Ph.D. COMMON ENTRANCE TEST - JANUARY 2025

SUBJECT – Physics

PART B

Roll No:	

Duration: 60 minutes **Maximum Marks: 50**

Instructions:

1. **This entrance test question paper is not to be taken out of the examination hall**
2. **Question paper consists of Section A and Section B**
3. **Section A consists of 30 MCQs carrying 1 Mark each. Write the Alphabet of the correct answer in the space given.**
4. **Section B consists of Descriptive questions carrying 5 marks each. Restrict your answer to 500 words. Additional plain sheets have been attached to the question paper to answer Section B**

SECTION – A

Answer the following questions by writing the Alphabet of the correct answer in the Box given: **30 X 1 = 30**

1. The residue of $f(z) = \frac{1}{(Z-1)^2}$ at Z=1 is:
   A. 1
   B. 0
   C. undefined
   D. -1

2. The Laplace transform of e^{at} is:
   A. 1/s
   B. 1/(s+a)
   C. (s+a)
   D. s

3. Which of the following is conserved in the Lagrangian formalism if the Lagrangian is independent of time?
   A. Linear momentum
   B. Angular momentum
   C. Energy
   D. None of the above

4. For a system in small oscillations, the number of normal modes is equal to:
   A. Degrees of freedom
   B. Constraints
   C. Generalized coordinates
   D. None of the above

5. he moment of inertia of a solid sphere of mass MMM and radius RRR, rotating about an axis passing through its center, is:

A. $\frac{2}{5}MR^2$

B. $\frac{1}{2}MR^2$

C. $\frac{2}{3}MR^2$

D. MR^2

6. A system is described by generalized coordinates q_i . If $\frac{\partial L}{\partial q_i} = 0$, what can be inferred?

A. q_i is a cyclic coordinate.

B. The system is at equilibrium

C. The Lagrangian is time-independent.

D. The system is non-conservative.

7. In the relativistic regime, the relationship between total energy E, momentum p, and rest mass m is:

A. $E = \sqrt{(p^2C^2 + m^2C^4)}$

B. $E = pC + mC^2$

C. $E = \frac{p^2}{2m} + m^2C^4$

D. $E = p^2C^2 + m^2C^4$

8. Which of the following describes the hyperfine structure in atomic spectra?

A. Interaction of an electron's spin with its orbital angular momentum.

B. Interaction between nuclear spin and the magnetic field of electrons.

C. Fine splitting of energy levels due to relativistic corrections.

D. Splitting due to external magnetic fields

9. The Paschen-Bach effect occurs when:

A. Atoms are placed in a weak magnetic field.

B. Magnetic field is strong enough to decouple LS coupling.

C. The Stark effect dominates.

D. The electron spin is ignored

10 The selection rule for rotational transitions in a diatomic molecule is:

A. ΔJ= 0, ±1

B. ΔJ=±1

C. ΔJ=±2

D. ΔJ=0,±2

11 According to the liquid drop model, the binding energy of a nucleus depends on:

A. Mass number only.

B. Proton number only.

C. Surface area, volume, Coulomb repulsion, and pairing terms.

D. Neutron-proton ratio only

12 Which type of nuclear decay involves the emission of an electron from the nucleus?

A. Alpha decay
B. Beta decay
C. Gamma decay
D. Spontaneous fission

13 The quark composition of a proton is:

A. uud
B. udd
C. uuu
D. ddd

14 The ground state energy of a quantum harmonic oscillator is:

A. $\frac{1}{2}\hbar\omega$
B. $\hbar\omega$
C. $\frac{3}{2}\hbar\omega$
D. None of the above

15 Which of the following devices converts analog signals into digital signals?

A. Operational amplifier
B. Diode
C. A/D converter
D. D/A converter

16 The output of an ideal operational amplifier is zero when:

A. The input voltages are equal.
B. The input voltages are different.
C. The gain is infinite.
D. None of the above

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17 In a two-body collision, the quantity conserved in the laboratory frame is

A. Kinetic energy only
B. Momentum only
C. Both Kinetic energy and Momentum
D. None of the above

18 What happens to the depletion region of a p-n junction diode under reverse bias?

A. It widens
B. It narrows.
C. It remains unchanged.
D. It disappears.

19 Which of the following materials is commonly used to make LEDs?

A. Silicon
B. Germanium
C. Zinc oxide
D. Gallium arsenide

20 In a MOSFET, the region where the current is independent of the drain voltage is called:

A. Ohmic region
B. Cut-off region
C. Saturation region
D. Breakdown region

21 An operational amplifier in an inverting configuration has a gain of -10. If the input is 0.5 V, the output will be:

A. 5V
B. -5V
C. 10 V
D. -10 V

22 In error analysis, the term 'propagation of errors' refers to:

A. Estimating how uncertainties in measurements affect the result.
B. Errors in the propagation of electromagnetic waves.
C. Systematic errors due to experimental setup.
D. Eliminating errors completely.

23 The chi-square test is used for:

A. Testing the equality of means.
B. Assessing goodness of fit for observed and expected data.
C. Estimating the correlation between variables.
D. Calculating standard deviation.

24 Wave-particle duality is experimentally demonstrated by:

A. Photoelectric effect
B. Double-slit experiment
C. Zeeman effect
D. Blackbody radiation

25 In the Stern-Gerlach experiment, the splitting of a beam of atoms demonstrates:

A. Wave-particle duality
B. Quantization of angular momentum
C. Tunneling effect
D. Pauli exclusion principle

26 According to the Pauli exclusion principle:

A. No two identical fermions can occupy the same quantum state simultaneously

B. No two identical bosons can occupy the same quantum state simultaneously.

C. Fermions and bosons can occupy the same state.

D. Identical particles cannot exist in the same system.

27 In time-independent perturbation theory, the first-order correction to the energy of a system is given by:

A. The expectation value of the perturbation Hamiltonian in the unperturbed state.

B. The square of the perturbation Hamiltonian

C. The derivative of the perturbation Hamiltonian

D. The integral of the perturbation Hamiltonian.

28 The variational method in quantum mechanics is primarily used to:

A. Solve exact eigenvalue problems.

B. Approximate the ground-state energy of a system.

C. Determine the momentum of particles.

D. Analyze tunneling through a barrier.

29 The splitting of spectral lines in the presence of a magnetic field is known as:

A. Zeeman effect

B. Stark effect

C. Raman effect

D. Doppler effect

30 The Frank-Condon principle explains:

A. The energy levels of electrons in a hydrogen atom

B. The intensity distribution of vibrational bands in electronic transitions

C. The population inversion in lasers

D. The broadening of spectral lines due to Doppler effects

Section - B

Answer any four questions (Each question carry 5 marks **4 × 5 = 20**

1. Derive the Lagrange equation for a particle moving under central force motion and find its trajectory equation.

2. A diatomic molecule has rotational levels given by $E_J=BJ(J+1)$. Calculate the rotational constant B if the spacing between adjacent energy levels is 1.2 cm^{-1}.

3. Derive the Eigen functions and eigenvalues for a particle in a one-dimensional box of length L

4. Explain the working principle of a p-n junction diode with energy band diagrams.

5. Describe the semi-empirical mass formula and explain the significance of each term.

6. Explain the stability criteria for a dynamical system in phase space.