

JAWAHARLAL NEHRU TECHNOLOGY UNIVERSITY, HYDERABAD
M .Tech. II Semester Supplementary Examinations, March – 2009

ADVANCED TRANSPORT PHENOMENA

(Chemical Engineering)

Time: 3 hours

Max. Marks.60

Answer any Five questions
All questions carry equal marks

- 1.a) What are the models available to describe the non-Newtonian fluids? Explain with examples.
- b) A fluid is contained between two infinite parallel horizontal plates separated by a distance 'h'. Making a momentum balance for a shell of finite thickness, obtain the velocity profile and average velocity when the top plate is moving with a velocity 'V' and the lower plate is stationary.
- 2.a) Explain the significance of geometric and dynamic similarities in dimensional analysis.
- b) Experiments with a small scale agitated tank are to be used to design a geometrically similar installation with linear dimensions 10 times as large. The fluid in the large tank with a heavy oil with viscosity = 13.5 cp and density 0.98 gm/cu. The large tank is to have an impeller speed of 120 rpm. Determine the impeller speed for the small scale model.
- 3.a) For the following stream function determine the velocity potential

$$\psi = (312)(x^2 - y^2)$$
- b) Assuming that the velocity distribution for flow of fluid over a plate is given by $v_x = a + by + cy^2$, where y is the distance from the plate, determine the thickness of the boundary layer, displacement thickness and momentum thickness.
- 4.a) A solid sphere of substance 'A' is suspended in liquid 'B' in which it is slightly soluble and with which it undergoes a first order chemical reaction with rate constant 'K'. At steady state the diffusion is exactly balanced by the chemical reaction. Derive the expression for concentration profile $\frac{C_A}{C_{A0}}$ in terms of R the radius of sphere where C_{A0} is molar solubility of A in B.
- b) Gas A is diffusing in the positive z directions at steady state through a stagnant film of thickness ' δ ' which contains non moving gases B and C. The average mole fraction of gases in the film on an A free basis is x_{B_0} . The system is isothermal. Obtain the Stefan-Maxwell equations for B and C.
5. A rotational viscometer consists of two concentric cylinders, outer one is stationary and the inner one rotates with an angular velocity Ω under known torque T. The gap between the two cylinders is filled with a Newtonian fluid (μ). The radius of the outer & inner cylinders are r_1, r_2 respectively. Derive an equation relating viscosity μ with angular velocity Ω , Torque T, dimensions of cylinder.

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6. A Newtonian fluid flows through a circular pipe in laminar flow and is heated by supplying heat at constant heat flux 'q' at the pipe surface. Prove that the limiting nussett number is 48/11, starting from the equation of energy. State all the assumptions made clearly.
- 7.a) A copper plate of 2 mm thick is heated upto 400 °C and then quenched into water at 25 °C. Find the time required for the plate to reach the temperature of 50 °C. Assume lumped parameter sytem.
Data: h = 80 kcal/m²h⁰C; Plate dimensions = 25 cm × 25 cm Properties of copper; c_p= 0.09 kcal1kg⁰C; ρ = 8800 kg/m³. Derive the equation used from energy balance.
- b) A heavy oil with a kinematic viscosity of 4×10⁻⁴ m² /sec is at rest in a long vertical tube with a radius of 1 cm. The fluid is suddenly allowed to flow from the bottom of the tube by virtue of gravity find the time when the velocity of the oil at the centre of tube attains 25% of its final value.
- 8.a) For the turbulent flow in smooth circular tube the curve fit equation is
- $$\frac{V_z}{V_{z,\max}} = \left(1 - \frac{r}{R}\right)^{\frac{1}{n}}$$
- Show that the ratio of average to maximum velocity is $\frac{V_{z,\text{avg}}}{V_{z,\max}} = \frac{2n^2}{(n+1)(2n+1)}$
- b) Derive the time smoothed equation for mass transfer in turbulent flow in a binary system.
