A1

VERSION CODE

ELIGIBILITY/COMPETITIVE EXAM 2024

PAPER-2

Total Number of Questions: 100

Maximum Marks : 200

Serial Number :

MENTION YOUR REGISTER NUMBER

Subject: PHYSICAL SCIENCE

INSTRUCTIONS FOR CANDIDATES

DOs:

1. This question booklet is issued to you at **9.55 a.m.** by the room invigilator.
2. Check whether the Register Number has been entered and shaded in the respective circles on the OMR answer sheet.
3. The Version Code of this question booklet should be entered on the OMR answer sheet and the respective circles should also be shaded completely.
4. The Version Code and Serial Number of this question booklet should also be entered on the Nominal Roll without any mistakes.
5. Compulsorily sign at the bottom portion of the OMR answer sheet in the space provided.

DONTs:

- **THE TIMING AND MARKS PRINTED ON THE OMR ANSWER SHEET SHOULD NOT BE DAMAGED / MUTILATED / SPOILED.**

IMPORTANT INSTRUCTIONS TO CANDIDATES

1. In case of usage of signs and symbols in the questions, the regular textbook connotation should be considered unless stated otherwise.
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.
3. At **10.00 a.m.** remove the paper seal of this question booklet and check that this booklet does not have any unprinted or torn or missing pages or items etc., if so, get it replaced by a complete test booklet within **5** minutes of the commencement of exam. Read each item and start answering on the OMR answer sheet.
4. Completely **darken / shade** the relevant circle with a **blue or black ink ballpoint pen against the question number on the OMR answer sheet.**

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①	●	③	④	⊗	②	③	④	①	②	③	④	①	●	●	④
				●	②	③	④	①	●	③	④	①	②	③	④

5. Please note that even a minute unintended ink dot on the OMR answer sheet will also be recognized and recorded by the scanner. Therefore, avoid multiple markings of any kind on the OMR answer sheet.
6. Use the space provided on each page of the question booklet for Rough Work. Do not use the OMR answer sheet for the same.
7. **Once the last Bell rings at 1.00 P.M.,** stop writing on the OMR answer sheet and hand over the **OMR answer sheet** to the room invigilator as it is.
8. After separating the top sheet (Office copy), the invigilator will return the bottom sheet replica (Candidate's copy) to you.
9. All questions carry equal marks.
10. Use of Mobile Phones, Calculators and other Electronic / Communication gadgets of any kind is prohibited inside the Examination venue.

1. The greatest rate of increase of $\phi = xyz^2$ at the point (0, 1, 2) is

(1) 0 (2) 1

(3) 2 (4) 4

2. The value of the integral $\frac{1}{2\pi i}\oint_C z^{m-n-1}dz$ where m,n are integers and C is a circle centered at the origin is given by

(1) zero (2) m – n

(3) zero if $m \neq n$ and 1 if m = n (4) 1

3. A real orthogonal 2 × 2 matrix is given by $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$. Which of the following gives A^{-1}?

(1) $\begin{pmatrix} b & a \\ d & c \end{pmatrix}$ (2) $\begin{pmatrix} a & c \\ b & d \end{pmatrix}$

(3) $\begin{pmatrix} d & b \\ c & a \end{pmatrix}$ (4) $\begin{pmatrix} c & b \\ a & d \end{pmatrix}$

4. What is the sum of residues of the function $f(z) = \frac{e^z}{z^2 + a^2}$ at all its poles?

(1) $\frac{\sin a}{a}$ (2) $\frac{-\sin a}{a}$

(3) $\frac{\cos a}{a}$ (4) $\frac{-\cos a}{a}$

5. The value of the Contour integral $\left|\oint_c \vec{r} \times d\vec{r}\right|$ for a circle c of unit radius with centre at the origin is

(1) π/4 (2) π/2

(3) 2π (4) π

6. Let $p_n(x)$, n = 0, 1, 2..... denote a polynomial of degree n with real coefficients for 2 ≤, ≤ 4. Given that $\int_2^4 p_n(x)p_m(x)dx = \delta_{mn}$, we obtain

(1) $p_0(x) = \frac{1}{\sqrt{2}}$ and $p_1(x) = \sqrt{\frac{3}{2}}(-3-x)$ (2) $p_0(x) = \frac{1}{2}$ and $p_1(x) = \sqrt{\frac{3}{2}}(3+x)$

(3) $p_0(x) = \frac{1}{\sqrt{2}}$ and $p_1(x) = \sqrt{\frac{3}{2}}(3-x)$ (4) $p_0(x) = \frac{1}{\sqrt{2}}$ and $p_1(x) = \sqrt{3}(3+x)$

SPACE FOR ROUGH WORK

7. Let S denote a closed surface enclosing a sphere of radius a = 2 units, and let $\hat{n}$ be the unit normal vector to the surface of the sphere at every point. The value of the integral $\oiint_S \vec{a}.\hat{n}\,ds$ is

(1) $\frac{4}{3}\pi$ (2) 32π

(3) zero (4) 8π

8. A particle is moving in a central force field given by $\vec{F} = \frac{-k}{r^3}\hat{r}$, where $\hat{r}$ is the unit vector away from the centre of field. The potential energy of the particle is given by

(1) k/r^2 (2) $k/2r^2$

(3) $-k/r^2$ (4) $-k/2r^2$

9. The Lagrangian of a system is given by

$L = \frac{1}{2}\dot{q}^2 + q\dot{q} - \frac{1}{2}q^2$; it describes the motion of a

(1) Harmonic oscillator

(2) Damped harmonic oscillator

(3) Anharmonic oscillator

(4) System with unbounded motion

10. The Lagrangian of particle moving in a plane under the influence of a central potential is given by $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - V(r)$. The generalized momenta corresponding to r and θ are given by

(1) $m\dot{r}$ and $mr^2\dot{\theta}$ (2) $m\dot{r}$ and $mr\dot{\theta}$

(3) $m\dot{r}^2$ and $mr^2\dot{\theta}$ (4) $m\dot{r}^2$ and $mr^2\dot{\theta}^2$

11. A heavy symmetry top is rotating about its own axis of symmetry (3 – axis). If I_1, I_2 and I_3 are the principal moment of inertia along x, y, z axis, respectively, then

(1) $I_2 = I_3$, $I_1 \neq I_2$ (2) $I_1 = I_3$, $I_1 \neq I_2$

(3) $I_1 = I_2$, $I_1 \neq I_3$ (4) $I_1 \neq I_2 \neq I_3$

SPACE FOR ROUGH WORK

12. A particle is moving in an inverse square law force. If the total energy of the particle is positive, then the trajectory of the particle is

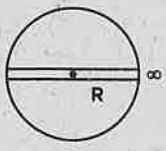
(1) Circular

(2) Elliptical

(3) Parabolic

(4) Hyperbolic

13. If a ball is dropped at one end of a tunnel drilled through the center of the earth, then the ball



(1) Comes out of the opposite end of the tunnel

(2) Stops at the center

(3) Executes oscillations about the center

(4) Bounces back to the staring point

14. The Hamiltonian corresponding to the Lagrangian $L = a\dot{x}^2 + b\dot{y}^2 - kxy$ is

(1) $\frac{px^2}{2a} + \frac{py^2}{2b} + kxy$

(2) $\frac{px^2}{4a} + \frac{py^2}{4b} - kxy$

(3) $\frac{px^2}{4a} + \frac{py^2}{4b} + kxy$

(4) $\frac{px^2 + py^2}{2a} + kxy$

15. A spherical conductor of radius 'a' carries a charge Q and is enclosed in linear dielectric material of susceptibility χ_e out to radius '*b*'. The energy of this configuration is

(1) $\frac{Q^2}{8\pi \in_0 (1+\chi_e)}\left(\frac{\chi_e}{a} + \frac{1}{b}\right)$

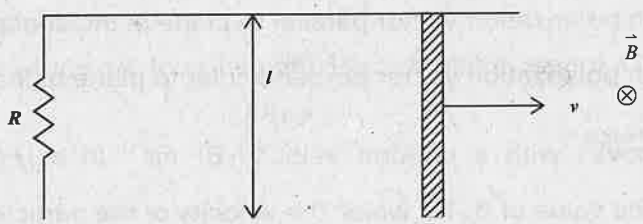
(2) $\frac{Q^2}{8\pi \in_0 \chi_e}\left(\frac{1}{a} + \frac{1}{b}\right)$

(3) $\frac{Q^2}{8\pi \in_0 (1+\chi_e)}\left(\frac{1}{a} + \frac{1}{b}\right)$

(4) $\frac{Q^2}{8\pi \in_0 (1+\chi_e)}\left(\frac{1}{a} + \frac{\chi_e}{b}\right)$

SPACE FOR ROUGH WORK

16. A metal bar of mass m slides without friction on two parallel conducting rails that are a distance l apart towards the right at speed v. A resistor R is connected across the rails as shown in the figure and uniform magnetic field $\vec{B}$, pointing perpendicularly into the plane of the paper, fills the entire region. If the bar starts at speed v_0 at time t = 0, its speed at a later time t is



(1) v_0

(2) $v_0 \exp\left[\frac{B^2l^2}{mR}t\right]$

(3) $v_0 \exp\left[-\frac{B^2l^2}{mR}t\right]$

(4) $v_0\left(1+\frac{B^2l^2}{mR}t\right)$

17. Which of the following statements are NOT true about electric force $\vec{F}_e$ and magnetic force $\vec{F}_m$ on a charged particle?

A. $\vec{E} \parallel \vec{F}_e$ whereas $\vec{B} \perp \vec{F}_m$

B. Both $\vec{F}_e$ and $\vec{F}_m$ depend on the velocity of the charged particle

C. Both $\vec{F}_e$ and $\vec{F}_m$ can perform work

D. $\vec{F}_e$ is an acceleration force while $\vec{F}_m$ is a purely deflecting force

(1) C and E

(2) B and C

(3) B only

(4) C and D

18. When light is incident normally on an air glass interface, what percentage of light is reflected back if the refractive index of glass is given to be 1.5?

(1) 80%

(2) 50%

(3) 10%

(4) 4%

SPACE FOR ROUGH WORK

19. If a plane wave of mixed polarization is incident on a plane interface between 2 media at the Brewster's angle, then the reflected radiation is

(1) Circularly polarized

(2) Unpolarized

(3) Completely plane polarized with polarization vector parallel to plane of incidence

(4) Completely plane polarized with polarization vector perpendicular to plane of incidence

20. Given that a charged particle moves with a uniform velocity $8\hat{i}$ ms^{-1} in a region with $\vec{E} = 32\,\hat{j}$ v/m and $\vec{B} = B_0\,\hat{k}$ Wb/m^2. The value of B_0 for which the velocity of the particle remains constant is

(1) 40 (2) 16

(3) 32 (4) 4

21. A thin uniform donut carrying charge Q and mass M rotates about its axis at an angular frequency ω. Its gyromagnetic ratio (ratio of its dipole moment to its angular momentum) is

(1) $\frac{Q}{2M}$ (2) $\frac{Q}{M}$

(3) $\frac{2Q}{M}$ (4) $\frac{4Q}{M}$

22. A wave function $\psi(\vec{r})$ of a particle in a 3d space has physical dimensions $M^aL^bT^c$ (with M being Mass, L being length and T being time), Identify the correct statement.

(1) a = 0, b = 3/2, c = 1 (2) a = 3/2, b = 0, c = 1

(3) a = 0, b = 3/2, c = 0 (4) a = 0, b = 0, c = 3/2

23. The wave function of a particle moving in free space is $4 = e^{ikx} + 2e^{-ikx}$. The probability current density to the real part of the wave function is

(1) 1 (2) $\frac{\hbar k}{m}$

(3) $\frac{\hbar k}{2m}$ (4) 0

SPACE FOR ROUGH WORK

24. Consider a quantum mechanical system with three linear operators $\hat{A}, \hat{B}$, and $\hat{C}$, which are related by $\hat{A}\hat{B} - \hat{C} = \hat{I}$, where $\hat{I}$ is the unit operator.

If $\hat{A} = \frac{d}{dx}$ and $\hat{B} = x$, then $\hat{C}$ must be

(1) zero

(2) $\frac{d}{dx}$

(3) $-x\frac{d}{dx}$

(4) $x\frac{d}{dx}$

25. A particle is initially in its ground state in a one dimensional harmonic oscillator potential. At t = 0 a perturbation $\hat{V}(x,t) = V_0 \hat{x}^3 e^{-t/\tau}$ is turned on. After long duration particle will be found

(1) Only in the ground state

(2) Only in the first excited state

(3) Only in the second excited state

(4) Either in first or in the third excited state

26. An electron is prepared in a spin state $\psi = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ i\end{pmatrix}$. In an experiment x-component of spin is measured. The probability of finding the value $\frac{\hbar}{2}$ is

(1) 5/4

(2) 1/2

(3) 1/3

(4) 1

27. Eigenstates of orbital angular momentum operators $\hat{L}^2$ and $\hat{L}_z$ are denoted by $|l, m\rangle$, $-l \le m \le l$. Given that a state $|\psi\rangle = \frac{1}{\sqrt{3}}[|1,1\rangle + |1,0\rangle + |1,-1\rangle]$ the expectation value of $\hat{L}_+ = \hat{L}_x + i\hat{L}_y$ is given by

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

(2) $\frac{2\sqrt{2}}{3}\hbar$

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

(4) 0

SPACE FOR ROUGH WORK

28. The ground state energy of positronium (a bound system of an electron and its antiparticle positron) is approximately equal to

(1) –13.6 eV
(2) –3.4 eV
(3) –27.2 eV
(4) –6.8 eV

29. Which one of the following represents the Maxwell's thermodynamic relation?

(1) $\left(\frac{\partial S}{\partial T}\right)_V = \left(\frac{\partial P}{\partial V}\right)_T$
(2) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$
(3) $\left(\frac{\partial T}{\partial P}\right)_V = \left(\frac{\partial V}{\partial P}\right)_T$
(4) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_T$

30. Helmhotz free energy (F) is defined as (symbols have usual meaning)

(1) F = U + TS
(2) F = U – TS
(3) F = U + PV
(4) F = U + PV – TS

31. The absolute temperature of a perfect black body is increased to twice its value. The rate of emission of energy per unit area will become

(1) 2 times
(2) 8 times
(3) 4 times
(4) 16 times

32. The number of ways two identical particles can be arranged in two states according to Maxwell – Boltzmann, Bose – Einstein and Fermi – Dirac statistics are given, respectively by

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

33. If f represents the number of degrees of freedom, p represents the number of phases and c represents the number of components, then

(1) f = p – c + 2
(2) f = p – c + 1
(3) f = c – p + 1
(4) f = c – p + 2

SPACE FOR ROUGH WORK

34. For a second order phase transition, which one of the following is true?

(1) Phase transition is associated with latent heat

(2) Volume is discontinuous at the transition temperature

(3) Entropy is discontinuous at the transition temperature

(4) Isothermal compressibility (χ_T) and specific heat (C_P) behave anomalously at the transition temperature

35. The electronic heat capacity of electrons in metals is proportional to

(1) T

(2) ln T

(3) 1/T

(4) T^2

36. If V_B is the built-in potential and $\pm$ Va is the applied voltage (positive sign for the reverse bias and negative sign for the forward bias), then the junction capacitance of an abrupt p-n junction is proportional to

(1) $(V_B \pm Va)^{1/2}$

(2) $(V_B \pm Va)^{-1/2}$

(3) $(V_B \pm Va)$

(4) $(V_B \pm Va)^{-1/3}$

37. For a certain JFET, I_{GSS} = 10 nA at V_{GS} = 10V. The input resistance is

(1) 100 M Ω

(2) 1 M Ω

(3) 1,000 M Ω

(4) 10,000 M Ω

38. A certain Op-Amp has an open-loop voltage gain of 1,00,000 and a common mode gain of 0.2. The CMRR is

(1) 5,00,000

(2) 6,00,000

(3) 4,00,000

(4) 3,00,000

39. The minimum number of NAND gates required to implement the Boolean function $A + A\overline{B} + A\overline{B}C$ is equal to

(1) 4

(2) 6

(3) Zero

(4) 1

SPACE FOR ROUGH WORK

40. A photo-diode functions as

(1) Photo conductive device while working with reverse voltage

(2) Photovoltaic device while working without a reverse voltage

(3) Photovoltaic device while working with a reverse voltage

(4) Photo conductive device while working without reverse voltage

41. The power in a circuit is measured by measuring a current through a resistor. The current is measured with an accuracy of ± 1.5% and the tolerance band of the resistor is ± 0.5%. The errors are limiting or guarantee errors. The accuracy with which power is measured is

(1) ± 1.125% (2) ± 3.5%

(3) ± 2% (4) ± 2.5%

42. How many flip-flops are required to construct a mod-1024 ripple counter?

(1) 9 (2) 10

(3) 12 (4) 14

43. General solutions to the following equation for Φ (x, y)

$a^2 \frac{\partial^2 \Phi(x,y)}{\partial x^2} - b^2 \frac{\partial^2 \Phi(x,y)}{\partial^2 y^2} = 0$ can be written as

(1) $\Phi = f_1 (bx + ay) + f_2 (bx - ay)$ (2) $\Phi = f_1 (ax + by) + f_2 (bx - ay)$

(3) $\Phi = f_1 (ax + by) + f_2 (ax - by)$ (4) $\Phi = f_1 (ax + by) + f_2 (bx - ay)$

(Here f_1 and f_2 are arbitrary differentiable functions)

44. Which of the following statements is FALSE?

(1) $\frac{\partial \psi}{\partial t} = \frac{1}{e^2} \frac{\partial^2 \psi}{\partial x^2}$ is parabolic, homogeneous and linear

(2) $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = f(x, y)$ is elliptic, homogeneous and linear

(3) $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$ is elliptic, homogeneous and linear

(4) $\frac{\partial \psi}{\partial t} + \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$ is hyperbolic, homogeneous and linear

SPACE FOR ROUGH WORK

45. For $y' = y + x$ with $y(0) = 1$ and step size $h = 0.1$, the value of k_1 in Runge-Kutta fourth order method is:

(1) 0.1 (2) 0.01

(3) 0.11 (4) 1.0

46. The number of independent components of a symmetric tensor A_{ij} with indices i, j = 1, 2, 3 is

(1) 1 (2) 3

(3) 6 (4) 9

47. The group of order less than four is

(1) Always cyclic (2) Always non-cyclic

(3) May or may not be cyclic (4) Cyclic under some conditions

48. Pick the correct statement:

(1) According to Noether's theorem, to each continuous symmetry there is a conservation law

(2) According to Noether's theorem, to each discrete symmetry, there is a conservation law

(3) According to Noether's theorem, isotropy in space leads to conservation of linear momentum

(4) According to Noether's theorem, homogeneity in time leads to conservation of angular momentum

49. Consider the following canonical transformations:

I. $Q = \frac{1}{2}q^2 p;\ P = \frac{p}{q}$

II. $Q = q\tan p;\ P = (p-3)\cos^2 q$

III. $Q = \sqrt{qe^t}\cos p;\ P = \sqrt{qe^t}\sin p$

Which of the above transformations are canonical?

(1) I, II, III (2) Only I

(3) I and III only (4) I and II only

50. The Hamilton's canonical equation of motion in terms of Poisson's bracket is

(1) $\dot{q} = \{q, H\};\ \dot{p} = \{p, H\}$ (2) $\dot{q} = \{H, q\};\ \dot{p} = \{H, p\}$

(3) $\dot{q} = \{H, p\};\ \dot{p} = \{H, q\}$ (4) $\dot{q} = \{p, H\};\ \dot{p} = \{q, H\}$

SPACE FOR ROUGH WORK

51. Let {A, B} denotes the Poisson bracket between A and B then {A, {B, C}} – {{A, B}, C} is equal to

(1) + {B, {C, A}}
(2) {{C, A}, B}
(3) {A, BC}
(4) {AB, C}

52. The phase velocity in a plasma is related to the plasma frequency ω_p and the acoustic velocity V_s as

(1) $V_p = \sqrt{\omega_P^2 / k^2 + V_s^2}$
(2) $V_p = \omega_p / k + V_s$
(3) $V_p = \sqrt{\omega_p^2 / k^2 - V_s^2}$
(4) $V_p = |\omega_p / k - v_s|$

53. The total power radiated by a charge q, moving with acceleration $\vec{a}$ is proportional to

(1) $q|\vec{a}|$
(2) $q^2|\vec{a}|^2$
(3) $q^2|\vec{a}|^3$
(4) $q^4|\vec{a}|^2$

54. Consider a rectangular wave guide with dimensions a = 3.1cm and b = 1.6cm. What is the cutoff frequency for TE_{10} mode in the wave guide?

(1) 1.5 × 10^{10} H_z
(2) 3.0 × 10^{10} H_z
(3) 4.5 × 10^{10} H_z
(4) 5.9 × 10^{10} H_z

55. If $\vec{E} = 3\hat{x} + 4\hat{y}$ and $\vec{B} = 3\hat{z}$ are the electric and magnetic fields of a system in an inertial frame, then the magnitude of the electric field in an inertial frame where the magnetic field is zero is given by

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

56. The value Landé g-factor and total magnetic moment of the state $^2S_{1/2}$ are

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

SPACE FOR ROUGH WORK

57. According to first Born approximation, the elastic scattering amplitude with U (r) = $-\frac{U_0}{r}e^{-\alpha\gamma}$, where U_0 and α are constants, for momentum transfer q and $\alpha \to 0$ is proportional to

(1) q (2) q^{-2}

(3) q^{-1} (4) q^2

58. In the WKB approximation, if E > V and potential V is constant, the particle wave function will take the form.

(1) $\psi(x) = A.\ e^{ikx}$ (2) $\psi(x) = A.\ e^{-ikx}$

(3) $\psi(x) = A.\ e^{ikx} + B.e^{-ikx}$ (4) $\psi(x) = A.\ e^{kx}$

59. For a spin ½ particle, let $|\uparrow\rangle$ and $|\downarrow\rangle$ denote its spin up and spin down states, respectively.

If $a = \frac{1}{\sqrt{2}}(|\uparrow\rangle|\downarrow\rangle + |\downarrow\rangle|\uparrow\rangle)$ and

$b = \frac{1}{\sqrt{2}}(|\uparrow\rangle|\downarrow\rangle - |\downarrow\rangle|\uparrow\rangle)$ are

composite states of the two such particles, which of the following statements is true for their total spin S?

(1) S = 1 is not an eigenstate of the operator $\hat{S}^2$ for $|a\rangle$ and $|b\rangle$

(2) $|a\rangle$ is not an eigenstate of the operator $\hat{S}^2$ and $S^1 = 0$ for $|b\rangle$

(3) S = 0 for $|a\rangle$ and S = 1 for $|b\rangle$

(4) S = 1 for $|a\rangle$ and S = 0 for $|b\rangle$

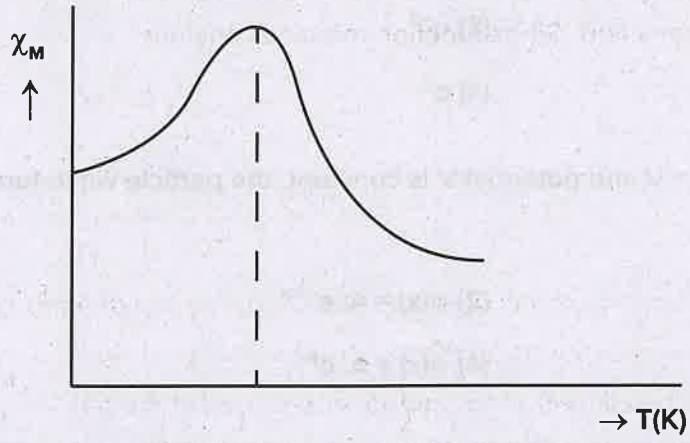
60. What is the total number of independent solutions to Dirac equation for a free particle?

(1) 1 (2) 2

(3) 3 (4) 4

SPACE FOR ROUGH WORK

61. The variation of magnetic susceptibility (χ_m) as a function of temperature (T) for a substance is shown below. The substance is most likely.



(1) Diamagnetic

(2) Paramagnetic

(3) Anti ferromagnetic

(4) Ferromagnetic

62. According to Einstein's equation for translational Brownian motion, the mean square of the displacement of Brownian particle during a time interval τ is

a) Proportional to the time interval τ

b) Proportional to the temperature T

c) Proportional to the viscosity of the fluid

d) Inversely proportional to the particle radius

Which of the above statement are correct?

(1) (a) , (b) and (d)

(2) (a), (b), (c) and (d)

(3) (a), (b) and (c)

(4) (a) and (b)

SPACE FOR ROUGH WORK

63. Which of the following statements are correct regarding phase transition?

i. Phase transition takes place under isobaric isothermal conditions

ii. In the first-order phase transition, volume and entropy remains constant

iii. In the second order phase transition, Gibbs function remains constant

(1) i and ii only

(2) i and iii only

(3) ii and iii only

(4) i, ii and iii

64. Which one of the following statements about Bose-Einstein condensation of a gas is FALSE?

(1) Pressure in a BE condensed gas depends on the temperature only

(2) Pressure in a BE condensed gas depends on number of particles of the gas

(3) Pressure in a BE condensed gas is independent of number of particles

(4) Finite number of particles in the condensed gas have zero momentum state.

65. For signal amplitude modulated to a depth of 100% by a sinusoidal signal, power is

(1) Same as the power of unmodulated carrier

(2) Twice as the power of unmodulated carrier

(3) $\frac{3}{2}$ times the power of unmodulated carrier

(4) $\frac{2}{3}$ times the power of unmodulated carrier

66. $y = ax^2 + b \log_{10} x$ reduced to linear form $Y = a X + b$, where

(1) $Y = y, X = \frac{x^2}{\log_{10} x}$

(2) $Y = \frac{y}{\log_{10} x}, X = \frac{x^2}{\log_{10} x}$

(3) $Y = y \log_{10} x, X = \frac{x^2}{\log_{10} x}$

(4) $Y = \frac{y}{\log_{10} x}, X = x^2 \log_{10} x$

SPACE FOR ROUGH WORK

67. In semiconductor strain gauges, when a tensile strain is applied

(1) Resistance increases in N-type of materials

(2) Resistance increases in P-type of materials

(3) Resistance increases in both P & N type of materials

(4) Resistance decreases in both P & N type of materials

68. In a PID controller, what does the "I" represent?

(1) Integral

(2) Input

(3) Inductive

(4) Intelligent

69. The Fourier transform of a voltage signal x (t) is X (f). The unit of |X (f)| is

(1) Volt

(2) Volt-sec

(3) Volt/sec

(4) $Volt^2$

70. The nucleus of a certain element has odd number of protons and odd number of neutrons. Then its nuclear spin quantum number would be

(1) Zero

(2) Half integral

(3) Integral

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

71. Due to application of a moderate magnetic field, the sodium D_1 line due to transition from $3\,^2p_{\frac{1}{2}} \rightarrow 3\,^2S_{\frac{1}{2}}$ splits up into

(1) 2 components

(2) 4 components

(3) 3 components

(4) 6 components

SPACE FOR ROUGH WORK

72. Intensities of pure rotational lines in the spectra of diatomic molecules

(1) Follow approximately Boltzmann distribution

(2) Follow Lorentzian distribution

(3) Increase monotonically with increase in rotational quantum number (J)

(4) Decrease monotonically with increase in rotational quantum number

73. In which one of the following molecules, pure rotational transitions are NOT allowed?

(1) $^{1}H\ ^{2}H$ (2) HF

(3) NO (4) S = C = S

74. The separation between J = 3 and J = 9 transitions in the far IR spectrum of $^{12}C^{18}O$ molecule is 23.15 cm^{-1}. Then what is the rotational constant of the molecule?

(1) 11.57 cm^{-1} (2) 1.93 cm^{-1}

(3) 5.79 cm^{-1} (4) 23.15 cm^{-1}

75. Franck-Condon principle accounts for

(1) Vibrational coarse structure in electronic spectrum of molecule

(2) Rotational fine structure in the electronic-vibrational spectrum of a molecule

(3) Intensity variation in the vibrational lines in electronic band spectrum of a molecule

(4) Convergence or divergence of different branch lines in the electronic spectrum

76. Light emission from ordinary optical sources is incoherent because

(1) Emission is predominantly spontaneous

(2) Emission is predominantly stimulated

(3) Emission occurs at multi wavelengths

(4) Emission occurs with low intensity

77. The rate of emission by spontaneous transitions from state 2 to state 1 in an atomic system depends on

(1) Population of the state 1 (2) Energy density

(3) Life time of the energy states (4) Population of the state 2

SPACE FOR ROUGH WORK

78. The upper level in a He-Ne laser emitting 6328A° line arises from the electron configuration of Ne atom given by:

(1) $2p^5 3p^1$ (2) $2p^5 4S^1$

(3) $2p^5 5S^1$ (4) $2p^5 3S^1$

79. The gain curve of a resonant cavity has a band width of about 1250 MHz. If the longitudinal modes are separated by 250 MHz, how many modes of oscillation that the resonator cavity supports?

(1) 8 (2) 4

(3) Only one mode (4) 5

80. An element crystallizes into FCC structure. 208g of the substance contains 4.28×10^{24} atoms. If the density is 7200 kg/m^3, then the length 'a' of the unit cell is

(1) 5 A° (2) 0.5 A°

(3) 0.3 A° (4) 3 A°

81. X-rays of unknown wave length are diffracted from an iron sample. First peak is observed for (110) planes at $2\theta = 44.70$. If the lattice parameter of bcc iron is 2.87 A° , then the wave length of x-ray used is

(1) 3 A° (2) 2.5 A°

(3) 1.5 A° (4) 4 A°

82. In a cubic system with cell edge 'a', two phonons with wave vectors $\vec{q}_1$ and $\vec{q}_2$ collide and produce a third phonon with a wave vector $\vec{q}_3$ such that $\vec{q}_1 + \vec{q}_2 = \vec{q}_3 + \vec{R}$, where $\vec{R}$ is a lattice vector. Such a collision process will lead to

(1) Finite thermal resistance

(2) Zero thermal resistance

(3) an infinite thermal resistance

(4) a finite thermal resistance for certain $|\vec{R}|$ only

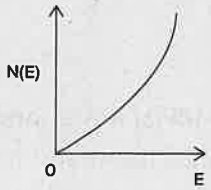
83. The relaxation time (mean free time) in second of the conduction electrons is

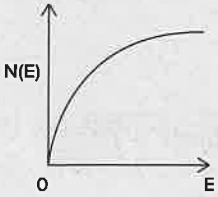
(1) 3.98×10^{-15} (2) 3.79×10^{-14}

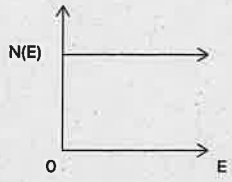
(3) 2.84×10^{-12} (4) 2.64×10^{-1}

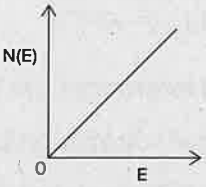
SPACE FOR ROUGH WORK

84. For a free electron gas in two dimensions, the variation of the density of states, N (E) as a function of energy E is represented by

(1) 

(2) 

(3) 

(4) 

85. In a one-dimensional Kronig-Penney model, the total number of possible wave functions is equal to

(1) Twice the number of unit cells
(2) Number of unit cells
(3) Half the number of unit cells
(4) Independent of the number of unit cells

86. In a n-type semiconductor, the Fermi level lies 0.4eV below the conduction band. If the concentration of donor atoms is doubled, the new position of the Fermi level is at (Assume $K_BT = 0.03eV$)

(1) 0.379 eV
(2) 0.579 eV
(3) 0.879 eV
(4) 0.779 eV

87. The London penetration depths for Pb at 3k and 7.1k are respectively 39.6nm and 173nm. Then at 0 k the transition temperatures and the depth are

(1) $T_c = 9.193$ k $\lambda_0 = 39$nm
(2) $T_c = 7.193$ k $\lambda_0 = 39$nm
(3) $T_c = 9.193$ k $\lambda_0 = 29$nm
(4) $T_c = 7.193$ k $\lambda_0 = 29$nm

88. The spacing between dislocation in a tilt boundary in FCC copper crystal, when the angle of tilt is 10° (Burgers vector = 2.6 A°)

(1) 12.75 A°
(2) 13.75 A°
(3) 14.75 A°
(4) 15.75 A°

SPACE FOR ROUGH WORK

89. For given temperatures, the order parameter 's' found by minimizing 'f' the free energy density as $\frac{\partial f}{\partial s}$ leads to following solutions:

i. $S_1 = 0$

ii. $S_2 = \frac{1}{2c}\left[b + \sqrt{b^2 - 4ac(T - T^*)}\right]$

iii. $S_3 = \frac{1}{2c}\left[b - \sqrt{b^2 - 4ac(T - T^*)}\right]$

Which of the following inferences are true?

(1) $S_1 = 0$ corresponds to isotropic phase

(2) At low temperature S_2 has global maximum free energy

(3) At low temperature S_3 has local maximum free energy

(4) $S_1 = 0$ corresponds to nematic-isotropic phase transition

90. Binding energy per nucleon of helium nucleus is 7MeV and that of deuteron is 1MeV. Then

(1) helium nucleus is more stable

(2) Deuteron nucleus is more stable

(3) Both are equally stable

(4) Both are unstable

91. Pick out the WRONG statement

(1) Nuclear forces have saturation property

(2) Nuclear forces are charge dependent

(3) Nuclear forces are spin dependent

(4) Nuclear forces are non-central

92. In a nucleon – nucleon interaction resulting in the production of deuteron in the reaction $p + n \rightarrow d + \pi^\circ$, the isospin (I) and the third component of isospin (I_3) of deuteron is

(1) 0, 0 (2) 1, 0

(3) 1, 1 (4) 1, –1

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93. The total angular momentum (j) and parity (π) of the ground state of $^{17}_{8}O_9$ nucleus is

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

(3) $\frac{3}{2}^+$ (4) $\frac{5}{2}^+$

94. The atomic ratio between uranium isotopes U^{238} and U^{234} in a mineral sample is found to be 1.8×10^4. The half life $\left(T_{\frac{1}{2}}\right)$ of U^{234} is 2.5×10^5 years. The $T_{\frac{1}{2}}$ of U^{238} is

(1) 4×10^3 years (2) 2×10^9 years

(3) 4.5×10^9 years (4) 3.5×10^6 years

95. The degeneracy of the j-states arising from 3p term with spin-orbit interaction is

(1) 1, 3, 5 (2) 1, 2, 3

(3) 3, 5, 7 (4) 2, 6, 3

96. Consider a system of two protons separated by a fixed distance r_0 rotating about an axis passing through its center of mass and normal to the plane containing the two particles. If I is the moment of inertia of such a system, the energy level corresponding to the orbital angular momentum l = 2 is given by

(1) $\frac{\hbar^2}{2I}$ (2) $\frac{\hbar^2}{I}$

(3) $\frac{2\hbar^2}{I}$ (4) $\frac{3\hbar^2}{I}$

97. According to standard model of particles, which one of the following is a fundamental particle?

(1) Pi – meson (2) Muon

(3) Deuteron (4) Neutron

98. A particle of mass M decays from rest into three equal masses that fly away each with a speed of 0.8c. What is the rest mass of the particles?

(1) 1/5 M (2) 2/5 M

(3) 1/3 M (4) 2/3 M

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99. For two proton system, the value of $\vec{S}_1, \vec{S}_2$ for the spin singlet system $\left({}^1S_0\right)$ is

(1) Zero (2) –1

(3) 1/4 (4) –3/4

100. The homogeneity of time leads to the law of conservation of

(1) Linear momentum (2) Angular momentum

(3) Energy (4) Parity

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