



NCD-1603010502020500 Seat No. _____

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

April / May - 2017

Physics : Paper - CT-5

(Quantum Mech-II & Statmech)

(New Course)

Time : $2\frac{1}{2}$ Hours]

[Total Marks : 70

- Instructions :** (1) Attempt all questions.
(2) Assigned marks are indicated in bracket of R.H.S.
(3) Mathematical symbols have usual meanings.

Answer any seven of following :

- 1 (a) What is differential scattering cross-section ? What is the dimension of it ? 2
(b) Convert Schrodinger equation into following form : 2

$$\left(\nabla^2 + k^2\right)u\left(x^{-1}\right) = U(\vec{x})u(\vec{x}), \text{ where } U(\vec{x}) = \frac{2mV(x)}{\hbar^2} \text{ and}$$

$$k^2 = \frac{2mE}{\hbar^2} .$$

- (c) In the validity of Born approximation using following equation 2

$$\frac{mV_0}{2\hbar^2k^2} \left[\rho^2 - 2\rho \sin \rho - 2 \cos \rho + 2 \right]^{1/2} \ll 1$$

prove that $\frac{V_0 a}{\hbar v} \ll 1$ for $\rho \gg 1$.

- (d) In the presence of potential the asymptotic form is 2
proportional to $\left(e^{-ikr} - e^{-2i\Delta_\ell} e^{ikr} \right)$, in this expression identify the incoming spherical wave and outgoing spherical wave and phase factor present.

- (e) In the partial wave analysis, using the following expression. 2

$$-A_\ell e^{-i\left(\delta_\ell - \frac{1}{2}\ell\pi\right)} + (2\ell+1)i^\ell e^{i\frac{1}{2}\ell\pi} = 0$$

Prove that the value of A_ℓ is $A_\ell = (2\ell+1)i^\ell e^{i\delta_\ell}$.

- (f) Define classical micro-canonical ensemble. 2
- (g) Define chemical potential using Helmholtz free energy expression. 2
- (h) Write postulates of quantum statistics. 2
- (i) What is the crawling effect of super fluid ? 2
- (j) Explain each term in the following expression of energy of the system having configuration $\{S_i\}$ for magnetic materials, using Ising model 2

$$E_I \{S_i\} = \sum_{\langle ij \rangle} \epsilon_{ij} S_i S_j - H \sum_{i=1}^N S_i$$

2 Answer any two :

- (a) Explain Born approximation and obtain following relation 7

$$f_B(\theta) = -\frac{1}{k} \int_0^\infty U(r) r \sin kr \, dr$$

- (b) Explain Eikonal approximation and derive the following expression. 7

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

- (c) In checking the validity of Born approximation use the following equation. 7

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

and obtain the following expression

$$\frac{m}{k\hbar^2} \left| \int_0^\infty (e^{2ikr} - 1) V(r) dr \right|$$

- 3 (a) In the partial wave analysis obtain the following relation 7

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

Explain the nature of each term.

- (b) Calculate the total s-wave scattering cross-section by spherical square well $V(r) = -V_0$ for $r < a$ and $V(r) = 0$ for $r > a$ and obtain the following formula. 7

$$\sigma = 4\pi a^2 \left(\frac{\tan ka}{ka} - 1 \right)^2$$

OR

- 3 (a) Obtain the following equation for ideal classical gas. 7

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

- (b) What is Gibbs paradox? How it is resolved? 7

4 Answer any two :

- (a) Define classical canonical ensemble and derive the following relation 7

$$\Gamma(E - E_1) = \exp\left[\frac{1}{k} S_2(E)\right] \left[\exp\left(-\frac{E_1}{kT}\right) \right]$$

- (b) Describe micro-canonical ensemble in quantum statistics. 7
- (c) Explain following phenomena of superfluids : 7
- (1) Mechano-caloric effect
 - (2) Fountain effect
 - (3) Second sound.

5 Write notes on any two :

- (a) Born Series. 7
- (b) Optical theorem and scattering. 7
- (c) Lattice gas by Ising model. 7
- (d) Density matrix. 7
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