

2022

1st Semester Examination
CHEMISTRY

Paper : CHEM 101

Full Marks : 40

Time : Two Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

Group - A

Answer any *four* of the following questions : $2 \times 4 = 8$

1. Classify the following molecules according to their moment of inertia along the three perpendicular directions.
 - (i) SF_6
 - (ii) Allene
2. How do you obtain the fundamental vibrational frequency of a diatomic molecule from the microwave spectral data?
3. Show the different modes of vibration of an AB_2 type linear molecule and assign the modes of vibrations which are IR active.

P.T.O.

4. Write down the Cartesian form for \hat{L}_z using rxp vector.
5. Explain the term fugacity. How is it related to the chemical potential?
6. Write down the conditions at which Bose-Einstein distribution reduces to Boltzmann distribution.

Group - B

Answer any *four* of the following questions : $4 \times 4 = 16$

7. Write down the rotational Hamiltonian and hence obtain the energy of the following class of molecules.
 - (i) prolate symmetric top, (ii) oblate symmetric top.

Give a comparison of their energy levels.
8. 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.
9. What is the energy difference between P_1 and R_0 branches of lines in vibration-rotation spectra? The fundamental and first overtone transitions of $^{14}\text{N}^{16}\text{O}$ are centred at 1876.06 cm^{-1} and 3724.20 cm^{-1} respectively. Evaluate the equilibrium vibration frequency and the zero-point energy. 1+3=4
10. Find out the best composition of a binary mixture. 4

11. Derive the expression which shows the rotational contribution to the molar entropy. 4
12. Calculate the translational partition function for toluene in a volume of 1 m^3 at 25°C . (Assuming ideal behaviour of toluene) 4

Group - C

Answer any *two* of the following questions : $8 \times 2 = 16$

13. 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 :

$$(2J+1)xP_J^M(x) = (J-|M|+1)P_{J+1}^M(x) + (J+|M|)P_{J-1}^M(x) \quad 8$$

14. For any dynamic variable of a quantum mechanical system, deduce the expression of Heisenberg equation of motion. Hence obtain the following expression for particle (mass, 'm') in 1-D box problem.

$$\frac{d\langle x \rangle}{dt} = \frac{\langle p_x \rangle}{m} \quad 8$$

P.T.O.

15. Obtain an expression for the thermodynamic probability distribution of particles described by antisymmetric wave functions and arrive at the appropriate quantum statistical distribution law. 8

16. *Either*

Explain the term activity. Discuss the principles of determination of the activity of a nonvolatile solute by measuring the freezing point depression. 2+6

Or

Using the Maxwell relations derive the thermodynamic equations of state. 8
