Electronic Devices Test 3

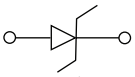
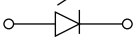
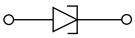
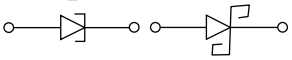
Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. The equation which relates diffusion constant with mobility is
(A) Poisson's equation (B) Continuity equation
(C) Einstein's equation (D) Current equation

2. The collector cut off current I_{CBO} reduces considerably by doping the
(A) emitter with low level of impurity
(B) base with high level of impurity
(C) collector with high level of impurity
(D) emitter with high level of impurity

3. Frequently used applications of a PIN diode is
(A) fast switching diode (B) harmonic generator
(C) voltage regulator (D) peak clipper

4. Circuit symbol of schottky barrier diode is _____.
(A) 
(B) 
(C) 
(D) 

5. Zener breakdown occurs for _____.
(A) $V_z > 6V$ (B) $V_z < 6V$
(C) $V_z = 6$ volts (D) Independent of V_z

6. Match list I with list II

List I (Diodes)		List II Application	
P.	zener diode	1.	Tuning circuits
Q.	Schottky diode	2.	Current controlled attenuator
R.	PIN diode	3.	Voltage reference
S.	Varactor diode	4.	High frequency switch

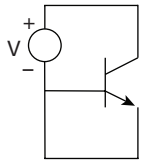
(A) P–2, Q–3, R–1, S–4
(B) P–4, Q–2, R–3, S–1
(C) P–3, Q–1, R–4, S–2
(D) P–3, Q – 4, R–2, S–1

7. In silicon at $T = 300°K$, the thermal equilibrium concentration of holes are 4.5×10^{15} cm^{-3}. The electron concentration is
(A) 0.3×10^{-6} cm^{-3} (B) 5×10^{4} cm^{-3}
(C) 5×10^{4} m^{-3} (D) 0.3×10^{-6} m^{-3}

8. A sample of silicon at $T = 300°$K is doped with arsenic at a concentration of 2.5×10^{13} cm^{-3} and with boron of 1×10^{13} cm^{-3}. The material is
(A) n type with $n_o = 1.5 \times 10^{13}$ cm^{-3}
(B) n type with $n_o = 1.5 \times 10^{7}$ cm^{-3}
(C) p type with $p_0 = 1.5 \times 10^{13}$ cm^{-3}
(D) p type with $p_0 = 1.5 \times 10^{7}$ cm^{-3}

9. 8 volt is applied across a 2 cm long semiconductor bar. The average drift velocity is 10^5 cm/s. The electron mobility is
(A) 3×10^4 cm^2/V–s (B) 4396 cm^2/V–s
(C) 2500 cm^2/V–s (D) 18000 cm^2/V–s

10. In the following circuit the transistor is in _____ mode.



(A) saturation (B) reverse active
(C) cut off (D) forward active

11. A silicon diode has reverse saturation current of 2.6 μA at 300°K. Find forward voltage for a forward current of 12 mA.
(A) 0.42 V (B) 0.43 V
(C) 0.49 V (D) 0.51 V

12. A pn junction has built in potential of 0.8 V. The depletion layer width at a reverse bias of 1.2 V is 4 μm. For a reverse bias of 8.2V. the depletion layer width will be
(A) 8.48 μm (B) 6.48μm
(C) 0.48 μm (D) 4 μm

13. If the base width of a BJT is increased by a factor of 4, then what is the collector current change
(A) collector current is independent of base width
(B) increased by a factor of 4
(C) neither increased nor decreased
(D) decreased by a factor of 4

14. In a bipolar junction transistor, the base current $I_B = 100$ μA and the collector current is $I_c = 4.6$ mA. The α is
(A) 0.862 (B) 0.978
(C) 0.962 (D) 0.876

15. A BJT has $I_B = 20$μA, $\beta = 99$ and $I_{co} = 2$μA what is the collector current I_c.
(A) 2.8 mA (B) .28 mA
(C) 2.9 mA (D) 0.29 mA

16. Photons of energy $1.6 \times 10^{-18} J$ are incident on photo diode which has a responsivity of 0.6 A/W. If the optical power level is 10 μW. The photo current generated is _____.
(A) 6μA (B) 7μA
(C) 5 μA (D) 8 μA

17. In a *CB* configuration, current gain factor is 0.8, if the emitter current is 1.6 mA, the value of I_B is
(A) 0.32 mA (B) 3.2 mA
(C) 0.41 mA (D) 4.1 mA

18. A silicon pn junction diode under reverse bias has depletion region of width 12 μm. The relative permitivity of silicon $\varepsilon_r = 11.7$ and the permitivity of free space is $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m.
The depletion capacitance of the diode per square meter is
(A) 8.6 μF (B) 7.6 μF
(C) 6.8 μF (D) 8.3 μF

19. A BJT has a base current of 250 μA and emitter current of 25 mA. Determine collector current.
(A) 19.8 mA (B) 24.75 mA
(C) 22.8 mA (D) 26.2 mA

20. If for a Si npn transistor the $V_{BE} = 0.8V$ and $V_{CB} = 0.3$ V, then the transistor is operating in the
(A) Inverse active mode (B) cut off region
(C) Active region (D) Saturation region

21. In a Si sample the electron concentration drops linearly from 10^{20} cm^{-3} to 10^{18} cm^{-3} over a length of 3 μm. The current density due to electron diffusion current is $(D_n = 36$ cm$^2/s)$
(A) 2.8×10^4 A/cm^2 (B) 1.9×10^6 A/cm^2
(C) 2.8×10^6 A/cm^2 (D) 1.9×10^4 A/cm^2

22. A *n* type silicon sample contains a donor concentration of $N_D = 10^{18}$ cm^{-3}. The minority carrier hole lifetime is $\tau_{po} = 12\mu s$.
The thermal equilibrium generation rate for electron is
(A) 1.67×10^7 cm$^{-3}s^{-1}$ (B) 1.67×10^9 cm$^{-3}s^{-1}$
(C) 2.3×10^{-9} cm$^3s^{-1}$ (D) 2.3×10^7 cm^3 s^{-1}

23. Silicon is doped with boron to a concentration of 6×10^{17} atoms/cm^3. Assume the intrinsic carrier concentration of silicon to be 1.5×10^{10}/cm^3 and the value of V_T to be 25mV at 300°K.
Compared to the undopped silicon, the fermi level of doped silicon is _____.
(A) 0.427eV (B) 0.326 eV
(C) 0.356 eV (D) 0.457 eV

24. A *Si* sample *P* is doped with 10^{16} atoms/cm^3 of boron. Another sample *Q* of identical dimension is doped with 10^{16} atoms/cm^3 phosphorous. The ratio of electron to hole mobility is 4. The ratio of conductivity of sample *P* to *Q* is _____.
(A) $\frac{1}{2}$ (B) $\frac{1}{3}$
(C) $\frac{1}{4}$ (D) $\frac{2}{3}$

25. A silicon PN junction at $T = 300$°K has $N_D = 10^{12}$ cm^{-3} and $N_A = 10^{15}$ cm^{-3}. The built in voltage is
(A) .297 V (B) .368 V
(C) .397 V (D) .289 V

Answer Keys

1. C	**2.** D	**3.** A	**4.** D	**5.** B	**6.** D	**7.** B	**8.** A	**9.** C	**10.** C
11. C	**12.** A	**13.** D	**14.** B	**15.** D	**16.** A	**17.** A	**18.** A	**19.** B	**20.** C
21. B	**22.** A	**23.** D	**24.** C	**25.** C					

Hints and Explanations

1. Einstein's relation $\frac{D}{\mu} = V_T$ Choice (C)

2. $I_C = \mu I_E + I_{CBO}$

$\mu = \frac{I_C - I_{CBO}}{I_E}$

μ increases, I_{CBO} decreases
μ increases means emitter doping is high Choice (D)

3. Choice (A)

4. Choice (D)

5. Choice (B)

6. Choice (D)

7. $n_0 = \frac{n_i^2}{p_0}$ $(n_i^2 = n_0 P_0)$

for *si*, $n_i = 1.5 \times 10^{10}$

$n_0 = \frac{(1.5 \times 10^{10})^2}{4.5 \times 10^{15}} = 5 \times 10^4$ cm^{-3} Choice (B)

8. Since $N_d > N_a$, material is n type $n_0 = N_D - N_A$
$= 2.5 \times 10^{13} - 1 \times 10^{13}$
$= 1.5 \times 10^{13}$ cm^3 Choice (A)

9. $E = \frac{V}{L} = \frac{8}{2} = 4$V/cm

$V_d = \mu E$ $\mu = \frac{V_d}{E}$

$= \frac{10^5}{4} = 2500\text{cm}^2/\text{V-s}$ Choice (C)

10. Emitter base– junction is in reverse bias condition
Collector base junction is also in reverse bias condition.
∴ Both are in RB. So it is in cut off mode
Choice (C)

11. $I = I_0 e^{(V/nV_T - 1)}$

$.012 = 2.6 \times 10^{-6} e^{\left(\frac{V}{2 \times .026^{-1}}\right)}$

$V = 0.49$ Volts Choice (C)

12. $W \propto \sqrt{V_j}$

$V_j = V_0 + V_R$

$\frac{W_1}{W_2} = \sqrt{\frac{V_0 + V_{R1}}{V_0 + V_{R2}}}$

$\frac{4\mu m}{W_2} = \sqrt{\frac{0.8+1.2}{0.8+8.2}}$

$\frac{4\mu m}{W_2} = \sqrt{\frac{2}{9}}$

$W_2 = 8.48\ \mu m$ Choice (A)

13. W_B & I_C

$I_C \propto \frac{1}{W_B}$ Choice (D)

14. $\beta = \frac{I_C}{I_B}$

$\alpha = \frac{\beta}{1+\beta}$

$\beta = \frac{4.6\ mA}{100\ \mu A} = 46$

$\alpha = \frac{\beta}{1+\beta} = \frac{46}{1+46} = 0.978$ Choice (B)

15. $I_B = 20\mu A$

$\beta = 99$

$I_{CO} = 2\mu A$

$I_C = \beta I_B + (1+\beta) I_{CBO}$

$= 99 \times 20 \times 10^{-6} + 100 \times 2 \times 10^{-6}$

$= 2.99 \times 10^{-4}$

$= 0.29 \times 10^{-3} A.$ Choice (D)

16. $R = \frac{I_p}{I_0}$

$I_p = RI_0 = 0.6 \times 10 \frac{\mu A}{W} = 6\ \mu A$ Choice (A)

17. $\alpha = \frac{I_C}{I_E}$

$I_C = \alpha I_E = 0.8 \times 1.6\ mA$

1.28×10^{-3}

$I_B = I_E - I_C$

$= 1.6\ mA - 1.28\ mA = 0.32\ mA.$ Choice (A)

18. $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$

$\frac{C}{A} = \frac{\varepsilon_0 \varepsilon_x}{d} = \frac{8.85 \times 10^{-12} \times 11.7}{12 \times 10^{-6}} = 8.6\ \mu F.$ Choice (A)

19. $I_B = 250\ nA$

$I_E = 25\ mA$

$I_C = I_E - I_B$

$= 25 \times 10^{-3} - 250 \times 10^{-6}$

$I_C = 24.75\ mA$ Choice (B)

20. $V_{BE} = 0.8\ V$

i.e., $V_B - V_E = 0.8\ V$

$V_B > V_E$ emitter base forward bias

$V_{CB} = 0.3V$

$V_C > V_B \Rightarrow$ collector junction reverse bias

So transistor is in the normal active node Choice (C)

21. $J_n = qD_n \frac{dn}{dx}$

$= 1.6 \times 10^{-19} \times 36 \left[\frac{10^{20} - 10^{18}}{3 \times 10^{-4}}\right]$

$= 1.9 \times 10^6\ A/cm^2.$ Choice (B)

22. Recombination rate for minority and majority carrier are equal. The generation rate is equal to recombination rate.

$g = R_{no} = R_{po}$

$R_{no} = p_0/\tau_{po},\ p_0 = \frac{n_i^2}{n_0}$

$n_0 = N_D = 10^{18}\ cm^{-3}$

$p_0 = \frac{(1.5 \times 10^{10})^2}{10^{18}}$

$= 2.25 \times 10^2\ cm^{-3}$

$R_{no} = p_0/T_{po} = \frac{2.25 \times 10^2}{12 \times 10^{-6}}$

$= 1.67 \times 10^7\ cm^{-3}\ s^{-1}.$ Choice (A)

23. $E_2 - E_1 = KT\ell n \frac{N_A}{n_i}$

$N_A = 6 \times 10^{17},\ n_i = 1.5 \times 10^{10}$

$E_2 - E_1 = 26 \times 10^{-3}\ e\ell n \frac{6 \times 10^{17}}{1.5 \times 10^{10}} = 0.457\ eV$

The fermilevel goes down by 0.457 eV as silicon is doped with boron. Choice (D)

24. $\sigma_n = nq\mu_n,\ \sigma p = pq\mu_p$

$n = p$

$\frac{\sigma_p}{\sigma_n} = \frac{\mu_p}{\mu_n} = \frac{1}{4}.$ Choice (C)

25. $V_{bi} = V_T \ell n \left(\frac{N_A N_D}{n_i^2}\right)$

$V_T = 26\ mV$

$V_{bi} = .026 \ell n \frac{10^{15} \times 10^{12}}{(1.5 \times 10^{10})^2} = .397V.$ Choice (C)