NATIONAL INSTITUTE OF TECHNOLOGY PATNA

Department of Chemical Science and Technology

Mid Semester Exam Jan-June-2025 (IV Sem.)

Subject: CH49105 – Material Science

Date: 10-03-2024 | Time: 2 hrs. | Max. Marks: 30

Note: Attempt all questions. Assume all the missing data, if any.

1. (a) Show that the atomic packing factor for face-centered cubic (FCC) is 0.74. [3]

   (b) Determine the interplanar spacing between (200), (220), and (111) planes in an FCC crystal. Take the atomic radius as 1.246 Å. [3]

2. (a) A body-centered cubic (BCC) crystal is used to measure the wavelength of some X-rays. The Bragg angle for reflection from the (110) plane is 20.2°. What is the wavelength? The lattice parameter of the crystal is 3.15 Å. [3]

   (b) Find the Miller indices of a plane that makes an intercept of 1 on the X-axis and 2 on the Y-axis and is parallel to the Z-axis. [3]

3. (a) Explain the interfacial defects and their types. [3]

   (b) What is a point defect? Differentiate between Schottky and Frankel Defect. [3]

4. (a) What do you mean by diffusion? Explain the atomic mechanism of diffusion. [3]

   (b) A hardened steel ball of 0.5 cm diameter is used to indent a steel specimen in Brinell hardness testing. The diameter of indentation measured by an optical microscope of magnification 10× gives a reading of 32.5 mm. Determine the hardness of the steel in BHN. Take $P = 30\ D^2$. [3]

5. Define and explain the following terms and their applications in industries: [1×6]

   (a) Toughness

   (b) Hardness

   (c) Stiffness

   (d) Resilience

   (e) Creep

   (d) Fatigue

NATIONAL INSTITUTE OF TECHNOLOGY PATNA

Department of Chemical Science and Technology

Mid Semester Exam, Session_Jan-June 2025

Subject: CH49101 – Chemical Engineering Thermodynamics

B.Tech-M.Tech-DD-CH-CT, 4th Sem

Max. Marks: 30 **Time: 2 h**

Instructions:

(i) Make suitable assumptions if needed, by clearly stating them.
(ii) Draw the figure wherever necessary.
(iii) The question paper consists of **five** questions and **two** pages. **All questions are compulsory.**

Sl. No.	Questions	Marks
1(a)	Explain the physical significance of the triple point and the critical point.	2
1(b)	Distinguish between state function and path functions with examples. A cyclic process may be defined as the one in which after a series of changes, the system is brought back to its initial conditions. What would be the change in a state function in a cyclic process?	2
1(c)	An ideal gas with molar heat capacity $C_p = \frac{5}{2}R$ (where, R = 8.314 J/mol-K) is compressed adiabatically from 1 bar and 300 K to pressure P_2 in closed system. The final temperature after compression is 600 K and mechanical efficiency of compression is 50 %. Calculate the final pressure P_2 (in bar) and the work required for compression (in kJ/mol).	2
2(a)	Show that the rate of change of chemical potential of a substance with pressure is equal to its partial molar volume in the solution.	3
2(b)	The enthalpy of a binary liquid mixture containing components 1 and 2 at 298 K and 1.0 bar is given by $H = 400x_1 + 600x_2 + x_1x_2(40x_1 + 4x_2)$ where H is in J/mol. Determine (a) Pure component enthalpies (b) Partial molar enthalpies.	3
3(a)	"All property changes of mixing are zero for ideal solutions". Do you agree? Explain.	2
3(b)	In a binary mixture, the activity coefficient γ_1 of component 1, in the entire range of composition, is given by $R \ln \gamma_1 = Ax_2^2 + Bx_2^3$ where R, A and B are constants. Derive expression for the activity coefficient of component 2.	4
4(a)	Derive the relationship between mole fraction of species in multiple reactions and the extent of reactions.	3

4(b)	Calculate the equilibrium constant at 500 K and 1 bar for the reaction $N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$ assuming that the heat of reaction remains constant in the temperature range involved. Take the standard heat of formation and standard free energy of formation of ammonia at 298 K to be – 46,100 J/mol and –16,500 J/mol respectively.	3
5(a)	How is the equilibrium constant K related to the standard free energy change? Does K vary with pressure?	3
5(b)	A mixture of 1 mol CO, and 1 mol water vapour is undergoing the water-gas shift reaction at a temperature of 1100 K and a pressure of 1 bar. $CO\,(g) + H_2O\,(g) \rightarrow CO_2\,(g) + H_2\,(g)$ The equilibrium constant for the reaction is $K = 1$. Assume that the gas mixture behaves as ideal gas. Calculate the fractional dissociation of steam if the reactant stream is diluted with 2 mol nitrogen.	3

.....End of Paper.....

National Institute of Technology Patna

Department of Mathematics

Mid Semester Examination :March 2025

MA47101/MA48101/MA49101 : Numerial Analysis/ Numerical Methods for Engineers

Branch: B. Tech + M.Tech (Dual Degree) CT, MCT & MSE — Maximum Marks: 30

Semester: 4th — Time: 02.00 hours

Answer All Questions

1. Instead of using the true values $x_T = 0.71456371$ and $y_T = 0.71456238$ in calculating $z_T = x_T - y_T (= 0.133 \times 10^{-5})$, if we use the approximate values $x_A = 0.71456414$ and $y_A = 0.71456103$, and calculate $z_A = x_A - y_A (= 0.311 \times^{-5})$, then find the loss of significant digits in the process of calculating z_A when compared to the significant digits in x_A. [5 Marks]

2. Use the Cholesky factorization to solve the system

$$\begin{aligned} x_1 - 2x_2 + 2x_3 &= 4 \\ -2x_1 + 5x_2 - 3x_3 &= -7 \\ 2x_1 - 3x_2 + 6x_3 &= 10. \end{aligned}$$

[5 Marks]

3. Consider the matrix $A = \begin{bmatrix} 1 & -2 \\ -3 & 4 \end{bmatrix}$. Find the norm of A_∞, A_2 and A_1. Also verify that $\|Ax\| \leq \|A\|\|x\|$ for the any of the two norm defined above (The vector norm is understood in the sense that matrix norm is subservient to it.). [5 Marks]

4. Define condition number for matrix. Compute the condition numbers of the following matrix relative to $\|\cdot\|_\infty$.

   (a) $\begin{bmatrix} 1/2 & 1/3 \\ 1/3 & 1/4 \end{bmatrix}$

   (b) $\begin{bmatrix} 3.9 & 1.6 \\ 6.8 & 2.9 \end{bmatrix}$

[5 Marks]

5. Solve the system $Ax = b$ by Gauss-Jacobi method with $A = \begin{bmatrix} 3 & -1 & 1 \\ 3 & 6 & 2 \\ 3 & 3 & 7 \end{bmatrix}$, $b = \begin{bmatrix} 1 \\ 0 \\ 4 \end{bmatrix}$, and $x^{(0)} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$. Tabulate the results upto first 5 iteration. [5 Marks] b.

6. Define Gauss-Seidel iterative method to solve system of equations. Determine and prove the conditions for convergence of the Gauss-Seidel method. [5 Marks]

— All the Best —

NATIONAL INSTITUTE OF TECHNOLOGY PATNA

Mid Semester Examination, Jan - Jun 2025

Session: 2024-2025, Even Semester

Program: **DD-Chemical Technology** | Semester: **4th**

Subject Code: **CH49102** | Time: **2 hr**

Subject Name: **Heat Transfer Operations** | Total Marks: **30**

All questions are compulsory.

1. Answer the following [1 x 5]
   a. What is the Fourier's Law? Write its mathematical expression.
   b. What is the critical thickness of insulation?
   c. What is the physical significance of the Biot number?
   d. What are the assumptions in one-dimensional heat conduction.
   e. Define the Nusselt number.

2. Answer any one of the following questions. [5]
   a. Derive the mathematical expression for the temperature distribution in a solid sphere with internal heat generation.
   b. Explain the concept of hydrodynamic and thermal boundary layers in forced convection. Derive an expression for the Nusselt number using dimensional analysis.

3. A cylindrical hot gas duct, 0.5m inside radius, has an inner layer of fireclay bricks (k = 1.3 W/m°C) of 0.27m thickness. The outer layer 0.14m thick, is made of special bricks (k = 0.92 W/m°C). The brickwork is enclosed by outer steel cover which has a temperature of 65°C. The inside temperature of the duct is 400°C. Neglecting the thermal resistance of the steel cover, Calculate (a) the heat loss per unit length of the duct and (b) the interface temperature between the ceramic layers. [6]

4. A 25cm diameter steel ball (ρ = 8055kg/m^3, C_p= 480 J/kg.K) is removed from the oven at the temperature of 300°C. The ball is then subjected to the flow of air at 1atm pressure and 25°C with velocity of 3m/s. The surface temperature of the ball eventually drops to 200°C. Determine (i) heat transfer coefficient and (ii) how long the process will take. Properties of air: Pr = 0.73, ρ = 1.184 kg/m^3, μ (at 25°C) = 1.849 x 10^{-5} kg/m.s, μ (at 300°C) = 2.76 x 10^{-5} kg/m.s, k=0.025W/m°C.
   Correlation for flow over sphere: $Nu = 2 + [0.4Re^{\frac{1}{2}} + 0.06Re^{\frac{2}{3}}]\, Pr^{0.4}(\mu/\mu_s)^{0.25}$ [6]

5. Hot water is flowing through a steel pipe (inner diameter = 3.5 cm, outer diameter = 4.22 cm, ks = 43 W/m°C) at a velocity of 1.8 m/s. The inlet temperature is 110°C, and the length of the pipe is 15 m. A 2 cm thick layer of insulation (k_c = 0.12W/m°C) covers the pipe. The outside film heat transfer coefficient is 10 W/m^2°C, and ambient temperature is 20°C. Calculate the drop in the temperature of the water over this section of the pipe. Properties of water: ρ = 950kg/m^3, C_p= 4.23kJ/kg, μ = 2.55 x 10^{-4} kg/m.s, k_w = 0.685 W/m°C.
   Correlation for flow through a circular pipe: $Nu = 0.027Re^{0.8}\, Pr^{0.33}(\mu/\mu_s)^{0.14}$ [8]

0.001 kg/m.s

NATIONAL INSTITUTE OF TECHNOLOGY PATNA

MID SEMESTER EXAMINATION, Mar 2025

Session: 2024-25, Even Semester

Program: **DD B.Tech+M.Tech** Batch: **Chem. Tech.** Semester: **4th**

Subject Code: **CH49104** Time: **2 hr**

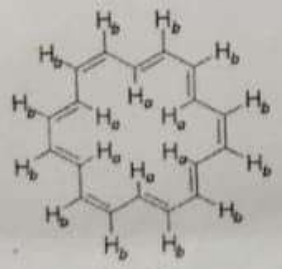
Subject Name: **Principles of Physical Chemistry** Full Marks: **30**

Answer **all** questions. Symbols and abbreviations have their usual meanings.

1. (a) How do the π-π^* and n-π^* bands shift with increasing solvent polarity? Explain with reasons.
(b) What is a CT band? Illustrate with example. How does it differ from the B-band in aromatic compounds?
(c) Using the Jablonski diagram show all the important photophysical processes occurring after photoexcitation of an organic molecule. Why the vibrational relaxation in the S_1 state occurs before the fluorescence or inter-system crossing? [12]

2. (a) Write short notes on (a) Overtone band, (b) Fermi Resonance. [4]
(b) Calculate C–H stretching frequency (in cm^{-1}) using harmonic oscillator approximation. $k = 5 \times 10^{-5}$ N m^{-1}, $c = 3.0 \times 10^{10}$ cm s^{-1}. Now if anharmonicity constant $x_e = 0.0125$ for the same bond, then calculate the stretching frequency, using anharmonic concept, for the fundamental and the first overtone band. [4]

3. (a) Explain elaborately the diamagnetic anisotropy due to aromatic ring current and its effect on chemical shift of aromatic protons. Now explain the following: [6]
(i) Marked difference in δ-value of two different types of protons
(ii) Unlike ethylene protons (δ 4.5-6.5 ppm), the acetelyne protons come around much lower δ of 1.5-2.8 ppm.



(b) What is Larmor precession? Show that the Larmor precessional frequency is equal to the frequency of radiation required for nuclear spin transition in protons. [2]
(c) Explain the theory for splitting of NMR lines. [2]

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