


Name:			
Enrolment No:			
UPES End Semester Examination, May 2023			
Course: Physics of Semiconductor Devices		Semester: II	
Program: B. Tech Electronics and Communication Engineering, Electronics and Computer Engineering			
Course Code: Phys 2202		Time: 03 hrs. Max. Marks: 100	
Instructions: The variables used in the text and equations having their usual meaning as introduced in the lectures. Boltzmann's constant, $k=1.38 \times 10^{-23}$ Joule/K, Charge on electron, $q=1.6 \times 10^{-19}$ C.			
SECTION A			
S. No.		Marks	CO
Q 1	(i) Which one of the following is trivalent material? (a) Antimony (b) Phosphorus (c) Arsenic (d) Boron (ii) In a material, the Fermi-level is located between the center of the forbidden band and the conduction band. Then what is that material? (a) A p-type semiconductor (b) An n-type semiconductor (c) An intrinsic semiconductor (d) An insulator (iii) As per Hall effect, if any specimen carrying a current, I is placed in a transverse magnetic field B, then an electric field E is induced in the specimen in the direction (a) Parallel to I (b) Perpendicular to B and parallel to I (c) Parallel to I and B (d) Perpendicular to both I and B (iv) The minimum energy of a photon required for intrinsic excitation is equal to (a) The energy of the bottom of the conduction band (b) The energy of the top of the valence band (c) Forbidden gap energy (d) Fermi energy	4	CO1
Q 2	(i) Atomic number of silicon is (a) 12 (b) 13 (c) 14 (d) 15 (ii) The diffusion length for holes L_p , is the (a) Average distance which an injected hole travels before recombining with an electron (b) Maximum distance travelled by a hole before recombining with an electron (c) Length of the region in which diffusion takes places (d) Minimum distance travelled by a hole before it recombines with an electron	4	CO1

	<p>(iii) When donor atoms are added to the semi-conductor,</p> <p>(a) Increases the energy band gap of the semiconductor</p> <p>(b) Decreases the energy band gap of the semiconductor</p> <p>(c) Introduces a new discrete energy level below the conduction band</p> <p>(d) None of above</p> <p>(iv) Doping intrinsic Silicon with Arsenic as an impurity</p> <p>(a) Produces a semiconductor in which the charge carriers are predominantly electrons, but holes are also present</p> <p>(b) Produces a semiconductor in which the charge carriers are predominantly holes but free electrons also present</p> <p>(c) Produces a semiconductor in which the charge carriers contain a nearly equal number of electrons and holes</p> <p>(d) None of above</p>		
Q 3	Explain the mechanism of avalanche and Zener breakdown in the p-n junction diode.	4	CO2
Q 4	The diffusion coefficient of an electron at room temperature, T=300K is 35 cm ² /sec. Find the mobility of an electron in Si at room temperature. Give the units of mobility also.	4	CO1
Q 5	Draw the V-I characteristics of p-n junction photodiode. Does the current correspond to a forward- or reverse- biased diode?	4	CO3
SECTION B			
Q 6	<p>(i) Draw the energy band diagram of insulator, semiconductor, and insulator.</p> <p>(ii) Explain why a semiconductor acts as insulator at 0⁰K and why its conductivity increases with temperature?</p> <p>(iii) A Si sample is doped with 10¹⁷ arsenic atoms/cm³, what is the equilibrium concentration p₀ at 300K? Given that n_i=1.5 x 10¹⁰ cm³.</p>	10	CO1
Q 7	A Si p-n junction with cross-sectional area, A=0.001 cm ² is formed with N _A =10 ¹⁵ cm ⁻³ , N _D =10 ¹⁷ cm ⁻³ , calculate the contact potential and space-charge width at zero bias.	10	CO1
Q 8	Prove that the junction capacitance due to the dipole in the depletion region is given by $C_j = \epsilon A \left[\frac{q}{2\epsilon(V_0 - V)} \frac{N_A N_D}{N_A + N_D} \right]^{1/2}$.	10	CO2
Q 9	<p>(i) Draw the I-V curves of solar cell at different irradiance.</p> <p>(ii) A Si solar cell has a short circuit current of 100 mA and an open circuit voltage of 0.8V under one Sun illumination. The fill factor is 0.7. What is the maximum power delivered to a load by this cell?</p>	10	CO3

SECTION-C

<p>Q 10</p>	<p>What is the law of junction? Plot the hole current, the electron current, and the total current as a function of distance on both sides of a p-n junction. Prove that the total diode current is given by the following equation:</p> $I = I_0 \left[e^{\frac{qV}{kT}} - 1 \right] \quad \text{where } I_0 = Aq \left[\frac{D_p p_{n0}}{L_p} + \frac{D_n n_{p0}}{L_n} \right]$ <p>Given that the current associated with diffusion of minority carriers (holes) is given by $I_p = \frac{AqD_p}{L_p} [p(0) - p_0]e^{-x/L_p}$</p>	<p>20</p>	<p>CO2</p>
<p>Q 11</p>	<p>(i) Sketch the basic structure of an n-channel junction field effect transistor. Show the circuit symbol for the JFET.</p> <p>(ii) Define the pinch-off-voltage, V_p. Sketch the depletion region before and after the pinch-off.</p> <p>(iii) Show that the pinch-off voltage is given by $V_p = \frac{qa^2N_D}{2\epsilon}$</p> <p style="text-align: center;">OR</p> <p>(i) Sketch the basic structure of an enhancement type n-channel MOSFET. Show the circuit symbol for it.</p> <p>(ii) Discuss the basic operation of an enhancement type n-channel MOSFET.</p> <p>(iii) Draw the output and transfer characteristics of enhancement type of MOSFET.</p>	<p>20</p>	<p>CO4</p>