Scheme of Valuation/Answer Key

(Scheme of evaluation (marks in brackets) and answers of problems/key)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, JULY 2019

Course Code: EC203

Course Name: SOLID STATE DEVICES (EC,AE)

Max. Marks: 100 Duration: 3 Hours

PART A

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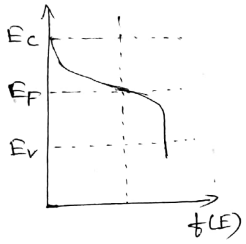
Part A

1 a) Explain Fermi Dirac distribution function

Definition :- 1 mark

Equation :- 1 mark

Diagram :- 2 marks



b) Definition of diffusion : 2 marks

Derivation :- 5 marks

Final Equation :- $J = J_n(x) + J_p(x)$

$$J_n(x) = q\mu_n n(x) \mathcal{E}(x) + q D_n \frac{dn(x)}{dx}$$

$$J_p(x) = q\mu_p p(x) \mathcal{E}(x) - q D_p \frac{dp(x)}{dx}$$

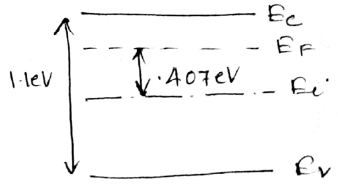
c) $N_d \gg n_i$, $n_0 = N_d$ ∴

$$p_0 = \frac{n_i^2}{n_{B_0}} = \frac{2.25 \times 10^{20}}{10^{17}} = 2.25 \times 10^3 \, cm^{-3} \quad (2 \text{ marks})$$

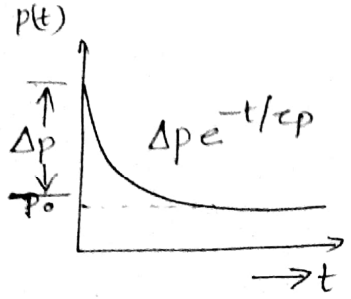
$$E_F - E_i = kT \ln \frac{n_0}{n_i} = .407 eV \quad (1 \text{ mark})$$

plot :- 1 mark

Total :- 4 marks



2a)



$\delta p(t) = \Delta p\, e^{-t/\tau_p}$

graph + equation – 3 marks

b) $f(E_c) = \dfrac{1}{1+e^{(E_c-E_F)/kT}}$ $\quad 1-f(E_v) = \dfrac{1}{e^{(E_F-E_v)/kT}}$

$N_c = 2\left(\dfrac{2\pi m_n^* kT}{h^2}\right)^{3/2}$ $\quad N_v = 2\left(\dfrac{2\pi m_p^* kT}{h^2}\right)^{3/2}$

$n_o = N_c e^{-(E_c-E_F)/kT}$ $\quad p_o = N_v e^{-(E_F-E_v)/kT}$

electron concentration – 3 marks

hole concentration – 3 marks

c) $\tau = \dfrac{1}{\alpha_r(n_o+p_o)}$

$\alpha_r = 10^{-8}\,cm^{-3}s^{-1}$ (2 marks)

a) $\delta n = g_{op}\tau_p$

$\delta p = \delta n = 2\times10^{15}\,cm^{-3}$ (2 marks)

b) $n = n_o + \delta n = 3\times10^{15}\,cm^{-3}$

$p = p_o + \delta p = 2\times10^{15}\,cm^{-3}$

$\tau = \dfrac{\delta n}{\alpha_r np} = 3.33\times10^{-8}\,s$ (2 marks)

3 a). High field effect - explanation - 2 marks
Diagram - 2 marks

b) Definition & Equation :- 3marks
Derivation :- 3marks
Total :- 6marks

c) $p_o = 10^{17}/cm^3$
$n_o = 6.25 \times 10^{19}/cm^3$ } 3marks

$E_i - E_F = kT \ln \frac{p_o}{n_i} = 0.215eV$ ⇒ 2marks

Total :- 5marks

Part B

4a) V-I characteristics

graph - 2marks
explanation 2marks

b) 2 types of capacitance : Junction capacitance
Diffusion capacitance
(3 marks each)

c) $L_n = \sqrt{D_n \tau_n} = .041\,cm$ $L_p = \sqrt{D_p \tau_p} = 0.0114\,cm$

$n_p = 2.25 \times 10^2\,cm^{-3}$ $p_n = 2.25 \times 10^4\,cm^{-3}$

$I_p = qA \frac{D_p}{L_p} p_n (e^{qV_a/kT} - 1) = 4.32 \times 10^{-2} A$ ⇒ 2marks

$I_n = qA \frac{D_n}{L_n} n_p (e^{qV_a/kT} - 1) = 3.14 \times 10^{-1} A$ ⇒ 2marks

$I = I_p(x_n = 0) + I_n(x_p = 0) = 43.5\,mA$ ⇒ 1marks

5a) $\Delta p_n = p_n(e^{qV_a/kT} - 1)$

$\Delta n_p = n_p(e^{qV_a/kT} - 1)$ } 4 marks

$I = I_{p\,diff}(x_n = 0) + I_{n\,diff}(x_p = 0)$

$= I_s(e^{qV_a/kT} - 1)$

$I_s = qA\left[\frac{D_p}{L_p} p_n + \frac{D_n}{L_n} n_p\right]$ } 6 marks

5 b). Zener breakdown - 2.5 marks
Avalanche Breakdown - 2.5 marks

6 a) $V_o = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2}$ derivation :- 7 marks

b) Metal p-type semiconductor schottky contact
figure - 2 marks ; explanation - 2 marks

Metal n-type semiconductor schottky contact
figure - 2 marks ; explanation - 2 marks

(5)

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7a) Basic structure & equilibrium energy band diagram of MOS capacitor — 4 marks

Accumulation, Depletion & Inversion :- 2 marks each

Total :- 10 marks

b) Base width modulation

figure :- 2 marks

explanation :- 2 marks

c) MOSFET scaling
Hot electron effect } :- 3 mark each

8a) Minority carrier distribution :- 8 marks

I_C, I_B & I_E :- 2 marks each

b) Capacitance - Voltage relation

figure - 3 marks

explanation - 3 marks.

9a) FINFET ; diagram - 4 marks

explanation - 3 marks.

b) Current components in pnp transistor

diagram - 3 marks

explanation - ~~3 marks~~ 4 marks

c) Working Principle - 3marks
Drain chara diagram - 3 marks