SLR-HX-1

Seat No.	

Set P

M.Sc. (Semester - I) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Mathematical Physics (MSC04101)

Day & Date: Friday, 10-05-2024 Max. Marks: 80
Time: 03:00 AM To 06:00 PM

Instructions: 1) Q. No. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figures to the right indicate full marks.

Q.1 A) Choose correct alternative. **10**

1) Function $f(Z) = 1 + \frac{1}{\sqrt{Z}}$ of a complex variable Z is _____.
   a) has a simple pole at $Z = 0$
   b) has a branch cut from $Z = 0$ to $Z = \infty$ along real axis
   c) is finite at all points inside a unit circle centred at origin
   d) has a branch point at $Z = 0$

2) The integral of Z along upper half of circle $|Z| = 1$ from $Z = -1$ to $Z = 1$ is _____.
   a) $-i\pi$ b) $i\pi$
   c) $2\pi i$ d) $-2\pi i$

3) What is the dimensionality of the vector space spanned by the vector $\{(1,0,0)\ (0,1,0)\ (0,0,1)\}$ _____.
   a) 1 b) 2
   c) 4 d) 3

4) What is the dimensionality of the vector space of 3×3 matrices?
   a) 6 b) 9
   c) 12 d) 3

5) If the characteristic equation $ar^2 + br + C = 0$ has complex roots, what type of solution do we expect?
   a) Real and Distinct b) Real and repeated
   c) Complex conjugate d) Imaginary

6) Which principle is allowed to solve non-homogeneous linear differential equation by adding the solutions of its homogeneous counterpart & particular solution?
   a) Superposition principal b) Homogeneous principle
   c) Integration principal d) Differential principal

7) Which theorem states that any periodic function can be represented as an infinite sum of sines and cosines of varying frequencies?
   a) Laplace's Theorem b) Fourier's Theorem
   c) Parseval's Theorem d) Fourier-Mellin Transform

8) The Fourier series expansion of a sawtooth wave contains _____.
   a) Only cosine terms
   b) Only sine terms
   c) Both cosine and sine terms
   d) Only complex exponential terms

9) Determinant of orthogonal matrix is _____.
   a) 0 b) 1
   c) -1 d) It can be real or Imaginary

10) Which function's Fourier transform results in a constant function?
   a) Box function b) Exponential function
   c) Delta function d) Rectangular function

B) Write True/False. **06**

1) Parseval's theorem relates the power of a single to its frequency-domain representation.
2) Analytic functions are necessarily harmonic functions.
3) The dimensionality of a Hilbert space can be infinite.
4) A second-order homogeneous equation with constant coefficients always has exponential solutions.
5) In the Argand diagram, the real part of a complex number is represented along the y-axis.
6) In a first-order homogeneous equation with variable coefficients, the superposition principle holds.

Q.2 Answer the following. **16**

a) State and Explain Cauchy's residue theorem in detail.
b) Prove that $I = A$ is invertible, where I is identity matrix and a square matrix $A^2 = A$.
c) Find the Laplace transform of $f(s)$ for the given function $f(t) = e^{-t}$ for $t \geq 0$.
d) State and prove superposition principle.

Q.3 Answer the following. **16**

a) Determine the general solution of given non-homogeneous differential equation $Y'' + 3y' + 2y = 4x$

b) Evaluate the integral $f(z) = \oint \frac{\cos(Z)}{Z^2+4} dz$ where C is the semicircle in the upper half plane centred at origin with radius R & $R > 2$.

Q.4 Answer the following. **16**

a) Find the eigen values and eigen vectors of the matrix $A = \begin{vmatrix} 2 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 2 \end{vmatrix}$

b) Find the inverse of the matrix $A = \begin{vmatrix} 2 & 1 & -1 \\ 1 & 0 & 2 \\ -3 & 2 & 1 \end{vmatrix}$ and verify $A \times A^{-} = I$.

Q.5 Answer the following. **16**

a) Evaluate the integral $(z) = \oint \frac{\sin(Z)}{Z^2+4} dz$ where, C is the circle $|Z| = 3$ traversed counterclockwise.

b) 1) Compute the Fourier series of the function $f(x) = x$ over the interval $-\pi \leq x \leq \pi$.

2) Determine the first three nonzero terms of the Fourier series for the sawtooth wave $g(x)$, which has period 2π and is defined as follows:

$$g(x) = \begin{cases} x & \text{for } -\pi \leq x < 0 \\ x - 2\pi & \text{for } 0 \leq x < \pi \end{cases}$$

Q.6 Answer the following. **16**

a) Solve $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = 2\cos x$ using successive integration method.

b) Discuss the second order non-homogeneous linear differential equation with constant coefficient.

Q.7 Answer the following. **16**

a) Expand the Fourier series for full wave rectifier

$$\begin{aligned} f(x) &= \sin x; && (0 \leq x < \pi) \\ &= -\sin x; && (-\pi \leq x \leq 0) \end{aligned}$$

b) Find the Laplace transform of

$$f(t) \begin{cases} \sin t & 0 < t < \pi \\ 0 & t > \pi \end{cases}$$

SLR-HX-2

Seat No.	

Set P

M.Sc. (Semester - I) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Solid State Physics (MSC04102)

Day & Date: Monday, 13-05-2024 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose the correct alternative. **10**

1) In the case of a superconductor, at Tc conductance becomes _____.
   a) Zero b) Finite
   c) Infinite d) None of the above

2) Induced electric dipole moment is directly proportional to _____.
   a) E b) E^2
   c) E^3 d) $E^{1/2}$

3) Number of tetrad axis in simple cubic system are _____.
   a) 2 b) 3
   c) 4 d) 8

4) According to mass action law, product of hole and electron concentration is equal to _____ of intrinsic concentration.
   a) Square b) 1/2
   c) 1/3 d) 1/4

5) Miller indices of crystal plane which intercepts at (2a, 3b, c) are _____.
   a) (3,3,6) b) (1,2,3)
   c) (2,1,6) d) (3,2,1)

6) _____ metals are generally not superconductors.
   a) Divalent b) Monovalent
   c) Trivalent d) A and b

7) Reciprocal lattice vector G = _____.
   a) K'-K b) K - K'
   c) K'+ K d) $(K'+K)^2$

8) The electronic polarizability αe of a monoatomic gas is _____.
   a) $4\pi\varepsilon_0$ b) $4\pi\varepsilon_0 R$
   c) $4\pi\varepsilon_0 R^3$ d) $4\pi\varepsilon_{\_0}{}^2$

9) The effective mass of localized electrons depends on _____.
   a) (d^2E/dK) b) (dE/dK)
   c) $(d^2E/d^2K)^{-2}$ d) $(d^2E/dK^2)^{-1}$

10) The coordination number of HCP is _____.
   a) Two b) Four
   c) Six d) Twelve

B) Fill in the blanks OR Write True or False. **06**

1) The coordination number of the body-centered cubic crystal structure is _____.
2) At _____ temperature materials show transition from normal to superconducting state.
3) Induced electric dipole moment is inversely proportional to electric field E. (T/F)
4) Crystalline solids are anisotropic. (T/F)
5) The relation between electronic polarizability and induced electric dipole moment is given by $\boldsymbol{\mu e} = \boldsymbol{\alpha e} \cdot \boldsymbol{E}$. (T/F)
6) Brillouin zones are represented on the EK curve. (T/F)

Q.2 Answer the following (Any Four) **16**

a) Define packing fraction.
b) Concept of Cooper pair
c) What is electronic polarization?
d) What is penetration depth?
e) Calculate the electronic polarization of isolated Se atom of atomic radius 0.18nm. Given $\varepsilon_0 = 8.854 \times 10^{-12} F/m$

Q.3 Answer the following.

a) Discuss the Meissner effect in detail. **10**
b) Distinguish direct and indirect band gap semiconductors. **06**

Q.4 Answer the following.

a) Give the expression for interplanar spacing (d). **10**
b) For simple cubic structure, calculate the number of atoms per square mm for the atomic planes (010), (110) and (111). **06**

Q.5 Answer the following.

a) Explain the Kronig-Penney model. **08**
b) Write about Ionic polarization. **08**

Q.6 Answer the following.

a) Give the expression for the concentration of electrons in the conduction band of Intrinsic semiconductors. **10**
b) Explain the concept of Brillouin zones. **06**

Q.7 Answer the following.

a) Explain BCC and FCC Crystal structures. **10**
b) Explain the defects in solids. **06**

SLR-HX-3

Seat No.	

Set P

M.Sc. (Semester - I) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Analog and Digital Electronics (MSC04103)

Day & Date: Wednesday, 15-05-2024 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) All questions are compulsory.
2) Attempt any three questions from Q.3 to Q.7.
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternative. (MCQ) **10**

1) Output impedance of ideal op-amp is _____.
   a) infinite b) zero
   c) 75Ω d) $1M\Omega$

2) _____ is used for Mod-2 addition.
   a) XOR-gate b) OR-gate
   c) Full adder d) Half adder

3) The device which changes from serial data to parallel data is _____.
   a) Multiplexer b) Demultiplexer
   c) Flip-Flop d) Counter

4) In J-K flip-flop, when J=1 and K=1, it is possible to _____ the flip-flop,
   a) set b) reset
   c) toggle d) forbidden

5) Stack pointer holds _____.
   a) 16 bit address b) 16 bit data
   c) 8 bit address d) 8 bit data

6) Calculate the output voltage of a non-inverting amplifier with $Ri = 200k\Omega$, $Rf = 2M\Omega$ and $Vi^{=}10mV$.
   a) $110mV$ b) $120mV$
   c) $200mV$ d) $210mV$

7) Unity gain voltage follower is also called as _____.
   a) Comparator b) Schmitt trigger
   c) Buffer d) Zero crossing detector

8) What is the word length of an 8-bit microprocessor?
   a) 8 bits-64 bits b) 4 bits -32 bits
   c) 8 bits-16 bits d) 8 bit-32 bits

9) A decoder converts _____.
   a) noncoded information into coded form
   b) coded information into noncoded form
   c) highs to lows
   d) lows to highs

10) What will be the output from a D flip-flop if the clock is low and D = 0?
   a) 0 b) 1
   c) No change d) Toggle between 0 and 1

B) Fill in the blanks OR Write true/false **06**

1) A phase shift oscillator uses LC network. (True/False)
2) The output stage of an op-amp usually a _____.
3) In _____ microprocessor, accumulator register used as a working area in CPU
4) Master slave flip is also referred to as Pulse -triggered flip-flop. (True/False)
5) Can an encoder be called a multiplexer? (True/False)
6) Voltage when applied at two inputs of Op-amp to get 0 V of output is called Output offset voltage. (True/False)

Q.2 Answer the following **16**

a) Explain the concept of virtual ground in op. amp.
b) State De Morgan's theorems with logical diagrams.
c) Explain dual input balance output differential amplifier.
d) Explain why open loop op-amp configurations are not used in linear applications.

Q.3 Answer the following.

a) Write the features of 8085 microprocessor. **06**
b) Explain with neat circuit diagram Wein bridge oscillator. **10**

Q.4 Answer the following.

a) Draw and explain functional block diagram of 8085 microprocessor. **08**
b) What is Demultiplexer? Explain 1:8 Demultiplexer. **08**

Q.5 Answer the following.

a) Draw logic diagram and truth table of RS flip flop and explain its working. **08**
b) Draw and explain the block diagram of op.amp. **08**

Q.6 Answer the following.

a) Explain summing amplifier using differential configuration. **08**
b) Describe 4 bit D flip-flop with timing diagram. **08**

Q.7 Answer the following.

a) Draw and explain Phase shift Oscillator using op. amp. Obtain an expression for its frequency. **08**
b) Write an assembly language program to add two 8bit numbers. **08**

SLR-HX-4

Seat No.	

Set P

M.Sc. (Semester - I) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Classical Mechanics (MSC04108)

Day & Date: Friday, 17-05-2024 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternative. **10**

1) A particle moving with constant velocity along a straight path parallel to +X axis is said to possess _____.
   a) linear momentum and angular momentum about given origin
   b) angular acceleration
   c) only linear momentum but not angular momentum about given origin
   d) nothing

2) In Galilean transformation, time in both the frames under consideration is treated as _____.
   a) absolute
   b) relative
   c) some times absolute and some times relative
   d) variant

3) If the condition of the constraint is expressed as $f(r_1, r_2, r_3, r_4 \ldots, t) = 0$ then it is known as _____.
   a) Holonomic, Rheonomous constraint
   b) Holonomic, Scaleronomous constraint
   c) Non-holonomic, Rheonomous constraint
   d) Non-holonomic, Scaleronomous constraint

4) As per Kepler's third law of planetary motion, square of a time period is directly proportional to cube of a _____.
   a) semi-minor axis b) semi-major axis
   c) diameter of a orbit d) average diameter of a orbit

5) The Rutherford scattering cross section $\sigma(\theta)$ varies_____ with _____ where θ is the scattering angle
   a) directly, $cosec^4(\frac{\theta}{2})$ b) inversely, $cosec^4(\frac{\theta}{2})$
   c) directly, $cosec^2(\frac{\theta}{2})$ d) inversely, $cosec^2(\frac{\theta}{2})$

6) Action is the integral product of _____.
   a) generalized momentum and velocity
   b) generalized momentum and force
   c) generalized momentum and co-ordinate
   d) none of these

7) Identify the correct equation for Jacobi's Identity _____.
   a) $[[p,q],r]+[[p,r],q]+[[q,r],p]=0$
   b) $[[q,q],r]+[[p,r],q]+[[q,r],p]=0$
   c) $[[p,q],r]+[[p,r],q]+[[r,q],p]=0$
   d) $[[p,q],r]+[[r,p],q]+[[q,r],p]=0$

8) Choose the correct equation for Hamiltonian _____.
   a) $H=p_iq'\,i-L$ b) $H=p_iq'\,i+L$
   c) $H=piqi+L$ d) $H=piqi-L$

9) The Lagrangian of the system gives _____ of the system.
   a) difference in kinetic and potential energy
   b) addition of kinetic and potential energy
   c) power
   d) rate of change of energy

10) The phase space is _____ dimensional space.
   a) 3N b) 2N
   c) N d) 6N

B) Fill in the blanks or write true /false. **06**

1) The transformation is canonical if pdq-PdQ ia an exact differential. (True/False)
2) In a simple pendulum (θ) is the generalized co-ordinate. (True/False)
3) Under Galilean transformation the inertial mass remains invariant. (True/False)
4) Hamiltonian; H is the function of _____.
5) Kepler's second law tells about _____.
6) A rigid body moving freely in space has the degrees of freedom ____.

Q.2 Answer the following questions. **16**

a) Explain in detail about the constraints and their classification.
b) Check whether the transformation defined as Q=1/p, $P=qp^2$ is canonical or not.
c) Write a note on Poisson brackets and their properties.
d) State Hamilton's variational principle and drive the Lagrange's equation of motion from it

Q.3 Answer the following.

a) Prove the laws of linear and angular momentum for a system of particles. **08**
b) Explain **08**
   i) Symmetries and laws of conservation
   ii) Jacobi integral

Q.4 Answer the following.

a) What are generalized co-ordinates? Express the D'Alembert's principle. **08**
b) What are the Kepler's laws of planetary motion? Derive the equation for Kepler's first law. **08**

Q.5 Answer the following.

a) Express the Hamilton's canonical equations of motion and deduce them from variational principle. **08**
b) Apply the Hamilton's equations to derive the equations of motion for simple pendulum and linear harmonic oscillator. **08**

Q.6 Answer the following.

a) What is canonical transformation? Discuss the exact differential condition to show that the transformation is to be canonical. **08**

b) Write about invariance under Galileon Transformation. **08**

Q.7 Answer the following.

a) i) Derive the equations of motion for a particle moving near surface of earth. **08**

ii) Show that the shortest distance between two points is a straight line.

b) Explain and prove the principle of least action. **08**

SLR-HX-6

Seat No.	

Set P

M.Sc. (Semester - II) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Quantum Mechanics (MSC04201)

Day & Date: Thursday, 09-05-2024 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose the correct alternative from the options. **10**

1) An electron, a neutron, an alpha particle and tennis ball are, moving at the same speed. Which one of them has the greatest de Broglie Wavelength?
   a) Neutron b) Electron
   c) Tennis ball d) Alpha particle

2) Consider an electron in a ring of constant potential energy. Let C be the length of circumference of the ring. Since wave functions must be single valued, then $\psi(x) =$ _____.
   a) $\psi\left(x+\frac{c}{4}\right)$ b) $\psi\left(x+\frac{c}{2}\right)$
   c) $\psi(x+C)$ d) $\psi\left(x+\frac{3c}{4}\right)$

3) Which of the following relation is true for wavelength of De Broglie waves?
   a) $\lambda=\frac{h}{p}$ b) $\lambda=\frac{p}{h}$
   c) $\lambda=\frac{1}{\sqrt{ph}}$ d) $\lambda=\frac{p}{m}$

4) The number of electrons circulating about the positively charged nucleus in hydrogen like atom is _____.
   a) negligible
   b) equal to the number of protons in the nucleus
   c) equal to mass number
   d) one

5) The zero-point energy of a particle in 3-dimensional box is _____.
   a) equal to that for a one-dimensional box.
   b) double that for a one-dimensional box.
   c) three times that for a one-dimensional box.
   d) nine times that for a one-dimensional box.

6) If electron 1 is placed at definite point in space, then the potential energy of electron 1 in the field of electron 2 is given by _____.
   a) $V_1=\int\frac{\phi_1^2(1)}{r_{12}}d\tau_1$ b) $V_1=\int\frac{\phi_1^2(1)}{r_{12}}d\tau_2$
   c) $V_1=\int\frac{\phi_2^2(2)}{r_{12}}d\tau_1$ d) $V_1=\int\frac{\phi_2^2(2)}{r_{12}}d\tau_2$

7) In atoms having many electrons, the electron repulsion term _____.
   a) can be ignored
   b) can be included in the momentum operator
   c) has to be included in the potential energy term of wave equation
   d) none of the above

8) The shell K, L, M, N, O, P, Q can accommodate _____ number of electrons.
   a) $2n^2$ b) $2(2l+1)$
   c) $2l+1$ d) $2n+1$

9) A system is in a state described by the function,
   $\Psi(\phi, Q) = \frac{1}{\sqrt{45}}[2Y_3^1 + 4Y_2^1 + 5Y_2^0]$ where Y_1^m are spherical harmonics.
   The probability of finding the system in a state with $m = 1$ is _____.
   a) $\frac{4}{9}$ b) $\frac{29}{45}$
   c) $\frac{41}{45}$ d) 1

10) The electrons in K shell have _____ spins.
   a) parallel b) antiparallel
   c) no d) perpendicular

B) Fill in the blanks OR Write True/False. **06**

1) To every physically measurable quantity of a system there corresponds _____ in quantum mechanics.
2) Free electron moving without any restriction has a _____ energy spectrum.
3) The s- type orbitals are _____ shaped.
4) The exact solution of a _____ is not obtained.
5) The M shell can accommodate _____ electrons.
6) Separation of electronic and nuclear function describes the _____ principle.

Q.2 Answer the following. **16**

a) The wave function for a particle moving in x direction is $\Psi(x) = A\, e^{ikx}$, where $0 < x < L$. Calculate the value of normalization constant A.
b) Explain wave and particle nature of radiation.
c) The lowest kinetic energy of an electron (E) confined in one dimensional box is 5 eV. Calculate its energy in the second excited state.
(Given: Planck's constant, $h = 6.626 \times 10^{-34}$J/s and mass of electron, $m = 9.1 \times 10^{-31}$ kg).
d) Write a note on shape of atomic orbital.

Q.3 Answer the following. **16**

a) Write a note on helium atom. Obtain expression for ground state energy of helium atom.
b) Discuss molecular orbital theory.

Q.4 Answer the following. **16**

a) State and explain 'Heisenberg's uncertainty principle.'
b) Write a note on hydrogen molecule ion.

Q.5 Answer the following. **16**

a) State and explain the postulates of quantum mechanics.
b) Explain physical interpretation of hydrogenic orbital.

Q.6 Answer the following. **16**

a) Obtain Total wave function of hydrogen- like atom.

b) Discuss wave function of many electron systems.

Q.7 Answer the following. **16**

a) Write a note on Slater's rules.

b) Give the formulation of Valence-Bond method for the Hydrogen molecule.

SLR-HX-7

Seat No.	

Set P

M.Sc. (Semester - II) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Electrodynamics (MSC04202)

Day & Date: Saturday, 11-05-2024 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. No. 1 and 2 are compulsory.
2) Attempt any Three questions from Q.No.3 to Q.No.7.
3) Figures to the right indicates full marks.

Q.1 A) Choose the correct alternatives from the options. **10**

1) If magnetic monopole existed, then which of the following Maxwell's equations will be modified _____.
   a) $\nabla.\vec{E} = \rho/\in_0$ b) $\nabla.\vec{B} = 0$
   c) $\nabla \times \vec{E} = -\partial\vec{B}/\partial t$ d) $\nabla \times \vec{B} = \mu_0 J + \mu_0 \in_0 \partial\vec{E}/\partial t$

2) The power radiated by an electric dipole is proportional to _____.
   a) ω b) ω^2
   c) ω^3 d) ω^4

3) Poynting's vector S gives _____.
   a) Energy transported per unit area per second
   b) Energy stored per unit volume
   c) Flux of fields
   d) Electromagnetic Momentum contained per unit volume

4) The sum of coefficient of reflection and transmission in absorption free case is _____.
   a) 1 b) 2
   c) 0.66 d) 0

5) The vectors of the electromagnetic wave propagation can be expressed in _____.
   a) dot product b) cross product
   c) unit vector d) perpendicular vector

6) The Poynting's vector S of an electromagnetic wave is _____.
   a) $\vec{S} = \vec{E} \times \vec{H}$ b) $\vec{S} = \vec{E} \times \vec{B}$
   c) $\vec{S} = \vec{E}/\vec{B}$ d) $\vec{S} = \vec{E}/\vec{H}$

7) Faraday's laws are consequence of the conservation of _____.
   a) charge b) energy
   c) magnetic field d) both (b) and (c)

8) The expression for the continuity equation is _____.
   a) $\rho + J = 0$ b) $d\rho/dt + \nabla.J = 0$
   c) $d\rho/dt + J = 0$ d) $\rho + \nabla J = 0$

9) SI unit of magnetic induction is _____.
   a) NC^{-1} b) tesla
   c) weber d) $\mathrm{NmA^{-1}}$

10) The Maxwell's equation derived from Ampere's law is _____.
   a) $\nabla . I = H$ b) $\nabla . H = J$
   c) $\nabla \times B = J$ d) $\nabla \times B = D$

B) Write Ture /False. **06**

1) The complete theory of electromagnetic waves is contained in Maxwell's equations. (True/False)
2) In equipotential surface, potential is different everywhere. (True/ False)
3) Total four Maxwell's equations in electrodynamics. (True/ False)
4) The direction of propagation of electromagnetic wave is $(\vec{E} \times \vec{B})$. (True/ False)
5) The equation of continuity is the consequence of conservation of charge. (True/ False)
6) Planck's law gives third Maxwell's equation. (True/ False)

Q.2 Answer the following. **16**

a) State and explain the Faraday's law.
b) Explain the concepts: skin effect and skin depth.
c) Derive the expression for the inhomogeneous wave equations.
d) Derive the expression for Thomson cross-section.

Q.3 Answer the following.

a) Write a detailed note on differential and integral forms of Maxwell's equations. **10**
b) Give detailed account on Maxwell's displacement current. **06**

Q.4 Answer the following.

a) Describe the reflection and refraction of electromagnetic waves at plane boundaries. **10**
b) Derive the expression for magnetic interaction between two current loops. **06**

Q.5 Answer the following.

a) What are the Gauge transformations? Derive the expressions for the wave equations in terms of electromagnetic potentials. **10**
b) Explain the Lorentz's and Coulomb's gauges with their gauge conditions. **06**

Q.6 Answer the following.

a) Derive the expression for the radiation from an oscillating electric dipole. **10**
b) Explain the concept radiation damping. **06**

Q.7 Answer the following.

a) Derive the Maxwell's equations for moving medium. **10**
b) State and prove the Poynting's theorem. **06**

SLR-HX-8

Seat No.	

Set P

M.Sc. (Semester - II) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Statistical Physics (MSC04206)

Day & Date: Tuesday, 14-05-2024 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Question no. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternatives. **10**

1) In Bose Einstein Condensation all the particle accumulates in _____.
   a) excited state b) meta state
   c) ground state d) all exited state

2) In Fermi Dirac statistics, particles are _____.
   a) indistinguishable b) distinguishable
   c) dimensionless d) weightless

3) The Boltzmann limit of Bosons and fermions is _____.
   a) $e^{\beta\mu} \ll 1$ b) $e^{\beta\mu} \gg 1$
   c) $e^{\beta\mu} = 0$ d) $e^{\beta\mu} = 1$

4) If r is the ratio of the probability that two particles are found in the same state to the probability that two particles belong to different states, then the ratio $r_{MB}: r_{BD}: r_{FD}$ is _____.
   a) $1/2 : 1 : 0$ b) $1 : 0 : 2$
   c) $1 : 1 : 2$ d) $1 : 1/2 : 0$

5) In grand canonical ensemble, the system exchange _____.
   a) only matter b) only energy
   c) both matter and energy d) neither matter nor energy

6) In Maxwell Boltzmann statistics, particles are _____.
   a) indistinguishable b) distinguishable
   c) dimensionless d) weightless

7) Entropy in thermodynamics is measure of _____.
   a) order of system b) pressure of system
   c) volume of system d) disorder of system

8) Phase equilibrium curve terminates at _____.
   a) Boiling point b) Sublimation point
   c) Triple point d) Critical point

9) At a critical point, $\frac{dp}{dv} =$
   a) 1 b) 0
   c) ∞ d) -1

10) Ideal gas is one for which mutual interaction between the molecules is ____.
   a) high b) negligible
   c) zero d) repulsive

B) State true or false. **06**

1) Photons in black body radiation obeys Bose Einstein Statistics.
2) The quantitative explanation of Brownian motion was given by Einstein.
3) Second law of thermodynamics deals with phase transition.
4) During first order transition of a matter from one phase to another, entropy remains constant.
5) The point at which the vapor pressure curve abruptly terminates is called transition point.
6) The transition from liquid He I to He II is called second order phase transition.

Q.2 Answer the following. **16**

a) Explain microstates and macrostates.
b) Distinguish between Fermi Dirac Statistics and Bose Einstein Statistics.
c) Derive the conditions for phase equilibrium.
d) Explain Law of corresponding states.

Q.3 Answer the following.

a) Explain the second order phase transition with an example of $BaTiO_3$. **08**
b) Define energy fluctuation. Derive energy fluctuation in Canonical ensemble. **08**

Q.4 Answer the following.

a) State and prove Liouville's theorem. **08**
b) Derive the expression for Bose Einstein distribution law. **08**

Q.5 Answer the following.

a) Derive Ehrenfest's equation for second order phase transition. **08**
b) Using Vander Waal's equation of reduced state, calculate the values of critical constants. **08**

Q.6 Answer the following.

a) Derive Clausius- Clapeyron equation for first order phase transition. **08**
b) Discuss the condition of ideal Bose gas. **08**

Q.7 Answer the following.

a) Define and explain types of ensemble. State their importance in statistical mechanics. **08**
b) Derive Sackur-Tetrode equation for entropy of a gas. **08**

SLR-HX-10

Seat No.		Set	P

M.Sc. (Semester - III) (New) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Semiconductor Physics (MSC04301)

Day & Date: Friday, 10-05-2024 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Q. No. 1 & 2 are compulsory.
2) Attempt any three questions from Q. 3 to 7.
3) Figures to the right indicate full marks.

Q.1 A) Choose correct alternatives. **10**

1) Epitaxial growth is best suited for growing _____.
   a) Polycrystalline silicon
   b) very thin single crystal layer on a substrate
   c) single crystals several inches in size
   d) single crystal of several mm in size

2) In a semiconductor, the energy gap between the valence band and conduction band is about _____.
   a) 5 eV b) 10 eV
   c) 15 eV d) 1 eV

3) A semiconductor has _____ temperature coefficient of resistance.
   a) Negative b) Positive
   c) Zero d) One

4) Electron-hole pairs are produced by _____.
   a) Recombination b) Thermal energy
   c) Ionization d) Doping

5) At the absolute zero temperature (-273° C), an intrinsic semiconductor has _____.
   a) A few free electrons b) Many Holes
   c) Many free electrons d) No holes or free electrons

6) The drift velocity of the conductor _____.
   a) Increase with an increase in temperature
   b) Decrease with decrease in temperature
   c) Increase with decrease in the temperature
   d) Decrease with the increase in temperature

7) Ohm's law is not obeyed by _____.
   a) conductor b) semiconductor
   c) insulator d) dielectrics

8) In Schottky barrier, barrier height depends on _____.
   a) Amount of doping material b) Type of doping material
   c) Temperature d) None of the above

9) In electroluminescence, the EHPs are generated by _____.
   a) Light absorption b) Electron bombardment
   c) Applying electric field d) none of above

10) The probability that an electron in a metal occupies the fermi level, at any temperature (> 0K) is _____.
   a) 0 b) 1
   c) 0.5 d) 1.0

B) Fill in the blanks OR write True /False. **06**

1) The current density (J) of semiconductor is _____.
2) In MBE evaporation of material that produces flux of atoms is _____ dependent.
3) A vacant partially filled band is called _____.
4) The random motion of holes and free electrons due to thermal agitation is called diffusion. (True/False)
5) The particle flux is inversely proportional to particle velocity. (True/False)
6) The strength of a semiconductor crystal comes from Electron-pair bonds. (True/False)

Q.2 Answer the following. **16**

a) Diffusion and recombination
b) Optical absorption in semiconductors
c) Chemical vapor deposition
d) Nucleation & crystal growth

Q.3 a) Define Luminescence? Explain different types of Luminescence with example. **10**
b) Elucidate Direct and Indirect semiconductors. **06**

Q.4 a) Describe growth of multiple crystals from Molecular Beam Epitaxy. **10**
b) Explain Vapor phase epitaxy. **06**

Q.5 a) Deduce an expression of electron and hole concentration at equilibrium. **10**
b) Write a note on Indirect recombination (trapping). **06**

Q.6 a) Describe crystal growth by Czochralski method. **10**
b) Elucidate gel method with suitable example. **06**

Q.7 a) Give an account of Metal-Semiconductor Interface with band diagrams. **10**
b) Draw equilibrium energy band diagram for a metal to an p-type semiconductor where **06**

1) $\Phi M < \Phi S$
2) $\Phi M > \Phi S$

SLR-HX-11

Seat No.	

Set P

M.Sc. (Semester - III) (New) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Atomic and Molecular Physics (MSC04302)

Day & Date: Monday, 13-05-2024 Max. Marks: 80
Time: 11:00 AM To 02:00 PM

Instructions: 1) Question no. 1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Multiple choice questions. **10**

1) Which model describes the structure of atoms as consisting of a dense, positively charged nucleus surrounded by electrons in orbit?
   a) Rutherford model b) Bohr model
   c) Vector atom model d) Larmar precession model

2) The Landé g-factor is a dimensionless quantity that determines the magnetic moment of an atomic or subatomic particle. What does it describe?
   a) Spin-orbit interaction b) Hyperfine structure
   c) Relativistic correction d) Magnetic interaction

3) Which of the following is responsible for the splitting of spectral lines into multiple components due to the interaction between the magnetic moment of the electron and the external magnetic field?
   a) Zeeman effect b) Stark effect
   c) Fine structure d) Lamb shift

4) Which phenomenon describes the splitting of spectral lines in the presence of an external magnetic field?
   a) Stark effect b) Zeeman effect
   c) Paschen-Back effect d) Fine structure spectra

5) What is the term used to describe the splitting of X-ray spectral lines?
   a) Stark effect b) Zeeman effect
   c) X-ray fine structure d) Hyperfine structure spectra

6) Which type of bonding involves the sharing of electron pairs between atoms?
   a) Covalent bonding b) Ionic bonding
   c) Van der Waals bonding d) Metallic bonding

7) What is the qualitative treatment of the H^{2+} molecule?
   a) It is a nonpolar molecule with a single bond.
   b) It is a polar molecule with a single bond.
   c) It is a nonpolar molecule with a double bond.
   d) It is a polar molecule with a double bond.

8) Which branch of spectroscopy studies the rotation of molecules and is based on the Born-Oppenheimer approximation?
   a) Vibrational spectroscopy
   b) Electronic spectroscopy
   c) Rotational spectroscopy
   d) Nuclear magnetic resonance spectroscopy

9) What is the molecular polarizability?
   a) Ability of a molecule to undergo nuclear magnetic resonance
   b) Measure of the molecule's ability to be polarized by an external electric field
   c) Ability of a molecule to emit Raman spectra
   d) Measure of the molecule's ability to absorb infrared radiation

10) Which spectroscopic technique is based on the interaction of electromagnetic radiation with molecular rotations?
   a) Infrared spectroscopy b) Raman spectroscopy
   c) Microwave spectroscopy d) Electronic spectroscopy

B) Write True or False. **06**

1) Atomic and molecular polarizability refers to the ability of an atom or molecule to be polarized by an external electric field.
2) Group theoretical selection rules for infrared and Raman transitions are based on the symmetry properties of the molecular vibrations.
3) Covalent bonding involves the transfer of electrons from one atom to another.
4) Ionic molecules have a balanced distribution of electrons between atoms, resulting in a nonpolar nature.
5) The wave function of an electron in a hydrogen atom depends only on the radial distance from the nucleus.
6) The orbital angular momentum of an electron in an atom can have any value from 0 to $\hbar$.

Q.2 Answer the following. **16**

a) Explain the significance of the fine structure in atomic spectra arises, and what are the factors contributing to it?
b) Explain the Zeeman effect in atomic spectra.
c) Explain the concept of van der Waals bonding and provide an example of a molecule where van der Waals forces are significant.
d) Define atomic and molecular polarizability.

Q.3 Answer the following. **16**

a) Explain how group theory is used to determine the allowed vibrational transitions in both infrared and Raman spectroscopy.
b) Discuss the principles of infrared spectroscopy and Explain how infrared radiation interacts with molecular vibrations to produce absorption spectra.

Q.4 Answer the following. **16**

a) Describe the differences between covalent, ionic, and van der Waals bonding.
b) Explain the concept of hybridization in molecules with its types of hybrid orbitals formed.

Q.5 Answer the following. **16**

a) Describe the vibrational levels in diatomic and polyatomic molecules, focusing on the Morse oscillator model for vibrational levels.
b) Explain the Zeeman effect in detail and how spectral lines split in the presence of an external magnetic field.

Q.6 Answer the following. **16**

a) Discuss the significance of X-ray spectra in atomic physics. Explain how X-ray spectral lines are produced and how they are used to study atomic structure and composition.

b) Describe the Stark effect and its role in atomic spectroscopy.

Q.7 Answer the following. **16**

a) Describe Born - Oppenheimer approximation in detail.

b) Give the schematic representation of interaction energies between 4p4d electrons in JJ coupling.

SLR-HX-14

Seat No.	

Set P

M.Sc. (Semester - IV) (New) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Semiconductor Devices (MSC04401)

Day & Date: Thursday, 09-05-2024 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Question No.1 and 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7.
3) Figure to right indicate full marks.

Q.1 A) Choose correct alternatives. **10**

1) A semiconductor has forbidden band gap of $0.7\ eV$. Its band gap in joule will be _____.
   a) $1.12 \times 10^{-23}\ J$ b) $1.12 \times 10^{-19}\ J$
   c) $1.12 \times 10^{-37}\ J$ d) $1.12 \times 10^{-11}\ J$

2) The high output of a CMOS inverter is _____.
   a) $V_{DD}/2$ b) V_{GS}
   c) V_{DS} d) V_{DD}

3) CMOS stands for _____.
   a) Common MOS
   b) Active load switching
   c) p-channel and n-channel devices
   d) Complementary MOS

4) A triac is generally considered most sensitive in _____.
   a) Quadrant I b) Quadrant II
   c) Quadrant III d) Quadrant IV

5) The _____ are unidirectional devices.
   a) four-layer diode and SCR b) four-layer diode and diac
   c) SCR and diac d) SCR and triac

6) The original CCD is proposed by _____ in Bell Laboratory.
   a) Boyle and Smith b) Hertz and Rutherford
   c) Newton d) Einstein

7) In CCD, transfer efficiency can be improved by moving the charge transfer layer below the _____ interface.
   a) metal-semiconductor b) metal-insulator
   c) semiconductor-insulator d) metal-metal

8) In CCD, the time required to fill the well thermally is called the _____ time.
   a) transit b) thermal relaxation
   c) on d) off

9) _____ was the first material to emit laser radiation.
   a) Silicon b) Germanium
   c) Gallium Arsenide d) Carbon

10) TED possesses the properties of _____.
   a) positive differential resistance
   b) positive differential capacitance
   c) negative differential resistance
   d) negative differential capacitance

B) Fill in the blanks OR write true/false. **06**

1) CMOS devices use _____ E-MOSFETs.
2) Triac acts like two _____ connected in reverse parallel.
3) An IGBT is essentially a MOSFET on the input and _____ on the output.
4) In CCD the time required to fill the well thermally is called the ____ time.
5) In PIN diode I stands for _____.
6) Double heterostructure (DH) laser, in which a thin layer of ____ is sandwiched between layers of a different semiconductor $(\mathrm{Al_xGa_{1-x}As})$.

Q.2 Answer the following. **16**

a) Calculate average random thermal energy of an electron in semiconductor, in electron volt, of the particle at $27\ ^{\circ}\mathrm{C}$.
[Given: Boltzmann constant; $k = 1.38 \times 10^{-23}\ J/K$].

b) Explain MIS structure.

c) In Fig.: Triac Problem, the switch is closed. If the triac has fired, what is the approximate current through the $22\ \Omega$ resister. $[\mathrm{Given}: V = 77\ V]$.

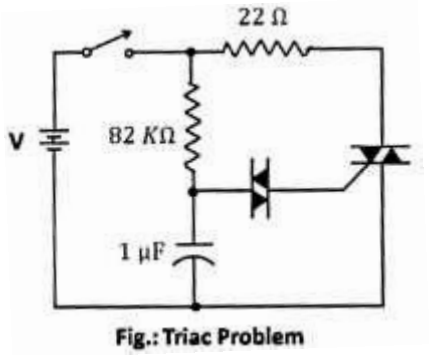

Fig.: Triac Problem

d) Draw energy band diagram for n-type semiconductor showing Fermi level (E_F), work function (E_w), electron affinity, (χ) and band gap energy (E_g).

Q.3 Answer the following. **16**

a) What are the requirements for electron transfer mechanism?

b) What is LASER? Explain p-n junction laser.

Q.4 Answer the following. **16**

a) Explain MS contact and Schottky diode.

b) What are photoconductors? Explain photocurrent gain and detectivity.

Q.5 Answer the following. **16**

a) Explain MIS capacitance.

b) Discuss I-V characteristics of SCR.

Q.6 Answer the following. **16**

a) Explain in brief IGBT.

b) Explain construction of P-i-n diode.

Q.7 Answer the following. **16**

a) Explain how transfer electron effect leads to negative differential resistance (NDR).

b) What is p-i-n diode? Discuss its characteristics.

SLR-HX-15

Seat No.	

Set P

M.Sc. (Semester - IV) (New) (CBCS) Examination: March/April-2024
PHYSICS (CONDENSED MATTER PHYSICS)
Nuclear and Particle Physics (MSC04402)

Day & Date: Saturday, 11-05-2024 Max. Marks: 80
Time: 03:00 PM To 06:00 PM

Instructions: 1) Q. Nos. 1 and. 2 are compulsory.
2) Attempt any three questions from Q. No. 3 to Q. No. 7
3) Figure to right indicate full marks.

Q.1 A) Choose the correct alternative. **10**

1) If R is the radius and A is the mass number, then the scattering experiments showed that, _____.
   a) $R = R_0 A^{1/3}$ b) $R = R_0 A^{2/3}$
   c) $R = R_0 A$ d) $R = R_0 A^3$

2) What does the mass defect stands for _____.
   a) The nucleus weighs less than the sum of the individual protons and neutrons it is composed off
   b) The mass of Uranium is smaller than of iron
   c) It is the missing term in semi empirical mass formula
   d) It is defect in the structure of atom

3) A constant mass density and constant value of binding energy per nucleon, are the properties of _____.
   a) shell model
   b) liquid drop model
   c) fermi gas model
   d) extreme single particle model

4) The _____ have explained the magic numbers.
   a) Liquid drop model b) Fermi gas model
   c) Shell model d) All of these

5) The particles having _____ spin quantum number are called fermions.
   a) 0 b) $\frac{1}{2}$
   c) 1 d) 2

6) The electric quadrupole moment is negative; shape of the nuclei is _____.
   a) Oblate b) Prolate
   c) Spherical d) All of these

7) The decay constant λ of a radioactive sample depends on _____.
   a) the number of atoms in the sample
   b) mass number of the nucleus
   c) the half life of the sample
   d) atomic number

8) One of the series that contain a magic number is _____.
   a) 2, 8, 20, 28, 50 b) 2, 8, 18, 28, 50
   c) 2, 8, 10, 28, 50, 82 d) 8, 18, 20, 28

9) The isotope of carbon, used for radiocarbon dating is _____.
   a) $^{12}_{6}\mathrm{C}$ b) $^{14}_{6}\mathrm{C}$
   c) $^{13}_{6}\mathrm{C}$ d) $^{16}_{6}\mathrm{C}$

10) Two-neutron separation energy is designated as _____.
   a) S_2 b) S_{2n}
   c) $2nS$ d) S^{2n}

B) Fill in the blanks / True or False. **06**

1) Nuclei with nucleons having a magic number are rare in nature. (True/False)
2) Stripping reaction can be explained by single particle model. (True/False)
3) If Q value of nuclear reaction is positive the reaction is endothermic. (True/False)
4) The radius of a nucleus is typically on the order of $10^{-15}\ to\ 10^{-14}$ m. (True/False)
5) Parity can provide information about the nuclear structure. (True/False)
6) Cosmic rays are high-energy particles that originate from sources beyond our solar system. (True/False)

Q.2 Answer the following. **16**

a) Explain the properties of nucleus.
b) Write a note on liquid drop model of the nucleus and state its assumptions.
c) Write a note on nuclear fission.
d) Derive the expression for threshold energy of an endoergic reaction

Q.3 Answer the following.

a) What is radioactivity? State law of radioactive decay and derive the expression for the decay rate of the sample. **10**
b) Give detailed account on radioactive dating and radioactive series. **06**

Q.4 Answer the following.

a) What are magic numbers? How does the shell model explain the existence of magic numbers and other nuclear properties? **10**
b) Explain the Fermi gas model of the nucleus. **06**

Q.5 Answer the following.

a) Give types of nuclear reactions and explain in detail nuclear transmutation reactions. **10**
b) Derive the expression for the nuclear reaction kinematics. **06**

Q.6 Answer the following.

a) Give detailed classification of elementary particles and explain the concepts conservation laws and symmetries for elementary particles. **10**
b) Write a note on different particle interactions in nature. **06**

Q.7 Answer the following

a) Derive the expression for semi-empirical mass formula and discuss its one application. **10**
b) Explain the direct reactions. **06**