A1 VERSION CODE	ELIGIBILITY EXAMINATION-2025 PAPER-2 Total Number of Questions : 100 Maximum Marks : 200 Subject : PHYSICAL SCIENCES Subject Code : 25	Serial Number :
	MENTION YOUR REGISTER NUMBER	Paper Code: PSC21125A

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2. This question booklet contains **100** questions and each question will have one statement and four different options / responses & out of which you have to choose one correct answer.
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				⊗	②	③	④	①	②	③	④	①	●	●	④
①	●	③	④	●	②	③	④	①	●	③	④	①	②	③	④

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1. If a force $\vec{F}$ is derivable from a potential function V(r), where r is the distance from the origin of the co-ordinate system, then it follows

(1) $\vec{\nabla} \times \vec{F} = 0$
(2) $\vec{\nabla} \cdot \vec{F} = 0$
(3) $\vec{\nabla} V = 0$
(4) $\nabla^2 V = 0$

2. Two standard dices with six faces with values 1 to 6 are rolled together. What is the probability of getting a value 8?

(1) $\frac{1}{6}$
(2) $\frac{1}{9}$
(3) $\frac{5}{36}$
(4) $\frac{2}{9}$

3. The orthogonality condition for $H_n(x)$ is ______ [$H_n(x)$ are Hermite polynomials]

(1) $\int_{-\infty}^{\infty} e^{-x^2} H_m(x) H_n(x)\, dx = 2^n \sqrt{\pi}\, n!\, \delta_{mn}$

(2) $\int_{-\infty}^{\infty} H_m(x) H_n(x)\, dx = \delta_{mn}$

(3) $\int_{-\infty}^{\infty} H_m(x) H_n(x)\, dx = \sqrt{\pi}\, n!\, \delta_{mn}$

(4) $\int_{-\infty}^{\infty} e^{-x^2} H_m(x) H_n(x)\, dx = 2^n \delta_{mn}$

4. The eigen values of the matrix $\begin{pmatrix} 3 & 2 \\ 2 & 0 \end{pmatrix}$ are

(1) 3, 0
(2) 4, 1
(3) 4, – 1
(4) 1, 1

5. Laplace transform of (1 + sin 2t) is

(1) $\frac{1}{S} + \frac{1}{S^2+1}$
(2) $\frac{1}{S} + \frac{4}{S^2+4}$
(3) $\frac{1}{S} + \frac{2}{S^2+4}$
(4) $1 + \frac{2}{S^2+4}$

6. The value of the integral $\int_{-2}^{2} (2x+3)\, \delta(3x-5)\, dx$ is

(1) 0
(2) $\frac{19}{9}$
(3) $\frac{33}{9}$
(4) $\frac{1}{3}$

7. What is the value of $\oint_C \frac{dz}{z}$ where C is a circular path of radius 2 centred at the origin and the integration is done anticlockwise?

(1) 0

(2) πi

(3) $-2\pi i$

(4) $2\pi i$

8. A pendulum consists of a ring of mass M and radius R suspended by a massless rigid rod of length l attached to its rim. When the pendulum oscillates in the plane of the ring, the time period of oscillation is

(1) $2\pi\sqrt{\frac{l+R}{g}}$

(2) $\frac{2\pi}{\sqrt{g}}(l^2+r^2)^{\frac{1}{4}}$

(3) $2\pi\sqrt{\frac{2R^2+2Rl+l^2}{g(R+l)}}$

(4) $\frac{2\pi}{\sqrt{g}}(2R^2+2Rl+l^2)^{\frac{1}{4}}$

9. The Lagrangian of a particle moving in a plane is given (in Cartesian coordinates) as

$$L = \dot{x}\dot{y} - x^2 - y^2$$

In polar coordinates, the expression for the canonical momentum P_r (conjugate to the radial coordinate r) is

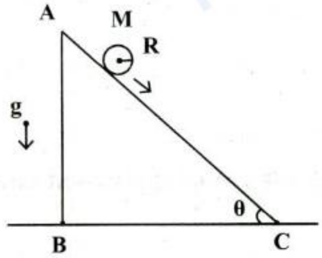
(1) $\dot{r}\sin\theta + r\dot{\theta}\cos\theta$

(2) $\dot{r}\cos\theta + r\dot{\theta}\sin\theta$

(3) $2\dot{r}\cos 2\theta - r\dot{\theta}\sin 2\theta$

(4) $\dot{r}\sin 2\theta + r\dot{\theta}\cos 2\theta$

10. A uniform circular disc of mass M and radius R is rolling down a frictionless inclined plane that makes an angle θ with the horizontal. Then the acceleration of the centre of mass of the disc along the inclined plane is



(1) $\frac{1}{3}g\sin\theta$

(2) $\frac{2}{3}g\sin\theta$

(3) $g\sin\theta$

(4) $\frac{3}{2}g\sin\theta$

11. An electron gains energy so that its relativistic mass becomes $2m_0$. Its speed is________ (where 'C' is speed of light).

(1) $\frac{\sqrt{3}}{2}C$

(2) $\frac{3}{4}C$

(3) $\frac{3}{2}C$

(4) $\sqrt{\frac{3}{2}}C$

12. A bead of mass m is constrained to move under gravity along a planar rigid wire that has a parabolic shape $y = x^2/l$, where x and y are the horizontal and vertical coordinates respectively. The Lagrangian for the system is

(1) $L = \frac{m(\ddot{x})^2}{2}\left(1+\frac{4x^2}{l^2}\right) - \frac{mg\,x^2}{l}$

(2) $L = \frac{m(\dot{x})^2}{2}\left(1+\frac{4x^2}{l^2}\right) - \frac{mg\,x^2}{l}$

(3) $L = \frac{m(\dot{x})^2}{2}\left(1+\frac{4x^2}{l^2}\right) - \frac{mg\,x}{l}$

(4) $L = \frac{m(\dot{x})^2}{2}\left(1+\frac{4x^2}{l^2}\right) - \frac{mg}{l}$

13. A planet moves in an elliptic orbit around a star, which is at one of the foci of the ellipse. Given that the ratio of the farthest distance to the closest distance from the star is 2, eccentricity of the orbit is

(1) $\frac{1}{4}$

(2) 1

(3) $\frac{1}{3}$

(4) $\frac{1}{2}$

14. A particle of mass m is moving in a potential $V(x) = K(3x-2)(4x-1)$. The period of small oscillations (T) about the point of equilibrium is

(1) $2\pi\sqrt{\frac{m}{48}}$

(2) $2\pi\sqrt{\frac{m}{24}}$

(3) $2\pi\sqrt{\frac{m}{12}}$

(4) $2\pi\sqrt{\frac{m}{6}}$

15. A particle of mass m is moving in a potential $V(x) = \frac{1}{2}m\omega^2x^2 - ax$. What are its quantised energy levels E_n?

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

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

(3) $\hbar\omega\left(n+\frac{1}{2}\right) + \frac{a^2}{2m\omega^2}$

(4) $\hbar\omega\left(n+\frac{1}{2}\right) - \frac{a^2}{4m\omega^2}$

16. The magnetic field at a point due to a long straight current carrying conductor of radius R, carrying current I, where r > R (r is the distance between the point and axis of the wire) is proportional to

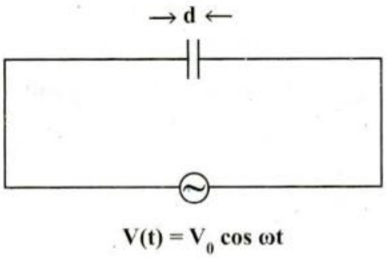
(1) r

(2) r^2

(3) $\frac{1}{r}$

(4) $\frac{1}{r^2}$

17. An oscillating voltage $V(t) = V_0 \cos \omega t$ is applied across a parallel plate capacitor having plate separation 'd'. The displacement current density through the capacitor is



(1) $\frac{-\epsilon_0 \omega V_0 \sin \omega t}{d}$

(2) $\frac{\epsilon_0 \omega V_0 \cos \omega t}{d}$

(3) $\frac{\omega \epsilon_0 \mu_0 V_0 \sin \omega t}{d}$

(4) $\frac{-\omega \epsilon_0 \mu_0 V_0 \cos \omega t}{d}$

18. If the electrostatic potential is given by $\phi = \phi_0 (x^2 + y^2 + z^2)$, where ϕ_0 is constant, then the charge density giving rise to the above potential would be

(1) $-6\,\phi_0/\epsilon_0$

(2) $-6\,\phi_0\epsilon_0$

(3) $-2\,\phi_0\epsilon_0$

(4) $-2\,\phi_0/\epsilon_0$

19. A cylindrical conductor placed in an uniform electric field E_0 with potential V at a point outside the cylinder is given by $V = -\left[1 - \frac{a^2}{r^2}\right] E_0\, r \cos\theta$, then the surface charge density (per unit area) of the conducting surface is

(1) $\epsilon_0 E_0 \cos\theta$

(2) $2\epsilon_0 E_0 \cos\theta$

(3) $3\epsilon_0 E_0 \cos\theta$

(4) $4\epsilon_0 E_0 \cos\theta$

20. Two positive point charges each of magnitude + q are fixed on y-axis at points y = + a and y = – a respectively. The potential at any point on the x-axis is $V = \frac{1}{2\pi\epsilon_0} \frac{q}{\sqrt{a^2 + x^2}}$. The values of x at which the potential is one-half of that at the origin is

(1) $\pm\sqrt{a}$

(2) $\pm\sqrt{2}\,a$

(3) $\pm\sqrt{3}\,a$

(4) $\pm 3a$

21. **If the electric and magnetic fields of a plane electromagnetic wave are proportional to $\left(\hat{i}-\hat{j}\right)$ and $\left(\hat{i}+\hat{j}\right)$ respectively, then the wave is propagating along the direction (where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x,y,z directions)**

(1) $\hat{k}+\hat{i}$ (2) $\hat{k}+\hat{j}$

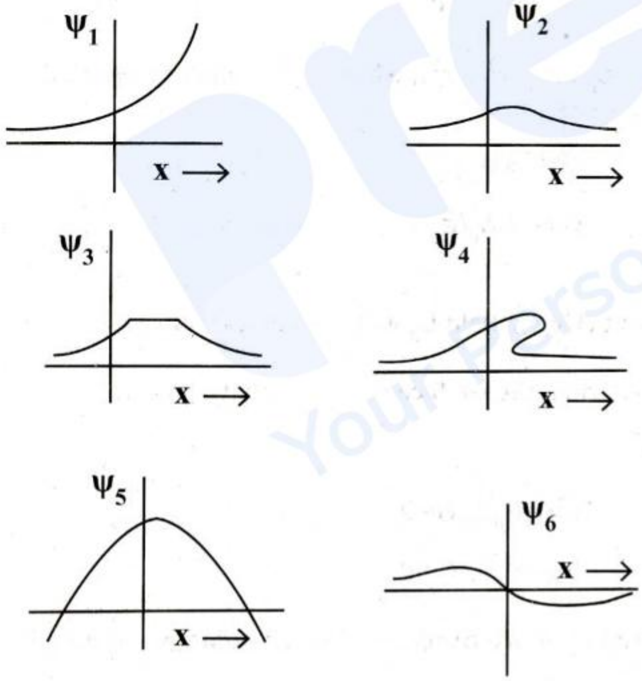
(3) $\hat{k}$ (4) $\hat{i}+\hat{j}+\hat{k}$

22. **If $\psi = a\chi_1 - b\chi_2 + (c + id)\chi_3$ is a state, where a,b,c and d are real numbers and χ_1, χ_2 and χ_3 are mutually orthonormal state functions, then the norm of ψ is**

(1) $a - b + c + id$ (2) $\sqrt{a^2 - b^2 + c^2 - d^2}$

(3) $\sqrt{a^2 + b^2 + c^2 + d^2}$ (4) $\sqrt{a^2 - b^2 + c^2 + d^2}$

23. **Given the following wave functions:**



Identify the physically acceptable wave functions for a bound state.

(1) ψ_2, ψ_3 and ψ_6 (2) ψ_1 and ψ_5

(3) ψ_2, ψ_3 and ψ_4 (4) ψ_2 and ψ_6

24. The potential energy of a simple harmonic oscillator in the x-y plane is given by $V(x, y) = \frac{1}{2} m\omega^2 (x^2 + 4y^2)$. Then the energy levels of the oscillator are given by the expression ______ (n_1 and n_2 are integers).

(1) $E(n_1, n_2) = \hbar\omega\left(n_1 + \frac{1}{2}\right) + \hbar\omega\left(n_2 + \frac{1}{2}\right)$
(2) $E(n_1, n_2) = \hbar\omega\left(n_1 + \frac{1}{2}\right) + 2\hbar\omega\left(n_2 + \frac{1}{2}\right)$
(3) $E(n_1, n_2) = \hbar\omega\left(n_1 + \frac{1}{2}\right) + \sqrt{2}\hbar\omega\left(n_2 + \frac{1}{2}\right)$
(4) $E(n_1, n_2) = \hbar\omega\left(n_1 + \frac{1}{2}\right) + 4\hbar\omega\left(n_2 + \frac{1}{2}\right)$

25. A particle of mass m is moving in a potential: $V(x) = \begin{cases} 0, & 0 < x < a \\ \infty, & \text{otherwise} \end{cases}$

Evaluate the expectation value of its energy when it is in the state $\psi(x) = N \sin^3\left(\frac{\pi x}{a}\right)$.

(1) $\frac{10\pi^2\hbar^2}{ma^2}$
(2) $\frac{9\pi^2\hbar^2}{2ma^2}$
(3) $\frac{9\pi^2\hbar^2}{10ma^2}$
(4) $\frac{18\pi^2\hbar^2}{10ma^2}$

26. If x and p are the position and momentum operators of a particle, then the commutator $[x^2, p^2]$ will be

(1) $i\hbar(xp + px)$
(2) $2i\hbar(xp + px)$
(3) $4i\hbar\, xp$
(4) $4i\hbar\, px$

27. Let $\psi_{n,l,m}\left(\vec{r}\right)$ denote the eigenfunctions of a Hamiltonian for a spherically-symmetric potential $V\left(|\vec{r}|\right)$, then $\psi_{nlm}\left(\vec{r}\right) = \frac{1}{4}\left[\psi_{2,1,0} + \sqrt{3}\psi_{2,1,-1} + \sqrt{12}\psi_{2,1,1}\right]$ is a state which is an eigenfunction of the operators ______

(1) H and L_z
(2) H and L^2
(3) L^2 and L_z
(4) H, L^2 and L_z

28. The Hamiltonian of a two-state system is given by $H = \begin{pmatrix} E & 0 \\ 0 & 2E \end{pmatrix}$. When it is subjected to a time independent perturbative Hamiltonian: $H' = \begin{pmatrix} 0 & \epsilon \\ \epsilon & 0 \end{pmatrix}$, when ϵ is small compared to E, then the lowest order corrections to the energies of the two states are given by

(1) (ϵ, ϵ)
(2) $\left(\frac{\epsilon^2}{E}, \frac{\epsilon^2}{E}\right)$
(3) $\left(-\frac{\epsilon^2}{E}, \frac{\epsilon^2}{E}\right)$
(4) $\left(-\frac{\epsilon^2}{E}, -\frac{\epsilon^2}{2E}\right)$

29. A sealed and thermally-insulated box of total volume 2V is divided into two equal divisions by an impermeable wall. The left half of the box is occupied by n moles of gas at temperature T. Identify the change in entropy, when the wall is suddenly removed and the gas expands to fill the entire volume of the box.

(1) $-nR\ln 2$
(2) $-2nR\ln 2$
(3) $+nR\ln 2$
(4) $+2nR\ln 2$

30. A one dimensional box of length L is occupied by 11 non-interacting spin $\frac{1}{2}$ Fermions. If the lowest one-particle energy is 0.5 eV, then the minimum energy of the system (in eV) is equal to

(1) 55
(2) 110
(3) 750
(4) 73

31. The dimension of phase-space of ten rigid diatomic molecules is

(1) 50
(2) 100
(3) 150
(4) 200

32. The pressure P of a gas of ultrarelativistic electrons with internal energy U and temperature T is

(1) $\frac{3U}{2V}$
(2) $\frac{2U}{3V}$
(3) $\frac{U}{3V}$
(4) $\frac{V}{3U}$

33. An ideal gas of Fermions is at zero Kelvin temperature. If the mass of the particles and their number density are both reduced by a factor of 2, then the corresponding Fermi energy is multiplied by a factor ________

(1) $2^{1/3}$
(2) $2^{1/2}$
(3) $2^{2/3}$
(4) $2^{3/2}$

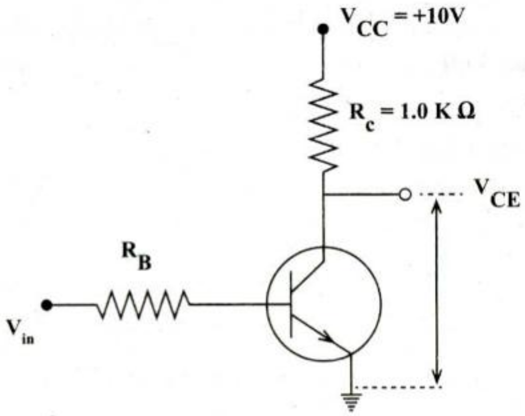
34. The number of ways in which n identical bosons can be distributed in two energy levels is

(1) n
(2) $n+1$
(3) $\frac{n(n-1)}{2}$
(4) $\frac{n(n+1)}{2}$

35. If the peak radiation of the Sun occurs at 800 nm and assuming the Sun to be a black body at 6000 K temperature, then what would be the wavelength at which there is peak radiation if we assume its temperature to be 300 K?

(1) 4 microns
(2) 8 microns
(3) 16 microns
(4) 32 microns

36. For a transistor circuit



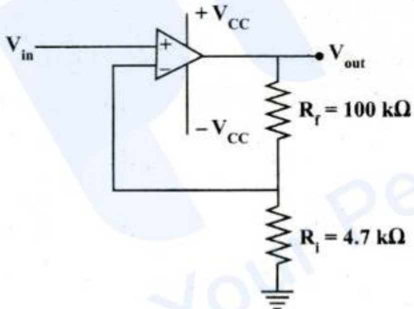
Find out V_{CE} when $V_{in} = 0V$.

(1) 10V
(2) 0V
(3) 5V
(4) 2.5V

37. A certain D-MOSFET is biased at $V_{GS} = 0V$. Its data sheet specifies $I_{DSS} = 20$ mA and $V_{GS(OFF)} = -5V$. The value of the drain current is

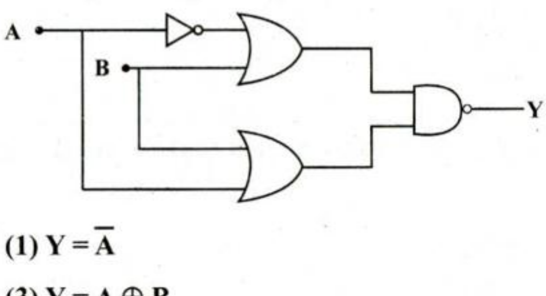
(1) 40 mA
(2) 10 mA
(3) 20 mA
(4) 30 mA

38. The gain of the amplifier shown in the figure is
(The open loop voltage gain of the op-Amp is 1,00,000)



(1) 20.3
(2) 24.3
(3) 22.3
(4) 28.3

39. In the given digital logic circuit, A and B form the input. The output Y is



(1) $Y = \overline{A}$
(2) $Y = A\overline{B}$
(3) $Y = A \oplus B$
(4) $Y = \overline{B}$

40. Match the items in List-1 with List-2

	List-1		List-2
a.	Transistor	(i)	Photovoltaic cell
b.	FET	(ii)	Ideal VCVS
c.	LED	(iii)	Current operating device
d.	op-Amp	(iv)	Voltage sensitive device
e.	Solar cell	(v)	Forward biased diode

Codes:

(1) a-(i), b-(ii), c-(iii), d-(iv), e-(v)
(2) a-(iii), b-(iv), c-(v), d-(ii), e-(i)
(3) a-(iii), b-(iv), c-(ii), d-(v), e-(i)
(4) a-(iii), b-(v), c-(iv), d-(ii), e-(i)

41. What is the largest decimal number that can be stored (in binary form) in a 74LS91 register?

(1) 155
(2) 255
(3) 355
(4) 455

42. If the resistance of certain conductor is measured with 1% error, its length is measured with 2% error and area of cross-section of the conductor measured with 3% error, then what is the error in resistivity? (The errors in measuring these quantities are independent and random)

(1) 14%
(2) 3.74%
(3) 2.45%
(4) 6%

43. The set $G = \{1, i, -i, -1\}$, where $i = \sqrt{-1}$

(1) forms an abelian group under multiplication
(2) forms a non-abelian group under multiplication
(3) has no inverse
(4) has no identity

44. Using Simpson's $\frac{1}{3}^{rd}$ rule, the value of $\int_1^5 f(x)\,dx$ for the following data is

x	1	2	3	4	5
f(x)	2	4	6	8	10

(1) 36
(2) 12
(3) 24
(4) 6

45. If L is a differential operator and $G(x, \xi)$ is a Green's function such that $LG(x, \xi) = \delta(x - \xi)$ and $\psi(x) = \int G(x, \xi) f(\xi)\, d\xi$, then $L\psi(x)$ is

(1) $f(x)$
(2) 0
(3) $f(x - \xi)$
(4) $\delta(x)$

46. The general second order partial differential equation is given by

$A(x, y)\, U_{xx} + B(x, y)\, U_{xy} + C(x, y)\, U_{yy} + D(x, y)\, U_x + E(x, y)\, U_y + F(x, y)\, U = G(x, y).$

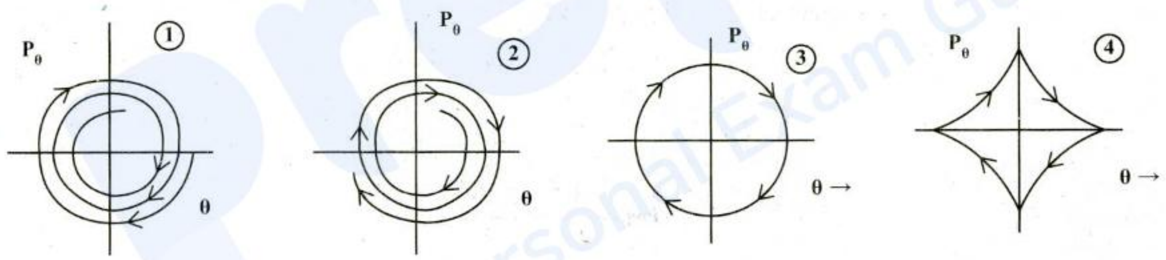
The above equation is said to be hyperbolic at point (x_0, y_0) depending upon the condition

(1) $B^2 - 4AC > 0$
(2) $B^2 - 4AC = 0$
(3) $B^2 - 4AC < 0$
(4) $4AC = 0$

47. If X_n is the n^{th} approximation to the root of $f(x) = 0$, then according to Newton-Raphson method, the $(n + 1)^{th}$ approximation to the root is given by

(1) $X_{n+1} = X_n + \frac{f(X_n)}{2f'(X_n)}$
(2) $X_{n+1} = X_n - \frac{f'(X_n)}{f(X_n)}$
(3) $X_{n+1} = X_n + \frac{f(X_n)}{f'(X_n)}$
(4) $X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)}$

48. The phase space diagram for small oscillations of a simple pendulum in air is represented by which of the following?



(1) 1
(2) 2
(3) 3
(4) 4

49. For the Hamiltonian $H = \frac{1}{2m} p^2 + \frac{1}{2} m\omega^2 q^2$, apply a canonical transformation using the generating function:

$F(q, Q) = qQ - \frac{1}{2} m\omega q^2 - \frac{Q^2}{4m\omega}.$

Express the Hamiltonian in terms of the new coordinates Q and P.

(1) $H = \frac{1}{2m} P^2 + \frac{1}{2} m\omega^2 Q^2$
(2) $H = \frac{1}{2m}\left(\frac{Q + 2m\omega P}{2}\right)^2 + \frac{1}{2} m\omega^2 \left(\frac{Q}{2m\omega} - P\right)^2$
(3) $H = \frac{1}{2m}\left(P - \frac{Q}{2m\omega}\right)^2 + \frac{1}{2} m\omega^2 (Q + m\omega P)^2$
(4) $H = \frac{1}{2m}(P + m\omega Q)^2 + \frac{1}{2} m\omega^2 \left(Q - \frac{P}{m\omega}\right)^2$

50. According to Noether's theorem, the conserved generalised momentum for the system with Lagrangian: $L(x,y;\dot{x},\dot{y}) = \frac{1}{2}m(\dot{x}^2+\dot{y}^2) - V\left(\sqrt{x^2+y^2}\right)$ is given by

(1) $-m(x\dot{y}+y\dot{x})$ (2) $-m(x\dot{y}-y\dot{x})$

(3) $m(\dot{x}^2+\dot{y}^2)$ (4) $m(\dot{x}^2-\dot{y}^2)$

51. If $\{A, B\}$ denotes the Poisson bracket between the variables A and B, then $\{A, \{B, C\}\} - \{\{A, B\}, C\}$ is equal to

(1) $\{\{C, A\}, B\}$ (2) $\{B, \{A, C\}\}$

(3) $\{AB, C\}$ (4) $\{A, BC\}$

52. The Hamilton-Jacobi equation for a projectile motion in the X–Z plane is given by

(1) $\frac{1}{2m}\left(\frac{\partial S}{\partial x}\right)^2 + \frac{1}{2m}\left(\frac{\partial S}{\partial z}\right)^2 - mg\,z = E$ (2) $\frac{1}{2m}\left(\frac{\partial S}{\partial x}\right)^2 + \frac{1}{2m}\left(\frac{\partial S}{\partial z}\right)^2 + mg\,z = E$

(3) $\frac{1}{2m}\left(\frac{\partial S}{\partial x}\right)^2 - \frac{1}{2m}\left(\frac{\partial S}{\partial z}\right)^2 - mg\,z = E$ (4) $-\frac{1}{2m}\left(\frac{\partial S}{\partial x}\right)^2 - \frac{1}{2m}\left(\frac{\partial S}{\partial z}\right)^2 + mg\,z = E$

53. The energy density in an electromagnetic field is given by

(1) $\frac{\epsilon_0 E^2}{2} + \frac{\mu_0}{2}B^2$ (2) $\frac{\epsilon_0 E^2}{2} + \frac{B^2}{2\mu_0}$

(3) $\frac{E^2}{2\epsilon_0} + \frac{B^2}{2\mu_0}$ (4) $\frac{\epsilon_0 E^2}{4} + \frac{\mu_0 B^2}{4}$

54. A plane wave travelling in the z-direction encounters a perfect conductor occupying region $z \geq 0$ and reflects back. Given $\vec{E}(z,t) = E_0[\cos(kz-\omega t) - \cos(kz+\omega t)]\,\hat{x}\,(z<0)$. Find the accompanying magnetic field in the region $z < 0$.

(1) $\vec{B}(z,t) = \frac{E_0}{c}[\cos(kz-\omega t) - \cos(kz+\omega t)]\,\hat{y}$

(2) $\vec{B}(z,t) = \frac{E_0}{c}[\cos(kz-\omega t) + \cos(kz+\omega t)]\,\hat{y}$

(3) $\vec{B}(z,t) = \frac{E_0}{c}[\cos(kz-\omega t) - \cos(kz-\omega t)]\,\hat{y}$

(4) $\vec{B}(z,t) = \frac{E_0}{c}[\cos(kz-\omega t) + \cos(kz-\omega t)]\,\hat{y}$

55. Consider a rectangular wave guide with dimensions (a = 2cm) × (b = 1cm). What is the propagation frequency of TE_{11} mode?

(1) 1.49×10^{10} Hz
(2) 1.97×10^{10} Hz
(3) 0.66×10^{10} Hz
(4) 1.68×10^{10} Hz

56. The power radiated by a dipole p oscillating with frequency ω is proportional to (p = dipole moment)

(1) $p^4\omega^2$
(2) $p^2\omega^2$
(3) $p^2\omega^4$
(4) $p^4\omega^4$

57. If the scattering amplitude is given by $f(\theta, \phi) = A + B\cos\theta$, then the total cross-section of scattering will be (assuming A and B to be real)

(1) $4\pi(A^2 + B^2)$
(2) $4\pi\left(A^2 + \frac{B^2}{2}\right)$
(3) $4\pi\left(A^2 + \frac{B^2}{3}\right)$
(4) $4\pi\left(A^2 + \frac{B^2}{6}\right)$

58. According to the semiclassical theory of radiation, the probability of spontaneous emission due to transition between the energy levels E_n and E_m is proportional to

(1) $(E_n - E_m)$
(2) $(E_n - E_m)^2$
(3) $(E_n - E_m)^3$
(4) $(E_n - E_m)^4$

59. The scattering amplitude for low energy particles in the Born approximation due to a soft sphere of radius *a* having a potential V_0 is proportional to

(1) $mV_0 a^3$
(2) $mV_0^2 a^3$
(3) $mV_0 a^2$
(4) $mV_0^3 a^3$

60. Complete the expression $2\sigma_x\sigma_y + \sigma_y\sigma_x$ = _______, where σ_x, σ_y and σ_z are Pauli spin matrices.

(1) $-3i\,\sigma_z$
(2) $-i\,\sigma_z$
(3) $i\,\sigma_z$
(4) $3i\,\sigma_z$

61. For the Dirac Hamiltonian $\hat{H} = c\,\vec{\alpha}\cdot\hat{\vec{p}} + \beta mc^2$, where $\hat{\vec{p}}$ is linear momentum of the relativistic free particle and $\vec{\alpha}$, β are Dirac matrices, which of the following is true?

(1) $[\hat{H}, \hat{\vec{p}}]$ = '0'
(2) $[\hat{H}, \vec{\alpha}]$ = '0'
(3) $[\hat{H}, \hat{\vec{r}} \times \hat{\vec{p}}]$ = '0'
(4) $[\hat{H}, \beta]$ = '0'

62. A certain system has 3 phases and 4 components. Then according Gibb's phase rule, the number of degrees of freedom that the system may have is

(1) 3
(2) 2
(3) 4
(4) 5

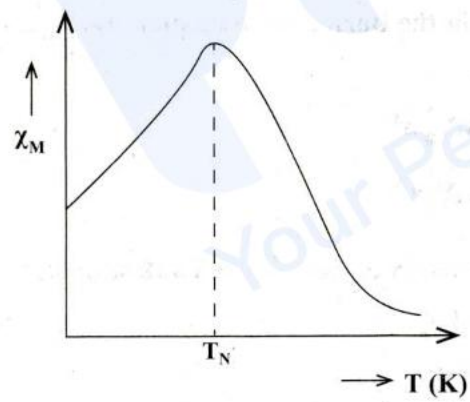
63. Consider a statistical system consisting of 2 interacting spins taking values $S_1 = \pm 1$, $S_2 = \pm 1$. If interaction energy $E_{S_1S_2} = -JS_1S_2$ at the equilibrium temperature T, then the mean energy of the system in the high temperature limit approaches the value ________

(1) $-\frac{2J^2}{kT}$
(2) $-2J^2 kT$
(3) $-\frac{J^2}{kT}$
(4) $-J^2 KT$

64. A random walker takes a step of unit length + 1 to his right with probability $\frac{1}{4}$ and a step covering a distance – 1 to unit to his left with probability $\frac{3}{4}$. The mean distance after 10 steps is given by

(1) – 6 units
(2) – 5 units
(3) – 4 units
(4) + 5 units

65. The variation of magnetic susceptibility (χ_M) as a function of temperature T is shown below:



The material is most likely:

(1) Diamagnetic
(2) Paramagnetic
(3) Antiferromagnetic
(4) Ferromagnetic

66. Consider a set of discrete data 1, 3, 3, 5, 8. By adding a constant 3 to each of the data, which of the following does not change?

(1) Mean (2) Median

(3) Mode (4) Standard deviation

67. If the correlation coefficient between two variables is – 0.8, then what does this indicate about their relationship?

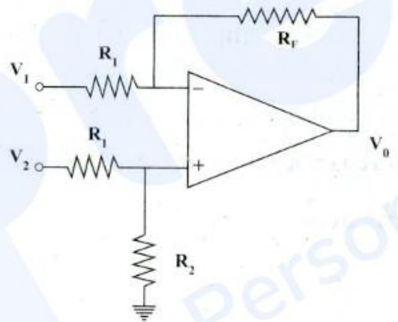
(1) A strong positive linear relationship

(2) A strong negative linear relationship

(3) A weak positive relationship

(4) No linear relationship

68. In the following circuit, for the output voltage to be $V_0 = \left(-V_1 + \frac{V_2}{2}\right)$; the ratio of $\frac{R_F}{R_1}$ and $\frac{R_2}{R_1}$ is



(1) 1; 1/2 (2) 2; 1/2

(3) 1; 3 (4) 1; 1/3

69. In a Hall effect sensor, the induced voltage is directly proportional to

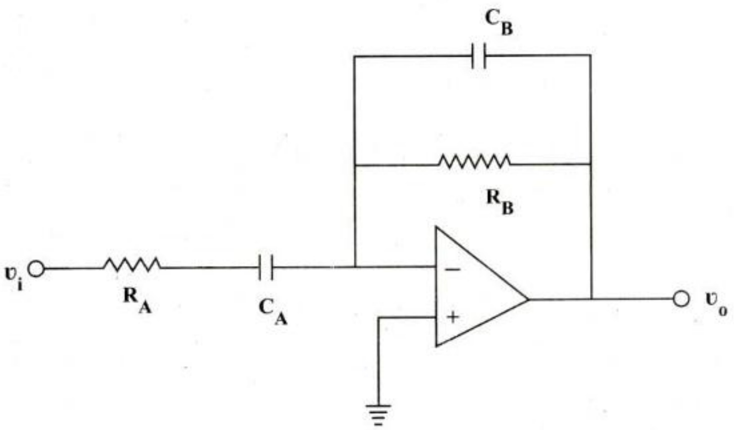
(1) The magnetic field strength

(2) Charge carrier density

(3) The temperature of the sensor

(4) The thickness of the sensor

70. **What does the following op-amp circuit represent?**



(1) Band-pass filter
(2) Low-pass filter
(3) High-pass filter
(4) Band-reject filter

71. **The rotational constant for $H^{35}Cl$ is observed to be 10.5909 cm^{-1}. Similarly the rotational constants are obtained for $H^{37}Cl$ and $^{2}D^{35}Cl$. How the three rotational constants are related?**

(1) $H^{35}Cl < H^{37}Cl < {}^{2}D^{35}Cl$
(2) $H^{37}Cl < H^{35}Cl < {}^{2}D^{35}Cl$
(3) $H^{37}Cl > H^{35}Cl > {}^{2}D^{35}Cl$
(4) $H^{35}Cl > H^{37}Cl > {}^{2}D^{35}Cl$

72. **The infrared spectrum of HCl shows a intense absorption at 2886 cm^{-1} and weaker one at 5668 cm^{-1}. What is equilibrium oscillation frequency of HCl?**

(1) 498.35 cm^{-1}
(2) 1993.4 cm^{-1}
(3) 2990.1 cm^{-1}
(4) 1495.05 cm^{-1}

73. **The force constant of HCl molecule is 480 N/m. Find the energy required to increase the nuclear separation by 1Å**

(1) 15 eV
(2) 3 eV
(3) 30 eV
(4) 6 eV

74. **What is the ratio of the intensities of the D_1 and D_2 lines of sodium at high temperatures?**

(1) 1:1
(2) 1:2
(3) 1:3
(4) 2:3

75. Write the values of quantum numbers l, s and j corresponding to $^2P_{\frac{3}{2}}$

(1) $1, \frac{1}{2}, \frac{3}{2}$ (2) $0, \frac{1}{2}, \frac{3}{2}$

(3) $2, \frac{1}{2}, \frac{3}{2}$ (4) $1, \frac{1}{2}, \frac{1}{2}$

76. A spectroscopic transition involves an energy change of 3×10^{-21} J/molecule. If there are 3000 molecules in the ground state, then what is the equilibrium population of the state when the temperature is 300K?

(1) 600 (2) 955

(3) 727 (4) 1454

77. In case of stark effect on n = 2 level of hydrogen atom, four-fold degeneracy is shifted due to the mixing of which of the following states?

(1) $|\,2\ 0\ 0\rangle$ and $|\,2\ 1\ {-1}\rangle$

(2) $|\,2\ 0\ 0\rangle$ and $|\,2\ 1\ 0\rangle$

(3) $|\,2\ 1\ 1\rangle$ and $|\,2\ 1\ {-1}\rangle$

(4) $|\,2\ 1\ 0\rangle$ and $|\,2\ 1\ {-1}\rangle$

78. An unpaired electron interacts with three equivalent protons. Four lines are observed in ESR spectrum. What is the intensity ratio of the four lines?

(1) 1 : 4 : 4 : 1 (2) 1 : 2 : 2 : 1

(3) 1 : 3 : 3 : 1 (4) 2 : 1 : 1 : 2

79. In a normal Zeeman effect observed due to transition from $^1P \rightarrow {}^1S$, the central line in the triplet is

(1) Right circularly polarized

(2) Left circularly polarized

(3) Elliptically polarized

(4) Linearly polarized

80. For an applied field of 1.5 T, calculate the difference in NMR absorption frequencies for two protons whose δ values differ by 1.5 ppm. (δ-chemical shift)

(1) 9.58 MHz (2) 95.8 MHz

(3) 95.8 Hz (4) 9.58 Hz

81. Consider the crystal structure of KBr, which is modeled as a set of touching spheres. Each potassium atom has radius r_1 and each bromine atom has a radius r_2. The centres of the spheres form a simple cubic lattice. The packing fraction of this system is

(1) $\pi\left[\left(\frac{r_1}{r_1+r_2}\right)^3+\left(\frac{r_2}{r_1+r_2}\right)^3\right]$

(2) $\frac{2\pi}{3}\frac{r_1^3+r_2^3}{(r_1+r_2)^3}$

(3) $\frac{r_1^3+r_2^3}{(r_1+r_2)^3}$

(4) $\pi\frac{r_1^3+r_2^3}{2(r_1+r_2)^3}$

82. In a periodic potential, the effective mass of an electron is related to

(1) Number of free electron

(2) Band curvature in the E-K diagram

(3) Atomic number

(4) Crystal lattice spacing

83. If the conductivity $\sigma = 5.8 \times 10^7$ S/m, $n = 8.5 \times 10^{28}$ m^{-3} and $e = 1.6 \times 10^{-19}$ c, then the relaxation time τ is

(1) 3.43×10^{-14} S

(2) 1.43×10^{-15} S

(3) 2.43×10^{-14} S

(4) 5.43×10^{-14} S

84. The AC Josephson effect is characterised by

(1) Constant current

(2) Voltage independent tunnelling

(3) Oscillating current under DC voltage

(4) Zero resistance

85. A single crystal does not have a 5-fold symmetry because

(1) it is energetically unfavourable

(2) it violates translational symmetry of the crystal

(3) it violates orientational symmetry of the crystal

(4) None of the above

86. The energy of two particles in the field of each other is given by $u(r) = -\frac{\alpha}{r} + \frac{\beta}{r^8}$, where α and β are constants and r is the distance between the centres of the particles. The separation (r_0) between two particles at equilibrium is

(1) $r_0 = \left(\frac{8\beta}{\alpha}\right)^{\frac{1}{7}}$

(2) $r_0 = \left(\frac{8\alpha}{\beta}\right)^{\frac{1}{7}}$

(3) $r_0 = \left(\frac{\beta}{8\alpha}\right)^{\frac{1}{7}}$

(4) $r_0 = \left(\frac{\alpha}{8\beta}\right)^{\frac{1}{7}}$

87. The defect that does not disturb electrical conductivity of an ionic crystal is

(1) Schottky defect

(2) Frenkel defect

(3) Interstitial defect

(4) Metal excess defect

88. During transition in an indirect band gap semiconductor,

(1) Optical absorption is stronger

(2) Electron hole recombination is more efficient

(3) Energy gap is zero

(4) Momentum conservation requires phonon participation

89. Kevlar is an example of __________

(1) Lyotropic liquid crystal

(2) Nematic liquid crystal

(3) Thermotropic liquid crystal

(4) Smectic liquid crystal

90. A Hall voltage of 5mv is observed across a 1cm thick sample with I = 3A and magnetic field 1T. The carrier concentration is

(1) $1.375 \times 10^{24}/m^3$

(2) $5 \times 10^{24}/m^3$

(3) $0.375 \times 10^{24}/m^3$

(4) $2.375 \times 10^{24}/m^3$

91. An experiment is performed to search for evidence of the reaction $p + p \rightarrow H + K^+ + K^+$. The values of electric charge, strangeness and Baryon number of the particle H are _______ respectively.

(1) 0, 2, – 2

(2) 0, – 2, 2

(3) 2, 2, 2

(4) 0, 2, 2

92. When beam of μ^- is passed through matter, some of them are captured in electron-like orbits round the nuclei of the capturing atoms forming a muonic atom. The radii of the muonic orbits being smaller by the factor

(1) $\frac{m_e}{m_\mu}$
(2) $\frac{m_\mu}{m_e}$
(3) $m_\mu m_e$
(4) $\frac{m_\mu + m_e}{m_\mu}$

93. A beam of α-particles of kinetic energy 5MeV passes through a thin foil of ^{9}Be. The number of alpha particles scattered between 50° and 70° and between 70° and 110° is measured. What would be the ratio of these numbers?

(1) 0.1
(2) 1
(3) 2
(4) 4

94. Bremsstrahlung radiation is produced when

(1) Energetic electrons move with uniform speed
(2) Energetic neutrons travel past the nucleus
(3) Energetic protons are accelerated by the nucleus
(4) Energetic electrons travel through electric field of a nucleus

95. What is the ratio of De-Broglie wavelength of a proton and that of a alpha particle if both have same kinetic energy?

[use: mass of proton = 1u
mass of alpha = 4u]

(1) 1
(2) 0.05
(3) $\sqrt{2}$
(4) 2

96. Out of the following, which one of the rays can pass through a concrete slab of 20 cm thickness?

(1) α-rays
(2) β-rays
(3) γ-rays
(4) UV-rays

97. Which quantum number combination for two nucleons leads to maximum attraction in the nuclear potential?

(1) S = 0, T = 1, L = 0
(2) S = 1, T = 0, L = 0
(3) S = 1, T = 1, L = 1
(4) S = 0, T = 0, L = 1

98. The theoretical condition for symmetric spontaneous fission on the basis of liquid drop model is [Given surface energy constant a_S = 0.019114 u, Coulomb energy constant a_C = 0.0007626 u]

(1) $\frac{Z^2}{A} > 17.6$
(2) $\frac{Z^2}{A} < 17.6$
(3) $\frac{Z^2}{A} = 17.6$
(4) $\frac{A}{Z^2} > 17.6$

99. Which of the following nuclear reactions is a stripping reaction?

(1) (t, p) **(2) (p, α)**

(3) (d, t) **(4) (p, t)**

100. The ground state spin and parity of C^{13} as predicted by shell model, considering spin-orbit interaction into account is

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

(3) $\frac{1^-}{2}$ (4) $\frac{3^+}{2}$

SPACE FOR ROUGH WORK

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