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TEST BOOKLET

Sl. No: 0639

Subject Code: 17 | **Subject: PHYSICS**

WRITTEN TEST FOR RECRUITMENT OF POST GRADUATE TEACHERS FOR NON-GOVT. AIDED HIGHER SECONDARY SCHOOLS OF ODISHA.

Time Allowed : 2 Hours | *Maximum Marks: 150*

: INSTRUCTIONS TO CANDIDATES:

1. **IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET CONTAINS 20 PAGES AND DOES NOT HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.**

2. 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.

3. The Test Booklet contains **100** questions. Each question comprises four options. You have to select the correct answer which you want to mark (darken) on the OMR Answer Sheet. In any case, choose ONLY ONE answer for each question. If more than one answer is darkened, it will be considered wrong.

4. You have to mark (darken) all your answers only on the **OMR Answer Sheet using BLACK BALL POINT PEN** provided by the State Selection Board. You have to do rough work only in the space provided at the end of the Test Booklet. See instructions in the OMR Answer Sheet.

5. All questions carry equal marks. While **1.5** marks will be awarded for each correct answer, each wrong answer will result in negative marking of **0.50** mark.

6. Before you proceed to mark (darken) the answers in the OMR Answer Sheet to the questions in the Test Booklet, you have to fill in some particulars in the OMR Answer Sheet as per the instructions in your Admit Card.

7. On completion of the Examination, you should hand over the **original copy of OMR Answer Sheet** issued to you to the Invigilator before leaving the Examination Hall. You are allowed to take with you the candidate's copy (second copy) of the OMR Answer Sheet along with the Test Booklet for your reference.

Candidate's full signature | **Invigilator's signature**

P.T.O.

1. The sum of the residues of the function $f(z) = \dfrac{\sin z}{z \cos z}$ at its poles inside the circle $|z| = 2$ is

(A) $\dfrac{2}{\pi}$ (B) $-\dfrac{2}{\pi}$

(C) 0 (D) $\dfrac{1}{\pi}$

2. Value of complex integration $\int_c \dfrac{4-3z}{z(z-1)(z-2)} dz$ c is the circle $|z| = 3/2$ is

(A) $2\pi i$ (B) $-\pi i$

(C) πi (D) $\dfrac{\pi}{4} i$

3. Value of the integration $\int_0^{2\pi} \dfrac{1}{5 - 4\sin\theta} d\theta$ is

(A) $\dfrac{\pi}{2}$ (B) $\dfrac{2\pi}{3}$

(C) $\dfrac{\pi}{4}$ (D) $\dfrac{\pi}{3}$

4. If A^μ and B_ν are the components of a contravariant and covariant tensor of rank one then $C^\mu_\nu = A^\mu B_\nu$ is component of mixed tensor of rank

(A) 1 (B) zero

(C) 2 (D) 3

5. $\delta_{ik}\ \varepsilon_{ikm} =$

(A) 1 (B) 3

(C) zero (D) −1

6. A symmetric tensor of rank 2 in n dimensional space has at most independent components of

(A) $\dfrac{n}{2}$ (B) $\dfrac{n(n+1)}{2}$

(C) $\dfrac{(n+1)}{2}$ (D) $\dfrac{n^2}{2}$

7. $J_{-1}(x) + J_1(x) =$

(A) zero

(B) $\sqrt{\frac{1}{\pi x}} \sin x$

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

(D) 1

8. $3x^2 + 3x + 1$ is

(A) $3P_0(x) + P_1(x) + 2P_2(x)$

(B) $2P_0(x) + 3P_1(x)$

(C) $2P_0(x) + 3P_1(x) + 2P_2(x)$

(D) $2P_1(x) + 3P_0(x)$

9. $L_2(x)$ is

(A) 1

(B) $1 - x$

(C) x^3

(D) $x^2 - 4x + 2$

10. Pick up the correct statement

(A) In Lie group, elements will not contain any varying parameters

(B) $x_i' = f_i(x_1, x_2, x_3, \theta)$, x_i' is a Lie group if the function f_i is not analytic functions of parameter θ

(C) If in a Lie group parameters vary over closed interval, the group is called compact

(D) A compact group is not equivalent to a unitary representation

11. Su(n) having unit determinant matrix has independent parameters equal to

(A) $n(n - 1)$

(B) $n^2 - 1$

(C) n^2

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

12. In Sw(3) scheme existence of eight baryons were proposed by

(A) M. Gell-Mann and Y. Ne'eman

(B) Yukawa

(C) Fermi

(D) E. Gardner

13. Green's function for Poisson's equation $\nabla^2\phi(r_2 - r_1) = -\frac{\rho(r_2 - r_1)}{\varepsilon_0}$ is

(A) $\frac{1}{4\pi}\frac{1}{|r_2 - r_1|}$

(B) $|r_2 - r_1|$

(C) $\frac{1}{|r_2 - r_1|}$

(D) $4\pi|r_2 - r_1|$

14. The parametric equations in case of problem of brachistocrone are of

(A) catenary

(B) parabola

(C) ellipse

(D) cycloid

15. If Lagrangian is expressed as $L = \frac{1}{2}ml^2\left(\dot{\theta}^2 + \dot{\phi}^2 \sin^2\theta\right) - mgl\cos\theta$ then Hamiltonian H is given by expression

(A) $H = \frac{1}{2ml^2}\left[P_\theta^2 + P_\phi^2\right] - mgl\cos\theta$

(B) $H = \frac{1}{2ml^2}\left[P_\theta^2 + \frac{P_\phi^2}{\sin\theta}\right] + mgl\cos\theta$

(C) $H = \frac{1}{2ml^2}\left[P_\theta^2 + \frac{P_\phi^2}{\sin^2\theta}\right] + mgl\cos\theta$

(D) $H = \frac{1}{2ml^2}\left[P_\theta^2 + \frac{P_\phi^2}{\sin^2\theta}\right] - mgl\cos\theta$

16. Jacobi's form of least action principle is

(A) $\Delta \int_{t_1}^{t_2} dt = 0$

(B) $\Delta \int_{t_1}^{t_2} \sum_i p_i \dot{q}_j \, dt = 0$

(C) $\Delta \int [H - V(q)] d\rho = 0$

(D) $\Delta \int \sqrt{2[H - V(q)]} d\rho = 0$

17. $Q = q^\alpha \cos\beta p$, $P = q^\alpha \sin\beta p$ represent canonical transformation for values of α and β

(A) $\frac{1}{2}$, 2

(B) 1, 1

(C) $\frac{1}{2}$, 1

(D) 2, $\frac{1}{2}$

18. The motion of the system in finite interval of time is described by an infinitesimal canonical transformation generated by

(A) Lagrangian

(B) Hamiltonian

(C) generating function $F_1(q, Q, t)$

(D) generating function $F_2(q, P, t)$

19. $[L_x, P_y] =$

(A) $-P_y$

(B) zero

(C) P_z

(D) $-P_x$

20. Pick up the wrong statement

(A) Lagranges brackets do not obey commutative law

(B) Lagranges brackets are invariant under canonical transformation

(C) $\{q_i, p_j\} = \delta_{ij}$

(D) Lagranges bracket obey commutative law

21. The angular velocity component ω_x is equal to

(A) $\dot{\phi}\sin\theta \sin\psi + \dot{\theta}\cos\psi$

(B) $\dot{\phi}\sin\theta \cos\psi - \dot{\theta}\sin\psi$

(C) $\dot{\phi}\cos\theta + \dot{\psi}$

(D) $\dot{\phi}\sin\theta \cos\psi - \dot{\theta}\cos\psi$

22. From Euler's equation, x component of torque τ_x is

(A) $I_1 \dot{\omega}_x - (I_2 - I_3)\omega_y\omega_z$

(B) $I_2 \dot{\omega}_x - (I_3 - I_1)\omega_y\omega_z$

(C) $I_1 \dot{\omega}_x - (I_1 - I_2)\omega_y\omega_z$

(D) $I_3 \dot{\omega}_x - (I_2 - I_1)\omega_y\omega_z$

I_1, I_2, I_3 are principal moment of inertia.

23. A particle is at rest in rotating frame, the pseudo force acting on the particle in the rotating frame is

(A) zero

(B) only centrifugal force

(C) only coriolis force

(D) both coriolis and centrifugal force

24. If the nutation of symmetry axis of top is fixed at an angle θ_0 then the top precesses with angular velocity, $\dot{\phi}$ =

(A) $b - a\cos\theta_0$

(B) $\frac{b - a\cos\theta_0}{\sin\theta_0}$

(C) $\frac{b - a\cos\theta_0}{\sin^2\theta_0}$

(D) $\frac{b - a\sin\theta_0}{\cos\theta_0}$

25. The frequencies related to oscillatory motion of tri atomic molecule having atoms of masses m, M, m are

(A) $\sqrt{\frac{K}{m}}$ and $\sqrt{\frac{K}{M}}$

(B) $\sqrt{\frac{K}{m}}$ and $\sqrt{\frac{K}{M+2m}}$

(C) $\sqrt{\frac{K}{2m}}$ and $\sqrt{\frac{K}{M}}$

(D) $\sqrt{\frac{K}{m}}$ and $\left\{\frac{K}{M}\left(1+\frac{2m}{M}\right)\right\}^{1/2}$

where K is force constant.

26. From action angle variable procedure the frequency of Kepler problem is given by

(A) $\frac{4\pi Km}{(J_r)^2}$

(B) $\frac{4\pi^2K^2m}{(J_r + J_\theta + J_\phi)^3}$

(C) $\frac{4\pi^2K^2m}{(J_\theta)^2}$

(D) $\frac{4\pi^2K^2m}{(J_\phi)^2}$

27. For harmonic oscillator Hamilton's Principal function S is

(A) $\int H dt$

(B) $\int P dq$

(C) $-\alpha t$

(D) $\int L dt$

where L is Lagrangian, H is hamiltorian, $\alpha = -\frac{\partial s}{\partial t}(q, t)$

28. The dipole term in the vector potential of a current loop at point $\vec{r}$ varies as

(A) $\frac{1}{|\vec{r}|}$
(B) $\frac{1}{|\vec{r}|^3}$
(C) $\frac{1}{|\vec{r}|^2}$
(D) $\frac{1}{|\vec{r}|^4}$

29. Pick up the wrong statement :

(A) Lorentz gauge treats scalar and vector potential on equal footing
(B) In Lorentz gauge vector and scalar potential satisfy the inhomogeneous wave equation with source term on the right
(C) $A' = A + \nabla\lambda$ and $V' = V - \frac{\partial\lambda}{\partial t}$ are gauge transformation equations
(D) In Lorentz gauge $\vec{\nabla}\cdot\vec{A} = \mu_0\varepsilon_0 V$ where A, V are vector and scalar potential and λ is a scalar function

30. The value of poynting vector at the surface of the sun, if the power radiated by sun is 30.8×10^{25} watts and radius of sun is 7×10^{8} m is,

(A) 10.2×10^{7} watt/meter^2
(B) 5×10^{7} watt/meter^2
(C) 4×10^{8} watt/meter^2
(D) 8×10^{7} watt/meter^2

31. For centre-fed linear antenna of length d, time averaged power radiated per unit solid angle at $kd = \pi$ is

(A) $\frac{I^2}{2\pi c}\frac{\cos^2\left(\frac{\pi}{2}\cos\theta\right)}{\sin^2\theta}$
(B) $\frac{I^2}{2\pi c}\cos\left(\frac{\pi}{2}\cos\theta\right)$
(C) $\frac{I^2}{2\pi c}\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}$
(D) $\frac{I^2}{2\pi c}\sin\left(\frac{\pi}{2}\cos\theta\right)$

32. Power radiated by an electric dipole is proportional to

(A) square of frequency
(B) frequency
(C) cube of frequency
(D) fourth power of frequency

33. In Kramer-Kronig relation with dielectric constant $\varepsilon(\omega)$

(A) Re $\varepsilon(\omega)$ is odd in ω
(B) Im $\varepsilon(\omega)$ is even in ω
(C) Both real and imaginary part $\varepsilon(\omega)$ are odd in ω
(D) Re $\varepsilon(\omega)$ is even in ω

34. A point charge q is at rest at the origin in system S_0. The electric field 'E_z' due to the charge in the system which moves to right with velocity v_0 along x axis relative to S_0 is

(A) $E_z = \frac{1}{4\pi\varepsilon_0}\frac{qx_0}{|r_0|^3}$

(B) $E_z = \frac{1}{4\pi\varepsilon_0}\frac{1}{\sqrt{1-\frac{v_0^2}{c^2}}}\frac{qx_0}{|r_0|^3}$

(C) $E_z = \frac{1}{4\pi\varepsilon_0}\frac{1}{\left[1-\frac{v_0^2}{c^2}\right]^{1/2}}\frac{qz_0}{|r_0|^3}$

(D) $E_z = \frac{1}{4\pi\varepsilon_0}\frac{1}{\left[1-\frac{v_0^2}{c^2}\right]^{1/2}}\frac{qy_0}{|r_0|^3}$

$|r_0| = \left[x_0^2 + y_0^2 + z_0^2\right]^{1/2}$

35. Larmor formula for the power radiated by non-relativistically accelerated charged particle is given by

(A) $P = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{e^2}{c^3}a$

(B) $P = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{e^2}{c^3}a^2$

(C) $P = \frac{1}{4\pi\varepsilon_0}\frac{e^2a^2}{c^3}$

(D) $P = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{e^2a^3}{c^3}$

where $a \rightarrow$ acceleration

36. The form of potentials (vector and scalar) which exhibit the dependence of potentials on the velocity of charged particle was named by

(A) Kramer Kroning potential

(B) Clausius - Mossoti potential

(C) Lienard - Wiechert potential

(D) Thomson potential

37. Relativistic Lagrangian for a charged particle is given by

(A) $L = \frac{e}{c}\vec{U}\cdot\vec{A} - e\phi$

(B) $L = -mc^2\sqrt{1-\frac{U^2}{c^2}} + \frac{e}{c}\vec{U}\cdot\vec{A} - e\phi$

(C) $L = -mc^2\sqrt{1-\frac{U^2}{c^2}} - e\phi$

(D) $L = -mc^2\sqrt{1-\frac{U^2}{c^2}} + \frac{e}{c}\vec{U}\cdot\vec{A}$

where $U \rightarrow$ velocity A, ϕ vector and scalar potential.

38. The classical Thomson formula for scattering is valid at

(A) high frequencies

(B) low frequencies

(C) incident photon momentum comparable to me

(D) where incident photon momentum can not be ignored

39. Width of the Gaussian wave packet in K space for wave function

$$\int_{-\infty}^{+\infty} e^{-(K-K_0)^2\alpha} e^{i(Kx-\omega t)} dt \text{ is}$$

(A) $\sqrt{2\alpha}$

(B) $2\sqrt{2\alpha}$

(C) $2\left(\frac{1}{2\alpha}\right)^{1/2}$

(D) $\frac{2}{\sqrt{\alpha}}$

40. Which of the following is true for Dirac delta function?

(A) $\delta(x) = \text{imaginary}$

(B) $\delta(x) = \text{odd function}$

(C) $x\delta(x) \neq 0$

(D) $\delta\left(x^2 - a^2\right) = \frac{1}{2a}[\delta(x+a) + \delta(x-a)]$ for a>0

41. In momentum space Hamiltonian is represented by

(A) $H = \frac{P^2}{2m} + v\left(-\frac{\hbar}{i}\vec{\nabla}_P\right)$

(B) $H = -\frac{\hbar^2}{2m}\nabla^2 + v(r)$

(C) $H = \frac{P^2}{2m} + v(r)$

(D) $H = i\hbar\frac{\partial}{\partial t} + \vec{\nabla}_P$

42. Which of the following statement is correct?

(A) Operator representing an observable and state ket are independent of time in schrodinger's picture

(B) In Heisenberg picture state ket changes with time and operator representing observable does not change with time

(C) In interaction or Dirac picture both state ket and operator may change with time

(D) In Heisenberg picture both state ket and operator also change with time.

43. The uncertainty product $(\Delta x)(\Delta P)$ in the n^{th} state $| n >$ of one dimensional harmonic oscillator is

(A) $n\hbar$

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

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

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

44. In case of addition of two commuting angular momenta with $j_1 = 1/2, j_2 = 1/2$ dimension of product space is

(A) 2

(B) 4

(C) 8

(D) 6

45. Pick up the wrong statement regarding Pauli-spin matrices $\sigma_1, \sigma_2, \sigma_3$.

(A) $\hat{\sigma}_1\hat{\sigma}_2\hat{\sigma}_3 = 0$

(B) They are traceless

(C) They are Hermitian

(D) Square of each pauli spin matrix is unitary

46. The Hamiltonian for a perturbed harmonic oscillator is given by

$\hat{H} = \frac{P_x^2}{2\mu} + \frac{1}{2}\mu\omega^2\hat{x}^2 - A\hat{x}$, where A is a constant, $A\hat{x}$ is small then $E_n^{(1)}$ is

(A) $n\hbar\omega$

(B) $-\frac{A^2}{2\mu\omega}$

(C) zero

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

47. Choose the correct statement

(A) The rotational matrix for infinitesimal small rotation is unitary

(B) For translational symmetry the symmetry operator does not commute with Hamiltonian

(C) Time displacement symmetry operator is not unitary

(D) For time displacement, symmetry Hamiltonian is time dependent.

48. Total ψ_{200} (r, θ, φ) wave function for hydrogen atom is given by

(A) $\left(\frac{z}{2a_0}\right)^{3/2} e^{-\frac{zr}{2a_0}}$

(B) $\left(\frac{1}{\pi}\right)^{1/2}\left(\frac{z}{2a_0}\right)^{3/2}\left(1-\frac{zr}{2a_0}\right)e^{-\frac{zr}{2a_0}}$

(C) $\left(1-\frac{zr}{2a_0}\right)e^{-\frac{zr}{2a_0}}$

(D) $\left(\frac{1}{\pi}\right)^{1/2}\left(\frac{z}{2a_0}\right)^{3/2} e^{-\frac{zr}{2a_0}}$

49. The Fermi energy E_F of N no of electrons in cubical three dimensional box of length L and number density n is given as

(A) $\frac{\hbar^2\pi^2}{m}\left(\frac{n}{\pi}\right)^{1/3}$

(B) $\frac{\hbar^2\pi^2}{2m}\left(\frac{n}{2\pi}\right)^{1/3}$

(C) $\frac{\hbar^2\pi^2}{2m}\left(\frac{3n}{2\pi}\right)^{2/3}$

(D) $\frac{\hbar^2\pi^2}{2m}\left(\frac{3n}{\pi}\right)^{2/3}$

50. For linear stark effect non vanishing Matrix elements of Perterbed Hamiltonian H′ are

(A) $<2,0,0|\hat{H}'|2,1,-1>,\ <2,1,0|\hat{H}'|2,1,1>$

(B) $<2,0,0|\hat{H}'|2,1,0>,\ <2,1,0|\hat{H}'|2,0,0>$

(C) $<2,1,-1|\hat{H}'|2,0,0>$ and $<2,0,0|\hat{H}'|2,1,-1>$

(D) $<2,1,1|\hat{H}'|2,1,-1>$ and $<2,1,-1|\hat{H}'|2,1,1>$

51. If spin-orbit interaction is considered then for $2P_{1/2}$ state, energy is

(A) $-\frac{Ke^2}{8a_0}\frac{\alpha^2}{12}$ (B) $-\frac{Ke^2}{8a_0}$

(C) $-\frac{Ke^2}{8a_0}\frac{\alpha^2}{6}$ (D) $\frac{Ke^2}{8a_0}\frac{\alpha^2}{12}$

where α - fine structure constant.

52. Clebsch-Gordon coefficients

(A) does not obey orthogonality condition

(B) does not obey normalisation condition

(C) can be evaluated with proper recursion relation

(D) can not be evaluated by any recursion relation

53. WKB approximation is valid when

(A) Potential is changing rapidly

(B) Potential must change slowly over many wave lengths

(C) Kinetic energy is not sufficiently large

(D) When the particle moves over the distance $\lambda\!\!\!^{-} = \frac{\lambda}{2\pi}$ then $\left|\frac{d\lambda\!\!\!^{-}(x)}{dx}\lambda\!\!\!^{-}(x)\right| >> \lambda\!\!\!^{-}(x)$

54. In variational method the trial wave function which produce agreeable result for ground state energy for He-atom is

(A) $\psi(r_1, r_2) = Ae^{\frac{-z'(r_1+r_2)}{a_0}(1+\sigma|r_1-r_2|)}$

(B) $\psi(r_i) = \left(\frac{z'^3}{\pi a_0^3}\right)^{1/2} e^{\frac{-z'r_i}{a_0}}$

(C) $\psi(r_1, r_2) = e^{\frac{-z'(r_1+r_2)}{a_0}} F[(r_1-r_2),(r_1+r_2),r_{12}]$

(D) $\psi(r_1, r_2) = Ae^{\frac{-z'|(r_1+r_2)|^2}{a_0}}$

55. Slater determinant for N particles gives information regarding

(A) Pauli's exclusion principle (B) Bohr's principle

(C) Transition probability (D) Phase shift in scattering

56. In perturbation theory if H_0 is constant and $H'(t) = 0$ for $t < 0$; $H'(t) = H'$ for $0 < t \le \tau$ then probability of transition from $| m >$ state to $| K >$ state varies as

(A) τ
(B) τ^2
(C) $\frac{1}{\tau}$
(D) $\frac{1}{\tau^2}$

57. A one dimensional harmonic oscillator with angular frequency ω_0 and charge q is in ground state at time t = 0 and electric field $\vec{E}$ is applied for time τ

where $H'(t) = \begin{vmatrix} -q\vec{E}\,\hat{x} & \text{for } 0 < t \le \tau \\ 0 & \text{otherwise} \end{vmatrix}$

Probability of transition to n=2 state is

(A) $\frac{q^2E^2}{m\hbar\omega_0}$
(B) $\frac{\sin^2\left[\frac{1}{2}(\omega_{10}\tau)\right]}{(\omega_{10}\tau)^2}$
(C) zero
(D) $\sin^2\frac{1}{2}(\omega_{10}\tau)$

58. For larger energy difference between two states

(A) spontaneous and induced emission are of equal probability
(B) spontaneous emission is of less probability
(C) Induced emission is of more probability
(D) spontaneous emission is more probable

59. In case of elastic scattering from a rigid sphere the total scattering cross section in low energy limit is

(A) $2\pi a^2$
(B) πa^2
(C) $4\pi a^2$
(D) $6\pi a^2$

60. Which of the following statement is true?

(A) Parity operator commutes with linear momentum operator.
(B) If P.E. U(r) is symmetric function of r then hamiltonian is invariant under parity transformation.
(C) Parity operator commutes with $\hat{\vec{r}}$ operator.
(D) Parity operator is not unitary.

61. The wave function for two identical particle with spin $\frac{1}{2}$ is

(A) symmetric
(B) antisymmetric
(C) both symmetric and antisymmetric
(D) represented by $\frac{1}{\sqrt{2}}\left[U_{E_1}(x_1)U_{E_2}(x_2) + U_{E_1}(x_1)U_{E_2}(x_2)\right]$

62. Dirac γ matrices satisfy

(A) γ^0 is hermitian

(B) γ matrices are 2×2 matrices

(C) They are not related to Pauli Spin Matrices

(D) $\gamma^0 = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$ where 1 is 4×4 matrix

63. Dirac equation for free particle is given by

(A) $\left[C\vec{\alpha}\cdot\vec{P} + \hat{\beta} mc^2 \right]\psi = E\psi$

(B) $\left[C\vec{\alpha}\cdot\vec{P} \right]\psi = E\psi$

(C) $\hat{\beta} mc^2 \psi = E\psi$

(D) $\left[\left[C\vec{\alpha}\cdot\left(\vec{P} - \frac{e\vec{A}}{C} \right) \right] + \beta mc^2 \right]\psi = E\psi$

64. The cross terms between the positive and negative energy solution in expression of current oscillate with frequency f, so

(A) f is less than $\frac{2mc^2}{\hbar}$

(B) f is related to amplitude of positive energy solution of wave packet

(C) f is order of 10 sec^{-1}

(D) f is proportional to amplitude of negative energy solution

65. The hole theory predicts

(A) negative energy electron cannot be excited to positive energy state

(B) the hole registers absence of an electron of charge –|e| and energy +E in vacuum

(C) pair production

(D) transition to many particle theory describing particles of single charge

66. The four solutions of Dirac equation corresponding to a free particle at rest is represented by equation

$$\psi^r(x) = \omega^r(0) e^{-\frac{(i\varepsilon_r mc^2)t}{\hbar}} \quad \text{for } \varepsilon_r = \begin{cases} +1 & \text{for } r = 1,2 \\ -1 & r = 3,4 \end{cases}$$ where the spinor $\omega^3(0)$ is

(A) $\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

(B) $\begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}$

(C) $\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$

(D) $\begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$

67. The Noether's theorem is related to continuous transformation of coordinates with

(A) variation of action is non zero

(B) variation of action is zero, field functions and their derivatives are conserved

(C) field function is not conserved

(D) derivative of field function is not conserved

68. Entropy of ideal monoatomic gas is given as

(A) $nk \log_e\left(\frac{f}{n}\right)+\frac{3}{2}nk$ (B) $nk \log_e\left(\frac{f}{n^2}\right)+\frac{5}{2}nk$

(C) $nk \log_e\left(\frac{f}{n}\right)+\frac{1}{2}nk$ (D) $nk \log_e\left(\frac{f}{n}\right)+\frac{5}{2}nk$

where $f = V\left(\frac{2\pi mkT}{h^2}\right)^{3/2}$

69. Second order phase transition is characterised by

(A) entropy is discontinuous at transition temperature

(B) no latent heat, continuous change in entropy, continuous change of order parameter from zero as the temperature drops below transition temperature

(C) there is latent heat

(D) the first order derivative of Gibb's function changes discontinuously at transition temperature

70. In case of white dwarf star of mass M in non relativistic case the radius R of star related to mass as

(A) $R \propto M^{-1/3}$ (B) $R \propto M$

(C) $R \propto M^2$ (D) $R \propto \frac{1}{M}$

71. Joining two moles of two different gases by removing partition between them, the entropy of joint system increases by

(A) $2 \log_e 2$ (B) 2nk

(C) $2nk \log_e 2$ (D) $2n \log_e 2$ which is Gibb's paradox

72. At high temperature and low density the equation of state for ideal spinless fermi gas is given by

(A) $\frac{PV}{KT}=1+\frac{1}{2^{5/2}}\frac{\lambda^3}{u}+....$ (B) $\frac{PV}{KT}=1-\frac{1}{2^{3/2}}\frac{\lambda^3}{u}+....$

(C) $\frac{PV}{KT}=1+\frac{1}{2^{3/2}}\frac{\lambda^3}{u}$ (D) $\frac{PV}{KT}=1+\frac{1}{2^{7/2}}\frac{\lambda^3}{u}$

where $u=\frac{N}{V}$ and $\lambda=\left(\frac{2\pi\hbar^2}{mkT}\right)^{1/2}$.

73. In case of Grand canonical ensemble the probability that a system has N′ particle is proportional to ω(N′) which is a Gaussian distribution of N′ centred abut N with a width equal to ΔN which is equal to

(A) $\sqrt{\frac{KTN}{v^2}}$

(B) $\sqrt{\frac{2KTN}{\left(-\frac{\partial P}{\partial u}\right)}}$

(C) $\left[\frac{KTN}{\left(-\frac{\partial P}{\partial v}\right)}\right]^{1/2}$

(D) $\left[\frac{2KTN}{v^2\left(-\frac{\partial P}{\partial v}\right)}\right]^{1/2}$

74. Quantum Mechanical version of Liouville's theorem is given by

(A) $i\hbar\frac{\partial P}{\partial t} = H\rho$

(B) $i\hbar\frac{\partial P}{\partial t} = [H,\rho]$

(C) $i\hbar\frac{\partial P}{\partial t} = H\rho + \rho H$

(D) $i\hbar\frac{\partial P}{\partial t} = \frac{d\rho}{dt}$

where ρ is the density operator and H is Hamiltonian

75. The equation for entropy $\frac{S}{K} = \frac{3}{2}N - N\log\left[\frac{N}{V}\left(\frac{2\pi\hbar^2}{mkT}\right)^{3/2}\right]$ for Boltzman gas in microcanonical ensemble is

(A) Maxwell Boltzman equation

(B) Navier Stokes equation

(C) Gibb's equation

(D) Sackur Tetrode equation

76. The transfer gain 'A_f' of an amplifier employing feedback is related to transfer gain A without feedback is

(A) $A_f = A$

(B) $A_f = \frac{A}{\beta}$

(C) $A_f = \frac{A}{1+\beta A}$

(D) $A_f = \frac{\beta}{A}$

where β is feedback factor

77. Amplifier has a voltage gain of –500. The gain is reduced to –100 on applying negative feedback. Then the feedback factor β is

(A) –0.004

(B) –0.008

(C) 0.005

(D) 0.003

78. The astable multivibrator has

(A) two quasistable states

(B) one stable one quasistable states

(C) two stable states

(D) one put wave form is saw tooth type

79. A wienbridge oscillator is to cover frequency range from 20 Hz to 20 KHz. The variable capacitance has a value from 30 PF to 300 PF. The resistance values required to cover the frequency range are

(A) 26.5 MΩ, 265 MΩ, 265 KΩ (B) 26.5 MΩ, 53 MΩ, 106 MΩ

(C) 26.5 MΩ, 13.25 MΩ, 6.6 MΩ (D) 26.5 MΩ, 2.65 MΩ, 265 KΩ

80. In case of differential amplifier the output voltage v_0 is related to difference between voltage $V_2 - V_1$ as

(A) $V_0 = \frac{R_2}{R_1}(V_2 - V_1)$ (B) $V_0 = \frac{R_2}{R_1}\frac{1}{V_2 - V_1}$

(C) $V_0 = \frac{R_2}{R_1}[V_2 - V_1]^{-2}$ (D) $V_0 = \frac{R_2}{R_1}(V_2 - V_1)^2$

where $\frac{R_2}{R_1}$ voltage gain of the amplifier system

81. Boolean identity (A + B)(B + C)(C + A) =

(A) A + BC (B) B + AC

(C) AB + BC + CA (D) C + AB

82. Boolean expression $Y = \overline{A.B}$ is the expression for

(A) NOR gate (B) OR gate

(C) XOR gate (D) NAND gate

83. If the angle between incident x ray and diffracted ray is 40° then the angle of incidence is

(A) 60° (B) 40°

(C) 70° (D) 20°

84. Madelung constant of ionic crystal having linear chain of ions of alternate sign is

(A) $\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_0}[2\log 2]$ (B) $\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_0^2}[2\log 2]$

(C) $\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_0^2}[3\log 2]$ (D) $\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_0}[3\log 2]$

where r_0 is shortest distance between adjacent ions.

85. In case vibrations of one dimensional diatomic lattice for $K \to 0$ the two values of ω are given by

(A) $\omega_+ = \sqrt{\frac{2\beta}{m}}$, $\omega_- = \sqrt{\frac{2\beta}{M}}$

(B) $\omega_+ = \left[2\beta\left(\frac{1}{m} + \frac{1}{M}\right)\right]^{1/2}$, $\omega_- = Ka\sqrt{\frac{2\beta}{m+M}}$

(C) $\omega_+ = \sqrt{\frac{2\beta}{m+M}}$, $\omega_- = \sqrt{\frac{2\beta}{M}}$

(D) $\omega_+ = \sqrt{\frac{2\beta}{M}}$, $\omega_- = \left[2\beta\left(\frac{1}{m} + \frac{1}{M}\right)\right]^{1/2}$

86. Specific heat at constant volume C_V at temperature T as per Einstein Model shows behaviour as

(A) $C_v = 3NK_\beta T$

(B) $C_v \propto T^3$

(C) $C_v \propto \frac{1}{T}$

(D) $C_v = 3NK_\beta \left(\frac{\hbar\omega_0}{K_\beta T}\right)^2 e^{-\frac{\hbar\omega_0}{K_\beta T}}$, $\omega_0 \rightarrow$ frequency

87. The density of states D(E) in three dimension is given by

(A) $D(E) = \frac{4L}{\hbar}\left(\frac{M}{2E}\right)^{1/2}$

(B) $D(E) = \frac{L^3}{2\pi}\left(\frac{M}{\hbar^2}\right)^{3/2} E^{-1/2}$

(C) $D(E) = \frac{L^3}{2\pi^2}\left(\frac{2M}{\hbar^2}\right)^{3/2} E^{1/2}$

(D) $D(E) = \frac{L^3}{2\pi^2}\left(\frac{2M}{\hbar^2}\right)^{3/2} E^{-1}$

L^3 is volume, $E \rightarrow$ energy

88. Ratio of thermal conductivity and electrical conductivity is

(A) $\frac{3}{2}\left(\frac{K_B}{e}\right)^2$

(B) $\frac{3}{2}\left(\frac{K_B}{e}\right)^2 T$

(C) $\frac{3}{2}\left(\frac{K_B}{e}\right)^2 \frac{1}{T}$

(D) $\frac{3}{2}\left(\frac{K_B}{e}\right)^2 T^2$

where T is absolute temperature, $K_B \rightarrow$ Boltzman constant, $e \rightarrow$ charge

89. The effective mass of electron is (E being energy and $k \rightarrow$ wave vector)

(A) $\hbar^2 \left[\frac{d^2E}{dk^2}\right]^{-1}$

(B) $\frac{1}{\hbar^2}\frac{d^2E}{dk^2}$

(C) $\hbar^2 \frac{d^2E}{dk^2}$

(D) $\hbar^2 \left(\frac{d^2E}{dk^2}\right)^2$

90. Lorentz field is given by

(A) $E + \frac{P}{\varepsilon_0}$

(B) $E + \frac{3P}{\varepsilon_0}$

(C) $E + \frac{P}{3\varepsilon_0}$

(D) $E + \frac{3P}{2\varepsilon_0}$

where E is applied electric field, P – polarisation density, ε_0 – dielectric constant

91. The maximum magnetic moment in case of paramagnetic substance is

(A) μ_B Ng J (B) μ_B Ng J(J + 1)

(C) μ_B Ng J^2 (D) μ_B Ng

where μ_B Bohr magneton, J total angular momentum g is Lande factor

92. The London Penetration depth $\lambda(T)$

(A) becomes zero at transition temperature

(B) increases to very high value at transition temperature

(C) At temperature less than $T < T_c$ penetration depth decreases and increases randomly

(D) $\lambda(T) \propto T$

93. Carrier concentration of electron in intrinsic semiconductor varies as

(A) $\exp\left[\left(E_F - E_C\right) / K_{BT}\right]$ (B) $\exp\left(\left(E_F - E_V\right) / K_{BT}\right)$

(C) $\exp\left(\left(E_F + E_C\right) / K_{BT}\right)$ (D) $\exp\left(\left(E_F + E_V\right) / K_{BT}\right)$

where E_F – Fermi energy, E_C – Conduction band energy and E_V – Valence band energy

94. The mean square radius $\langle r^2 \rangle$ of nuclear charge distribution of nucleus of radius R is

(A) $\langle r^2 \rangle = \frac{2}{3}R^2$ (B) $\langle r^2 \rangle = \frac{3}{5}R^2$

(C) $\langle r^2 \rangle = \frac{5}{3}R^2$ (D) $\langle r^2 \rangle = \frac{3}{2}R^2$

95. In case of deuteron problem

(A) The necessity of tensor force was due to zero qudrupole moment.

(B) The tensor operator was not spin dependent.

(C) The tensor operator was expressed as $S_{12} = 3\left(\hat{\sigma}_1 \cdot \hat{r}\right)\left(\hat{\sigma}_2 \cdot \hat{r}\right) - \hat{\sigma}_1 \cdot \hat{\sigma}_2$

where $\hat{r} = \frac{\vec{r}}{|r|}$, $\vec{r}$ separation distance between proton and neutron.

σ_1, σ_2 are related to spins of particle 1 and 2

(D) Average value of S_{12} overall direction is non zero.

96. Choose the wrong statement

(A) Positive and negative sign of scattering length indicates whether the system is a bound or unbound state

(B) For low energy the same nuclear potential can describe the singlet state scattering of both n–p and p–p systems.

(C) Heisenberg suggested that saturation of nuclear force can be explained by assuming the existence of exchange interaction between nucleon pairs.

(D) There is no isospin invariance nor spin dependence in case of nuclear force.

97. Which statement is true?

(A) $^{6}_{2}He \xrightarrow{\beta^- \text{ decay}} {}^{6}_{3}Li$ is governed by pure allowed Gamow-Teller selection rule

(B) $^{3}_{1}H \rightarrow {}^{3}_{2}He + \beta^-$ is governed by only Fermi selection rule

(C) $^{14}_{8}O \xrightarrow{\beta^+} {}^{14}_{7}N^+$ is governed by Gamow-Teller selection rule and Fermi selection rule

(D) $^{6}_{2}He \xrightarrow{\beta^-} {}^{6}_{3}Li$ decay is governed by Fermi selection rule

98. In Bethe Weizsacker formula for binding energy the coulomb repulsion energy term is given by

(A) $-\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 r_0}\frac{Z}{A^2}$ (B) $-\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 r_0}\left(Z^2 / A^{1/3}\right)$

(C) $-\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 r_0}\frac{Z^2}{A}$ (D) $-\frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 r_0}\frac{Z}{A^{1/3}}$

where $R \rightarrow$ Radius of nucleus is $r_0 A^{1/3}$, $Ze \rightarrow$ Total nuclear charge, A – Atomic number

99. Fission process based on liquid drop model has features as

(A) If coulomb energy is greater than twice of surface energy then the nucleus is stable

(B) If $2E_{S_0} = E_{C_0}$ then critical value of $\left(\frac{Z^2}{A}\right)_C \simeq 50$

(C) If $\frac{Z^2/A}{\left(Z^2/A\right)_C} < 1$ then nucleus is unstable against spontaneous fission

(D) The critical energy for fission does not depend on $\left(\frac{Z^2}{A}\right) \Big/ \left(\frac{Z^2}{A}\right)_C$

100. Pick up the correct statement :

(A) The difference between the masses of the particles of different isospin in a super multiplet owe their origin to weak interaction

(B) The weak interaction is due to exchange of photons

(C) The colour property of quarks are proposed to avoid failure of Pauli's exclusion principle

(D) In the quark model the strong interaction is due to exchange of ω bosons.

SPACE FOR ROUGH WORK

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