TEST ID: 205

ACE Engineering Academy

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ESE- 2019 (Prelims) - Offline Test Series Test-9

ELECTRONICS & TELECOMMUNICATION ENGINEERING

SUBJECT: MATERIALS SCIENCE AND NETWORK THEORY SOLUTIONS

01. Ans: (c)

Sol: $R_1 = \frac{\ell}{\sigma_1 \ell^2} = \frac{1}{\sigma_1 \ell}$

$R_2 = \frac{2\ell}{\sigma_2 4\ell^2} = \frac{1}{2\ell\sigma_2}$

So, $R_1 = R_2 \Rightarrow \frac{1}{\sigma_1 \ell} = \frac{1}{2\ell\sigma_2}$

$\Rightarrow \frac{\sigma_1}{\sigma_2} = \frac{2}{1}$

02. Ans: (b)

Sol: The charge deposited on the object, q = it

$q = 8\text{ k} \times 15\mu = 120\text{ mC}$

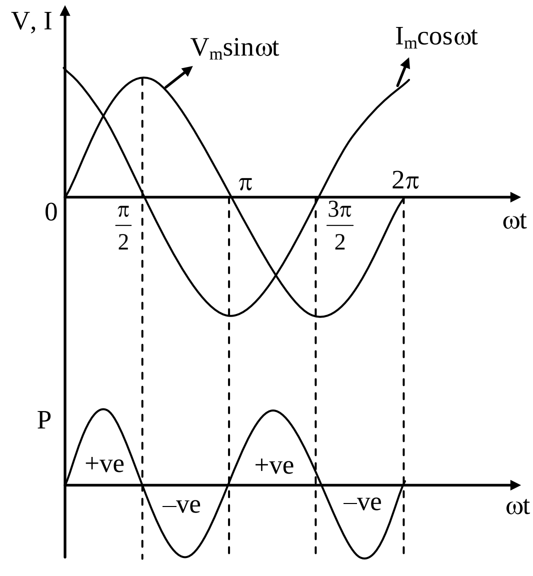
03. Ans: (a)

Sol: In a Pure capacitor

Let applied voltage $V = V_m \sin\omega t$

Current drawn from the supply $I = I_m \cos\omega t$ (as capacitor is pure)

Power drawn from the source will be positive when applied voltage increases but current decreases.



04. Ans: (b)

Sol: The supply voltage =220 V

Initial current $I(0^+) = I(0^-) = 0A$

Steady state current, $I(\infty) = \frac{220}{100} = 2.2A$

Time constant, $\tau = \frac{L}{R} = \frac{0.5}{100} = 5\text{mSec}$

The current flowing through Inductor,

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

$1 = 2.2\,[1 - e^{-200t}]$

$t \approx 3.03$ msec

05. Ans: (d)

Sol: $\cos\phi = \frac{R}{|Z|} = \frac{10}{\sqrt{100+100}} = \frac{1}{\sqrt{2}}$

$= 0.707$ (lead)

$\because X_C > X_L$

06. Ans: (c)

Sol: Current $i = 2\left[\frac{100\angle 0^o}{\sqrt{64+36}}\right] = 20$ A

07. Ans: (d)

Sol: At parallel resonance the supply current, voltages are in phase.

$\Rightarrow$Input power factor is unity. $\Rightarrow$ Supply voltage (V) and current (I) are in phase

08. Ans: (a)

Sol: $S_1 = P_1 + jQ_1 \Rightarrow S_1 = 20000 + j0$

$S_2 = P_2 + jQ_2$

$\Rightarrow S_2 = 30000\,(0.8) + j30000\,(0.6)$

$S_3 = P_3 - jQ_3$

$\Rightarrow S_3 = 35000\,(0.9) - j35000\,(\sqrt{1-0.9^2}\,)$

Total active power, $P_T = P_1 + P_2 + P_3$

$= 20\text{ k} + 24\text{ k} + 31.5\text{ k}$

$= 75.5$ kW

09. Ans: (d)

Sol: Given $V = 3\cos 3t$,

$I = -2\sin(3t + 10°)$

$= 2\cos(3t + 10° + 90°)$

$= 2\cos(3t + 100°)$

I leads V by an angle 100°

10. Ans: (a)

Sol: $Z_1 = 3+j4$, $Z_2 = 10 + j0$

$I_1Z_1 = I_2Z_2$ [$\because$ parallel]

$\frac{|I_1|}{|I_2|} = \frac{|Z_2|}{|Z_1|} = \frac{10}{\sqrt{3^2+4^2}} = 2$

$\Rightarrow |I_1| = 2|I_2|$

$\frac{P_1}{P_2} = \frac{|I_1|^2 R_1}{|I_2|^2 R_2} = \frac{\left[|2I_2|^2\right]3}{|I_2|^2 .10}$

$\frac{P_1}{P_2} = \frac{12}{10} = \frac{6}{5}$ …………(1)

& $P_1 + P_2 = 1100$ ……….(2)

So, $P_1 = 600$ W, $P_2 = 500$ W

11. Ans: (b)

Sol: $P_{Lost} = (I_{Rms})^2 .R$

$I_{Rms} = \sqrt{\frac{1}{8}\left[100(2)+16(2)+4(2)\right]}$

$= \sqrt{\frac{120\times 2}{8}}$

$= \sqrt{\frac{120}{4}}$

$= \sqrt{30}$

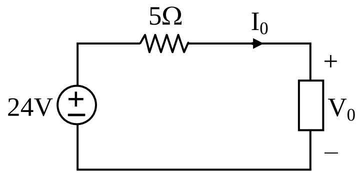
$P = \left(\sqrt{30}\right)^2(1) = 30$ W

12. Ans: (b)

Sol: Apply Thevenin's theorem

$\rightarrow R_{TH} = 2 + [12//4] = 5\ \Omega$

$\rightarrow V_{TH} = 32\left[\frac{12}{16}\right] = 24$ V



KVL $-24 + 5I_0 + V_0 = 0$

$V_0 = 24 - 5I_0$

13. Ans: (d)

Sol: time constant, $\tau = \frac{L}{R} = \frac{20}{(10//10)}$ = 4 sec

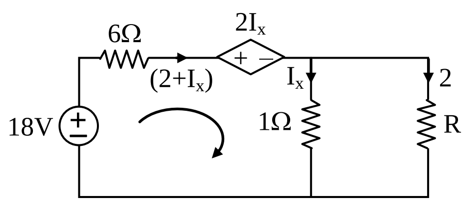
14. Ans: (c)

Sol: $I_N = 10\left[\frac{3}{9}\right] = \frac{10}{3} = 3.33$ A

$R_N = 6 + 3 = 9\ \Omega$

15. Ans: (d)

Sol:



KVL $-18 + 6[2 + I_x] + 2[I_x] + I_x = 0$

$9I_x = 18 - 12$

$I_x = \frac{2}{3}$ A

Voltage across R = $\frac{2}{3}$ V

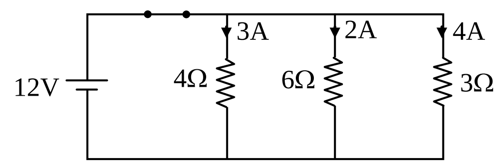
Then $R = \frac{V}{i} = \frac{\frac{2}{3}}{2} = \frac{1}{3}\Omega$

16. Ans: (d)

Sol: $R_A = \frac{12\times12}{36} = 4\ \Omega$

$R_B = \frac{12\times12}{24} = 6\ \Omega$

$R_C = \frac{12\times12}{48} = 3\ \Omega$



$I_T = 3 + 2 + 4 = 9$ A

If another 11 A flows fuse will blow but each bulb A carries 3A.

So, x[3] ≥ 11

$x \geq \frac{11}{3} \approx 3.66 = 4$ bulbs

17. Ans: (d)

Sol: Network nodes (n) =4

Branches (b) =6

Complete graph will have nc_2 branches

$\Rightarrow 4c_2 = 6$, given network graph is complete.

Number of trees = n^{n-2}

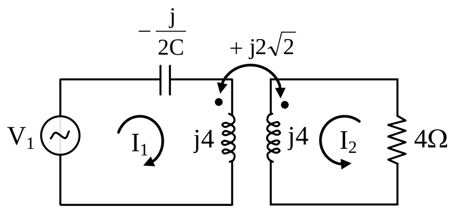
($\because$ as graph is complete)

= 16

Number of cut set matrices = Number of tie set matrices =number of trees= 16

18. Ans: (d)

Sol:



KVL-1: $V_1 = -j\dfrac{I_1}{2C} + j4I_1 + j\,2\sqrt{2}\,I_2$ ….(1)

KVL-2: $0 = (4 + j4)\,I_2 + j\,2\sqrt{2}\,I_1$ ………(2)

$$\Rightarrow I_2 = \frac{-j\sqrt{2}\,I_1}{2[1+j]}$$

Now, $\dfrac{V_1}{I_1} = \dfrac{-j}{2C} + j4 + \dfrac{2}{1+j}$

$$\frac{V_1}{I_1} = \frac{-j + j8C + 2C - j2C}{2C}$$

$$Z_{in} = \frac{V_1}{I_1} = \frac{-j + j8C + 2C - j2C}{2C}$$

Under Resonance,

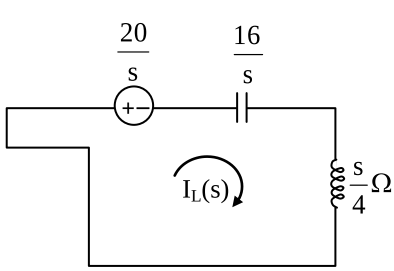
$$I_m(z_{in}) = 0 \Rightarrow -j + j8C - j2C = 0$$

$$6C = 1$$

$$C = \frac{1}{6}F$$

19. Ans: (a)

Sol: $V_c(0^-) = 20$ V, $i_L(0^-) = 0$



$$I(s)\left[\frac{16}{s} + \frac{s}{4}\right] = -\frac{20}{s}$$

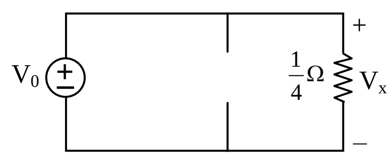
$$I(s)\left[\frac{64 + s^2}{4s}\right] = -\frac{20}{s}$$

$$I(s) = \frac{-80}{s^2 + 8^2} = -10\left[\frac{8}{s^2 + 8^2}\right]$$

$i(t) = -10\sin 8t$ A

20. Ans: (b)

Sol: Circuit at $t = 0^+$



$V_x(0^+) = V_0 = 2V$ only

21. Ans: (d)

Sol: The h-parameters

$$V_1 = h_{11}I_1 + h_{12}V_2$$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

When $I_1 = 0$

$$V_1 = 20\,I_2$$

$$V_2 = 20\,I_2$$

$$h_{12} = \frac{V_1}{V_2} = 1$$

$$h_{22} = \frac{I_2}{V_2} = \frac{1}{20} = 0.05$$

When $V_2 = 0$,

$$V_1 = 10I_1$$

$$I_1 = -I_2$$

$$h_{11} = \frac{V_1}{I_1} = \frac{10}{1} = 10$$

$$h_{21} = \frac{I_2}{I_1} = -1$$

22. Ans: (a)

Sol: $\frac{F(s)}{s} = \frac{1}{s} - \frac{1}{(s+\alpha)}$

$F(s) = 1 - \frac{s}{s+\alpha}$

$= 1 - \left[\frac{s+\alpha-\alpha}{s+\alpha}\right]$

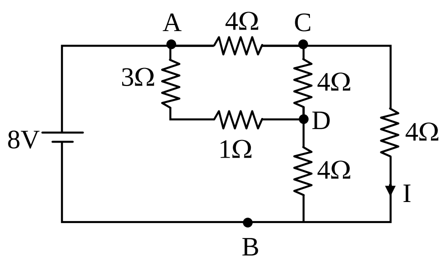
$= 1 - \left[1 - \frac{\alpha}{s+\alpha}\right]$

$= \frac{\alpha}{s+\alpha}$

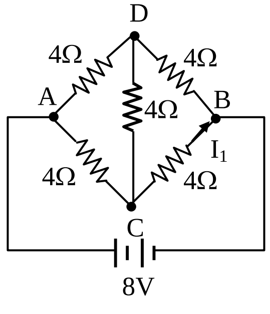
Impulse response is, $\alpha e^{-\alpha t}$

23. Ans: (b)

Sol: What is the current I in the given below



Redrawn the circuit



As the bridge is balanced the current flowing through in the branch CD is zero.

So $I_1 = \frac{8V}{8\Omega} = 1A$

24. Ans: (c)

Sol: Tree is a connected sub graph, which connects all the nodes without any closed loop.

Tree branches are called twigs

The number of tree branches of any graph = (n-1)

The rank of tree is n-1

25. Ans: (c)

Sol: **damped frequency,** $\omega_d = \omega_0\sqrt{1-\delta^2}$

$\sqrt{15} = \omega_0\sqrt{1-\delta^2}$

Bandwidth, BW $= \frac{\omega_0}{Q}$, $Q = \frac{1}{2\delta}$

$BW = 2\delta\omega_0$,

$2 = 2\delta\omega_0$,

$\delta\omega_0 = 1$

$\omega_0^2(1-\delta^2) = 15$

$\omega_0^2 - \omega_0^2\delta^2 = 15$

$\omega_0^2 = 15 + 1 = 16$,

Resonant frequency = 4 rad/sec

26. Ans: (c)

Sol: In 3-ϕ star-connected system

$V_L = \sqrt{3}V_{phase}$

$I_L = I_{ph}$

Line voltages are 30° ahead of the corresponding phase voltage

Output power = $3V_{ph}I_{ph}\cos\phi = \sqrt{3}V_L I_L \cos\phi$

Where ϕ angle between phase voltage and phase current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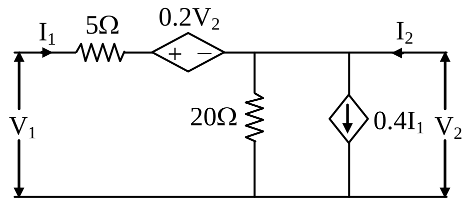
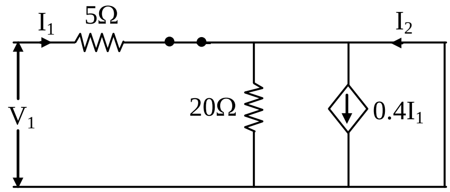
27. Ans: (c)

Sol:



$$Y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0}$$



$V_1 = 5I_1$

$I_1 + I_2 = 0.4\ I_1$

$\Rightarrow I_2 = -0.6 I_1$

$= -0.6 \times \frac{V_1}{5}$

$\frac{I_2}{V_1} = -0.12$

28. Ans: (b)

Sol: Resistance of blub, $R = \frac{V^2}{P}$

$= \frac{(120)(120)}{60}$

$= 240\ \Omega$

29. Ans: (b)

30. Ans: (c)

Sol: $I_1 = 4\ V_1 + V_2$

$I_2 = 2\ V_1 + 3\ V_2$

$$Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$

$I_1 = 0,\ V_2 = -4\ V_1,\ I_2 = -10\ V_1,$

$Z_{22} = 0.4\Omega$

31. Ans: (b)

32. Ans: (a)

Sol: $L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt = v_s(t)$

Characteristic equation:

$$\frac{d^2 i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{1}{LC}\,i(t) = 0$$

For critical damping:

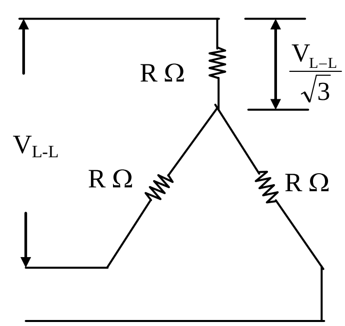
$$\left(\frac{R}{L}\right)^2 = \left(\frac{4}{LC}\right),\ R^2 = 4\frac{L}{C},\ R = 2\sqrt{\frac{L}{C}}$$

$$R = 2\sqrt{\frac{1}{4}} = 1\Omega$$

33. Ans: (c)

Sol: R = resistance of each phase.

(i) Star:



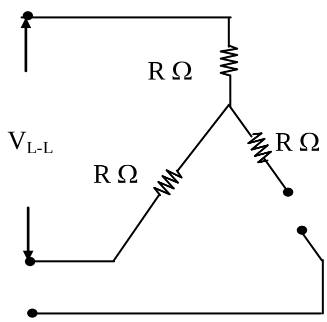
$P = 3.\ V_{ph}\ I_{ph}$

$$I_{ph} = \frac{\frac{V_{L-L}}{\sqrt{3}}}{R}$$

$$\Rightarrow p = (3)(V_{ph})(I_{ph}) = (3)\left(\frac{V_{L-L}}{\sqrt{3}}\right)\left(\frac{\frac{V_{L-L}}{\sqrt{3}}}{R}\right)$$

$$P_Y = \frac{V_{L-L}^2}{R}$$

If one of the resistance in star connection gets open

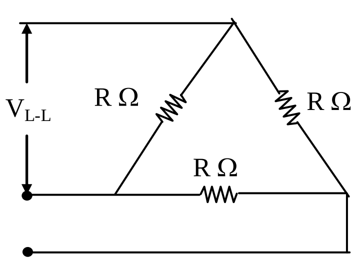


$$P = \frac{(V_{L-L})^2}{(R+R)} = \frac{V_{L-L}^2}{2R}$$

P_{open-Y} = reduction power consume

Reduction in load = $\dfrac{P_Y - P_{open-Y}}{P_Y} = 50\%$

(ii) Delta

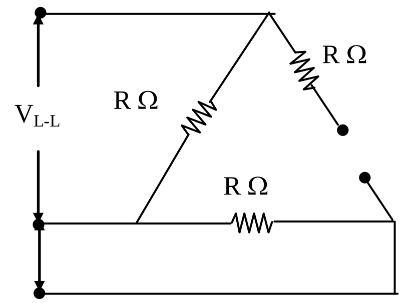


$$I_{ph} = \frac{V_{L-L}}{R}$$

$P = (3)\ (V_{ph})\ (I_{ph})$

$$P_\Delta = (3)\ (V_{L-L})\ \frac{V_{L-L}}{R} = \frac{3V_{L-L}^2}{R}$$

If one of the resistance in delta connection gets open



$$P = \frac{(V_{L-L})^2}{R} + \frac{(V_{L-L})^2}{R}$$

$$P_{open-\Delta} = \frac{2V_{L-L}^2}{R}$$

Reduction in load = $\dfrac{P_\Delta - P_{open-\Delta}}{P_\Delta} = 33.33\%$

34. Ans: (a)

Sol: Given $V_C(0) = 2V$,

$V_C(\infty) = 1$,

$\tau = R_{eq}.C = 2 \times 1/4 = 0.5$ sec

Voltage across capacitor

$V_C(t) = 1 + (2 - 1)\ e^{-2t}$ V

$= 1 + e^{-2t}$

35. Ans: (b)

Sol: Bandwidth $= \dfrac{1}{\tau} = \dfrac{1}{RC}$

So, $R = \dfrac{1}{BW \times C}$

$= \dfrac{1}{10 \times 10^3 \times 100 \times 10^{-12}}$

$= \dfrac{10^6}{1} = 10^6\ \Omega$

$\Rightarrow R = 1M\Omega$

36. Ans: (d)

Sol: $L_{eff} = L_1 + L_2 + L_3 + 2(M_{12} + M_{13} + M_{23})$

$L_1 = 2H,\ M_{12} = 1H,$

$L_2 = 3H,\ M_{23} = 1H,$

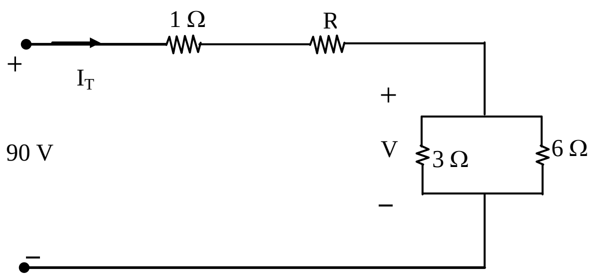
$L_3 = 5H,\ M_{13} = 2H,$

$L_{eff} = 2 + 3 + 5 + 2(1 + 1 + 2)$

$= 18\ H$

37. Ans:(a)

Sol:



Given that

$$P_3 = 300\ W \Rightarrow \frac{V^2}{3} = 300$$

$$\Rightarrow V = 30V$$

So, $I_T = \frac{30}{3} + \frac{30}{6} = 15\,A$

By KVL

$- 90 + 15(1) + 15\ R + 30 = 0$

$$15\ R = 90 - 45 \Rightarrow R = \frac{45}{15} = 3\Omega$$

38. Ans: (c)

Sol: If the radius ratio x = 0.414, a more stable configuration is possible with six anions bonding with a cation. This configuration called the octahedral configuration is stable for 0.414 < x < 0.732. Here the cation occupies the void created by six anions forming an octahedral structure.

39. Ans: (d)

Sol: A crystal structure characterized by a rectangular lattice and square base and height.

$a = b = c,\ \alpha = \beta = \gamma \neq 90^0$

This is formed in As, Sb, Bi and Calcite

40. Ans: (d)

Sol: Volume of unit cell = a^3

number of atoms per unit cell = 4

radius of Atoms = $\frac{a\sqrt{2}}{4}$

packing fraction = $\frac{4 \times \frac{4}{3}\pi r^3}{a^3}$

$$= 4 \times \frac{4}{3}\pi\left(\frac{\sqrt{2}}{4}\right)^3$$

$$= \frac{\pi\sqrt{8}}{12} \Rightarrow \frac{\pi \times 2\sqrt{2}}{12}$$

$$= \frac{\pi\sqrt{2}}{6}$$

41. Ans: (b)

Sol: The number of atoms per unit cell of HCP crystal = 6.

The number of atoms per unit cell of FCC crystal = 4.

So difference is = 6 – 4 = 2

42. Ans: (c)

Sol: Physical mixing of more than two materials is called as composite that may not be required in similar phases. Composite is a combination of matrix and reinforcement where thermostets are used preferably due to their high strength.

43. Ans: (b)

Sol: Charcoal – Amorphous

Chromium – BCC

Copper – FCC

Graphite - . H.C.P

44. Ans: (a)

Sol: A special class of ferrites called 'ferrox cubes' are used as computer memory elements.

45. Ans: (c)

Sol: If the temperature of metal increases, the lattice vibration in the crystal structure increases. Hence collision frequency increases and relaxation time decreases. Due to the resistivity of metal increases.

46. Ans: (b)

Sol: Any impurities will act as scattering centers and resistivity increases (or) conductivity decreases

47. Ans: (a)

Sol: Ionic compounds are very strong in nature. They require a lot of energy to break them. Therefore they have high melting and boiling points.

48. Ans: (d)

Sol: In tungsten, atoms are arranged in all eight corners and has an additional atom in the centre satisfying the body centered cubic lattice condition.

49. Ans: (b)

Sol: When a large value of a.c. current is applied to a super conducting material it induces some magnetic field in the material and because of this magnetic field, the superconducting property of the material is destroyed.

50. Ans: (a)

Sol: Magnetic lines of force are defined as the continuous curve in a magnetic field. The tangent drawn at any point on the curve gives the direction of resultant magnetic field at that point.

51. Ans: (a)

Sol: Nano particles are produced by generating plasma using Radio frequency heating coils in plasma arching method. It consists of an evacuated chamber, wounded by high voltage RF coils.

52. Ans: (b)

Sol: When alkali halides are heated in an atmosphere of the constituent metal, halide ions diffuse to the surface to react with the vapour particles. These results in excess of cations over anions.

53. Ans: (a)

Sol: The magnetic bubbles used in computer memories to store the data which made up of Yttrium-iron garnet.

54. Ans: (d)

Sol: Maglev trains which can reach very high velocity

→ MRI scan machine (medical science, brain imaging)

→ energy storage

→ The Large Hadron Collider (LHC) for generating high velocity particles travelling at speed of high.

55. Ans: (b)

Sol: $\sqrt{2}\,a = 4R$

$$a = \frac{4R}{\sqrt{2}}$$

$$= \frac{4(0.175)}{\sqrt{2}}$$

$$= 0.494 \text{ nm}$$

56. Ans: (a)

Sol: Given data:

$V = 10$

$d = 2 \times 10^{-3}$ m

$\varepsilon_r = 6$

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

Dielectric displacement $D = \varepsilon_0 \varepsilon_r E$

$$\therefore\ E = \frac{V}{d} = \frac{10}{2\times10^{-3}\,\text{V/m}}$$

$D = 6 \times 8.85 \times 10^{-12} \times 5 \times 10^{3}$

$= 265.5 \times 10^{-9}$ C/m^2

57. Ans: (d)

Sol: In an intrinsic semiconductor the probability of finding an electron at the edge of the conduction band is equal to that of finding a hole at the edge of valence band at all temperatures.

Hence the Fermi level lies in the middle of the band gap always at all temperatures.

58. Ans: (b)

Sol: Metallic materials have large number of valence electron and they are more compact than non-metallic elements.

59. Ans: (c)

Sol: Dielectric constant depends on a frequency and temperature.

60. Ans: (b)

Sol: The residual polarization can be eliminated by

→ Applying field in opposite direction

→ Heating material above curie temperature

61. Ans: (b)

Sol: Statement 3 is incorrect, only some of piezo electric materials are ferro electric materials.

62. Ans: (c)

Sol: The material for use as permanent magnets should have the following:

→ Low permeability

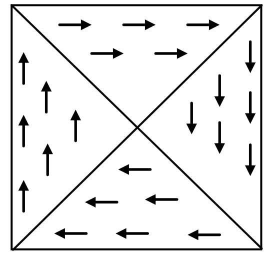
→ High coercive force

→ Appreciable remnant flue density

→ High curie temperature, to minimize easy demagnetization.

63. Ans: (c)

Sol: As per wiess-Domain theory, atomic dipole moment is individual domain is parallel



H = 0

64. Ans: (b)

Sol: Ferrites for permanent magnets → Hard ferrites

Ferrites for transformers and inductors→ Soft ferrites

Data storage → rectangular loop ferrites

Microwave isolators → Ferrites and Garnets

65. Ans: (d)

Sol: The conductivity is in descending order as follows. Hard drawn copper, cadmium copper, Aluminium & galvanised steel.

66. Ans: (a)

Sol: → In rock salt structure, number of cations =4 and number of anions = 4

→ Coordination number is 6

→MgO, FeO are rock salt structure materials.

→ Automatic packing factor = 0.793

67. Ans: (c)

Sol: → Magnetic susceptibility equal to –1

→Magnetic flux density of super conductor is not zero.

→Super conductors are used in maglev trains.

→ With increasing temperature of a super conductor required magnetic field to destroy super conductor is decreases.

68. Ans: (b)

Sol: Physical mixing of more from two materials is known as composite. Based on the combination of materials, the final properties are dependent.

69. Ans: (a)

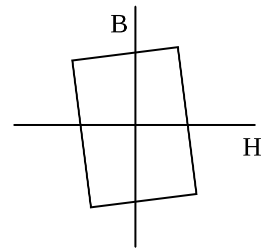
Sol: The Curie temperature is the critical point where a material's intrinsic magnetic moments change direction. Magnetic moments are permanent dipole moments within the atom which originate from electrons angular momentum and spin. Materials have different structures of intrinsic magnetic moments that depend on temperature. At a material's Curie temperature those intrinsic magnetic moments change direction.

70. Ans: (a)

Sol: Ferrox cube in also known as rectangular ferrite with rectangle hysteresis loop.

Eg: Mn-Mg Fe_2O_4

Zn-MnFe_2O_4



71. Ans: (c)

Sol: Fine grain materials are produced by fast cooling rate and possess more grain boundaries with small grain and these materials require more applied field to magnetize.

72. Ans: (c)

Sol: Statement (II) is incorrect, quantum dot is a zero dimensional material produced by reducing size of bulk material in all dimensions.

73. Ans: (c)

Sol: In frequency domain, the response obtained after solution contain both steady state response as well as transient response. So statement –II is wrong.

74. Ans: (c)

Sol: Cross section of A is less than B ⇒ for same length the resistance experienced by A will be more than B.

Section near to A will be more heated compared to section near B $\Rightarrow$Statement I is correct

Current per area section near A will be more than B $\Rightarrow$ Statement II is incorrect.

75. Ans: (a)

Sol: In resonance the current in series RLC circuit is maximum and the voltage across the capacitor is quality factor times the input voltage.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