EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2016

MODEL QUESTION

13.801 TRANSPORT PHENOMENA (H)

Time: 3 Hours Maximum Marks: 100

PART A

Answer **all** questions. **Each** carries **2** marks.

1. List the different Non-Newtonian models for fluids. Explain the behavior of power law fluids and represent it schematically.

2. Give the significance of the Lennard Jones potential energy function and give the significance of its parameters.

3. Compute the mean molecular velocity and mean free path in O_2 at 1 atm and 273.2 K. Assume molecular diameter as 3 ^{0}A. Calculate the ratio of the mean free path to the molecular diameter in this situation?

4. Give the significance of Partial derivate, total derivative and substantial derivative with respect to the dependent variable as concentration

5. Use appropriate assumptions and deduce the differential equation to obtain the velocity profile in a fluid confined in the annular region between two rotating cylinders from the Navier Stoke's equation. If the radius of the inner cylinder is kR and that of the outer cylinder is R and the angular velocity of inner and outer cylinders are respectively Ω_i and $\Omega_{0,}$ write the relevant boundary conditions also.

6. Write Eucken's formula and give its significance

7. Give the physical significance of Brinkman number. Write and explain the applicability of the equation.

8. Discuss the different types of velocities and fluxes in a multi-component mixture.

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10. A gas A reacts on the surface of a solid catalyst B and undergoes a reaction to produce gaseous products C and D. The reaction is $$A(s)+B(s)\rightarrow 3C(g)+2D(g)$$. Deduce the expression to find out the molar flux of A on the catalyst surface

(10x2=20 Marks)

PART B

Answer any ONE full question from each module. Each full question carries 20 Marks.

MODULE I

11(a) Derive the expression for the viscosity of low density gases using rigid sphere model citing all the assumptions

b. Writing a shell momentum balance, derive the expressions for the velocity distribution in a Newtonian fluid falling under laminar flow as a film along the surface of a wall inclined at an angle β degree with the vertical and hence obtain expressions for the average velocity, maximum velocity, the force exerted on the walls and the film thickness. (8+12 = 20 Marks)

12. A Bingham fluid is flowing vertically downwards as a result of pressure gradient and/or gravitational acceleration, through a cylindrical pipe of radius 'R' and length 'L'. Develop an expression for the volumetric flow rate Q that is known as Buckingham-Reiner equation. Discuss the result. (20 Marks)

MODULE II

13. An incompressible Newtonian fluid flows under the influence of pressure gradient in between a slit formed by two vertical plates. Using Navier-Stoke's equation and derive the expression for the shear stress and velocity distribution of the fluid in the flow domain. The equations that you derive should match with the coordinates indicated in the sketch.. Also obtain the expressions for maximum velocity, average velocity and flow rate. (20 marks)

14. Deduce from Navier Stoke's equation the expressions for the velocity and shear stress distribution in a viscous fluid confined in the annular region of a rotating cylinder assembly of two coaxial cylinders of which the inner one is rotating at an angular velocity Ωi and the outer cylinder is stationary. The outer radius of the inner cylinder is *k*R and the inner radius of the outer cylinder is R. Also sketch the velocity distribution within the domain considered. Also derive the expression for the torque required to t urn the inner cylinder. (20 Marks)

MODULE III

15(a) A large body of stagnant oil contains a heated spherical ball of diameter 'D' fixed in the centre. The temperature at the surface of the sphere is T_s and the bulk liquid temperature is T_a. Steady state conditions can be assumed. Using a shell balance, develop the expression of the temperature distribution in the liquid. Prove that the Nusselt number is a constant and identify the constant. (10 marks)

(b) Heat flows by natural convection through the medium of air held between two parallel plates, of which one is heated to a temperature T_2 and the other cooled to a temperature T_1. Using a shell balance or starting from the general appropriate conservation equation, obtain the expression for the temperature distribution in the air. State the assumptions used. (10 marks)

16. An electrically heated copper wire has a radius of 2 mm and a length of 5 m. Determine the voltage drop required to maintain a temperature rise of 10 ^{0}C at the wire axis if the surface temperature of the wire is 20 ^{0}C. Also derive the equations that you use to solve the problem. For copper, the Lorenze number at the surface temperature is given as 2.23 x 10^{-8} $volt^2$. K^2 (20 Marks)

MODULE IV

17. A gas A dissolves and diffuses in a liquid B kept in a container. During its dissolution, the gas undergoes a first order irreversible reaction to form another product C. Using suitable assumption, geometry and appropriate boundary conditions applicable to the problem, obtain the expression for the concentration profile and the average concentration of the gas A in the liquid. Further obtain the molar flux of the gas at the gas-liquid interface. Also sketch the concentration profile of gas A in the liquid. (20 Marks)

18. A liquid droplet A of radius r_1 is evaporating into an isothermal film of gas B surrounding the liquid. The outer surface of the gas film is at a distance r_2 from the centre of the liquid droplet. Assume that the concentration of A in terms of molefraction of A at the liquid-gas interface and at the outer surface of the gas film are constant at x_{A1} and x_{A2} respectively. Assume that gas B does not dissolve in the liquid. Using a shell balance approach, obtain the concentration profile of A in the gas film, the molar flux of A at the liquid-vapour interface and the rate of evaporation of liquid. (20 Marks)

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