RIB RANK IMPROVEMENT BATCH
ELECTRONICS ENGINEERING

RIB-R | T8

Session 2019-20 | S.No. : 030919_LS1

ANSWER KEY ➤ Electrtronic Devices & Circuits

1.	(c)	7.	(b)	13.	(c)	19.	(a)	25.	(c)
2.	(d)	8.	(c)	14.	(c)	20.	(b)	26.	(c)
3.	(a)	9.	(b)	15.	(a)	21.	(c)	27.	(b)
4.	(c)	10.	(b)	16.	(d)	22.	(d)	28.	(a)
5.	(b)	11.	(d)	17.	(d)	23.	(c)	29.	(b)
6.	(d)	12.	(b)	18.	(a)	24.	(d)	30.	(a)

DETAILED EXPLANATIONS

2. (d)

Hall effect is used to determine the following
* type of semiconductor
* carries concentration
* conductivity
* mobility

5. (b)

$$\Delta T = 45 - 25 = 20°C$$

$$\frac{dV}{dT} = -2.5 \text{ mV/°C}$$

$$\Delta V = 2.5 \times 20 = 50 \text{ mV}$$

$$\therefore \quad V_D = V - \Delta V = 625 \text{ mV} - 50 \text{ mV}$$
$$= 575 \text{ mV.}$$

6. (d)

$$f_F(E_c) = \frac{1}{1+\exp\left(\frac{E_c - E_f}{kT}\right)}$$

$$\approx \exp\left(\frac{-(E_c - E_f)}{kT}\right) = 9.69 \times 10^{-7}$$

7. (b)

According to mass-action law

$$np = n_i^2$$

$$n = \frac{n_i^2}{p} = \frac{(1.5\times10^{10})^2}{2.25\times10^{15}} = 1 \times 10^5 \text{ /cm}^3$$

9. (b)

$$I_{CBO} = 500\times10^{-9}\left[2^{\frac{90-25}{10}}\right] = 45.25\ \mu\text{A}$$

11. (d)

$$\text{Photocurrent} = 0.65 \times 10 \times 10^{-6} = 6.5\ \mu\text{A}$$

12. (b)

$$g' = \frac{\Delta p}{\tau_p}$$

$$10^{26} = \frac{\Delta p}{2\times10^{-6}}$$

$$\Delta p = 2\times10^{20}\text{ m}^{-3}$$

$$= 2\times10^{14}\text{ cm}^{-3}$$

13. (c)

$$\frac{N_A}{N_D} = \frac{x_n}{x_p}$$

$$x_n = \left(\frac{N_A}{N_D}\right)(x_p)$$

$$x_n = \frac{1}{10}\times0.5$$

$$x_n = 0.05\ \mu\text{m}$$

$$x = x_n + x_p = 0.5 + 0.05 = 0.55\ \mu\text{m}$$

14. (c)

$$J_p = -qD_p\frac{dp}{dx} = -1.6\times10^{-19}\times20\times10^{12}\left(-\frac{1}{10^{-3}}\right) = 3.2\text{ mA/cm}^2$$

$$I_p = J_p \times A = 3.2 \times 10^{-3} \times 1.25 \times 10^{-4} = 0.4\ \mu\text{A}$$

15. (a)

$$\lambda \le \frac{1.24}{E_g(\text{eV})}\mu\text{m}$$

For silicon

At $T = 300°\text{K}$ $E_g = 1.1 \text{ eV}$

so, wavelength λ at $E_g = 1.1 \text{ eV}$

$$\Rightarrow \quad \lambda \le \frac{1.24}{1.1}\mu\text{m} = 1.13\ \mu\text{m}$$

So clearly option (a) is out of the range.

16. (d)

As doping increases, Fermi level moves closer to the conduction band.

17. (d)

The percentage increase in the reverse saturation current is

$$\frac{I_{02}}{I_{01}} = 2^{(T_2 - T_1)/10} = 2^{(55-25)/10} = 8$$

$$\frac{I_{02} - I_{01}}{I_{01}} \times 100 = (8-1) \times 100 = 700\%$$

18. (a)

Zener breakdown voltage is less because it occurs in higher doping region.
Hence, zener breakdown voltage V_1 corresponds to point A.

19. (a)

$$E_i - E_F = kT\, l\text{n}\frac{N_A}{N_i} = 26 \times 10^{-3}\, l\text{n}\left(\frac{5 \times 10^{17}}{1.5 \times 10^{16}}\right) = 0.45 \text{ eV}$$

Since boron is p-type impurity, therefore fermi level goes down.

20. (b)

For n-type substrate, inversion occurs for higher negative voltage. So, point 1 corresponds to inversion.
For low negative voltages, first the substrate becomes depleted of charge carriers and then inversion starts. The point at which inversion starts is threshold point i.e. point 2.
Point 3 corresponds to depletion region.
For positive voltage accumulation of electrons occurs in n-type substrate. Hence point 4 corresponds to accumulation.

21. (c)

$$I_0 = qA\left(\frac{D_p}{L_p}p_{n0} + \frac{D_n}{L_n}n_{p0}\right)$$

As $N_A >> N_D$

$\Rightarrow n_{p0}$ is negligible

$$I_0 \approx \frac{qAD_p}{L_p}p_{n0}$$

$$p_{n0} = \frac{n_i^2}{N_D}$$

$$I_0 = \frac{1.6\times10^{-19}\times10^{-3}\times10\times4.5\times10^{3}}{3.16\times10^{-3}}\times\frac{2.25\times10^{20}}{5\times10^{16}}$$

$$I_0 = 2.278\times10^{-15}\text{ A}$$

$$|I_r| \approx |I_0| \qquad \left[I_r = I_0(e^{-V/\eta V_T}-1)\right]$$

$$|I_r| = 2.278\times10^{-15}\text{ A}$$

22. (d)

n = new concentration of electrons at the surface

n_0 = equilibrium concentration of electrons

$$n_0 = \frac{n_i^2}{p_0} \approx \frac{n_i^2}{N_A} = 1.8\times10^5\text{ cm}^{-3}$$

$$n = n_0 e^{\Psi/V_t}; \quad V_t = \frac{kT}{q}, \qquad \Psi = \text{surface potential}$$

$$\Psi = \frac{kT}{q} ln\left(\frac{n}{n_0}\right) = 0.026\, ln\left(\frac{3\times10^{10}}{1.8}\right) \approx 0.612\text{ V}$$

23. (c)

$$I_{D,\text{sat}} = \frac{W\mu_n C_{ox}}{2L}(V_{GS}-V_T)^2$$

$$4\times10^{-3} = \frac{W(650)(6.9\times10^{-8})}{2(1.25\times10^{-4})}(5-0.65)^2$$

$$W = 11.8\ \mu\text{m}$$

24. (d)

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

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$$

$\therefore$ $$I_C = 49\times20 + 50\times0.6 = 980 + 30 = 1010\ \mu\text{A}$$

or $$I_C = 1.01\text{ mA}$$

25. (c)

In linear region

$$I_D = \mu_n C_{ox}\frac{W}{L}\left((V_{GS}-V_T)V_{DS}-\frac{V_{DS}^2}{2}\right)$$

$$\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{linear}} = K'_n V_{DS} \qquad \ldots(1)$$

$$\left[\begin{aligned} &\left(\text{here } k_n = \mu_n C_{ox}\right)\\ &k'_n = k_n\left(\frac{W}{L}\right)\\ &k = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\\ &k = \frac{1}{2}k'_n\\ &k'_n = 2k \end{aligned}\right]$$

In saturation region

$$I_D = k(V_{GS}-V_T)^2$$

$$\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{saturation}} = 2k(V_{GS}-V_T) \qquad \ldots(2)$$

$$\frac{\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{linear}}}{\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{saturation}}} = \frac{k'_n V_{DS}}{2k(V_{GS}-V_T)}$$

$$\frac{\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{linear}}}{\left(\frac{\partial I_D}{\partial V_{GS}}\right)_{\text{saturation}}} = \frac{2k V_{DS}}{2k(V_{GS}-V_T)} = \frac{V_{DS}}{(V_{GS}-V_T)}$$

26. (c)

$$C \propto \frac{1}{\sqrt{V_{bi}+V_{RB}}}$$

$$\frac{C_1}{C_2} = \frac{\sqrt{V_{bi}+V_{RB2}}}{\sqrt{V_{bi}+V_{RB1}}}$$

at $V_{RB1} = 0$ V, $C_1 = 1$ μF.

at $V_{RB2} = 6$ V, $C_2 = 0.5$ μF.

$$\frac{1}{0.5} = \frac{\sqrt{V_{bi}+6}}{\sqrt{V_{bi}+0}}$$

$$2 = \frac{\sqrt{V_{bi}+6}}{\sqrt{V_{bi}}}$$

$$4V_{bi} = V_{bi}+6$$
$$3V_{bi} = 6$$

$$V_{bi} = 2\text{ V}$$

27. (b)

Given the probability of state being empty is 0.9258

i.e. $1 - f(E) = 0.9258$

The energy level being occupied by electron is $f(E)$

$\therefore \quad f(E) = 1 - 0.9258 = 0.0742$

$$f(E) = \frac{1}{1+e^{\left(\frac{E-E_F}{kT}\right)}}$$

$$0.0742 = \frac{1}{1+e^{\left(\frac{E-E_F}{kT}\right)}}$$

$$1+e^{\left(\frac{E-E_F}{kT}\right)} = 13.477$$

$$\frac{E-E_F}{kT} = 2.523$$

$\therefore \quad E - E_F \approx 2.52\text{ kT}$

$$E = E_F + 2.52\text{ kT}$$

The energy level 2.52 kT above the Fermi energy is occupied by electron with probability 0.0742.

28. (a)

We know that electrical neutrality condition

$$N_D + P = N_A + n$$

for lightly doped P-type semiconductor

$$N_D = 0$$

$\therefore \quad P = N_A + n$

$$N_A = P - n$$

$$= P - \frac{n_i^2}{P} = n_i\sqrt{\frac{\mu_n}{\mu_p}} - \frac{n_i^2}{n_i\sqrt{\frac{\mu_n}{\mu_p}}}$$

$$N_A = n_i\left[\left(\frac{\mu_n}{\mu_p}\right)^{\frac{1}{2}} - \left(\frac{\mu_p}{\mu_n}\right)^{\frac{1}{2}}\right] = 2.4\times 10^{10}\left[\sqrt{9} - \sqrt{\frac{1}{9}}\right]$$

$$N_A = 6.4\times 10^{10}\text{ cm}^{-3}$$

29. (b)

Phosphorous is a pentavalent atom when it is added as a dopant with Si sample it behaves as a n-type semiconductor and Boron is a trivalent atom when it is added as a impurities with Si sample it behaves as a p-type semiconductor. When both the atoms as a donar and acceptor atoms are added together then it will neutralised to each-other, and as per the given concentration the net charge will be 10^{16} Boron atoms, so it will behave as p-type, semiconductor with net carrier concentration of 10^{16} /cm^3.

30. (a)

$$I_D = 0.4 \text{ mA}, \; V_D = 0.5 \text{ V}$$

$$R_D = \frac{V_{DD} - V_D}{I_D} \Rightarrow R_D = 5 \text{ k}\Omega$$

Since $V_D = 0.5$ V is greater than V_G, this means the NMOS transistor is operating in the saturation region.

$$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS} - V_t)^2$$

$$\Rightarrow \quad V_{GS} - V_t = 0.5 \text{ V}$$

$$\Rightarrow \quad V_{GS} = V_t + 0.5 = 1.2 \text{ V}$$

$$R_S = \frac{V_S - V_{SS}}{I_D} = \frac{-V_{GS} - V_{SS}}{I_D} = \frac{1.3}{0.4} \text{ k}\Omega = 3.25 \text{ k}\Omega$$

■■■■