Electronic Devices Test 2

Number of Questions: 35 **Time: 90 min.**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. An LED made using GaAs emits radiation in
(A) infrared region
(B) microwave frequency region
(C) visible region
(D) U.V. region

2. A resistance thermometer has a temperature co-efficient of resistance 10^{-2} per degree and its resistance at 10°C is 0.5Ω. At what temperature is its resistance 1.4Ω?
(A) 150°C (B) 180°C
(C) 160°C (D) 190°C

3. A cu wire is 1m long and has a uniform cross section of 0.5 mm^2. The resistance of the wire at room temperature is 0.25Ω. What is the resistivity of the material?
(A) 0.125×10^{-6} Ω /m (B) 1.25×10^{-7} Ω–m
(C) 4×10^{7} Ω /m (D) 1.52×10^{-7} Ω–m

4. Piezo electricity is the reverse effect of
(A) electro luminescence (B) Hall effect
(C) electro striction (D) All the above

5. What is the chemical bonding in the silicon semiconductor?
(A) Covalent (B) Ionic
(C) Metallic (D) Vander Waals

6. The diffusion constant for e^-'s in Ge is 15 cm^2/sec, what is the diffusion current density if the gradient of the e^-'s concentration $\frac{n}{x} = -2.5 \times 10^{15}$ electrons per cm^3 per cm?
(A) 6 mA (B) –4.5 mA
(C) –6.23 mA (D) 7.5 mA

7. A 800 mW maximum power dissipation diode at 27°C has 5mW/°C de-rating factor. If the forward voltage drop remains constant at 0.7V, the maximum forward current at 54°C is
(A) 0.095 mA (B) 0.757 Amp
(C) 0.95 Amp (D) 7.23 mA

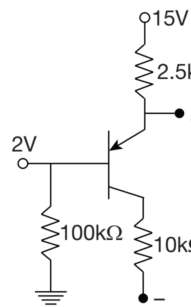
8. The Hall constant in a n-type bar is given by 2×10^3 cm^3/coulomb. The electron concentration in the bar is given by
(A) 3.125×10^{15} cm^{-3} (B) 3.2×10^{16} cm^3
(C) 4.25×10^{16} cm^{-3} (D) 1.27×10^{15} cm^{-3}

9. The output impedance of a BJT under common collector configuration is
(A) high (B) medium
(C) low (D) very high

10. Body effect in MOSFETS results in
(A) increase in the value of output resistance
(B) increase in the value of transconductance
(C) change in the value of threshold
(D) decrease in the value of transconductance

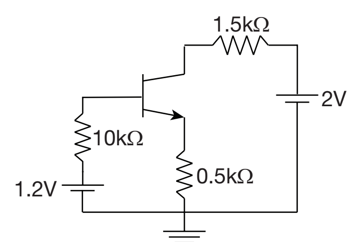
11. The modified work function of an n-channel MOSFET is –0.75V. If the interface charge is 2×10^{-4} C/m^2 and the oxide capacitance is 250μF/m^2, the flat band voltage is
(A) 1.4 V (B) 1.25 V
(C) 1.75 V (D) 0.2 V

12. A circuit using the BJT is shown in the below figure, the value of β is



(A) 250 (B) 175
(C) 176 (D) 249

13. For the circuit shown in the below figure, by assuming β = 150 and V_{BE} = 0.7V, the best approximation for the collector current I_C in the active region is



(A) 0.65 mA (B) 2.5 mA
(C) 1.23 mA (D) 0.87 mA

14. Which one of the following statements is correct? A photo diode works on the principle of
(A) photo electric effect
(B) photo conductive effect
(C) photo-voltaic effect
(D) photo-thermal effect

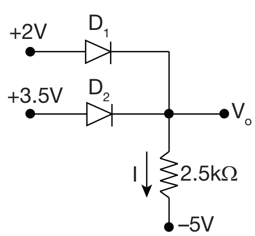
15. Match List-I (Type of device) with List-II (characteristics/application) and select the correct answer using the codes given below the lists.

List-I	List-II
p. Zener diode	1. microwave generator
q. Tunnel diode	2. low frequency rectifier
r. Schottky barrier diode	3. voltage reference
s. Photo diode	4. high frequency rectifier
	5. light detection

Codes:
(A) p–3, q–4, r–1, s–2 (B) p–3, q–1, r–4, s–5
(C) p–3, q–2, r–4, s–5 (D) p–2, q–3, r–4, s–1

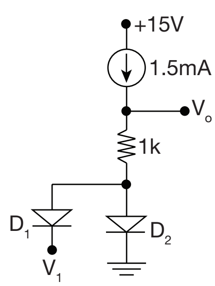
16. A silicon PN-junction is forward biased with a constant current at room temperature, when the temperature is decreased by 15°C, the forward bias voltage across the PN junction is
(A) decreases by 37.5mV
(B) decreases by 42.5mV
(C) Increased by 375mV
(D) Increased by 30mV

17. The output current I is (consider $V_{r1} = 0.2V$, $V_{r2} = 0.7V$)



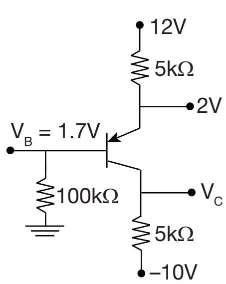
(A) 3.12mA (B) 3.68mA
(C) –0.88mA (D) 2.8 mA

18.



Consider diodes are ideal, If $V_1 = -2V$, find the value of V_o.
(A) –3.5V (B) 0.75V
(C) –0.5V (D) 2.8V

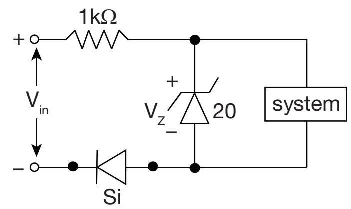
19.



Find the voltage across capacitor V_C.
(A) –0.023 V (B) 9.91 V
(C) 19.915 V (D) –0.085 V

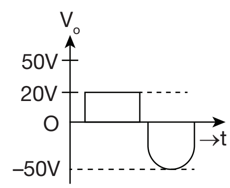
20. The data sheet for an E-MOSFET gives $I_{D(on)} = 4mA$ at $V_{GS} = 10V$ and $V_{GS(th)} = 2V$. Then find the value of K.
(A) 62.5 μA/V² (B) 54.75 μA/V²
(C) 6.25 mA/V² (D) 5.47 mA/V²

21.

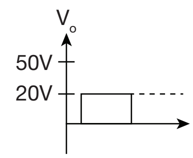


If $V_{in} = 50 \sin 2t$ volts, the output wave form across the system would be

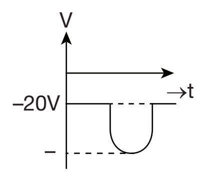
(A)



(B)

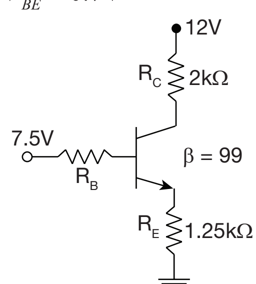


(C)



(D) None of these

22. For the transistor circuit shown in figure $I_B = 35$ μA and $V_{BE} = 0.7V$



The value of R_B would be
(A) 55 kΩ (B) 5.23 kΩ
(C) 69.28 kΩ (D) 7.28 kΩ

23. A silicon PN junction diode under reverse bias has the depletion capacitance of the diode per square meter is 80μF. The relative permittivity of Si, $\varepsilon_r = 11.7$ and $\varepsilon_o = 8.852 \times 10^{-12}$ F/m. Then the depletion width W is ______
(A) 1.12μm (B) 1.294μm
(C) 12.93m (D) 0.11μm

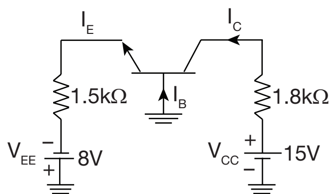
24. Two MOSFETS M_1 and M_2 are connected parallel to carry a total current of 25mA. The drain to source voltage of M_1 is 2.5V and that of M_2 is 3V. What are the drain currents of M_1 and M_2 when the current sharing

series resistances are each of 0.75KΩ?
(A) $I_1 = 12.833$mA, $I_2 = 12.166$ mA
(B) $I_1 = 1.833$mA, $I_2 = 13.166$ mA
(C) $I_1 = 12.166$mA and $I_2 = 12.833$ mA
(D) $I_1 = 8.25$mA and $I_2 = 15.75$ mA

25. Compared to the BJT JFET:
1. has a larger gain bandwidth
2. less noisy
3. has current flow due to only majority carriers
4. thermal runaway

(A) 1 and 2 correct (B) 2, 3 and 4 are correct
(C) 2 and 3 are correct (D) 1, 2 and 3 are correct

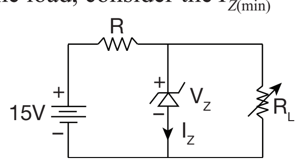
26.



For the common base circuit shown in figure, then find the value of V_{CB}.
(A) 6.24V (B) 8.76V
(C) 12.48V (D) 10.3V

27. The data sheet of a JFET gives the following information: $I_D = 3$mA, $V_{GS} = -1.5$V, $V_{GS(\text{off})} = -5V$ and $g_{m(\max)} = 4.5$mS. If amplification factor $\mu = 85$, then find the value of drain resistance r_d.
(A) 25 kΩ (B) 32.45 kΩ
(C) 42 kΩ (D) 28.33 kΩ

28. A 7.5V zener diode is used in the circuit shown in figure, and the load current is to vary from 15 to 80mA. Find the value of series resistance 'R' to maintain a voltage of 7.5V across the load, consider the $I_{Z(\min)} = 8$mA.

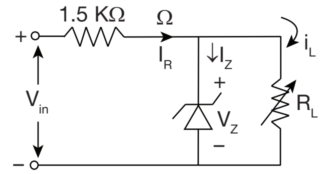


(A) 85.22Ω (B) 8.27kΩ
(C) 4.25kΩ (D) 98.24Ω

29. An ideal p-channel MOSFET has the parameters $\frac{W}{L} = 8$, $\mu_p = 350\text{cm}^2/\text{V–s}$, $t_{ox} = 850\ A^o$ and $V_{Tp} = -1V$. If transistor is operating in saturation region at $V_{SG} = 4.5$V, then the value of g_m is (consider $\varepsilon_r = 3.9$)
(A) $9.66 \times 10^{-4}\ S$ (B) $4.83 \times 10^{-4}\ S$
(C) $19.32 \times 10^{-4}\ S$ (D) $1.02 \times 10^{-4}\ S$

Data for Questions 30 and 31

The zener voltage regulator circuit shown in below



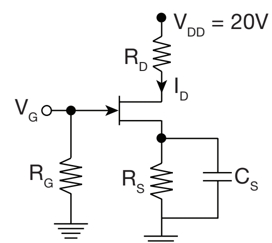
Consider $V_{in} = 40$V, $V_z = 10$V and $I_{zM} = 15$mA

30. Determine the range of R_L values that will turn the zener diode 'ON'.
(A) $500\Omega \le R_L \le 2\text{k}\Omega$ (B) $550\ \Omega \le R_L \le 2.5\text{k}\Omega$
(C) $500\Omega \le R_L \le 2.5\text{k}\Omega$ (D) $0 < R_L \le 2\text{k}\Omega$

31. Determine the load current I_L range.
(A) $5\text{mA} \le I_L \le 15\text{mA}$ (B) $10\text{mA} \le I_L \le 25\text{mA}$
(C) $15\text{mA} \le I_L \le 20\text{mA}$ (D) $5\text{mA} \le I_L \le 20\text{mA}$

Data for Questions 32 and 33

In a self-bias n-channel JFET, the operating point is to be set at $I_D = 1.5$mA and $V_{DS} = 12$V. The JFET parameters are $I_{DSS} = 5$mA and $V_{Gs(\text{off})} = -2$V.



32. The value of R_S would be
(A) 500 Ω (B) 600 Ω
(C) 1.6 kΩ (D) 6 kΩ

33. The value of R_D would be
(A) 4.25 kΩ (B) 2.23 kΩ
(C) 6.25 kΩ (D) 4.733 kΩ

Data for Questions 34 and 35

Consider a MOS structure with p-type Si. The doping concentration is $N_A = 5 \times 10^{20}\ \text{m}^{-3}$ and $n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$ (consider $\varepsilon_r = 3.9$)

34. If gate is p^+ poly silicon, then the metal semi conductor work function difference (ϕ_{ms}) is
(A) 2.3 eV (B) 0.285V
(C) 0.32V (D) 0.285eV

35. At $T = 300^o k$, the maximum space charge density is
(A) $4.56 \times 10^{-9}\ \text{C/m}^2$ (B) $2.52 \times 10^{-6}\ \text{C/m}^2$
(C) $5.456 \times 10^{-8}\ \text{C/cm}^2$ (D) $6.52 \times 10^{-8}\ \text{C/cm}^2$

Answer Keys

1. A	**2.** D	**3.** B	**4.** C	**5.** A	**6.** A	**7.** C	**8.** A	**9.** C	**10.** C
11. A	**12.** D	**13.** D	**14.** B	**15.** B	**16.** C	**17.** A	**18.** C	**19.** D	**20.** A
21. B	**22.** C	**23.** B	**24.** A	**25.** C	**26.** A	**27.** D	**28.** A	**29.** A	**30.** A
31. D	**32.** B	**33.** D	**34.** B	**35.** C					

Hints and Explanations

1. $Eg = \frac{hc}{\lambda}$

We know GaAs. Eg = 1.43eV

∴ $\lambda = 8.68 \times 10^{-7}$ m

$\lambda = 0.868$ μm

∴ It is in infrared region.

0.75 μm to 10^{-3}m.

Visible light λ ranges from 390 to 700 nm.

Choice (A)

2. $R_2 = R_o(1 + \alpha\, \Delta T)$

From the given data $\alpha = 10^{-2}/^{o}$C

$\Delta T = (T_2 - 10°C)$

$1.4 = 0.5(1 + 10^{-2}.\Delta T)$

$1 + 10^{-2}.\Delta T = \frac{1.4}{0.5} = 2.8$

$\Delta T = \frac{1.8}{10^{-2}} = 180^{o}$

∴ $T_2 = 190°C$ Choice (D)

3. $R = \frac{\rho \ell}{A}\Omega$

From the given data $A = 0.5mm^2 = 0.5 \times 10^{-6}$ m^2

$R = 0.25\Omega$

$\ell = 1$m

∴ $\rho = \frac{R.A}{\ell} = \frac{0.25 \times 0.5 \times 10^{-6}}{1}$

$= 0.125 \times 10^{-6}$ Ω – m

$= 1.25 \times 10^{-7}$ Ω – m Choice (B)

4. Choice (C)

5. Choice (A)

6. $D_n = 15$ cm^2/sec

$\frac{\partial n}{\partial x} = -2.5 \times 10^{15}$

Diffusion current $= +q.D_n.\ \frac{\partial n}{\partial x}$

$= 1.6 \times 10^{-19} \times 15 \times 2.5 \times 10^{15}$

$= 60 \times 10^{-4}\ A \Rightarrow 6$mA Choice (A)

7. From the given data $\frac{dw}{dt} = -5m$ W/°C

$V = 0.7$ volt

We know $P = V.I$

P at $54°C = 800 \times 10^{-3} - 5 \times 10^{-3} \times 27°C = 665$ mW

$\therefore I = \frac{665}{0.7} mA = 0.95$ Amp Choice (C)

8. Hall coefficient $R_H = \frac{1}{\rho}$

ρ = n.q

$n = \frac{1}{R_H.q} = \frac{1}{2 \times 10^3 \times 1.6 \times 10^{-19}}$

$= 3.125 \times 10^{15}$ per cm^3 Choice (A)

9. For *CC* amplifier

R_{in} = high

R_o = low Choice (C)

10. Choice (C)

11. We know that flat band voltage

$V = \frac{q}{C}(1 - W_c)$ volts

$= \frac{2 \times 10^{-4}}{250 \times 10^{-6}}(1 + 0.75) = 1.4$ volts Choice (A)

12. $I_E = \frac{15 - 2.5}{2.5k\Omega} = 5mA$

$I_B = \frac{2}{100} mA = 20\mu A$

$(1 + \beta) = \frac{I_E}{I_B} = 250$

∴ $\beta = 249$ Choice (D)

13. Applying KVL to the input loop

$1.2 - I_B R_B - V_{BE} - R_E.I_E = 0$

$1.2 - 0.7 = I_B[10 \times 10^3 + 0.5 \times 10^3 \times 151]$

$I_B = 5.8479\mu A$

$I_C = \beta.I_B = 150 \times 5.8479\mu A = 0.877mA$ Choice (D)

14. Choice (B)

15. Choice (B)

16. $\frac{dV_D}{dT} = -2.5mV/°C$

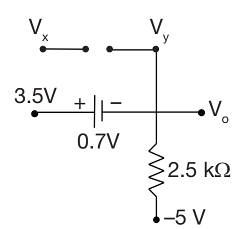
∴ $V_D \downarrow \Rightarrow T\uparrow$

V_D increased by $2.5 \times 15mV = 37.5$ mV

Choice (C)

17. Let $D_1 \rightarrow$ OFF, $D_2 \rightarrow$ ON

The given circuit becomes



$V_o = 3.5 - 0.7 = 2.8V$

∵ $V_x = 2V$ at $V_y = V_o = 2.8V$

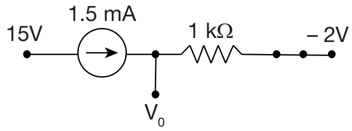
$V_x < V_y \Rightarrow D_1 \rightarrow$ OFF

∴ $I = \frac{V_o + 5}{2.5} mA = \frac{2.8 + 5}{2.5} mA = 3.12$ mA

Choice (A)

18. From the given circuit $D_1 \rightarrow$ ON, $D_2 \rightarrow$ OFF

∴ It becomes



$V_o = 1.5 - 2 = -0.5$ volts Choice (C)

19. We know $I_E = I_B + I_C$

$$I_E = \frac{12-2}{5}\text{mA} = 2\text{mA}$$

$$I_B = \frac{1.7}{100}\text{mA} = 0.017\text{mA}$$

$I_C = 1.983\text{mA}$

$$I_C = \frac{V_C + 10}{5}\text{mA}$$

$V_C + 10 = 1.983 \times 5$

$V_C = 9.915 - 10 = -0.085$ volts. Choice (D)

20. $I_D = k[V_{GS} - V_{GS(\text{th})}]^2$ Amp

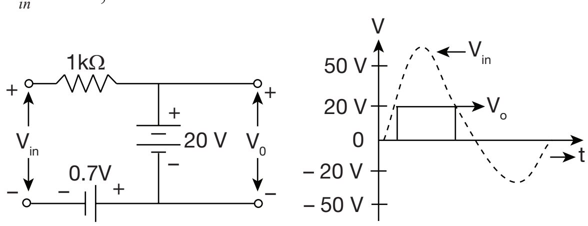
$$K = \frac{I_{D(on)}}{\left[V_{GS(on)} - \text{V}_{\text{GS(th)}}\right]^2}$$

$$= \frac{4\times10^{-3}}{[10-2]^2} = 62.5\times10^{-6}\ A/V^2$$ Choice (A)

21. For +ve cycles-

If $V_{in} \leq 20\text{V}$; zener diode OFF

$V_{in} > 20\text{V}$, zener diode 'ON'



For –ve cycles

If $V_{in} < 20.7$V, Si diode OFF; $V_o = 0$ Choice (B)

22. Applying KVL to input loop

$7.5 - R_B.I_B - V_{BE} - R_E.I_E = 0$

$I_E = (1 + \beta).I_B = 100 \times 35 \times 10^{-6} = 3.5$ mA

$7.5 - 0.7 - 4.375 = R_B.I_B$

$$R_B = \frac{2.425}{35}\times10^6 = 69.28\text{k}\Omega$$ Choice (C)

23. We know $C = \dfrac{\varepsilon.A}{d}$

From the given data $\dfrac{C}{A} = 80\mu\text{F}$,

$$d = \frac{\varepsilon_r.\varepsilon_o}{C}\times A$$

$$= \frac{11.7\times8.852\times10^{-12}}{80\times10^{-6}} = 1.294\times10^{-6}\text{ m}$$

$d = 1.294\ \mu$m Choice (B)

24. From the given data

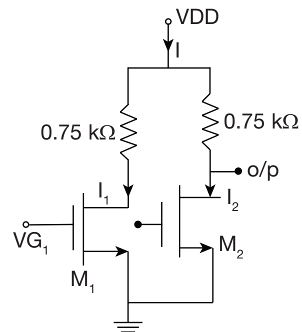
$I = I_1 + I_2 = 25$mA

$V_{DS1} = 2.5$V

$V_{DS2} = 3$V

$V_{D1} = 2.5$V

$V_{D2} = 3$V



$$\frac{V_{DD}-2.5}{750} + \frac{V_{DD}-3}{750} = 25\times10^{-3}$$

$2\,V_{DD} = 18.75 + 5.5$

$V_{DD} = 12.125$ volts

$$\therefore I_1 = \frac{V_{DD} - \text{V}_{\text{D1}}}{750}Amp = 12.833\text{ mA}$$

$I_2 = 12.166$ mA Choice (A)

25. JFET has

(i) less gain bandwidth compared to BJT

(ii) only majority carrier current

(iii) less noisy than BJT

(iv) No thermal runaway Choice (C)

26. Applying *KVL* to the emitter loop

$V_{EE} = I_E R_E + V_{BE}$

$$I_E = \frac{V_{EE} - \text{V}_{\text{BE}}}{R_E}$$

$$= \frac{8-0.7}{1.5}mA = 4.866\text{ mA}$$

Applying *KVL* to the collector – side loop, we have

$V_{CC} = I_C R_C + V_{CB}$

$15 - 1.8 \times 4.866 = V_{CB}$

$V_{CB} = 6.24$ volts Choice (A)

27. We know

$\mu = g_m.r_d$

$$g_m = g_{m0}\left[1 - \frac{\text{V}_{\text{GS}}}{V_{GS}(off)}\right]$$

$$= 4.5\times10^{-3}\left[1 - \frac{1.5}{4.5}\right] = 3\text{mS}$$

Given $\mu = 85$

$r_d = \frac{85}{3} \times 10^3$

$= 28.33 k\Omega$ Choice (D)

28. $I = I_Z + I_L$

$I_{R(\max)} = I_{Z(\min)} + I_{L(\max)}$

$= (8 + 80)$ mA $= 88$ mA

$R = \frac{15-7.5}{88} k\Omega = 85.22\Omega$ Choice (A)

29. $I_D(sat) = \frac{\mu_p C^1_{0x}}{2} \frac{W}{L}.[V_{SG} + V_{TP}]^2$ Amp

$C^1_{0x} = \frac{\varepsilon_{0x}}{t_{0x}} = \frac{3.9 \times 8.852 \times 10^{-14}}{350 \times 10^{-8}}$ F/cm^2

$= 9.86 \times 10^{-8}$ F/cm^2

Let $K_n = \frac{\mu_p C^1_{ox}}{2} \times \frac{W}{L}$

$= \frac{350 \times 9.86 \times 10^{-8}}{2} = 1.38 \times 10^{-4}$

$g_m = \frac{\partial_{ID}}{\partial_{VSG}} = 2k_n[V_{SG} + V_{Tp}] = 2 \times 1.38 \times 10^{-4} \times [4.5 - 1]$

$= 9.66 \times 10^{-4}$ S Choice (A)

30. To determine the value of R_L that will turn the zener diode 'ON'

$\therefore R_{L\min} = \frac{R.V_z}{V_{in} - V_z} = \frac{1.5 \times 10^3 \times 10}{30} = 500\Omega$

$I_R = \frac{V_{in} - V_Z}{R} = \frac{30}{1.5}$ mA $= 20$mA

$I_{L\min} = I_R - I_{Z\max} = (20 - 15)$mA $= 5$mA

$\therefore R_{L\max} = \frac{V_z}{I_{L\min}} = \frac{10}{5} k\Omega = 2k\Omega$

$\therefore \quad 500\Omega \le R_{in} \le 2k\Omega$ Choice (A)

31. We know

$I_R = I_Z + I_L$

$I_{L\min} = I_R - I_{Z(\max)}$

$= (20 - 15)$mA $= 5$ mA

$I_{L\max} = I_R - I_{Z(\min)} = (20 - 0)$mA $= 20$ mA Choice (D)

32. $I_D = I_{Dss}\left[1 - \frac{V_{GS}}{V_P}\right]^2$

$1.5 = 5\left[1 + \frac{V_{GS}}{2}\right]^2$

$\frac{V_{GS}}{2} = -0.4522$

$V_{GS} = -0.9$ Volts

$V_S = 0 - (-0.9) = 0.9$ volts

$R_S = \frac{V_S}{I_D} = \frac{0.9}{1.5} k\Omega = 0.6 k\Omega$ Choice (B)

33. Applying KVL to the drain current

$V_{DD} = I_D R_D + V_{DS} + I_D R_S$

$20 - 12 - 1.5 \times 0.6 = I_D.R_D$

$R_D = \frac{7.1}{1.5} k\Omega = 4.733k\Omega$ Choice (D)

34. For p^+ – polysilicon gate

$\varphi_{ms} = \left[\frac{E_g}{2q} - \varphi_{fp}\right]$

For n^+ poly silicon gate

$\varphi_{ms} = -\left[\frac{E_g}{2q} + \varphi_{fp}\right]$

Where

ϕ_{fp} = potential difference of p-type S.C

$\varphi_{fp} = V_T . \ln\left[\frac{N_A}{n_i}\right]$ volts

$= 0.026 \ln\left[\frac{5 \times 10^{14}}{1.5 \times 10^{10}}\right] = 0.27$ volts

$\therefore \varphi_{ms} = \left[\frac{E_g}{2q} - \varphi_{fp}\right]$

$E_g = 1.11$ eV at room temperature

$\phi_{ms} = \left[\frac{1.11}{2} - 0.27\right]$ volts $= 0.285$ volts Choice (B)

35. $|Q_{SD(max)}| = q.N_A.W_{dT}$

Where $Q_{SD} \rightarrow$ max space charge density per unit area

$W_{dT} \rightarrow$ space charge width

$W_{dT} = \left[\frac{4.\varepsilon_r\ \varepsilon_o.\varphi_{fp}}{q.N_A}\right]^{\frac{1}{2}} = \left[\frac{4 \times 3.9 \times 8.852 \times 10^{-12} \times 0.27}{1.6 \times 10^{-19} \times 5 \times 10^{14}}\right]^{\frac{1}{4}}$

$W_{dT} = (4.66 \times 10^{-7})^{1/2} = 6.82 \times 10^{-4}$ cm

$|Q_{DS(\max)}| = 1.6 \times 10^{-19} \times 5 \times 10^{14} \times 6.82 \times 10^{-4}$

$= 5.456 \times 10^{-8}$ C/cm^2 Choice (C)