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PAPER – III

PHYSICAL SCIENCES

Signature of the Invigilator

Question Booklet No. 050443

1.

OMR Sheet No.. .....

Subject Code 05 **ROLL No.**

Time Allowed : 150 Minutes **Max. Marks : 150**

No. of pages in this Booklet : **12** No. of Questions : **75**

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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 seventy five (75) 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.



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05-16

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PAPER-III
PHYSICAL SCIENCES

1. In which of the following numerical integration methods the value of number of intervals (n) must be multiple of three ?

   (A) Trapezoidal rule

   (B) Simpson's 1/3 rule

   (C) Simpson's 3/8 rule

   (D) Newton-Cotes formula

2. Eigen values of the matrix $\begin{bmatrix} 1 & i \\ -i & 1 \end{bmatrix}$ are :

   (A) 1

   (B) 0,1

   (C) 0,2

   (D) $-1,1$

3. Newton-Raphson method is to be used to calculate $\sqrt[3]{65}$. Initial guess is to be taken as 4. The first approximation is :

   (A) 65/16

   (B) 131/32

   (C) 191/48

   (D) 193/48

4. In which of the following algebraic equations root finding methods the error is of the order of square of the error of previous iteration ?

   (A) Bisection method

   (B) False position method

   (C) Newton-Raphson method

   (D) Secant method

5. $A^{ijk}{}_{lm}B^{m}{}_{i}$ is a tensor of rank :

   (A) 3

   (B) 5

   (C) 7

   (D) 6

6. If A^i and B_j are tensors, then their product is :

   (A) Tensor of rank zero

   (B) Covariant tensor of rank one

   (C) Contravariant tensor of rank one

   (D) Mixed tensor of rank two

7. For a conservative system the relation between Hamilton's principal function S and Characteristic function W is :

   (A) $S = W$

   (B) $S = W + Et$

   (C) $S = W - Et$

   (D) $S = Wt - E$

   where E is the total energy and t is the time.

8. Hamilton's canonical equations of motion in Poisson bracket form are :

   (A) $\dot{q}_k = -[q_k, H], \dot{p}_k = [p_k, H]$

   (B) $\dot{q}_k = [q_k, H], \dot{p}_k = -[p_k, H]$

   (C) $\dot{q}_k = -[q_k, H], \dot{p}_k = -[p_k, H]$

   (D) $\dot{q}_k = [q_k, H], \dot{p}_k = [p_k, H]$

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9. Canonical transformations can often be conveniently found or verified by using a :

(A) Generating function

(B) Degenerating function

(C) Separation tensor

(D) Separation matrix

10. If the generating function has the form $F = F(q_k, P_k, t)$, then :

(A) $p_k = -\frac{\partial F}{\partial q_k}, Q_k = \frac{\partial F}{\partial P_k}$

(B) $p_k = \frac{\partial F}{\partial q_k}, Q_k = \frac{\partial F}{\partial P_k}$

(C) $p_k = \frac{\partial F}{\partial q_k}, Q_k = -\frac{\partial F}{\partial P_k}$

(D) $p_k = -\frac{\partial F}{\partial q_k}, Q_k = -\frac{\partial F}{\partial P_k}$

11. For a second order system, the nature of fixed points for unstable mode is :

(A) $\lambda_1, \lambda_2 < 0$

(B) $\lambda_1, \lambda_2 > 0$

(C) $\lambda_1 > 0, \lambda_2 < 0$

(D) $\lambda_1 < 0, \lambda_2 > 0$

where λ_1, & λ_2 are eigen values of the stability matrix.

12. The generating function for point transformation is :

(A) $F = \Sigma q_i Q_i$

(B) $F = -\Sigma q_i Q_i$

(C) $F = \Sigma q_i P_i$

(D) $F = \Sigma P_i f_i(q, t)$

13. Choose the wrong statement related to Noether's Theorem :

(A) If the Lagrangian is independent of the location of the origin then the system will conserve linear momentum

(B) If the Lagrangian is independent of the base time then energy is not conserved

(C) If the Lagrangian is independent of the angle of measurement then angular momentum is conserved

(D) If a transformation of the co-ordinate system satisfies certain condition, namely being continuous, then necessarily there exist a quantity that is conserved

14. The action and angle variables have the dimensions of :

(A) Energy and angle

(B) Force and angle

(C) Pressure and angle

(D) Angular momentum and angle

15. If the generating function has the form $F = F(p_k, Q_k, t)$, then :

(A) $q_k = -\frac{\partial F}{\partial p_k}, P_k = -\frac{\partial F}{\partial Q_k}$

(B) $q_k = \frac{\partial F}{\partial p_k}, P_k = -\frac{\partial F}{\partial Q_k}$

(C) $q_k = \frac{\partial F}{\partial p_k}, P_k = \frac{\partial F}{\partial Q_k}$

(D) $q_k = -\frac{\partial F}{\partial p_k}, P_k = \frac{\partial F}{\partial Q_k}$

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16. The correct relation for Poisson brackets are :

(A) $[q_k, q_l] = \delta_{kl}$

(B) $[q_k, q_l] = 0$

(C) $[q_k, p_k] = 0$

(D) $[p_k, p_l] = 1$

17. Consider a transmission line of characteristic impedance 50 ohms. It is terminated at one end by j50 ohms. The VSWR of the line is :

(A) 1

(B) 0

(C) infinity

(D) +j

18. Which of the following statements are not true of the line parameters R, L, G and C ?

(A) R and L are series elements

(B) G and C are shunt elements

(C) The parameters are not lumped but distributed

(D) $LC = \mu\varepsilon$ and $RG = \sigma\varepsilon$

19. At microwave frequencies, waveguides are preferred to transmission lines for transporting EM energy because of all the following except that :

(A) Losses in transmission line are prohibitively large

(B) Waveguides have larger bandwidths and lower signal attenuation

(C) Transmission lines support only TEM mode

(D) Transmission lines are smaller than waveguides

20. When a high speed electron hits a metal target it decelerates giving off :

(A) Bremsstrahlung

(B) Cerenkov radiation

(C) Synchrotron radiation

(D) None of the above

21. The ratio of electric field E and magnetic field H i.e. E/H has the units of :

(A) Resistance

(B) Inductance

(C) Capacitance

(D) Time

22. The Maxwell equation which remains unchanged when a medium changes is :

(A) $\nabla.B = 0$

(B) $\nabla.E = 0$

(C) $\nabla \times B = \mu J + \mu \in \frac{\partial E}{\partial t}$

(D) None of the above

23. Radiated power by an oscillating electric dipole of dipole moment p proportional to (ω = angular frequency) :

(A) $\omega^4 p$

(B) $\omega^4 p^2$

(C) $\omega^4 p^3$

(D) $\omega^4 p^4$

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24. The dispersion relation for electromagnetic wave in a certain medium is given by $\omega^2 = ak$ where a is constant, ω is angular frequency and k is wave vector. The velocity of the energy propogation is :

(A) $a/(2\omega)$

(B) a/k

(C) $2\omega/k$

(D) $a/(4\omega)$

25. In a transmission line in air, adjacent maximum are found at 12 cm and 37 cm. The operating frequency is :

(A) 1.5 GHz

(B) 600 MHz

(C) 300 MHz

(D) 1.0 GHz

26. Characteristic impedance (Z_0) of a loss less transmission line is :

(A) $\sqrt{\frac{R}{G}}$

(B) $\sqrt{\frac{G}{R}}$

(C) $\sqrt{\frac{L}{C}}$

(D) $\sqrt{\frac{C}{L}}$

27. The dominant mode of a rectangular wave guide is :

(A) TE_{11}

(B) TM_{11}

(C) TE_{101}

(D) TE_{10}

28. The relations between Hamiltonian (H) and momentum (**p**) are given below, which of the statements is correct ?

(A) H is proportional to **p** in the Dirac equation

(B) H is proportional to **p** in the Schrödinger equation

(C) H is proportional to **p** in the Klein-Gordon equation

(D) H^2 is proportional to **p** in the Klein-Gordon equation

29. WKB approximation is suitable for a _____ potential system.

(A) Slowly varying

(B) Fast varying

(C) Constant

(D) None of these

30. The validity condition for the WKB approximation is :

(A) $\lambda/4\pi \mid dx/dk \mid << k$

(B) $\lambda/4\pi \mid dx/dk \mid << 1$

(C) $4\pi / \lambda / \mid dx/dk \mid << k$

(D) $\lambda/4\pi \mid dk/dx \mid << k$

31. According to Dirac relativistic theory, the energy spectrum of a free particle has two branches of corresponding to E_+ and E_- and these two branches are separated by a forbidden gap of width _____ .

(A) mc^2

(B) $-mc^2$

(C) $2\,mc^2$

(D) $-2\,mc^2$

32. In the relativistic, quantum mechanics, Klein-Gordon equation leads to _____ probability density values.

(A) Only positive

(B) Only negative

(C) Positive and negative

(D) Zero

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33. The normalization constant of a wave function $\psi(x) = A \sin(n\pi x/L)$ of a particle, constrained to move in the domain $0 \leq x \geq L$, is :

(A) $\sqrt{(2/L)}$ (B) $\sqrt{(L/2)}$

(C) one (D) zero

34. Which of the following is a correct Maxwell's relation ?

(A) $-(\partial T/\partial V)_s = (\partial P/\partial S)_v$

(B) $(\partial T/\partial P)_s = \left(\frac{\partial V}{\partial S}\right)_p$

(C) $(\partial P/\partial T)_v = \left(\frac{\partial S}{\partial V}\right)_p$

(D) $(\partial V/\partial T)_p = (\partial S/\partial P)_T$

35. In case of Second-order phase transition, which of the following statements is/are correct ?

I. There is no discontinuity in the first order derivative of Gibbs function

II. Second order derivatives of Gibbs function change discontinuously

(A) I only

(B) II only

(C) I and II, both

(D) Neither I nor II

36. Thermodynamical potentials are :

(A) Power terms

(B) Velocity functions

(C) Momentum functions

(D) Energy functions

37. The Claussius-Clapeyron equation $L/(V_2-V_1)=T(\partial P/\partial T)$ can be derived from :

(A) $(\partial S/\partial P)_T = -(\partial V/\partial T)_P$

(B) $(\partial C_P/\partial T)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$

(C) $(\partial S/\partial V)_T = -(\partial P/\partial T)_V$

(D) $(\partial P/\partial V)_T = -(\partial P/\partial T)_V (\partial T/\partial V)_P$

38. In an isothermal isobaric reversible process, the value of Gibbs function G = H – TS (where H-enthalpy, T-temperature, S-entropy) :

(A) remains constant, but not zero

(B) varies linearly

(C) varies non-linearly

(D) is zero

39. Isotope effect in superconductors is related to :

(A) Electron-electron interaction

(B) Photon-phonon interaction

(C) Phonon-phonon interaction

(D) Electron-phonon interaction

40. For a ferromagnetic material, if J is an Exchange integral :

(A) J is positive and spins are parallel

(B) J is negative and spins are parallel

(C) J is positive and spins are anti-parallel

(D) J is negative and spins are anti-parallel

41. With symbols of usual notation, conduction electron paramagnetic susceptibility is :

(A) $\chi_p = N^2_\mu / E_F$ (B) $\chi_p = N^2_\mu / 2E_F$

(C) $\chi_p = 3N^2_\mu / 2E_F$ (D) $\chi_p = 2N^2_\mu / 3E_F$

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42. The number of super electrons (n_s) is given by :

(A) $n_s = n_o [1 - (T/T_c)^4]$

(B) $n_s = n_o [1 - (T/T_c)^{-4}]$

(C) $n_s = n_o [1 - T^4/T_c^4]$

(D) $n_s = n_o [1 + T^4/T_c^4]$

43. According to Curie-Weiss Law, susceptibility χ is (for C-Curie constant, T_c-Curie temperature) :

(A) $\chi = C / (T - 2T_c)$

(B) $\chi = C / (T - T_c)$

(C) $\chi = 2C / T - T_c$

(D) $\chi = C / (2T - T_c)$

44. A band reject filter has :

(A) One pass band and two stop bands

(B) Two stop bands and two pass bands

(C) One pass band and one stop band

(D) Two pass bands and one stop band

45. Expression for high cut off frequency (f_H) in Second order low pass Butterworth filter :

(A) $2\pi\sqrt{R_2R_3C_2C_3}$

(B) $1/2\pi RC$

(C) $1/2\pi\sqrt{R_2R_3C_2C_3}$

(D) $1/12\pi RC$

46. The size of air cored transducers as compared with their iron cored counterparts is :

(A) Smaller

(B) Bigger

(C) Same

(D) All of the above

47. Which of the following acts as an inverse transducer ?

(A) Capacitive transducer

(B) LVDT

(C) Piezo electric crystal

(D) None of the above

48. For an oscillator, the gain around the feedback loop must initially be :

(A) 1

(B) Less than 1

(C) Greater than 1

(D) 0

49. The typical wavelengths emitted by diatomic molecules of purely vibrational and purely rotational transitions are respectively in the region of :

(A) Infrared, visible

(B) Visible, infrared

(C) Infrared, microwave

(D) Microwave and infrared

50. Lande g factor for level $3\ ^2P_{3/2}$ is :

(A) 3/2

(B) 3

(C) 2

(D) 4/3

51. On application of weak magnetic field the level $^2D_{5/2}$ will have _____ number of Zeeman levels.

(A) 6

(B) 4

(C) 2

(D) 8

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52. Hyper fine structure of $3^2P_{3/2}$ level with nuclear spin I = 3/2 has :

(A) 1 state

(B) 2 states

(C) 3 states

(D) 4 states

53. The L_β line of X-ray spectra of an atom arises from the following transitions :

(A) n = 4 to n = 2

(B) n = 3 to n = 2

(C) n = 5 to n = 2

(D) n = 3 to n = 1

54. IR absorption can be observed in which of the following molecules ?

(A) N_2

(B) O_2

(C) HCl

(D) H_2

55. The value of total angular momentum of a one electron atom in the state $^2D_{5/2}$ is :

(A) $\sqrt{15}\,\hbar$

(B) $\sqrt{35}\,\hbar/2$

(C) $\sqrt{51}\,\hbar$

(D) $\sqrt{45}\,\hbar$

56. In Zeeman effect when viewed perpendicular to the applied field magnetic field, $\Delta m_j = \pm 1$ give :

(A) σ – lines

(B) π – lines

(C) Δ – lines

(D) Σ – lines

57. Presence of isotopes results in the following changes in the atomic spectral lines :

(A) Splitting

(B) Shifting

(C) Merging

(D) All of the above

58. Which of the following is not a character of laser light ?

(A) Monochromaticity

(B) Directionality

(C) Coherence

(D) Reflectivity

59. Choose the correct relation for the thermal conductivity (σ_T) of metals :

(A) $\sigma_T = \sigma_p - \sigma_e$

(B) $\sigma_T = \sigma_p / \sigma_e$

(C) $\sigma_T = \sigma_p + \sigma_e$

(D) $\sigma_p > \sigma_e$

where σ_p, σ_e are the thermal conductivities due to phonons and electrons respectively.

60. Consider an ideal intrinsic semiconductor in thermal equilibrium at room temperature. No external forces or fields are applied to this semiconductor. If n denotes the concentration of electrons in the conduction band while p denotes the number of holes in the valence band, then :

(A) n = p

(B) $n \approx p$ but $p \neq n$

(C) $n \ll p$

(D) $n \gg p$

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61. The relation between H_c and T_c for a super conductor is :

(A) $H_c(T) = H_c(0)\left[\frac{T^2}{T_c^2}\right]$

(B) $H_c(T) = H_c(0)\left[1+\frac{T^2}{T_c^2}\right]$

(C) $H_c(T) = H_c(0)\left[\frac{T^2}{T_c}\right]$

(D) $H_c(T) = H_c(0)\left[1+\frac{T}{T_c^2}\right]$

62. The planes (112) and (224) are :

(A) Differently oriented planes

(B) Parallel to each other

(C) Perpendicular to each other

(D) None of the above

63. In screw dislocation the angle between Burgers vector and dislocation line is :

(A) 90^0

(B) 180^0

(C) 45^0

(D) 120^0

64. The target of an x-ray tube is subjected to an excitation voltage V. The wavelength of emitted x-rays is proportionate to :

(A) $1/\sqrt{V}$

(B) $\sqrt{V}$

(C) $1/V$

(D) V

65. The second Brillouin zone range of k values :

(A) from $-\pi/a$ to $+\pi/a$

(B) from $-\pi/a$ to $-2\pi/a$ and $+\pi/a$ to $+2\pi/a$

(C) from 0 to $+\pi/a$

(D) from 0 to $-\pi/a$

66. For long wavelength limit vibration of monoatomic solid :

(A) Group velocity is more than phase velocity

(B) Group velocity is less than phase velocity

(C) Both group and phase velocities are zero

(D) Group velocity is equal to phase velocity

67. The effective mass of an electron is :

(A) Minimum at the point of inflection

(B) Maximum at $k = 0$

(C) Negative from $k = 0$

(D) Maximum at point of inflection

68. Number of nearest neighbors in bcc lattice is :

(A) 12

(B) 8

(C) 6

(D) 10

69. Which one of the following is a point defect ?

(A) Edge dislocation

(B) Screw dislocation

(C) Grain boundary

(D) Vacancy

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70. The mode of disintegration of a compound nucleus is :

(A) Dependent on the mode of formation, on its energy, angular momentum and parity

(B) Independent of the mode of formation and depends only on its energy, angular momentum and parity

(C) Dependent on the mode of formation and independent of its energy, angular momentum and parity

(D) Independent of the mode of formation, and independent of its energy but depends on angular momentum and parity

71. The beta decay can be explained using :

(A) Time-Dependent perturbation theory

(B) Time-Independent perturbation theory

(C) Variation theory

(D) WKB approximation

72. Which of the following is not made of quarks ?

(A) Baryons

(B) Mesons

(C) Leptons

(D) Pions

73. Which of the following models is generally used to explain the nuclear fission ?

(A) Shell model

(B) Collective model

(C) Liquid drop model

(D) Independent particle model

74. The binding energy, on an average, per nucleon of nuclei is :

(A) 8 eV

(B) 8 keV

(C) 8 MeV

(D) 8 GeV

75. In the semi-empirical formula, the surface energy term is proportional to :

(A) A

(B) $A^{2/3}$

(C) $A^{1/2}$

(D) $A^{-3/4}$

where A represents atomic mass number.

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