647510 **MSC2PhyC201x** **Seat No :_________**

M.SC.(Physics) Semester - 2 (*CBCS*) Examination
April/May-2023 (NEW COURSE)
Quantum Mechanics–II and Statistical Mechanics

Time: 2:30 Hours **Marks: 70**

Instructions:

1. All questions are compulsory.
2. Figures to the right indicate marks.

Q.1 Answer in brief any **seven**: **(14)**

(a) In the following formula, define each quantity:

$$\Delta N = \frac{d\sigma(\theta,\phi)}{d\Omega}\Delta t \Delta F.$$

(b) Why Green's function is used in scattering theory?

(c) Explain in brief how eikonel approximation is related to the WKB approximation?

(d) Briefly compare partial wave analysis with Born approximation.

(e) Explain in brief, how the phase shift of partial wave depends on the potential? How the sign of phase shift δ_l changes?

(f) What is micro–canonical ensemble in classical statistics?

(g) What is fugacity? Why it is used?

(h) Explain in brief how ensemble approach is considered for incoming beam of particles in scattering theory?

(i) Write properties of super fluid.

(j) In Ising model, the energy of the system for the configuration is given by:

$$E_I\{S_i\} = -\sum_{<ij>} \in_{ij} S_i S_j - H\sum_{i=1}^{N} S_i.$$

Define each term in the above equation.

Q.2 Answer any **two** of following questions: **(14)**

(a) Discuss in detail the Green's function theory for scattering and derive the formulation:

$$G_{\pm}(\vec{x},\vec{x}') = \frac{\exp[\pm iK|\vec{x}-\vec{x}'|]}{-4\pi|\vec{x}-\vec{x}'|}.$$

(b) What is screened coulomb potential? Explain in detail with necessary formulations.

(c) Explain in detail Born approximation and derive:

$$f_B(\theta) = -\frac{1}{K}\int_0^{\infty} U(r) r \sin Kr dr.$$

Q.3 (a) For the partial wave analysis in scattering theory, obtain the following expression: **(07)**

$$f(\theta) = K^{-1}\sum_{l=0}^{\infty}(2l+1)e^{i\delta_l}(\sin\delta_l)P_l(\cos\theta)$$

(b) In the partial wave analysis use the following equation: **(07)**

$$f(\theta) = (2iK)^{-1}\sum_{l=0}^{\infty}(2l+1)(e^{2i\delta_l}-1)P_l(\cos\theta)$$

For δ_l very small, obtain the expression for f (θ) and compare that with the expression of f (θ) obtained from the born approximation and obtain

$$\sum(2l+1)\,j_l^{\,2}(Kr)P_l(\cos\theta) = \frac{\sin Kr}{Kr}$$

OR

(a) If Hamiltonian is given as: $H = \sum_i A_i P_i^2 + \sum_i B_i Q_i^2$, **(07)**

where A and B are constants. Using equipartition theorem, obtain the following relation:

$$< H >= (fKT/2)$$

And, further derive the heat capacity formulation as:

$$\frac{C_V}{K} = \frac{f}{2}$$

Does above equation give any paradox? Explain in brief. How the solution is obtained for this paradox?

(b) For classical ideal gas, derive the following expression for energy: **(07)**

$$E = \left(\frac{3}{4\pi}\frac{h^2}{m}\right)\frac{N}{V^{2/3}}\exp\left(\frac{2}{3}\frac{S}{NK}-1\right)$$

Q.4 Answer any **two** of following questions: **(14)**

(a) Discuss in detail the classical canonical ensemble.

(b) Describe quantum statistical micro–canonical ensemble with necessary expressions.

(c) Draw the map showing different spin up and spin down interactions in Ising model. Derive the following equation of interaction energy:

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

Q.5 Answer any **two** of following questions: **(14)**

(a) Write a note on λ–transition in liquid helium.

(b) Write a note on Gibbs paradox.

(c) Write a note on Born series.

(d) Write a note on optical theorem.

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