[66] SEAT No._____ SC

No. of printed pages: 02

SARDAR PATEL UNIVERSITY

M.Sc. (PHYSICS) First Semester Examination

Day & Date: Friday & 22/03/2019

Time: 02:00 PM to 05:00 PM

Title: CLASSICAL & STATISTICAL MECHANICS

SUBJECT CODE: PS01CPHY02

Total marks: 70

Q.1 **Write answers of all questions by showing your choice against the question number.** [8]

(1) In the given expression $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - \frac{GMm}{r}$, find the cyclic coordinate.

(a) θ (b) $\dot{r}$ (c) r (d) $\dot{\theta}$

(2) The constraints that explicitly dependent on time.

(a) Cleronomous (b) Rheonomous
(c) Scleronomous (d) Real

(3) The Poisson bracket $[p_i, H]$ of momentum p_i and Hamilton H is equal to _____.

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

(4) The equilibrium is said to be unstable if extremum value of potential energy V is a _____.

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

(5) At very low temperature, the fugacity of a system of ideal bosons approaches to

(a) zero (b) one
(c) infinity (d) the total number of particles

(6) Ideal Fermi gas pressure at absolute zero temperature is given by

(a) $\frac{3}{2}nE_F$ (b) $\frac{2}{5}nE_F$
(c) $\frac{1}{2}nE_F$ (d) nE_F

(7) The white dwarf stars in equilibrium must have mass less than

(a) $1.44M_o$ (b) $1.34M_o$
(c) $0.44M_o$ (d) $2.44M_o$

(8) Order parameter is always _____ above critical temperature.

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

Q.2 **Attempt any Seven of the followings:** [14]

(1) Prove that the Poisson brackets are invariant under canonical transformations.

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

(3) With suitable examples discuss stable and unstable equilibrium?

(4) Derive the secular equation for small oscillatory motion.

(P.T.O.)

(5) Prove that the Poisson bracket obeys the distributive laws of algebra.

(6) What is partition function? Write partition functions for different ensembles.

(7) Define density operator? How a pure state is defined in terms of the density operator?

(8) Write Clausius – Clapeyron equation and its physical significance.

(9) Define phase transition. Explain 1st order and 2nd order phase transition with examples.

Q.3(a) Derive Hamilton-Jacobi equation for conserved Hamiltonian 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]

Q.3(b) Using canonical transformation solve the harmonic oscillator problem. The given generating function for the harmonic oscillator is $F_1 = \frac{1}{2}m\omega q^2 \cot Q$. [6]

OR

Q.3(b) In the gauge transformation derive the relation between new and old Lagrange's. Explain the importance of generating function. [6]

Q.4(a) Derive the Hamilton-Jacobi equation and prove that they are first order partial differential equations in (n+1) variables. [6]

Q.4(b) For a two coupled simple pendulums derive the fundamental frequencies using secular equation. [6]

OR

Q.4(b) Show that the eigenvectors corresponding to the two distinct eigen frequencies are orthogonal. Discuss the meaning of orthogonality. [6]

Q.5(a) Derive density matrix and the partition function for a system of free particles in co-ordinate space. [6]

Q.5(b) What is white dwarf star? Derive Chandrasekhar limit. [6]

OR

Q.5(b) Derive thermodynamic properties of ideal Bose gas at very low temperature. [6]

Q.6(a) Discuss the Mayer's cluster expansion. Obtain an expression for the second virial coefficient. [6]

Q.6(b) What are critical exponents? Deduce the various scaling relations among them. [6]

OR

Q.6(b) Explain Boltzmann H – theorem and prove $dH/dt \leq 0$. [6]

****