Seat No. _____

# HN-1603010502020500

## M. Sc. (Sem. II) (CBCS) (W.E.F. 2016) Examination

**April - 2023**

## Physics : CT-05

***(Quantum Mechanics-2 & Statistical Mechanics)***

Time : $2\frac{1}{2}$ / Total Marks : **70**

**Instructions :** (1) All questions carry equal marks.
(2) Full marks are indicated at the right end of each question.
(3) Symbols have their usual meanings.

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

(a) With neat diagram explain the phenomenon of scattering and label cleary target, reference plane, scattering plane, angles $\theta$ and $\phi$ in the figure.

(b) Why Green's function is used in scattering ?

(c) What is Yakawa potential ? Which quantity in this potential can be considered as a measure of the radius of the atom ?

(d) How the eikonel approximation is superior to the born approximation ? Discuss in brief.

(e) In the equation : $ds(E, V) = \left(\frac{\partial S}{\partial E}\right)_v dE + \left(\frac{\partial S}{\partial V}\right) E\, dV$, the quantities $\left(\frac{\partial S}{\partial E}\right)_v$ and $\left(\frac{\partial S}{\partial V}\right)_E$ are related to which physical quantities ?

(f) In classical grand canonical ensemble, what is chemical potential ? Write its formula.

(g) Write postulates of quantum statistics.

(h) Describe with necessary diagram : mechano-caloric effect in super fluid.

(i) What is concept of lattice-gas in Ising model ? Why it is important ?

(j) Write properties of super fluid.

2 Answer any two of the following : **14**

(a) Explain Born approximation and derive the following relation,

$$f_B(\theta) = \frac{1}{-K}\int_0^\infty U(r) r \sin Kr dr.$$

(b) With necessary formulation write Born Series and discuss its importance.

(c) Explain in detail the Green's function theory in scattering and obtain the expression,

$$u(\vec{x}) = e^{ikz} - \frac{1}{4\pi}\int \frac{e^{ikz|\vec{x}-\vec{x}'|}}{|\vec{x}-\vec{x}'|} U(\vec{x}')u(\vec{x}')d\tau'.$$

3 Answer both of the following : **14**

(a) For the partial wave analysis in scattering theory derive :

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

(b) Explain, how the phase shift $\delta_l$ of partial wave is related to the potential ? Derive the following equation of phase shift :

$$\sin\delta_l = -k\int_0^\infty U(r) r^2 j_l^2(k\,r)\,dr.$$

**OR**

3 Answer both of the following : **14**

(a) Obtain the following expression for equipartition of energy :

$$< H >= \frac{1}{2} f\, k\, T.$$

(b) For ideal classical gas, derive the following equation for entropy :

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

**4** Answer any two of the following : **14**

(a) What is grand canonical ensemble in classical statistics ? Derive the following formulation,

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

(b) Describe the quantum statistical micro-canonical ensemble in detail.

(c) Draw the map or diagram showing different spin up and spin down interactions in Ising model and obtain the following equation of interaction energy :

$$E_I(N_+, N_{++}) = -4 \in N_{++} - \left(\frac{1}{2} r \in -H\right) N + 2(\in r - H) N_+$$

**5** Write short-notes on any two of the following : **14**

(a) Density Matrix

(b) Gibbs Paradox

(c) Optical Theorem

(d) Eikonel Approximation

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