltage is now raised at 100 V what will be the change in current? Electron and hole mobility are 1350 cm^2/V-sec and 400 cm^2/ V-sec for low electric field. For higher field, saturation velocity for electron is V_s = 10^7 cm/sec. [5]

6. Consider a Si sample kept at room temperature having band gap E_g = 1.12 eV. [5]

(a) If the Fermi level E_F, is located exactly at the middle of the band gap for this sample, then what will be the probability of finding an electron at $E = E_C + 2KT$.

(b) If the Fermi level E_F, is located such that $E_F = E_V$, then what will be the probability of finding an electron at $E = E_V + KT$.

Note: Put *"Tick (√)" Marks* on the write option wherever applicable (Bold) / *Fill in the blanks.*

7. (a) In an *npn* $Si/Si_{1-x}Ge_x$ heterojunction bipolar transistor (HBT), base is **heavily/ lightly** doped and increases the **hole/ electron** injection efficiency. [2]

(b) Body or substrate bias effect **increases/ decreases** the current in MOSFETs and Boron ion implantation **increases/ decreases** the threshold voltage (V_T) in n-channel MOSFETs. [2]

(c) Usually in MOS scaling, the oxide layer thickness **increases/ decreases** and gate capacitance of the device **increases/ decreases.** [2]

(d) Substrate leakage current in n-MOS devices are due to secondary **electrons/ holes** and this current **increases/ reduces** at higher gate voltage. [2]

(e) Avalanche breakdown voltage **increases/ decreases** as band gap of the semiconductor increases and this voltage **increases/ decreases** as doping of the lighter region decreases. [2]

(f) The probability of finding an electron at an energy level 4kT above the Fermi level would be ___0.0183______and number of electrons would be 0.0183×10^{19} /cm^3 if the density of states is 10^{19} /cm^3. [2]

(g) For a Si at a given temperature it is found that 1×10^{10} electrons/ cm^3 have moved from valance band (VB) to conduction band (CB) when density of atoms is 10^{22} /cm^3. Then number of holes in the VB would be _____10^{10}______ and this will be a factor of value ________10^{-11}______ of the total available electrons in the VB. [3]

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