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SARDAR PATEL UNIVERSITY

M. Sc. (Physics) (Ist Semester) Examination

Day: Monday, Date: 24/10/2016, Time: 10:00 a.m. to 01:00 p.m.

Course No. PS01CPHY02 (Classical and Statistical Mechanics)

CBCS (choice based credit system)

Important Note: Signs have their usual meaning.

Q.1: Eight multiple choice questions (MCQ) carry one mark each.

Q.2: Short answer questions carrying two marks each (attempt any seven out of nine).

Q.3 to Q.6: Long answer questions carrying 12 marks each.

Total Marks: 70

Q1 (i) In spherical coordinate system (r, θ, ϕ) if the Lagrangian L is given as $L = \frac{1}{2}m[\dot{r}^2 + r\dot{\theta}^2 + r^2\dot{\phi}^2\sin^2\theta]$, then determine the cyclic coordinate; where mass m is a constant.

(a) r (b) m (c) θ (d) ϕ

(ii) For a transformation $P_k = P_k(p, t)$, p and P_k are dependent variable than which generating function is excluded;

(a) $F_1(q, Q, t)$ (b) $F_2(q, P, t)$

(c) $F_3(p, Q, t)$ (d) $F_4(p, P, t)$

(iii) The Poisson bracket $[p_i, H]$ is equal to _____.

(a) $-\dot{p}_i$ (b) $-\frac{\partial H}{\partial q_i}$ (c) p_i (d) $\dot{q}_i$

(iv) The equilibrium is said to be stable if extremum value of potential energy V is _____.

(a) maximum (b) minimum

(c) zero (d) any value between minimum and maximum

(v) The expectation value of any observable quantity $\hat{F}$ in terms of density matrix is given as

(a) $Tr(\hat{F}|\hat{\rho})$ (b) $\hat{F}/Tr(\hat{\rho})$

(c) $\hat{F}Tr(\hat{\rho})$ (d) $Tr(\hat{\rho}\hat{F})$

(vi) Ideal Fermi gas pressure at T = 0K is given by,

(a) $3/2n\varepsilon_F$ (b) $1/2n\varepsilon_F$ (c) $n\varepsilon_F$ (d) $2/5n\varepsilon_F$

(vii) According to Clausius-Clapeyron equation, the change of vapour pressure with temperature is given as.

(a) $\frac{1}{T(V_2 - V_1)}$ (b) $\frac{L}{T(V_2 - V_1)}$ (c) $\frac{T}{L(V_2 - V_1)}$ (d) $\frac{L}{V_2 - V_1}$

(viii) Order parameter is always _____ above critical point.

(a) 1 (b) 0 (c) 0.5 (d) 1.5

Q2 (i) Discuss Poisson brackets of representing the equation of motion in a symmetric form. Prove Kronecker delta property?

(ii) Explain with suitable examples stable and unstable equilibrium?

(iii) What are the characteristics of a chaotic motion?

(iv) Explain with suitable example the virtual displacement of a system.

(v) Explain how the Hamilton-Jacobi equations are first-order partial differential equation in (n+1) variable.

(vi) Write the density operators of various ensembles in the energy representation.

(vii) Obtain the conduction electron density in terms of the Fermi energy ε_F for ideal Fermi gas.

(viii) Define phase transition and explain pressure versus temperature diagram of matter.

(ix) Express the partition function for a real gas in terms of a two body interaction potential $U(r_{ij})$.

Q3 (a) Solve the harmonic oscillator problem by canonical transformation. The given generating function for the harmonic oscillator is $\mathbf{F_1 = \frac{1}{2}m\omega q^2 cotQ}$. 6

(b) What is gauge transformation? What arbitrariness does it introduces? Derive the new Lagrangian $\mathbf{L'}$ in terms of old Lagrangian $\mathbf{L}$ using generating function. 6

OR

(b) Derive Hamilton-Jacobi equation for conserved Hamiltonion **H**. Discuss about Hamilton's principal function and show that it differs from the indefinite time integral of the Lagrangian by a constant term. 6

Q4 (a) Explain small oscillations, stable and unstable equilibrium. Derive the equation of Lagrangian for the small oscillations near its equilibrium position. 6

(b) Explain secular equation of oscillatory motion of a system. Solve the problem of two coupled simple pendulums and derive the equations of frequencies. 6

OR

(b) Show that the eigenvectors corresponding to the two distinct eigenfrequencies are orthogonal. Explain the meaning of orthogonality. 6

Q5 (a) Obtain the expression for the total number of particles in ideal Bose gas and discuss the Bose-Einstein condensation in detail. 6

(b) Derive partition function and density matrix of free particle in the momentum representation. 6

OR

(b) Write a note on white dwarf star and derive Chandrasekhar limit. 6

Q6 (a) Express the following cluster integral terms in the perturbation expansion of an interacting system of eight particles diagrammatically and identify the number of l – particle clusters. 6
(a) $\int - - - - \int f_{12}f_{35}f_{23}f_{78}d^3r_1 \_\_\_\_\_ d^3r_8$
(b) $\int - - - - \int f_{12}f_{23}f_{13}f_{56}d^3r_1 - - - - d^3r_8$

(b) Discuss 1-D Ising model and its limitations. 6

OR

(b) Derive Boltzmann transport equation and prove that $\frac{dH}{dt} \leq 0$. 6

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