DBW-1603010502020500 Seat No. _____

M. Sc. (Physics) (Sem. II) (CBCS) Examination

July - 2022

CT-05 : Quantum Mechanics - II & Statistical Mechanics

Time : $2\frac{1}{2}$ Hours] [Total Marks : **70**

Instructions : (1) All questions are compulsory.
(2) All questions carry equal marks.

1 Answer the following questions : (Any **seven** out of ten) **14**

(i) With diagram, explain the scattering phenomenon. In the diagram, indicate clearly: Target, incident beam, scattering cone, reference plane, scattering plane and angles θ and φ.

(ii) In the Green's function analysis using vector diagram how the term $\left|\vec{x}-\vec{x}'\right| \approx \vec{r}-\vec{x}'\cdot\hat{k}$ is obtained?

(iii) Write the formula of screened Coulomb potential. What is the dimension of $1/x$ and it indicates measure of what?

(iv) Briefly give comparison between the Born approximation and the partial wave analysis.

(v) With suitable diagram explain how the potential V introduces positive or negative sign in δ_i depending on the nature of the potential for partial waves?

(vi) Define the energy surface of energy E in classical statistics.

(vii) In the thermodynamic formulations the change in entropy is given by $dS(E,V)=\left(\frac{\partial S}{\partial E}\right)_V dE+\left(\frac{\partial S}{\partial V}\right)_E dV$, then prove that $dE = T\,dS - P\,dV$.

(viii) What is partition function? Write its formula for canonical ensemble. Why constant h is introduced in a formula?

(ix) Define the density matrix in quantum statistics.

(x) What is the importance of lattice gas concept pertaining to Ising model?

2 Write any **two** : **14**

(a) Considering the wave mechanical approach to the scattering, obtain the relation between the scattering amplitude and the differential scattering cross section as follows : $\left| f(\theta, \phi) \right|^2 = \frac{d\sigma(\theta, \phi)}{d\Omega}$.

(b) Using the Green's theory approach obtained the solution of Schrodinger equation as follows :

$$u(x) = e^{ikz} - \frac{1}{4\pi} \int \frac{e^{ikz|x-x'|}}{|x-x'|} U(x') u(x') d\tau'$$

(c) Discuss in detail: Eikonal approximation with necessary derivation.

3 Answer the following questions : (All are compulsory) **14**

(a) For the partial wave analysis, derive the following expression for scattering amplitude in terms of phase shift : $f(\theta) = K^{-1} \sum_{i=0}^{\infty} (2l+1) e^{i\delta_l} \sin\delta_l P_l(\cos\theta)$

(b) For the partial wave analysis, derive the following result of the Born approximation for the phase shift :

$$\sin\delta_l = -K \int_0^{\infty} U(r) r^2 J_l^2(kr) dr .$$

OR

3 Answer the following questions : (All are compulsory) **14**

(a) Derive the following expression for the generalized equipartition theorem : $\left\langle x_i, \frac{\partial H}{\partial x_j} \right\rangle = \delta_{ij} kT$

(b) Discuss the Gibbs paradox with necessary formulations. How the paradox is solved?

4 Write any **two** : **14**

(a) What is the classical canonical ensemble? Discuss with necessary derivations.

(b) Write postulates of quantum statistics. Explain micro-canonical ensemble in quantum statistics.

(c) Derive the following expression of the energy in Ising model $\left(E_I\right)$

$$E_I\left(N_+, N_{++}\right) = -4\varepsilon N_{++} - \left(\frac{1}{2}\gamma\varepsilon - H\right)N + 2\left(\varepsilon\gamma - H\right)N_+$$

5 Write notes on any **two** : **14**

(i) X - transition in liquid helium.

(ii) Ideal classical gas.

(iii) Optical theorem.

(iv) Born series.
