Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SIXTH SEMESTER B.TECH DEGREE EXAMINATION (R), MAY 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT304**

Course Name: **Transport Phenomena**

Max. Marks : **100** **Duration: 3 Hours**

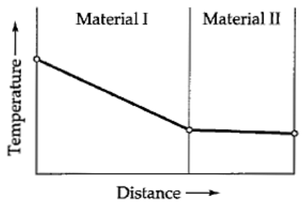
Use of Photostat copies of the following equations duly attested by the concerned faculty shall be permitted in the exam hall.

1. *Tables containing equation of continuity and motion in rectangular, cylindrical and spherical coordinates.*
2. *Tables containing equations of the components of the stress tensor for Newtonian fluids in rectangular, cylindrical and spherical coordinates.*
3. *Tables containing equation of energy in terms of momentum fluxes and transport properties in rectangular, cylindrical and spherical coordinates.*

PART A

(Answer all questions. Each question carries 3 marks)

1. State Newton's law of viscosity and mention its significance.
2. Differentiate between rigid sphere model and rigorous model.
3. Express partial time derivative and total time derivative with suitable examples.
4. Using the equation of continuity in Cartesian coordinates, show that for an incompressible fluid (constant density), $(\nabla.v) = 0$.
5. Explain the steps involved in solving shell energy balance problems.
6. The temperature profile during heat transfer through a laminated system at steady state condition is shown below. Assume material I and II have same thickness. Which material has the higher thermal conductivity? Justify.



7. Calculate D_{AB} for the system CO-CO_2 at 296.1K, $\Omega_{D,AB}$ = 1.067 and 1.0 atm total pressure.

CO	σ_A = 3.590 Å
CO_2	σ_B = 3.996 Å

8. Write a short note on analogies between heat conduction and mass diffusion equation in a steady state flow system.
9. Prove that the sum of the molar diffusion fluxes with relative to the molar average velocity is zero in a binary mixture.
10. Distinguish between homogeneous and heterogeneous reactions. Describe the boundary conditions applied during diffusion with a heterogeneous chemical reaction.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. Compute the viscosities of molecular oxygen, nitrogen, and methane at 20°C and atmospheric pressure, and express the results in mPa.s. (14)
Data: For O_2; σ = 3.433 Å and Ω_μ = 1.086, for N_2: σ = 3.667 Å and Ω_μ = 1.044, for CH_4: σ = 3.780 Å and Ω_μ = 1.197.

OR

12. a) Compute the thermal conductivity of argon at 100°C and atmospheric pressure, using the Chapman-Enskog theory and the Lennard-Jones constants derived from viscosity data. Data: σ = 3.43 Å and Ω_k = 1.044. (10)
b) Compute the thermal conductivities of NO at 300K and atmospheric pressure. Data: $\mu = 1929\times10^{7}$ g/cm.s and C_p = 7.15 cal/g . mol. K. (4)

MODULE II

13. Derive expressions for the momentum flux distribution, velocity distribution and maximum velocity of fluid flowing through an annulus. Also sketch the velocity profiles and the shear stress distribution. (14)

OR

14. Using shell momentum balance, derive expressions for the velocity distribution and momentum flux of two immiscible liquids A and B flowing between two parallel horizontal plates of length L and width W. The channel is half-filled with a more viscous dense fluid A and a less viscous light fluid B. The effect of gravity may be neglected, so that the pressure is essentially only a function of the horizontal distance, x. (14)

MODULE III

15. Derive expressions for maximum temperature rise, average temperature and heat flow during conduction in a cylinder of length 'L' and radius 'R' with electrical heat source. (14)

OR

16. Determine the temperature distribution in an incompressible liquid confined between two coaxial cylinders, the outer one of which is rotating at a steady angular velocity Ω. (14)
The temperatures of the inner and outer surfaces of the annular region are maintained at T_k, and T_1, respectively, with T_k not equal to T_1. Assume steady laminar flow, and neglect the temperature dependence of the physical properties.

MODULE IV

17. a) Write short note on diffusive mass and molar flux vectors. Also estimate the diffusivity for a dilute aqueous solution of acetic acid at 12.5°C, using the Wilke-Chang equation. The density of pure acetic acid is 0.937 g/cm^3 at its boiling point. Data: Ψ_B = 2.6 and μ = 1.2 cp. (10)
b) The diffusivity of a dilute aqueous solution of methanol at 15°C is about 1.28×10^{-5} cm/s. Estimate the diffusivity for the same solution at 100°C. Data: μ at T_1 = 1.14 cp and μ at T_2 = 0.2821 cp. (4)

OR

18. a) Derive the rigid sphere model for the estimation of diffusivity of gases with temperature and pressure. List the assumptions used. (10)

b) Why do we use both mass and molar units in the description of diffusing systems? Write Fick's law in both system of units. (4)

MODULE V

19. Derive an expression for the rate of mass transfer at the liquid-gas interface during the steady-state diffusion of 'A' through stagnant 'B' with the liquid-vapor interface maintained at a fixed position. (14)

OR

20. Gas 'A' dissolves in liquid 'B' in a beaker and diffuses isothermally into the liquid phase. As it diffuses, A also undergoes an irreversible first-order homogeneous reaction as given below. (14)

$$A + B \rightarrow AB$$

Derive expressions for the average concentration of 'A' and molar flux of 'A'.

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