NOV-32211/II

# Physics
## Paper II

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

**Note :** This Paper contains **Fifty (50)** multiple choice questions. Each question carries **Two (2)** marks. Attempt *All* questions.

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1. Which of the following corresponds to $\sqrt{i}$, where $i = \sqrt{-1}$ :

(A) $\frac{1}{\sqrt{2}}(1+i)$

(B) $\frac{1}{\sqrt{2}}(1-i)$

(C) $-1$

(D) $1$

2. The eigenvalues of the matrix

$$\begin{bmatrix} i & -i & 0 \\ 0 & 1 & i \\ 0 & 0 & -i \end{bmatrix}$$

are :

(A) $i, -i, 0$

(B) $i, i^2, i^3$

(C) $1, 0, -1$

(D) $1, i, -i$

3. Which of the following is a valid solution of the differential equation ?

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0 \text{ ?}$$

(A) $x^2 - y^2$

(B) $x^2 y^2$

(C) $x^2 + y^2$

(D) $x^4 - y^4$

4. For the Legendre differential equation

$$(1 - x^2)\, y'' - 2xy' + n(n+1)\, y = 0$$

which of the following is an ordinary point ?

(A) $x = 1$

(B) $x = 0$

(C) $x = -1$

(D) $x = \infty$

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[P.T.O.

5. If

$$\overline{A} \cdot (\overline{B} \times \overline{C}) = 0$$

in 3-dimensional space, then :

(A) $\overline{A}, \overline{B}, \overline{C}$ are co-planer

(B) $\overline{A}$ is a null vector

(C) $\overline{A}, \overline{B}, \overline{C}$ span the whole 3-*d* space

(D) $\overline{B} = 0$

6. The dimension of the subspace spanned by the real vectors :

$$\begin{bmatrix}1\\1\\0\\0\end{bmatrix}, \begin{bmatrix}2\\2\\0\\0\end{bmatrix}, \begin{bmatrix}0\\1\\0\\0\end{bmatrix}, \begin{bmatrix}2\\0\\0\\3\end{bmatrix}, \begin{bmatrix}1\\-2\\0\\0\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix},$$

(A) 2

(B) 3

(C) 4

(D) 5

7. $f(x) = \begin{cases} 1 & 0 < x < \pi \\ 0 & -\pi < x < 0 \end{cases}$

when *f(x)* is represented by corresponding Fourier series, then the value of Fourier series at $x = 0$ is :

(A) 1

(B) 0

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

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

8. The Laplace transform of $f(t)$ is F$(s)$, then the Laplace transform of $df/dt$ is :

(A) $dF/ds$

(B) $\int_0^\infty F(s-t) f(t)\, dt$

(C) $s\ F(s) - f(0)$

(D) $F(s)\ e^{-s}$

9. The ground state energy is always :
   (A) suppressed due to the first order perturbation
   (B) elevated due to the first order perturbation
   (C) suppressed due to the second order perturbation
   (D) elevated due to the second order perturbation

10. For 3-dimensional square well potential well potential in quantum mechanics

    ($v = -v_0$ for $0 < r < a$ and $v = 0$ for $r > a$)
    (A) the bound state exists only if the potential is sufficiently deep
    (B) there always exists at least one bound state
    (C) there are always at least three bound states
    (D) the bound state wave function has property $\psi(r = 0) = 0$

11. Which of the following is an eigen-function of linear momentum operator $\frac{\hbar}{i}\frac{\partial}{\partial x}$, such that it describes a particle moving in free space in the direction of +ve $x$-axis with no uncertainty in the linear momentum ?
    (A) $\cos kx$
    (B) $\sin kx$
    (C) $e^{-kx}$
    (D) $e^{ikx}$

12. A transition, in which one photon is radiated by the electron in a hydrogen atom, when the electron wave function changes from $\Psi_1$ to $\Psi_2$; is forbidden if $\Psi_1$ and $\Psi_2$ :
    (A) have opposite parity
    (B) are both spherically symmetric
    (C) are orthogonal to one another
    (D) are zero at the center of the atom

13. A particle of mass $m$ confined to an infinitely deep square well potential :

$$V(x) = \infty \quad \text{for} \quad x \le 0, \; x > a$$
$$= 0 \quad \text{for} \quad 0 < x < a$$

has eigenfunction :

$$\psi_n = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}.$$

The expectation value of the momentum of the particle is :

(A) zero

(B) $\frac{n\pi\hbar}{a}$

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

(D) $\frac{\hbar}{a}$

14. A system of mass $m$ in one dimension is in a state described by :

$$\psi(x, t) = A \exp\{(ipx - iEt)/\hbar\} + B \exp\{(-ipx - iEt)/\hbar\}$$

where A and B are complex numbers; $p$ and E are real. The probability current density is given by :

(A) $(|A|^2 + |B|^2)\, p/m$

(B) $(|A|^2 - |B|^2)\, p/m$

(C) $p/m$

(D) $(|A| - |B|)\, p/m$

15. The wave function for identical fermions is antisymmetric under particle interchange. Which of the following is a consequence of this property ?

(A) Pauli's exclusion principle

(B) Heisenberg's uncertainty principle

(C) Bose-Einstein condensation

(D) Bohr correspondence principle

16. $\vec{L} \times \vec{L}$ in quantum mechanics is equal to :

(A) 0

(B) $L^2$

(C) $l(l+1)\,\hbar^2$

(D) $i\hbar\,\vec{L}$

17. The spacing between (111) planes of a cubic system of lattice parameter '$a$' is :

(A) $\frac{\sqrt{3}}{2}a$

(B) $a/\sqrt{3}$

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

(D) $\frac{2a}{\sqrt{3}}$

18. If $I_G$, $I_K$ and $I_P$ are grid current, cathode current and plate current respectively in ionization types of vacuum gauges, then the pressure (P) measured will be :

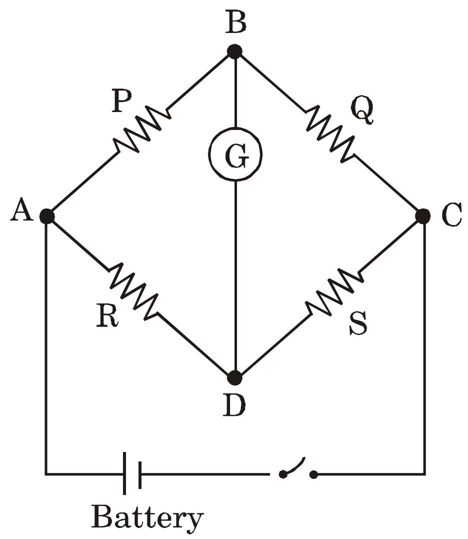
(A) $P \propto I_G/I_P$

(B) $P \propto I_P/I_G$

(C) $P \propto I_K/I_G$

(D) $P \propto I_P/I_K$

19. In a Wheatstone bridge the sensitivity is maximum when :




(A) P, Q, R, S are of small order

(B) P, Q are large, R, S are small

(C) P, R are large, Q, S are small

(D) Q, S are large P, R are small

20. The movable mirror of Michelson's interferometer is moved through a distance of 0.02603 mm. The number of fringes shifted across the cross-wire of eyepiece of the telescope if a wavelength of 5206 Å is used is :

(A) 200

(B) 300

(C) 100

(D) 400

21. An analog transducer has a range 0 – 10 V. The bits of an A/D converter if the resolution is 5 mV are :

(A) 9

(B) 10

(C) 11

(D) 12

22. In a Michelson's interferometer 200 fringes cross the field of view when the movable mirror is displaced through 0.0589 mm. The wavelength of monochromatic light used is :

(A) $5890 \times 10^{-8}$ cm

(B) $5895 \times 10^{-8}$ cm

(C) $5925 \times 10^{-8}$ cm

(D) $5950 \times 10^{-8}$ cm

23. In vacuum measurement, the gauge factor is given by :

(A) $\frac{\Delta L / L}{\Delta R / R}$

(B) $\frac{\Delta R / R}{\Delta L / L}$

(C) $\frac{\Delta R / R}{\Delta D / D}$

(D) $\frac{\Delta R / R}{\Delta P / P}$

where L, D, P and R are respectively length, diameter, resistivity and resistance of strain.

24. The life time of μ-meson is $2 \times 10^{-6}$ sec. A beam of μ mesons emerges from a cyclotron with velocity 0.8 C, where C is the speed of light in free space. What would be the mean life of the μ-mesons in this beam as observed in the laboratory ?

(A) $3 \times 10^{-6}$ sec

(B) $3 \times 10^{-7}$ sec

(C) $6 \times 10^{-6}$ sec

(D) $6 \times 10^{-8}$ sec

25. A pulley of negligible weight is suspended by a spring balance. Weights of 1 kg and 5 kg are attached to the opposite ends of a string passing over the pulley and move with acceleration because of gravity. During their motion, the spring balance will read a weight :

(A) 6 kg

(B) Less than 6 kg

(C) Greater than 6 kg

(D) Reading depends on the stiffness of the spring

26. A bullet is fired from a rifle. If the rifle were allowed to recoil freely (i.e. without being restrained by the person's shoulder) its kinetic energy as a result of recoil would be :

(A) Equal to

(B) Less than

(C) Greater than

(D) Not related to

that of the bullet.

27. The 0 – 10 V A/D converter has to have a resolution of 0.025 per cent. The r.m.s. value of quantization error is :

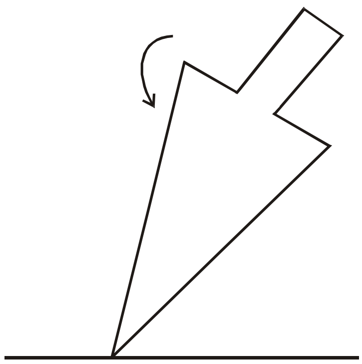
(A) 176 μV

(B) 705 μV

(C) 352 μV

(D) 1410 μV

28. The top is spinning about its axis in the sense indicated by the arrow. The lower end of the top pivots on a table. Then, as seen from above looking down apon it :



(A) top will woble in a vertical plane

(B) top will precess clockwise

(C) top will precess counter-clockwise

(D) top will periodically change its sense of precession

29. Masses $m$ and $3m$ are attached to the two ends of a spring of spring constant $k$. Its period of oscillation is :

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

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

(C) $\pi\sqrt{\frac{m}{3k}}$

(D) $\pi\sqrt{\frac{3m}{k}}$

30. The mutual potential energy V of two particles depends on their mutual distance $r$ as follows,

$$V = \frac{a}{r^2} - \frac{b}{r}$$

where $a > 0$ and $b > 0$ are constants. For what separation $r$ are the particles in static equilibrium ?

(A) $r = \frac{a}{2b}$

(B) $r = \frac{a}{a+br}$

(C) $r = \frac{ab}{(a+br)^2}$

(D) $r = \frac{2a}{b}$

31. Suppose that the radius of the earth were to shrink by 1% its mass remaining the same. Then the acceleration due to gravity *g* on the earth's surface :

(A) increases by 2%

(B) increases by 1%

(C) decreases by 1%

(D) decreases by 2%

32. Continuity equation in electromagnetism is equivalent to :

(A) Quantization of energy

(B) Quantization of charge

(C) Conservation of energy

(D) Conservation of charge

33. A current carrying straight wire is kept along the axis perpendicular to the plane of a current carrying circular loop. The straight wire :

(A) will exert an inward force on the loop

(B) will exert an outward force on the loop

(C) will exert a force on the loop but the direction of the force cannot be determined as the directions of the currents are not specified

(D) will not exert any force on the loop

34. A conducting rod of length $l$ is moved with a constant velocity $\bar{v}$ in the uniform magnetic field $\bar{B}$. In which of the following cases, a potential difference will appear across the two ends of the rod ?

(A) $\bar{v} \square \bar{l}$

(B) $\bar{v} \square \bar{B}$

(C) $\bar{l} \square \bar{B}$

(D) None of the above

35. Electric charges are distributed in a small volume of sphere of radius 1 cm. The flux of the electric field through a spherical surface of radius 10 cm surrounding the total charge is 20 Vm. The flux through a concentric spherical surface of radius 20 cm is :

(A) 5 Vm

(B) 20 Vm

(C) 80 Vm

(D) 0 Vm

36. An electric dipole is placed in a uniform electric field. The net electric force on the dipole :

(A) is always zero

(B) depends only on the strength of the dipole

(C) depends only on the orientation of the dipole

(D) depends on both the strength and the orientation of the dipole

37. Two resistors R and 2R are connected in parallel in an electric circuit. The thermal energies developed in them are $Q_1$ and $Q_2$ respectively, then $\frac{Q_1}{Q_2}$ = ................. .

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

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

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

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

38. Two point charges are placed in air at a certain distance apart. If a slab of mica is placed in the region between them, then which of the following will happen ?

(A) The force between the charges increases

(B) The force between the charges decreases

(C) The force between the charges remains unchanged

(D) Both the point charges move to infinity

39. Three capacitors of capacitances 3 μF, 9 μF and 18 μF are connected once in series and another time in parallel. The ratio of equivalent capacitances in the two cases $\frac{C_S}{C_P}$ = ................. .

(A) $\frac{1}{15}$

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

(C) 1

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

40. For motion of 2 particles moving in 2 dimensional space, the phase space required to represent the state of the particles must have at least :

(A) 8 dimensions

(B) 6 dimensions

(C) 4 dimensions

(D) 16 dimensions

41. The mean energy of a classical ideal gas having N monatomic particles at a temperature T will be :

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

(B) NkT

(C) 2 NkT

(D) $\frac{3}{2}$ NkT

42. Consider a system of 4 spins with spin $S = \frac{1}{2}$ and magnetic moment μ each. It is placed in an external magnetic field H. The magnetic moments can either be parallel or antiparallel to the magnetic field. Consider a macrostate of the system with energy $-2\mu H$. Using the postulate of equal a priori probability, the probability of finding the system with the magnetic moment $-2\mu$ is given by :

(A) 1/16

(B) 1/4

(C) 1/8

(D) 1/2

43. The volume of a perfect gas is doubled, the number N of atoms and the energy being held constant. The change in entropy will be :
    (A) Nk *ln* V
    (B) 2 Nk *ln* V
    (C) Nk *ln* 2
    (D) $\frac{1}{2}$ Nk *ln* (2 V)

44. Consider N particles with spin angular momentum S each. Each spin has 2S + 1 projections along the axis of quantization. The total number of microstates of the system will be :
    (A) N (2S + 1)
    (B) $(2S + 1)^N$
    (C) $N^{2S + 1}$
    (D) N (2S + 1) !

45. In a process, a thermally isolated system goes over to one macrostate to another, then the entropy tends to :
    (A) Increase only
    (B) Decrease only
    (C) Increase or remain constant
    (D) Zero

46. For the Fermi-Dirac distribution, the probability of occupation of a single particle energy level is equal to :
    (A) the average occupancy of that level
    (B) one
    (C) $\frac{1}{2}$ the average occupancy of that level
    (D) 0

47. Consider degenerate Fermi gas at T = 0 with the Fermi energy $E_F$. The mean energy per particle will be :
    (A) $\frac{3}{5} E_F$
    (B) $\frac{1}{2} E_F$
    (C) $\frac{2}{3} E_F$
    (D) $\frac{5}{3} E_F$

48. The equation of state of an ideal gas in the non-relativistic state is given by :

(A) $PV = \frac{2}{3} U$

(B) $PV = \frac{2}{5} U$

(C) $PV = \frac{1}{3} U$

(D) $PV = \frac{5}{2} U$

49. Electrostatic potential V at a distance $r$ from the ideal dipole follows the relation :

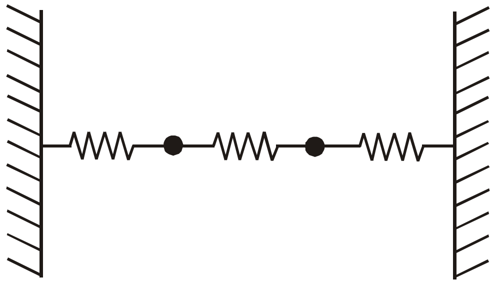
(A) $V \propto r$

(B) $V \propto \frac{1}{r}$

(C) $V \propto \frac{1}{r^2}$

(D) $V \propto r^2$

50. Two particles of equal mass are connected by springs as shown and are free to execute longitudinal one-dimensional oscillations. Then the vibrations superposition of :



(A) Two normal modes one with out of phase and the other with in phase vibrations along the springs (longitudinal)

(B) Two normal modes one out of phase and one in phase, transverse to the springs

(C) Three longitudinal normal modes

(D) Three transverse normal modes

## ROUGH WORK

**ROUGH WORK**