647510 **MSC2PhyC201x** **Seat No :** ________

M.Sc. (Physics) Semester - 2 (*CBCS*) Examination
August/September -2020 [NEW COURSE]
Quantum Mechanics - 2 and Statistical Mechanics (CORE)

Time: 2:00 Hours **Marks: 56**

Instructions:

1. Figure to the right indicate marks.
2. There are five questions in the question paper.
3. Answer any four of the following questions.

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

(a) Write the formula for Yukawa potential. Which parameter is considered as a measure of the atomic radius? 02

(b) In the validity of Born approximation using the following relation: 02

$$\frac{mV_0}{2\hbar^2k^2}\left(\rho^2 - 2\rho\sin\rho - 2\cos\rho + 2\right)^{1/2} \ll 1$$ (where, ρ = 2ka), prove that, $\frac{V_0 a}{\hbar v} \ll 1$, for ρ >> 1.

(c) How from the sign of phase shift δ_l, one can predict the nature of the potential? Explain in brief. 02

(d) How the optical theorem is used in scattering? Briefly explain. 02

(e) Define the most probable value. 02

(f) What is Gibbsian ensemble? 02

(g) What is partition function? Write its formula. What are the β and h in the formula? 02

(h) Differentiate between grand canonical and canonical ensembles in terms of definition. 02

(i) Explain second sound in superfluid. 02

(j) Write postulate of quantum statistical mechanics. 02

2. Answer any **two** of following questions: **14**

(a) What is Green's function? Obtain following equation: 07

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

(b) Discuss the Born approximation and obtain the following equation: 07

$$f_B(\theta) = -k^{-1}\int_0^a r\sin krU(r)dr.$$

(c) In case of validity of Born approximation, use the following expression:

$$\frac{m}{\hbar^2 k^2}\left|\int_0^a (e^{2ikr}-1)V(r)dr\right| << 1$$, and apply to square well potential of depth V_0 and range a and derive the following result:

$$\frac{mV_0}{2\hbar^2 k^2}\left(\rho^2 - 2\rho\sin\rho - 2\cos\rho + 2\right)^{1/2} << 1$$, where $\rho = 2ka$ and further show that it is approximated

$$\approx \frac{mV_0}{2\hbar^2 k^2}\left(\frac{1}{2}\rho^2\right)$$, for $\rho << 1$.

3. (a) For classical ideal gas, obtain the following expression: 07

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

(b) For partial wave analysis, obtain the following expression: 07

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

OR

(a) In energy fluctuations in canonical ensemble, using partition function approach, derive the following expression: 07

$$\frac{1}{N!h^{3N}}\int dpdq\,\exp[-\beta \mathrm{H}(P,q)] \approx \exp\beta(TS-U)\sqrt{2\pi kT^2 C_V}$$

(b) Define u(x) in terms of partial wave of angular momentum l summations. Why the Z-component of angular momentum is zero? Compare partial wave analysis with Born approximation. 07

4. Answer any two of following questions: **14**

(a) In the grand canonical ensemble, derive the following relation: 07

$$\rho(p,q,N) = \frac{Z^N \exp[-\beta VP - \beta \mathrm{H}(P,q)]}{N!h^{3N}}$$

(b) Explain micro canonical ensemble in quantum statistics. 07

(c) Explain in detail why helium does not solidify. 07

5. Answer any two of following questions (write a note on ... ...): **14**

(a) Gibbs paradox 07

(b) Ising model 07

(c) Density matrix 07

(d) Born series 07

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