

PG CBCS
M.SC. SEMESTER-I EXAMINATION, 2022
CHEMISTRY
PAPER: CEM 101
(PHYSICAL CHEMISTRY - I)



Full Marks: 40

Time: 2 Hours

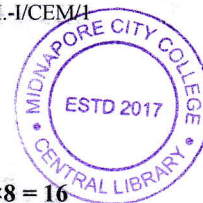
GROUP - A**1. Answer any FOUR questions from the following questions: 4×2 = 8**

- What is the orthonormal function? Write down the criteria.
- Determine the eigen value of Ae^{mx} with respect to $\frac{d^2}{dx^2}$.
- What do you mean by accessible microstates of a system?
- What are the conditions for a system of particles to obey Maxwell-Boltzmann statistics?
- What is a fermion? Give an example.
- Define morse potential.
- State the consequence of anharmonicity to a diatomic oscillator.
- Write applications of rotational spectroscopy.

GROUP - B**2. Answer any FOUR questions from the following questions: 4×4 = 16**

- Write down the forms of L_x , L_y , and L_z operators starting from $r \times p$ vectors.
- What are the properties of a well-behaved wave function? Check that, the wave function $\psi(x) = A \sin\left(\frac{m\pi x}{L}\right)$, integration range $0 \leq x \leq L$ is a well-behaved one or it is not. (2+2)
- What is a stationary state in quantum mechanics? Write the importance of the stationary state of a system. (2+2)
- Write the Nernst heat theorem. Write the limitations of this theorem. (3+1)
- Establish the relation between entropy and thermodynamic probability.
- Define the terms macrostate and microstate.
- Classify the following molecules with an explanation based on the moment of inertia of the molecule. The following molecules are benzene, water, cyclobutadiene, and methane. (1×4)
- Obtain the expression for internal energy in terms of the molecular partition function.

P.T.O.

**GROUP - C**

3. Answer any **TWO** questions from the following questions: **2×8 = 16**

- a) What is the linear operator? What is a Hermitian operator? Write down two important properties of Hermitian operators that have significant roles in quantum mechanics. Prove that the linear momentum operator is a Hermitian operator. (Consider the wave function $\psi(x) = A \sin\left(\frac{m\pi x}{L}\right)$, integration range $0 \leq x \leq L$). (2+2+2+2)
- b) Starting from the appropriate expression for the thermodynamic probability of distribution, obtain the Bose-Einstein distribution law. What are bosons? Give one example. (6+2)
- c) Using Maxwell relations derive thermodynamic equations of State. Why is it called 'thermodynamic equations of state'? (6+2)
- d) (i) Give the expression for the vibrational energy of a diatomic molecule taking it as a simple harmonic oscillator. Sketch the vibrational energy levels of such a molecule. Define zero-point energy.
(ii) The vibrational frequency and anharmonicity constant of a diatomic molecule are 350 cm^{-1} and 0.0035 respectively. Find out the positions of the fundamental and first overtone band. (1+2+2)+3
