Qn. Booklet No : 92408 **Roll Number :** | | | | | | | | |

INSTRUCTIONS TO CANDIDATES

1. Fill in the OMR sheet carefully as per the instructions given on the back of the OMR sheet.
2. Use only ball point pen (black ink) to fill in the OMR sheet.
3. Write your Roll Number (all eight digits) on the Question Booklet and on the left hand side of the OMR sheet (basic data part).
4. The duration of the examination is **120 Minutes.**
5. After opening the Question Booklet at 2 PM, ensure that there are 120 Questions and that the printing of all the questions are legible. If there are any missing or illegibly printed questions, the matter may be reported to the Invigilator immediately.
6. There are 4 options (A, B, C & D) for each question. Mark your answer corresponding to each question by blackening the corresponding bubble in the OMR sheet with a black ink ball point pen.
7. For every correct answer 1 mark will be awarded. No deduction of mark will be made for unanswered questions and incorrect answers. Marking of more than one bubble against a question number in the OMR sheet will result in the exclusion of that answer from valuation.
8. Calculator, Logarithm table, Mobile phone, Electronics instruments, etc. will not be allowed in the Examination Hall.
9. Rough work and calculations can be made in the blank pages attached to this Question Booklet.
10. **The OMR Answer sheet and Admit Card should be handed over to the Invigilator. The candidate's copy of the OMR Answer sheet and the counterfoil of the Admit Card can be obtained from the Invigilator before leaving the examination hall.**
11. The candidates will be allowed to leave the hall only after the completion of the examination time.
12. The answer sheets of candidates, who resort to any kind of malpractice during the examination, will not be valued.

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1. $\vec{\nabla}.\vec{r}r^{n-1}$ is
(A) nr^{n-1} (B) $(n+2)r^{n-1}$ (C) $(n+2)r^{n}$ (D) $(n+1)r^{n-1}$

2. Cauchy - Riemann conditions for the analyticity of a complex function $f(z) = u(x,y) + i\,v(x,y)$ are
(A) $\frac{\partial u}{\partial x} = \frac{\partial v}{dy}$, $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$
(B) $\frac{\partial u}{\partial x} = \frac{\partial v}{dy}$
(C) $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$
(D) $\frac{\partial^2 u}{\partial x^2} = \frac{\partial^2 v}{dy^2}$, $\frac{\partial^2 u}{\partial y^2} = -\frac{\partial^2 v}{\partial x^2}$

3. Given $\vec{F} = \hat{i}3xy - \hat{j}y^2$. The value of the integral $\int_C \vec{F}.d\vec{r}$ where C is the curve in the xy plane, $y = 2x^2$, from (0,0) to (1,2) is
(A) $\frac{7}{6}$ (B) -7 (C) $\frac{6}{7}$ (D) $-\frac{7}{6}$

4. If A is an $n \times n$ matrix, then det $(-A)$ is
(A) $-$det (A) (B) det A (C) $(-1)^n$ det A (D) det $(-A)$

5. The eigen values of the matrix $\begin{bmatrix} 3 & 1 \\ 2 & 2 \end{bmatrix}$ are
(A) 1 and 4 (B) 3 and 2 (C) 1 and 2 (D) 1 and 0

6. The dielectric susceptibility of an anisotropic medium is
(A) A scalar quantity (B) A second rank tensor
(C) A vector quantity (D) An axial vector

7. Choose the correct statement
(A) The rank of a Cartesian tensor increases by one on contraction
(B) The rank of a Cartesian tensor decreases by one on differentiation
(C) The rank of a Cartesian tensor increases by one on differentiation
(D) The rank of a Cartesian tensor is not affected by differentiation

8. The relationship between the Bessel functions $J_n(x)$ and $J_{-n}(x)$ is
(A) $J_{-n}(x) = -J_n(x)$ (B) $J_{-n}(x) = J_n(x)$
(C) $J_{-n}(x) = (-1)^{n+1} J_n(x)$ (D) $J_{-n}(x) = (-1)^n J_n(x)$

9. The Fourier series expansion of $f(x)=x$ for $-\pi \le x \le \pi$ is

(A) $2\sum_{n=1}^{\infty}\frac{(-1)^n \sin nx}{n}$ (B) $\sum_{n=1}^{\infty}\frac{(-1)^{n+1} \sin nx}{n}$

(C) $2\sum_{n=1}^{\infty}\frac{(-1)^{n+1} \sin nx}{n}$ (D) $2\sum_{n=1}^{\infty}\frac{(-1)^{n+1} \cos nx}{n}$

10. The square roots of i are

(A) $\pm\frac{1}{\sqrt{2}}(1-i)$ (B) 1 and 2 (C) $\pm(1+i)$ (D) $\pm\frac{1}{\sqrt{2}}(1+i)$

11. The degrees of freedom of a rigid body fixed at one point is

(A) 3 (B) 6 (C) 4 (D) 5

12. A particle of unit mass is attracted by gravitational inverse square law of force to a fixed point. The Lagrangian function of the system is,

(A) $L=\frac{1}{2}(r^2+\dot{r}^2\dot{\theta}^2)+\frac{k}{r}$ (B) $L=\frac{1}{2}(\dot{r}^2+r^2\dot{\theta}^2)+\frac{k}{r}$

(C) $L=\frac{1}{2}(\dot{r}^2+r^2\dot{\theta}^2)+\frac{k}{r^2}$ (D) $L=\frac{1}{2}(\dot{r}^2+\dot{r}^2\dot{\theta}^2)+\frac{k}{r}$

13. A particle is moving under a central force with potential energy function $V(r)=br^{n+1}$, where b is a constant and n is an integer. Stable circular orbits can be formed if

(A) $n=-5$ (B) $n=-4$ (C) $n=-3$ (D) $n>-3$

14. Dimension of total cross section is that of

(A) Length (B) Volume

(C) Area (D) Dimensionless

15. The relation between Lagrangian and Hamiltonian is

(A) $H(q,p,t)=q_i\dot{p}_i-L(q,\dot{q},t)$ (B) $H(q,p,t)=\dot{q}_i p_i-L(q,\dot{q},t)$

(C) $H(q,p,t)=\dot{q}_i\dot{p}_i-L(q,\dot{q},t)$ (D) $H(q,p,t)=q_i p_i-L(q,\dot{q},t)$

16. Consider small oscillations of a linear triatomic molecule. The resonant frequencies of vibration are such that

(A) One frequency is zero and the remaining two are unequal
(B) All the three are equal
(C) Two are zeros and one has a nonzero value
(D) One is zero and the other two are equal

17. The phase velocity of a wave packet is given by

(A) $v = \frac{\omega}{k}$ (B) $v = \frac{d\omega}{dk}$

(C) $v = \frac{k}{\omega}$ (D) $v = \frac{d^2\omega}{dk^2}$

18. A column of mercury of total length L partially fills a U tube. The tube is rocked gently so that the column of mercury begins to oscillate with a frequency given by

(A) $\omega = \frac{2g}{L}$ (B) $\omega = \sqrt{\frac{2g}{L}}$

(C) $\omega = \sqrt{\frac{g}{L}}$ (D) $\omega = \sqrt{\frac{g}{2L}}$

19. If the Hamiltonian of a system is invariant under time translation
(A) Kinetic energy of the system is conserved
(B) Linear momentum is conserved
(C) Total energy of the system is conserved
(D) Angular momentum is conserved

20. If the Lagrangian of a system is $L = \frac{1}{2}m(\dot{r}^2 + r\dot{\vartheta}^2 + \dot{z}^2)$, then
(A) r alone is a cyclic coordinate
(B) z alone is a cyclic coordinate
(C) z and r are cyclic coordinates
(D) ϑ and z are cyclic coordinates

21. Hamilton's variational principle says that

(A) $\delta \int \dot{L} dt = 0$ (B) $\int_{t_1}^{t_2} L dt = 0$

(C) $\delta \int_{t_1}^{t_2} L dt = 0$ (D) $\delta \int_{t_1}^{t_2} L dx = 0$

22. The length of a spaceship is measured to be exactly half of its proper length. The speed of the spaceship is

(A) $\frac{\sqrt{2}}{3}c$ (B) $\sqrt{\frac{3}{2}}c$

(C) $\frac{2}{3}c$ (D) $\frac{\sqrt{3}}{2}c$

23. Two electrons leave a radioactive sample in opposite directions, each having a speed of 0.67c with respect to the sample. Then speed of one electron with respect to the other is
(A) 0.92c (B) 0.67c (C) 1.34c (D) c

24. The energy equivalent of 1 gram is
(A) 8.99×10^{16}J (B) 8.99×10^{13}J
(C) 8.99J (D) 8.99×10^{13}eV

25. Electric field $\vec{E}(x)$ satisfies the relation $\vec{\nabla}\times\vec{E}(x)=0$. This relation follows from
(A) Gauss' law (B) Ampere's law
(C) Stokes' theorem (D) Coulomb's law

26. Differential form of Gauss' law is
(A) $\vec{\nabla}.\vec{E}=\frac{\rho}{\varepsilon_0}$ (B) $\vec{\nabla}\times\vec{E}=\frac{\rho}{\varepsilon_0}$
(C) $\nabla E=\frac{\rho}{\varepsilon_0}$ (D) $\vec{\nabla}.\vec{E}=\frac{\rho}{\mu_0}$

27. The direction of the magnetic field produced at a point on the axis of a circular coil carrying electric current is
(A) Along the axis of the coil and directed towards the centre of the coil
(B) Along the axis of the coil and directed away from the centre of the coil
(C) Along a direction inclined to the axis and passing through the point
(D) Perpendicular to the axis of the coil passing through the point

28. Total energy of magnetic field is
(A) $\int\vec{H}.\vec{B}d^3x$ (B) $\frac{1}{2}\int\vec{H}.\vec{E}d^3x$
(C) $\frac{1}{2}\int\vec{H}.\vec{B}d^3x$ (D) $\frac{1}{2}\int\vec{H}\times\vec{B}d^3x$

29. The skin depth due to a time varying magnetic field with frequency ω is proportional to
(A) $\omega^{\frac{1}{2}}$ (B) $\omega^{-\frac{1}{2}}$ (C) ω (D) ω^{-1}

30. The equation $\vec{\nabla}.\vec{B}=0$ enables us to write
(A) $\vec{B}=0$ (B) $\vec{B}=\vec{\nabla}.\vec{A}$ (C) $\vec{B}=\vec{\nabla}\times\vec{A}$ (D) $\vec{B}=\vec{\nabla}\varphi$

31. Choose the correct statement
(A) Ampere's law is valid for dynamic current
(B) Displacement current is introduced to modify Faraday's law
(C) Displacement current modifies Coulomb's law
(D) Ampere's law is valid only for steady state current

32. Choose the correct statement
(A) Using scalar and vector potentials, Maxwell's equations can be reduced to simple second order differential equations
(B) Maxwell's equations are second order differential equations
(C Scalar and vector potentials lead to simple first order differential equations
(D) Maxwell's equations are a set of inhomogeneous differential equations

33. Choose the correct statement
(A) Dielectric constant is in general a complex quantity
(B) Dielectric quantity is purely imaginary
(C) Dielectric quantity is purely real
(D) Real part of the dielectric constant always increases with frequency

34. Plasma frequency of a medium depends on
(A) The resistivity of the medium
(B) Total number of electrons per unit volume of the medium
(C) Conductivity of the medium
(D) Total electrons of the medium

35. Transverse electric (TE) waves means
(A) E_z is zero everywhere with the boundary condition $\frac{\partial B_z}{\partial n}\Big|_s = 0$
(B) E_z is not zero everywhere
(C) B_z is zero everywhere
(D) Both E_z and B_z zeros everywhere

36. For a rectangular wave guide
(A) $TE_{1,0}$ has the lowest cutoff frequency for both TE and TM modes
(B) $TE_{1,0}$ has the lowest cutoff frequency for the TE modes only
(C) $TE_{1,0}$ has the lowest cutoff frequency for the TM modes only
(D) $TM_{1,0}$ has the lowest cutoff frequency for both TE and TM modes

37. Choose the correct statement
(A) The Q factor of a cavity depends on the area of cross section of the cavity
(B) The Q factor of a cavity depends only on the incident frequency of the electromagnetic wave
(C) The Q factor of a cavity depends on the length of the cavity
(D) The Q factor of a cavity is a measure of the sharpness of the response of the cavity to external excitations

38. The index of refraction 'n' of a medium of permeability μ and permittivity ε is

(A) $n=\sqrt{\mu\varepsilon}$
(B) $n=\mu\varepsilon$
(C) $n=\frac{\sqrt{\mu_0\varepsilon_0}}{\sqrt{\mu\varepsilon}}$
(D) $n=\sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

39. The total instantaneous power radiated by an accelerated nonrelativistic charged particle is given by
(A) Lienard-Wiechert formula
(B) Coulomb formula
(C) Larmor formula
(D) Langevin formula

40. The total power radiated by a short, center-fed antenna for a fixed input current increases as
(A) Frequency
(B) Square root of the frequency
(C) Inverse of the frequency
(D) Square of the frequency

41. Consider the motion of a charged particle moving in a uniform static magnetic field of induction 'B'. The gyration frequency (relativistic case) is given by

(A) $\omega_B=\frac{e\vec{B}}{\gamma mc}$
(B) $\omega_B=\frac{c\vec{B}}{\gamma mc}$
(C) $\omega_B=\frac{ec\vec{B}}{\gamma c}$
(D) $\omega_B=\frac{1}{2}\frac{ec\vec{B}}{\gamma mc}$

42. In a $2n$ dimensional phase space, if $\delta q\delta p=h$, the volume of a phase cell is given by
(A) h^{2n}
(B) h^n
(C) h
(D) h^2

43. A linear harmonic oscillator is in thermal equilibrium with a heat bath at temperature T. Its partition function is given by

(A) $z(T)=\sum_n \log^{\frac{(n+\frac{1}{2})\hbar\omega}{kT}}$
(B) $z(T)=\sum_n e^{\frac{(n+\frac{1}{2})\hbar\omega}{2kT}}$
(C) $z(T)=\sum_n e^{\frac{(n+\frac{1}{2})\hbar\omega}{kT}}$
(D) $z(T)=\frac{(n+\frac{1}{2})\hbar\omega}{kT}$

44. Liquid helium- 4 becomes a superfluid when its temperature is lowered below
(A) 3.1K
(B) 4.3K
(C) 1.2K
(D) 2.17K

45. For adiabatic expansion of photon gas

(A) $pV = RT$

(B) $pV^{4/3}$ = a constant

(C) pV^3 = a constant

(D) $pV^{3/2}$ = a constant

46. The heat capacity of a degenerate Fermi gas at low temperatures, T, is proportional

(A) T^2

(B) $\sqrt{T}$

(C) T

(D) Does not depend on temperature

47. The de Broglie wavelength of an electron of kinetic energy $E(eV)$ is proportional to

(A) E

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

(C) E^{-1}

(D) $E^{-\frac{1}{2}}$

48. If the wave function of a particle is $\psi = A\exp\{-(x-x_0)^2)/4a^2\}$ then value of A is

(A) $\frac{1}{\sqrt{\sqrt{2\pi}a}}$

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

(C) $\sqrt{\sqrt{2\pi}a}$

(D) $\sqrt{2a}$

49. If A is a hermitian operator then e^{iA} is

(A) Hermitian operator

(B) Orthogonal operator

(C) Antihermitian operator

(D) Unitary operator

50. The hamiltonian of a perturbed harmonic oscillator is given by

$H = \frac{1}{2}\frac{p^2}{m} + \frac{1}{2}kx^2 + bx^3$. The first order correction to energy is

(A) $\hbar\omega$

(B) 0

(C) $\frac{\hbar\omega}{2}$

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

51. Given that A and B are Hermitian operators such that $[A, B] = iC$, then

(A) $\Delta A\Delta B \geq \frac{1}{2}|\langle C\rangle|$

(B) $\Delta A\Delta B = 0$

(C) $\Delta A\Delta B = \frac{1}{2}\hbar$

(D) $\Delta A\Delta B \leq \frac{1}{2}|\langle C\rangle|$

52. A particle is moving in one dimension in a potential $V(x)$. If the Hamiltonian of the particle is $\hat{H} = \frac{\hat{p}^2}{2m} + V(x)$, then $\frac{d\langle x\rangle}{dt}$ is given by

(A) 0

(B) $\frac{p^2}{2m}$

(C) $\left\langle \frac{p}{m} \right\rangle$

(D) $\langle x \rangle$

53. The expectation value of momentum p in the n^{th} state of a harmonic oscillator is

(A) 0 (B) $\frac{1}{2}\hbar\omega$ (C) $(n+\frac{1}{2})\hbar\omega$ (D) $\frac{1}{2}$

54. The expectation value of L_x^2 in an eigen state of L_z is

(A) 0

(B) $\frac{\hbar m}{2}$

(C) $\frac{\hbar^2}{2}[l(l+1)-m^2]$

(D) $\frac{\hbar^2}{2}l(l+1)$

55. Which one of the relations given below is *not* satisfied by Pauli Matrices?

(A) $\sigma_x\sigma_y+\sigma_y\sigma_x=0$

(B) $\sigma_x\sigma_y=i\sigma_z$

(C) $\sigma_x^2=\sigma_y^2=\sigma_z^2=1$

(D) $\sigma_x\sigma_y-\sigma_y\sigma_x=0$

56. Assuming that the alpha particles "bounce" freely between the walls presented by the spherical well potential with a speed $\sim 10^9$ cm/s and the radius of the radioactive nucleus is 10^{-12} cm, if T is the transmission coefficient of the barrier, the probability of tunneling through the barrier per second is

(A) 10^{-21}T (B) 10^{21}T (C) 10^{-12}T (D) 0

57. Choose the correct statement

(A) The degeneracy of the $n=2$ state of hydrogen atom can be fully removed due to Stark effect

(B) The degeneracy of the $n=2$ state of hydrogen atom can be partially removed due to Stark effect

(C) The ground state of hydrogen atom shows Stark effect

(D) The energy of the ground state gets changed due to Stark effect

58. The total scattering cross section of a particle from a hard sphere of radius 'a' is

A) $\sigma=4\pi a^2$ (B) $\sigma=\pi a^2$ (C) $\sigma=4a^2$ (D) $\sigma=a^2$

59. Optical theorem in scattering says that

(A) $\sigma=\frac{4\pi}{k}\mathrm{Re}\, f_k(0)$

(B) $\sigma=\frac{4\pi}{k}\mathrm{Im}\, f_k(0)$

(C) $\sigma=\mathrm{Im}\, f_k(0)$

(D) $\sigma=4\pi\,\mathrm{Im}\, f_k(0)$

60. For a Dirac particle

(A) Spin angular momentum is zero

(B) Orbital angular momentum is not conserved

(C) The total angular momentum is not conserved

(D) Orbital angular momentum is conserved

61. The current density for a relativistic fermi system is

(A) $J=\psi^\dagger\alpha\psi$ (B) $J=c\psi^\dagger\psi$ (C) $J=c\psi^\dagger\alpha\psi$ (D) $J=\psi^\dagger\psi$

62. In a clamping circuit
    (A) The time constant RC of the circuit should be less with respect to the period of the input wave
    (B) The time constant RC of the circuit should be comparable with respect to the period of the input wave
    (C) The time constant RC of the circuit should be large with respect to the period of the input wave
    (D) The polarity switching property of the diode is employed

63. The ripple factor of a rectifier is

    (A) $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right) - 1}$ (B) $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)}$ (C) $\gamma = \frac{I_{rms}^2}{I_{rms}^2}$ (D) $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

64. The small-signal collector-emitter current gain α_f and the small-signal collector-base current gain h_{fe} are related through the relation

    (A) $\alpha_f = \frac{h_{fe}^2}{1 + h_{fe}^2}$ (B) $\alpha_f = \frac{1 + h_{fe}}{h_{fe}}$ (C) $\alpha_f = \frac{h_{fe}}{1 + h_{fe}}$ (D) $\alpha_f = \frac{1}{h_{fe}}$

65. The parameter that measures the performance of FET is
    (A) Transconductance (B) Transresistance
    (C) Amplification factor (D) Drain current

66. Effect of negative voltage feedback in amplifier circuit is to
    (A) Decrease the output resistance of the amplifier
    (B) Increase the output resistance of the amplifier
    (C) Decrease the output voltage of the amplifier
    (D) Decrease the output current of the amplifier.

67. Consider an operational amplifier with A = 10^5, $Z_1(s) = R_1 =$ 1000 ohms and $Z_1(f) = R_f =$ 10000 ohms. The non-inverting gain is
    (A) –10 (B) 11 (C) 10 (D) –11

68. An amplifier has a slew rate given by the manufacturer as 5V/μs. At a signal frequency of 0.1MHz, the maximum amplitude of the undistorted sine-wave amplitude is
    (A) 0.5 V (B) 7.96 V (C) 0.796 V (D) 5V

69. Logarithmic action of an operational amplifier can be achieved by having
    (A) A transistor in a common-emitter connection in the feedback loop
    (B) A resistor and a capacitor in the feedback loop
    (C) A transistor in a common-base connection in the feedback loop
    (D) A resistor in the feedback loop

70. The gates which are extensively used as standard logic gates are
    (A) AND and OR (B) OR and NOR
    (C) NAND and NOR (D) OR and XOR

71. Which one of the following Boolean identities is wrong?

(A) $A + AB = A$ (B) $A + \bar{A}B = A + B$

(C) $A(A + B) = A$ (D) $A(A+B) = AB$

72. The truth table given below corresponds to

A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

(A) NOR (B) OR (C) XOR (D) NAND

73. The decimal equivalent of the binary '1111' is

(A) 15 (B) 4 (C) 14 (D) 8

74. The bipolar junction transistors (BJT) operate with

(A) Electrons only (B) Both holes and electrons

(C) Holes only (D) Majority carriers

75. The basic circuit of a Schmitt trigger consists of

(A) A differential amplifier followed by an inverter

(B) A differential amplifier alone

(C) An integrated amplifier

(D) An integrated amplifier followed by an inverter

76. The bandwidth required for transmission of an amplitude-modulated radio-frequency signal is

(A) Same as the highest modulating frequency

(B) Twice the highest modulating frequency

(C) Thrice the highest modulating frequency

(D) Half of the highest modulating frequency

77. The role of ionosphere in communication purposes is that

(A) Visible light gets reflected from the ionosphere layers

(B) Microwaves get reflected from the ionosphere

(C) Radio waves get reflected from the ionosphere layers

(D) It does not play any particular role

78. The principle behind light propagation through optical fibre is

(A) Refraction (B) Dispersion

(C) Reflection (D) Total internal reflection

79. Balmer series of the hydrogen spectrum appears in wavelength range

(A) Ultraviolet (B) Infrared

(C) Near UV and visible (D) Far infrared

80. Hyperfine structure of spectral lines are obtained when
   (A) The orbital angular momentum is coupled to spin angular momentum
   (B) The atom is placed in a magnetic field
   (C) The atom is placed in an electric field
   (D) The effect of nuclear spin is included

81. Consider the splitting up of a $^2P_{\frac{3}{2}}$ level in a weak magnetic field. The number of spectral lines which can be observed are
   (A) 4 (B) 1 (C) 2 (D) 3

82. The quantum mechanical expression for the magnetic dipole moment of an atom with angular momentum 'J' is
   (A) $\vec{\mu} = \frac{ge}{2m}\vec{J}$ (B) $\vec{\mu} = -\frac{e}{m}\vec{J}$ (C) $\vec{\mu} = -\frac{ge}{2m}\vec{J}$ (D) $\vec{\mu} = -\frac{e}{m^2}\vec{J}$

83. The splitting up spectral lines of atoms placed in an electric field is known as
   (A) Stark effect (B) Paschen-Back effect
   (C) Zeeman effect (D) Anomalous Zeeman effect

84. The term symbol for a particular atomic state is quoted as $^4P_{\frac{5}{2}}$, the values of L, S and J are
   (A) L = 1, S = 3/2, J = 5/2 (B) L = 1, S = 1/2, J = 1/2
   (C) L = 2, S = 1/2 , J = 5/2 (D) L = 2, S = 1/2, J = 3/2

85. Microwave spectrum is produced by molecules showing
   (A) No variation in the dipole moment during rotation
   (B) Change in the dipole moment during vibration
   (C) Change in the dipole moment during electronic transition
   (D) A change in the dipole moment during rotation

86. The approximation that a diatomic molecule can execute rotations and vibrations independently is known as
   (A) Born approximation (B) Born-Oppenheimer approximation
   (C) Frank-Condon principle (D) Pauli's approximation

87. Choose the correct statement
   (A) O_2 molecule gives rotational spectra
   (B) O_2 molecule gives rotational Raman spectra
   (C) O_2 molecule gives vibrational spectra
   (D) O_2 molecule does not give a rotational Raman spectra

88. Symmetric stretching of CO_2 molecule is
(A) Raman and IR active (B) Raman and IR inactive
(C) Raman inactive while IR active (D) Raman active while IR inactive

89. The selection rule for the formation of Q branch in molecular spectrum is
(A) $\Delta J = 0$, J' = J" (B) $\Delta J = 1$, J' = J"
(C) $\Delta J = 0$, J' = J" +1 (D) $\Delta J = -1$, J" = J' +1

90. Which one of the following nuclei *does not* possess NMR spectrum?
(A) ^{13}C (B) ^{1}H (C) ^{31}P (D) ^{12}C

91. A triclinic crystal is characterized with lattice parameters
(A) $a_1 \neq a_2 \neq a_3$, $\alpha = \beta = 90^0 \neq \gamma$ (B) $a_1 \neq a_2 \neq a_3$, $\alpha = \beta = \gamma = 90^0$
(C) $a_1 = a_2 \neq a_3$, $\alpha = \beta = 90^0 \neq \gamma$ (D) $a_1 \neq a_2 \neq a_3$, $\alpha \neq \beta \neq \gamma$

92. The space lattice of diamond is
(A) fcc (B) bcc (C) hcp (D) sc

93. Bragg law of reflection is $n\lambda = 2d\sin\vartheta$, Bragg reflection can occur if
(A) $\lambda \geq 2d$ (B) $\lambda \leq 2d$ (C) $\lambda = 2d$ (D) $\lambda \leq d$

94. The boundaries of the first Brillouin zone of the linear lattice lies at
(A) $K = \pm\frac{2\pi}{a}$ (B) $K = \pm\frac{\pi}{2a}$ (C) $K = \pm\frac{\pi}{a}$ (D) $K = \pm\frac{\pi}{a^2}$

95. The quantum of lattice vibration is called
(A) Photon (B) Magnon (C) Phonon (D) Exciton

96. The relation connecting Fermi energy and wave vector at the Fermi surface is
(A) $\varepsilon_F = \frac{\hbar^2}{2m}k_F$ (B) $\varepsilon_F = \frac{\hbar^2}{2m}k_F^{\ 2}$ (C) $\varepsilon_F = \frac{\hbar^2}{m}k_F^{\ 2}$ (D) $\varepsilon_F = \frac{\hbar}{2m}k_F^{\ 2}$

97. The heat capacity of electron gas at temperature T, is proportional to
(A) T^2 (B) T^{-1} (C) $\sqrt{T}$ (D) T

98. Solutions of the wave equation in a periodic lattice are of the
(A) Bloch form (B) Gaussian form (C) Wigner form (D) Lorentzian form

99. The model which predicts the T^3 law for specific heat at very low temperature is
(A) Einstein model (B) Debye model (C) Fermi model (D) Dirac model

100. The band gap of Ge at room temperature is
(A) 0.66 V (B) 0.66 J (C) 0.66 eV (D) 0.844 eV

101. Hall coefficient is given by
(A) $R_H = \frac{E_y}{j_x B}$ (B) $R_H = \frac{E_x}{j_x B}$ (C) $R_H = \frac{E_y}{B}$ (D) $R_H = \frac{E_y}{j_x}$

102. The relation between dielectric constant ε and the susceptibility χ in SI units is

(A) $\varepsilon = 1 + 4\pi\chi$ (B) $\varepsilon = 1 + \chi$

(C) $\varepsilon = 1 - \chi$ (D) $\varepsilon = 1 - 4\pi\chi$

103. Choose the correct statement

(A) Magnetic lines of force are expelled from a ferromagnet

(B) A ferromagnet becomes a paramagnet when the temperature is decreased below the Curie temperature

(C) Magnetic lines of force are expelled from a diamagnet

(D) A diamagnet becomes a paramagnet when the temperature is decreased below the Curie temperature

104. When a specimen is placed in a magnetic field and is then cooled below the transition temperature for superconductivity, the magnetic field originally present in the specimen is ejected from the specimen. This effect is known as

(A) Isotope effect (B) Cooper effect

(C) Langevin effect (D) Meissner effect

105. When a conductor becomes a superconductor,

(A) Heat capacity becomes zero at the transition temperature

(B) There is a discontinuity in heat capacity at the transition temperature

(C) Heat capacity remains constant in the superconducting state

(D) Heat capacity decreases without showing any discontinuity at the transition temperature

106. One atomic mass unit is equivalent to

(A) 1.66×10^{-24} kg (B) 0.166×10^{-27} kg

(C) 1.66×10^{-27} kg (D) 0.166×10^{-24} kg

107. The nuclear radius R and atomic mass number A of a nucleus are related as

(A) $R \propto A^3$ (B) $R \propto A$ (C) $R \propto A^{-1}$ (D) $R \propto A^{\frac{1}{3}}$

108. The spin of neutron is

(A) 1/2 (B) 0 (C) 2 (D) 1

109. The quadrupole electric moment of the nucleus is a measure of

(A) The charge of the nucleus

(B) Angular momentum of the nucleus

(C) The deviation of charge distribution from spherical symmetry

(D) Charge independence of the nuclear force

110. The existence of neutrino was proposed by Pauli to explain

(A) Conservation of charge in beta decay

(B) Conservation of energy in alpha decay

(C) Stability of nucleus

(D) Conservation of energy in beta decay

111. Liquid drop model of the nucleus can explain
(A) Nuclear fission
(B) Nuclear fusion
(C) Nuclear stability
(D) Gamma decay

112. A condition for nuclear isomerism is
(A) The presence of an energy level near the ground state
(B) The presence of an energy level near the ground state differing strongly in angular momentum
(C) The presence of states differing in angular momentum
(D) The existence of mirror nuclei

113. Nuclear force is
(A) Long ranged
(B) Coulombic
(C) Short ranged
(D) Inverse square law type

114. Existence of magic nuclei can be understood using
(A) Liquid drop model
(B) Collective model
(C) Nuclear shell model
(D) Optical model

115. GM counter works on the principle
(A) That electron from the ion-pair produces an avalanche at one point in the counter
(B) That electron from the ion-pair produces an avalanche which spreads through the counter
(C) That number of charged particles can be counted
(D) That charged particles recombine to form neutral particles

116. Nuclear reactions is understood using
(A) Shell model
(B) Compound nucleus model
(C) Collective model
(D) Single particle model

117. Gluons
(A) Are colourless
(B) Mediate weak interactions
(C) Mediate strong interactions
(D) Mediate gravitational interactions

118. In beta decay
(A) Parity is conserved
(B) Parity is violated
(C) Spin is not conserved
(D) Energy is not conserved

119. The number of states a quark can have is
(A) 2
(B) 1
(C) 3
(D) 8

120. The quark structure of hadrons was first proposed by
(A) Gell-Mann and Okubo
(B) Gell-Mann
(C) Feynman
(D) Gamow

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