MBZ-1603010502020500 Seat No. _____

M. Sc. (Sem. II) (W.I.F. 2016) Examination

April / May - 2018

CT-05 : Physics

(Quantum Mechanics-2 & Statistical Mechanics)

(New Course)

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

Instructions : (1) All questions carry equal marks.
(2) Figures to the right indicate full marks of the question.
(3) Symbols have their usual meanings.

1 Answer any **seven** of the following : **14**

(a) Define differential scattering cross section with proper mathematical expression. What is its dimension ?

(b) Why Green's function is used in the formal expression for scattering ?

(c) Why eikonel approximation is superior to born approximation ?

(d) Compare briefly the partial wave theory with born approximation.

(e) In the partial wave analysis using the following expression :

$$f(\theta) = (22°K)^{-1} \sum_{\ell=0}^{\infty} (2\ell+1)\left(e^{2i\delta\ell} - 1\right) P_\ell(\cos\theta),$$

How the above expression is simplified into

$F(\theta) \approx \frac{1}{K} \sum_{\ell=0}^{\infty} (2\ell+1) \sin\delta_\ell P_\ell(\cos\theta)$ form for small value

of S_ℓ ? Show the derivation briefly.

(f) Define the most probable value.

(g) What is partition function ? Write the mathematical expression for partition function.

(h) What is fugacity ? Why is it needed ?

(i) What is mechanocaloric effect in superfluid ? Explain briefly with suitable diagram.

(j) Write the postulates of quantum statistics.

2 Answer any two of the following :

(a) What is Born approximation ? Derive the following expression, **7**

$$f_{\beta}(\theta) = \frac{-1}{K} \int_{0}^{\infty} U(r) r \sin kr \, dr .$$

(b) Discuss the eikonel approximation and obtain the following expression : **7**

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

(c) Calculate the differential scattering cross-section $\frac{d\sigma}{d\Omega}$ **7**

for the following potential well using Born approximation

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

The potential well is :

$V(r) = -V_0$ for $r < a$

$V(r) = 0$ for $r > a$.

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

$$F(\theta) = K^{-1} \sum_{\ell=0}^{\infty} (2\ell+1) e^{i\delta_\ell} \sin\delta_\ell P_\ell(\cos\theta).$$

(b) In the partial wave analysis, the following term represents interference between different partial waves for $\ell \neq \ell'$. 7

$$\frac{d\sigma(\theta)}{d\Omega} = \frac{1}{K^2} \sum_{\ell=0}^{\infty} \sum_{\ell'=0}^{\infty} (2\ell+1)(2\ell'+1) e^{i\left(\delta_\ell - \delta'_\ell\right)}$$

$$\cdot \sin\delta_{\ell'} P_\ell(\cos\theta) P_{\ell'}(\cos\theta).$$

Considering that except δ_0 and δ_1 all other phase shifts are negligibly small then evaluate the above equation for $(a)\ \ell = 0,\ \ell' = 0\ \ (b)\ \ell = 0,\ \ell' = 1\ \ (c)\ \ell = 1, \ell' = 1$.

OR

3 (a) For ideal gas, obtain the value of entropy as follows : 7

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

(b) 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 - 7

$$\approx e^{\beta(TS-U)} \sqrt{2\pi KT^2 C_v}$$

Under which condition the energy distribution is converted the delta function from Gaussian distribution ?

4 Answer any **two** of the following :

(a) The density fluctuations in the grand canonical ensemble can be shown by the following expression for mean square fluctuation : **7**

$$\left\langle N^2 \right\rangle - \left\langle N \right\rangle^2 = KTV \frac{\partial^2 p}{\partial \mu^2} \quad \text{and obtain} \quad \frac{\partial^2 p}{\partial \mu^2} = -\frac{1}{v^3 \, \partial p / \partial v}$$

through a series of derivations.

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

(c) Explain binary alloy β – brass through Ising model. **7**

5 Write notes on any **two** :

(a) Gibbs paradox **7**

(b) λ -transition in superfluid. **7**

(c) Density matrix. **7**

(d) Screened coulomb potential. **7**