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# PAQ-003-020201

Seat No. _____

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

**August / September - 2020**

## Physics : CT-05

*(Quantum Mechanics-II & Statistical Mechanics)*

*(Old Course)*

**Faculty Code : 003**

**Subject Code : 020201**

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

**Instructions :** (1) Attempt all questions.
(2) All questions carry equal marks.
(3) Assigned marks are given on RHS.
(4) Mathematical symbols have usual meanings.

**1** Answer any **seven** in brief : **14**

(a) Write the formula for screened Coulomb potential. Which parameter is considered as a measure of the atomic radius ? **2**

(b) In the validity of Born approximation using the following relation $\frac{mV_0}{2\hbar^2k^2}\left(\rho^2 - 2\rho\sin\rho - 2\cos\rho + 2\right)^{1/2} << 1,$ $\rho = 2ka$ then prove that $\frac{V_0 a}{\hbar v} << 1$ for $\rho >> 1$. **2**

(c) How from the sign of phase shift $\delta_\ell$ one can predict the nature of the potential ? Explain in brief. **2**

(d) Compare partial wave analysis and Born approximation in scattering theory briefly. **2**

(e) Define Gibbsian ensemble. **2**

(f) What is partition function ? Write formula. **2**

(g) Differentiate between grand canonical ensemble and canonical ensemble in terms of definitions. **2**

(h) How the quantum Statistical mechanics ensemble approach is applied to scattering ? **2**

(i) What are the uses of Ising model ? **2**

(g) Define superfluid. What are its properties ? **2**

2 Answer any **two** :

(a) What is Green's function ? Obtain the following expression **7**

$$G_{\pm}(x, x') = \frac{\exp\left[\pm ik\,|x-x'|\right]}{-4\pi\,|x-x'|}$$

(b) Discuss in detail Born approximation and obtain **7**

$$f(\theta) = -k^{-1}\int_0^{\infty} r \sin kr\, U(r)\, dr \,.$$

(c) In the validity of Born approximation using **7**

$$\frac{m}{k\hbar^2}\left|\int_0^{\infty}\left(e^{2ikr}-1\right)V(r)\,dr\right| << 1$$ for the screened Coulomb potential and obtain $\frac{Ze^2m}{\hbar^2 k}\,\ell n\left(\frac{2k}{\chi}\right) << 1$.

3 (a) For the partial wave analysis obtain the following expression : **7**

$$\frac{d\sigma(\theta)}{d\Omega} = \frac{1}{k^2}\Big[\sin^2\delta_0 + 9\sin^2\delta_1\cos^2\theta + 6\sin\delta_0\sin\delta_1\cos(\delta_0-\delta_1)\cos\theta\Big]$$

(b) Explain optical theorem. **7**

**OR**

3 (a) Discuss the equipartition theorem and obtain the generalized expression as **7**

$$\left\langle x_i ; \frac{\partial \mathrm{H}}{\partial x_j}\right\rangle = \delta_{ij} k^T$$

(b) In the energy fluctuations in canonical ensemble, using the partition function approach show that the partition function can be represented as : **7**

$$\approx e^{\beta(TS-U)}\int_0^{\infty} dE e^{-(E-U)^2/2kT^2C_V}$$

This shows the energy distribution in which nature ?

4 Answer any **two** :

(a) The density fluctuations in the grand canonical ensemble, derive the following expression **7**

$$\left\langle N^2 \right\rangle - \langle N \rangle^2 = \bar{N}\, kT\, K_T / v$$

where $K_T = \dfrac{1}{v\left(-\partial P / \partial v\right)}$

(b) Explain micro-canonical ensemble in quantum statistics. **7**

(c) Explain, why helium does not solidify ? **7**

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

(a) Ising model **7**

(b) Gibbs paradox **7**

(c) Density matrix **7**

(d) Born series **7**