



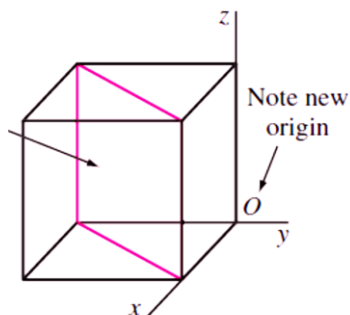
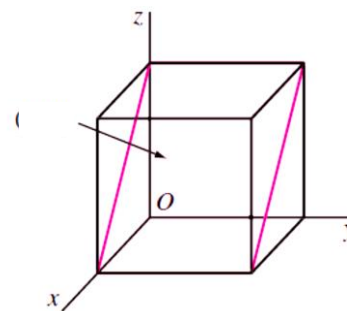
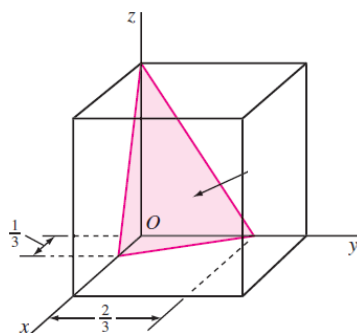
Post Graduate Teaching Department of Chemistry
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Master of Science (M.Sc.) CHEMISTRY Examination (CBCS)
Second Semester Physical Chemistry
Paper – VII (2T3)

Time: Three Hours]

[Max Marks: 60

- N.B.:**
- 1. All questions carry equal marks.**
 - 2. All questions are compulsory.**
 - 3. Use of calculator is permitted.**

1. a) A certain system is described by the operator $\hat{A} = -\frac{d^2}{dx^2} + x^2$ Show that
 - a) Show that $\psi = cxe^{-\frac{x^2}{2}}$ is eigen function of $\hat{A}$. What is the eigen value?
 - b) Determine the constant 'c' so that ψ is normalized. (4)
 - b) Show that:
 1. eigen values corresponding to Hermitian operator are always real.
 2. Eigen functions corresponding to different eigen values are orthogonal to each other. (4)
 - c) For a particle in a cube of edge length 'L' give the expression for energy and indicate the degeneracies for $\frac{9h^2}{8mL^2}$ and $\frac{12h^2}{8mL^2}$ (4)
- OR**
1. d) For an electron wave derive the expressions for momentum and Hamiltonian operators. (4)
 - e) For an atom like Hydrogen give the expression for Hamiltonian in Polar coordinates. Separate the equation in Radial and Angular/Azimuthal Part and discuss their significance. (4)
 - f) Which of the following are eigen functions of the operator $\frac{d^2}{dx^2}$
 - i. $\sin 3x$
 - ii. $6\cos 4x$
 - iii. $5x^2$
 - iv. $3e^{-5x}$ (4)
2. a) What is Fugacity? Derive the expressions for entropy of mixing, Free energy of mixing and enthalpy of mixing for a non-ideal solution. (4)
 - b) Discuss the conservation of mass and energy in closed and open systems. (4)
 - c) Calculate the ionic strength of a solution prepared by mixing 50 mL of 0.2 M KNO_3 , 20 mL K_2SO_4 , and 30 mL $\text{Cu}(\text{NO}_3)_2$. (4)
- OR**
2. d) Derive the Debye-Hückel Limiting Law (DHLL) for mean ionic activity coefficient in terms of ionic strength. (4)
 - e) What are excess thermodynamic functions? Derive the expressions for Excess Gibbs free energy and excess entropy. (4)
 - f) Discuss the thermodynamic constraints and their significance on the signs of chemical affinity and the velocity of chemical reaction. (4)
3. a) What are Miller Indices? Find the miller indices from below figures: (4)



- b) How Packing in crystals exist? Discuss Hexagonal Closest Packing (HCP) and Cubic Closest Packing (CCP) (4)
- c) Discuss the thermodynamics of Frenkel Defects (4)
- OR**
3. d) Copper has an FCC crystal structure and an atomic radius of 0.1278 nm. Assuming the atoms to be hard spheres that touch each other along the face diagonals of the FCC unit cell, calculate a theoretical value for the density of copper. The atomic mass of copper is 63.54 g/mol. (4)
- e) What are Perfect and imperfect crystals? Discuss the point and line defects in crystals. (4)
- f) Write Notes on:
- Absence of fivefold symmetry axis
 - The Bravais Lattices (4)
4. a) Based on Lagrange method of undetermined multipliers derive the Maxwell-Boltzmann statistical distribution law. Consider the degeneracy factor in the expression. (4)
- b) Write a note of isotopic dilution analysis. (4)
- c) Calculate the number of ways of arranging 5 energy quanta among 3 energy levels such that one energy level has one quanta and two has two each. (4)
- OR**
4. d) What is most probable distribution? What will be the different probability distribution of getting head and tail if 10 coins are tossed at a time? Derive a general formula. (4)
- e) Give a brief account of GM counter. (4)
- f) Give the expression for Fermi-Dirac Statistical Distribution law. What is Fermi function? Explain its significance for the condition of $E < E_f$ (4)
5. a) Derive an expression for the energy of rigid rotor (3)
- b) Define with suitable example,
- Ionic strength
 - Clausius inequality (3)
- c) Give an account of Non-stoichiometry defects (3)
- d) What is radioactive decay? (3)