

**M. Sc. 1st Semester Examination, 2024****CHEMISTRY**

PAPER – CEM-101

*Full Marks : 50**Time : 2 hours*Answer **all** questions*The figures in the right hand margin indicate marks**Candidates are required to give their answers in their own words as far as practicable***GROUP – A**Answer any **four** the followings :  $2 \times 4$ 

1. What is Gibb's paradox ? How would you eliminate it ?
2. Maxwell-Boltzmann energy distribution law is a limiting case of Bose-Einstein distribution. Explain.

3. How many normal modes of vibrational are possible for a benzene molecule ?
4. The A rotational constant of a phosphorus pentafluoride,  $\text{PF}_5$ , molecule is 3.566 Hz. Calculate the lengths of the equatorial P-F bonds.
5. If spatial wave function of excited Helium atom is given by  $\frac{1}{\sqrt{2}}[1S(1)2S(2) - 1S(2)2S(1)]$ , then write down its possible spin wave function(s).
6. Show that  $[x^2, p_x^2] = 2\hbar^2 + 4i \hbar x p_x$ .

### GROUP - B

Answer any **four** of the following :  $4 \times 4$

7. "The best composition for a binary mixture is mixing of equal amount of two components."  
- Justify.

8. For  $H_2$  gas at 3000K, calculate the characteristic vibrational temperature,  $\theta_v$  and vibrational partition function. Given that the fundamental vibrational frequency of  $H_2$  molecule, obtained from its Raman spectrum is  $4405.3 \text{ cm}^{-1}$ .
9. The rotational constant for  $H^{35}Cl$  is observed to be  $10.5909 \text{ cm}^{-1}$ . What are the values of  $B$  for  $H^{37}Cl$  and  $^2D^{35}Cl$  ?
10. Which is the correct order of increasing wave number of the stretching vibrations of (i) C-H (alkane), (ii) C-H (alkene), (iii) C-H (alkyne) and (iv) C-H (arene) ? Explain with proper reasons.
11. Show that time evolution of average value of any physical observable corresponding to operator  $D$  is given by,
- $$\frac{d \langle D \rangle}{dt} = \frac{1}{i\hbar} \langle [D, H] \rangle; \text{ Symbols have their usual significances.}$$

12. Find the degeneracy of the level having energy  $\frac{6h^2}{8ma^2}$  for a particle confined in a cubical box whose length of each side is 'a'. If the length of the box along the x-axis is distorted by 'da', then find the fate of the above energy levels.

## GROUP – C

Answer any **two** of the following :  $8 \times 2$

13. Derive the expression for the thermodynamic probability distribution of particles describe by antisymmetric wave function and arrive at the appropriate quantum statistical distribution law.
14. Define the term activity and hence derive the expression for activity of solute for a system showing freezing point depression.

15. Use rigid rotator approximation to determine the selection rules and the essential criteria for a molecule to be microwave active. Recursion relation for spherical Harmonics is given below;

$$(2J+1)xP_J^M(x) = (J-|M|+1)P_{J+1}^M(x) + (J+|M|)P_{J-1}^M(x)$$

16. (a) Evaluate the commutator,  $[L_-, L_+]$ .

- (b) The wave function  $\psi$  of a certain system is given by the linear combination of two

functions,  $\psi = \sqrt{\frac{1}{4}}\psi_1 + \sqrt{\frac{3}{4}}\psi_2$ .

Where  $\psi_1$  and  $\psi_2$  are the eigen function with energy eigen  $E_1$  and  $E_2$  respectively. Calculate (i) the energy expectation value of the system and (ii) the probability that the system energy to be observed  $E_2$ . (Assume  $\psi_1$  and  $\psi_2$  are orthonormal set of function)

- (c) Find out the dimension of wave function for particle in two-dimensional box problem. 4 + 4 + 2

