Seat
No.

Ph.D. Entrance Examination 2025
PHYSICS
Sub. Code: 58795

Day and Date : Tuesday, 09-Sep-2025   **Total Marks : 100**
Time : 01.00 pm to 03.00 pm

Instructions:

1) All questions are compulsory.

2) Each question carries 2 mark.

3) Answers should be marked in the given OMR answer sheet by darkening the appropriate option.

4) Follow the instructions given on OMR sheet.

5) Rough work shall be done on the sheet provided at the end of question paper.

1. A particle describes the circular orbit given by $r = 2a \cos\theta$ under the influence of an attractive central force directed towards a point on the circle. The force causing such an orbit is a central force and varies as:
    (a) r^{-3}
    (b) r^3
    (c) r^{-5}
    (d) r^5

2. The velocities of a satellite (orbiting around earth) at perigee and apogee points are $25\ km/s$ and $10\ km/s$ respectively. If the perigee distance from the centre of the earth is $10000\ km$, what is the apogee distance?
    (a) $20000\ km$
    (b) $25000\ km$
    (c) $2500\ km$
    (d) $200\ km$

3. The dispersion relation for a low-density plasma is $\omega^2 = \omega_0{}^2 + c^2 k^2$ where ω_0 is the plasma frequency and c is the speed of light in free space. The relationship between the group velocity (V_g) and phase velocity (V_p) is:
    (a) $V_g = V_p$
    (b) $V_p = \sqrt{V_g}$
    (c) $V_g V_p = c^2$
    (d) $V_g = \sqrt{V_p}$

4. You cannot separate North pole and South pole of a magnet because if you could, ...
   (a) it would have violate Maxwell equation, $\vec{\nabla}.\vec{B} = 0$
   (b) it would have violate Maxwell equation, $\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t}\right)$
   (c) it would have violate charge conservation, $\vec{\nabla}.\vec{J} + \frac{\partial \rho}{\partial t} = 0$
   (d) none of the Maxwell equations or charge conservation would have been violated but it is not possible for different reasons.

5. In the Born approximation, the effective cross-section of scattering depends:
   (a) Linearly on scattering angle θ
   (b) on $p sin^2\theta$
   (c) on $p \, sin\,(\theta/2)$
   (d) only on the momentum p

6. Points P and Q are at a distance of 10 cm and 20 cm respectively from the ideal magnetic dipole. The ratio of magnitude of vector potential at point P to that at point Q is:
   (a) 8
   (b) 1/4
   (c) 1/8
   (d) 4

7. A one-dimensional box contains three identical particles in the ground state of the system. The ratio of the total energies of these particles if they were spin-1/2 fermions, to that if they were bosons is:
   (a) 14/3
   (b) 1/3
   (c) 2
   (d) 4

8. Consider a random walk on a two-dimensional triangular lattice. The probability of taking any of the six possible steps is same. What is the probability that the walker returns to the starting position after taking exactly three steps?
   (a) 1/18
   (b) 1/36
   (c) 1/216
   (d) 1/12

9. Consider the function $f(z) = \frac{1}{z^2(z-3)^2}$ of a complex variable z. The residues of the function at $z = 0$ and $z = 2$, respectively, are:
   (a) $-\frac{3}{8}$ and $\frac{3}{8}$
   (b) $\frac{3}{8}$ and $\frac{3}{16}$
   (c) $-\frac{3}{16}$ and $\frac{3}{16}$
   (d) $-\frac{3}{8}$ and $\frac{3}{16}$

10. A particle leaving a cyclotron has a total relativistic energy of 10 GeV and a relativistic momentum of 8 GeV/c. The rest mass (m_0) of this particle is:
    (a) $6\,GeV/c^2$
    (b) $3\,GeV/c^2$
    (c) $9\,GeV/c^2$
    (d) $1.5\,GeV/c^2$

11. Which of the following statement is not correct for a Type I superconductor?
    (a) The phase transition to the normal state in the absence of a magnetic field is of second order.
    (b) With increase in temperature, the critical magnetic field decreases linearly to zero.
    (c) Below the critical temperature, the entropy in the superconducting state is less than that in the normal state.
    (d) The phase transition to the normal state in the presence of a magnetic field is of first order.

12. As per the Drude model of metals, the electrical resistance (R) of a metallic wire of length L and cross-section area A is:
    (Consider τ as the relaxation time, m as electron mass, n as carrier concentration and e as electronic charge)
    (a) $R = \frac{mL}{ne^2 A\tau}$
    (b) $R = \frac{2mL}{ne^2 A\tau}$
    (c) $R = \frac{mL}{2ne^2 A\tau}$
    (d) $R = \frac{mL}{4ne^2 A\tau}$

13. Eigenvalues of the sum of two operators is the sum of the eigenvalues if:
    (a) The operators are Hermitian
    (b) The operators are unitary
    (c) The operators are anti-Hermitian
    (d) The operators have diagonalizable commuting matrices

14. A quantum particle is incident on a potential barrier. The particle has incident energy that is less than the height of the potential barrier. When the particle penetrates the barrier, its wave function is:
    (a) Exponentially increasing
    (b) Exponentially decreasing
    (c) Oscillatory
    (d) A positive constant

15. For a good conductor, skin depth varies inversely with .... power of frequency.
    (a) 3/2
    (b) 2/3
    (c) 1/2
    (d) 3

16. The order of magnitude of the error in estimating the value of the integral $\int_0^1 (x^3 + 2x^2 + 4x + 9)dx$ numerically, using Simpson's 1/3rd method with a step size of 0.1 is:
    (a) 0
    (b) 10^{-4}
    (c) 10^{-3}
    (d) 10^{-5}

17. The first Brillouin zone of FCC lattice is:
    (a) Rhombic dodecahedron
    (b) Parallelepiped
    (c) Truncated octahedron
    (d) Cube

18. For the given reaction, $n + \bar{p} = \pi^- + \pi^0$, which of the conservation statement is true?
    (a) Baryon number (B) is not conserved, the reaction is forbidden
    (b) Charge (Q) is not conserved, the reaction is forbidden
    (c) Electron lepton number (L_e) is not conserved, the reaction is forbidden
    (d) All conservations hold true; the reaction is allowed

19. Which of the following option(s) is/are correct for the ground state of a hydrogen atom?
    (a) Linear Stark effect is zero
    (b) It has definite parity
    (c) Spin-orbit coupling is zero
    (d) All the above

20. Consider N_α (Avogadro number) number of classical one-dimensional oscillators each having energy given by, $E = \frac{p^2}{2m} + 0.5kx^2 + \alpha x^4$ (here k and α are positive constants). The classical specific heat (C_v) at temperature $T = 400\ K$ is:
    (a) $3R$ (R is gas constant)
    (b) $2.5\ R$
    (c) $1.25\ R$
    (d) R

21. The radius of a nucleus is given by the formula $R = R_0 A^{1/3}$, where A is the mass number and $R_0 \approx 1.2\ fm$. What is the approximate ratio of the nuclear density of $^{16}_{8}O$ to that of $^{27}_{13}Al$?
    (a) 16/27
    (b) 27/16
    (c) 1
    (d) 1.20

22. A hydrogen atom is placed in a weak magnetic field. For an electron in the $2p$ state $(n = 2,\ l = 1)$, the number of possible energy levels in the presence of the anomalous Zeeman effect are:
    (a) 3
    (b) 5
    (c) 6
    (d) 10

23. The transconductance (g_m) of a JFET is defined as:
    (a) $\frac{\partial I_D}{\partial V_{DS}}$ at constant V_{GS}
    (b) $\frac{\partial I_D}{\partial V_{GS}}$ at constant V_{DS}
    (c) $\frac{\partial V_{DS}}{\partial I_D}$ at constant V_{GS}
    (d) $\frac{\partial V_{GS}}{\partial I_D}$ at constant V_{DS}

24. If 'A_1' and 'A_2' are the amplitudes of two electromagnetic waves (same frequency) coming from two slits in Young's double slit experiment, then the maximum intensity of interference fringe is:
    (a) $A_1 + A_2$
    (b) $A_1^2 + A_2^2$
    (c) $(A_1 + A_2)^2$
    (d) $\sqrt{A_1^2 + A_2^2}$

25. The temperature of an ideal monoatomic gas is changed from T_1 to T_2, keeping (i) pressure constant, and (ii) keeping its volume constant. Then the ratio of the change in entropy $(\Delta S)_P/(\Delta S)_V$ is:
(a) 1/2
(b) 1
(c) 5/3
(d) 2/3

26. The Hall effect is primarily used to measure which two properties of a semiconductor?
(a) Thermal conductivity and specific heat
(b) Magnetic susceptibility and dielectric constant
(c) Carrier concentration and mobility
(d) Bandgap energy and lattice constant

27. What is the fundamental principle behind Raman spectroscopy?
(a) Absorption of light by a sample
(b) Diffraction of electrons
(c) Elastic scattering of photons
(d) Inelastic scattering of photons

28. What is the main advantage of FESEM (Field Emission Scanning Electron Microscopy) over a conventional SEM?
(a) It can only be used on non-conductive samples.
(b) It uses a brighter, more coherent electron source, leading to higher resolution.
(c) It measures the weight change of a sample.
(d) It has a lower resolution.

29. The primary function of the SOHO (Solar and Heliospheric Observatory) spacecraft is to:
(a) Monitor Earth's weather patterns
(b) Explore the moons of Jupiter
(c) Provide continuous observation of the Sun
(d) Study the cosmic microwave background

30. In the context of numerical techniques and error analysis, what does 'round-off error' refer to:
(a) The error resulting from representing a number with a finite number of digits
(b) The error caused by approximating a continuous function with a discrete one
(c) The error from a simplified mathematical model
(d) The error due to human mistakes in calculation

31. The Beer-Lambert law, fundamental to UV-VIS-near IR spectroscopy, relates absorbance to:
    (a) Molar absorptivity, concentration, and path length
    (b) Wavelength and frequency of light
    (c) Temperature and pressure
    (d) Molecular vibrations

32. What is the primary role of a photomultiplier tube (PMT) in a nuclear detector system that uses a scintillator?
    (a) To convert electrical signals into light pulses
    (b) To stop incoming high-energy particles
    (c) To measure the mass change of the sample
    (d) To convert light pulses from the scintillator into an electrical signal and amplify it

33. In Thermogravimetric Analysis (TGA), what does a sharp mass loss at a specific temperature typically indicate?
    (a) A phase transition, such as melting
    (b) A change in the magnetic properties of material
    (c) An exothermic reaction, such as crystallization
    (d) An endothermic reaction, such as decomposition or dehydration

34. What is a key limitation of Atomic Force Microscopy (AFM)?
    (a) It can only be used on conductive samples
    (b) It has a very slow scanning speed, limiting its use for dynamic processes
    (c) It requires a high vacuum to operate
    (d) It provides a 2D image without height information

35. In UV-VIS-near IR spectroscopy, the energy absorbed by a molecule corresponds to which of the following transitions?
    (a) Rotational transitions
    (b) Vibrational transitions
    (c) Electronic transitions
    (d) Nuclear spin transitions

36. Which of the following is an application of a microwave-based technique in research?
    (a) Measuring the crystallographic structure of a material
    (b) Determining molecular rotation and electron spin resonance (ESR)
    (c) Measuring the thermal expansion of a polymer
    (d) Imaging the surface of a biological sample

37. What is the purpose of rotating the sample during an XRD measurement?
    (a) To increase the intensity of the diffracted peaks
    (b) To ensure that a random orientation of crystallites is exposed to the X-ray beam
    (c) To prevent sample damage from the X-ray beam
    (d) To heat the sample for thermal analysis

38. The laser source in a Raman spectrometer is used for:
    (a) Heating the sample
    (b) Providing a strong, monochromatic light source for scattering
    (c) Inducing fluorescence
    (d) Exciting electrons to a higher energy level

39. The directional gain of an antenna is a measure of:
    (a) The total power radiated by the antenna
    (b) The power radiated in a specific direction compared to an isotropic source
    (c) The antenna's efficiency at a given frequency
    (d) The power absorbed by the antenna

40. Which of the following thin-film deposition techniques relies on the sequential immersion of a substrate into different precursor solutions?
    (a) Chemical Bath Deposition
    (b) Spray Pyrolysis
    (c) Electrodeposition
    (d) SILAR

41. Which of these methods is a bottom-up approach for synthesizing nanomaterials in an aqueous solution under high temperature and pressure?
    (a) Spin coating
    (b) Solvothermal synthesis
    (c) Hydrothermal synthesis
    (d) Dip coating

42. Which type of magnetometer is based on the principle of nuclear magnetic resonance (NMR)?
    (a) Fluxgate magnetometer
    (b) SQUID magnetometer
    (c) Hall effect magnetometer
    (d) Proton precession magnetometer

43. In the context of RF receivers, what does IF stand for?
    (a) Instantaneous Frequency
    (b) Internal Filter
    (c) Intermediate Frequency
    (d) Interference Factor

44. Which of the following synthesis techniques is most dependent on the precursor's viscosity to control the final film thickness?
    (a) SILAR
    (b) Hydrothermal synthesis
    (c) Dip coating
    (d) Electrodeposition

45. Which of the following thin-film deposition methods is a non-vacuum, solution-based process that is inherently a 'bottom-up' approach for producing nanomaterials?
    (a) Spin coating
    (b) Spray Pyrolysis
    (c) Dip coating
    (d) All the above

46. The second order maximum in the diffraction of X-rays of 0.20 nanometer wavelength from a simple cubic crystal is found to occur at an angle of thirty degrees to the crystal plane. The distance between the lattice planes is:
    (a) 1 Angstrom
    (b) 2 Angstrom
    (c) 8 Angstrom
    (d) 4 Angstrom

47. A researcher wants to study the effects of a new teaching method on student performance. Which type of research design would be most appropriate?
    (a) Descriptive Research
    (b) Experimental Research
    (c) Exploratory Research
    (d) Correlational Research

48. Properly citing a source involves:
    (a) Just mentioning the author's name in your text
    (b) Only including the source in the bibliography
    (c) Copying the text exactly as it is written
    (d) Giving credit to the original author for their ideas and words

49. What is the purpose of a citation style (e.g., MLA, APA)?
    (a) To make it easier to find sources on the internet
    (b) To protect your work from being plagiarized by others
    (c) To show that you have a good understanding of formatting rules
    (d) To ensure all citations are formatted in a consistent way

50. What is the main difference between 'a research topic'' and 'a research hypothesis'?
    (a) A topic is a broad area of interest, while a hypothesis is a specific, testable statement.
    (b) A topic is testable, while a hypothesis is not.
    (c) A topic is a question, while a hypothesis is an answer.
    (d) There is no difference between them.