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Test Booklet Series **T. B. C. : PGT – 2/17**

A

TEST BOOKLET

PART – B **Serial No.** 2345

(PHYSICS)

Time Allowed : 2 Hours *Maximum Marks : 100*

: INSTRUCTIONS TO CANDIDATES :

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET **DOES NOT** HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET OF THE SAME SERIES ISSUED TO YOU.
2. ENCODE CLEARLY THE TEST BOOKLET SERIES **A, B, C** OR **D**, AS THE CASE MAY BE, IN THE APPROPRIATE PLACE IN THE ANSWER SHEET USING BALL POINT PEN (BLUE OR BLACK).
3. You have to enter your **Roll No.** on the Test Booklet in the Box provided alongside. **DO NOT** write *anything else* on the Test Booklet.
4. **YOU ARE REQUIRED TO FILL UP & DARKEN ROLL NO., TEST BOOKLET / QUESTION BOOKLET SERIES IN THE ANSWER SHEET AS WELL AS FILL UP TEST BOOKLET / QUESTION BOOKLET SERIES AND SERIAL NO. AND ANSWER SHEET SERIAL NO. IN THE ATTENDANCE SHEET CAREFULLY. WRONGLY FILLED UP ANSWER SHEETS ARE LIABLE FOR REJECTION AT THE RISK OF THE CANDIDATE.**
5. This Test Booklet contains **100** items (questions). Each item (question) comprises four responses (answers). You have to select the correct response (answer) which you want to mark (darken) on the Answer Sheet. In case, you feel that there is more than one correct response (answer), you should mark (darken) the response (answer) which you consider the best. In any case, choose **ONLY ONE** response (answer) for each item (question).
6. You have to mark (darken) all your responses (answers) **ONLY** on the **separate Answer Sheet** provided by **using BALL POINT PEN (BLUE OR BLACK)**. See instructions in the Answer Sheet.
7. All items (questions) carry equal marks. All items (questions) are compulsory. Your total marks will depend only on the number of correct responses (answers) marked by you in the Answer Sheet. **There will be no negative markings for wrong answers.**
8. Before you proceed to mark (darken) in the Answer Sheet the responses to various items (questions) in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per the instructions sent to you with your **Admission Certificate**.
9. After you have completed filling in all your responses (answers) on the Answer Sheet and after conclusion of the examination, you should hand over to the Invigilator the *Answer Sheet* issued to you. You are allowed to take with you the candidate's copy / second page of the Answer Sheet along with the **Test Booklet**, after completion of the examination, for your reference.
10. Sheets for rough work are appended in the Test Booklet at the end.

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1. The Legendre polynomial of degree 2, $P_2(x)$ is given by :

(A) $\frac{1}{2}(x^2 - 3)$

(B) $\frac{1}{3}(2x^2 - 1)$

(C) $\frac{1}{2}(3x^2 - 1)$

(D) $\frac{1}{3}(3x^2 - 1)$

2. The Gamma function, $\Gamma(n)$, is defined as :

(A) $\int_0^\infty e^{-1} t^{n-1} dt$

(B) $\int_0^\infty e^{1} t^{n-1} dt$

(C) $\int_0^\infty e^{1} t^{n+1} dt$

(D) $\int_0^\infty e^{-1} t^{n+1} dt$

3. The Bessel function $J_{1/2}(x)$ is :

(A) $\sqrt{\frac{2}{\pi x}} \cos x$

(B) $\sqrt{\frac{2}{\pi x}} \sin x$

(C) $\sqrt{\frac{3}{\pi x}} \cos x$

(D) $\sqrt{\frac{3}{\pi x}} \sin x$

4. The Lauguerre polynomial of degree 2, $L_2(x)$, is given by :

(A) $1 - 2x + x^2$

(B) $1 + x - x^2/2$

(C) $1 - x + 2x^2$

(D) $1 - 2x + x^2/2$

5. The value of $\oint_c \frac{dz}{z}$ for counter-clockwise direction around a unit circle is :

(A) 2π

(B) $2\pi i$

(C) $-2\pi i$

(D) -2π

6. The value of $\oint_c \frac{z^3 - 6}{2z - i} dz$ is :

(A) $\frac{\pi}{8} - 6\pi i$

(B) $\frac{\pi}{4} + 6\pi i$

(C) $\frac{\pi}{2} - 6\pi i$

(D) $\frac{\pi}{6} - 3\pi i$

7. If ε_{123} is an antisymmetric tensor of third rank, then $2\varepsilon_{123} + \varepsilon_{213} - \varepsilon_{113}$ is :

(A) -1

(B) 1

(C) 0

(D) 2

8. SU(2) group has 2 × 2 ________ matrices with determinant ________.

(A) Unitary and 1

(B) Hermitian and 2

(C) Unitary and 2

(D) Hermitian and 1

9. The orbital angular momentum $\vec{L}$ is :

(A) $\vec{r} \times \vec{F}$

(B) $\vec{r} \times \vec{p}$

(C) $\vec{F} \times \vec{p}$

(D) $(\vec{r} \times \vec{p}) \times \vec{F}$

where $\vec{r}$ = position vector, $\vec{p}$ = linear momentum and $\vec{F}$ = force.

10. Which of the following describes the Lagrangian equation of motion ?

(A) $\frac{dL}{dx} - \frac{d}{dt}\frac{dL}{d\dot{x}} = 0$

(B) $\frac{dL}{d\dot{x}} - \frac{d}{dt}\frac{dL}{dx} = 0$

(C) $\frac{dL}{dt} - \frac{d}{d\dot{x}}\frac{dL}{d\dot{x}} = 0$

(D) $\frac{dL}{d\dot{x}} - \frac{d}{dx}\frac{dL}{d\dot{x}} = 0$

where L is the Lagrangian.

11. In an orthogonal transformation $x_i' = a_{ij}x_j$, then $a_{ij}a_{jk}$ is :

(A) δ_{ij}

(B) δ_{jk}

(C) δ_{ik}

(D) 0

where repeated indices imply summation.

12. Which of the following relation is correct ?

(A) $\vec{L} = I\vec{\omega}$

(B) $I = \vec{L} \cdot \vec{\omega}$

(C) $\vec{\omega} = I\vec{L}$

(D) $\vec{p} = I\vec{\omega}$

where $\vec{L}$ = orbital angular momentum, I = moment of inertia, $\vec{\omega}$ = angular velocity and $\vec{p}$ = linear momentum.

13. For small oscillations, a potential function V(x) is expanded around its equilibrium value as $V(x) = V(x_0) + \left(\frac{\partial V}{\partial x}\right)_{x_0} (x - x_0) + \frac{1}{2}\left(\frac{\partial^2 V}{\partial x^2}\right)_{x_0} (x - x_0)^2 + \ldots$

then at equilibrium, which term in the RHs will be zero ?

(A) First

(B) Second

(C) Third

(D) None of these

14. If the Lagrangian $L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2$,

then the equation of motion is :

(A) $m\ddot{x} = -kx$

(B) $k\ddot{x} = -mx$

(C) $mx = k\dot{x}$

(D) $x\dot{x} = km$

15. The sum L + H of the Lagrangian and the Hamiltonian of a particle with coordinate x, is :

(A) $x\frac{dL}{dx}$

(B) $\dot{x}\frac{dL}{dx}$

(C) $\dot{x}\frac{dH}{dx}$

(D) $x\frac{dH}{dx}$

16. Jacobi's identity is :

(A) $[u, v] + [v, w] + [w, u] = 0$

(B) $[u, [v, w]] = 0$

(C) $[u, [v, w]] + [v, [w, u]] + [w, [u, v]] = 0$

(D) $[uv, w] + [vw, u] + [wu, v] = 0$

where u, v and w are three functions with continuous second derivatives and the brackets are Poisson brackets.

17. For a one dimensional system with Hamiltonian, $H = \frac{p^2}{2} - \frac{1}{2q^2}$, the constant of motion is :

(A) $\frac{\dot{p}q}{2} - Ht$

(B) $\frac{p\dot{q}}{2} + Ht$

(C) $pq + \frac{Ht}{2}$

(D) $pq + \frac{1}{2}Ht$

18. For a canonical transformation of the form, $p = f(P) \cos Q$ and $q = \frac{f(P)}{m\omega} \sin Q$, the Hamiltonian is :

(A) $\frac{1}{2m} f(P)(\sin Q + \cos Q)$

(B) $\frac{1}{2m} f(P)$

(C) $\frac{1}{2m} f^2(P)$

(D) None of the above

19. Which of the following is not a Maxwell's equation ?

(A) $\vec{\nabla} \cdot \vec{D} = \rho$

(B) $\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$

(C) $\vec{\nabla} \cdot \vec{B} = 0$

(D) $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$

where $\vec{E}$ is the electric field, $\vec{D}$ is the displacement vector, ρ is the charge density, $\vec{B}$ is the magnetic induction, c is the velocity of light and $\vec{J}$ is the current density.

20. The force acting on a particle of charge q and velocity $\vec{v}$ in the presence of a magnetic field is :

(A) $q\vec{v}\left(\vec{\nabla} \times \vec{B}\right)$

(B) $\frac{q}{c}\vec{v} \times \vec{B}$

(C) $qc\vec{v} \times \vec{B}$

(D) $\frac{c}{q}\vec{v} \times \vec{B}$

21. Identify the equation $\nabla^2\phi = -4\pi\rho$, where ϕ is scalar potential. It is :

(A) Laplace equation

(B) Faraday equation

(C) Poisson equation

(D) Rayleigh equation

22. The interaction energy U_{dd} of two dipoles of moments $\vec{p}_1$ and $\vec{p}_2$, separated by $|\vec{x}_1 - \vec{x}_2|$ is :

(A) $\dfrac{\vec{p}_1 \cdot \vec{p}_2 - \left(\hat{n} \cdot \vec{p}_1\right)\left(\hat{n} \cdot \vec{p}_2\right)}{|\vec{x}_1 - \vec{x}_2|^3}$

(B) $\dfrac{\vec{p}_1 \cdot \vec{p}_2 - 3\left(\hat{n} \cdot \vec{p}_1\right)\left(\hat{n} \cdot \vec{p}_2\right)}{|\vec{x}_1 - \vec{x}_2|^2}$

(C) $\dfrac{\vec{p}_1 \cdot \vec{p}_2 - 3\left(\hat{n} \cdot \vec{p}_1\right)\left(\hat{n} \cdot \vec{p}_2\right)}{|\vec{x}_1 - \vec{x}_2|^3}$

(D) $\dfrac{3\vec{p}_1 \cdot \vec{p}_2 - 2\left(\hat{n} \cdot \vec{p}_1\right)\left(\hat{n} \cdot \vec{p}_2\right)}{|\vec{x}_1 - \vec{x}_2|^2}$

23. Which of the following equations defines a magnetic vector potential $\vec{A}$?

(A) $\vec{B} = \vec{\nabla} \times \vec{A}$

(B) $\vec{A} = \vec{\nabla} \times \vec{B}$

(C) $\vec{A} = \vec{\nabla} \times \vec{J}$

(D) $\vec{J} = \vec{\nabla} \times \vec{B}$

24. Faraday's law of electromagnetic induction is given by :

(A) $F = -k\dfrac{dE}{dt}$

(B) $F = k\dfrac{dE}{dt}$

(C) $E = k\dfrac{dF}{dt}$

(D) $E = -k\dfrac{dF}{dt}$

where F is the magnetic flux and E is the electromotive force.

25. In the presence of a magnetic field, the change in momentum of an electron is :

(A) $\vec{p} - \frac{c}{e}\vec{A}$

(B) $\vec{p} - \frac{e}{c}\vec{A}$

(C) $\vec{p} - \frac{e}{c}\overleftarrow{B}$

(D) $\vec{p} - \frac{c}{e}\overleftarrow{B}$

26. Which of the following interactions results from relativistic effect ?

(A) Coulomb interaction

(B) Gravitational interaction

(C) Spin-orbit interaction

(D) Electric dipolar interaction

27. The Poynting vector is given by :

(A) $\vec{E} \times \vec{B}$

(B) $\vec{E} \times \vec{J}$

(C) $\vec{J} \times \vec{B}$

(D) $\vec{E} \times \vec{D}$

28. For moderate electric fields, the relation between the current density and the electric field is :

(A) Quadratic

(B) Exponential

(C) Linear

(D) Inverse

29. Which of the following conditions is an uncertainty principle ?

(A) $\Delta t \cdot \Delta x \geq \hbar$

(B) $\Delta x \cdot \Delta p_x \geq \hbar$

(C) $\Delta p_x \cdot \Delta E \geq \hbar$

(D) $\Delta E \cdot \Delta x \geq \hbar$

30. Which of the following relations is correct for a > 0 ?

(A) $\delta(ax) = a\delta(x)$

(B) $\delta(ax) = a^{-1}\delta(x)$

(C) $\delta(ax) = \delta(x + a)$

(D) $\delta(ax) = \delta(x - a)$

31. In the Heisenberg picture, the equation of motion for a time dependent operator Ω_H is :

(A) $\frac{d\Omega_H}{dt} = \frac{\partial\Omega_H}{\partial t} + \frac{1}{i\hbar}[\Omega_H, H]$

(B) $\frac{d\Omega_H}{dt} = \frac{\partial\Omega_H}{\partial t} - \frac{1}{i\hbar}[\Omega_H, H]$

(C) $\frac{d\Omega_H}{dt} = \frac{\partial\Omega_H}{\partial t} + i\hbar[\Omega_H, H]$

(D) $\frac{d\Omega_H}{dt} = \frac{\partial\Omega_H}{\partial t} - i\hbar[\Omega_H, H]$

32. The value of $[x^n, p_x]$ is :

(A) $-ni\hbar x^n$

(B) $(n-1)i\hbar x^n$

(C) $ni\hbar x^{n-1}$

(D) $(n-1)i\hbar x^{n-1}$

33. The total energy E of an electron in equilibrium in an orbit depends on the principal quantum number n according to :

(A) $E \propto -n$

(B) $E \propto -\frac{1}{n}$

(C) $E \propto -n^2$

(D) $E \propto -\frac{1}{n^2}$

34. Which of the following sets represents the Pauli spin matrices correctly ?

(A) $\sigma_x = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix},$

$\sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$

(B) $\sigma_x = \begin{pmatrix} 0 & 1 \\ 1, & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix},$

$\sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$

(C) $\sigma_x = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix},$

$\sigma_z = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$

(D) None of the above

35. The matrix I that produces a space inversion $I\vec{r} = -\vec{r}$ is :

(A) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

(B) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

(C) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

(D) $\begin{pmatrix} 0 & 0 & -1 \\ 0 & -1 & 0 \\ -1 & 0 & 0 \end{pmatrix}$

36. The second order term $E_m^{(2)}$ for the m^{th} state of the perturbing Hamiltonian H' is given by :

(A) $\sum_{n,\, n \neq m} \frac{|\langle m|H'|n\rangle|^2}{E_n - E_m}$

(B) $\sum_{n,\, n \neq m} \frac{|\langle m|H'|n\rangle|^2}{E_m - E_n}$

(C) $\sum_{m,\, n \neq m} \frac{|\langle m|H'|n\rangle|^2}{E_n - E_m}$

(D) $\sum_{m,\, n \neq m} \frac{|\langle m|H'|n\rangle|^2}{E_m - E_n}$

37. Zeeman effect is the change in the energy levels of an atom caused by :

(A) Uniform electric field

(B) Electromagnetic field

(C) Uniform magnetic field

(D) Coulomb interaction between electron and nucleus

38. For a spin $-\frac{1}{2}$ particle the time reversal operator is :

(A) $-i\sigma_x K$

(B) $-i\sigma_y K$

(C) $-i\sigma_z K$

(D) None of the above

39. The components of the orbital angular momentum operator are :

(A) $L_x = yp_z - zp_x$, $L_y = zp_x - xp_z$, $L_z = xp_y - yp_x$

(B) $L_x = yp_z + zp_x$, $L_y = zp_x + xp_z$, $L_z = xp_y + yp_x$

(C) $L_x = p_z x + yp_x$, $L_y = p_x y + zp_z$, $L_z = p_y z + xp_x$

(D) None of the above

40. In terms raising $a^†$ and lowering a operators, the Hamiltonian H of Harmonic oscillator satisfies the following equation :

(A) $aa^† = \frac{H}{\hbar\omega_c} - \frac{1}{2}$

(B) $aa^† = \frac{1}{\hbar\omega_c} - \frac{H}{2}$

(C) $aa^† = \frac{1}{\hbar\omega_c} + \frac{H}{2}$

(D) $aa^† = \frac{H}{\hbar\omega_c} + \frac{1}{2}$

41. The Boltzman distribution of a particle of energy ε at temperature T is :

(A) $e^{\beta\varepsilon}$

(B) $e^{-\beta\varepsilon}$

(C) $e^{-\varepsilon/\beta}$

(D) $e^{\varepsilon/\beta}$

where $\beta = (k_B T)^{-1}$.

42. If the number of particles N is very large, then we use Stirling's approximation to calculate ln N ! which is :

(A) $N \ln N - N$

(B) $\frac{1}{N} \ln N - \frac{1}{N}$

(C) $\frac{1}{N} \ln N + \frac{1}{N}$

(D) $\frac{1}{N} \ln N$

43. Gibb's potential is given by :

(A) U – TS

(B) U + PV + TS

(C) U – PV + TS

(D) U + PV – TS

where U = internal energy, P = Pressure, V = Volume, T = Temperature and S = entropy.

44. The Fermi distribution function $f(\varepsilon - \varepsilon_F)$ in the limit of T – > 0 for $\varepsilon < \varepsilon_F$ is :

(A) 0

(B) ε

(C) ε_F

(D) 1

where ε_F is the Fermi energy.

45. The ground state energy for N Fermions is given by :

(A) $\frac{2}{3}N\varepsilon_F$

(B) $\frac{3}{5}N\varepsilon_F$

(C) $N\varepsilon_F$

(D) $\frac{1}{2}N\varepsilon_F$

46. For a system of N Fermions with Fermi energy ε_F, N is proportional to :

(A) $\varepsilon_F^{1/2}$

(B) $\varepsilon_F^{3/2}$

(C) $\varepsilon_F^{-1/2}$

(D) $\varepsilon_F^{-3/2}$

47. For a system of phonons the specific heat at low temperature is proportional to :

(A) T

(B) T^2

(C) T^3

(D) lnT

48. For an ideal Fermi gas, the chemical potential is related to the Fermi energy by the following relation :

(A) $\varepsilon_F\left[1-\frac{\pi^2}{12}\left(\frac{k_BT}{\varepsilon_F}\right)^2\right]$

(B) $\varepsilon_F\left[1+\frac{\pi^2}{12}\left(\frac{k_BT}{\varepsilon_F}\right)^2\right]$

(C) $\varepsilon_F\left[1+3\left(\frac{k_BT}{\varepsilon_F}\right)^2\right]$

(D) $\varepsilon_F\left[1-3\left(\frac{k_BT}{\varepsilon_F}\right)^2\right]$

49. In Landau's theory of second order phase transition from ferromagnetism to paramagnetism, the order parameter is :

(A) Curie temperature

(B) Magnetic field

(C) Magnetisation

(D) Magnetic susceptibility

50. Bose statistics is named after :

(A) J. C. Bose

(B) D. M. Bose

(C) R. C. Bose

(D) S. N. Bose

51. The WKB approximation works well when the potential energy is :

(A) Slowly varying function of position

(B) Constant

(C) Oscillatory

(D) None of the above

52. The main principle of laser is :

(A) Spontaneous emission

(B) Population inversion

(C) That the ground state is empty

(D) Stimulated absorption

53. The step function $\theta(r)$ is 1 if :

(A) $r < 0$

(B) $r = 0$

(C) $r > 0$

(D) $r = \infty$

54. Bohr angular frequency ω_{kn} is given by :

(A) $\hbar^{-1}(E_k - E_n)$

(B) $\hbar(E_k - E_n)$

(C) $\hbar(E_k - E_n)^{-1}$

(D) $\hbar(E_n - E_k)$

55. The transition probability is :

(A) Independent of time

(B) Dependent on time

(C) Sinusoidal function of time

(D) None of the above

56. The variational method :

(A) Needs an accurate knowledge of the wave function

(B) Works well if the wave function is well defined

(C) Does not need an accurate detailed knowledge of the wave function

(D) Does not require the minimisation of the energy

57. The commutation relation $[x, p_y]$ is :

(A) $i\hbar$

(B) $-i\hbar$

(C) 0

(D) $\hbar$

58. For a system of two particles, the reduced mass is given by :

(A) $\frac{m_1 + m_2}{m_1 m_2}$

(B) $\frac{|m_1 - m_2|}{m_1 m_2}$

(C) $\frac{m_1 m_2}{m_1 + m_2}$

(D) $\frac{m_1 m_2}{|m_1 - m_2|}$

59. The commutation relation of $[L_x, L_z]$ is :

(A) $i\hbar L_y$

(B) $-i\hbar L_y$

(C) $\hbar L_y$

(D) $-\hbar L_y$

60. The time dependent Schrodinger equation is :

(A) $-i\hbar\frac{\partial\psi}{\partial t} = E\psi$

(B) $\hbar\frac{\partial\psi}{\partial t} = E\psi$

(C) $i\hbar\frac{\partial\psi}{\partial t} = E\psi$

(D) $-\hbar\frac{\partial\psi}{\partial t} = E\psi$

61. The fine structure constant α is given by :

(A) $(137)^{-1}$

(B) 0.529

(C) 13.6

(D) $(3\pi)^{-1}$

62. The energy of a quantum harmonic oscillator :

(A) $\left(n+\frac{1}{2}\right)\omega\hbar^{-1}$

(B) $\left(n+\frac{1}{2}\right)\omega\hbar$

(C) $\left(1+\frac{n}{2}\right)\hbar\omega$

(D) $\left(1+\frac{n}{2}\right)\omega\hbar^{-1}$

where n takes integer values and ω is the frequency of the harmonic oscillator.

63. Dirac's Hamiltonian for a free particle is :

(A) $H = c\vec{\alpha}\cdot\vec{p} + \beta mc^2$

(B) $H = c\vec{\alpha}\cdot\vec{p} - \beta mc^2$

(C) $H = p^2/2m + \beta mc^2$

(D) $H = c\vec{\alpha}\cdot\vec{p} - \beta mc^2 + V(\vec{r})$

64. In the above question $\vec{\alpha}$ is a :

(A) 2×2 matrix

(B) 3×3 matrix

(C) 4×4 matrix

(D) Null matrix

65. The –ve energy solution of a Dirac free particle equation corresponds to the energy of :

(A) An electron

(B) A muon

(C) A neutrino

(D) A positron

66. The probability current density $S(\vec{r}, t)$ is $(\psi^* \vec{\nabla} \psi - \psi \vec{\nabla} \psi^*)$ multiplied by :

(A) $\frac{\hbar}{2m}$

(B) $\frac{i\hbar}{m}$

(C) $\frac{\hbar}{2im}$

(D) $\frac{2i\hbar}{m}$

67. Which of the following relations is true ?

(A) $\alpha_x\beta - \beta\alpha_x = 0$

(B) $\alpha_x^2 = \alpha_y^2 = \alpha_z^2 = 0$

(C) $\beta^2 = 0$

(D) $\alpha_x\beta + \beta\alpha_x = 0$

68. If N_k is a number operator, then :

(A) $i\hbar\dot{N}_k = \left[a_k^\dagger a_k, H\right]$

(B) $i\hbar\dot{N}_k = \left[H, a_k^\dagger a_k\right]$

(C) $\hbar\dot{N}_k = \left[a_k^\dagger a_k, H\right]$

(D) $\hbar\dot{N}_k = \left[H, a_k^\dagger a_k\right]$

69. If c and $c^\dagger$ are the annihilation and creation operators of a Fermion, then :

(A) $[c, c^\dagger] = 1$

(B) $\{c, c^\dagger\} = 1$

(C) $[c, c^\dagger] = 0$

(D) $\{c, c^\dagger\} = 0$

70. For a many particle state $|n_1, n_2, ...n_k.....n_N\rangle$, $a_k|n_1, n_2, ...n_k.....n_N\rangle = \eta|n_1, n_2,....... \delta.....n_N\rangle$, then :

(A) $\eta = \sqrt{n_k}, \delta = n_k - 1$

(B) $\eta = \sqrt{n_k - 1}, \delta = n_k$

(C) $\eta = \sqrt{n_k - 1}, \delta = n_k - 1$

(D) $\eta = \sqrt{n_k}, \delta = n_k$

71. If A = cd, where c and d are annihilation operators of two different types of Fermions, then $[A, A^\dagger]$ is :

(A) $1 - n_c + n_d$

(B) $1 + n_c + n_d$

(C) $1 - n_c - n_d$

(D) $1 + n_c - n_d$

where n_c and n_d are the corresponding number operators.

72. If $n = c^{\dagger} c$ for a Fermion system, then n^2 is :

(A) $n-1$

(B) $n+1$

(C) n

(D) 0

73. In a RC coupled amplifier the voltage gain over mid-frequency range :

(A) Changes abruptly with frequency

(B) Is constant

(C) Changes uniformly with frequency

(D) None of the above

74. If C_b is the coupling capacitor in a RC coupling employing a bipolar transistor and C_f is the corresponding value for a FET employed amplifier, then :

(A) $C_b < C_f$

(B) $C_b \sim C_f$

(C) $C_b = C_f = 0$

(D) $C_b > C_f$

75. For an operational amplifier, if the input voltages are +1.0 mV and +0.09 mV, the differential mode gain is 2000 and the CMRR = 100. The output voltage will be :

(A) 118 mV

(B) 219 mV

(C) 407 mV

(D) 523 mV

76. For an inverting amplifier, the output voltage in terms of an input resistance R_i, feedback resistance R_f and input voltage V_1 is :

(A) $\frac{R_f}{R_i} V_1$

(B) $\frac{R_i}{R_i + R_f} V_1$

(C) $-\frac{R_f}{R_i} V_1$

(D) $\frac{R_f}{R_i + R_f} V_1$

77. The feedback that a Wien bridge oscillator uses is :

(A) Only positive

(B) Only negative

(C) Both positive and negative

(D) None of the above

78. The application where one would most likely find a crystal oscillator is :

(A) Radio receiver

(B) Radio transmitter

(C) AF sweep generator

(D) None of the above

79. Resonant frequencies in a crystal oscillator lie normally between :

(A) 1 KHz and 5 KHz

(B) 10 KHz and 10 MHz

(C) 50 MHz and 100 MHz

(D) None of the above

80. In a FET, how many p-n junctions are at the sides ?

(A) 3

(B) 4

(C) 5

(D) 2

81. The NAND gate is AND gate followed by :

(A) A NOT gate

(B) An OR gate

(C) An AND gate

(D) None of the above

82. In Boolean algebra, the bar sign indicates :

(A) OR operation

(B) AND operation

(C) NOT operation

(D) None of the above

83. Madelung energy describes the binding in :

(A) Inert gas crystals

(B) Ionic crystals

(C) Covalent crystals

(D) Metallic crystals

84. Specific heat of electrons at low temperatures is proportional to :

(A) T

(B) T^2

(C) T^3

(D) $T^{3/2}$

85. The Hall coefficient RH is given by :

(A) $\frac{E_y}{J_x B}$

(B) $\frac{J_x}{E_y B}$

(C) $\frac{J_x B_y}{E}$

(D) $\frac{E_y B}{J_x}$

where J_x is the current density in x-direction, B is the magnetic field in the z-direction and E_y is the electric field along y-direction.

86. In the tight binding approximation the Bloch function, $\psi_{\vec{k}}(\vec{r})$ is written as :

(A) $\frac{1}{\sqrt{N}}\sum_{\vec{k}} e^{i\vec{k}.\vec{R}_j}\phi\left(\vec{r}-\vec{R}_j\right)$

(B) $\frac{1}{\sqrt{N}}\sum_{\vec{j}} e^{i\vec{k}.\vec{R}_j}\phi\left(\vec{r}-\vec{R}_j\right)$

(C) $\frac{1}{\sqrt{V}}\sum_{\vec{k}} e^{i\vec{k}.\vec{R}_j}\phi\left(\vec{r}-\vec{R}_j\right)$

(D) $\frac{1}{\sqrt{V}}\sum_{\vec{j}} e^{i\vec{k}.\vec{R}_j}\phi\left(\vec{r}-\vec{R}_j\right)$

where $\vec{R}_j$ is the j^{th} lattice vector, ϕ is an atomic orbital at the j^{th} lattice site and $\vec{k}$ is the electron wave vector.

87. In a superconductor the free energy for a magnetic field $H < H_c$ varies as :

(A) H^3

(B) H

(C) H^2

(D) H^{-2}

where H_c is the critical magnetic field.

88. The current density $\vec{J}(\vec{r})$ in a super conductor is given by :

(A) $-\frac{\lambda_L^2}{4\pi c}\vec{A}(\vec{r})$

(B) $-\frac{4\pi\lambda_L^2}{c}\vec{A}(\vec{r})$

(C) $-\frac{2c}{\pi\lambda_L^2}\vec{A}(\vec{r})$

(D) $-\frac{c}{4\pi\lambda_L^2}\vec{A}(\vec{r})$

where $\vec{A}(\vec{r})$ is the magnetic vector potential, λ_L is the London penetration depth and c is the velocity of light.

89. In ferromagnetic iron the internal magnetic field is of the order of :

(A) 10 Tesla

(B) 100 Tesla

(C) 1000 Tesla

(D) 10000 Tesla

90. Which of the following magnetic susceptibilities is temperature dependent ?

(A) Pauli paramagnetic susceptibility

(B) Landau diamagnetic susceptibility

(C) Curie susceptibility

(D) Van-Vleck susceptibility

91. In Germanium the band gap is :

(A) Indirect and about 0.7 eV

(B) Direct and about 1.5 eV

(C) Indirect and about 2.5 eV

(D) Direct and about 0.2 eV

92. The Lorentz field in a dielectric is given by :

(A) $2\pi\vec{P}$

(B) $\frac{4\pi}{3}\vec{P}$

(C) $4\pi\vec{P}$

(D) $\frac{2\pi}{3}\vec{P}$

where $\vec{P}$ is the electrical polarization vector.

93. Discovery of the nucleus was made by :

(A) Scattering of X-Rays

(B) Scattering of neutrons

(C) α-particle scattering

(D) Electron scattering

94. Which one is not a magic number ?

(A) 8

(B) 20

(C) 60

(D) 82

95. In β decay, a neutron decays to :

(A) a proton, an electron and a photon

(B) a proton, an electron and a neutrino

(C) a photon, an electron and a positron

(D) a proton, an electron and an antineutrino

96. The deuteron binding energy lies between :

(A) 1 and 2 MeV

(B) 2 and 3 MeV

(C) 3 and 4 MeV

(D) 4 and 5 MeV

97. Which particle do not take part in an electromagnetic interaction ?

(A) Hadrons

(B) Electrons

(C) Neutrinos

(D) Photons

98. Which of the following choices lists the four known types of forces in nature in order of decreasing strength ?

(A) Strong, Electromagnetic, Weak and Gravitational

(B) Strong, Weak, Electromagnetic and Gravitational

(C) Strong, Gravitational, Weak and Electromagnetic

(D) Gravitational, Strong, Electromagnetic and Weak

99. The G-parity of any particle that strongly decays into n pions is given by :

(A) $G = (-1)^{n-1}$

(B) $G = (-1)^{n}$

(C) $G = (-1)^{n+1}$

(D) $G = (-1)^{n/2}$

100. In all known reactions, the number L_e of electron type leptons is exactly conserved if the individual L_e numbers are taken as :

(A) +1 for e^- and $\bar{v}_e$ and – 1 for e^+ and v_e

(B) +1 for e^+ and v_e and – 1 for e^- and $\bar{v}_e$

(C) +1 for e^- and v_e and – 1 for e^+ and $\bar{v}_e$

(D) +1 for e^+ and $\bar{v}_e$ and – 1 for e^- and v_e

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