K23P 0506

Reg. No. : ....

Name : ....

II Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.) Examination, April 2023
(2019 Admission Onwards)
PHYSICS
PHY 2C09 : Spectroscopy

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) Give main features of the pure rotational band spectrum of a heteronuclear diatomic molecule. How are they explained, treating the molecule as a rigid rotator ? What information is provided by the study of its spectrum ?

OR

b) Discuss the main features of the vibrational-rotational spectra of diatomic molecules. How are they explained ? Why are such spectra not obtained for molecules having identical nuclei ?

2. a) Give an account of the salient features observed in the electronic spectrum of a diatomic molecule. Discuss the conditions under which the band-heads are degraded towards violet or red in the electromagnetic spectrum.

OR

b) Discuss the main features of the vibrational and pure rotational Raman spectra of diatomic molecules. Give the necessary theory. **(2×12=24)**

SECTION – B

Answer **any four** questions (**One** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Name the new concepts introduced by vector atom model.

b) Explain the Paschen-Back effect.

c) Calculate the two possible orientations of the spin vector $\vec{S}$ with respect to a magnetic field $\vec{B}$.

P.T.O.

4. a) Give the necessary condition for a molecule to show pure rotational spectrum.

   b) Write a note on the intensity of pure rotational lines.

   c) The spacing of a series of lines in the micro wave spectrum of AlH is constant at 12.604 cm^{-1}. Calculate the moment of inertia and the internuclear distance of the molecule. What are the energy of rotation and the rate of rotation when J = 15 ?

5. a) What is predissociation ?

   b) Explain Frank-Condon principle.

   c) The fundamental band for CO molecule is centered at 2143.3 cm^{-1} and the first overtone is at 4259.7 cm^{-1}. Calculate the vibrational frequency and the simple harmonic force constant of the molecule.

6. a) Define chemical shift.

   b) Distinguish between δ and τ chemical shifts.

   c) Obtain the ratio of number of proton spins in the lower state to that in the upper state, if a system of protons at a temperature of 27°C is placed in a magnetic field of 3 T. Given, $g_N = 5.585$.

7. a) Explain the principle of ESR.

   b) What are the factors responsible for the hyperfine structure in ESR spectra ?

   c) Electron spin resonance is observed in atomic hydrogen at magnetic field B = 0.34 T. Calculate g value for the electron in the hydrogen atom, if the operating frequency is 9.50 GHz. Into how many lines this transition splits due to hyperfine interaction. Represent the transitions in an energy level diagram. Given $\mu_B = 9.274 \times 10^{-24} JT^{-1}$.

8. a) Anti-stokes lines have much less intensity than stokes line. Why ?

   b) Explain recoilless emission and absorption of gamma rays.

   c) The fine structure lines of CN band at 3883.4 Å can be represented by the following equation $\overline{\nu} = 25798 + 3.85\,m + 0.068\,m^2\ cm^{-1}$.
   Calculate the separation between the null line and the band head and the direction of degradation of the band. **(4×9=36)**

K24P 0868

Reg. No. : ....

Name : ....

Second Semester M.Sc. Degree (CBSS – Supple. (One Time Mercy Chance)/Imp.) Examination, April 2024
(2014 to 2022 Admissions)
PHYSICS
PHY2C08 : Statistical Mechanics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) Describe the thermodynamic potentials and relationship among them. Obtain the Maxwell's equations of thermodynamics.

OR

b) For a system in thermal equilibrium with the surrounding obtain the canonical distribution. Hence obtain the expressions for internal energy, Helmholtz's free energy, entropy and pressure.

2. a) Discuss the thermodynamics of an ideal Bose gas and hence obtain Bose-Einstein condensate.

OR

b) Briefly discuss Pauli para magnetism and Landau diamagnetism. **(2×12=24)**

SECTION – B

Answer **any four** questions (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Give two examples of intensive thermodynamic variables.

b) Write down the Gibbs-Duhem relation. What is its relevance ?

c) The entropy of a certain system is given by the expression $S = B(NVU)^{\frac{1}{3}}$. Calculate the temperature and pressure of the system. S-entropy, U-internal energy, V-volume and N-number of particles. B is a constant.

4. a) What is the postulate of "equal a priori probabilities" ?

   b) Write down the Maxwell-Boltzmann velocity distribution. Draw the distribution function.

   c) A thermodynamic system of three energy levels $E_1 = 0$, $E_2 = 1$, $E_3 = 2$ has two Bosons and total energy 2. Calculate the entropy.

5. a) What do you know about the potential energy of a system of particles in an ideal gas ?

   b) Obtain the Grand Partition function of a system of quantum harmonic oscillators. Hence find the internal energy of the system.

   c) Calculate the average energy of a three-dimensional classical harmonic oscillator in thermal equilibrium with the surroundings at temperature T.

6. a) Define Fermi energy at absolute zero temperature.

   b) Considering photons as bosons in thermal equilibrium, obtain black body distribution law. Draw the distribution function at different temperatures.

   c) Calculate the total Magnetic moment M of a system of N non interacting spin $\frac{1}{2}$ particles in an external magnetic field H. Draw M as a function of H.

7. a) What is exchange energy ?

   b) Describe lattice gas.

   c) A certain system at temperature T has N number of particles. Each particle can independently occupy two energy states with energy $E_1 = 0$, $E_2 = E$. Calculate the specific heat of the system.

8. a) What is the difference between first order and second order phase transitions ?

   b) Briefly explain Landau's theory of phase transition.

   c) Discuss the general features of Ising Model. **(4×9=36)**

K23P 0505

Reg. No. : ....

Name : ....

II Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.) Examination, April 2023
(2019 Admission Onwards)
PHYSICS
PHY 2C08 : Statistical Mechanics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) Discuss the Gibbs's paradox of a classical ideal gas. How is resolved ?

OR

b) For a system in thermal equilibrium with the surrounding, obtain the canonical distribution. Hence prove the theorem of equipartition.

2. a) Considering the ideal gas as a quantum mechanical microcanonical ensemble, obtain the Maxwell – Boltzmann, Fermi – Dirac and Bose-Einstein statistics. Comment on the thermodynamic properties.

OR

b) Describe the Ising model of phase transition. Briefly mention how it is applicable to binary alloy. **(2×12=24)**

SECTION – B

Answer **any four** questions (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Give two examples for thermodynamic state function.

b) Define the four thermodynamic potentials and hence explain the relationship among them.

c) For an ideal gas obeying the equation of state PV = nRT and molar specific heat at constant volume $C_v = \frac{3}{2}R$, find the Helmholtz free energy as a function of number of moles – n, volume – V and temperature – T, where R is the gas constant.

P.T.O.

4. a) Define ensemble average.

   b) Draw the phase space diagram of a quantum harmonic oscillator.

   c) Two classical distinguishable particles are distributed among three energy levels with energy $E_1 = 0$, $E_2 = 1$, $E_3 = 2$, such that total energy of the system is $E_T = 2$. Calculate the entropy of the system.

5. a) State Virial theorem.

   b) For a system in equilibrium with a particle-energy reservoir, obtain probability function of the Grand canonical ensemble.

   c) Show that the average energy of a three-dimensional classical harmonic oscillator in thermal equilibrium with the surroundings at temperature T is 3kT, where k is the Boltzmann's constant.

6. a) What do you understand by Fermi energy at non-zero temperature ?

   b) Write a brief note on Pauli para magnetism.

   c) A certain system at temperature 3000 K has electron number density 13×10^{28} per cubic meter. Are the electrons degenerate ? Explain.

7. a) What is phase transition ?

   b) Explain Bose-Einstein Condensate.

   c) Using Bose-Einstein statistics, obtain the black body distribution. Hence calculate Stefan constant.

8. a) What do you understand by the term lattice gas ?

   b) Write a short note on Landau's phenomenological theory of phase transition.

   c) Obtain the partition function of Ising model in one dimension. **(4×9=36)**

K23P 0504

Reg. No. : ....

Name : ....

II Semester M.Sc. Degree (C.B.S.S. – Reg./Supple./Imp.) Examination, April 2023
(2019 Admission Onwards)
PHYSICS
PHY2C07 : Mathematical Physics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) i) Write the three-dimensional Laplace's equation in Cartesian, cylindrical and spherical polar coordinates. Solve it in Cartesian coordinates.

   ii) Solve the following equation $\frac{\partial^2 z}{\partial x^2} - 2\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} = 0$ by the method of separation of variables.

   OR

   b) i) What is Geometric series ? Under what condition a geometric series is convergent, divergent or oscillatory.

   ii) State and explain any three methods for testing the convergence or divergence of a series.

2. a) State and prove the following properties of the Fourier Transforms :

   i) Linearity property
   ii) Change of scale property
   iii) Shifting property
   iv) Convolution property
   v) Conjugate property.

   OR

   b) i) What are reducible and irreducible representations ? Give examples.

   ii) State and prove orthogonality theorem. What is its importance ? **(2×12=24)**

SECTION – B

Answer **any four** questions (**One** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Show that the following series is convergent.

$$\frac{1}{1.2}+\frac{1}{2.3}+\frac{1}{3.4}+............+\frac{1}{n(n+1)}+.......\infty$$

b) "The nature of an infinite series remains unaltered by addition or removal of finite number of terms". Justify.

c) Discuss the Cauchy's ratio test for the convergence or divergence of a series.

4. a) What is the importance of character table in Group theory ?

b) Illustrate the method of splitting partial differential equation into ordinary differential equations by taking Helmholtz equation as example.

c) Applying the method of separation of variable techniques, find the solution of the equation $3\frac{\partial u}{\partial x}+2\frac{\partial u}{\partial y}=0$.

5. a) What is the uniqueness of Green's function ?

b) What is Green's function ? State and explain its symmetry property.

c) Find the Green's function required for the boundary value problem $\frac{d^2y}{dx^2}+k^2y=f(x)$ where f(x) is a known function of x, and y(x) satisfy the boundary conditions y(0) = 0 and y(L) = 0.

6. a) How many irreducible representations are possible for the C_{3v} point group ?

b) Show that the groups of order 2 and 3 are always cyclic.

c) If an Abelian group is constructed with two distinct elements a and b such that, $a^2 = b^2 = I$, where I is the group identity. What is the order of the smallest Abelian group containing a, b and I ? Justify your answer.

7. a) What is meant by self-reciprocal with respect to Fourier Transform ?
   b) Find the Fourier transform of e^{-ax^2}, where $a > 0$.
   c) Define a group. Show that (1, i, –1, –i) form a cyclic group under multiplication.

8. a) State any property of Inverse Laplace transforms.
   b) State and prove Laplace convolution theorem.
   c) Find the Laplace transform of (1 + cos 2t). **(4×9=36)**

K22P 0195

Reg. No. : ....

Name : ....

II Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.) Examination, April 2022
(2018 Admission Onwards)
PHYSICS
PHY – 2C07 : Mathematical Physics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions, either (**a**) or (**b**). **Each** question carries **12** marks.

1. a) State and prove Cauchy's integral test. Discuss the convergence of $\sum_{n=2}^{\infty} \frac{1}{n\log n}$.

OR

b) Using the method of separation of variables, solve one dimensional diffusion equation.

2. a) State and prove convolution theorem for Laplace transform. Hence find inverse Laplace transform of $\frac{1}{(s+2)(s^2+1)}$.

OR

b) Explain irreducible representation of C_{4v}. **(2×12=24)**

SECTION – B

Answer **any four** (**1** mark for part **'a'**, **3** marks for part **'b'**, **5** marks for part **'c'**) .

3. a) State comparison test for convergence of series.

b) Discuss the convergence of the geometric series.

c) Find the Maclaurin's series expansion of e^x. Also discuss the convergence of this expansion.

P.T.O.

4. a) What do you mean by a partial differential equation ? Write Poisson equation.

   b) Find the general solution of $\frac{\partial \phi}{\partial x} + \frac{\partial \phi}{\partial y} = \frac{\partial \phi}{\partial z}$.

   c) Find the Green's function for the equation $-\frac{d^2y}{dx^2} - \frac{y}{4} = f(x)$, with boundary conditions $y(0) = y(\pi) = 0$.

5. a) Define Fourier sine transform.

   b) Find the Fourier transform of $e^{-a|t|}$, $a > 0$.

   c) Show that $f(x) = x^{-1/2}$ is a self-reciprocal under Fourier sine transform.

6. a) What is the condition for the convergence of Laplace transform integral ?

   b) Find Laplace transform of $f(t) = t\cos kt$.

   c) Using Laplace transform, prove that $\int_0^\infty \frac{\sin t}{t} dt = \frac{\pi}{2}$.

7. a) Define a cyclic group.

   b) Describe the elements of the permutation group on 3 symbols, S_3.

   c) What do you mean by direct product groups ? Give one example.

8. a) What do you mean by equivalent representations of a group ?

   b) What do you mean by discrete group and continuous groups ? Give examples in each case.

   c) Explain the method of characteristics to solve a homogeneous linear first order partial differential equation $a\frac{\partial \phi}{\partial x} + b\frac{\partial \phi}{\partial b} = 0$, where a and b are constants.

(4×9=36)

K23P 0503

Reg. No. : ....

Name : ....

II Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.) Examination, April 2023
(2019 Admission Onwards)
PHYSICS
PHY 2C06 : Quantum Mechanics – I

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) Obtain eigenstates and eigenvalues of angular momentum operators J^2 and J_z.

OR

b) Obtain the energy eigenvalues of linear harmonic oscillator by applying Schrödinger picture.

2. a) Give time independent perturbation theory and apply it to find the effect of electric field on the ground state of hydrogen atom.

OR

b) Discuss WKB method and apply it to find the energy levels of linear harmonic oscillator. **(2×12=24)**

SECTION – B

Answer **any four** questions (**One** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Define Hilbert space.

b) Explain the properties of ket and bra space.

c) Prove that the expectation value of a Hermitian Operator is real and that of an anti-Hermitian operator is imaginary.

P.T.O.

4. a) Write any two postulates of quantum mechanics.

   b) Obtain the time derivative of the expectation value of an observable in Schrödinger picture.

   c) If the Hamiltonian of a system $H = P_x^2/2m + V(x)$, obtain the value of the commutator $[x, H]$. Hence find the uncertainty product (Δx) (ΔH).

5. a) What is the meaning of spin of an electron ?

   b) Discuss Pauli's spin matrices.

   c) Obtain the eigenvectors of Pauli's spin matrices S_x and S_y.

6. a) What are symmetry transformations ?

   b) List out characteristic properties of symmetry transformations.

   c) Show that conservation of linear momentum of a physical system is a consequence of the translational invariance of the Hamiltonian of the system.

7. a) Give Heisenberg's uncertainty relationship.

   b) Explain general uncertainty principle.

   c) Prove that zero-point energy of a harmonic is a consequence of uncertainty principle.

8. a) What is expectation value of an observable ?

   b) Explain variational principle.

   c) Evaluate the first order correction to the ground state energy of an anharmonic oscillator subjected to a potential ½ $(m\omega^2x^2) + bx^4$. **(4×9=36)**

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K24P 1111

Reg. No. : ....

Name : ....

Second Semester M.Sc. Degree (C.B.C.S.S. – OBE-Regular)
Examination, April 2024
(2023 Admission)
PHYSICS
MSPHY02C10/MSPHN02C10 : Mathematical Physics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **any 5**. **Each** one carries **3** marks.

1. State and derive Cauchy's integral theorem.
2. State and prove Heaviside's Shifting Theorem (Second Translation Property).
3. Set up a Newton iteration for computing the square root of the number two.
4. Explain Poisson distribution with two examples.
5. Explain Group, subgroup and cyclic group.
6. What do you mean by absolute and conditional convergence ? **(5×3=15)**

SECTION – B

Answer **any 3**. **Each** one carries **6** marks.

7. State Cauchy's Root test for convergence of series.
8. Evaluate inverse Laplace transform of $\frac{5s+3}{(s-1)(s^2+2s+5)}$.
9. Explain the fixed-point iteration of the equation $f(x) = x^2 - 3x + 1 = 0$.
10. Explain the normal distribution, draw the curve and its four features.
11. Obtain Laplace transform of rectangular wave given. **(3×6=18)**

P.T.O.

SECTION – C

Answer **any 3**. **Each** one carries **9** marks.

12. a) State and derive Cauchy's integral formula.

    b) Use Cauchy's integral formula to evaluate $\int_c \frac{z}{(z^2 - 3z + 2)} dz$ where c is the circle $|z - 2| = ½$.

13. State and prove convolution theorem for Laplace transform. Using convolution theorem, evaluate inverse Laplace transform of $\frac{s^2}{(s^2 + a^2)(s^2 + b^2)}$, $a^2 \neq b^2$.

14. Explain the theory of Simpson's rule and evaluate the integral

    $J = \int_0^1 \exp(-x^2\} \, dx$, with 2n = 10 and estimate the error.

15. Explain the χ^2 test, regression analysis and correlation analysis.

16. Find the two eigenvalues and two normalized eigenvectors of the matrix.

(3×9=27)
