HCU (Ph.D.) ENTRACE EXAMINATION - 2016

SECTION A

Q1. The inverse of $\begin{pmatrix} a, & -b \\ b & a \end{pmatrix}, b \neq a \neq 0$ is

(a) $\begin{pmatrix} a & +b \\ -b & a \end{pmatrix}$

(b) $\frac{1}{a^2+b^2}\begin{pmatrix} a & -b \\ b & a \end{pmatrix}$

(c) $\frac{1}{a^2+b^2}\begin{pmatrix} a & b \\ -b & a \end{pmatrix}$

(d) $\frac{1}{a^2-b^2}\begin{pmatrix} -b & a \\ a & b \end{pmatrix}$

Q2. Which of the following is an appropriate Lagrangian for a charged particle (of charge q, mass m) is an electromagnetic field with scalar potential ϕ and vector potential $\vec{A}$?

(a) $L = \frac{1}{2}m\dot{r}^2 - q\left(\phi - \vec{A}\cdot\vec{r}\right)$

(b) $L = \frac{1}{2}m\dot{r}^2 - q\left(\phi + \vec{A}\cdot\vec{r}\right)$

(c) $L = \frac{1}{2}m\dot{r}^2 + q\left(\phi - \vec{A}\cdot\vec{r}\right)$

(d) $L = \frac{1}{2}m\dot{r}^2 + q\left(\phi + \vec{A}\cdot\vec{r}\right)$

Q3. The integral $\oint_C \frac{dz}{z^2-1}$ where C is the contour such that $|z| = 2$ is

(a) 0 (b) πi (c) $\frac{\pi i}{2}$ (d) $\frac{\pi}{2}$

Q4. $\int_0^1 \frac{x}{1+x^2}dx =$

(a) 1 (b) $\frac{\pi}{4}$ (c) $\tan^{-1}\frac{\sqrt{2}}{2}$ (d) $\log\sqrt{2}$

Q5. In a quantum mechanical Coulomb system, the energy levels are:

(a) equally spaced

(b) with spacing that increases with n^2

(c) with spacing that decreases with n^2

(d) with spacing that increases with n^3

Q6. If $L=\frac{1}{2}m\dot{r}^2+\frac{e^2}{4m\varepsilon_0 r}$ be the Lagrangian of a system (particle) under a central force, then what are the conserved quantities associated with the motion of the particle?

(a) Energy and angular momentum

(b) Energy, angular momentum, and Laplace-Runge-Lenz vector

(c) Energy, angular momentum, and radial distance

(d) Energy, angular momentum, and Laplace-Runge-Lenz vector and radial distance

Q7. A charged particle moving in non-zero perpendicular electric and magnetic fields follows a

(a) Circular path

(b) Elliptical path

(c) Helical path

(d) Straight line

Q8. A dipole of dipole moment $\vec{P}$ is placed in the external $\vec{E}$. The force acting on the dipole is given by

(a) $-\vec{P}\times\vec{E}$

(b) $\nabla\times\left(\vec{P}\times\vec{E}\right)$

(c) $-\vec{P}.\vec{E}$

(d) $\vec{\nabla}\left(\vec{P}.\vec{E}\right)$

Q9. A student obtains a large amount of data which she has to numerically fit using one of the given methods. Which method would be suitable for fitting her data?

(a) Gauss Jordan Method

(b) Trapezoidal Method

(c) Lagrange's interpolation

(d) Newton-Raphson method

Q10. An electron and a proton are injected into a uniform magnetic field perpendicular to ' it with the same momentum. Which of the following is true?

(a) Radius of curvature is less for electron

(b) Radius of curvature is more for the electron

(c) Radius of curvature is the same for both

(d) They both move in straight lines'

Q11. There are 4 particles in a one dimensional box of width L with hard walls. If they are fermions, the total ground state energy is E_F, if bosons, it is E_B and if they are classical particles then the energy is E_d. Which of the following is true?

(a) $E_F = E_B = E_d$ (b) $E_F > E_B = E_d$

(c) $E_F < E_B < E_d$ (d) $E_F > E_B > E_d$

Q12. At the Brewster's angle the reflected light from the dielectric is polarized

(a) parallel to the plane of incidence.

(b) perpendicular to the plane of incidence.

(c) may have any arbitrary polarization.

(d) depends on the nature of the dielectric material'

Q13. What is the coordination number of FCC crystal?

(a) 6 (b) 8 (c) 12 (d) 16

Q14. The binary number 1011 0110 is equivalent to the decimal number

(a)180 (b) 64 (c) 182 (d) 132

Q15. For operators A and B satisfying the relation $\left[\hat{A},\hat{B}\right]=1$. $\left[\hat{A},\hat{B}^2\right]$ is given by

(a) $\hat{A}\hat{B}$ (b) $\hat{B}$ (c) $2\hat{B}$ (d) $\hat{A}$

Q16. At what value of the speed v does the de Broglie wavelength of a micro-particle equal its Compton wavelength?

(a) $v=\frac{C}{\sqrt{2}}$ (b) $v=\frac{C}{2}$ (c) $v=C$ (d) $v=\frac{\sqrt{C}}{2}$

Q17. In the nuclear process ${}_6C^{11} \rightarrow {}_5B^{11} + e^+ + X$, X stands for

(a) neutron (b) neutrino (c) antineutrino (d) photon

Q18. A spring of constant k is stretched a certain distance. It takes twice as much force to stretch a second spring to half the distance. The spring constant of the second spring is

(a) k (b) $2k$ (c) $4k$ (d) $8k$

Q19. Isospin symmetry implies that

(a) electron and proton are indistinguishable.

(b) electron and neutron are indistinguishable.

(c) eiectron and photon are indistinguishable.

(d) proton and neutron are indistinguishable.

Q20. In beta decay which of the following invariances is violated?

(a) Gauge Invariance

(b) Tanslational Invariance

(c) Reflection Invariance

(d) Rotation Invariance

Q21. The electron energy states in a solid are shown in terms of bands. In a semiconductor we have electrons in the conduction band, inner bands and valance bands. Which of the following is correct?

(a) The upper most band is the valance band.

(b) All semiconductors are electrically neutral.

(c) With increase of temperature, the resistivity of a semiconductor decreases.

(d) Addition of a small amount of impurity III and IV group element to a pure semiconductor increases its resistivity.

Q22. A resistor in a circuit dissipates energy at the rate of $1W$. The voltage across the resistor is doubled, what will be the new rate of dissipation?

(a) $0.25W$ (b) $4W$ (c) $2W$ (d) $0.5W$

Q23. The root mean square velocity of molecules of mass m of an ideal gas at temperature T is

(a) 0 (b) $\sqrt{\frac{3kT}{m}}$ (c) $\sqrt{\frac{kT}{m}}$ (d) $\sqrt{\frac{3kT}{m\pi}}$

Q24. Which of these ions cannot be used as a dopant in germanium to make an n-type semi-conductor

(a) As (b) B (c) Sb (d) N

Q25. A pipe closed at one end and open at the other end has length L. If c_s is the velocity of sound, then the fundamental frequency of this closed pipe is

(a) $\frac{c_s}{2L}$ (b) $\frac{c_s}{4L}$ (c) $\frac{3c_s}{2L}$ (d) $\frac{3c_s}{4L}$

SECTION - B

Q26. The action of a linear operator O on an element $x(t)$ of the vector space of all polynomials in t is given by $Ox(t) = x(t-1)$. Then $O^{-1}x(t)$ is given by

(a) $x\left(\frac{1}{t}-1\right)$ (b) $x(t+1)$ (c) $x\left(\frac{1}{t}+1\right)$ (d) $x\left(\frac{2}{t}-1\right)$

Q27. The solution of the second order differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} - 3y = 6$ is

(a) $c_1e^{-x} + c_2e^{3x}$ (b) $c_1e^{-3x} + c_2e^{x}$

(c) $c_1e^{-x} + c_2e^{3x} - 2$ (d) $c_1e^{-x} + c_2e^{3x} + 6$

Q28. Which of the following are the eigenvalues of the matrix $\begin{pmatrix} 2 & i \\ -i & 2 \end{pmatrix}$?

(a) $1-i, 1+i$ (b) $1, 3$ (c) $2, 2$ (d) $i, -i$

Q29. A particle emerging from an accelerator has relativistic energy $10\,GeV$ and relativistic momentum $8\frac{GeV}{c}$. The rest mass of the particle is

(a) $0.25\frac{GeV}{c^2}$ (b) $1.20\frac{GeV}{c^2}$ (c) $2.00\frac{GeV}{c^2}$ (d) $6.00\frac{GeV}{c^2}$

Q30. For $0 < t < \pi \begin{pmatrix} \cos t & -\sin t \\ \sin t & \cos t \end{pmatrix}$ has distinct complex eigenvalues λ_1 and λ_2. For what value of t, $0 < t < \pi$ is $\lambda_1 + \lambda_2 = 1$?

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{3}$ (d) $\frac{\pi}{2}$

Q31. A particle is trapped in a one dimensional potential given by $V(x)=\frac{1}{2}kx^2$. At a time $t=0$ the state of the particle is described by the wave function $\psi(x)=c_1\psi_0(x)+c_2\psi_1(x)$ where $\psi_n(x)$ is the eigenfunction belonging to the eigen value E_n. The expected value of energy $<E>$ is

(a) $\frac{1}{2}\hbar\omega\left(c_1^2+3c_2^2\right)$ (b) $\frac{1}{2}\hbar\omega$

(c) $\frac{1}{2}\hbar\omega\left(c_1^2+2c_2^2\right)$ (d) $\frac{1}{2}\hbar\omega\left(c_1+2c_2\right)^2$

Q32. Motion of ripples of short wave length on water is controlled by surface tension S. Phase velocity of such ripples is given by $V_0=\left(\frac{2\pi S}{\rho\lambda}\right)^{1/2}$ where ρ is density of water. What is the group velocity for disturbance mode of wavelength close to λ?

(a) V_p (b) $\frac{3}{2}V_p$ (c) $\frac{1}{2}V_p$ (d) $\frac{3}{4}V_p$

Q33. Which of the following is an eigenstate of the Pauli matrix σ_x?

(a) $\begin{pmatrix}1\\1\end{pmatrix}$ (b) $\begin{pmatrix}1\\-i\end{pmatrix}$ (c) $\begin{pmatrix}1\\i\end{pmatrix}$ (d) $\begin{pmatrix}1\\0\end{pmatrix}$

Q34. The amplitude of the resultant wave obtained by adding $E_1=E_0\sin\omega t$ and $E_2=E_0\sin(\omega t+60)$ is

(a) $E_r=\sqrt{3}E_0$ (b) $E_r=\sqrt{2}E_0$ (c) $E_r=\frac{3}{2}E_0$ (d) $E_r=2E_0$

Q35. Force per unit area between two parallel infinite current sheets with current densities λ_1 and λ_2 in the same direction is

(a) $\frac{\mu_0\lambda_1\lambda_2}{2}$ (b) $\frac{\mu_0\lambda_1\lambda_2}{4}$ (c) $4\mu_0\lambda_1\lambda_2$ (d) $2\mu_0\lambda_1\lambda_2$

Q36. The dipole moment of a thin charged rod bearing charge density $\rho = \lambda\delta(x)\delta(y)$ for $z \in (-a, a)$ is

(a) $\frac{2}{3}\lambda a^3 \hat{z}$ (b) $\frac{1}{12}\lambda a^3 \hat{z}$ (c) $\frac{1}{6}\lambda a^3 \hat{z}$ (d) $\frac{1}{3}\lambda a^3 \hat{z}$

Q37. The electric field of a plane electromagnetic wave propagating in free space along z-direction is given as $\vec{E}(z,t) = E_0 \cos(kz - \omega t)\hat{x}$. The time averaged value of the Poynting vector $< \vec{S} >$ for such wave is

(a) $\frac{1}{2} \in_0 E_0^2 \hat{z}$ (b) $\frac{1}{2} \in_0 E_0^2 \hat{z}$ (c) $\frac{1}{2\mu_0} c E_0^2 \hat{z}$ (d) $\frac{1}{2} c \in_0 E_0^2 \hat{z}$

Q38. Two linearly polarized light waves of same frequency and amplitude are superimposed such that their polarizations are perpendicular to each other. What should be phase difference between these two waves to generate circularly polarized light?

(a) π (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{3}$

Q39. The solution to the Schrödinger equation for a particle in an infinitely deep potential well indicates that in the middle of the well, the probability density vanishes for

(a) ground state $(n = 0)$ only

(b) state of even $n(n = 2, 4, 6, ...)$

(c) states of odd $n(= 1, 3, 5, ...)$

(d) all states $(n = 1, 2, 3, ...)$

Q40. The probability of occupation of a quantum state with energy $0.10\,eV$ above the Fermi energy to be occupied at temperature $800^0 K$ (with $k = 8.62 \times 10^{-5} eV/K$) is

(a) 10% (b) 81% (c) 19% (d) 90%

Q41. For the relativistic decay $A \rightarrow B + C$ with A at rest, the energy of B is

(a) $\frac{M_A^2 + M_B^2 + M_C^2}{2M_A}$ (b) $\frac{M_A^2 + M_B^2 - M_C^2}{2M_A}$

(c) $\frac{M_A^2+M_C^2-M_B^2}{2M_B}$ (d) $\frac{M_A^2+M_B^2-M_C^2}{2M_C}$

Q42. A nucleus of mass M emits a γ-ray photon of frequency ν. What is the loss of internal energy by the nucleus?

(a) $h\nu$

(b) $h^2\nu^2/2Mc^2$

(c) $h^2\nu\left(1+h\nu/2Mc^2\right)$

(d) $h\nu\left(1-h\nu/2Mc^2\right)^*$

Q43. In a Flank-Hertz type experiment, atomic hydrogen is bombarded with electron and excitation potentials are found at $10.21V$ and $12.10V$. The wavelengths of different lines of spectral emission accompanying these excitations are?

(a) $121.5\,nm$, $102.5\,nm$ and $656.7\,nm$

(b) $121.5\,nm$, $102.5\,nm$

(c) $121.5\,nm$, $102.5\,nm$ and $242\,nm$

(d) $121.5\,nm$, $102.5\,nm$ and $205\,nm$

Q44. According to BCS theory the attraction between the electrons of a Cooper pair is due to

(a) weak force

(b) vacuum polarization

(c) Casimir force

(d) exchange of quanta of lattice vibrations.

Q45. The primitive translation vectors of a two-dimensional lattice are

$$\vec{a}=2\hat{i}+\hat{j} \text{ and } \vec{b}=2\hat{j}$$

assume that the third vector and of the lattice is along z-axis with unit magnitude $\left(\vec{c}=\hat{k}\right)$. The primitive translation vectors of its reciprocal lattice is

(a) $\vec{a}^*=\pi\hat{i}$ and $\vec{b}^*=\frac{\pi}{2}\left(-\hat{i}+2\hat{j}\right)$

(b) $\vec{a}^* = 2\pi\hat{i}$ and $\vec{b}^* = \pi(\hat{i}+\hat{j})$

(c) $\vec{a}^* = \pi(\hat{i}+\hat{j})$ and $\vec{b}^* = \pi(\hat{i}-\hat{j})$

(d) $\vec{a}^* = \pi(\hat{i}-\hat{j})$ and $\vec{b}^* = \pi(\hat{i}+\hat{j})$

Q46. A metal has free electron density $2\times10^{28}/m^3$. The charge relaxation time is given by 7.1×10^{-14} sec. The static conductivity of the metal is given by

(a) $4\times10^7\ mho/m$ (b) $8\times10^7\ mho/m$

(c) $15\times10^7\ mho/m$ (d) $30\times10^7\ mho/m$

Q47. The total parity of any quantum mechanical state ψ with intrinsic parity η_ψ and orbital angular momentum l is given by

(a) $\eta_{TOT} = \eta_\psi(-1)^l$ (b) $\eta_{TOT} = \eta_\psi(-1)^{l+1}$

(c) $\eta_{TOT} = (\eta_\psi + 1)$ (d) $\eta_{TOT} = (\eta_\psi - 1)^l$

Q48. The angular resolution of a telescope is given by

(a) $\frac{2.44\lambda}{D}$ (b) $\frac{1.22\lambda}{D}$ (c) $\frac{2.44D}{\lambda}$ (d) $\frac{1.22D}{\lambda}$

Q49. The mediator W of the weak interaction has a mass $M = 80\,Gev/c^2$. In the framework of a Yukawa like model, the range of the weak interaction is

(a) $2.5\times10^{-15}\ m$ (b) $2.5\times10^{-18}\ m$

(c) $2.5\times10^{-15}\ m$ (d) infinite

Q50. If h be the step size the local truncation error for the fourth order Runge Kutta Method is of the order of

(a) h^4 (b) h^5 (c) h (d) h^2

Q51. A committee has 6 ladies and 5 gentlemen. A 5-member subcommittee is to be selected at random from these 11 committee members. Find the probability that the committee has 2 ladies and 3 gentlemen

(a) $\frac{200}{462}$ (b) $\frac{81}{462}$ (c) $\frac{150}{462}$ (d) $\frac{240}{462}$

Q52. A gas consists of non-interacting and identical particles, whose energy depends on its momentum in a non-trivial way. $\in = C|p|^n$. The energy per particle in the gas is found to be [you may use $\int dx x^{\alpha-1}e^{-x} = \Gamma|\alpha|$]

(a) $\frac{3T}{2}$ (b) $\frac{3T}{n}$ (c) $\frac{2T}{3}$ (d) $\frac{2T}{n}$

Q53. Molecular oxygen has a net magnetic spin $\vec{s}$ unity, i.e. s_z is quantized to $-1, 0, +1$. The partition function z of such a system in a magnetic field $\vec{B} \parallel \hat{z}$ is given by

$$z = \frac{1}{N!}\left(\frac{v}{\lambda^3}\left(e^{\beta\mu B} + 1 + e^{-\beta\mu B}\right)\right)^N$$

The average magnetic dipole moment is given by

(a) $N\mu\left(\frac{2\sinh\beta\mu B}{2\cosh\beta\mu B + 1}\right)$ (b) $N\mu\left(\frac{2\cosh\beta\mu B}{2\cosh\beta\mu B + 1}\right)$

(c) $N\mu\left(\frac{2\sinh\beta\mu B}{2\sinh\beta\mu B + 1}\right)$ (d) $N\mu\left(\frac{2\cosh\beta\mu B}{2\sinh\beta\mu B + 1}\right)$

Q54. Which of the following relations (with the eigenstate of angular momentum operator) is most appropriate

(a) $0 \le \left\langle \psi_{l,m} \middle| \left(\hat{L}_x^2 + \hat{L}_y^2\right) \middle| \psi_{l,m} \right\rangle \le \hbar^2\left(l(l+1) - m^2\right)$

(b) $0 \le \left\langle \psi_{l,m} \middle| \left(\hat{L}_x^2 + \hat{L}_y^2\right) \middle| \psi_{l,m} \right\rangle \le \left(l(l+1)\right)\hbar^2$

(c) $m^2\hbar^2 \le \left\langle \psi_{l,m} \middle| \left(\hat{L}_x^2 + \hat{L}_y^2\right) \middle| \psi_{l,m} \right\rangle \le \left(l(l+1)\right)$

(d) $l\hbar^2 \le \left\langle \psi_{l,m} \middle| \left(\hat{L}_x^2 + \hat{L}_y^2\right) \middle| \psi_{l,m} \right\rangle \le \left(l(l+1)\right)$

Q55. In a one step random walk, you flip a coin, if it is heads you take a step, if it is tail, you do not take a step. If all your step sizes are equal $(1cm)$, for a walk of 10 steps what is your probability of reaching any point less than $10\,cms$?

(a) $\frac{1}{10}$ (b) $\frac{1}{2}$ (c) $\frac{2}{10}$ (d) $\frac{2}{5}$

Q56. Suppose that we measure the acceleration due to gravity g, using a simple pendulum. The period of such pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$, where l is the length of the pendulum and T is the time period. In a particular measurement, the errors in measuring l and T are 0.1% and 0.2% respectively. The percentage error in measuring g is given by

(a) 0.1% (b) 1% (c) 0.3% (d) 2%

Q57. The invariant mass spectrum of Λ^0 and π^+ in the reaction $K^0 + p \to \Lambda^0 + \pi^+ + \pi^-$ shows a peak Y_1^* at $1385 MeV$ with a full width of $50 MeV$. The strngeness, hypercharge and isospin of Y_1^* are

(a) $S = -1, Y = 0, I = 1$ (b) $S = 0, Y = 0, I = 1$

(c) $S = -1, Y = 0, I = 0$ (d) $S = 0, Y = 1, I = 0$

Q58. In a certain colliding-beam storage ring, protons of energy $30 GeV$ collide head on. The energy that a single proton must have to give the same centre-of-mass energy when colliding with a stationary proton is

(a) $1 GeV$ (b) $30 GeV$ (c) $900 GeV$ (d) $1800 GeV$

Q59. The decay $\mu^- \to e^- + \gamma$ is not observed because

(a) Baryon number is not conserved

(b) Strangeness is not conserved

(c) Lepton number is not conserved

(d) Isospin is not conserved

Q60. The probability for an event occurring is given by the Poisson distribution defined by $W(n) = \frac{\lambda^n}{n!}e^{-\lambda}$. If λ is the mean number of events, the variance of the distribution is given by

(a) λ (b) $\frac{\lambda}{2}$ (c) 2λ (d) 0

Q61. If v is the velocity of a galaxy and r is its distance, then according to Hubble's law

(a) $v \propto r^3$ (b) $v \propto \frac{1}{r}$ (c) $v \propto r$ (d) $v \propto \frac{1}{r^2}$

Q62. The cutoff wavelength of TE_{10} mode in a rectangular wave guide of dimensions a and b with $a > b$ is

(a) $\frac{a}{2}$ (b) $2a$ (c) $\pi\left(\frac{b}{2}\right)$ (d) $\frac{\sqrt{a^2+b^2}}{2}$

Q63. If a uniform electric field is directed along z-direction the diagonal components of Maxwell's stress tensor will be

(a) $T_{xx}=0,\ T_{yy}=0,\ T_{zz}=0$

(b) $T_{xx}=0,\ T_{yy}=0,\ T_{zz}=\frac{1}{2}\in_0 E_0^2$

(c) $T_{xx}=-\frac{1}{2}\in_0 E_0^2,\ T_{yy}=-\frac{1}{2}\in_0 E_0^2,\ T_{zz}=\frac{1}{2}\in_0 E_0^2$

(d) $T_{xx}=\frac{1}{2}\in_0 E_0^2,\ T_{yy}=\frac{1}{2}\in_0 E_0^2,\ T_{zz}=0$

Q64. What is the contour integral of $f(z)=1+z^2$ in anti-clockwise sense over a unit square with corners at the four points $(0,0)(1,0),(0,1)$ and $(1,1)$ at the origin in the complex plane?

(a) $\frac{8\pi}{3}$ (b) $2\pi\left(1+\frac{1+x}{3}\right)$

(c) $2\pi\left(1+\frac{1-x}{3}\right)$ (d) 0

Q65. There are N non-interacting, identical but distinguishable particles in equilibrium at temperature T. Each of the particles can be in only two energy levels. One of them which is non-degenerate has energy zero (0), while the other is doubly degenerate with energy $2k_BT$. Find the approximate value of N if the mean energy of the system is $100\,k_BT$

(a) 34 (b) 235 (c) 1000 (d) 540

Q66. A half-wave plate (HWP) is introduced between two crossed polaroids $P1$ and $P2$. The optics axis of (HWP) makes an angle 15^0 with the axis of $P1$. If an unpolarized beam of intensity I_o is normally incident on $P1$ and I_2 is the intensity after $P2$ then I_2/I_o is given by

(a) $\frac{l_2}{I_0}=\frac{1}{8}$ (b) $\frac{l_2}{I_0}=\frac{1}{4}$ (c) $\frac{l_2}{I_0}=\frac{1}{2}$ (d) $\frac{l_2}{I_0}=\frac{1}{6}$

Q67. In a FET V_{P1} is the pinch-off voltage for a gate-source voltage $(V_{GS})=$. If the gate is now reverse biased, then which of the following is true for the pinch-off voltage V_{P2} at this value of GS

(a) $V_{P2}<V_{P1}$ (b) $V_{P2}>V_{P1}$

(c) $V_{P2}=V_{P1}$ (d) V_{P2} is independent of V_{P1}

Q68. In an abrupt $p-n$ junction, the doping concentrations on the p-side and n-side are $N_A=9\times 16/cc$ and $N_D=1\times 10^{16}\,cc$. If the $p-n$ junction is increase biased and the total depletion width is $3\mu m$, then the value of depletion width on the donor side is

(a) $2.7\,\mu m$ (b) $0.3\,\mu m$ (c) $3\,\mu m$ (d) $0.27\,\mu m$

Q69. The dual of the Boolean function $F=A\bar{B}+AC+BC$

(a) $(\bar{A}+B)(\bar{A}+\bar{C})(\bar{B}+\bar{C})$ (b) $(A+\bar{B})(A+C)(B+C)$

(c) $\bar{A}B+\bar{A}\bar{C}+\bar{B}\bar{C}$ (d) $\bar{A}\bar{B}+\bar{A}\bar{C}+B\bar{C}$

Q70. The state of a $J-K$ flip flop goes from "1" to "0" after applying a clock pulse (that is $Q(t)=1$ and $Q(t+1)=0$). Which of the following is the correct and complete input combination?

(a) $J=0$ and $K=1$ (b) $J=0$ and $K=X$

(c) $J=X$ and $K=1$ (d) $J=1$ and $K=1$

Q71. A transmission line of length of l has characteristic impedance A_0. The line is cut into half. The value of characteristic impedance becomes

(a) $\frac{Z_0}{2}$ (b) $\frac{Z_0}{4}$ (c) iZ_0 (d) Z_0

Q72. Antenna 1 has radiation resistance twice that of antenna 2. It implies that

(a) Antenna 2 delivers double power to space from antenna 1.

(b) Antenna 2 delivers half power to space than antenna 1.

(c) Antenna 2 delivers quarter power to space than antenna 1.

(d) Antenna 2 delivers equal power to space as antenna 1.

Q73. For a two-dimensional free electron gas, the electron density n and the Fermi energy E_F are related by

(a) $n = \frac{(2mE_F)^{3/2}}{3\pi^2\hbar^3}$ (b) $n = \frac{mE_F}{\pi\hbar^2}$ (c) $n = \frac{mE_F}{2\pi\hbar^2}$ (d) $n = \frac{(2mE_F)^{1/3}}{\pi\hbar}$

Q74. The temperature (T) dependence of magnetic susceptibility (X) of a ferromagnetic substance with a (Curie) temperature (T_c) is given by

(a) $\frac{C}{T-T_c}$ for $T < T_c$

(b) $\frac{C}{T-T_c}$ for $T > T_c$

(c) $\frac{C}{T+T_c}$ for $T > T_c$

(d) $\frac{C}{T-T_c}$ for all temperatures, where C is a constant.

Q75. A flat circular disc of radius a has uniform charge density $-\sigma$ from its center upto a certain radius r and uniform surface charge density $+\sigma$ from r to a. Total charge on disc is zero. If the disc is moving with angular velocity ω about its axis passing through the center, find its magnetic moment m

(a) $\frac{\sigma\pi\omega a^4}{2}$ (b) $\frac{\sigma\pi\omega a^4}{4}$ (c) $\frac{\sigma\pi\omega a^4}{8}$ (d) $\frac{\sigma\pi\omega a^4}{16}$