R1026

Sub. Code
521201

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Physics

QUANTUM MECHANICS — I

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. For the normalizable $\psi = \sec h(ax)$ the normalization constant is (CO1, K2)

   (a) $(2/a)^{1/2}$ (b) $(a/2)^{1/2}$

   (c) 1 (d) $2/a$

2. The significance of div. $J = 0$ is (CO1, K1)

   (a) $\psi^* \psi$ is independent of time

   (b) the particle is at rest

   (c) ψ is normalizable

   (d) the eigen values are discrete

3. What would happen if the energy of a quantum linear harmonic oscillator is zero? (CO2, K2)

(a) $\psi = \infty$

(b) $\psi = 0$

(c) ψ is non normalizable

(d) Violates uncertainty principle

4. The spacing between the successive energy levels of hydrogen atom ———————— (CO2, K2)

(a) decreases (b) increases

(c) constant (d) oscillates

5. The Hermitian conjugate of $\lambda|\psi> A^{+} B$ is (CO3, K3)

(a) $\lambda^{*}|\psi> A\, B^{+}$ (b) $\lambda^{*} B^{+} A<\psi|$

(c) $\lambda^{*} AB^{+}<\psi|$ (d) $\lambda^{*} A\, B^{+}|\psi>$

6. Choose the incorrect statement associated with the Hilbert space. (CO3, K3)

(a) A quantum state is represented by a point

(b) The dimension of the Hilbert space for energy is infinite

(c) $|\psi>$ and $5|\psi>$ are different

(d) A state vector is represented by a line passing through the origin

7. The perturbation of the hydrogen atom subjected to an electric field along z-direction is (CO4, K4)

(a) $\mathrm{eEr}\cos\theta$ (b) $-\mathrm{eEr}\sin\theta$

(c) $-Er\cos\theta$ (d) $-eEr\cos\theta$

8. The first excited state of the hydrogen atom is _____ fold degenerate (CO4, K3)

(a) 0 (b) 2

(c) 4 (d) 8

9. The Fermi's golden rule is called so because (CO5, K3)

(a) it is same for all states

(b) the area under the main peak is large

(c) it is independent of time

(d) it is often used in spectroscopy

10. In the adiabatic process (CO5, K2)

(a) the perturbed and unperturbed states remain the same

(b) the total probability is 1

(c) total change in the probability is 0

(d) the potential is weak

Part B ($5 \times 5 = 25$)

Answer **all** questions not more than 500 words each.

11. (a) For a linear harmonic oscillator with $V(x)=(1/2)kx^2$ find $[H, p_x]$. (CO1, K2)

Or

(b) If $\psi = \exp(-kx)$ for $x>0$ and 0 for $x<0$, normalize ψ and then find $\langle x \rangle$. (CO1, K2)

12. (a) Compare the degeneracy of energy levels of rigid rotator and hydrogen atom. (CO2, K2)

Or

(b) Draw the first few energy levels of linear harmonic oscillator, particle in a box and hydrogen atom (no need to write the expressions for energy eigenvalues). (CO2, K2)

13. (a) Write a note Hilbert space. (CO3, K2)

Or

(b) Set up the Schrödinger equation in matrix form. (CO3, K3)

14. (a) Applying the variational method determine the ground state energy of helium atom. (CO3, K3)

Or

(b) Outline the application of WKB method to the tunnelling phenomenon. (CO3, K4)

15. (a) Consider the infinite height potential confining a particle in the region $0<x<L$. The system is in the ground state for $t<0$ and the right wall is suddenly shifted to the position $x=2L$ at $t=0$. Determine the probability of it being in the ground state of the new well. (CO5, K2)

Or

(b) Explain the spontaneous and stimulated emissions with examples. (CO5, K2)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1000 words each.

16. (a) Set up the time-dependent Schrödinger equation for a particle in a potential. (CO1, K1)

Or

(b) State and prove the Ehrenfest's theorem. (CO1, K2)

17. (a) For a particle in the presence of a square barrier potential establish the occurrence of tunnelling phenomenon. (CO2, K2)

Or

(b) Obtain the energy levels of linear harmonic oscillator with $V=(1/2)(x^2+y^2+z^2)$ and then find the degeneracy of the energy levels. (CO2, K2)

18. (a) Work out the matrix forms of the position and momentum operators of linear harmonic oscillator. (CO2, K3)

Or

(b) State the Heisenberg representation and obtain the Heisenberg equation of motion. (CO2, K3)

19. (a) Develop a perturbation theory applicable for degenerate states. (CO4, K4)

Or

(b) Account Stark effect in hydrogen atom by appropriate perturbation theory. (CO4, K3)

20. (a) Obtain the transition rate for a system subjected to a harmonic perturbation. (CO5, K5)

Or

(b) Find the transition probabilities for absorption and emission in a radiation field. (CO5, K5)

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R1027

Sub. Code
521202

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Physics

MATHEMATICAL PHYSICS – II

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. Which of the following function is not analytic everywhere? (CO1, K1)

   (a) $e^{\sin z}$ (b) $\log z$

   (c) e^{z} (d) $\sin z$

2. The coefficient of the term $(z-1)^2$ in the Taylor series of the function $f(z)=\frac{1}{z^2-9}$ about the point $z=1$ is (CO1, K2)

   (a) $\frac{-1}{32}$ (b) $\frac{1}{32}$

   (c) $\frac{-3}{128}$ (d) $\frac{3}{128}$

3. What is the class of Laplace equation? (CO2, K1)

(a) elliptic (b) parabolic

(c) hyperbolic (d) none of these

4. Which of the following equation is Poisson's equation? (CO2, K3)

(a) $\nabla^2 u = 0$ (b) $\nabla^2 u = \frac{-\rho}{\in_0}$

(c) $\rho \nabla^2 u = \in_0$ (d) $\nabla^2 u - \frac{\partial^2 u}{\partial t^2} = \frac{\rho}{\in_0}$

5. Find the value of $\frac{\Gamma\left(\frac{-1}{2}\right)}{\Gamma\left(\frac{1}{2}\right)}$ (CO3, K5)

(a) 2 (b) –2

(c) 1/2 (d) –1/2

6. Find the value of the integral $\int_{-1}^{1} xP_n(x)P_{n-1}(x)dx$ (CO3, K5)

(a) 0 (b) $\frac{2}{2n+1}$

(c) $\frac{1}{4n^2-1}$ (d) $\frac{2n}{4n^2-1}$

7. Given $\frac{d^m}{dx^m}H_n(x) = AH_{n-m}(x)$, find A (CO4, K4)

(a) $2^n n!$ (b) $2^m n!$

(c) $2^m \frac{n!}{(n-m)!}$ (d) $2^n \frac{n!}{(n-m)!}$

8. What is the value of $L_n'(0)$? (CO4, K5)

(a) 1 (b) n

(c) $-n$ (d) none of these

9. If every subgroup of a group is normal subgroup then the group is (CO5, K2)

(a) Non-abelian (b) Abelian

(c) Necessarily cycle (d) None of these

10. Set of all even integers form the group under the law of combination as (CO5, K1)

(a) ordinary multiplication

(b) ordinary addition

(c) addition modulo

(d) multiplication modulo

Part B ($5 \times 5 = 25$)

Answer **all** questions not more than 500 words each.

11. (a) Using Cauchy integral formula, calculate the integral $\int_C \frac{dz}{9-z^2}$, where C is the circle $|z|=2$ described in the positive sense. (CO1, K3)

Or

(b) Obtain the Laurent series expansion of $f(z)=\frac{1}{z^2-3z+2}$ in the region $1<|z|<2$. (CO1, K4)

12. (a) Obtain the solution of one dimensional heat equation by separation of variables method. (CO2, K1)

Or

(b) Transform two-dimensional Laplace equation into polar coordinates. (CO2, K2)

13. (a) Express the period for 180° swings (back and forth –90° to 90°) of a simple pendulum in terms of a beta function and then find its value. (CO3, K4)

Or

(b) Find the expression for the integral $\int x^4 J_1(x)dx$, where $J(x)$ is the Bessel function. (CO3, K3)

14. (a) Prove that $\int_{-\infty}^{\infty} e^{-x^2} H_{2n}(\alpha x)dx = \sqrt{\pi}\frac{(2n)!}{n!}(\alpha^2 - 1)^n$ and hence show that $e^{-\alpha^2 x^2} = \sum_{n=0}^{\infty} \frac{(-1)^n \alpha^{2n}}{2^{2n} n!(1+\alpha^2)^{n+\frac{1}{2}}} H_{2n}(x)$. (CO4, K4)

Or

(b) Using the generating function show that $\frac{e^{\frac{-xt}{1-t}}}{1-t} = \sum_{n=0}^{\infty} L_n(x)t^n$, where $L_n(x)$ is the Laguerre polynomial. (CO4, K3)

15. (a) Define isomorphic and homomorphic groups. Differentiate between them and give at least two properties of each. (CO5, K2)

Or

(b) Define cyclic group and show that a group of order four may or may not be a cyclic group. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1,000 words each.

16. (a) Using Contour integration evaluate the integral $I = \int_0^{\infty} \frac{x^2}{(x^2+9)(x^2+4)^2} dx$. (CO1, K5)

Or

(b) Evaluate $\oint \frac{dz}{z^2+1}$ where C is the circle $|z| = 4$. (CO1, K5)

17. (a) Obtain the solution of two-dimensional Laplace equation. (CO2, K3)

Or

(b) Set up one-dimensional wave equation and solve it. (CO2, K2)

18. (a) Show that $\int_{-1}^{1} P_n(x) P_m(x) dx = \frac{2}{2n+1} \delta_{nm}$. (CO3, K3)

Or

(b) Solve the differential equation $x^2 y'' + xy' + \left(x^2 - \frac{1}{4}\right) y = 0$. Prove that two solutions can be written in the form $\frac{\sin x}{\sqrt{x}}$ and $\frac{\cos x}{\sqrt{x}}$. (CO3, K4)

19. (a) Show that Hermite polynomials are generated by the function $e^{x^2-(z-x)^2}$ and hence prove that $H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n}\left(e^{-x^2}\right)$. (CO4, K4)

Or

(b) Solve the Laguerre's differential equation $xy'' + (1-x)y' + \lambda y = 0$, where λ is a constant and obtain the values of the first four Laguerre polynomials. (CO4, K3)

20. (a) Explain reducible and irreducible representation and list out their main features. (CO5, K2)

Or

(b) Obtain the irreducible representations of C_{3v} point group and construct its character table. (CO5, K3)

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R1028

Sub. Code
521203

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Physics

ELECTROMAGNETIC THEORY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option

1. Poisson equation reduces to Laplace equation when the charge is _____. (CO1, K3)

   (a) Constant (b) Variable

   (c) Zero (d) Both (a) and (c)

2. Biot-Savart's law states magnetic induction is independent of ————————. (CO1, K5)

   (a) Current (b) Current element

   (c) Current density (d) All of them

3. In electrodynamics, rate of change of electric displacement vector is _____ (CO2, K3)

   (a) Magnetic field (b) Electric field

   (c) Current density (d) Maxwell current

4. In conducting medium, the field vectors E and H are _____ (CO2, K2)

(a) damped, out of phase

(b) damped, in phase

(c) undamped, out of phase

(d) undamped, in phase

5. If r is the amplitude reflection coefficient, then reflectance, R is _____. (CO3, K1)

(a) r (b) r^2

(c) r^3 (d) r^4

6. Given the polarizing angle is 30°, then its angle of refraction ————————. (CO3, K2)

(a) 30° (b) 45°

(c) 60° (d) 90°

7. The increased bending of violet light over red by a glass prism is due to ———————— dispersion. (CO4, K2)

(a) Normal (b) Anomalous

(c) Both (a) and (b) (d) None of them

8. Clausius Mossotti relation is applicable for non-polar liquids. (CO4, K4)

(a) True (b) False

(c) Case dependent (d) None of them

9. Pick out the odd man out. (CO5, K3)

(a) Auroras (b) Lightning

(c) Neon tubes (d) Bulbs

10. Magneto hydrodynamics is based on————————law. (CO5, K5)

(a) Coulomb's (b) Gauss

(c) Faraday (d) Ampere

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Derive Gauss's law in differential form. (CO1, K3)

Or

(b) Compare electrostatics and magnetostatics. (CO1, K2)

12. (a) Interpret transverse nature of electromagnetic waves. (CO2, K3)

Or

(b) Solve Maxwell's equation in free space to show that electromagnetic field vectors E and H are both perpendicular to the direction of propagation vector K. (CO2, K4)

13. (a) Discuss the boundary conditions at the surface of discontinuity. (CO3, K1)

Or

(b) Comment on Brewster's law and degree of polarization. (CO3, K2)

14. (a) Elaborate dispersion in gases. (CO4, K3)

Or

(b) Give a brief outline on the polarization of scattered light. (CO4, K6)

15. (a) Compute the condition for plasma existence. (CO5, K2)

Or

(b) Explain magnetic confinement. (CO5, K4)

Part C ($5 \times 8 = 40$)

Answer **all** the questions not more than 1000 words each.

16. (a) State and explain Ampere's theorem. (CO1, K4)

Or

(b) Arrive at the expression for magnetic vector potential. In what way it differs from the electric potential in electrostatics. (CO1, K6)

17. (a) Derive Maxwell's equation for electromagnetic field and discuss their physical meaning. (CO2, K6)

Or

(b) Outline the significance of propagation of electromagnetic waves in isotropic non conducting medium. (CO2, K3)

18. (a) Interpret Fresnel's equation. (CO3, K2)

Or

(b) Elaborate the condition for total internal reflection. (CO3, K5)

19. (a) By arriving at an expression for local electric field, derive Clausius Mossotti relation. (CO4, K6)

Or

(b) Elucidate coherence of scattered light. (CO4, K3)

20. (a) Interpret the behavior of charged particles in homogenous magnetic fields. (CO5, K4)

Or

(b) Discuss Pinch Effect. (CO5, K2)

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R1029

Sub. Code
521505

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Second Semester

Physics

Elective — MATERIALS AND CHARACTERIZATION

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. What does the term "supersaturation" signify in crystal growth? (CO1, K1)

   (a) The state where the solution concentration is lower than equilibrium solubility

   (b) The state where the solution concentration is exactly at equilibrium solubility

   (c) The state where the solution concentration is higher than equilibrium solubility

   (d) The state where the solution concentration remains constant over time

2. The choice of flux in flux growth depends on ————————. (CO1, K2)

   (a) Its solubility with the compound to be grown

   (b) Its temperature stability

   (c) Its crystalline structure

   (d) Its colouration properties

3. What is the primary advantage of the bottom-up approach in nanomaterial synthesis? (CO2, K2)

(a) Precise control over structure and properties

(b) Faster fabrication process

(c) Cost-effectiveness

(d) Compatibility with existing manufacturing techniques

4. How does excitation confinement in quantum dots lead to their unique optical properties? (CO2, K4)

(a) It limits the movement of electrons and holes

(b) It increases the size of the quantum dots

(c) It reduces the bandgap of the material

(d) It enhances the scattering of light within the quantum dots

5. Which sputtering technique relies on the use of a magnetron to confine electrons and increase the plasma density? (CO3, K3)

(a) DC sputtering

(b) RF sputtering

(c) Ion beam sputtering

(d) Reactive sputtering

6. In metalorganic chemical vapour deposition (MOCVD), metalorganic precursors are introduced into the reactor chamber in what form? (CO3, K3)

(a) Solid (b) Liquid

(c) Gas (d) Plasma

7. Free volume theory suggests that ionic conductivity is primarily influenced by (CO4, K4)

(a) Ionic size

(b) Crystal structure

(c) Defect concentration

(d) Temperature

8. Nanocrystalline ceramics are preferred for ion conduction due to their (CO4, K5)

(a) High mechanical strength

(b) Low grain boundary resistance

(c) Insulating properties

(d) Limited defect density

9. In thermography, contact inspection methods involve (CO5, K1)

(a) Direct contact with the surface being inspected

(b) Indirect contact through a medium

(c) No physical contact with the surface

(d) The use of physical probes to measure temperature

10. Liquid Penetrant Testing (LPT) is advantageous for (CO5, K1)

(a) Detecting internal voids

(b) Detecting surface cracks

(c) Inspecting material thickness

(d) Measuring electrical conductivity

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Discuss the classification of crystal growth methods. (CO1, K3)

Or

(b) Describe the process of hydrothermal growth. (CO1, K6)

12. (a) Discuss the principles and applications of the polyol route in the synthesis of nanomaterials. (CO2, K5)

Or

(b) Discuss the role of magnetic nanoparticles in Nanotechnology. (CO2, K4)

13. (a) Explain laser ablation and cathode arc deposition techniques briefly. (CO3, K2)

Or

(b) Describe the process of spin coating and its applications in thin film fabrication. (CO3, K2)

14. (a) Explain the concept of ionic conduction theories and models briefly. (CO4, K3)

Or

(b) Describe the mechanisms involved in lithium transport in lithium batteries in a concise manner. (CO4, K6)

15. (a) Discuss the advantages of using non-contact inspection methods in Thermography testing and provide examples of their applications. (CO5, K4)

Or

(b) Explain the principle behind Acoustic Emission (AE) technique and discuss its parameters briefly. (CO5, K5)

Part C ($5 \times 8 = 40$)

Answer **all** the questions not more than 1000 words each.

16. (a) Explain the principles of flux growth in high-temperature solution crystal growth, including the role of flux materials, selection criteria and crystal growth mechanisms. (CO1, K5)

Or

(b) Describe the working principle, equipment setups, advantages and limitations of the Czochralski technique. (CO1, K6)

17. (a) Explain the different types of nanostructure materials, including 1D, 2D and 3D nanostructures detailing their synthesis methods and properties. (CO2, K5)

Or

(b) Discuss the unique properties, functionalities and potential applications of nanocomposites, focusing on examples such as ZnO, TiO_2 and MoS_2. (CO2, K4)

18. (a) Explain the operation principles and setup of RF magnetron sputtering and DC magnetron sputtering. (CO3, K2)

Or

(b) Discuss the process and advantages of spray pyrolysis in thin film deposition. (CO3, K3)

19. (a) Discuss the classification of superionic materials and provide detailed examples of each class. (CO4, K5)

Or

(b) Explain the principles of nanocrystalline ceramics for ion conduction and their advantages over conventional materials. (CO4, K4)

20. (a) Describe the principle, types, advantages and limitations of Liquid Penetrant Testing (LPT) comprehensively. (CO5, K6)

Or

(b) Discuss the principles, instrumentation and applications of Ultrasonic Testing(UT) in detail. (CO5, K4)

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R1030

Sub. Code
521401

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Fourth Semester

Physics

CONDENSED MATTER PHYSICS – II

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. Frequency and temperature effects on polarization primarily influence the _____. (CO1, K1)

   (a) Dielectric constant

   (b) Polarization field

   (c) Local electric field

   (d) Dipole moment

2. Dielectric breakdown refers to ————. (CO1, K2)

   (a) The complete failure of a dielectric material to polarize under an electric field

   (b) The sudden increase in polarization with increasing electric field

   (c) The failure of a dielectric material to resist electric current

   (d) The sudden loss of insulating properties due to excessive electric field

3. The polarization catastrophe phenomenon in ferroelectric crystals occurs when ————————. (CO2, K2)

(a) The crystal undergoes spontaneous polarization

(b) The crystal loses its ferroelectric properties

(c) The polarization exceeds a critical value, leading to breakdown

(d) The crystal becomes antiferroelectric

4. What drives the motion of ferroelectric domain walls within a crystal? (CO2, K3)

(a) External magnetic field

(b) External electric field

(c) Temperature gradient

(d) Pressure gradient

5. Langevin's theory of paramagnetism primarily focuses on _____. (CO3, K1)

(a) Quantum mechanical effects

(b) Molecular field interactions

(c) Magnetic susceptibility of materials

(d) Spin waves in ferromagnetic materials

6. Ferrimagnetism is characterized by materials exhibiting ————————. (CO3, K2)

(a) Strong ferromagnetic properties

(b) Alternating alignment of magnetic moments

(c) No response to external magnetic fields

(d) Weak antiferromagnetic properties

7. The Isotope effect in superconductors refers to the phenomenon where ——————. (CO4, K4)

(a) Different isotopes of the same element exhibit different superconducting transition temperatures

(b) Isotopes have no effect on the superconducting properties of a material

(c) Isotopes enhance the superconducting transition temperature

(d) Isotopes decrease the superconducting transition temperature

8. The coherence length in superconductors represents ——————. (CO4, K5)

(a) The length over which the superconducting state persists

(b) The length over which magnetic fields can penetrate the superconductor

(c) The length over which Cooper pairs form

(d) The length over which Josephson junctions occur

9. Excitons in Nano semiconductors are ——————.

(CO5, K1)

(a) Mobile ions

(b) Electrons in the valence band

(c) Bound electron-hole pairs

(d) Protons

10. Graphene is a two-dimensional material composed of —————— . (CO5, K2)

(a) Carbon nanotubes

(b) Carbon atoms arranged in a hexagonal lattice

(c) Nanodiamond

(d) Silicon atoms arranged in a hexagonal lattice

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Differentiate between the various classifications of polarization in dielectric materials. (CO1, K6)

Or

(b) Discuss the concept of dielectric loss and its relationship with polarization. (CO1, K2)

12. (a) Define polarization catastrophe in ferroelectric crystals and discuss its implications on their stability and behavior under an electric field. (CO2, K4)

Or

(b) Describe the concept of ferroeletric domains and how their formation contributes to the overall polarization. (CO2, K3)

13. (a) Explain the Weiss molecular field theory and discuss its role in explaining the alignment of magnetic moments in ferromagnetic materials. (CO3, K3)

Or

(b) Explain Hund's rules and how they govern the arrangement of electrons in atomic orbitals. (CO3, K5)

14. (a) Explain the phenomenon of superconductivity and its occurrence in certain materials. (CO4, K1)

Or

(b) Compare and contrast Type I and Type II superconductors discussing their critical magnetic fields, flux penetration behaviors. (CO4, K6)

15. (a) Discuss the techniques used for the preparation of nanomaterials highlighting the differences between bottom-up and top-down approaches. (CO5, K5)

Or

(b) Discuss the properties and application of Nano diamond. (CO5, K2)

Part C $(5 \times 8 = 40)$

Answer **all** the questions not more than 1000 words each.

16. (a) Derive the Clausius-Mosotti relation and explain its significance. (CO1, K5)

Or

(b) Explain the classical theory of electronic polarizability and how it contributes to the overall polarization. (CO1, K3)

17. (a) Discuss the dipole theory of ferroelectricity, detailing how it explains the spontaneous polarization observed in ferroelectric materials.

(CO2, K3)

Or

(b) Discuss the phenomenological approach to studying piezoelectric effects, outlining its principles and methodologies, and explain how it characterizes the macroscopic behavior of piezoelectric materials.

(CO2, K4)

18. (a) Discuss the key principles of the Quantum theory of paramagnetism and how it accounts for the magnetic properties of materials at the atomic level.

(CO3, K3)

Or

(b) Explore the concept of antiferromagnetism, including the alignment of magnetic moments, the Neel temperature, and the behavior of antiferromagnetic materials at different temperatures and magnetic fields. (CO3, K3)

19. (a) Explore the BCS theory of superconductivity, detailing the formation of Cooper pairs, the role of electron-phonon interactions, and the predictions of the theory in relation to experimental observations. (CO4, K2)

Or

(b) Discuss the theory of DC and AC Josephson effects with suitable illustrations. (CO4, K2)

20. (a) Discuss the density of states of nanostructures, explaining its importance in determining electronic properties and behaviors such as conductivity and bandgap engineering (CO5, K6)

Or

(b) Explore the unique properties and potential applications of Carbon nanotubes in various fields. (CO5, K2)

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R1031	Sub. Code
	521402

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Fourth Semester

Physics

NUCLEAR AND PARTICLE PHYSICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option

1. Nuclear forces are non-central forces. (CO1, K3)

   (a) True (b) False

   (c) Atom dependent (d) None of them

2. Which of the following is the unit of scattering cross-section? (CO1, K5)

   (a) barn (b) cm^2

   (c) m^2 (d) All of them

3. Pick out the odd man out in the following numbers. (CO2, K3)

   (a) 2 (b) 20

   (c) 40 (d) 82

4. ———— model is treated as the extension of liquid drop model? (CO2, K2)

   (a) Bohr (b) Shell

   (c) Collective (d) Nilsson

5. The source of stellar energy is _____. (CO3, K1)

(a) Fission

(b) Fusion

(c) Fission and Fusion

(d) Nuclear decay

6. Which of the following is not a neutron moderator? (CO3, K2)

(a) Boron (b) Beryllium

(c) Light water (d) Heavy water

7. Radioactive decay in which atomic and mass number does not change is ———— (CO4, K2)

(a) Alpha (b) Beta

(c) Gamma (d) All of them

8. In internal conversion, high-energy electron is emitted from ———— (CO4, K4)

(a) Nucleus (b) Excited atom

(c) Both (a) and (b) (d) None of them

9. "Isospin is independent of spacetime symmetry". (CO5, K3)

(a) True (b) False

(c) Case dependent (d) None of them

10. The quantum number that account for previously puzzling decay patterns is ———— (CO5, K5)

(a) Spin (b) Iso-spin

(c) Parity (d) Strangeness

Part B (5 × 5 = 25)

Answer **all** the questions, not more than 500 words each.

11. (a) Prove that nuclear forces are spin dependent but charge independent. (CO1, K3)

Or

(b) Give a short note on ground state of deuteron. (CO1, K2)

12. (a) Interpret the contribution of various terms in Weizacker's formula. (CO2, K3)

Or

(b) Comment on spin-orbit coupling. (CO2, K4)

13. (a) Compare nuclear fission and fusion. (CO3, K1)

Or

(b) Classify nuclear reactors. (CO3, K2)

14. (a) List out the selection rules that govern the beta decay. (CO4, K3)

Or

(b) Give a brief outline on the role of nuclear particles in cancer therapy. (CO4, K6)

15. (a) How are fundamental forces classified? (CO5, K2)

Or

(b) Explain CPT invariance. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each

16. (a) Give a detailed note on Yukawa's Meson theory of nuclear forces. (CO1, K5)

Or

(b) Elaborate the effective range theory of n-p scattering at low energies. (CO1, K4)

17. (a) Sketch and explain Bohr Wheeler theory. (CO2, K6)

Or

(b) Outline the significance of Nilsson model of nucleus. (CO2, K3)

18. (a) Explain compound nucleus theory. (CO3, K2)

Or

(b) Derive Breit-wigner dispersion formula. (CO3, K5)

19. (a) Describe Gamow's theory of alpha decay. (CO4, K6)

Or

(b) Elucidate nuclear isomerism. (CO4, K3)

20. (a) Outline Leptons and Baryons. (CO5, K4)

Or

(b) Discuss Gell-Mann-Nishijima formula. (CO5, K2)

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R1032

Sub. Code
521403

M.Sc. DEGREE EXAMINATION, APRIL – 2024

Fourth Semester

Physics

THERMODYNAMICS AND STATISTICAL MECHANICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. A highly compressed gas is adiabatically expanded. Its temperature (CO1, K1)

   (a) Increases

   (b) Decreases

   (c) Does not change

   (d) May change in any direction

2. Density of states, $g(\in)$, of a non-relativistic particle moving in three-dimensions is proportional to (CO1, K2)

   (a) $\in$ (b) $\in^2$

   (c) $\in^{\frac{-1}{2}}$ (d) $\in^{\frac{1}{2}}$

3. Which of the following are the state functions of a grand-canonical ensemble? (CO2, K1)

   (a) E, V, N (b) T, V, μ

   (c) T, V, N (d) E, N, T

4. In a canonical ensemble at equilibrium, F is (CO2, K2)

(a) maximum (b) minimum

(c) zero (d) constant

5. The number of ways in which N identical bosons can be distributed in two energy levels, is (CO3, K3)

(a) $N+1$ (b) $\frac{N(N-1)}{2}$

(c) $\frac{N(N+1)}{2}$ (d) N

6. Work function of a metal is equal to (CO3, K1)

(a) Its Fermi-energy

(b) Energy of an electron in it

(c) Work done by an electron in its ground state to leave the metal

(d) Minimum energy needed by an electron in it to leave the metal surface

7. The wavelength corresponding to maximum emission from a black-body is given by (CO4, K1)

(a) Stefan's law

(b) Kirchoff's law

(c) Wien's displacement law

(d) Wien's distribution law

8. What is the maximum energy of a fermion in a Fermi-system at a temperature T (CO4, K3)

(a) E_F (b) $E_F + kT$

(c) $E_F - kT$ (d) $E_F + \frac{1}{2}kT$

9. The one dimensional using model consists of a chain of N-spins. Each spin interacting only with its nearest neighbours. The energy of the configuration specified by $\{s_1, s_2, \ldots \ldots s_n\}$ is (CO5, K4)

(a) $E_I = 0$ (b) $E_I = \frac{3}{2}kT$

(c) $E_I = -\in \sum_{i=1}^{\infty} s_i s_{i+1}$ (d) $E_I = -\in \sum_{i=1}^{N} s_i s_i$

10. The transition from the non-ferromagnetic state to the ferromagnetic state is a (CO5, K1)

(a) phase transition of the second order

(b) phase transition of the first order

(c) phase transition of the liquid state to gaseous state

(d) none of the above

Part B ($5 \times 5 = 25$)

Answer **all** questions not more than 500 words each.

11. (a) With the help of examples, explain the difference between macrostates and microstates of a system. (CO1, K2)

Or

(b) Define the thermodynamic process (CO1, K1)

(i) reversible,

(ii) irreversible,

(iii) quasi-state,

(iv) adiabatic and

(v) isothermal.

12. (a) Show that the entropy of a system in canonical ensemble is given by $S = -k\sum p_i \log p_i$, where p_i is the probability that the system is in a microstate with energy E_i. (CO2, K4)

Or

(b) Obtain the expression for the thermodynamic functions E, S, F, P and c_V of a system in terms of its canonical partition function. (CO2, K3)

13. (a) Obtain the expression for the thermodynamic probability of a system obeying Maxwell-Boltzmann statistics and hence obtain the Maxwell-Boltzmann distribution formula. (CO3, K3)

Or

(b) Derive Fermi-Dirac distribution formula. (CO3, K4)

14. (a) What do you mean by the terms Fermi-energy and Fermi-temperature? Obtain their expressions in terms of the particle-density n of a Fermi gas. (CO4, K3)

Or

(b) State and prove equipartition theorem. (CO4, K5)

15. (a) Derive Clapeyron-Clausius equation and show that the boiling point of a liquid increases with the increase in pressure. (CO5, K3)

Or

(b) Discuss about the equilibrium between two phases. Show that during a phase transition the Gibb's energy does not change. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1000 words each.

16. (a) Derive Maxwell thermodynamic relations. (CO1, K3)

Or

(b) Prove the following thermodynamic relations (CO1, K4)

(i) $c_v = -T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$

(ii) $c_p = -T\left(\frac{\partial^2 G}{\partial T^2}\right)_p$

17. (a) Find out the equation of state of an ideal classical gas in canonical ensemble. (CO2, K5)

Or

(b) Show that the probability that a system in a grand canonical ensemble has energy E_i and particle N_j is $p_i = \frac{e^{-\beta(E_i - \mu N_j)}}{Z}$ where $Z = \sum_{i,j} e^{-\beta(E_i - \mu N_j)}$ is the grand partition function. (CO2, K5)

18. (a) Derive Boltzmann transport equation. (CO3, K4)

Or

(b) What is Joule-Thompson effect? Show that Joule-Thompson coefficient for a gas is given by $\mu = \frac{1}{c_p}\left[T\left(\frac{\partial V}{\partial T}\right)_p - V\right]$. Using this expression prove that the ideal gas shows no change in temperature in Joule-Thompson effect. (CO3, K3)

19. (a) Derive Planck's radiation formula by counting the number of modes in a cavity at temperature T. Show that it reduces to Wien's law for short wavelength and to Rayleigh-Jeans law for longer wavelength. (CO4, K4)

Or

(b) What is Brownian motion? Discuss its theory. (CO4, K3)

20. (a) Deduce Einstein's expression for specific heat of a solid and discuss its limitations. (CO5, K4)

Or

(b) What do you mean by first order and second order phase transition? Give a clear distinction between them. (CO5, K2)

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