

Seat No. : \_\_\_\_\_

**DB-145**

**December-2018**

**M.Sc., Sem.-I**

**402 : Physics**

**(Classical Mechanics and Statistical Mechanics)**

**Time : 2:30 Hours]**

**[Max. Marks : 70**

- Instructions :** (1) Attempt **all** questions.  
(2) Symbols used have their usual meanings.

1. (A) Write the following :

- (i) What is gauge transformation ? Explain it by taking example of the Lagrangian function and simple harmonic oscillator. 7
- (ii) Write usefulness of the Hamilton-Jacobi theory. Explain harmonic oscillator by using such theory. 7

**OR**

- (i) What do you mean by action and angle variables ? Discuss how they are used to obtain the frequencies of periodic motion and calculate the frequency of linear harmonic oscillator.
- (ii) Prove that the problem of motion of a body in a central force field is separable in polar co-ordinates but not in cartesian co-ordinates.

(B) Answer the following in brief : (any **four**) 4

- (i) Verify :  $[A, B] = -[B, A]$ .
- (ii) Show that the transformation  $P = \sqrt{2qe^{-\alpha}} \sin p$  and  $Q = \sqrt{2qe^{\alpha}} \cos p$  is canonical.
- (iii) Explain why Lagrangian formulation is more suitable for the transition to quantum field theory.
- (iv) Define generating function.
- (v) State importance of the Hamiltonian formulation in physics.
- (vi) Prove that  $[v, q_k] = -\frac{\partial v}{\partial p_k}$ .

2. (A) Write the following :  
(i) Obtain values of eigen frequencies of oscillations and their related eigen vectors for CO<sub>2</sub> molecule. 7

(ii) What are normal co-ordinates ? Obtain kinetic energy and potential energy in terms of normal co-ordinates and find out Lagrangian equation of motion. 7

**OR**

(i) If frequencies of oscillations are  $\omega_1 = \sqrt{\frac{g}{l}}$  and  $\omega_2 = \sqrt{\frac{g}{l} + \frac{2k}{m}}$  for coupled simple pendulum joined by spring having a force constant k, then find out the (1) eigen vectors, (2) generalised co-ordinates and (3) normal co-ordinates.

(ii) Define orthogonality. Prove that eigen vectors corresponding to the two different eigen frequencies are orthogonal.

(B) Answer the following in brief : (any **four**) 4

(i) Differentiate stable and unstable equilibrium.

(ii) Give applications of theory of small oscillations in physics.

(iii) What is meant by degeneracy ?

(iv) State physical significance of equation  $|V_{jk} - \omega^2 T_{jk}| = 0$ .

(v) How many independent modes of vibration of the system having N coupled oscillator with N degrees of freedom ?

(vi) What do you understand by normal modes in relation to coupled oscillator ?

3. (A) Write the following :

(i) What do you mean by time dependence of fluctuations ? Establish a relationship between correlation function and power spectrum of time dependent fluctuations. 7

(ii) Define Shot noise. Obtain an expression for rms shot noise current. State its applications. 7

**OR**

(i) Discuss the Langevin theory of time independent fluctuations.

(ii) Derive Wiener-Khinchin theorem and show that for an exponentially decaying system, the rapid fluctuations rests faster than slowly varying fluctuations.

(B) Answer the following in brief : (any **three**) 3

(i) State the significance of auto co-rrrelation function.

(ii) Give the unit of diffusion coefficient of Brownian particles.

(iii) State any two applications of Johnson noise.

(iv) What is the origin of shot noise ?

(v) Define Brownian motion.

4. (A) Write the following :

- (i) Prove that in the second order phase transition the second derivatives of the Gibbs function are discontinuous. 7
- (ii) Explain : (a) Critical indices (b) Order parameter. 7

**OR**

- (i) Using zeroth order Ising model, show that one dimensional Ising chain can not be ferromagnet.
- (ii) Explain statistical equilibrium. Obtain Clausius-Clayperon equation and state its significance.

(B) Answer the following in brief : (any **three**) 3

- (i) "Critical exponents are all independent of each other". (True/False)
- (ii) Plot a graph of specific heat versus temperature in first order phase transition.
- (iii) Define order parameter for  $\beta$ -Brass.
- (iv) Differentiate between first order and second order phase transition.
- (v) Define co-operative processes.

@geniussguraji