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PHYSICS

Time Allowed : 3 Hours]

[Maximum Marks : 190

**DO NOT OPEN THE SEAL GIVEN ON THE RIGHT HAND SIDE UNLESS
INSTRUCTED BY THE INVIGILATOR**

The Question Paper will contain 150 questions and will have 3 Sections as below :

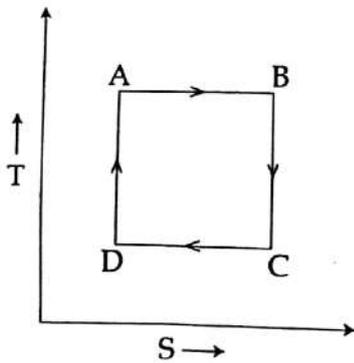
Section		No. of Questions	Marks
(a)	Part A	100	100
(b)	Part B	40	80
(c)	Part C - General Knowledge (Common Part of all Subjects)	10	10
Total		150 Questions	190 Marks

INSTRUCTIONS TO THE CANDIDATES

1. Read carefully and comply.
2. Fill the details including Name of the Candidate, Register Number, Question Paper Booklet Series in the OMR Answer Sheet. If you fail to fill the details and sign as instructed correctly, you will be personally responsible for the consequences arising during the scanning of your Answer Sheet.
3. All the 150 questions are of MCQ (Multiple Choice Questions) type. For each Question you will find 4 possible answers marked by the letters A, B, C and D. You are to select only one correct answer and mark in OMR Answer Sheet as per the instructions given therein. In any case, choose only one answer for each question. There will be no negative marking for wrong answers.
4. In the OMR Answer Sheet for each and every question shade only one answer. If more than one answers are shaded that question will be rejected for valuation.
5. Indicate your answer by darkening the appropriate circle as per the instructions given in the OMR Answer Sheet otherwise his/her Answer Sheet is liable to be rejected. For marking answers use Blue or Black Ball Point Pen only. Ensure that you darken only one circle. Darken it completely and don't overlap with any other circle.
6. Don't mark anything (including marking like \checkmark , \odot , \square) in the question paper booklet other than space provided for this purpose. If you fail to follow this, you will be disqualified.
7. In any event of any mistake in any Questions, candidates will not be penalized. However, no corrections will be made in Questions during the Examination.
8. Use of Mobile Phone, Pager, Digital Diary or any other Electronic Instrument etc., is not allowed. Their use will result in disqualification.
9. No candidate should leave the Examination Hall before the final bell. The OMR Answer Sheet should be handed over to the invigilator before leaving the Examination Hall. **The candidate is allowed to take the Question Booklet and Carbon copy of the OMR Answer Sheet with Him/ Her after the examination.**

1. The PES spectrum is a plot of the :
- (A) intensity of the electron beam versus the glancing angle
 - (B) intensity of the electron beam versus the wavenumber
 - (C) number of electrons emitted versus the kinetic energy
 - (D) ionization energy versus the wavenumber
2. In FT - IR spectrometer :
- (A) frequency domain plot is converted into time domain plot
 - (B) time domain plot is converted into frequency domain plot
 - (C) complex frequency plot is converted into line frequency plot
 - (D) weak signal is strengthened
3. In Raman spectroscopy, the frequency difference between the modified and parent line represents the :
- (A) Polarizability of the substance
 - (B) Frequency of the absorption band of the material
 - (C) Scattering constant of the solvent
 - (D) Strength of the applied field
4. The depolarization ratio (ρ) for completely unpolarized light and completely plane polarized light, respectively, are :
- (A) $\rho = 1$ and $\rho = 0$
 - (B) $\rho = 0$ and $\rho = \text{infinity}$
 - (C) $\rho < 0$ and $\rho > 1$
 - (D) $\rho = 0$ and $\rho = 1$
5. Choose the INCORRECT statement.
- (A) ^{13}C nuclei always have resonance at a frequency lower than proton
 - (B) Gyromagnetic ratio of ^{13}C nucleus is smaller than that of hydrogen
 - (C) The resonances of proton (^1H) are more difficult to observe than those of ^{13}C
 - (D) ^{13}C nuclei, with nuclear spin $I = \frac{1}{2}$ are important in determining the structure of organic molecules.

6. In the below T - S diagram, the vertical line BC represents :



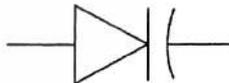
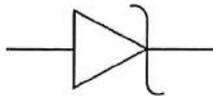
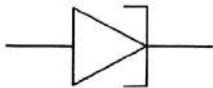
- (A) Isothermal process (B) Adiabatic process
 (C) Isochoric process (D) Isobaric process
7. The state of a gas described in terms of the properties of its constituent particles is called its :
 (A) macroscopic state (B) microscopic state
 (C) phase space (D) μ - space
8. The probability that two particles obeying B - E statistics can be found in same state is :
 (A) Zero (B) 1/2 (C) 1 (D) 1/4
9. If three molecules a, b, c are to be distributed between two halves of a box, if none can be outside the box, then the accessible microstates are :
 (A) (a, b) and (ab, c) (B) (b, c) and (a, bc)
 (C) (a, b) and (a, c) (D) (ab, c) and (ac, b)
10. Second order phase transitions involve abrupt changes in :
 (A) entropy (B) volume (C) heat capacity (D) pressure
11. In a transistor as a current source circuit _____ is the key to rock - solid values of collector current.
 (A) The use of base resistor (B) The use of emitter resistor
 (C) The direct grounding of emitter (D) The use of collector resistor
12. _____ is a measure of the Early effect in common emitter mode transistor amplifiers.
 (A) h_{ie} the input impedance (B) h_{re} reverse voltage gain
 (C) h_{fe} forward current gain (D) h_{oe} output admittance

13. In the Non - inverting voltage feedback mode, if the open - loop voltage gain is A and the feedback ratio is B, then the desensitivity and closed loop voltage gain respectively are :
- (A) $1 + AB ; A/(1 + AB)$ (B) $1 - AB ; A/(1 + AB)$
 (C) $1 + AB ; A/(1 - AB)$ (D) $1 - AB ; A/(1 - AB)$
14. The values of resistance of _____ resistors can be easily adjusted even after fabrication by cutting a part of the resistor with a laser beam.
- (A) Diffused (B) Epitaxial (C) Thin film (D) Pinched
15. In a A/D converter the monotonicity type of output response means, a converter :
- (A) Whose output is progressively higher for progressively higher input
 (B) Whose output is progressively lower for progressively higher input
 (C) Whose output is progressively higher for progressively lower input
 (D) Whose output does not depend on input voltage
16. The probability current density for a particle described by the wave function $\psi(x, t) = e^{i(kx - \omega t)}$ is given by :
- (A) $2\hbar K$ (B) $\hbar K$ (C) $\frac{\hbar K}{2m}$ (D) $\frac{\hbar K}{m}$
17. (a) The eigenvalues of a self - adjoint operator are real.
 (b) Any two eigenfunctions belonging to distinct (un equal) eigenvalues of a self - adjoint operator are mutually orthogonal.
 (c) An operator A is said to be self - adjoint if its adjoint is equal to itself ($A^+ = A$).
- The true statements are :
- (A) (a) and (b) only (B) (b) and (c) only
 (C) (a) and (c) only (D) (a), (b) and (c)
18. (a) $[J_x, J_y] = i\hbar J_z$
 (b) $[J_+, J_-] = 2\hbar J_z$
 (c) $\langle J_z^2 \rangle = m^2 \hbar^2$
 (d) $J_+^+ = J_+$
- The correct statements are :
- (A) (a), (b) and (c) only (B) (a), (c) and (d) only
 (C) (b), (c) and (d) only (D) (a), (b), (c) and (d)

19. The selection rules for the allowed transitions in dipole approximation are :
- (A) $\Delta l = \pm 1 ; \Delta m = 0$ (B) $\Delta l = 0 ; \Delta m = \pm 1$
 (C) $\Delta l = 0 ; \Delta m = \pm 1, 0$ (D) $\Delta l = \pm 1 ; \Delta m = \pm 1, 0$
20. The total angular momentum that may arise when $j_1 = 1$ and $j_2 = 1$ are added is :
- (A) 1, 0, -1 (B) 2, 1, 0 (C) 2, 1, 0, -1, -2 (D) 2, 3/2, 1, 1/2, 0
21. If a plane is parallel to a Co-ordinate axis the corresponding miller index is :
- (A) 1 (B) 0 (C) infinity (D) $\bar{1}$
22. A cubic BaTiO_3 ferroelectric becomes tetragonal when :
- (A) $T = T_c$ (B) $T > T_c$ (C) $T_c = 0\text{K}$ (D) $T < T_c$
23. One among the following properties of the reciprocal lattice is wrong :
- (A) The reciprocal of the reciprocal lattice is the direct lattice
 (B) The volume of the unit cell of the reciprocal lattice is inversely proportional to the volume of a unit cell of direct lattice
 (C) Every reciprocal lattice vector is normal to the lattice plane of the crystal lattice
 (D) The volume of the unit cell of the reciprocal lattice is directly proportional to the volume of a unit cell of direct lattice
24. In metallic sodium having BCC structure. The lines present in the diffraction pattern are :
- (A) (100), (300) (B) (111), (221) (C) (200), (110) (D) (001), (003)
25. The Depolarization factor for a sphere along any axis is :
- (A) 1/2 (B) 1 (C) 0 (D) 1/3
26. The combined form of first and second Law of Thermodynamics is given by :
- (A) $T ds = du - P dv$ (B) $du = T ds + dQ$ (C) $dQ = T ds + P dv$ (D) $T ds = du + P dv$
27. Which is correct ?
 According to Bose - Einstein statistics,
- (A) Particles are identical and distinguishable
 (B) Particles are without any spin
 (C) Particles are called fermions
 (D) Particles are called Bosons

28. Fermi - Dirac statistics applies to _____.
- (A) Common gas at normal temperatures
 (B) Photon gas
 (C) Phonon gas
 (D) electron gas in metals
29. Which is wrong ?
- (A) An ensemble is a collection of a number of particles.
 (B) An ensemble is a collection of a large number of macroscopically identical, but essentially independent systems.
 (C) Macroscopically means each of the systems constituting an ensemble satisfies the same or different macroscopic conditions.
 (D) Example for macroscopic condition is total number of particles.
30. According to Debye's theory of specific heat at low temperature the specific heat is proportional to _____.
- (A) T (B) T^2 (C) T^3 (D) independent of T

31. Match the following :

- | | |
|--------------------|---|
| (a) Zener diode | (i)  |
| (b) Tunnel diode | (ii)  |
| (c) Varactor diode | (iii)  |
| (d) Schottky diode | (iv)  |

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-------|-------|------|------|
| (A) | (iii) | (iv) | (ii) | (i) |
| (B) | (iv) | (iii) | (ii) | (i) |
| (C) | (iii) | (iv) | (i) | (ii) |
| (D) | (iv) | (iii) | (i) | (ii) |

32. A transistor has a typical of $\beta = 100$. If the collector current is 40 mA. The value of emitter current is :
- (A) 0.4 mA (B) 40.4 mA (C) 40 mA (D) 4.04 mA

33. Which of the following statements are correct ?
- (a) D - MOSFET can be operated in both depletion mode and enhancement mode
 - (b) E - MOSFET can be operated only in enhancement mode
 - (c) E - MOSFET can be operated only in depletion mode
 - (A) All are correct
 - (B) (b), (c) are correct
 - (C) (a), (b) are correct
 - (D) (a), (c) are correct
34. Push pull amplifier is a combination of :
- (A) two class A amplifier
 - (B) two class AB amplifier
 - (C) two class C amplifier
 - (D) two class B amplifier
35. In monolithic IC technology, the capacitance that are fabricated have values :
- (A) less than 200 nF
 - (B) Greater than 200 μ F
 - (C) Greater than 200 PF
 - (D) less than 200 PF
36. The K_{α} line of X-rays produced due to the electron transition from :
- (A) $n=3$ to $n=1$
 - (B) $n=2$ to $n=1$
 - (C) $n=3$ to $n=2$
 - (D) $n=4$ to $n=1$
37. In ultraviolet photoelectron spectrometer, the primary and secondary beams are made up respectively of :
- (A) electrons, UV photons
 - (B) electrons, electrons
 - (C) UV photons, electrons
 - (D) UV photons, UV photons
38. There is no IR absorption for nitrogen molecules because :
- (A) Its polarizability is zero
 - (B) It has no vibrational level
 - (C) Its dipole moment is zero
 - (D) It has no rotational level
39. Which of the following region of infrared is extremely useful for spectroscopic studies of organic compounds ?
- (A) Near infrared
 - (B) Middle infrared
 - (C) Far infrared
 - (D) Cannot predict
40. As the temperature is increased, the intensity of an anti - stokes Raman lines :
- (A) Increases
 - (B) Decreases
 - (C) remains unchanged
 - (D) Increases and decreases depending on the mode of vibrations

41. In a region the electric potential is given by :

$$V = 2x^2y + 3y^2z + 4z^2x$$

then the expression for electric field \vec{E} is :

(A) $+(4xy+4z^2)\vec{i} + (2x^2+6yz)\vec{j} + (3y^2+8zx)\vec{k}$

(B) $+(2x^2y+4z^2x)\vec{i} + (2x^2y+3y^2z)\vec{j} + (3y^2z+4z^2x)\vec{k}$

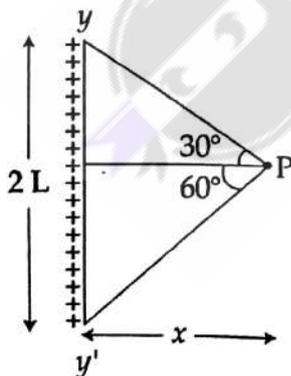
(C) $-(4xy+4z^2)\vec{i} - (2x^2+6yz)\vec{j} - (3y^2+8zx)\vec{k}$

(D) $-\left(\frac{2}{3}x^3y+2z^2x\right)\vec{i} - (x^2y^2+y^3z)\vec{j} - \left(\frac{3}{2}y^2z^2+\frac{4}{3}z^3x\right)\vec{k}$

42. The vector potential \vec{A} corresponds to a constant magnetic field in the z direction can be represented by :

(A) $-B\vec{k}$ (B) $\frac{B}{2}(\vec{i}x - \vec{j}y)$ (C) $\frac{B}{2}(\vec{j}x - \vec{i}y)$ (D) $B(\vec{i}x - \vec{j}y)$

43. A straight line segment of length $2L$ having line charge density λ is lying along yy' axis as shown below. The electric field intensity at a point 'P' which is at a distance 'x' from the line segment and along yy' is :



(A) Zero

(B) $\frac{\lambda}{4\pi\epsilon_0 x} \left[\frac{1+\sqrt{3}}{2} \right]$ (C) $\frac{\lambda}{4\pi\epsilon_0 x} [1-\sqrt{3}]$ (D) $\frac{\lambda}{8\pi\epsilon_0 x} [\sqrt{3}-1]$

44. Suppose a magnetic monopole q_m passes through a resistance less loop of wire with self inductance L . What current is induced in the loop ?
- (A) $I = \frac{\mu_0 q_m}{L}$ (B) $I = \frac{\mu_0 q_m}{2L}$ (C) $I = \frac{2\mu_0 q_m}{\sqrt{L}}$ (D) $I = \frac{\sqrt{L}}{2\mu_0 q_m}$
45. Between the two ends of a cylindrical wire of radius 'a' and length L , a potential difference V exist. If the current is I , What is the magnitude of pointing vector in the cylinder ?
- (A) Zero (B) VI (C) $\frac{VI}{\pi a^2}$ (D) $\frac{VI}{2\pi aL}$
46. For measurement of mixed radiation environment, which one of the following radiation detection mode is used :
- (A) Pulse mode (B) Current mode
(C) Frequency mode (D) Mean square voltage mode
47. Correlation coefficient is independent of change of :
- (A) Origin only (B) Scale only
(C) Both origin and scale (D) None of these
48. Which one of the following is incorrect condition for validity of chi-square test of goodness of fit between theory and experiment ?
- (A) The sample observation should be dependent
(B) Constrains on the cell frequencies should be linear
(C) Total number of frequency should be greater than 50
(D) No theoretical cell frequency should be less than 5
49. Two capacitors of $0.0003 \mu\text{F}$ and $0.0006 \mu\text{F}$ are connected in series, then the combined capacitance is :
- (A) $0.0002 \mu\text{F}$ (B) $0.0009 \mu\text{F}$ (C) $0.0006 \mu\text{F}$ (D) $0.0005 \mu\text{F}$
50. Low resistance can be measured accurately by :
- (A) Kelvin double bridge (B) Kelvin single bridge
(C) Wheatstone bridge (D) Megohm bridge
51. ${}^{11}_6\text{C}$ and ${}^{11}_5\text{B}$ are examples of :
- (A) Isotopes (B) Isobars (C) Isotones (D) Mirror nuclei

52. Which of the following nucleus is most stable ?
- (A) Nucleus having odd neutrons and odd protons
 (B) Nucleus having odd neutrons and even protons
 (C) Nucleus having even neutrons and even protons
 (D) Nucleus having even neutrons and odd protons
53. From meson theory of exchange forces, the potential energy of interaction between two nucleons is proportional to :
- (A) $\frac{e^{-\mu r}}{r^2}$ (B) $\frac{e^{-\mu r}}{r}$ (C) $\frac{e^{-\mu r^2}}{r^2}$ (D) $\frac{e^{-\mu r^2}}{r}$
54. Liquid drop model predict :
- (A) depth of net nuclear potential asymmetry term
 (B) magnetic numbers, nuclear spins, nuclear particles pairing term
 (C) electric quadrupole moment
 (D) accurate average masses and binding energy through semi empirical mass formula
55. In nuclear reaction ${}^{12}_6\text{C} (d, x) {}^{13}_7\text{N}$, the particle x is :
- (A) α - particle (B) Proton (C) Neutron (D) Gamma - photon
56. Which of the following reactions can occur ?
- (a) $\Lambda^0 \rightarrow \pi^+ + \pi^-$
 (b) $\pi^- + p \rightarrow \pi^0 + \pi$
 (c) $\pi^+ + p \rightarrow \pi^+ + p + \pi^- + \pi^0$
 (d) $\nu + n \rightarrow \pi^- + p$
- (A) (a), (b) and (c) (B) (b) and (d)
 (C) (b), (c) and (d) (D) (a), (b) and (d)
57. The value of Compton wavelength is :
- (A) 2.426×10^{-12} m (B) 0.53×10^{-10} m
 (C) 1.03×10^{-12} m (D) 0.53×10^{-12} m
58. A hyper nuclei is the one :
- (A) Which has hyper charge value $Y = 1$
 (B) Which decays through only mesonic decay
 (C) Which is a meta stable nucleus with bound hyperon replaces one of the nucleons
 (D) Whose nucleon - nucleon force is spin independent

59. The binding energy per nucleon of C^{12} is 7.68 MeV and of C^{13} is 7.48 MeV. The energy required to remove the extra neutron from C^{13} is very nearly equal to :
 (A) 5.08 MeV (B) 0.2 MeV (C) 3.7 MeV (D) 3.9 MeV
60. Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be $\frac{1}{e}$ after a time :
 (A) $\frac{1}{10\lambda}$ (B) $\frac{1}{9\lambda}$ (C) $\frac{1}{11\lambda}$ (D) $\frac{11}{10\lambda}$
61. In n-type semiconductor, the concentration of electrons is $2 \times 10^{22} m^{-3}$ and its electrical conductivity is $112 \Omega^{-1} m^{-1}$. The mobility of electrons, in SI units, will be :
 (A) 0.252 (B) 0.035 (C) 0.140 (D) 0.435
62. According to molecular field theory, above Curie point, the :
 (A) material becomes ferromagnetic
 (B) spontaneous magnetisation vanishes
 (C) substance do not obey Curie - Weiss law
 (D) spontaneous magnetisation occur
63. Calculate the polarization produced in a dielectric medium of dielectric constant 6, when subjected to an electric field of $100 V^{-1} m^{-1}$.
 (given : permittivity of free space $= 8.85 \times 10^{-12} Fm^{-1}$:
 (A) $5.31 \times 10^{-9} C.m^{-2}$ (B) $1.48 \times 10^{-14} C.m^{-2}$
 (C) $4.43 \times 10^{-9} C.m^{-2}$ (D) $4.39 \times 10^{-40} C.m^{-2}$
64. **Statement (I)** : All ferroelectrics are pyroelectric and piezoelectric.
Statement (II) : All pyroelectrics are piezoelectric, but the converse is not true.
 (A) Both statements are correct
 (B) Both statements are wrong
 (C) Statement (I) is correct and statement (II) is wrong
 (D) Statement (I) is wrong and statement (II) is correct
65. In a semiconductor, the product of the electron and hole concentration at a given temperature is :
 (A) always equal to unity
 (B) a constant and independent of impurity concentration
 (C) always equal to zero
 (D) directly proportional to Fermi energy

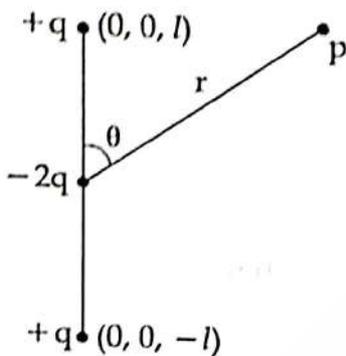
66. Electric field intensity, inside a uniformly charged sphere of radius R and charge density ρ , at a point r ($r < R$) from the centre of the sphere is :

- (A) Zero (B) $\frac{\rho r}{3\epsilon_0}$ (C) $\frac{\rho}{4\pi\epsilon_0 r^2}$ (D) $\frac{\rho}{3\epsilon_0 r^3}$

67. Sea water at frequency $\nu = 4 \times 10^8$ Hz has permittivity $\epsilon = 81\epsilon_0$, permeability $\mu = \mu_0$ and resistivity $\rho = 0.23 \Omega\text{m}$. What is the ratio of conduction current to displacement current ?

- (A) 0.41 (B) Zero (C) 2.41 (D) 1.00

68. Three charges are arranged in a linear array. The charge $-2q$ is placed at the origin and two charges each of $+q$ are placed at $(0, 0, l)$ and $(0, 0, -l)$ as shown below. The potential and electric field at 'p' are respectively proportional to :



- (A) $\frac{1}{r}$ and $\frac{1}{r^2}$ (B) $\frac{1}{r^2}$ and $\frac{1}{r^3}$ (C) $\frac{1}{r^3}$ and $\frac{1}{r^4}$ (D) $\frac{1}{r^4}$ and $\frac{1}{r^5}$

69. A metallic sphere A of radius 'a' carries a charge Q . It is brought in contact with an uncharged sphere B of radius 'b'. The charge on sphere A now will be :

- (A) $\frac{bQ}{a+b}$ (B) $\frac{aQ}{a+b}$ (C) $\frac{aQ}{b}$ (D) $\frac{bQ}{a}$

70. A circular loop has its radius increasing at a rate of 3 m/s. The loop is placed perpendicular to a constant magnetic field of strength 0.5 wb/m^2 . When the radius of the loop is 6m, the magnitude of Induced emf is :

- (A) 4.5π volts (B) 0.9π volts (C) 18π volts (D) 0.45π volts

71. The symmetric property of a tensor is _____ used.

- (A) dependent of coordinate system used
 (B) independent of coordinate system used
 (C) dependent on transformation law
 (D) independent of transformation law

72. The velocity of a particle is :

- (A) a scalar (B) a contravariant vector
(C) a covariant vector (D) a tensor of rank 2

73. If all the elements of a group may be expressed by the power of a single element, the group is called :

- (A) Cyclic group (B) Sub-group
(C) Non-Abelian group (D) Power group

74. The value of $\frac{J_{1/2}(x)}{J_{-1/2}(x)}$ is :

- (A) 1 (B) $\tan x$ (C) $\cot x$ (D) $\tan hx$

75. The value of $H_2(x)$ is :

- (A) $x^2 - 1$ (B) $2x^2 - 1$ (C) $4x^2 - 2$ (D) $\frac{3x^2 - 1}{2}$

76. The value of $\overline{m} \overline{1-m} = ?$

- (A) $\sin m \sin(1-m)$ (B) $\frac{\pi}{\sin m \pi}$
(C) $\frac{\pi}{\sin(m-1)\pi}$ (D) $\frac{\sin(m-1)\pi}{\sin(m+1)\pi}$

77. The value of $\sqrt{\frac{1}{4}} \sqrt{\frac{3}{4}} = ?$

- (A) 1 (B) $\pi\sqrt{2}$ (C) $\sqrt{2\pi}$ (D) $2\sqrt{\pi}$

78. Three Cube roots of unity form :

- (A) an abelian group under addition
(B) an abelian group under multiplication
(C) non abelian group under multiplication
(D) non abelian group under addition

79. Moment of Inertia is a :

- (A) Scalar (B) Vector
(C) a tensor of rank 2 (D) a tensor of higher rank

80. The value of $\beta(3, 2)$ is :

- (A) $\frac{1}{12}$ (B) $\frac{1}{6}$ (C) $\frac{1}{3}$ (D) $\frac{1}{2}$

81. The generalised force need not always have the dimensions of _____.

- (A) Energy (B) Work (C) Momentum (D) Force

82. Which is wrong ?

- (A) The distance between any two points of a rigid body remains fixed.
(B) The relative velocity of any point at the position of i^{th} particle is expressed in terms of angular velocity ω as,

$$v_i = \omega \times r_i$$

- (C) The position vector of any point relative to origin of the body set of axes is constant in magnitude.
(D) The position vector changes in direction only when the body is in motion (rotation).

83. Which is correct ?

- (A) The expression for one - dimensional Linear Harmonic Oscillator is $m\ddot{x} + kx^2 = 0$
(B) The expression for one - dimensional Linear Harmonic Oscillator is $m\dot{x} + kx = 0$
(C) The expression for one - dimensional Linear Harmonic Oscillator is $\ddot{\theta} + \frac{g}{l}\theta = 0$
(D) The expression for one - dimensional Linear Harmonic Oscillator is $m\ddot{x} + kx = 0$

84. Which is wrong ?

For an isotropic oscillator, the equation of motion in polar Co-ordinates is :

- (A) $m\ddot{r} - mr\dot{\theta}^2 - mr\sin^2\theta\dot{\phi}^2 + kr = 0$ (B) $\frac{d}{dt}(mr^2\dot{\theta}) - mr^2\sin\theta\cos\theta\dot{\phi}^2 = 0$
(C) $\frac{d}{dt}(mr^2\sin\theta\dot{\phi}) = 0$ (D) $m\ddot{r} - mr\dot{\theta}^2 + mr\sin^2\theta\dot{\phi}^2 + kr = 0$

85. Which is wrong ?
- (A) Hamiltonian $H = H(q_j, p_j)$ (B) Hamiltonian $H = T - V$
 (C) Hamiltonian $H = T + V$ (D) Hamiltonian $H = \sum_j p_j \dot{q}_j - L(q_j, \dot{q}_j)$
86. The number of comparators needed in parallel conversion type 8 bit A/D converter is :
- (A) 8 (B) 16 (C) 255 (D) 256
87. Find the odd one out :
 Low temperature can be achieved by
- (A) the process of adiabatic demagnetization
 (B) adding a salt to ice
 (C) utilizing the cooling due to peltier effect
 (D) by cooling a liquid under reduced pressure
88. For the accurate measurement of small capacitance which of the following method is used ?
- (A) Schering bridge (B) Robinson's bridge
 (C) Desauchy's bridge (D) Wein's bridge
89. A proportional counter filled with argon and a thin sheet of paraffin placed at one end of the chamber is used for the detection of :
- (A) α - particles (B) β - particles (C) fast neutrons (D) γ - rays
90. The only liquid thermometer that can be used upto -190°C is :
- (A) Alcohol thermometer
 (B) Mercury thermometer
 (C) Liquid thermometer containing fractionally distilled petroleum
 (D) Maximum and minimum thermometer
91. \vec{F} represents the resultant force acting on a system of particles. If \vec{F} represents a conservative force, then, which of the following statements are correct ?
- (a) The work done by the force is independent of the path of the particle.
 (b) $\text{Curl of } \vec{F} = 0$
 (c) Work done by the force over any closed path is infinite.
- (A) (a) and (b) (B) (b) and (c) (C) (a) and (c) (D) (a), (b) and (c)

92. For a canonical transformation from (q, p) to (Q, P) , one of the transformations is $q = (e^Q - 1)^2 \sec^2 p$. The generating function $F(P, Q)$ is given by :
- (A) $F(P, Q) = (e^Q - 1)^2 \sec^2 p$ (B) $F(P, Q) = -(e^Q - 1)^2 \sec^2 p$
 (C) $F(P, Q) = -(e^Q - 1)^2 \tan p$ (D) $F(P, Q) = (e^Q - 1)^2 \tan p$

93. Match the following :

- | | |
|-------------------------|--------------------------------|
| (a) Euler's equations | (i) Four vectors |
| (b) Generating function | (ii) Total energy |
| (c) Hamiltonian | (iii) Canonical transformation |
| (d) Minkowski space | (iv) Rigid body dynamics |

Codes :

- | | | | | |
|-----|-------|-------|------|------|
| | (a) | (b) | (c) | (d) |
| (A) | (ii) | (iii) | (iv) | (i) |
| (B) | (iii) | (i) | (iv) | (ii) |
| (C) | (iv) | (iii) | (ii) | (i) |
| (D) | (iii) | (iv) | (ii) | (i) |

94. F is an arbitrary function of the variables $q_1, q_2, \dots, q_n, p_1, p_2, \dots, p_n$. The poisson bracket of q_k with F is given by :

- (A) $[q_k, F] = 0$ (B) $[q_k, F] = 1$ (C) $[q_k, F] = -1$ (D) $[q_k, F] = \frac{\partial F}{\partial p_k}$

95. A rigid body is rotating about a fixed point O , with angular velocity $\vec{\omega}$. θ, ϕ and ψ represent the Euler angles through which the coordinate axes rotate. Now, the component of $\vec{\omega}$ along z -axis is given by :

- (A) $\omega_z = \dot{\theta} \sin\psi - \dot{\phi} \sin\theta \cos\psi$ (B) $\omega_z = \dot{\theta} \sin\psi + \dot{\phi} \cos\psi$
 (C) $\omega_z = \dot{\phi} \cos\theta + \dot{\psi}$ (D) $\omega_z = \dot{\phi} + \dot{\theta} + \dot{\psi}$

96. Match the following :

- | | |
|---------------------------|----------------------------------|
| (a) Matter waves | (i) Heisenberg - ψ |
| (b) Wave equation | (ii) Real eigenvalue - λ |
| (c) Uncertainty principle | (iii) De Broglie - λ |
| (d) Hermitian operator | (iv) Schrodinger - ψ |

Codes :

- | | | | | |
|-----|-------|-------|------|------|
| | (a) | (b) | (c) | (d) |
| (A) | (iii) | (iv) | (i) | (ii) |
| (B) | (iv) | (iii) | (ii) | (i) |
| (C) | (ii) | (iii) | (iv) | (i) |
| (D) | (iv) | (iii) | (i) | (ii) |

97. For a square well represented by $V(x)=0$ if $|x|<a$ and $V(x)=\infty$, if $|x|\geq a$, the wave function is given by $\psi(x)=A\cos\left(\frac{n\pi x}{2a}\right)$. The value of constant A by the normalization of wave function is :

- (A) $A=1/\sqrt{a}$ (B) $A=\frac{2}{\sqrt{a}}$ (C) $A=\frac{\sqrt{a}}{2}$ (D) $A=\frac{1}{\sqrt{2a}}$

98. Which of the following statements are correct ?

- (i) The zero point energy of a linear harmonic oscillator arises as a consequence of uncertainty principle.
 (ii) The Eigenvalues of a Hermitian operator are complex or real.
 (iii) Ket vector is used to represent a wave function.
- (A) (i) and (ii) are correct (B) (ii) and (iii) are correct
 (C) (i) and (iii) are correct (D) (i), (ii) and (iii) are correct

99. For a spin = $1/2$ system like an electron, the Pauli matrices, which are used to represent the spin matrices, are

$$\sigma_x = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}; \sigma_y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} \text{ and } \sigma_z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

Then, which of the following statements are correct ?

- (a) $\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = 0$
 (b) $\sigma_x \sigma_y = i \sigma_z$
 (c) $\sigma_x \sigma_y = \sigma_y \sigma_x = 0$
- (A) (b) only is correct (B) (c) only is correct
 (C) (a) and (b) are correct (D) (b) and (c) are correct

100. In the ground state of hydrogen atom, an electron exists in 1s state. When it is given a photon of sufficient energy, which of the following dipole transitions are possible ?

- (a) $1s \rightarrow 2s$
 (b) $1s \rightarrow 2p$
 (c) $1s \rightarrow 3s$
- (A) (a) and (b) (B) (b) and (c) (C) (b) only (D) (a) only

101. The strongest IR absorption band of CO molecule occurs at 4.9×10^{13} Hz. If the reduced mass of CO is 1.385×10^{-26} kg, then the approximate zero point energy is :

- (A) 0.22 eV (B) 0.1 eV (C) 2.2 eV (D) 1.0 eV

107. An ADC has a total conversion time of $200 \mu\text{s}$. What is the highest frequency that its analog input should be allowed to contain :
- (A) 2.5 kHz (B) 2.5 Hz (C) 2 kHz (D) 50 kHz
108. In hot cathode gauge, _____ measures the pressure of a gas.
- (A) Temperature (B) Ionisation (C) Resistance (D) e.m.f.
109. Spectra of monoenergetic X - rays often show two peaks in proportional counter. This is due to :
- (A) Escape of fluorescent radiation (B) Auger electron
(C) Compton scattering (D) Photoelectric effect
110. The light emission in organic scintillators is caused by transitions between :
- (A) Level of delocalized electrons
(B) Vibrational levels
(C) Rotational levels
(D) Vibrational and rotational levels
111. For a vector potential \vec{A} , the divergence of \vec{A} is $\nabla \cdot \vec{A} = \frac{-\mu_0 Q}{4\pi r^2}$ where Q is a constant of appropriate dimension. The corresponding scalar potential $\phi(\vec{r}, t)$, that makes \vec{A} and ϕ Lorentz gauge invariant is :
- (A) $\frac{Q}{4\pi\epsilon_0 r}$ (B) $\frac{Qt}{4\pi\epsilon_0 r}$ (C) $\frac{Qt}{4\pi\epsilon_0 r^2}$ (D) $\frac{Q}{4\pi\epsilon_0 r^2}$
112. Which is a correct statement ?
- (A) An extensive variable of a system is a macroscopic parameter which describes a system in equilibrium and which has a value equal to the sum of its values in each part of the system
(B) The intensive variable depends in the mass or the size of the substance
(C) Example for intensive variable is entropy
(D) Example for extensive variable is pressure
113. A manufacturer developed an engine with an efficiency of 40% while operating between the temperatures 2100 K and 700 K. The percentage of this efficiency if the maximum possible efficiency of an engine working between these two temperatures is _____.
- (A) 40% (B) 50% (C) 60% (D) 45%

114. An ideal gas at 27°C has a pressure of 760 mm of Hg. The gas is thermally until its volume is halved. The resultant pressure of the gas becomes :
 (A) 380 mm of Hg (B) 760 mm of Hg (C) 1140 mm of Hg (D) 1520 mm of Hg
115. The momentum of a photon gas of energy 3 J is about :
 (A) $1 \times 10^8 \text{ kg ms}^{-1}$ (B) $1 \times 10^{-8} \text{ kg ms}^{-1}$
 (C) $9 \times 10^8 \text{ kg ms}^{-1}$ (D) $9 \times 10^{-8} \text{ kg ms}^{-1}$
116. When a beam of cosmic ray particles was studied in a laboratory, the energy of the particles was found to be 870 MeV and its momentum was 720 MeV/C. The rest mass of the particle is :
 (A) $m_0 = 488.4 \text{ MeV}/C^2$ (B) $m_0 = 488.4 \text{ MeV}/C$
 (C) $m_0 = 48.84 \text{ MeV}/C^2$ (D) $m_0 = 48.84 \text{ MeV}/C$
117. Jacobi Identity for Poisson bracket _____.
 (A) $[X, [Y, H]] + [Y, [H, X]] + [H, [X, Y]] = 0$
 (B) $[X, [Y, H]] + [Y, [H, X]] - [H, [X, Y]] = 0$
 (C) $[X, [Y, H]] - [Y, [H, X]] + [H, [Y, X]] = 0$
 (D) $[X, [Y, H]] - [Y, [H, X]] - [X, [Y, X]] = 0$
118. Like classical _____, relativistic _____ also represents the total energy of the system.
 (A) Lagrangian, Lagrangian (B) Hamiltonian, Lagrangian
 (C) Lagrangian, Hamiltonian (D) Hamiltonian, Hamiltonian
119. A gamma photon is associated with a De Broglie wave whose wavelength is $\lambda = 1\text{\AA}$. The energy of gamma photon is given by.
 (A) $1.99 \times 10^{-15} \text{ J}$ (B) $1.99 \times 10^{-17} \text{ J}$ (C) $1.99 \times 10^{-15} \text{ eV}$ (D) $1.99 \times 10^{-17} \text{ eV}$
 Note : Value of constants
 $h = 6.62 \times 10^{-34} \text{ Js}$
 $C = 3 \times 10^8 \text{ m/s}$
120. In a neutron - proton scattering, it is assumed that the mass of neutron and proton are equal. If θ_L and θ_C represent the angle of scattering in laboratory frame and centre of mass frame, respectively, then the relation between them is,
 (A) $\theta_L = \theta_C$ (B) $\theta_L = 2 \theta_C$ (C) $\theta_L = \frac{\theta_C}{2}$ (D) $\theta = \frac{\theta_C}{4}$

121. Charge of deuteron is :
- (A) -1.6×10^{-19} coulomb (B) $+1.6 \times 10^{-19}$ coulomb
 (C) -1.9×10^{-31} coulomb (D) $+1.9 \times 10^{-31}$ coulomb
122. The spin and parity of ${}_8\text{C}^{12}$ according to nuclear shell model is :
- (A) $(\frac{1}{2})^+$ (B) 0^+ (C) 0^- (D) 6^+
123. The negative feedback :
- (A) reduces the gain (B) increases the gain
 (C) neither increases nor decreases (D) slightly increases the gain
124. In an op - amp the ratio of differential mode gain to common mode gain is known as :
- (A) Slew rate (B) input offset voltage
 (C) CMRR (D) Current gain
125. The aspect ratio of $4 \text{ k}\Omega$ diffused resistor with the sheet resistance of P - type diffusion is $200 \Omega/\text{sq}$ is :
- (A) $1/4$ (B) $20/1$ (C) $1/20$ (D) $4/1$
126. The relationship between frequency spread ($\Delta\nu$) and wavelength spread ($\Delta\lambda$) for a laser source is :
- (A) $\Delta\lambda = -\left(\frac{C}{\nu^2}\right) \Delta\nu$ (B) $\Delta\lambda = \left(\frac{C}{\nu^2}\right) \Delta\nu$
 (C) $\Delta\lambda = \left(\frac{C}{\nu^3}\right) \Delta\nu$ (D) $\Delta\lambda = \left(\frac{C^2}{\nu}\right) \Delta\nu$
127. In rotation - vibration (IR) spectra of diatomic molecules, the lines corresponding to $\Delta J = -1$ is called :
- (A) Q - branch (B) R - branch (C) P - branch (D) S - branch
128. In pure rotational Raman spectrum of HCl, the displacement from the exciting line is $\Delta\nu = \pm(62.4 + 41.6 \text{ J}) \text{ cm}^{-1}$. Given the planck's constant $= 6.62 \times 10^{-27} \text{ erg}\cdot\text{sec}$ and velocity of light in free space $= 3 \times 10^{10} \text{ cm s}^{-1}$, calculate the moment of inertia of the molecule.
- (A) $2.7 \times 10^{-40} \text{ g}\cdot\text{cm}^2$ (B) $9.6 \times 10^{-34} \text{ g}\cdot\text{cm}^2$
 (C) $8.4 \times 10^{-32} \text{ g}\cdot\text{cm}^2$ (D) $6.2 \times 10^{-38} \text{ g}\cdot\text{cm}^2$

129. Doppler broadening is proportional to _____ and inversely
- (A) absolute temperature, atomic weight
 (B) square root of absolute temperature, square root of atomic weight
 (C) square of absolute temperature, square root of atomic weight
 (D) absolute temperature, wavelength of the source
130. The Bragg angle corresponding to the first order reflection from (111) planes in a crystal 30° when x-rays of wavelength 1.75 \AA are used, then the interatomic spacing is :
- (A) 10.8 \AA (B) 9.47 \AA (C) 3.01 \AA (D) 1.75 \AA
131. If E is the macroscopic field and P is polarization, then according to Lorentz the local field experienced by a dielectric material of cubic crystal structure is :
- (A) $E - \left(\frac{4\pi}{3}\right)P$ (B) $\frac{E}{\left(\frac{4\pi}{3}\right)P}$ (C) $\frac{\left(\frac{4\pi}{3}\right)P}{E}$ (D) $E + \left(\frac{4\pi}{3}\right)P$
132. The primitive translation vectors of a two dimensional lattice are
- $$a = 2 \hat{i}$$
- $$b = \hat{i} + 2 \hat{j}$$
- The primitive translational vectors of its reciprocal lattice are :
- (A) $a^* = 2 \hat{i} + \hat{j} ; b^* = 2 \hat{j}$ (B) $a^* = \pi \hat{i} - \frac{\pi}{2} \hat{j} ; b^* = \pi \hat{j}$
 (C) $a^* = \pi \hat{j} + \pi \hat{k} ; b^* = \pi \hat{i} + \frac{\pi}{2} \hat{j}$ (D) $a^* = 2 \pi \hat{i} ; b^* = \frac{\pi}{2} \hat{j}$
133. Calculate the magnitude of change in the magnetic moment of a circulating electron in a applied field of 2 tesla acting perpendicular to the plane of the orbit. Radius of the circular orbit $= 5.3 \times 10^{-11} \text{ m}$. Mass of electron $= 9.1 \times 10^{-31} \text{ kg}$.
- (A) $0.46 \times 10^{-19} \text{ Am}^2$ (B) $4.86 \times 10^{-6} \text{ Am}^2$
 (C) $1.08 \times 10^{-11} \text{ Am}^2$ (D) $3.95 \times 10^{-29} \text{ Am}^2$
134. In a Bain bridge mass spectrograph, singly ionised atoms of ^{20}Ne and ^{22}Ne pass into the deflection chamber with a velocity 10^5 m/s . They strike the photographic plate at two different points. Linear distance between the points is :
- (A) $29.76 \times 10^{-2} \text{ m}$ (B) $32.74 \times 10^{-2} \text{ m}$ (C) $5.96 \times 10^{-2} \text{ m}$ (D) $2.98 \times 10^{-2} \text{ m}$

135. Match the following :

	Column I		Column II
(a)	Nuclear fusion	(p)	Converts some matter into energy
(b)	Nuclear fission	(q)	Generally possible for nuclei with low atomic number
(c)	β - decay	(r)	Generally possible for nuclei with higher atomic number
(d)	Exothermic nuclear reaction	(s)	Essentially proceeds by weak nuclear forces

- (A) (a) \rightarrow (p), (q) (b) \rightarrow (p), (r) (c) \rightarrow (p), (s) (d) \rightarrow (p), (r)
- (B) (a) \rightarrow (p), (q) (b) \rightarrow (p), (r) (c) \rightarrow (q), (s) (d) \rightarrow (p), (r)
- (C) (a) \rightarrow (p), (q) (b) \rightarrow (p), (r) (c) \rightarrow (p), (s) (d) \rightarrow (p), (q)
- (D) (a) \rightarrow (p), (r) (b) \rightarrow (p), (q) (c) \rightarrow (p), (s) (d) \rightarrow (p), (r)

136. A symmetrical tensor of rank 2 in n-dimensional space has at most :

- (A) $\frac{n(n+1)}{2}$ independent components
- (B) $\frac{n^2-n}{2}$ dependent components
- (C) n^2-n independent components
- (D) $\frac{n^2+n}{2}$ dependent components

137. The value of $J_{1/2}$ is equal to :

- (A) $\sqrt{\frac{\pi}{2x}} \cos x$ (B) $\sqrt{\frac{2}{\pi x}} \sin x$ (C) $\sqrt{\frac{2\pi}{x}} \sin x$ (D) $\sqrt{\frac{2\pi}{x}} \cos x$

138. The value of $\int_0^{\pi/2} (\tan\theta)^{1/2} d\theta$ is :

- (A) $\frac{\sqrt{\pi}}{2}$ (B) $\frac{\sqrt{\frac{3}{4}} \sqrt{\frac{1}{4}}}{2}$ (C) $\frac{\sqrt{\frac{3}{4}} \sqrt{\frac{3}{2}}}{2}$ (D) $\frac{\sqrt{\frac{3}{2}} \sqrt{\frac{1}{2}}}{\sqrt{\pi}}$

139. If A is conjugate to B and C, then :

- (A) B and C are necessary conjugate with each other
 (B) not conjugate with each other
 (C) may or may not be conjugate with each other
 (D) conjugate only if either B or C is identity element

140. In the case of a motion of a rigid body, the distance between two particles of the body always remains fixed and does not change with time. if \vec{r}_i and \vec{r}_j represent the position vectors i^{th} and j^{th} particles, which of the following describes the constraint correctly ?

- (A) Holonomic constraint with $|\vec{r}_i - \vec{r}_j| = C_{ij}$
 (B) Non - holonomic constraint with $|\vec{r}_i - \vec{r}_j| \leq C_{ij}$
 (C) Non - holonomic and scleronomous with $|\vec{r}_i - \vec{r}_j| \leq C_{ij}$
 (D) Holonomic and scleronomous with $|\vec{r}_i - \vec{r}_j| = C_{ij}$

141. Consider the following rivers :

- (a) Narmada (b) Brahmaputra
 (c) Godavari (d) Tapti

Which of the above is/are flowing into the Bay of Bengal ?

- (A) (a), (b) and (c) only (B) (b) and (c) only
 (C) (a) and (b) only (D) (a) and (c) only

142. In a class of 45 students, a boy is ranked 20th. When two boys joined, his rank was dropped by one. What is his new rank from the end ?
- (A) 25th (B) 26th (C) 27th (D) 28th
143. The parliament can make any law for whole or any part of India for implementing international treaties :
- (A) with the consent of all the states
(B) with the consent of the majority of states
(C) with the consent of the states concerned
(D) without the consent of any state
144. In which of the following temple, the front Mandapam is in the form of a huge chariot drawn by horses ?
- (A) Patteswaram temple
(B) Darasuram temple
(C) Thanjavur Brihadeeswarar temple
(D) Thiruvarur Thyagaraja temple
145. Who won the gold both in the 5,000 and 10,000 metres event in 2017 Asian Athletics Championship ?
- (A) Lakshmanan (B) Gopi Thonkanal
(C) Jinson Johnson (D) Neeraj Chopra
146. What temperature are Fahrenheit and Celsius equal ?
- (A) -40° (B) 574.59 (C) 40 (D) -574.59
147. First state to fix minimum education qualification for cooperative body poll :
- (A) Rajasthan (B) West Bengal (C) Tamil Nadu (D) Karnataka

148. Who wrote the novel - 'KavalKottam' ?
(A) Vannadasan (B) S. Venkatesan (C) Joe D Cruz (D) Puviarasan

149. Article 21-A and the RTE Act came into effect :
(A) On 1st April 2010 (B) On 1st April 2009
(C) On 1st April 2017 (D) On 1st April 2005

150. Quit India Movement was launched in response to :
(A) Cabinet Mission plan (B) Cripps proposals
(C) Simon Commission Report (D) Wavell plan

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