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PAPER – II

PHYSICAL SCIENCES

Signature of the Invigilator

Question Booklet No. 050866

1.

OMR Sheet No.. .....

Subject Code 05 **ROLL No.**

Time Allowed : 75 Minutes **Max. Marks : 100**

No. of pages in this Booklet : **12** No. of Questions : **50**

INSTRUCTIONS FOR CANDIDATES

1. Write your Roll No. and the OMR Sheet No. in the spaces provided on top of this page.
2. Fill in the necessary information in the spaces provided on the OMR response sheet.
3. This booklet consists of fifty (50) compulsory questions each carrying 2 marks.
4. Examine the question booklet carefully and tally the number of pages/questions in the booklet with the information printed above. **Do not accept a damaged or open booklet.** Damaged or faulty booklet may be got replaced within the first **5** minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time given.
5. Each Question has four alternative responses marked (A), (B), (C) and (D) in the OMR sheet. You have to completely darken the circle indicating the most appropriate response against each item as in the illustration.



6. All entries in the common OMR response sheet for Papers I and II are to be recorded in the original copy only.
7. Use only Blue/Black Ball point pen.
8. Rough Work is to be done on the blank pages provided at the end of this booklet.
9. If you write your Name, Roll Number, Phone Number or put any mark on any part of the OMR Sheet, except in the spaces allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
10. You have to return the Original OMR Sheet to the invigilators at the end of the examination compulsorily and must not carry it with you outside the Examination Hall. **You are, however, allowed to carry the test booklet and the duplicate copy of OMR Sheet** on conclusion of examination.
11. Use of any calculator, mobile phone or log table etc. is strictly prohibited.
12. **There is no negative marking.**

05-16

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PAPER-II
PHYSICAL SCIENCES

1. If $u = x^2 - y^2 + z^2$ and $\vec{V} = x\hat{i} + y\hat{j} + z\hat{k}$ then $\vec{\nabla} \cdot (u\vec{V})$ is equal to :

(A) $5\vec{V}$

(B) $5(u - |\vec{V}|)$

(C) $5u$

(D) $5(u + |\vec{V}|)$

2. The line integral $\int_C x^2dx + y^2dy$, where C is the boundary of the region $x^2 + y^2 < a^2$ equals to :

(A) a

(B) πa^2

(C) $\frac{1}{3}\pi a^3$

(D) 0

3. The difference between the maximum and the minimum values of the function $a \sin x = b \cos x$ is :

(A) $2(a^2 + b^2)$

(B) $2\sqrt{a^2 + b^2}$

(C) $\sqrt{a^2 + b^2}$

(D) $-\sqrt{a^2 + b^2}$

4. The integral value of $\frac{1}{(z^3 - 1)^2}$ in the counter clock-wise direction around the circle $|z - 1| = 1$ is :

(A) $-\frac{4\pi i}{9}$

(B) $\frac{4\pi i}{9}$

(C) $-4\pi i/3$

(D) $4\pi i/3$

5. If $f(s) = \int_0^\infty F(t)e^{-st}dt$, then the value of $\int_0^\infty tF(t)e^{-st}dt$ is :

(A) $-dF(t)/dt$

(B) $-dF(t)/ds$

(C) $-df(s)/ds$

(D) $-df(s)/dt$

6. The real part of the principal value of 5^{5-i} is :

(A) $625 \cos(\ell n\, 5)$

(B) $3125 \sin(\ell n\, 5)$

(C) $5^{-5} \cos(\ell n\, 5)$

(D) $3125 \cos(\ell n\, 5)$

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7. The eigen values of the antisymmetric matrix

$$A = \begin{bmatrix} 0 & -u_3 & u_2 \\ u_3 & 0 & -u_1 \\ -u_2 & u_1 & 0 \end{bmatrix}$$, where u_1, u_2 and u_3 are components of a unit vector, are :

(A) $0, +i$ and $-i$

(B) $0, +2i$ and $-2i$

(C) $0, +2i$ and $-i$

(D) $0, +i$ and $-2i$

8. Poisson Distribution is given by $P_x = \frac{e^m m^x}{x!}$. Which of the following is correct ?

(I) $P_{x-1} = \frac{x}{m} P_m$

(II) $P_{x+1} = \frac{m}{x+1} P_x$

(III) $P_{m-1} = P_m$

(A) (I) and (III) only

(B) (I), (II) and (III)

(C) (II) only

(D) (II) and (III) only

9. The solution of the differential equation

$$\frac{dy}{dx} + y\left(\frac{d\phi}{dx}\right) = \phi(x)\frac{d\phi}{dx}$$ is :

(A) $y = \phi(x) + 1 + ce^{-\phi(x)}$

(B) $y = \phi(x) - ce^{-\phi(x)}$

(C) $y = \phi(x) - 1 + ce^{-\phi(x)}$

(D) $y = \phi(x) + ce^{-\phi(x)}$

10. For the function $\psi_n(x)$ defined by the $\psi_n(x) = e^{-\frac{1}{2}x^2} H_n(x)$ where $H_n(x)$ is Hermite polynomial of degree 'n', which of the following relations is true ?

(I) $2n\psi_{n-1} = x\psi_n + \frac{\partial \psi_n}{\partial x}$

(II) $2x\psi_n = 2n\psi_{n-1} + \psi_{n+1}$

(III) $\partial\psi_n/\partial x = x\psi_n - \psi_{n+1}$

(A) (I) and (II)

(B) (II) and (III)

(C) (III) and (I)

(D) (I), (II) and (III)

11. Rutherford's scattering cross-section :

(A) has the dimensions of area

(B) has the dimensions of solid angle

(C) is proportional to the square of the kinetic energy of the incident particle

(D) is inversely proportional to the square of the charge on the particle (ze)

12. Hamilton's principle is an example of a :

(A) Force

(B) Hamiltonian

(C) Lagrange multiplier

(D) Variational principle

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13. The Lagrangian for a charged particle moving with a velocity v in an electromagnetic field is :

(A) $L = T + q\phi + q(v.A)$

(B) $L = T - q\phi - q(v.A)$

(C) $L = T - q\phi + q(v.A)$

(D) $L = T + q\phi - q(v.A)$

where, T is the kinetic energy and ϕ and A are magnetic scalar and vector potentials.

14. The _____ of a system of particles moves as if it were a particle of mass equal to the total mass of the system subjected to the external forces applied on the system.

(A) Centre of gravity

(B) Centre of mass

(C) Both the centre of mass and centre of gravity

(D) Neither centre of mass nor centre of gravity

15. The general expression for canonical or conjugate momentum is, $p_j = \frac{\partial L}{\partial \dot{q}_j}$. Given the Lagrangian $L = \frac{1}{2}m\dot{x}^2 - V(x)$, what is x's conjugate momentum ?

(A) $\frac{1}{2}m\dot{x}^2$

(B) mx

(C) $m\dot{x}$

(D) $-\left(\frac{\partial V}{\partial x}\right)$

16. If the Lagrangian is cyclic in q_j, then :

(A) p_j is not conserved.

(B) p_j is conserved.

(C) q_j appears in the Lagrangian.

(D) $\dot{q}_j$ (i.e., dq_j/dt) does not appear in the Lagrangian.

q_j & p_j are generalized coordinates and momentum respectively.

17. The work done is zero in the case of arbitrary virtual displacement of a system from a position of equilibrium is called the :

(A) Hamilton's principle

(B) D'Alembert's principle

(C) Principle of least action

(D) Principle of virtual work

18. An expression for the canonical angular momentum in a central force problem is :

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

(C) $\frac{1}{2}mr^2\dot{\theta}$ (D) $\frac{m_1m_2}{m_1+m_2}$

19. If a particle of rest mass m_0 moves with a velocity v, its energy is :

(A) $\sqrt{p^2c^2 - m_0^2c^4}$

(B) $p^2c^2 + m_0^2c^4$

(C) $m_0^2c^2$

(D) $\sqrt{p^2c^2 + m_0^2c^4}$

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20. In case of a linear tri-atomic molecule of type AB_2, the eigen frequencies ω_1, ω_2 and ω_3 can be represented as :

(A) $\omega_1 = 0, \omega_2 = \omega_3$
(B) $\omega_1 = 0, \omega_2 \neq \omega_3$
(C) $\omega_1 = \omega_2 = \omega_3$
(D) $\omega_1 = \omega_2 \neq \omega_3$

21. Which of the following is not a Gaussian surface of a symmetric charge distribution ?

(A) Concentric sphere
(B) Co-axial cylinder
(C) Pill box
(D) Prism

22. If electrostatic field E is conservative, which of the these statements is false ?

(A) E is gradient of a scalar field
(B) Curl of E is zero
(C) Work done in a closed path inside electric field is zero
(D) Potential difference between any two points inside the field is zero

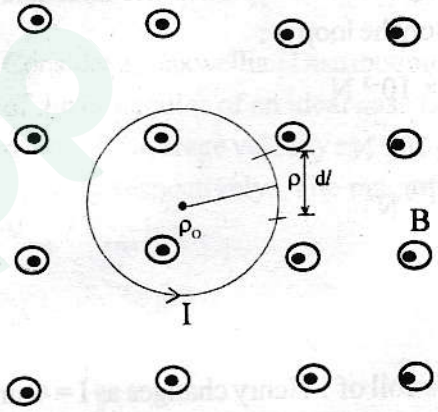
23. Which of the following potentials does not satisfy the Laplace equation ?

(A) 2x+5
(B) 10/r
(C) 10xy
(D) rcosφ

24. Which of the following is not characteristic of a static magnetic field ?

(A) it is solenoidal
(B) it is conservative
(C) magnetic flux lines are always closed
(D) number of magnetic flux lines entering a given region is equal to number of lines leaving

25. The resultant force on the circular loop shown in the figure has magnitude of



(A) $2\pi\rho_0 IB$
(B) $\pi\rho_0^2 IB$
(C) $2\rho_0 IB$
(D) Zero

26. Which of the following is a major factor for determining whether a medium is free space, lossless dielectric, lossy dielectric or a good conductor?

(A) attenuation constant
(B) reflection coefficient
(C) constitutive parameters (ε, σ and μ)
(D) loss tangent

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27. A charged particle moving in crossed electric field E and magnetic field B undergoes no deflection. The magnitude of its velocity is :

(A) E/B

(B) B/E

(C) E^2/B^2

(D) B^2/E^2

28. A circular wire loop of diameter 20 cm carrying current of 1.8A lies in XY- plane. It is immersed in a uniform magnetic field of 1 Tesla in Z-direction. The total force on the loop is :

(A) 3.14×10^{-3} N

(B) 4.5×10^{-5} N

(C) 9×10^{-5} N

(D) Zero

29. Current in a coil of 1 Henry changes as $I = 4 \sin 2t$. During the time current changes from 0 to 4 Amperes, the amount of energy spent is :

(A) 24 J

(B) 16 J

(C) 8 J

(D) 4 J

30. A plane electromagnetic wave of angular frequency ω has propagation vector k. Its velocity is :

(A) ωk

(B) ω/k

(C) ω^2/k^2

(D) k^2/ω^2

31. In the time independent perturbation theory, the perturbed Hamiltonian is :

(A) Greater than unperturbed Hamiltonian

(B) Equivalent to unperturbed Hamiltonian

(C) Small compared to unperturbed Hamiltonian

(D) Not considered

32. The zero-point energy of a linear harmonic oscillator is :

(A) Zero

(B) One

(C) $\hbar\omega$

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

33. Which of the following is correct ?

(A) $\sigma \times \sigma = 0$

(B) $\sigma \times \sigma = 1$

(C) $\sigma \times \sigma = \hbar\sigma$

(D) $\sigma \times \sigma = 2i\,\sigma$

where σ represent Pauli's matrices.

34. Any two eigen functions of a Hermitian operator that belong to two different eigen values are :

(A) Normal

(B) Orthogonal

(C) Orthonormal

(D) Either normal or orthogonal

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35. Which of the following is not a Maxwell's thermodynamic relation?

(A) $\left[\frac{\partial S}{\partial V}\right]_T = \left[\frac{\partial P}{\partial T}\right]_V$

(B) $\left[\frac{\partial T}{\partial P}\right]_S = \left[\frac{\partial V}{\partial S}\right]_P$

(C) $\left[\frac{\partial T}{\partial V}\right]_S = -\left[\frac{\partial P}{\partial S}\right]_V$

(D) $\left[\frac{\partial V}{\partial P}\right]_T = -\left[\frac{\partial S}{\partial T}\right]_P$

36. A heat engine works on a Carnot cycle with the heat sink at a temperature of 127 °C. If the efficiency is 20%, the temperature of the heat source will be:

(A) 227 °C

(B) 327 °C

(C) 273 °C

(D) 373 °C

37. The rectangular surface of area 8cm × 4cm of a black body at a temperature of 127 °C emits energy at the rate of E per second. If the length and breadth of the surface are each reduced to half of its initial value and the temperature is raised to 727 °C, the rate of emission of energy will become :

(A) $\frac{625}{16}E$

(B) $\frac{625}{64}E$

(C) $\frac{625}{32}E$

(D) $\frac{125}{16}E$

38. N bosons occupy two levels, one with energy zero and the other with energy unity. The system is in thermal equilibrium at temperature $T = 1/k_B\,\beta$, where k_B is the Boltzmann constant. The canonical partition function of the system is :

(A) $[1+\exp(-\beta)]^{-N}$

(B) $[1-\exp(-\beta)]^{-N}$

(C) $[1+\exp(-\beta)]^{N}$

(D) $[1-\exp(-\beta)]^{N}$

39. Consider a Maxwellian Distribution of the velocities of the molecules of an ideal gas. Let V_{avg} and V_{rms} denote the average velocity and the root mean square velocity respectively. The magnitude of the ratio V_{avg}/V_{rms} is :

(A) $\sqrt{2/3}$

(B) $\sqrt{4/3\pi}$

(C) $\sqrt{8\pi/3}$

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

40. Planck's law of thermal radiation reduces to Wien's formula and Rayleigh-Jeans formula respectively at :

(A) Short and Long frequencies

(B) Low and High temperatures

(C) Short wavelength & Long wavelength

(D) Long wavelength and Short wavelength

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41. For a three dimensional free electron gas, the electron density n, and the Fermi energy E_F are related by

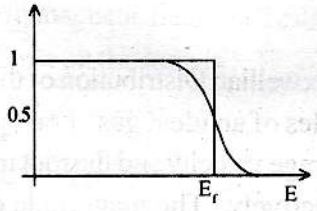
(A) $n = mE_F / 2\pi\hbar^2$

(B) $n = 2^{3/2}(mE_F)^{3/2}/\pi\hbar$

(C) $n = mE_F/\pi\hbar^2$

(D) $n = \frac{1}{3\pi^2}\left(\frac{2mE_F}{\hbar^2}\right)^{3/2}$

42. The plot of the figure represents :



(A) Fermi-Dirac distribution at zero temperature

(B) Fermi-Dirac distribution at non-zero temperature

(C) Bose-Einstein distribution at zero temperature

(D) Bose-Einstein distribution at non-zero temperature

43. First order phase transition involves :

(A) Discontinuity in entropy

(B) Latent Heat

(C) Continuity of specific heat

(D) Discontinuity in Gibbs function

44. Expression for the diode equation

(A) $I = I_0[\exp.(eV/\eta kT) - 1]$

(B) $I = I_0[\exp.(\eta kT/eV) + 1]$

(C) $I = I_0[\exp.(eV/\eta kT) + 1]$

(D) $I = I_0[\exp.(\eta kT/eV) - 1]$

45. What is the difference between common-mode and differential-mode input signals?

(A) Phase relationship

(B) Voltage

(C) Current

(D) Power

46. A field effect transistor is a :

(A) Unipolar device

(B) Special type of BJT

(C) Unijunction device

(D) Device with low input impedance

47. A bipolar junction transistor with one junction forward biased and either the collector or emitter open, operates in the :

(A) Cut-off region

(B) Saturation region

(C) Pinch off region

(D) Active region

48. An n-stage ripple counter will count upto :

(A) 2^n

(B) n

(C) 2^{n+1}

(D) $2^n - 1$

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49. Which of the following ADC is the fastest?

(A) Successive Approximation

(B) Dual Slope

(C) Ramp ADC

(D) Flash type

50. Which of the following error is used to correct the human mistakes in reading instruments?

(A) Gross error

(B) Random error

(C) Systematic error

(D) Instrumental error

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