Roll No.

PHYSICAL SCIENCES

Paper II

D/03/2

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 [Ⓐ]

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. One 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 માટેની સૂચનાઓ :

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

૨. આ પ્રશ્નપત્રમાં કુલ **પચ્ચાસ (50)** 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) અને (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] , [Ⓐ]

૪. આ પ્રશ્નપત્રના જવાબ આપેલ ICR Answer Sheetના Paper II વિભાગની નીચે આપેલ ખાનાંઓમાં આપવાના રહેશે.

૫. અંદર આપેલ સૂચનાઓ કાળજીપૂર્વક વાંચો.

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

૭. પરીક્ષાસમય પૂરો થઈ ગયા પછી આ બુકલેટ જે તે નિરીક્ષકને સોંપી દેવી. કોઈ પણ કાગળ પરીક્ષાખંડની બહાર લઈ જવો નહી.

PHYSICAL SCIENCES

PAPER—II

Note :—This paper contains **fifty (50)** multiple choice questions, each carrying **two (2)** marks. Attempt *all* of them.

1. Given a matrix

$$A = \begin{pmatrix} \cos\phi & \sin\phi \\ -\sin\phi & \cos\phi \end{pmatrix}.$$

The eigenvalues of A are :

(A) $\cos\phi$, $e^{i\phi}$

(B) $e^{-i\phi}$, $e^{i\phi}$

(C) $e^{-i\phi}$, $\sin\phi$

(D) $\sin\phi$, $\cos\phi$

2. The poles of

$$f(z) = \frac{1}{e^z + 1}$$

are :

(A) $z = 0, 2\pi i, 4\pi i, \ldots\ldots 2n\pi i$

(B) $z = 0, \pi i, 2\pi i, 3\pi i, \ldots\ldots n\pi i$

(C) $z = \pi i, 3\pi i, 5\pi i, \ldots\ldots (2n + 1)\pi i$

(D) $z = 0, \pi, 2\pi, 3\pi \ldots\ldots n\pi$

3. Given a Lagrangian

$$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2) - mgy.$$

(A) x is cyclic co-ordinate, p_x is constant but energy E is not constant

(B) y is cyclic, p_y is constant and E is also constant

(C) Both p_x and p_y are constant and therefore the energy is also constant

(D) Both p_x and E are constant and x is cyclic co-ordinate

4. Points α and β are connected by a wire. A bead moves from α to β along the curve under the action of gravity.
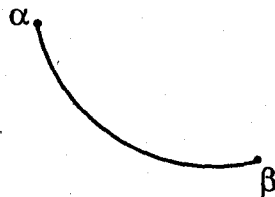
The curve αβ for which the time of motion is shortest is :

(A) Cycloid

(B) Straight line

(C) Parabola

(D) Arc of a circle

5. The phase space diagram for free particle motion is :
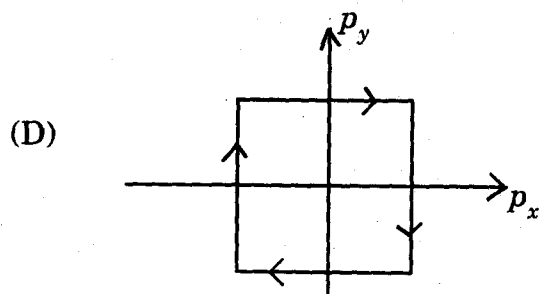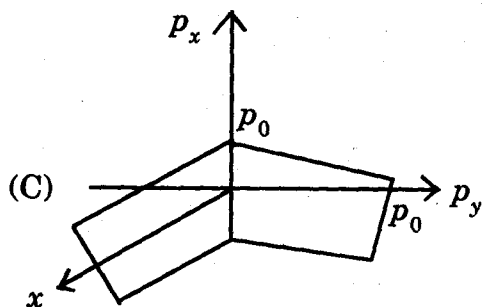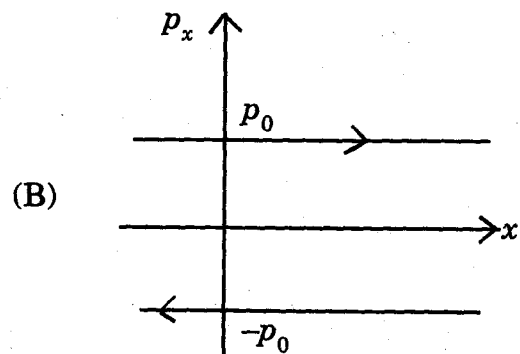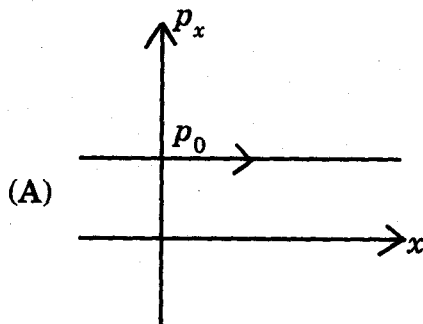
6. The degrees of freedom for the motion of rigid body of N particles are :

(A) 3N

(B) 6N

(C) 6

(D) Infinite

7. If p is momentum of the particle of rest mass m and energy E, then its kinetic energy is ($cp \lesssim$ E) :

(A) $\dfrac{p^2}{2m}$

(B) $\sqrt{c^2 p^2 + m^2 c^4}$

(C) $\sqrt{c^2 p^2 + m^2 c^4} - mc^2$

(D) mc^2

8. Choose the *correct* statement :

(A) Kepler's second law is a consequence of elliptic orbit

(B) Kepler's second law is a consequence of the fact that the period of motion is proportional to $a^{3/2}$

(C) Kepler's second law is a consequence of the fact that the orbit has apsidal points

(D) Kepler's second law is a consequence of constancy of angular momentum

9. Given a linear triatomic molecule, the normal modes of oscillation along its line are :

(equilibrium configuration)

(A) and

(B) and

(C) and

(D)
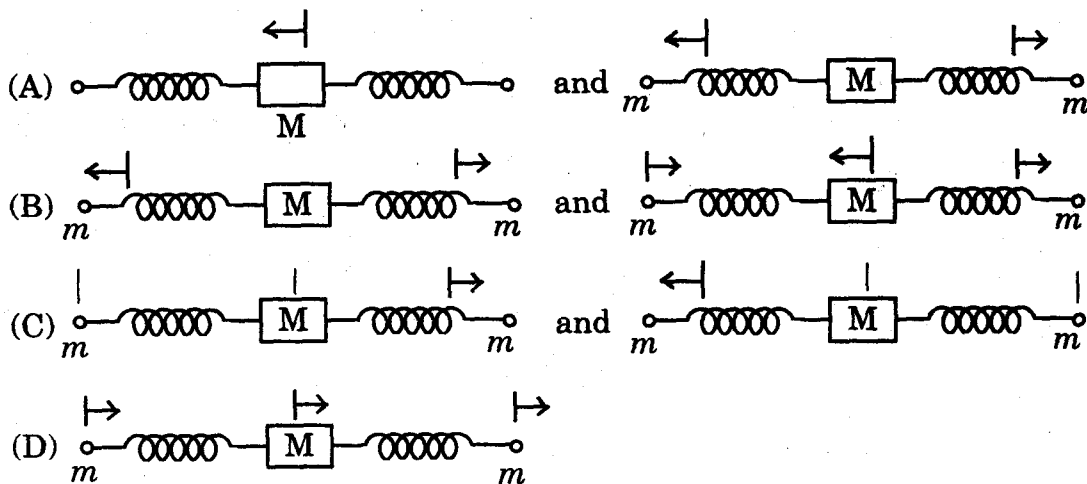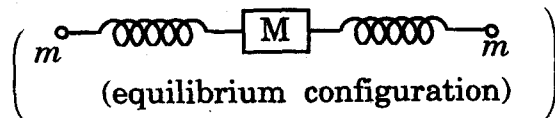
where $|$ on the top of the masses is their equilibrium position.

10. The general solution $\psi(x, t)$ of a wave motion for a wave moving in x direction with velocity v is :

(A) $y(x, t) = f(x) \cdot g(t) \pm g(x) \cdot f(t)$,

where f and g are continuous functions

(B) $\psi(x, t) = Af(x + vt) + Bf(x - vt)$

(C) $\psi(x, t) = \dfrac{e^{ikx}}{x + vt}$

(D) $\psi(x, t) = \dfrac{e^{-ikx}}{x - vt}$

11. Given a magnetic vector potential

$$\vec{A}(x, y, z) = -\frac{1}{2}(y\hat{i} - x\hat{j}) \cdot B_0,$$

where B_0 is a constant, then the magnetic induction produced is :

(A) $B_0 \hat{k}$ (B) $B_0 \hat{j}$

(C) $B_0 \hat{i}$ (D) $\dfrac{B_0 xy}{x^2 + y^2} \cdot \hat{k}$

12. A long wire carries a steady current I. Then the magnetic induction at a distance r from wire :

(A) Varies as $\dfrac{1}{r}$ and is along the direction of the wire

(B) Varies as $\dfrac{1}{r^2}$ and is along the direction of the wire

(C) Varies as $\dfrac{1}{r^2}$ and is at right angles to the wire

(D) Varies as $\dfrac{1}{r}$ and is at right angles to the wire

13. Consider an oscillating dipole with time variation $q = q_0 e^{iwt}$. The dipole moment has its maximum value as p_0. The electric field $\vec{E}$ and magnetic field $\vec{H}$:

(A) varies as $p_0 k^2 e^{i\vec{k}.\vec{r}} \sin\theta$

(B) varies as $p_0 k^2 e^{ik.r/r}$

(C) varies as $p_0 k^2 e^{ik.r}.\sin\theta$

(D) varies as $p_0 k^2 \dfrac{e^{ik.r}}{r} \sin\theta$

14. Given a spherical charge distribution

$$\rho = \rho_0 \left(1 - \frac{r^2}{a^2} \right) \qquad r \le a$$

$$= 0 \qquad r > a$$

The electric field inside the distribution is :

(A) $E = \text{constant} = \dfrac{4}{3}\pi(\rho_0 a^3)/a^2$ and is radial

(B) $E = \dfrac{\rho_0}{\epsilon_0}\left(\dfrac{r^3}{3} - \dfrac{r^5}{5a^2} \right)$ and is in radial direction

(C) $E = \dfrac{\rho_0}{\epsilon_0}.\dfrac{r^5}{5a^2}$ and is in axial direction

(D) $E = \dfrac{8\pi a^3.\rho_0}{4\pi \epsilon_0}.\dfrac{1}{r}$ and is in radial direction

15. Two metallic grounded plates are held at right angles as shown in the following figure. A charge q is kept at the position (a, b) as shown :
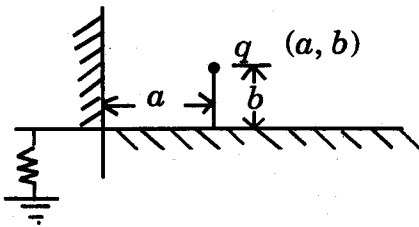
Then the image charges q' are at :

(A) $q' = q$ at $(a,-b)$, $q' = -q$ at $(-a, -b)$, $q' = q$ at $(-a, b)$.

(B) $q' = -q$ at $(a, -b)$, $q' = -q$ at $(-a, -b)$ and $q' = -q$ at $(-a, +b)$

(C) $q' = -q$ at $(a,-b)$, $q' = q$ at $(-a, -b)$, $q' = -q$ at $(-a, b)$

(D) $q' = q$ at $(a,-b)$, $q' = q$ at $(-a, -b)$, $q' = q$ at $(-a, b)$

16. For an electromagnetic wave in vacuum :

(A) The group and phase velocity are same

(B) The group velocity is C but phase velocity is smaller than C

(C) Phase velocity is C and group velocity is smaller than C

(D) The phase velocity can exceed C but group velocity is always less than C

17. Poynting's vector :

(A) is proportional to $\dfrac{E^2 + B^2}{2} \cdot \hat{k}$ and is also energy density

(B) is proportional to $\vec{E} \cdot \vec{B} \cdot \hat{k}$ and gives intensity of e.m. wave

(C) is proportional to angular momentum of the wave

(D) is proportional to $\vec{E} \times \vec{B}$ and is proportional to the intensity of the wave

18. Choose *correct* statement :

(A) Newton's law of gravitation, Coulomb's law and Biot-Savart's law are same because all behave as $1/r^2$

(B) Newton's law of gravitation, Coulomb's law and Biot-Savart's law give central force

(C) Biot-Savart's law is applicable for stationary charges

(D) Newton's law and Coulomb's law give a central force between its sources, whereas, Biot-Savart's law gives a force at right angles to the line joining the point of observation and the current element

19. Given a charge density

$$\rho(\vec{r}) = \frac{q}{64\pi a^5} r^2 \cdot e^{-r/a} \sin^2\theta.$$

Then :

(A) It is a mixture of monopole and dipole charge distribution

(B) It is a mixture of monopole and quadrapole charge distribution

(C) It is a monopole distribution

(D) It is a quadrapole distribution

20. Choose the *correct* statement :

(A) Both Coulomb and Lorentz gauges are relativistically invariant.

(B) Both Coulomb and Lorentz gauges are not consistent with special theory of relativity.

(C) Lorentz gauge is relativistically covariant whereas Coulomb gauge is not relativistically covariant.

(D) Lorentz gauge is not relativistically invariant whereas Coulomb gauge is.

21. According to de Broglie's hypothesis for matter waves, the linear momentum of the particle can be expressed by :

(A) $\hbar k$

(B) $\hbar \omega$

(C) $\dfrac{\lambda}{h}$

(D) $h \cdot \lambda$

22. If A and B are canonically conjugate pair of dynamical variables, according to Heisenberg's uncertainty principle, the value of [A, B] is :

(A) $\dfrac{\hbar}{2}$

(B) $i\hbar$

(C) $\hbar$

(D) $\dfrac{\hbar^2}{4}$

23. The principal degeneracy of the energy eigenvalue for a free particle Schrödinger equation is :

(A) 0

(B) 2

(C) 4

(D) 9

24. The Hamiltonian of the anharmonic oscillator is given as

$$H = \frac{p^2}{2m} + \frac{1}{2}kx^2 + \lambda x^4$$

in one dimension. The perturbation term of this expression is :

(A) $\dfrac{p^2}{2m}$

(B) $\dfrac{p^2}{2m} + \dfrac{1}{2}kx^2$

(C) $\dfrac{1}{2}kx^2$

(D) λx^4

25. The eigenvalue of the L_z component of orbital angular momentum $\vec{L}$ can be :

(A) $l\hbar$

(B) $l(l + 1)\hbar^2$

(C) $l(l + 1)\hbar$

(D) $\sqrt{l(l + 1)}\hbar$

26. The total number of degenerate states excluding spin for the 5th excited state in Hydrogen atom are :

(A) 4

(B) 5

(C) 9

(D) 36

27. According to time-independent non-degenerate perturbation theory, the first order correction to the energy of the respective state is :

(A) negative value of the perturbation

(B) expectation value of the perturbation

(C) positive value of the perturbation

(D) square root of the perturbation

28. Fastest transitions in atom are dipole transitions which involve the matrix elements $< m \mid e\vec{r} \mid n >$. Then :

(A) States $\mid m >$ and $\mid n >$ have same angular momentum

(B) States $\mid m >$ and $\mid n >$ differ in angular momentum by $2\hbar$

(C) States $\mid m >$ and $\mid n >$ have same parity

(D) States $\mid m >$ and $\mid n >$ differ in angular momentum by $\hbar$

29. A particle is scattered by a spherically symmetric potential V (r). The incident wave is $\psi = A \exp(ikx)$ and the scattered wave is :

$$\psi_{sc} = A \exp(ikx) + \frac{f(\theta)}{r} \exp(ik.r).$$

Then the differential cross-section is :

(A) $\mid f(\theta)\mid^2$

(B) $\mid f(\theta)\mid^2 . r^2$

(C) $\mid A \mid^2$

(D) $\mid f(\theta)\mid^2 . \mid A \mid^2$

30. For the systems of identical particles, the eigenvalues of the exchange operator are :

(A) always unity   (B) negative

(C) ± 1 (D) zero

31. Change in free energy at constant temperature and change in enthalpy at constant pressure, give :

(A) amount of heat absorbed and amount of work done respectively.

(B) amount of work done and amount of heat absorbed respectively.

(C) change in chemical potential and change in pressure respectively.

(D) change in pressure and change in chemical potential respectively.

32. During the solid-liquid transition :

(A) Gibbs' free energy for both phases remain the same

(B) Helmholtz free energy for both phases remain the same

(C) Enthalpy for both phases remain the same

(D) Entropy for both phases remain the same

33. You are given a gas of 1 gm mole of N_2 molecules at NTP. Its temperature is raised to 100°C. Then the specific heat of the gas per molecule is :

(A) $\dfrac{7}{2}K_BT$ where $T = 373°K$ (B) $\dfrac{3}{2}K_BT$ where $T = 373°K$

(C) $\dfrac{5}{2}K_BT$ where $T = 373°K$ (D) $\dfrac{5}{2}K_BT$ where $T = 100°C$

34. If two states i and j having energies E_i and E_j respectively and have probabilities of occurring as P_i and P_j, then temperature of the system will be given by :

(A) $\quad T = -\dfrac{(E_i - E_f)}{K \ln\left(\dfrac{P_i}{P_j}\right)}$ (B) $\quad T = -\dfrac{(E_f - E_i)}{K \ln\left(\dfrac{P_i}{P_j}\right)}$

(C) $\quad T = -K(E_i - E_f)\,\ln\left(\dfrac{P_i}{P_j}\right)$ (D) $\quad T = \dfrac{K.\ln\left(\dfrac{P_i}{P_j}\right)}{(E_i - E_f)}$

35. Consider two identical particles. Each particle can be in one of the three possible quantum states 0, $\in$ and $3\in$. Then the number of microstates of the system for Fermi-Dirac statistics will be :

(A) 6

(B) 9

(C) 3

(D) 12

36. A system has 5 different macrostates under which there are 6, 20, 42, 12 and 2 microstates. A certain property X associated with the system has values 4, 4, 2, 6 and 10 respectively, for 5 macrostates. The expectation value $<x>$ will be :

(A) 6.25

(B) 12.50

(C) 3.41

(D) 9.41

37. The value of chemical potential for photon gas is :

(A) $K_BT \ln\left(\dfrac{\lambda^3 N}{V}\right)$, where $\lambda = \dfrac{h}{\sqrt{2\pi m K_B T}}$ and N is the number of photons in volume V

(B) $\left(\dfrac{K_BT}{E}\right) \ln\left(\dfrac{\lambda^3 N}{V}\right)$ where E is energy of the photon of frequency ω

(C) $\dfrac{\hbar\omega}{e^{\hbar\omega/K_BT} - 1}$

(D) Zero

38. You are given N particles of spin 1/2 arranged in one line, and are periodically placed. Distance between two spins is a. The length of line is L = Na. The system is at temperature T = 0°K. The entropy of the spin system is :

(A) $S = K_B$

(B) $S = 2K_B \cdot N$

(C) $S = N \cdot K_B \ln 2$

(D) $S = \ln (2NK_B)$

39. Consider a black-body spectrum at an absolute temperature T. Then the energy density between ω and $\omega + d\omega$:

(A) goes as $\omega^3 e^{-\frac{\hbar\omega}{K_BT}}$ at high frequencies and goes as $K_BT \cdot \omega^2$ at low frequencies

(B) goes at $(K_BT)\omega^2$ at high frequencies and goes as $\omega^3 \cdot e^{-\frac{\hbar\omega}{K_BT}}$ at low frequencies

(C) goes as $e^{-\frac{\hbar\omega}{K_BT}}$ at high frequencies and goes as $e^{-\frac{\hbar\omega}{K_BT}}$ at low frequencies

(D) goes as $(K_BT) \cdot \omega$ at high frequencies and goes as $e^{-\frac{\hbar\omega}{K_BT}}$ at low frequencies

40. Which one of the following is a *correct* statement ?

(A) In canonical ensemble, both the energy and matter are exchanged with the reservoir

(B) In grand canonical ensemble only the energy is exchanged with the reservoir

(C) In canonical ensemble, only energy is exchange with the reservoir whereas in grand canonical ensemble, both the energy and the matter are exchanged with the reservoir

(D) In grand canonical ensemble no energy but only the matter is exchanged with reservior

41. For low energy X-rays the following detector has the best energy resolution :

(A) Ionisation chamber   (B) G.M. Counter

(C) Scintillation counter   (D) Si(Li) detector

42. The intensity of a beam of the following particles passing through matter undergoes an exponential attenuation :

(A) Electrons   (B) Protons

(C) Gamma rays   (D) β-particles

43. Hall effect experiment measures :

(A) Amount of ionisation produced

(B) Charge carrier density in the material

(C) Energy of the electron

(D) The density of minority carrier in a solid

44. In order to measure the 'time' using the electronic signals from the detectors the output pulse should have :

(A) a very short rise time   (B) a very long decay time

(C) a very long rise time   (D) a very large pulse width

45. Coincidence measurements are used to :

(A) Improve noise to signal ratio

(B) Improve signal to noise ratio

(C) Improve the efficiency of detection

(D) Reduce the time of collection of data

46. The timing measurements that can be done with the pulses from the detectors are in the range of :

(A) Minutes   (B) Seconds

(C) Milliseconds   (D) Microseconds

47. A preamplifier at the output of detector is used to :

(A) Amplify the signal   (B) Match the impedance

(C) Count the pulses   (D) Feedback the signal

48. To measure the temperatures below the liquid nitrogen temperature we need to use :

(A) Thermocouple   (B) Semiconductor diode

(C) Transistor   (D) Thermistor

49. Reproducibility of a measurement is determined by :

(A) Deviation from standard value (B) Standard deviation

(C) Mean of the measurement   (D) Mode of the measurement

50. If a signal $x(t + T) = -x(t)$ with T is the period of its signal, the signal is an :

(A) Even function   (B) Odd function

(C) Energy function   (D) Even-odd function

ROUGH WORK

ROUGH WORK

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