Qualify Exam.

Transport Phenomena (Closed Book)

Make assumptions and clearly show all your work including the governing equations and the conditions.

1. (12 pts)
   (a) In a flowing fluid can Dc/Dt be zero when $\partial c/\partial t$ is nonzero? Explain.
   (b) What is the equation of continuity for an incompressible fluid?

2. (18 pts)
   Two immiscible liquid films (a & b with density ρ_a & ρ_b and viscosity μ_a & μ_b; $\rho_a > \rho_b$) flow down an inclined smooth plane (which is at an angle θ to the vertical) under the influence of gravity. Neglect the end-effect and assume that the flow is unidirectional and the film thickness are h_a and h_b.
   Obtain the governing equations and boundary conditions for both liquid films.

3. (20 pts)
   A stormer viscometer consists essentially of two concentric cylinders (length L), the inner (radius KR) of which rotates while the outer (radius R) is held stationary. Viscosity is determined by measuring the rate of rotation of the inner cylinder under the application of a known torque (T).
   Develop an expression for the velocity distribution in this kind of apparatus, as a function of applied torque, for laminar flow of a Newtonian fluid.

4. (25 pts)

A cold liquid film flowing down a vertical or inclined solid wall, as shown in Fig. 1, has a considerable cooling effect on the solid surface. The contact time between the fluid and the wall is so short that the fluid temperature changes appreciably only in the immediately vicinity of the wall. Find the steady state temperature profile T(y, z) within the flowing film.

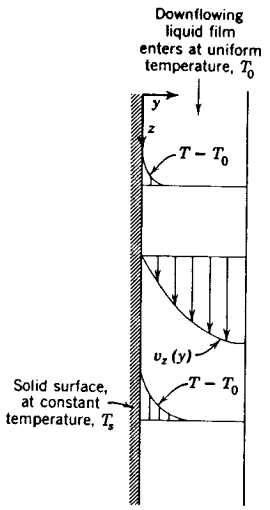

Fig. 1 Heat transfer to a falling liquid film.

5. (25 pts)

As shown in Fig. 2, a chemical species A diffuses from a gas phase into a porous catalyst sphere of radius R in which it is converted into species B. The concentration of A at the surface of the sphere is C_{AS}. The rate at which A is consumed per unit volume of the sphere is $r_A = -k\,a\,C_A$, where k is the first-order reaction rate constant and a is the available catalytic surface per unit volume of the sphere. Find the steady-state concentration distribution of A in the sphere. The effective diffusion concentration of A in the sphere is D_A. Assume constant properties and constant T, P.

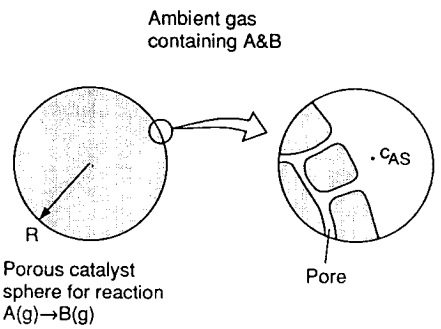

Fig. 2 Diffusion and chemical reaction in a porous catalyst sphere.