647510 **MSC2PhyC201x** **Seat No :_____**

M.SC.(Physics) Semester - 2 (*CBCS*) Examination
May/June-2022 (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) Provide the postulates of quantum statistics.
(b) Define micro–canonical ensemble.
(c) What is mechano–caloric effect in superfluid?
(d) Define crawling effect of superfluid.
(e) What is fugacity and why it is required?
(f) Explain the partition function with proper mathematical expressions.
(g) Explain in brief the differential scattering cross–section with its dimension.
(h) Write the formula for Yukawa potential. Which parameter is considered as a measure of the atomic radius?
(i) Define the most probable value.
(j) With neat diagram, indicate the cone of scattering, scattering angle, azimuthal angle and scattering plane.

Q.2 Answer any two of following questions: 14

(a) For ideal gas, obtain the values of entropy as follows:

$$S = NK\log\left[V\left(\frac{4\pi mE}{3h^2N}\right)^{3/2}\right]+\frac{3}{2}NK \quad .$$

(b) Define the grand canonical ensemble and derive the following formulation of density of points of N particles:

$$\rho(p,q,N)=\frac{Z^N e^{-\beta VP-\beta H(p,q)}}{N!h^{3N}} \quad .$$

(c) In the classical canonical ensemble, the energy fluctuations can be represented by partition function of the form:

$$\frac{1}{N!h^{3N}}\int d_p d_q e^{-\beta H(p,q)}$$ simplify this and prove that it is approximately equal to: $\approx e^{\beta(TS-U)}\sqrt{2\pi KT^2C_V}$, under which condition, the energy distribution is converted the delta function from Gaussian distribution?

Q.3 (a) Explain the micro–canonical ensemble in quantum statistical. 07

(b) Write a note on density matrix. 07

OR

(a) By using the neat diagram, explain in detail the λ–transition in liquid helium with neat diagrams. 07

(b) Write a note on Born series. 07

Q.4 Answer any two of following questions: 14

(a) What is Born approximation? Derive the following expression:

$$f_\beta(\theta) = -\frac{1}{K}\int_0^\infty U(r) r \sin kr\, dr .$$

(b) Discuss the eikonel approximation and obtain the following expression:

$$F(\theta,\phi) = -\frac{m}{2\pi\hbar^2}\int V(\vec{x}) \exp\left\{ i\left[-K\cdot\vec{x} - \frac{1}{h_v}\int_{-\infty}^{2} V(x,y,z')dz' \right]\right\} dT' .$$

(c) Calculate the differential scattering cross–section $\frac{d\sigma}{d\Omega}$ for the following potential well using Born approximation as:

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{4\mu^2 V_0^{\,2}}{\hbar^4 q^6}\left|(\sin qa - qa\cos qa)^2\right| .$$

Q.5 Answer any two of following questions: 14

(a) Write a note on Optical theorem in scattering.

(b) Write a note on Gibbs paradox.

(c) Write a note on Ising model.

(d) For ideal gas, obtain the value of entropy as follows:

$$S = NK\log\left[V\left(\frac{4\pi mE}{3h^2 N}\right)^{3/2}\right] + \frac{3}{2}NK .$$

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