ACE Engineering Academy

Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad - 500001.

Ph: 040-23234418, 040-2324419, 040-2324420, 040-24750437

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ESE- 2020 (Prelims) - Offline Test Series Test- 17

ELECTRONICS & TELECOMMUNICATION ENGINEERING

SUBJECT: ELECTROMAGNETICS, MATERIALS SCIENCE, NETWORK THEORY & BASIC ELECTRONICS ENGINEERING(EDC & VLSI) - SOLUTIONS

01. Ans: (d)

Sol: The cylinder ρ = 20 mm don't encloses the cylinder of radius 40 mm. Hence $\overline{K} = 200\hat{a}_z$ will not contribute in $\overline{H}$, but due to solenoid $(\rho = 80\text{mm}, \overline{K} = 160\hat{a}_\phi \text{A/m})$ there will be a magnetic field intensity so we have $\overline{H} = 160\hat{a}_z \text{A/m}$.

$\therefore |\overline{H}| = 160 \text{A/m}$.

02. Ans: (b)

Sol: $Q = \int_V \overline{\nabla}.\overline{D} dv$

$$\overline{\nabla}.\overline{D} = \frac{\partial}{\partial x}(6xyz^2) + \frac{\partial}{\partial y}(3x^2z^2) + \frac{\partial}{\partial z}(6x^2yz)$$

$$= 6yz^2 + 6x^2y$$

$$\therefore Q = \int_1^3\int_0^1\int_{-1}^1 (6yz^2 + 6x^2y)dxdydz$$

$$= 6[x]_1^3\left[\frac{y^2}{2}\right]_0^1\left[\frac{z^3}{3}\right]_{-1}^1 + 6\left[\frac{x^3}{3}\right]_1^3\left[\frac{y^2}{2}\right]_0^1[z]_{-1}^1$$

$$= 56\,C$$

03. Ans: (c)

Sol: $\overline{G}.\overline{dL} = (x^2\hat{a}_x - xyz\hat{a}_z).(dx\hat{a}_x + dy\hat{a}_y + dz\hat{a}_z)$

$$= x^2dx - xyzdz$$

$$\therefore \int_{P_1}^{P_2} \overline{G}.\overline{dL} = \int_1^5 x^2dx - \int_3^4 xyzdz$$

Path of integration is P(1, 2, 3) to (5, 2, 3) to (5, 0, 3) to (5, 0, 4). Between first and second point, y and z coordinates are constant where as x coordinate varies from x = 1 to x = 5. Hence in the first integral, if required substitute y = 2 and z = 3.

Between third and fourth point, x and y coordinates are constant where as z coordinate varies from z = 3 to z = 4. Hence in the second integral, substitute x = 5 and y = 0.

$$\therefore \int_{P_1}^{P_2} \overline{G}.\overline{dL} = \int_1^5 x^2dx = \left[\frac{x^3}{3}\right]_1^5$$

$$= \frac{125-1}{3} = 41.333$$

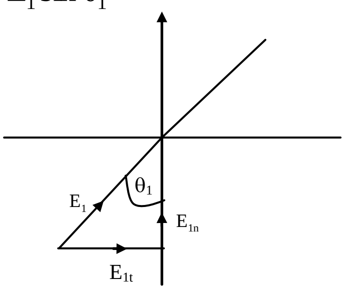
04. Ans: (b)

Sol: From boundary condition, $D_{1n} = D_{2n}$

and $E_{t1} = E_{t2}$

Now $E_{t1} = E_1 \sin\theta_1$

So $E_{t2} = E_1 \sin\theta_1$



$$D_{2n} = D_{1n} \Rightarrow E_{2n} = \frac{\varepsilon_1}{\varepsilon_2} E_{1n}$$

$$E_{2n} = \frac{\varepsilon_1}{\varepsilon_2} E_1 \cos\theta_1$$

$$E_2 = \sqrt{(E_1 \sin\theta_1)^2 + \left(\frac{\varepsilon_1}{\varepsilon_2} E_1 \cos\theta_2\right)^2}$$

$$\therefore E_2 = E_1 \sqrt{\sin^2\theta_1 + \left(\frac{\varepsilon_1}{\varepsilon_2}\right)^2 \cos^2\theta_1}$$

05. Ans: (a)

Sol: $\nabla^2 \overline{E} = \mu\sigma \frac{\partial \overline{E}}{\partial t} + \mu\varepsilon \frac{\partial^2 \overline{E}}{\partial t^2}$

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} = \frac{\partial^2}{dx^2}$$

$$\left(\because \frac{\partial^2}{\partial y^2} = \frac{\partial^2}{\partial z^2} = 0\right)$$

$$\frac{\partial^2 \overline{E}}{\partial x^2} = \mu\sigma \frac{\partial \overline{E}}{\partial t} + \mu\varepsilon \frac{\partial^2 \overline{E}}{\partial t^2}$$

06. Ans: (a)

Sol: From the given electric field, the wave is linearly polarized.

07. Ans: (c)

Sol: Given: $Z_R = 15 + j20\Omega$

$Z_0 = 25\Omega$

Normalized impedance,

$$Z'_R = \frac{Z_R}{Z_0} = \frac{15 + j20}{25}$$

$$\therefore Z'_R = 0.6 + j0.8$$

08. Ans: (d)

Sol: Given:

Characteristic impedance: Z_0

Load impedance: Z_R (or) $Z_L = \frac{Z_0}{3}$

Reflection coefficient, $K = \frac{Z_L - Z_0}{Z_L + Z_0}$

$$= \frac{\frac{Z_0}{3} - Z_0}{\frac{Z_0}{3} + Z_0}$$

$$= \frac{-2Z_0}{4Z_0}$$

$$\therefore K = -\frac{1}{2} (\text{or}) \frac{1}{2}\angle 180^o$$

voltage standing wave ratio,

$$VSWR = \frac{1+|K|}{1-|K|} = \frac{1+\frac{1}{2}}{1-\frac{1}{2}}$$

$\therefore$ VSWR = 3

09. Ans: (b)

Sol: Let R, L, G and C are primary constants of two wire transmission line.

Series impedance, Z = R + jωL

Shunt admittance, Y = G + jωC

Propagation constant,

$$P = \sqrt{ZY} = \sqrt{(R + j\omega L)(G + j\omega C)}$$

Characteristic impedance

$$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{(R + j\omega L)}{(G + j\omega C)}}$$

10. Ans: (b)

Sol: The radiation resistance,

$$R_r = 80\pi^2\left(\frac{d\ell}{\lambda}\right)^2 = 80 \times 9.86 \times \left(\frac{\lambda}{15\lambda}\right)^2$$

$$= \frac{80 \times 9.86}{225} = 3.5\Omega$$

$$\eta = \frac{R_r}{R_r + R_\ell} = \frac{3.5}{3.5 + 1.5} = 0.7$$

$$\eta\% = 0.7 \times 100 = 70\%$$

11. Ans: (d)

Sol: The directivity of n-element end fire array is given by

$$D = \frac{4L}{\lambda}$$

Where L: length of the array

L = (n –1)d

L = nd (if n is large)

'd' spacing between array elements.

Given n = 1000, $d = \frac{\lambda}{4}$

$$D \approx \frac{4 \times (1000)\left(\frac{\lambda}{4}\right)}{\lambda}$$

D = 1000

Directivity, D(in dB) = 10 log 1000

D = 30 dB

12. Ans: (c)

Sol: Aperture ratio (or) aspect ratio (or) width to height ratio of standard rectangular waveguide, $\frac{a}{b} = \frac{2}{1}$ (or) a = 2b

Cut off wavelength for TM_{mn} mode is given by

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

As m = 1, n = 2 for TM_{12}

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{2}{b}\right)^2}} = \frac{2a}{\sqrt{17}} (\text{or}) \frac{4b}{\sqrt{17}}$$

13. Ans: (c)

Sol: Spacing between maximum and minimum is $= \frac{\lambda_g}{4}$

Given $\frac{\lambda_g}{4} = 2.5\text{cm}$

λ_g = 10 cm

Phase shift constant, $\bar{\beta}$ inside a waveguide is given by

$$\bar{\beta} = \frac{2\pi}{\lambda_g} = \frac{2\pi}{10}\text{rad/cm}$$

$$= \frac{\pi \text{ rad}}{5\times10^{-2}\text{m}} = \frac{100\pi}{5} \text{ rad/m}$$

$= 20\pi$ rad/m

14. Ans: (b)

Sol: Given: Interface z = 0 (xy plane)

$$\vec{E}_1 = -3\hat{a}_x + 4\hat{a}_y - 2\hat{a}_z \text{ (for } z < 0)$$

$$\varepsilon_{r_1} = 2$$

$$\varepsilon_{r_2} = 8$$

$$\vec{E}_{t_1} = -3\hat{a}_x + 4\hat{a}_y$$

$$\vec{E}_{n_1} = -2\vec{a}_z$$

From boundary conditions:

$$\vec{E}_{t_2} = \vec{E}_{t_1} = -3\hat{a}_x + 4\hat{a}_y$$

$$\varepsilon_1\vec{E}_{n_1} = \varepsilon_2\vec{E}_{n_2}$$

$$\vec{E}_{n_2} = \left(\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}}\right)\vec{E}_{n_1}$$

$$= \left(\frac{2}{8}\right)(-2\hat{a}_z) = -0.5\hat{a}_Z$$

$$\therefore \vec{E}_2 = \left(-3\hat{a}_x + 4\hat{a}_y - 0.5\hat{a}_z\right)\text{V/m} \quad (\text{for } Z > 0)$$

15. Ans: (c)

Sol: → Stationary charges produces electrostatic fields.

→ A steady current produces magneto static field.

→ An emf-produced field $\bar{E}_f$ is a non-conservative field.

→ Magneto static field is not conservative but magnetic flux is conserved.

16. Ans: (c)

Sol: Electronic and Ionic polarizations does not depends on temperature.

17. Ans: (b)

Sol: $R_H = \frac{1}{nq}$

$$= \frac{1}{10^{22}\times1.6\times10^{-19}} = 6.25\times10^{-4}\text{ m}^3/\text{C}$$

18. Ans: (c)

Sol: Polarization = $D\left(1-\frac{1}{\varepsilon}\right) = 3\left(1-\frac{1}{4}\right) = 2.2 \text{ c/m}^2$

19. Ans: (a)

Sol: $M_3Fe_5O_{12}$ is a general formula of garnets.

$CuOFe_2O_3$ is a ferri magnetic material.

Ferrox cube has square hysteresis loop.

20. Ans: (d)

Sol: Anti ferromagnetic material has zero susceptibility.

$\mu_r = 1 + \chi$

$\mu_r = 1$ ($\because \chi = 0$)

21. Ans: (b)

Sol: The materials used for magnetic shielding must have high saturation induction and low coercivity.

22. Ans: (d)

Sol: Alnico is a permanent magnet, remaining all are soft magnetic materials.

23. Ans: (b)

Sol: The material used for cores of electromagnets must have low hysteresis loss, low coercivity, high retentivity, high initial permeability, maximum flux density.

24. Ans: (a)

Sol: Super conductor properties:

1. A super conductor is a perfect diamagnetic with magnetic susceptibility $= -1$.
2. A super conductor has bound electron pairs also known as cooper pairs within it cooper pair showed that an arbitrarily small attraction between electrons.
3. A super conductor becomes a normal conductor when

(a) Increasing temperature above transition temperature

(b) Increasing magnetic field above critical field

(c) Increasing current above critical current

25. Ans: (d)

Sol: A superconductor is used to generate magnetic field.

26. Ans: (b)

Sol: The bond length of grain boundary is more compare to inside grain and hence they have low energy and easily react with chemical.

27. Ans: (a)

Sol: Hot working does not vary the recrystallisation temperature (RCT) and cold working reduces RCT.

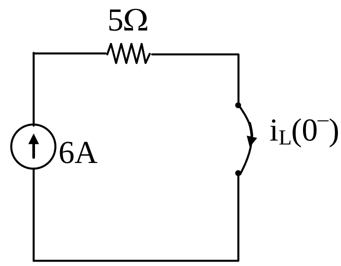
28. Ans: (a)

Sol: The correct ascending order of the resistivity of Fe, Ag, Constantan, Mica and Aluminium is given below

Metal	**Resistivity(in μΩ-cm)**
1 Fe	8.85
2 Ag	1.51
3 Constantan	49
4 Mica	$\sim 10^{21}$
5 Aluminium	2.62

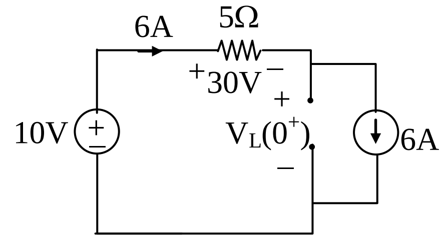
29. Ans: (a)

Sol: Circuit at t = 0^-



$i_L(0^-) = i_L(0^+) = 6A$

Circuit at t = 0^+



By KVL, $10 - 30 - V_L(0^+) = 0$

$\Rightarrow V_L(0^+) = -20$ Volts

30. Ans: (b)

Sol: Hence, $Y_C + Y_A = 4$

$\Rightarrow Y_A = 4 - Y_C = 4 + 5 = 9℧$

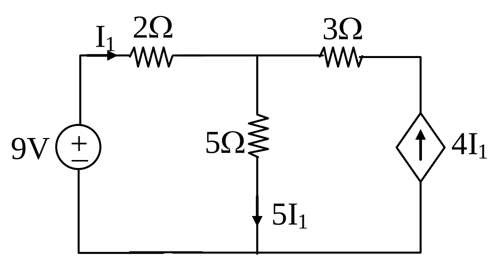
$Y_C = -5℧$

$Y_B + Y_C = 8$

$\Rightarrow Y_B = 8 - Y_C = 8 + 5 = 13℧$

31. Ans: (c)

Sol:



By KVL, $9 - 2I_1 - 25\,I_1 = 0$

$\Rightarrow 27I_1 = 9$

$\Rightarrow I_1 = \frac{9}{27} = \frac{1}{3}$

$\therefore P_{2\Omega} = I_1^2 R = \left(\frac{1}{3}\right)^2 \times 2 = \frac{2}{9} W$

$= 0.22$ Watts

32. Ans: (d)

Sol: By KCL, $8 = I + I + 4I + \frac{I}{2}$

$\Rightarrow I = \frac{8}{6.5} = \frac{80}{65} = \frac{16}{13} A$

33. Ans: (d)

Sol: Q-factor $= \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{25\times10^{-3}}{0.1\times10^{-6}}}$

$= \frac{1}{10}\sqrt{\frac{25\times10^{-2+6}}{1}} = \frac{5\times100}{10} = 50$

34. Ans: (d)

Sol: V(0) = 5×10 = 50 Volts

$V(\infty) = \frac{15\times10}{15} = 10$ Volts

$\tau = R_{eq}C = \frac{50}{15}\times10^3\times3\times10^{-6}$

$= 10\times10^{-3} = 10^{-2}$ sec

$\therefore V(t) = V(\infty) + [V(0) - V(\infty)]e^{-t/\tau}$

$= 10 + [50 - 10]e^{-100t}$

$= 10 + 40e^{-100t}$

$V(t) = 10\,(1 + 4e^{-100t})$ Volts

35. Ans: (a)

Sol: Equivalent Voltage,

V = 40 – 15 + 20 – 15 = 30 Volts

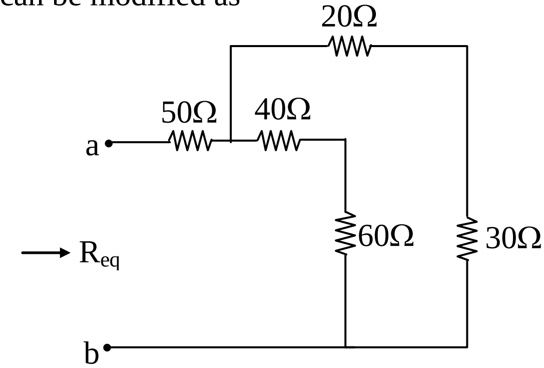
Equivalent Resistance,

R = 5 + 8 + 7 + 5 + 3 = 28 Ω

36. Ans: (b)

37. Ans: (d)

Sol: Using bridge balance condition given circuit can be modified as



$R_{eq} = 50 + [100//50]$

$= 50 + \frac{100\times50}{150} = 50 + \frac{100}{3}$

$= 50 + 33.33 = 83.33\Omega$

38. Ans: (a)

Sol: $L_1 = 4 - 2 + 1 = 3H$

$L_2 = 8 - 2 + 4 = 2H$

$L_3 = 11 + 1 - 4 = 8H$

$\therefore L_{eq} = 3 + 2 + 8 = 13H$

39. Ans: (d)

Sol: By observing figure (A) & (B) we can directly say that figure (B) is derivative of figure (A)

V(t) waveform is derivative of i(t) waveform

$V(t) = k\frac{d}{dt}i(t)$ ----(1) k = constant (any)

This equation exactly similar to inductive nature element response

$V_L(t) = L\frac{di(t)}{dt}$ ----(2)

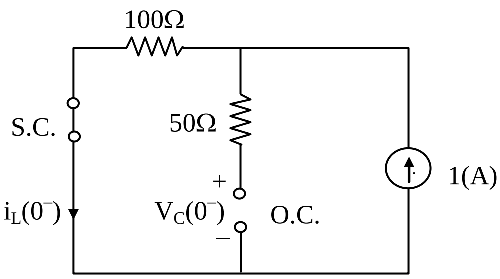
$L = \frac{V_L(t)}{\frac{di_L(t)}{dt}}$

$L = \left.\frac{V_L(t)}{\frac{di_L(t)}{dt}}\right|_{t=10\,to\,15}$

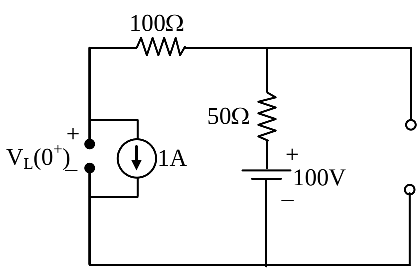
$$\Rightarrow L = \frac{-20}{\frac{d}{dt}\left[-4(t-15)\right]} = 5H$$

40. Ans: (d)

Sol: Network at t = 0^- inductor short circuit capacitor open circuit



$V_C(0^-) = 100$ V
$i_L(0^-) = 1$A
network at t = 0^+



$-100 + (50\times1) + (100\times1) + V_L(0^+) = 0$
$V_L(0^+) = -50$ V

$$V_L(0^+) = L\frac{di_L(0^+)}{dt}$$

$$\frac{di_L(0^+)}{dt} = \frac{V_L(0^+)}{L} = \frac{-50}{1}$$

$$\frac{di_L(0^+)}{dt} = -50\left(\frac{A}{sec}\right)$$

41. Ans: (c)

42. Ans: (d)

Sol: $V_1 = -20\cos(\omega t+70^0) = 20\cos(\omega t+70-180^0)$
$= 20\cos(\omega t-110^0)$
$V_2 = 40\sin(\omega t-20^0) = 40\cos(\omega t - 20 - 90^0)$
$= 40\cos(\omega t-110^0)$

Hence the phase angle between V_1 and V_2 is $110 - 110 = 0^0$

43. Ans: (d)

Sol: By applying superposition theorem
$i_x = 5A$, $i_y = 10A$

44. Ans: (c)

Sol: $I_s = \frac{6}{6} + \frac{6}{12} + \frac{6}{3}$

$I_s = 1 + \frac{1}{2} + 2 = 3.5A$

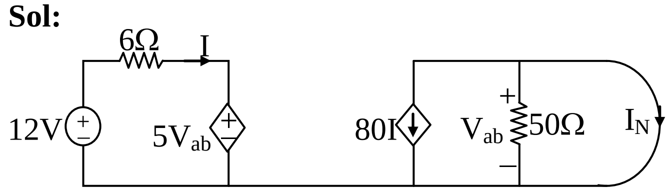
45. Ans: (a)

Sol: By KVL $18 - 2I - 3V_0 + 7 - 4I = 0$
$18 + 7 = 6I + 3V_0$
Here $V_0 = 4I$
$6I + 12I = 25$

$I = \frac{25}{18}A$

46. Ans: (b)

Sol:



Hence $V_{ab} = 0$

$\therefore\ I = \frac{12}{6} = 2A$

$I_N = -80I$
$I_N = -160A$

47. Ans: (a)

Sol: In active filter inductor is absent which is bulky and expensive at lower frequency.

48. Ans: (b)

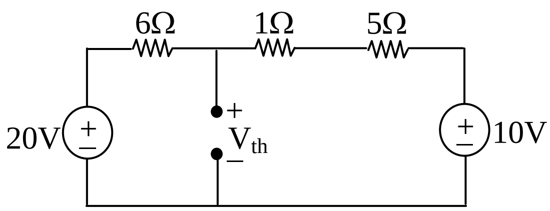
Sol: In the given circuit R_3 decrease means increase the current through R_3 and decrease the current through R_2 because R_2 and R_3

are parallel connection, so power dissipated in R_2 decrease.

49. Ans: (b)

50. Ans: (a)

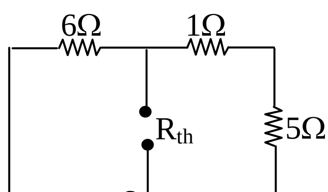
Sol: Calculation for V_{th}



$$\therefore \frac{V_{th}-20}{6}+\frac{V_{th}-10}{6}=0$$

$\Rightarrow V_{th} = 15$ Volts

Calculation for R_{th}



$$\therefore R_{th} = 6 // 6 = \frac{6}{2} = 3\Omega$$

$$\therefore P_{max} = \frac{V_{th}}{4R_{th}} = \frac{15^2}{4\times 3} = \frac{15\times 15}{4\times 3}$$

$$= \frac{15\times 5}{4} = \frac{75}{4} = 18.75\text{W}$$

51. Ans: (c)

Sol: In an Opto-electronic communication system, the system component in which free electrons are involved in its operation is Photo detector

52. Ans: (c)

Sol: The correct statement is
Maximum velocity of electrons increases with decreasing wavelength.

53. Ans: (b)

Sol: Due to body effect, V_{SB} change and as a result threshold voltage change.

54. Ans: (b)

Sol: $V_{DS} = V_{GS} - V_T = 3V - 0.5V = 2.5V$

55. Ans: (c)

Sol: 1: TRUE
2: FALSE, as channel length reduces, output resistance reduces
3: FALSE, as channel length reduces, threshold voltage reduces
4: TRUE

56. Ans: (d)

Sol: $$r_{ds} = \frac{1}{\mu_n c_{ox}\frac{W}{L}[V_{GS}-V_T]}$$

As V_{GS} increases, resistance decreases, therefore option (d) is not correct.

57. Ans: (d)

Sol: The electrical properties of dry oxidation is better than wet oxidation. But it is slow process.

58. Ans: (a)

Sol: The N-channel MOSFETs having inputs A, B are parallel and C is in series.
Hence output, $Y = \overline{(A+B)C} = \overline{A}\,\overline{B} + \overline{C}$

59. Ans: (c)

Sol: Fermi level of p-type semiconductor
$\rightarrow$ Very close to the valence band

Continuity equation
$\rightarrow$ Law of conservation of charge

Ohm's low for conduction in metal
$\rightarrow \sigma E$

Conductivity of intrinsic semiconductor
$\rightarrow n_i q\,(\mu_n+\mu_p)$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60. Ans: (a)

Sol: → TRIAC is a bidirectional switch equivalent to 2 separate SCR devices connected in inverse parallel. So, 1 is false.

→ Shockley diode is a four-layered pnpn diode with only two external terminals. So, 2 is correct.

→ Silicon-controlled switch (SCS) is a Unidirectional device with characteristics similar to SCR. So, 3 is correct.

→ DIAC is a two-terminal AC switch mainly used to trigger the SCR. So, 4 is false.

61. Ans: (d)

Sol: $R_H = \frac{1}{qn}$

$$\Rightarrow n = \frac{1}{qR_H} = \frac{1}{1.6\times10^{-19}\times15\times10^5}$$

$$= 4.167\times10^{12}\,\text{cm}^{-3}$$

62. Ans: (a)

Sol: Fill factor $(ff) = \frac{V_m I_m}{V_{oc} I_{sc}} = \frac{P_m}{V_{oc} I_{sc}}$

P_m = (ff) $V_{oc}I_{sc}$

= (0.7)(0.9)(80m)

= 50.4mW.

63. Ans: (b)

Sol:

$$I_o = Aq\left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A}\right) n_i^2$$

$$= 10^{-4}\times1.6\times10^{-19}\left(\frac{10}{5\times10^{-4}\times10^{16}} + \frac{18}{10\times10^{-4}\times10^{18}}\right)(1.5\times10^{10})^2$$

$= 7.26\times10^{-15}$A

64. Ans: (a)

Sol: $p_p \approx N_A = 10^{18}/\text{cm}^3$

$$p_{no} = \frac{n_1^2}{N_D} = \frac{(1.5\times10^{10})^2}{10^{16}}$$

$= 2.25\times10^2/\text{cm}^3$

$n_n \approx N_D = 10^{16}/\text{cm}^3$

$$n_{po} = \frac{n_i^2}{N_A} = \frac{(1.5\times10^{10})^2}{10^{18}}$$

$= 2.25\times10^4/\text{cm}^3$

65. Ans: (c)

Sol: The dielectric constant of the vacuum is less than that of any other medium.

66. Ans: (a)

Sol: Assume the line is terminated by a reactive (capacitive or inductive) load.

i.e. $Z_R = \pm\, jX$

+ jX → for inductive load

–jX → for capacitive load

Reflection coefficient,

$$K = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{\pm jX - Z_0}{\pm jX + Z_0}$$

$$|K| = \frac{\sqrt{X^2 + Z_0^2}}{\sqrt{X^2 + Z_0^2}} = 1$$

Therefore for reactive loads magnitude of reflection coefficient is unity.

$$VSWR = \frac{1+|K|}{1-|K|} = \infty$$

Hence for reactive load VSWR is unity.
Therefore both S1 and S2 are true and S2 is the correct explanation of S1.

67. Ans: (a)

Sol: As magnetic monopole does not exist, always magnetic flux lines are continuously closed loops.

Therefore magnetic flux leaving any closed surface is equal to zero

$$\phi\Big|_{\text{closed surface}} = \oint_s \vec{B}.\vec{ds} = 0$$

From divergence theorem

$$\oint_v \nabla.\vec{B}.dv = 0$$

$$\nabla.\vec{B} = 0$$

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Hence magnetic flux density is said to be solenoidal.

68. Ans: (d)

Sol: $BaTiO_3$ can not be used as an amplifier because it is an insulator.

69. Ans: (d)

Sol: The change in dimension of material (i.e. strain produced in it) when it is magnetized is called 'Magnetostiction'. The deformation is different along different directions and is independent of direction of field.

Based on weiss-Domain Theory, the magnetic

1. Expand at initial field. If is a reversible process
2. Rotate the dipoles in domains in the direction of fields high magnetic field. It is an irreversible process.

70. Ans: (a)

Sol: Entropy and thermal conductivity decreases with decreasing temperature.

71. Ans: (c)

Sol: The electrical resistivity of silver is lower than that copper. So the statement II is incorrect.

The electrical conductivity of metal decreases by adding impurities to the host material, even though by adding high conductivity (silver) atoms added to copper as an impurity, it's overall conductivity decreases than pure host material.

72. Ans: (a)

73. Ans: (b)

74. Ans: (c)

Sol: Reciprocity theorem cannot applied to the non linear network.

75. Ans: (d)

Sol: For same drain current rating p-channel MOSFET occupies more area than n-channel MOSFET.