

Ph.D. ENTRANCE EXAMINATION, APRIL 2022

PHYSICS

Time : Two Hours

Maximum : 100 Marks

Part A

*Answer all questions.**Each question carries 2 marks.**Circle the most appropriate choice in the given answer sheet.*1. The value of the integral $\int_0^3 t^2 \delta(3t - 6) dt$ is:

a) 0.

b) $\frac{4}{3}$.

c) $\frac{4}{5}$.

d) $\frac{1}{3}$.

2. If $A = \begin{bmatrix} -3 & 2 \\ -1 & 0 \end{bmatrix}$ then $A^9 =$

a) $511 A + 510 I$.

b) $309 A + 104 I$.

c) $154 A + 155 I$.

d) e^{9A} .

3. The value of the integral $\oint_C \frac{z^3}{e^z + 1} dz$, $|z| = 4$.

a) $\pi^3 i$.

b) $2\pi^3 i$.

c) $3\pi^3 i$.

d) $4\pi^3 i$.

4. Which of the following is not an exact quantity :

a) Speed of light in vacuum.

b) Permeability of vacuum.

c) Permittivity of vacuum.

d) Nuclear magneton.

Turn over

12. For making a capacitor, it is better to select a dielectric having :
- a) Low permittivity.
 - b) High permittivity.
 - c) Permittivity same as that of air.
 - d) Permittivity slightly more than that of air.
13. The bar magnet has :
- a) The dipole moment.
 - b) Monopole moment.
 - c) (a) and (b) both.
 - d) None of the above.
14. If the area of hysteresis loop of a material is large, the hysteresis loss in this material will be :
- a) Zero.
 - b) Small.
 - c) Large.
 - d) None of the above.
15. The particle in a box loses energy when it collides with the wall :
- a) True.
 - b) False.
 - c) In infinite potential wall.
 - d) None of the above.
16. For a particle inside a box, the potential is maximum at $x =$:
- a) L .
 - b) $2L$.
 - c) $3L$.
 - d) $L/2$.
17. The de-Broglie relation describe the relation between :
- a) Wavelength and momentum.
 - b) Wavelength and velocity.
 - c) Wavelength and energy.
 - d) Position and momentum.

18. In which statistics number of particles are limited :
- a) Fermi Dirac Statistics.
 - b) Bose Einstein Statistics.
 - c) a) and b).
 - d) None.
19. Which statistics follow classical mechanics ?
- a) Maxwell Boltzmann statistics.
 - b) Fermi Dirac Statistics.
 - c) a and b.
 - d) None.
20. Which statistics follow Quantum mechanics ?
- a) Maxwell Boltzmann statistics.
 - b) Fermi Dirac Statistics.
 - c) Bose Einstein Statistics.
 - d) Both (b) and (c).
21. Where statistical mechanics can be applied ?
- a) Molecules and phonons.
 - b) Elastic waves.
 - c) Both of the above.
 - d) None of the above.
22. Correct canonical pair of entropy is :
- a) Pressure.
 - b) Temperature.
 - c) Volume.
 - d) Enthalpy.

- (25 × 2 = 50 marks)

Answer any **ten** questions.
Each question carries 5 marks.

6. For Bessel's function show that $\frac{d}{dx} [x^n J_n(x)] = x^n J_{n-1}(x)$.

Turn over

7. State and explain Biot-Savart law and hence obtain the magnetic field at a point due to an infinitely long straight current carrying conductor.
8. An op-amp is used in the following modes with $R_i = 1k\Omega$ and $R_f = 100k\Omega$, $V_i = 120mV$ and $V_{cc} = \pm 12V$. Find output V_o in each case.
i) Inverting mode ; and ii) Non-inverting mode.
9. What is the significance of Fermi energy level ? Under what condition Fermi Dirac distribution function changes to Boltzmann distribution ?
10. A neutral pion whose kinetic energy is equal to its rest mass energy decays in flight. Find the angle between two gamma ray photons that are produced if their energies are same :
 $\pi_0 \rightarrow \gamma + \gamma$.
11. For canonical ensemble, obtain the expression for mean energy $(\bar{E})$ and mean square energy $(\bar{E}^2)$ in terms of β and z .
12. Discuss the HR diagram.
13. What is meant by chemical shift in *nmr* spectroscopy ? Describe the factors affecting chemical shift.
14. What do you mean by constraints ? Explain holonomic and non-holonomic constraints with example.
15. Find $L \left[\frac{\sin at}{t} \right]$. Hence show that $\int_0^\infty \frac{\sin t}{t} dt = \frac{\pi}{2}$.

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- i) $[\hat{L}_x, \hat{L}_y] = i\hbar \hat{L}_z$

$$\text{ii) } [\hat{L}_x, \hat{L}_x] = \hbar \hat{L}_x,$$

4. State and prove Ehrenfest's theorem in Quantum Mechanics.
5. A damped harmonic oscillator is described by the equation $m \frac{d^2x}{dt^2} + R \frac{dx}{dt} + kx = 0$. Determine the phase trajectory of the oscillator.
6. For Bessel's function show that $\frac{d}{dx} [x^n J_n(x)] = x^n J_{n-1}(x)$.

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