DGG-003-020201 Seat No. _____

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

May/June – 2015

CT-5 : Quantum Mech.-II & Statistical Mech.

Faculty Code : 003
Subject Code : 020201

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

Instructions : (i) Attempt all five questions.
(ii) All questions carry equal marks.
(iii) Mathematical symbols have usual meanings.
(iv) Assigned marks are written in brackets.

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

(a) With neat diagram explain angle of scattering and plane of scattering. **2**

(b) The first Born approximation to the scattering amplitude is written as $f_B(\theta,\phi) = -\frac{1}{4\pi}\int e^{-i\left(\vec{k}-\vec{k}_0\right)\cdot\vec{x}} U(\vec{x})\,d\tau$

identify each term in this formula. Clearly state on which terms the above formula depends on ? **2**

(c) Why optical theorem is important in scattering ? **2**

(d) Define partial waves. **2**

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

(f) Define canonical ensemble in classical statistics. **2**

(g) If $\mu = a(v) - v\frac{\partial a(v)}{\partial v}$ and $v = \frac{V}{N}$ then prove that **2**

$$\frac{\partial \mu}{\partial v} = -v\frac{\partial^2 a(v)}{\partial v^2}$$

(h) Write the following postulates for quantum statistics : 2

(i) Postulate of equal a priori probability

(ii) Postulate of random phases.

(i) By which method the relative amount of normal fluid and superfluid present can be found ? Write briefly its principle. 2

(j) What is lattice gas ? Explain its concept briefly. 2

2 Answer any two :

(a) Explain the wave mechanical picture of scattering and show that the differential scattering cross-section is equal to $\left|f(\theta,\phi)\right|^2$. 7

(b) Calculate the differential scattering cross-section $d\sigma/d\Omega$ for the following potential well using Born approximation and prove that 7

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

where the potential well is given as

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

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

(c) What is Eikonel approximation ? Derive the expression for scattering amplitude in Eikonel approximation. 7

3 (a) Solve the following equation by assuming the x_l as 7

$$x_l(r) = \nu_l(r) e^{\pm ikr}$$

$$\frac{d^2 x_l}{dr^2} + \left[k^2 - U(r) - \frac{l(l+1)}{r^2} \right] x_l = 0$$

and obtain the following equation

$$\log \nu_l = \mp \frac{i}{2k} \int^r \left[U + \frac{l(l+1)}{r^2} \right] dr$$

What happens to the above equation if $r \to \infty$?

(b) Obtain the following relation for partial wave analysis 7

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

What is the importance of this expression ?

OR

3 (a) Obtained the generalized equipartition theorem expression as follows 7

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

(b) Explain the Gibbs paradox in detail. 7

4 Answer any two :

(a) In the energy fluctuations in Canonical ensemble use the partition function approach and show that the Canonical ensemble is having energy distribution of Gaussian nature. Under which condition the Gaussian nature approaches to delta function ? **7**

(b) Define grand canonical ensemble and obtain the expression involving chemical potential μ and pressure p with Helmholtz free energy. **7**

(c) Explain the micro-canonical ensemble in Quantum statistics. **7**

5 Answer any two :

(a) Discuss the density matrix in detail. **7**

(b) Explain the binary alloy β-Brass using Ising model. **7**

(c) With neat diagram explain the λ-transition. **7**

(d) Explain the following effects related with the two fluid model : **7**

(i) Mechano-caloric effect

(ii) Second sound.