PHYSICAL SCIENCE

PAPER - II

Signature of Invigilators

1. ....

2. ....

Roll No. ☐☐☐☐☐
(In figures as in Admit Card)

Roll No. ....
....
(in words)

JY–06/02

Name of the Areas/Section (if any)...............

Time Allowed :75 Minutes] **[Maximum Marks : 100**

Instructions for the Candidates

1. Write your Roll Number in the space provided on the top of this page.
2. This paper consists of **fifty (50)** multiple choice type questions. **All questions** are compulsory.
3. Each item has upto four alternative responses marked (A), (B), (C) and (D). The answer should be a capital letter for the selected option. The answer letter should entirely be contained within the corresponding square.

   Correct method **[A]** Wrong method **[A** OR **[A]**
4. Your responses to the items for this paper are to be indicated on the ICR Answer Sheet under Paper II only.
5. Read instructions given inside carefully.
6. Extra sheet is attached at the end of the booklet for rough work.
7. You should return the test booklet to the invigilator at the end of paper and should not carry any paper with you outside the examination hall.

પરીક્ષાર્થીઓ માટે સૂચનાઓ :

૧. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.

૨. આ પ્રશ્નપત્રમાં કુલ **પચાસ (૫૦)** બહુવૈકલ્પિક ઉત્તરો ધરાવતા પ્રશ્નો આપેલા છે. **બધા જ** પ્રશ્નો ફરજિયાત છે.

૩. પ્રત્યેક પ્રશ્ન વધુમાં વધુ ચાર બહુવૈકલ્પિક ઉત્તરો ધરાવે છે. જે (A), (B), (C) and (D). વડે દર્શાવવામાં આવ્યા છે. પ્રશ્નનો ઉત્તર કેપીટલ સંજ્ઞા વડે આપવાનો રહેશે. ઉત્તરની સંજ્ઞા આપેલ ખાનામાં બરાબર સમાઈ જાય તે રીતે લખવાની રહેશે.

   ખરી રીત : **[A]** ખોટી રીત : **[A** , **[A]**

૪. આ પ્રશ્નપત્રના જવાબ આપેલ ICR Answer Sheet ના Paper II વિભાગની નીચે આપેલ ખાનાઓમાં આપવાના રહેશે.

૫. અંદર આપેલ સૂચનાઓ કાળજીપૂર્વક વાંચો.

૬. આ બુકલેટની પાછળ આપેલું પાનું રફ કામ માટે છે.

૭. પરીક્ષા સમય પૂરો થઈ ગયા પછી આ બુકલેટ જે તે નિરીક્ષકને સોંપી દેવી. કોઈપણ કાગળ પરીક્ષા ખંડની બહાર લઈ જવો નહી.

PHYSICAL SCIENCE
Paper - II

NOTE : This paper contains FIFTY (50) multiple-choice / Assertion & Reasoning/ Matching questions, each questions carrying two (02) marks. Attempt ALL the questions.

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1. Which of the following does not satisfy the wave equation ?

   (A) $50 \exp [i(\omega t - \beta z)]$ (B) $\sin \omega (10z + 5t)$

   (C) $(x + 2t)^2$ (D) $\cos (5y + 2x)$

2. What is the value of $\iiint \vec{\nabla} \cdot \vec{F}\, dx\, dy\, dz$ over the region $x^2 + y^2 + z^2 \le 16$, where $F = (x^2 + y^2 + z^2)(x\hat{i} + y\hat{j} + z\hat{k})$

   (A) 4π (B) $4^3\pi$

   (C) $4^6\pi$ (D) zero

3. The Lgrangian of a particle of mass M moving in a plane is given by $L = \frac{1}{2}M[v_x^2 + v_y^2] + a[xv_y - yv_x]$ where v_x and v_y are velocity components and 'a' is a constant. The canonical movement of the particle are given by

   (A) $p_x = Mv_x$ and $p_y = Mv_y$

   (B) $p_x = Mv_x + ay$ and $p_y = Mv_y + ax$

   (C) $p_x = Mv_x - ay$ and $p_y = Mv_y + ax$

   (D) $p_x = Mv_x - ay$ and $p_y = Mv_y - ax$

4. Given a wave with the dispersion relation $\omega = ck + m$ for $k > 0$ and $m > 0$, which one of the following is true ?

   (A) The group velocity is greater than the phase velocity

   (B) The group velocity is less than the phase velocity

   (C) The group velocity and the phase velocity are equal

   (D) There is no definite relation between the group velocity and the phase velocity.

5. Which one of the following remains invariant under Lorentz transformation ?

(A) $\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z} - \frac{1}{c^2}\frac{\partial}{\partial t}$

(B) $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} + \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$

(C) $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$

(D) $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$.

6. The Lagrangian of a 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 generalised momenta corresponding to r and θ are given by

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

(B) $m\dot{r}$ and $mr\,\dot{\theta}$

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

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

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

(A) $\frac{p_x^2}{2a} + \frac{p_y^2}{2b} + kxy$

(B) $\frac{p_x^2}{4a} + \frac{p_y^2}{4b} - kxy$

(C) $\frac{p_x^2}{4a} + \frac{p_y^2}{4b} + kxy$

(D) $\frac{p_x^2 + p_y^2}{4ab} + kxy$

8. The value of the Poisson bracket $\left[\vec{a}.\vec{r}, \vec{b}.\vec{p}\right]$, where $\vec{a}$ and $\vec{b}$ are constant vectors, is

(A) $\vec{a}\,\vec{b}$

(B) $\vec{a} - \vec{b}$

(C) $\vec{a} + \vec{b}$

(D) $\vec{a} \cdot \vec{b}$

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

(A) Linear momentum

(B) Angular momentum

(C) Energy

(D) Parity

10. A sphere of radius R carries charge density proportional to the distance from the center, $\rho = Ar$ where A is a positive constant. At a distance of $\frac{R}{2}$ from the center the magnitude of the electric field is

(A) $A/4\pi \epsilon_o$

(B) AR/ϵ_o

(C) $AR^2/16 \epsilon_o$

(D) $AR^3/4\pi \epsilon_o$

11. Steady current I flows down a uniform circular wire of length L, radius R and resistivity ρ, V is the applied voltage. The pointing vector at the surface of the wire is

(A) zero

(B) pointing along wire with magnitude $\frac{VI}{\pi r^2}$

(C) pointing inward at the surface with the magnitude $\frac{VI}{2\pi RL}$

(D) pointing inside the wire at the surface with the magnitude $\frac{\rho L}{\pi R^2}$

12. Infinite $x - y$ plane is a non-conducting surface, with the surface charge density σ as measured by an observer at rest on the surface. A second observer moves with a velocity $v\hat{x}$ relative to the surfae at a height h above it, which of the following expressions gives the electric field measured by the second observer?

(A) $\sigma/2\epsilon_0\, \hat{z}$

(B) $\frac{\sigma}{2\epsilon_0}\sqrt{1-v^2/c^2}\ \hat{z}$

(C) $\frac{\sigma}{2\epsilon_0}\frac{1}{\sqrt{1-v^2/c^2}}\ \hat{z}$

(D) $\frac{\sigma}{2\epsilon_0}\left(\sqrt{1-v^2/c^2}\ \hat{z}+\frac{v}{c}\hat{x}\right)$

13. The electric field in an electro-magnetic wave is described by the relation

$\vec{E}(\vec{r},t) = (\vec{\epsilon}_1 E_1 + \vec{\epsilon}_2 E_2)e^{i(\vec{k}\cdot\vec{r}-wt)}$ where $\vec{\epsilon}_1$ and $\vec{\epsilon}_2$ are two mutually orthogonal unit ectors, both are perpendicular to vector $\vec{k}$ and E_1 and E_2 are two numbers. If $E_2 = iE_1$ (where $i=\sqrt{-1}$), then the electro-magnetic wave is

(A) plane polarized

(B) circularly polarized

(C) partially polarized

(D) elliptically polarized

14. A charged particle is released from rest in a region where there is a constant electric field and a consant magnetic field. If the two fields are parallel to each other, the path of the particle is

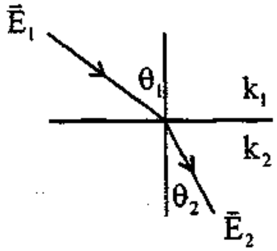
(A) Helix

(B) Parabola

(C) Straight line

(D) Cycloid

15. For electrostatic fields $\vec{E}_1$ and $\vec{E}_2$ shown at the interface between two dielectrics with dielectric constants k_1 and k_2, the angles θ_1 and θ_2 are related by



(A) $k_1 \tan\theta_1 = k_2 \tan\theta_2$

(B) $k_1 \sin\theta_1 = k_2 \sin\theta_2$

(C) $k_1 \cot\theta_1 = k_2 \cot\theta_2$

(D) $k_1 \cos\theta_1 = k_2 \cos\theta_2$

16. Listed below are Maxwell's equations of electromagnetism. If the magnetic poles exist, which of the equations would need notifications ?

(i) curl $\vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

(ii) curl $\vec{E} = -\frac{\partial \vec{B}}{\partial t}$

(iii) div $\vec{D} = \rho$

(vi) div $\vec{B} = 0$

(A) iv only

(B) (i) & (ii)

(C) (ii) & (iv)

(D) (iii) & (iv)

17. If the matrices σ_x, σ_y and σ_z have their usual meaning, the value of $[\sigma_x, \sigma_y]$ is

(A) $i\sigma_z$

(B) $2i\,\sigma_z$

(C) σ_z

(D) $2\,\sigma_z$

18. The value of $[L_Z , y]$ is

(A) $-i\hbar x$

(B) $i\hbar x$

(C) $-i\hbar L_x$

(D) $i\hbar L_x$

19. The explicit expression for the operator $\left(x\frac{d}{dx}\right)^2$ is

(A) $x^2\frac{d^2}{dx^2} + 3x\frac{d}{dx} + 1$

(B) $x^2\frac{d^2}{dx^2}$

(C) $\frac{d}{dx}x^2 + 1$

(D) $x^2\frac{d^2}{dx^2} + x\frac{d}{dx}$

20. A particle of mass m is represented by a wave equation $\psi(x) = Ae^{ikx}$ where k is wave vector and A is a constant. The magnitude of probability current density of the particle is

(A) $\frac{\hbar k}{m}|A|^2$

(B) $|A|^2 \frac{\hbar k}{2m}$

(C) $|A|^2 \frac{(\hbar k)^2}{m}$

(D) $\frac{(\hbar k)^2}{2m}$

21. The normalised wavefunction of a certain particle is $\psi = A\cos x$ for $-\frac{\pi}{2} \le x \le \frac{\pi}{2}$, then the value of A is

(A) $\sqrt{\frac{3}{8\pi}}$

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

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

(D) $\sqrt{\frac{8\pi}{3}}$

22. The ground state wave function of the harmonic oscillator is

(A) $\psi_o(x) = \left(\frac{m\omega}{\hbar\pi}\right)^{1/4} \exp\left[-\frac{m\omega x^2}{2\hbar}\right]$

(B) $\psi_o(x) = \left(\frac{\pi\hbar}{m\omega}\right)^{1/4} \exp\left[-\frac{m\omega x^2}{2\hbar}\right]$

(C) $\psi_o(x) = \left(\frac{m\omega}{\pi\hbar}\right)^{1/2} \exp\left[-\frac{m^2\omega^2 x^2}{2\hbar^2}\right]$

(D) $\psi_o(x) = \left(\frac{\pi\hbar}{m\omega}\right)^{1/2} \exp\left[-\frac{m^2\omega^2 x^2}{2\hbar^2}\right]$

23. One dimensional hormonic oscillator is in the state $\psi(x) = \frac{1}{\sqrt{2a}}\left[4\psi_o(x) - 3\psi_1(x) + 2\psi_2(x)\right]$ where $\psi_o(x), \psi_1(x)$ and $\psi_2(x)$ are ground, first excited and second excited states respectively. The probability of finding the oscillator in the first excited state is

(A) zero

(B) $9/29$

(C) $3/\sqrt{29}$

(D) $16/\sqrt{29}$

24. A harmonic oscillator is perturbed by a perturbation potential αx^3. The ground state energy of the oscillator to a first order in perturbation is

(A) $\frac{1}{2}\hbar\omega$ (B) $\frac{1}{2}\hbar\omega+\alpha$

(C) $\frac{3}{2}\hbar\omega+\alpha$ (D) $(n+\frac{1}{2})\hbar\omega$ where n is odd.

25. For a rigid sphere of radius 'a' the quantum mechanical scattering cross section is given by

(A) $3\pi a^2$ (B) πa^2

(C) $4\pi a^2$ (D) $2\pi a^2$

26. The three dimensional wave function : $\psi(\bar{r})$

(A) has dimension of energy · time (B) has dimension of $(\text{length})^{-3/2}$

(C) is a dimensionless quantity (D) has dimension of energy

27. The Fermi Golden rule expresses

(A) probable transition rate (B) density of states

(C) probability per unit volume (D) transition matrix element

28. Given a thermodynamic system at pressure P in volume V at temperature T, the Helmholtz free energy is given by

(A) F = U + PV (B) F = U – TS

(C) F = U + PV + TS (D) F = U – PV + TS

where S is entropy and U is internal energy.

29. In a throttling process,

(A) enthalpy remains constant (B) Free energy remains constant

(C) Gibb's energy remains constant (D) Internal energy remains fixed.

30. There are N Fermi particles with energies $\epsilon_0, \epsilon_1, \epsilon_2 \ldots\ldots\ldots \epsilon_{N-1}$.. At absolute zero, they are distributed as

(A) one particle in each energy level

(B) two particles in each energy level

(C) all particles in ϵ_0

(D) half particle in ϵ_0 and remaining half in ϵ_1

31. Specific heat of black body radiation is

(A) proportional to T

(B) proportional to T^2

(C) proportional to T^3

(D) proportional to T^4

where T is absolute temperature of the black body.

32. For Bose - Einstein condensation, the chemical potential μ is

(A) $\mu = -\infty$

(B) μ = negative but not $-\infty$

(C) μ is positive

(D) μ is zero

33. You are given N particles, each with spin $\frac{1}{2}\hbar$. Its entropy at $T = O^oK$ is

(A) $k_B (2^N)$

(B) $Nk_B/2$

(C) $Nk_B \ln 2$

(D) $k_B (\ln 2)^N$

34. Given three energy states with energies E_1, E_2 and E_3, number of ways by which two Fermions can be distributed is

(A) three

(B) ten

(C) six

(D) one

35. When thermal energy is much larger than vibrational energy of the diatomic molecules, gas of the diatomic molecules has specific heat per gramme atom to be

(A) $3\ k_B N_A$

(B) $3/2\ k_B N_A$

(C) $1/2\ k_B N_A$

(D) $k_B N_A$

where N_A is Avegadro number.

36. A gas of N molecules is continued in a volume V. The probability that all N molecules go in a volume V/2 is

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

(B) $\frac{N}{2}\ln 2$

(C) $N \ln 2$

(D) $\left(\frac{1}{2}\right)^N$

37. Consider an ideal gas enclosed in volume V at a temperature T. The gas is at pressure $P > P_o$ where P_o is atmospheric pressure. A small hole is pierced to the wall of the enclosure and the gas comes out from it untill inside pressure equalises to P_o. Then

(A) Temperature of an emerging gas is T

(B) Temperature of an emerging gas is less than T

(C) Temperature of an emerging gas is more than T

(D) Emerging gas obeys PV^γ = constant

38. A point charge Q is placed at a distance 'a' from an infinite plane conducting surface. If the surface is grounded, what is the charge induced on the surface

(A) $\frac{Q}{2}$ (B) $-Q/2$

(C) $-Q$ (D) $-\frac{Q}{2a}$

39. Which of the following equations rules out the possibility of magnetic monopoles

(A) $\vec{\nabla}\times\vec{E}$ (B) $\nabla^2\phi = 0$

(C) $\vec{\nabla}.\vec{B} = 0$ (D) $\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$

40. The intensity of radiation by an oscillating electric dipole is

(A) maximum along the direction of dipole moment

(B) maximum in direction perpendicular to the dipole moment

(C) zero along the direction perpendicular to the dipole moment

(D) is same along all directions.

41. For γ-ray spectroscopy, the following detector is used

(A) scintillation detector (B) photomultiplier

(C) G-M counter (D) bolometer

42. Which of the following gauge can measure vacuum in the range of 10^{-10} to 10^{-3} torr. ?

(A) Mcleod gauge (B) Pirani gauge

(C) Penning gauge (D) Ionization gauge

43. X-rays are

(A) electromagnetic radiation of frequency higher than that of visible light

(B) electromagnetic radiation of frequency lower than that of visible light

(C) beam of electrons

(D) beam of positive ions.

44. To measure temperature above 1800°C the most suitable instrument is

(A) Platinum resistance thermometer

(B) thermocouple

(C) radiation pyrometer

(D) gas thermometer

45. Velocity of light is related to electric permittivity ϵ_o and magnetic permeability μ_0 by the relation

(A) $c = (\mu_0 \epsilon_o)^{-1}$ (B) $c = (\mu_0 / \epsilon_o)$

(C) $c = (\epsilon_o / \mu_0)^{-1/2}$ (D) $c = (\epsilon_o / \mu_0)^{1/2}$

46. Relation between pumping speed S throughput Q and pressure P is given by

(A) Q = S/P (B) Q = P/S

(C) Q = PS (D) $Q = e^{P/S}$

47. In a linear regression analysis data are fitted with equation Y = mx + c and results yield slope, intercept and regression co-efficient 'r'. The fit is good if 'r' is

(A) 1.0 (B) 0.5

(C) 0.3 (D) 0.7

48. A 10-bit A/D converter has a full scale range of 10V. The percentage resolution is

(A) 10 (B) 1.0

(C) 0.1 (D) 0.01

49. To attain temperature less than 4K, one utilizes

(A) Newton's law of cooling (B) Joule Thomson Effect

(C) Adiabatic demagnetization (D) Peltier cooling

50. If the results are expressed as $\bar{x} \pm 3\sigma$, where $\bar{x}$ = mean value and σ is the standard deviation, it means that

(A) approximately 99% of the readings will lie between $\pm 3\sigma$

(B) 66% of the readings will lie between $\pm 3\sigma$

(C) 33% of the readings will lie between $\pm 3\sigma$

(D) non of the readings will lie between $\pm 3\sigma$

ROUGH WORK