C - 7

C-7

ENTRANCE EXAMINATIONS – 2023

(Ph.D. Admissions - January 2024 Session)

Ph.D. Physics

Marks: 70

Time: 2.00 hrs. Hall Ticket No.: ______

1. Please enter your **Hall Ticket Number on Page 1 of this question paper and on the OMR sheet** without fail.

2. **Read the following instructions carefully:**

   (a) This Question paper has two parts: **Part - A** and **Part - B**

   (b) **Part - A** consists of 20 multiple choice questions related to Research methods.

   (c) **Part - B** consists of 20 multiple choice questions related to Physics.

   (d) All questions carry 1.75 marks each.

   (e) **There is negative marking of 0.5 marks for every wrong answer.** The marks obtained by a candidate in Part-A will be used for resolving tie cases.

   (f) Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below

   100. (A) (B) (C) ●

   (g) Only non-scientific, non-programmable calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.

   (h) No additional sheets will be provided. Rough work can be done in the question paper itself / space provided at the end of the booklet.

   (i) **Handover the OMR Answer Sheet at the end of the examination to the Invigilator. You may take the Question Paper after the examination is over.**

This book contains 16 pages

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3. Values of physical constants:
   $c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K
   $e = 1.6 \times 10^{-19}$ C; $\mu_\circ = 4\pi \times 10^{-7}$ Henry/m; $\epsilon_\circ = 8.85 \times 10^{-12}$ Farad/m

C-7

PART - A

1. The commutator $[L_x, L^2]$ is

   A. $2i\hbar L_x$
   B. 0
   C. $2i\hbar L_y$
   D. $2i\hbar L_z$

2. For the following distribution $f(x) = \frac{1}{\sigma\sqrt{2\pi}}\, e^{\frac{-(x-\mu)^2}{2\sigma^2}}$, $-\infty \leq x \leq \infty$. The variance is given by

   A. σ^2
   B. μ^2
   C. 0
   D. $\frac{\mu^2}{\sigma^2}$

3. A function is defined as $f(x) = Ax^3 + Bx^2 + x$. A plot of $f(x)$ with respect to x will have a stable minima at $x = 0$, only if

   A. $B >> A$
   B. $B << A$
   C. $B = A$
   D. $B = 0$

4. If m_H is the atomic mass of Hydrogen, m_n is the mass of a neutron, and M is the atomic mass of an atom whose atomic number is Z, which of the following gives the mass defect (Δm)?

   A. $\Delta m = Zm_H + Nm_n - M$
   B. $\Delta m = Zm_H + Nm_n + M$
   C. $\Delta m = Zm_H - Nm_n - M$
   D. $\Delta m = Zm_H - Nm_n + M$

5. The Fourier transform of $f(t) = \begin{cases} 1, & \text{if } |t| < \frac{d}{2}, \\ 0, & \text{otherwise.} \end{cases}$ is

   A. $\frac{2d}{\omega}\, sin(\frac{\omega d}{2})$
   B. $\frac{2d}{\omega}\, cos\left(\frac{\omega d}{2}\right)$
   C. $\frac{2d}{\omega}\, cos(\omega d)$
   D. $\frac{2}{\omega}\, sin\left(\frac{\omega d}{2}\right)$

6. The residue of $\dfrac{sin\ \pi z}{(z-1)^2}$ at $z = 1$

   A. π

   B. $-\dfrac{\pi}{2!}$

   C. $-\dfrac{\pi}{3!}$

   D. $-\pi$

7. The basic element of programming required to reduce time in a repetitive computer program is the

   A. loop element

   B. input and output element

   C. conditional element

   D. variable element

8. The definition of matrix multiplication as $C = AB$ is used in numerical algorithms. If A and B are square matrices of n x n dimensions, the running time for the algorithm will be of the order

   A. n^3

   B. n^2

   C. n

   D. $\frac{1}{n}$

9. The RMS voltage difference across the inductor (L), capacitor (C) and resistance (R) of an LCR circuit is 2 V each. Then, the RMS voltage difference across the LCR is

   A. 0 V

   B. 2 V

   C. 4 V

   D. 6 V

10. A detector kept at a distance of 2 m from a source emitting light uniformly in all directions measures the intensity to be 5 arbitrary units. If the detector is moved by 8 m radially outwards from the initial position of the detector, then the intensity measured in the same arbitrary units is?

    A. $\sqrt{5}$

    B. 5

    C. $\dfrac{1}{\sqrt{5}}$

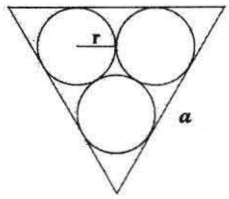
    D. $\dfrac{1}{5}$

11. The number that comes next in the series 12, 50, 204,

   A. 408
   B. 612
   C. 824
   D. 1020

12. If three circles of equal radius r are fit into an equilateral triangle of side a as shown in the figure, then the length of the triangle a in terms of r is

   A. $2r(2\sqrt{3}+1)$
   B. $4r(\sqrt{3}+1)$
   C. $2r(\sqrt{3}+1)$
   D. $\frac{2r}{\sqrt{3}}(\sqrt{3}+4)$



13. Two waves of frequencies 350 Hz and 352 Hz are superimposed to obtain an amplitude modulated wave with an envelope whose frequency is

   A. 2 Hz
   B. 1 Hz
   C. 4 Hz
   D. 351 Hz

14. Assume the pupil diameter of an eye is 6 mm. The smallest size of the object that can be resolved at a distance of 30 m with a light of wavelength 600 nm is

   A. 2.1 mm
   B. 3.6 mm
   C. 4.8 mm
   D. 6.8 mm

15. If you divide 1 by 9, you get an unending sequence of 0.111...If you replace every other 1 by -1 to get 0.abc... $= a10^{-1} + b10^{-2} + c10^{-3}\ldots$ where, $a = 1, b = -1, c = 1$ and so on, then the resulting fraction is

   A. $\frac{1}{9}$
   B. $\frac{1}{10}$
   C. $\frac{1}{11}$
   D. It is not a fraction

C-7

16. A closely wound coil of radius R is made with an insulated copper wire of radius r and length l. The length of the coil is given by

A. $\dfrac{lr}{\pi R}$

B. $\dfrac{lr}{2\pi R}$

C. $\dfrac{2lR}{\pi r}$

D. $\dfrac{lR}{2\pi r}$

17. The degree of degeneracy of an energy level $\frac{38h^2}{8ma^2}$ of a particle of mass m in a cubical potential box of side a is

A. 0

B. 3

C. 6

D. 9

18. The Miller indices representing the family of close packed direction in face centered cubic crystal system is

A. $< 100 >$

B. $< 110 >$

C. $< 111 >$

D. $\{111\}$

19. The Laplace transform of $f(t) = \sin^2 4t$ is

A. $\dfrac{16}{s(s^2+64)}$

B. $\dfrac{32s}{(s^2+64)}$

C. $\dfrac{32}{s(s^2+64)}$

D. $\dfrac{32}{s^2(s^2+64)}$

20. Which one of the following is the final product formed from the radioactive disintegration of uranium?

A. Iron

B. Radium

C. Thorium

D. Lead

PART- B

21. Consider an electron in the Hydrogen atom with a wave function $\psi(\vec{r})= \frac{1}{\sqrt{N}}[\phi_{100}(\vec{r})+ 2\phi_{200}(\vec{r}) + 3\phi_{211}(\vec{r})]$, where $\phi_{nlm}(\vec{r})$ is the energy eigen function with the principal quantum number n, angular momentum l, azimuthal quantum number m, and N is the normalization constant. The expectation value of L_z and L^2 in this state, respectively are

A. $\frac{9}{14}\hbar,\ \frac{18}{14}\hbar^2$

B. $\frac{9}{14}\hbar,\ \frac{81}{14}\hbar^2$

C. $\frac{9}{6}\hbar,\ \frac{18}{6}\hbar^2$

D. $\frac{9}{6}\hbar,\ \frac{81}{6}\hbar^2$

22. A particle of mass m is constrained to move on the surface of a cone of half-angle α placed in a uniform gravitational field. The cone is placed with its apex at the origin O and its axis along the z-axis. The Lagrangian of the particle is

A. $\frac{1}{2}m(\dot{r}^2\frac{1}{sin^2\alpha} + r^2\dot{\phi}^2) - mgrcot\alpha$

B. $\frac{1}{2}m(r^2\frac{1}{sin^2\alpha} + \dot{r}^2\phi^2) - mgrcot\alpha$

C. $\frac{1}{2}m(\dot{r}^2\frac{1}{sin^2\alpha} + r^2\dot{\phi}^2) - mgrcos\alpha$

D. $\frac{1}{2}m(r^2\frac{1}{sin^2\alpha} + \dot{r}^2\phi^2) - mgrcos\alpha$

23. A particle moving in 1-dimension is described by the wave function $\psi(x,0) = C_1\psi_1(x)+ C_2\psi_2(x)$. $\psi_1(x)$ and $\psi_2(x)$ are stationary states with energy eigen values E_1 and E_2, respectively. The probability density $\psi^*(x,t)\psi(x,t) is$

A. $|C_1|^2|\psi_1|^2 + |C_2|^2|\psi_2|^2 + 2|C_1||C_2|cos\left(\frac{(E_2-E_1)t}{\hbar}\right)$

B. $|C_1|^2|\psi_1|^2 + |C_2|^2|\psi_2|^2 + C_1^*C_2\psi_1^*\psi_2e^{\frac{i}{\hbar}(E_1-E_2)t} + C_1C_2^*\psi_1\psi_2^*e^{\frac{i}{\hbar}(E_2-E_1)t}$

C. $|C_1|^2|\psi_1|^2 + |C_2|^2|\psi_2|^2$

D. $|C_1|^2|\psi_1|^2 + |C_2|^2|\psi_2|^2 + C_1^*C_2\psi_1^*\psi_2e^{\frac{-i}{\hbar}(E_1-E_2)t} - C_1C_2^*\psi_1\psi_2^*e^{\frac{-i}{\hbar}(E_2-E_1)t}$

24. If equation of state for a 3-D free gas of non-relativistic particles at very low temperatures be given by $p = n\lambda T^{5/2}$ where λ is a positive constant, n is the number density of particles, and T is the temperature of the system, then its specific heat per particle would be

   A. $c_v = \frac{3}{2}k_B$.
   B. $c_v = \frac{15}{4}\lambda T^{3/2}$.
   C. $c_v = \frac{15}{4}\lambda n T^{3/2}$.
   D. $c_v = \frac{5}{2}\lambda T^{3/2}$.

25. Partition function for a free gas of N indistinguishable classical particles of mass m each in a very large container of volume V at a temperature T is given by $Z_N = \frac{1}{N!}\left(\frac{V}{\lambda_T^3}\right)^N$ where $\lambda_T = (2\pi\hbar^2/mk_BT)^{1/2}$ is the thermal de Broglie wavelength. The partition function in the thermodynamic limit with the number density n can be written as

   A. $Z_N = (\frac{e}{n\lambda_T^3})^N$.
   B. $Z_N = (\frac{1}{n\lambda_T^3})^N$.
   C. $Z_N = N(\frac{e}{n\lambda_T^3})$.
   D. $Z_N = N(\frac{e}{n\lambda_T^3})$.

26. From the shell model of the nucleus, the spin-parity of the ground state of $^{13}_{7}N$ is predicted to be

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

27. The magnetic field corresponding to the vector potential $\vec{A} = \frac{1}{2}\vec{F} \times \vec{r} + \frac{10}{r^3}\vec{r}$, where $\vec{F}$ is a constant vector is

   A. $\vec{F}$
   B. $-\vec{F}$
   C. $\vec{F} + \frac{30}{r^4}\vec{r}$
   D. $\vec{F} - \frac{30}{r^4}\vec{r}$

28. For the charge distribution with the charge density $\rho(r) = q[\delta^3(\vec{r}) + \frac{k}{r^2}e^{-kr}]$ (where $k > 0$),the electric field $\vec{E}(\vec{r})$ for $r > 0$ is given by

A. $\frac{q}{4\pi\epsilon_0 r^2}\left[1 + 4\pi(1 + e^{-kr})\right]$

B. $\frac{q}{4\pi\epsilon_0 r^2}\left[1 + 4\pi(1 - e^{-kr})\right]$

C. $\frac{q}{4\pi\epsilon_0 r^2}\left[1 + \pi(1 + e^{-kr})\right]$

D. $\frac{q}{4\pi\epsilon_0 r^2}\left[1 + \pi(1 - e^{-kr})\right]$

29. The exclusive space occupied by 2^{nd} Brillouin zone of a cubic lattice of lattice constant a is given by

A. $\frac{4\pi^3}{a^3}$

B. $\frac{8\pi^3}{a^3}$

C. $\frac{(14.6)\pi^3}{a^3}$

D. $\frac{(18.2)\pi^3}{a^3}$

30. A system with volume V is in contact with a heat bath of temperature T. Which of the following is true of Helmholtz free energy $F(T, V)$

A. $\delta F \leq 0$

B. $\delta F = 0$

C. $\delta F \geq 0$

D. δF cant be determined

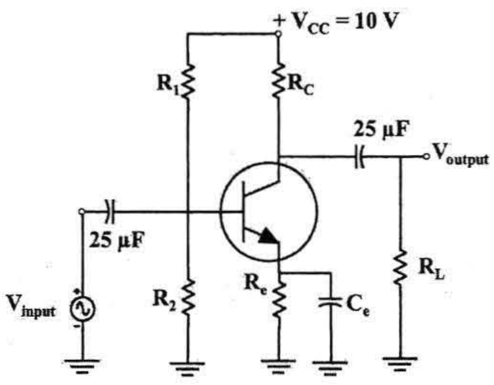
31. For the given CE circuit shown in figure, the h_{fe}= 40 , h_{ie}= 1 $k\Omega$, R_s= 600 Ω, V_{CE}= 5.0 V, V_{BE}= 0.7 V, and V_{CC}= 10 V. The values of R_C and R_e such that a voltage gain of 20 is obtained are

A. $R_C = 1.6\ k\Omega$ and $R_e = 600\ \Omega$

B. $R_C = 400\ \Omega$ and $R_e = 300\ \Omega$

C. $R_C = 800\ \Omega$ and $R_e = 200\ \Omega$

D. $R_C = 200\ \Omega$ and $R_e = 800\ \Omega$



32. For the given truth table, the Boolean expression for the output is

X	Y	W	Z (output)
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

A. $\bar{X}\bar{Y} + XW + X\bar{W}$

B. $\bar{X}\bar{Y} + XW + \bar{X}\bar{W}$

C. $\bar{X}\bar{Y} + XW + \bar{X}W$

D. $\bar{X}\bar{Y} + XW + \bar{W}$

33. The residue of $f(z)$= $(z^2 - 2z)(z^2+4)^{-1}(z+1)^{-2}$ at z= -1 is

A. $-\frac{12}{25}$

B. $\frac{12}{25}$

C. $-\frac{14}{25}$

D. $\frac{14}{25}$

34. Consider a localized spin-1/2 particle interacting with a magnetic field $B\hat{z}$ through the Hamiltonian H= $-\mu_B B\sigma_z$, where μ_B is the magnetic moment and σ_z is a Pauli spin matrix. At temperature T, the expectation value of σ_z is

A. $tan(\frac{\mu_B B}{k_B T})$

B. $tanh(\frac{\mu_B B}{k_B T})$

C. $cosh(\frac{\mu_B B}{k_B T})$

D. $\frac{1}{1 - e^{-mu_B B/k_B T}}$

35. If $\phi(T)$ is the single particle canonical partition function, the grand partition function for a set of localized particles is (z can be taken as fugacity)

A. $1 - z\phi(T)$

B. $\frac{1}{1 - z\phi(T)}$

C. $e^{-z\phi(T)}$

D. $e^{z\phi(T)}$

36. Consider a laser beam of central frequency 6 x 10^{14} Hz and a spectral bandwidth of 700 MHz incident normally on a Fabry-Perot resonator cavity. If the refractive index of the medium in the cavity is 1 and the cavity mirrors are separated by 10 cm, the output beam central mode number and the number of spectral lines within the laser bandwidth are

A. 400,000 and 5

B. 400,000 and 3

C. 200,000 and 0

D. 200,000 and 5

37. In a one-dimensional monoatomic lattice, the group velocity associated with a chain of atoms at propagation constant $\frac{\pi}{a}$ is equal to

A. phase velocity

B. double the phase velocity

C. sound velocity of the medium

D. zero

38. The elements of a group G are of the form a^n where n belongs to the set of whole numbers. The group G can be labeled as

A. cyclic and abelian group

B. cyclic and non-abelian group

C. non-cyclic and abelian group

D. non-cyclic and non-abelian group

39. Consider N (N-is an even integer) spins, each of which can take values $S = \pm 1$. The total energy of this collection of spins is given by $E = E_0 \Sigma_{n=1}^{N} S_n$, where S_n is the spin quantum number of n^{th} spin. The number of microstates corresponding to the macrostate with zero total energy is

A. $2^{\frac{N}{2}}$

B. ${}^{N}C_{N/2}$

C. $\frac{N}{2}!$

D. 2^N

C-7

40. Consider the energy levels of a quantum one-dimensional harmonic oscillator with spacing $\hbar\omega$, in thermal equilibrium at temperature T. The probability of finding the system in first excited state is

A. $e^{-\hbar\omega/k_{\rm B}T}$

B. 1 - $e^{-\hbar\omega/k_{\rm B}T}$

C. $e^{-\hbar\omega/k_{\rm B}T}(1 - e^{-\hbar\omega/k_{\rm B}T})$

D. $1/(1 - e^{-\hbar\omega/k_{\rm B}T})$

University of Hyderabad
Entrance Examinations - 2023
Ph.D. Admissions – January 2024 session

School/Department/Centre : **Physics**
Course : Ph.D. **Subject : Physics**

Q.No.	Answer	Q.No.	Answer
1	B	26	B
2	A	27	A
3	A	28	B
4	A	29	C
5	D	30	C
6	D	31	C
7	A	32	B
8	A	33	**C**
9	B	34	B
10	D	35	B
11	C	36	A
12	**C**	37	D
13	A	38	A
14	B	39	B
15	C	40	C
16	A	41	
17	D	42	
18	B	43	
19	C	44	
20	B	45	
21	A	46	
22	A	47	
23	B	48	
24	B	49	
25	A	50	

Note/Remarks: (a) All questions carry 1.75 marks each.
(b) There is negative marking of 0.5 marks for every wrong answer.
(c) The marks obtained by a candidate in Part-A will be used for resolving tie cases

25/1/2024
Signature
School/Department/Centre