



ENTRANCE EXAMINATION FOR ADMISSION, MAY 2010.

M.Phil. / Ph.D. (PHYSICS)

COURSE CODE : 255/122

Register Number :

Signature of the Invigilator
(with date)

COURSE CODE : 255/122

Time : 2 Hours

Max : 400 Marks

Instructions to Candidates :

1. Write your Register Number within the box provided on the top of this page and fill in the page 1 of the answer sheet using pen.
2. Do not write your name anywhere in this booklet or answer sheet. Violation of this entails disqualification.
3. Read each question carefully and shade the relevant answer (A) or (B) or (C) or (D) in the relevant box of the ANSWER SHEET using HB pencil.
4. Avoid blind guessing. A wrong answer will fetch you -1 mark and the correct answer will fetch 4 marks.
5. Do not write anything in the question paper. Use the white sheets attached at the end for rough works.
6. Do not open the question paper until the start signal is given.
7. Do not attempt to answer after stop signal is given. Any such attempt will disqualify your candidature.
8. On stop signal, keep the question paper and the answer sheet on your table and wait for the invigilator to collect them.
9. Use of Calculators, Tables, etc. are prohibited.

1. A very powerful tool for spin determination is

(A) Raman spectroscopy	(B) FT-IR spectroscopy
(C) Mössbauer spectroscopy	(D) Microwave spectroscopy

2. In partial wave analysis, the effect of scattering results in change in

(A) Energy	(B) Angular momentum
(C) Velocity of partial waves	(D) Phase of partial waves

3. If the total energy of an electron is 4 times its rest energy, then the ratio of its speed to the velocity of light is

(A) $\sqrt{\frac{15}{4}}$	(B) $\frac{3}{4}$	(C) $\sqrt{\frac{3}{2}}$	(D) $\frac{1}{4}$
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4. Parity is *not* conserved in

(A) Nuclear fission	(B) Nuclear fusion
(C) Strong interaction	(D) Electro-weak interactions

5. Schmidt line gives information about

(A) Magnetic moment of the nucleus	(B) Charge of the nucleus
(C) Quadrupole moment of the nucleus	(D) Size of the nucleus

6. Which of the following reactions is *forbidden* by energy conservation?

(A) $\Sigma^+ \rightarrow \pi^0 + \mu^+ + \nu_\mu$	(B) $K^- + d \rightarrow \pi^+ + \Sigma^-$
(C) $K^+ \rightarrow \pi^0 + e^+ + \nu_e$	(D) $\mu^- + p \rightarrow A^0 + \nu_\mu$

7. In Gamow-Teller transition, the interaction involved are about

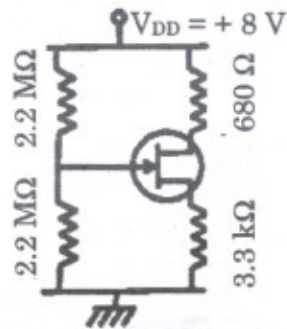
(A) Vector and tensor	(B) Tensor and axial vector
(C) Scalar and vector	(D) Tensor and pseudoscalar

8. If λ is the disintegration constant for α -emission and R is the range of α -particles emitted, the two are related by the equation

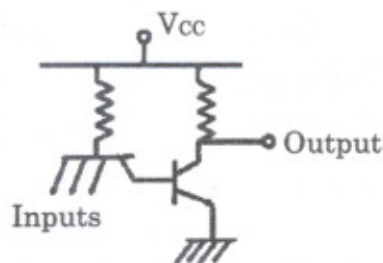
(A) $\lambda = AR + B$	(B) $\lambda = AR^2 + B$
(C) $\lambda = Ae^R + B$	(D) $\log \lambda = \log R + B$

9. The energy E and the thermodynamic potential Ω of a quarks is
- (A) $3E - 4\Omega = 0$ (B) $3E - 4\Omega > 0$
 (C) $3E - 4\Omega < 0$ (D) $3E - 4\Omega \neq 0$
10. The selection rule for Fermi transition is (I is the nuclear spin)
- (A) $\Delta I = 0$ (B) $\Delta I = 1$
 (C) $\Delta I = -1$ (D) $\Delta I \pm 1$
11. A diode that has a negative resistance characteristic is the
- (A) Schottky diode (B) Tunnel diode
 (C) Zener diode (D) Varactor diode
12. The open loop gain and the CMRR of an Op-Amp are 200,000 and 400,000 respectively. The common-mode gain of this Op-Amp is
- (A) 2 (B) 1
 (C) 0.5 (D) 0.25
13. The logic function $Y = A(B + \overline{C}) + B(A + \overline{C}) + C(A + B)$ can be simplified as
- (A) $Y = A(B + C)$ (B) $Y = A + BC$
 (C) $Y = AB$ (D) $Y = A + B$
14. The Fermi level of an n -type semiconductor is
- (A) close to the valence band (B) at the middle of the band gap
 (C) inside the conduction band (D) close to the conduction band
15. Which of the following elements can be added to silicon to create a p-type semiconductor?
- (A) Germanium (B) Arsenic
 (C) Gallium (D) Antimony
16. The maximum efficiency of a Class A power amplifier is
- (A) 100% (B) 75%
 (C) 50% (D) 25%

17. Calculate the value of V_{GS} for the circuit shown in figure



- (A) 4 V (B) 2.2 V (C) 8 V (D) 6.43 V
18. A P-N junction diode is a
- (A) unidirectional and unipolar device (B) unidirectional and bipolar device
- (C) bidirectional and unipolar device (D) bidirectional and bipolar device
19. The phase (Φ) between the input and output voltages of an RC-LOW PASS filter is
- (A) $-\tan^{-1}(\omega RC)$ (B) $\tan^{-1}(\omega / RC)$
- (C) $\tan^{-1}(R / \omega C)$ (D) $-\tan^{-1}(1 / \omega RC)$
20. The circuit shown in the figure represents a



- (A) NOT gate (B) NAND gate
- (C) OR gate (D) XOR gate
21. The change of nuclear configuration takes place in _____ region of electromagnetic spectrum
- (A) UV-Visible (B) Microwave
- (C) X-ray (D) γ -ray

22. The H_β line of Balmer series of hydrogen is 20565 cm^{-1} . The separation between this line and the corresponding line of deuterium is ($R_H = 109710 \text{ cm}^{-1}$) given by
- (A) 0.6 cm^{-1} (B) 15 cm^{-1}
(C) 6 cm^{-1} (D) None of the above
23. The orbital magnetic dipole moment of a Hydrogen like atom is $1.3115 \times 10^{-23} \text{ JT}^{-1}$ and Bohr magneton value is $9.274 \times 10^{-24} \text{ JT}^{-1}$. The value of $l(l+1)$ is given by
- (A) 2 (B) 1
(C) 0 (D) None of the above
24. The rotational and centrifugal constants of HCl molecule are 10.53 cm^{-1} and $5.3 \times 10^{-4} \text{ cm}^{-1}$. Then the vibrational frequency of the molecule is given by
- (A) 299.5 cm^{-1} (B) 2995.2 cm^{-1}
(C) 29.952 cm^{-1} (D) None of the above
25. The linear N-atomic molecule can have fundamental vibrations are
- (A) $3N-5$ (B) $3N$
(C) $3N+5$ (D) None of the above
26. The band origin of a transition in C_2 is observed at 19.378 cm^{-1} while the rotational fine structure indicates that the rotational constants in excited and ground states are 1.6326 cm^{-1} and 1.7257 cm^{-1} respectively. Then the band origin is present in
- (A) S-branch (B) P-branch
(C) R-branch (D) None of the above
27. The first three rotational Raman lines of a linear molecule are at 4.86 cm^{-1} , 8.14 cm^{-1} and 11.36 cm^{-1} from the exciting Raman line. The rotational constant and moment of inertia of the molecule is given by
- (A) 8.118 m^{-1} , $3.443 \times 10^{-47} \text{ kgm}^2$ (B) 81.18 m^{-1} , $34.43 \times 10^{-47} \text{ kgm}^2$
(C) 811.8 m^{-1} , $344.3 \times 10^{-47} \text{ kgm}^2$ (D) None of the above
28. The nuclear g_N factor of ^{19}F nucleus with $I = 1/2$ has a magnetic moment of $2.6273 \mu_N$ is
- (A) 5254.6 (B) 52.546 (C) 525.46 (D) 5.2546

29. If the environment of the emitting and absorbing nuclei are different, the energy of nuclear transition E_0 may differ by a small amount. This energy difference is known as
- (A) Isomer shift (B) Doppler shift
(C) Raman shift (D) None of the above
30. The electronegativities of atomic bonds can be obtained using
- (A) Mossbauer spectroscopy
(B) Infrared spectroscopy
(C) Nuclear Quadrupolar resonance spectroscopy
(D) None of the above
31. Consider a one dimensional harmonic oscillator. If a perturbation linear in position is added, the harmonic oscillator is called
- (A) anharmonic oscillator (B) displaced harmonic oscillator
(C) anisotropic oscillator (D) asymmetric oscillator
32. Let $\hat{A} = x \frac{d}{dx}$ and $\hat{B} = \frac{d}{dx}$, the commutator $[\hat{A}, \hat{B}]$ is
- (A) $\frac{d}{dx}$ (B) $x \frac{d}{dx}$ (C) $-\frac{d}{dx}$ (D) 0
33. The degeneracy of second excited state of a three dimensional isotropic harmonic oscillator is
- (A) 6 (B) 3 (C) 0 (D) 8
34. For which of the following systems, can Schrodinger equation be exactly solved?
- (A) He (B) Li (C) Li^{++} (D) H_2
35. The eigenvalues of a matrix whose trace is -2 and determinant is -3 are
- (A) 1, -3 (B) -1, 3 (C) -1, -3 (D) 1, 3
36. Let $\{|1\rangle, |2\rangle\}$ be two orthonormal states of a two level system. Which of the following operator effects the transition from state 2 to 1?
- (A) $|2\rangle\langle 1|$ (B) $|1\rangle\langle 1|$ (C) $|2\rangle\langle 2|$ (D) $|1\rangle\langle 2|$

37. Radial node of a hydrogen atom wavefunction corresponds to wavefunction is being zero for which of the following surface
 (A) Plane (B) Sphere (C) Dumbbell (D) Ellipsoid
38. Stark effect is a result of applying which of the following to hydrogen atom?
 (A) Magnetic field (B) Mechanical stress
 (C) Electric field (D) Pressure
39. Rutherford scattering cross section varies with the scattering angle as
 (A) $\sin^4 \Theta$ (B) $\csc^4 \Theta$ (C) $\csc^4 \frac{\Theta}{2}$ (D) $\cos^4 \frac{\Theta}{2}$
40. Which of the following is not true for Dirac matrices?
 (A) Dirac matrices anticommute
 (B) Dirac matrices are traceless
 (C) Eigenvalues of Dirac matrices are 1 and -1
 (D) Dirac matrices commute
41. What is the number of degrees of freedom of a rod sliding on an inclined plane?
 (A) 1 (B) 2 (C) 3 (D) 5
42. Which of the following value of θ correspond to unstable equilibrium of planar simple pendulum?
 (A) 0 (B) π (C) $\pi/2$ (D) $\pi/3$
43. Which of the following quantity is conserved in a central force motion?
 (A) Kinetic energy (B) Linear momentum
 (C) Angular momentum (D) All the above
44. In a rotational frame, the force acting on a body by virtue of its velocity is
 (A) centrifugal force (B) centripetal force
 (C) coriolis force (D) frictional force
45. Which of the following is not a type of motion found in symmetrical top?
 (A) Translation (B) Spinning (C) Precession (D) Nutation
46. If a canonical momentum is a constant of motion, the corresponding coordinate is
 (A) also constant (B) zero
 (C) cyclic (D) periodic in time

47. Canonical transformations preserve
- (A) Hamiltonian (B) Poisson Bracket
(C) Lagrangian (D) Phase space density
48. Moment of inertia tensor is diagonal if the angular momentum and angular velocity are
- (A) in same direction
(B) in perpendicular directions
(C) in arbitrary directions
(D) in arbitrary directions, but in the same plane
49. What is the differential cross section of the scattering of hard spheres of radius R ?
- (A) R^2 (B) $R^2/2$ (C) $2R^2$ (D) $R^2/4$
50. A space ship is moving with velocity $0.8c$. If the time interval between two events in the space ship is measured from the space ship as 1.2 s, what is the time between those events if measured from earth?
- (A) 2 s (B) 0.5 s (C) 1.2 s (D) 0 s
51. Orthorhombic crystal structure is defined by
- (A) $a = b = c, \alpha = \beta = \gamma = 90^\circ$ (B) $a \neq b = c, \alpha = \beta = \gamma = 90^\circ$
(C) $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$ (D) $a \neq b \neq c, \alpha = \beta = \gamma \neq 90^\circ$
52. The number of atoms per unit cell of the reciprocal of bcc structure is
- (A) 1 (B) 2 (C) 3 (D) 4
53. The maximum number of states for a crystal of N number of atoms is
- (A) N (B) $2N$ (C) $3N$ (D) $4N$
54. Which degeneracy is not permitted for the rotational symmetry in a crystal?
- (A) 2 fold (B) 3 fold (C) 4 fold (D) 5 fold
55. The unit of Hall coefficient is
- (A) $\text{Vm}^3 \text{A}^{-1} \text{wb}^{-1}$ (B) $\text{Vm} \text{A} \text{wb}^{-1}$
(C) $\text{Vm}^3 \text{A} \text{wb}^{-1}$ (D) $\text{Vm}^2 \text{A}^{-2} \text{wb}$

56. Magnetic susceptibility of a perfect diamagnet is
 (A) 0 (B) +1 (C) -1 (D) infinity
57. The temperature at the Fermi level (0.15 eV) is
 (A) 739 K (B) 1739 K (C) 2739 K (D) 3739 K
58. Curie temperature is the temperature above which
 (A) a paramagnetic material becomes diamagnetic
 (B) a ferromagnetic material becomes diamagnetic
 (C) a paramagnetic material becomes ferromagnetic
 (D) a ferromagnetic material becomes paramagnetic
59. Number of nearest neighbors in a diamond lattice is
 (A) 1 (B) 2 (C) 4 (D) 8
60. One Bohr magneton is equal to
 (A) $2.27 \times 10^{-24} \text{ A m}^2$ (B) $9.27 \times 10^{-24} \text{ A m}^2$
 (C) $9.27 \times 10^{-28} \text{ A m}^2$ (D) $6.27 \times 10^{-24} \text{ A m}^2$
61. The nitrogen liquid boils at 77 K at atmospheric pressure. Which can be a valid suggestion to keep it in liquid state at higher temperature
 (A) increase the pressure (B) increase the volume
 (C) decrease the pressure (D) maintain constant volume
62. When cells in phase space are occupied by particles then they are called
 (A) accessible state (B) particle state
 (C) atomic cell (D) representative point
63. Time average is equal to space average in phase space is the basic idea of
 (A) ergodicity (B) non-equilibrium condition
 (C) irreversible process (D) isothermal process
64. The variation of logarithm of partition function in an ensemble with respect to an external variable like volume or space coordinate defines
 (A) A generalized force conjugate to external parameter
 (B) Internal energy of canonical ensemble
 (C) Temperature of micro canonical ensemble
 (D) Volume of a gas

65. The occupation number for some particles is 0, 1, the particles are
 (A) fermions (B) bosons (C) magnetons (D) photons
66. The super fluidity in liquid ^3He results from the formation of Cooper pairs formed by fermions in
 (A) $S = 0$ state
 (B) $S = 1$ state
 (C) Both the singlet and triplet state
 (D) $P = 0$ state
67. An exchange interaction is expressed by the following expression $H_{\text{exc}} = -J \mathbf{s}_i \cdot \mathbf{s}_j$. It represents
 (A) Ising model (B) Heisenberg model
 (C) William's model (D) Pauli model
68. Imagine that a system A_1 has probability $P_r(1)$ of being found in a state (r) and a system A_2 has probability $P_s(2)$ of being found in a state (s). Let them be weakly interacting and in equilibrium when they form a composite system A consisting of A_1 and A_2 . Under these circumstances the entropy is simply additive. The probabilities of composite system be
 (A) $P_{rs} = P_r(1)P_s(2)$ (B) $P_{rs} = P_r(1) + P_s(2)$
 (C) $P_{rs} = P_r(1) - P_s(2)$ (D) $P_{rs} = P_r(1)/P_s(2)$
69. The equation satisfied by a distribution function of a single particle $f(r, v)$ is given $(\partial f / \partial t)_{\text{collision}} = \partial f / \partial t + \bar{v} \cdot \nabla_r f + \bar{a} \cdot \nabla_v f$ where r and v are Cartesian coordinates and velocity of particle. The equation has one of the following names
 (A) Boltzmann transport equation
 (B) Fick's diffusion equation
 (C) Liouville's theorem equation
 (D) Fermi's distribution function equation
70. Ising model can simulate the properties of magnetic alignments, atoms of binary alloys and lattice gas using pair wise interaction of neighbours. The lattice gas is
 (A) atoms and vacancies (B) ideal gas
 (C) boson gas (D) fermion gas

71. The divergence of a curl of a vector is
 (A) 1 (B) -1
 (C) 0 (D) none
72. The value of $\int_c \frac{dz}{z^2 + a^2}$, where 'c' is a unit circle (anticlockwise) centered at the origin in the complex z -plane is
 (A) π for $a = 2$ (B) zero for $a = 1/2$
 (C) 4π for $a = 2$ (D) $\pi/2$ for $a = 1/2$
73. The Fourier transform of the function $f(x)$ is defined as $g(k) = \int_{-\infty}^{\infty} dx f(x) \exp(ikx)$. Then $g(k)$ for $f(x) = \exp(-\alpha x^2)$ where α is a constant, is
 (A) $\frac{1}{\sqrt{2\pi\alpha}} \exp(-\alpha k^2)$ (B) $\frac{\alpha}{\sqrt{2\pi}} \exp(-\alpha k^2 / 4)$
 (C) $\sqrt{\frac{\pi}{\alpha}} \exp(-k^2 / 4\alpha^2)$ (D) $\exp(-k^2 / \alpha)$
74. If $A = \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}$ then A is
 (A) Hermitian (B) Orthogonal
 (C) Symmetric (D) Skew-symmetric
75. How many generators will be there in an $SU(n)$ group?
 (A) $n^2 - 1$ (B) n^2 (C) $n - 1$ (D) n
76. If $F(t) = t^{-1/2}$, then Laplace transform of $F(t)$ is
 (A) $\sqrt{\frac{\pi}{s}}$ (B) $\frac{\pi}{s^{3/2}}$ (C) $\sqrt{\frac{s}{\pi}}$ (D) none
77. In the Levi-civita tensor $\epsilon_{\mu\nu\lambda}$, if μ, ν , and λ are odd-permuting, then $\epsilon_{\mu\nu\lambda}$ is equal to
 (A) 1 (B) -1 (C) 0 (D) none
78. For the Legendre's differential equation, $P_1(x) = \text{_____}$
 (A) 1 (B) $1 - x$ (C) x (D) $1 - x^2$

79. For the Fourier series which represents $f(x) = x^2$ in the interval $-\pi < x < \pi$, the sum of the series

$$\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots$$

- (A) $\frac{\pi}{12}$ (B) $\frac{\pi^2}{4}$ (C) $\frac{\pi^2}{12}$ (D) $\frac{\pi}{8}$

80. The relation between Beta and Gamma functions is

- (A) $B(l, m) = \frac{\Gamma(l)\Gamma(m)}{\Gamma(l+m)}$ (B) $B(l, m) = \frac{\Gamma(l)\Gamma(m)}{\Gamma(l-m)}$
 (C) $B(l, m) = \frac{\Gamma(l+m)}{\Gamma(l)\Gamma(m)}$ (D) $B(l, m) = \frac{\Gamma(l-m)}{\Gamma(l)\Gamma(m)}$

81. Which of the following states is invalid for an S-R flip-flop?

- (A) $S = 1, R = 0$ (B) $S = 0, R = 1$
 (C) $S = 0, R = 0$ (D) $S = 1, R = 1$

82. A DRAM must be

- (A) replaced periodically (B) refreshed periodically
 (C) cleaned periodically (D) none of the above

83. A modulus 12 counter must have

- (A) 16 flip-flops (B) 8 flip-flops
 (C) 4 flip-flops (D) 2 flip-flops

84. A J-K flip-flop with $J = 1$ and $K = 1$ has a 20 kHz clock input, The Q output is

- (A) Constantly HIGH (B) Constantly LOW
 (C) A 10 kHz square wave (D) $J = 1$ and $K = 1$ is not valid

85. White light illuminates a single slit of width 'x'. The first minimum for red light ($\lambda = 650 \text{ nm}$) falls at $\theta = 15^\circ$. The width 'x' is

- (A) 430 nm (B) 650 nm (C) 2510 nm (D) 1255 nm

86. Unpolarized waves can be polarized by

- (A) scattering (B) reflection
 (C) polarization (D) all of the above

87. The light beam is incident on the mirror at an angle ' α ' with respect to normal on the mirror. If the mirror is tilted '+ θ ' from its original position, the reflected ray now makes an angle of _____ with respect to its original reflected position.
- (A) θ (B) 2θ (C) $\alpha + \theta$ (D) $\alpha + 2\theta$
88. What is the degeneracy of n^{th} stationary state of a two dimensional isotropic harmonic oscillator?
- (A) n (B) 1 (C) $n + 1$ (D) $n - 1$
89. What is the ground state energy of a three dimensional isotropic harmonic oscillator of natural frequency?
- (A) $\hbar\omega$ (B) $\hbar\omega/2$ (C) $2\hbar\omega$ (D) $3\hbar\omega/2$
90. When a long spiral spring is stretched by 2 cm, its potential energy is U. If the spring is stretched by 6 cm, the increase in its potential energy will be
- (A) 4 U (B) 6 U (C) 8 U (D) 9 U
91. Which force together with gravitational force generates a torque for a spinning symmetrical top?
- (A) Reaction force (B) Air drag
(C) Centripetal force (D) Frictional force
92. The intensities of lines in the rotational Raman of H_2 molecule are in the ratio
- (A) 1 : 1 (B) 1 : 2 (C) 1 : 3 (D) 1 : 4
93. The ratio of ground state energy of Hydrogen atom and Helium atom, according to Bohr model, is
- (A) 1 : 2 (B) 2 : 1 (C) 1 : 4 (D) 4 : 1
94. The change of orientation takes place in _____ region of electromagnetic spectrum
- (A) X-ray (B) Visible (C) γ -ray (D) Microwave

95. A molecule containing N atoms has $N-1$ bond stretching and $2N-4$ bending fundamental vibrations. Then the molecule is
- (A) Linear (B) Non-linear
(C) We can't say (D) None of the above
96. A uniform current sheet with $K = K_0 j$ is located $z = b > 2$ and another sheet with $K = -K_0 j$, is located $z = -b$. The magnetic flux crossing the area defined by $x = \text{constant}$, $-2 \leq z \leq 2$, $0 \leq y \leq L$ is thus (for free space)
- (A) $4\mu_0 K_0 L$ (B) $2\mu_0 K_0 L$ (C) $\mu_0 K_0 L$ (D) $\mu_0 K_0 L/2$
97. A proton in a magnetic field completes one circular orbit in 2.35 micro seconds. The magnitude of magnetic field B is
- (A) 0.00279 Tesla (B) 0.279 Tesla
(C) 0.479 Tesla (D) 0.0279 Tesla
98. Two parallel cylindrical conductors separated by 1 m have an inductance per unit length of 2.12 micro Henry/meter. The radius of the conductor is
- (A) 5 mm (B) 4 mm (C) 3 mm (D) 2 mm
99. A uniform line charge distribution with linear charge density of 3.30 nano Coulombs per meter is located at $x = 3$ meters and $y = 4$ meters. The electric field strength at origin is thus
- (A) $-7.13 i - 9.50 j$ V/m (B) $+7.13 i - 9.50 j$ V/m
(C) $+7.13 i + 9.50 j$ V/m (D) $-7.13 i + 9.50 j$ V/m
100. Energy is absorbed or liberated as heat when a current flows along an unequally heated conductor depending upon the direction of flow of the current
- (A) Thomson effect (B) Peltier effect
(C) Seebeck effect (D) None of the above