A

19724 **120 MINUTES**

1. Dimension of Lagrangian is -------.

   A) MLT^{-1} B) MLT^{-2} C) ML^2T^{-1} D) ML^2T^{-2}

2. If $\vec{A} = \frac{\sqrt{3}}{2}\hat{\imath} + \frac{1}{2}\hat{\jmath}$ and $\vec{B} = \frac{1}{2}\hat{\imath} + \frac{\sqrt{3}}{2}\hat{\jmath}$ then the angle between the two vectors is:

   A) 60° B) 45° C) $\frac{\pi}{6}$ radians D) $\frac{\pi}{3}$ radians

3. Which among the following is TRUE?

   A) $\nabla^2\varphi = \nabla.(\nabla\varphi)$ B) $\nabla^2\varphi = \nabla X(\nabla\varphi)$

   C) $\nabla^2\varphi = \nabla X(\nabla X\varphi)$ D) None of these

4. Which among the following quantities is not a vector?

   A) moment of inertia B) linear momentum
   C) angular momentum D) moment of a force

5. Every square matrix A can be uniquely expressed as the sum of ------.

   A) a Unitary matrix and a non-unitary matrix
   B) a Hermition matrix and a Skew-Hermition matrix
   C) two Hermition matrices
   D) a Hermition matrix and a unitary matrix

6. Which among the following statement is TRUE for a Skew-Hermition Matrix?

   A) diagonal elements must be real numbers
   B) diagonal elements should be complex numbers with nonzero real and imaginary parts
   C) diagonal elements can only be pure imaginary numbers
   D) diagonal elements can be only pure imaginary numbers or zero

7. For a singular matrix A, which among the following statements is TRUE?

   A) $|A| = 0$ B) $|A| < 0$ C) $|A| > 0$ D) $|A| \neq 0$

8. Newton's equation of motion is a -------differential equation of ------order

   A) non-linear, second B) linear, second
   C) nonlinear, first D) none of these

9. Find the Fourier sine transform of e^{-x}

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

10. The residue of $\frac{Z}{(Z-a)(Z-b)}$ at infinity is

A) $\frac{a}{b}$ B) $-\frac{b}{a}$ C) 1 D) -1

11. If f(z) is a regular function of z and if f(z) is continuous at each point within and on a closed contour C, then $\int_c f(z)dz = 0$. This is ---------.
A) Cauchy's theorem B) Rieman equality
C) Residue theorem D) Drichlett condition

12. For the function $f(z) = \frac{z^4}{(z-1)^4(z-2)(z-3)}$; the pole at z =1 is of -------order.

A) 1 B) 2 C) 3 D) none of these

13. Give $\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2vy = 0,$ where v is a parameter . This differential equation is called -----.
A) Legendere's equation B) Laguerre's equation
C) Hermite equation D) Associated Lauguerre's equation

14. If the probability that a horse A winning a race is 1/3 and the probability that another horse B winning the race is 1/5 , the probability that one of the horses wins is --------
A) 1/15 B) 1/3 C) 2/5 D) None of these

15. The radius of a $_{29}Cu^{64}$ is measured to be 4.8F. Radius of a $_{12}Mg^{27}$ nucleus can be estimated to be:
A) 2.86 F B) 7.1 F C) 5.1 F D) 3.6 F

16. In an inelastic collision --------is not conserved
A) linear momentum B) Kinetic energy
C) Total energy D) none of these

17. The density of the $_6C^{12}$ nucleus is

A) $24 \times 10^{17} kg/m^3$ B) $2.4 \times 10^{19} kg/m^3$

C) $2.4 \times 10^{17} kg/m^3$ D) $24 \times 10^{19} kg/m^3$

18. Which among the following is true for constraints
A) holonomic constraint can be expressed as an algebraic equation
B) non-holonomic constraint can be expressed as a differential equation
C) Constraint force corresponding to rheonomous constraints cannot do work
D) A constraint can be holonomic and scleronomous at the same time

19. Hamilton's principle is defined in --------.
A) configuration space B) phase space
C) eucledian space D) none of these

20. Which among the following is NOT TRUE?
A) Generalized coordinates can have any dimension
B) Generalized momenta should always have the dimension of angular momentum
C) Lagrangian is defined in terms of generalized coordinates, generalized velocities and time.
D) Hamiltonian and Lagrangian are related through Legendre transformation

21. Law of conservation of angular momentum is a consequence of ---------.
A) Homogeneity of space
B) Isotropy of space
C) Homogeneity of flow of time
D) Law of conservation of energy

22. Hamilton-Jacobi method is used for solving --------systems.
A) conservative B) nonconservative
C) holonomic D) periodic

23. For a particle moving under central force, -------is conserved.
A) linear momentum B) kinetic energy
C) angular momentum D) potential energy

24. α, β, γ radiations come out of a radio-active substance:

A) When it is heated B) When put in an atomic reactor
C) Spontaneously D) By hitting it by other particles

25. When an electron and a positron meet together, two photons are produced. This process is called:
A) Alpha decay B) Nuclear fusion
C) Annihilation of matter D) Beta decay

26. Which among the following is the spallation reaction?
A) Radio activity B) Nuclear fission
C) Nuclear fusion D) All the above

27. Complete the following nuclear reaction

$${}_3Li^7 + {}_2He^4 \rightarrow \ldots\ldots + {}_0n^1$$

A) ${}_8O^6$ B) ${}_5B^{10}$ C) ${}_1H^1$ D) ${}_8O^{17}$

28. Number of degrees of freedom for a mass point constrained move along the circumference of a circle = -------.
A) 1 B) 2 C) 3 D) 0

29. The spin and charge of down quark is

A) $\left(\frac{1}{2}\ and\ \frac{-1}{3}e\right)$ B) $\left(\frac{1}{2}\ and\ \frac{2}{3}e\right)$
C) $\left(\frac{1}{2}\ and\ \frac{-1}{2}e\right)$ D) $\left(\frac{-1}{2}\ and\ \frac{-2}{3}e\right)$

30. Modified Ampere's circuital law is expressed as ----(Symbols have their usual meaning; quantities in bold represent vectors)

A) $\nabla . \boldsymbol{J} = -\frac{\partial p}{\partial t}$ B) $\nabla \mathrm{x}\mathbf{H} = \frac{\partial p}{\partial t} + \mathrm{D}$

C) $\nabla \mathrm{x}\mathbf{H} = \boldsymbol{J} + \frac{\partial p}{\partial t}$ D) none of these

31. Considering planes waves propagating in homogeneous non-permeable but anisotropic dielectric, for a given wave vector k, there are ---------distinct modes of propagation with different phase velocity satisfying Fresnel equation.

A) 2 B) 4 C) 3 D) 6

32. Poynting vector has the dimension as--------.

A) Energy B) Energy per unit area
C) Power D) Power per unit area

33. For a plane electromagnetic wave in free space which of the following relations is true (terms have usual meaning)

A) $E = \varepsilon_0 cH$ B) $E = \varepsilon_0 H$ C) $H = \varepsilon_0 cE$ D) H= $\mu_0 \varepsilon_0 E$

34. When an electromagnetic wave propagates through a conducting media, which among the following statement is TRUE?

A) div **E=0** B) div **H** $\neq 0$ C) Curl **H** = 0 D) Curl **E=0**

35. A plane electromagnetic wave travels through a uniform plasma. If the Poyntings vector is zero, then ----------.

A) frequency of the wave is greater than the plasma frequency
B) frequency of the wave is less than the plasma frequency
C) frequency of the wave and plasma frequency are equal
D) none of these

36. During reflection and refraction of electromagnetic wave, which of the following statement is true?

A) frequency of the wave is unchanged in reflection but changes during refraction
B) frequency of the wave is changed during reflection but unchanged during refraction
C) frequency of the wave remains unchanged during reflection and refraction
D) frequency of the wave always changes during both reflection and refraction

37. For a rectangular wave guide, -------is called the principal or dominant mode

A) TE_{01} B) TM_{01} C) TE_{02} D) none of these

38. In a rectangular wave guide which of the following statement is TRUE

A) TEM waves can propagate along the axis
B) TM_{01} mode can exist
C) The phase velocity V_g is greater than c while guide velocity V_z is less than c
D) TE_{01} mode cannot exist

39. A rod of proper length 1 metre long is moving along its length. For an observer in earth the length of the rod is 0.8 m. The velocity of the rod with respect to earth is -------; c is the speed of light.
A) c B) 0.8c C) 0.66c D) none of these

40. Meson paradox can be explained using -------.
A) length contraction
B) time dilation
C) both length contraction and time dilation
D) none of these

41. An α-particle is moving with a speed of 0.7 c in a direction opposite to the direction of a moving photon. The relative velocity of the photon with respect to the α-particle is ------
A) 1.7c B) c C) 0.7c D) 0.3c

42. The temperature of the antiferromagnetic -to- paramagnetic transition is called:

A) Debye temperature B) Neel temperature
C) Curie - Weiss temperature D) None of the above

43. The magnetic susceptibility of a super conductor is
A) +1 B) 0 C) -1 D) None of these

44. Which among the following is TRUE?
A) Constancy of speed of light is consistent with Galilean transformations
B) Constancy of speed of light is not consistent with Fourier transformations
C) Constancy of speed of light is not consistent with Galilean transformations
D) Constancy of speed of light is consistent with Fourier transformations.

45. Maximum kinetic energy of photoelectron emitted from a metal when radiation of wavelength 1200Å is 9.93 x10^{-19} J. The threshold wavelength for the metal is
A) 3000 Å B) 1000 Å C) 300 Å D) none of these

46. A 'free quantum mechanical particle' is represented by a ---------.
A) plane wave with definite wavelength
B) spherical wave
C) exponentially decaying wave
D) none of these

47. Expectation value of a dynamical variable are in general -------.
A) functions of space
B) functions of time
C) not functions of space and time
D) constants

48. The conductivity of a semiconductor can be written as -
A) $\sigma = (n_e e\mu_e + n_h e\mu_h)$ B) $\sigma = (n_e \mu_e + n_h e\mu_h)$
C) $\sigma = (n_e e^2\mu_e + n_h e\mu_h)$ D) $\sigma = (n_e e\mu_e + n_h e^2\mu_h)$

49. In a superconducting state -
A) Entropy increases & thermal conductivity decreases
B) Entropy & thermal conductivity decreases
C) Entropy & thermal conductivity increases
D) Entropy decreases & thermal conductivity increases

50. For a particle confined in a rectangular potential well with finite walls, (E<V) which among the following is NOT TRUE?
A) energy eigenvalues are discrete
B) wave functions are symmetric or antisymmetric about the symmetry point
C) wave function vanish at the boundary of the well
D) minimum energy permitted is not zero

51. For a particle confined in a two dimensional square well with impenetrable walls the ----
A) ground state has two fold degeneracy
B) ground state is non degenerate
C) first excited state is non degenerate
D) all energy states are degenerate

52. For a particle confined in a one dimensional finite square well centered at x = 0 and width 2a, the expectation value of position when it is in the ground state is -------.
A) x= a/2 B) x=0 C) x=a/4 D) none of these

53. Which among the following statement is TRUE?
A) If two Hermition operators commute they have simultaneous eigen values
B) Hermition operators can have both real and imaginary eigen values
C) For Hermition operators eigen functions corresponding to two different eigen values are orthogonal
D) None of these

54. For a particle confined in a one dimensional square potential well of infinite height and a one dimensional harmonic oscillator the quantum number corresponding to ground state are ---------respectively.
A) 1 and 1 B) 1and 0 C) 0 and1 D 0 and 0

55. Which among the following commutation relations is TRUE?
A) $\left[\hat{Y}, \widehat{L_Y}\right] = 0$ B) $\left[\hat{Y}, \widehat{L_Z}\right] = 0$

C) $\left[\hat{Y}, \widehat{L_X}\right] = i\hbar\hat{Z}$ D) none of these

56. Which among the following dynamical variables can have half integer quantum numbers?
A) linear momentum of a particle confined in a square well
B) total energy of one dimensional linear harmonic oscillator
C) orbital angular momentum of a quantum mechanical particle
D) total angular momentum of a quantum mechanical particle

57. Which among the following techniques can be used for calculating the ground state energy of He atom?
A) Time dependent perturbation theory
B) Variational principle
C) Harmonic approximation
D) Bloch theorem

58. Origin of electronic energy bands in a crystalline solid can be qualitatively accounted using
A) Time independent perturbation theory
B) Time dependent perturbation theory
C) Kronig-Penny model
D) Variational principle

59. The wave function corresponding to a system consisting of two identical particles is symmetric with respect to exchange operation, then the one value possible for intrinsic angular momentum in unit of ħ is ------.
A) 1/2 B) 1 C) 3/2 D) none of these

60. Which among the following particles obey Pauli's exclusion principle?
A) gravitons B) photons
C) cooper pairs D) none of these

61. The registers used in pocket calculators are -
A) Shift register B) Static shift register
C) Buffer shift register D) Dynamic MOS

62. Anomalous Zeeman effect is explained using the theory of ---------.
A) spin angular momenta B) spin-orbit coupling
C) orbital angular momenta D) variational principle

63. Energy spectrum of an unbound quantum mechanical particle is ---------.
A) continuous
B) discrete
C) partly continuous and discrete
D) continuous or discrete

64 Asynchronous counters are also known as:
A) Decade counter B) Multiple clock counter
C) Ripple counter D) Modulus counter

65. In a Fourier transform spectrometer, spectra is recorded in ----------.
A) frequency domain B) time domain
C) energy domain D) intensity domain

66. Which among the following is an example for a four level laser?
A) Ruby laser B) CO_2 laser
C) Diode laser D) He-Ne laser

67. Electromagnetic radiation is passing through a solution and a part of it is absorbed and the rest is transmitted. If the concentration of the solution is doubled, increase in absorption is---.
A) exactly double B) less than double
C) more than double D) none of these

68. Which among the following is an example of a symmetric top molecule?
A) CH_4 B) HCl C) CH_3F D) H_2O

69. The rotational spectral lines -------when $C^{12}$is substituted by C^{13} in CO.
A) are shifted to lower wavenumber side
B) shifted to higher wavenumber side
C) shifted wither to lower or higher wavenumber side depending on J
D) are not shifted

70. The number of normal modes of vibration for HBr is -------.
A) 3 B) 2 C) 5 D) none of these

71. Condition for a molecular vibration to be Raman active is that -----.
A) it should be asymmetric
B) it should cause a change in polarization
C) it should cause a change in polarizability
D) it should not be IR active

72. According to Frank Condon principle electronic transition is ------that the vibrational time period of a molecule.
A) much faster B) slightly faster
C) much slower D) slightly slower

73. The fine structure of E.S. R. Spectra is due to -------.
A) electron-nuclueon coupling B) orbital-spin coupling
C) electron-electron coupling D) nucleon-nucleon coupling

74. Crystal structure of NaCl is ------.
A) simple cubic B) hexagonal
C) body centered cubic D) face centered cubic

75. Which among the following is a correct statement of Laue's theorem?
A) $\Delta k = G$ B) $2k \cdot G + G^2 = 0$
C) both A and B D) none of these

76. In a one dimensional diatomic lattice, both the atoms vibrate against each other with their centre of gravity fixed for ------.
A) acoustic mode B) optical mode
C) transverse acoustic mode D) none of these

77. Low temperature lattice specific heat capacity of solids is explained by -----.
A) Einstein's theory of specific heat
B) Bloch theorem
C) Debye theory of specific heat
D) London theory

78. Tunnelling of Cooper pairs at ------is called Josephoson effect.
A) superconductor-superconductor
B) n-semiconductor-p-type semiconductor
C) superconductor-insulator-superconductor
D) superconductor-semiconductor

79. For an n-type semiconductor at ordinary temperatures, the Fermi level is --------.
A) exactly at the centre of the forbidden energy gap
B) closer to the conduction band
C) closer to the valence band
D) within the valence band

80. In the case of a ferroelectric crystal which among the following is TRUE?
A) it has electric dipole moment only when an external electric field is applied
B) centre of positive charge and centre of negative charge will coincide
C) electric dipole moment is temperature dependent
D) specific heat is temperature independent

81. Ferromagnetic crystals show magnetic hysteresis due to -------.
A) the presence of magnetic domains
B) the presence of uncompensated surface moments
C) the electron-phonon interaction
D) electron-nucleus interaction

82. Which among the following is NOT an intensive thermodynamic variable?
A) temperature B) pressure
C) volume D) magnetic field

83. Any thermometer works on the basis of ------.
A) law of minimum energy B) zeroth law of thermodynamics
C) equipartition principle D) ergodic hypothesis

84. "A process whose sole result is to convert into work heat from a source at one temperature throughout is impossible". This is:
A) Third law of thermodynamics
B) First law of thermodynamics
C) Kelvin's statement of second law of thermodynamics
D) Calusius statement of second law of thermodynamics

85. Melting of ice is an example of ------phase transition.
A) first order B) second order
C) zeroth order D) lambda

86. The probability of occupancy of Fermi level at 0°C and 100°C are respectively-----.
A) 0 and1 B) 1 and 0 C) 1 and 1 D) none of these

87. ---------ensemble is used for studying systems in equilibrium with a reservoir.
A) microcanonical B) canonical
C) grand canonical D) macrocanonical

88. For statistically analysing spectral distribution of black body radiation, one has to use----
A) Maxwell-Boltzmann statistics
B) Fermi-Dirac statistics
C) Bose-Einstein statistics
D) Ergodic hypothesis

89. -------is the λ-transition temperature in liquid He.
A) 4.2K B) 2.186°C C) 72K D) none of these

90. The minimum number of flip-flops required for a mod-12 ripple counter is:
A) 3 B) 4 C) 6 D) 12

91. What is the value of $[L_z, L^2]$?
A) 1 B) L^2 C) $(L_x + L_y)$ D) 0

92. The direct evidence for the existence of magnetic moments of atoms and their space quantization is provided by the ---- experiment.
A) Davisson and Germer B) Hall effect
C) Stern -Gerlach D) Stark effect

93. $_{92}U^{238}$ is emitting an α-particle. The resulting nucleus is -------.

A) $_{91}Pa^{234}$ B) $_{90}Th^{234}$ C) $_{93}Np^{234}$ D) $_{92}U^{235}$

94. Which of the following is Fermi's Golden rule?

A) $\omega = \frac{2\pi}{\hbar}\left|H'_{kn}\right|^2 \rho(E_k)$ B) $\omega = \frac{2\pi}{\hbar}\left|H'_{kn}\right|^3 (E_k)$

C) $\omega = \frac{2\pi^2}{\hbar}\left|H'_{kn}\right|^2 \rho(E_k)$ D) $\omega = \frac{2\pi}{\hbar}\left|H'_{kn}\right| \rho(E_k)$

95. Consider a one dimensional infinite square well of width 1 cm with free electrons in it. If its Fermi energy is 2eV, what is the number of electrons inside the well?
A) 46.2×10^7 B) 462×10^7 C) 0.462×10^7 D) 4.62×10^7

96. The Shell model of nucleus could explain------.
A) Magic numbers B) Nuclear fission
C) Nuclear fusion D) Both B and C

97. Neutrino is a --------.
A) Baryon B) Meson C) Lepton D) hyperon

98. A particle and its antiparticle have ------.
A) same spin and opposite charges
B) same spin and same charges
C) different spin and opposite charges
D) different spin and different charges

99. Particles that are involved in weak interaction are -------.
A) hadrons only B) leptons only
C) hadrons and leptons D) charged particles

100. The electric field intensity $\bar{E}$ due to an infinite uniformly charged plane sheet at a point distant r from the sheet is related as
A) $\bar{E} \propto r^3$ B) $\bar{E} \propto r^2$ C) $\bar{E} \propto r$ D) None of these

101. For a p-n junction formed by heavily doped n-and p-type semiconductors which among the following is TRUE?
A) depletion region will be wider
B) depletion region will be narrower
C) width of depletion region is independent of level of doping
D) none of these

102. Potential barrier at a p-n junction is typically about ---------.
A) 10 -20 eV B) 2-3 eV C) 0.1-0.3 eV D) 5-10 eV

103. The atomic bond is Si and Ge are --------.
A) ionic bonds B) coordinate bonds
C) van der Waal's bonds D) covalent bonds

104. Knee voltage for p-n junction diode made using an indirect band gap semiconductor is 0.3 eV. The semiconductor used is --------.
A) GaAs B) GaSb C) Si D) Ge

105. Approximate equivalent circuit of a p-n junction diode is -------.
A) a switch in series with a battery and a resistor
B) a battery in series with a capacitor
C) a resistor in series with a capacitor
D) none of these

106. What is the energy of a uniformly charged spherical shell of total charge q and radius R?

A) $\frac{q}{8\pi\epsilon_0 R}$ B) $\frac{q^2}{8\pi\epsilon_0 R}$

C) $\frac{q^2}{8\pi\epsilon_0 R^2}$ D) $\frac{q}{8\pi\epsilon_0 R^2}$

107. The Poynting theorem is a mathematical statement of the conservation of:
A) Electromagnetic energy
B) Electromagnetic velocity
C) Electromagnetic charge
D) States

108. The Gibb's potential is defined as
A) G = U- PV-TS B) G = U-PV+TS
C) G = U+PV+TS D) G = U+ PV-TS

109. The self destruction of an unstabilised transistor is known as --------.
A) avalanche break down B) zener break down
C) thermal runaway D) peak depreciation

110. A Si transistor has $I_{CBO} = 0.02$ A at 27°C. The leakage current doubles for every 6°C rise in temperature. Find the base current at 57°C when the emitter current is 1 mA. Given $\alpha = 0.99$
A) 94 A B) 9.4mA C) 9.4 A D) 0.94mA

111. 2's complement of a binary number is obtained by -------.
A) adding 1 to its 1's complement
B) by replacing 0s by 1 and 1s by zeros
C) adding 2 to its 1's complement
D) adding 1 to it

112. In Asynchronous counters, --------.
A) Flip flops are connected in parallel
B) Clock pulses are simultaneously applied to all flip flops
C) Flip flops are connected in series and Clock pulses are simultaneously applied to all flip flops
D) None of these

113. According to Boolean algebra AC + ABC = --------.
A) AC B) ABC C) AB D) A+B

114. When a large step input voltage is applied to OP AMP 741, the output voltage changes from 0 to 10 V in 20 microseconds. Slew rate of the OPAMP is -----.
A) 10 S B) 20 S C) 0.5V/ S D) 0.5V

115. In an OPAMP integrator, the feedback is through -------.
A) resistor B) diode C) capacitor D) inductor

116. According to which statistics, the energy at absolute zero cannot be zero?
A) M - B B) F-D C) B-E D) All the above

117. Two bodies of mass m and 2m are connected by a spring constant k. The frequency of the normal mode is -

A) $\sqrt{3k/2m}$ B) $\sqrt{2k/3m}$

C) $\sqrt{k/2m}$ D) $\sqrt{k/m}$

118. The splitting of spectral line the presence of an electric field is called -

A) Zeeman effect B) Raman effect

C) Paschen back effect D) Stark effect

119. Match List I with List II:

List I	**List II**
a. Normal distribution	1. $\frac{standard\ deviation}{Mean}$
b Poisson distribution	2. Mean = Variance
c. Binomial distribution	3. Mean = Median = Mode
d. Coefficient of variation	4. Mean > variance

A) a-4, b-2, c-1, d-3 B) a-3, b-1, c-2, d-4
C) a-3, b-2, c-4, d-1 D) a-2, b-4, c-3, d-1

120. The rotational energy levels of a linear molecule can be written as

A) $\in_j = B\ (J+1) cm^{-1}$ B) $\in_j = BJ\ (J+1) cm^{-1}$
C) $\in_j = BJ^2 (J+1) cm^{-1}$ D) $\in_j = 2BJ\ (J+1)(J+3) cm^{-1}$