國立雲林科技大學
九十二學年度研究所博士班招生考試試題
所別：化學工程系
科目：化工原理

1. Consider the steady pressure-driven flow of an incompressible non-Newtonian fluid in a horizontal circular pipe of radius a and length L (Fig. 1). Assume the fluid viscosity is given by the power law model, i.e. the shear stress τ_{rz} is given by

$$\tau_{rz} = -\kappa \dot{\gamma}^n \quad \text{and} \quad \dot{\gamma} = \left| \frac{dv_z}{dr} \right|$$

where κ is consistency index and n is the power law index. Note that n=1 corresponds to a Newtonian fluid.

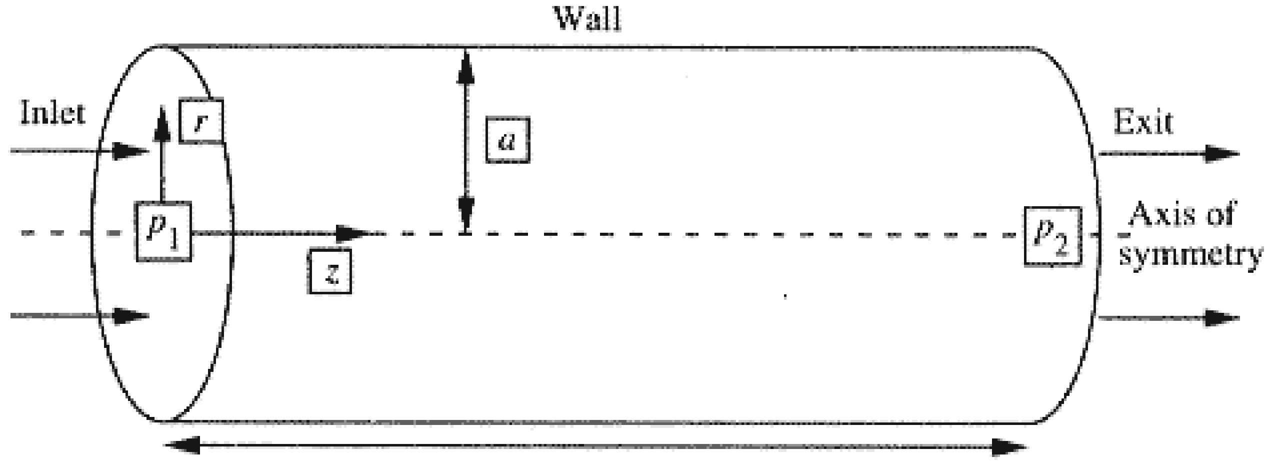

Fig. 1

(a) If the end effect is negligible, showing the momentum balance equation for this flow. (5%)

(b) To show the corresponding boundary conditions if the fluid no slip at the wall. (5%)

(c) If n=1, please show the velocity profile. (5%)

2. (10%) Consider the laminar flow parallel to a flat surface (Fig. 2).

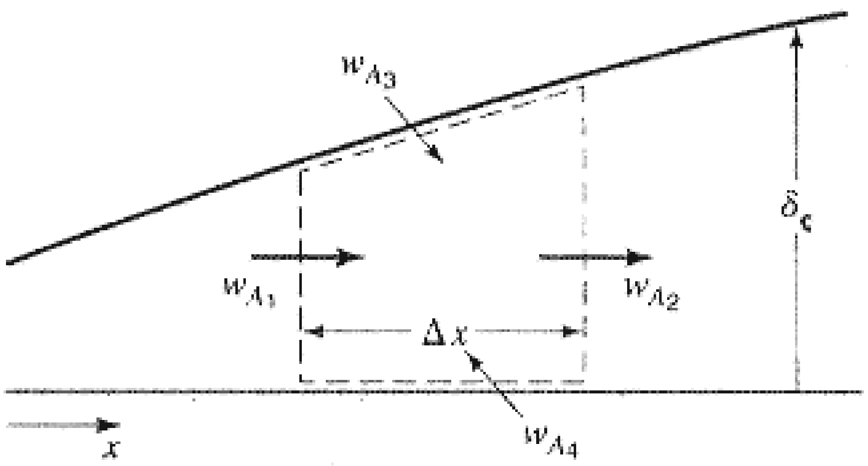

Fig. 2

where δ_c is the thickness of the concentration boundary layer. The steady-state molar mass balance is shown as

$$W_{A_1} + W_{A_3} + W_{A_4} = W_{A_2}$$

where W_A is the molar rate of mass transfer of component A, and

$$W_{A_1} = \int_0^{\delta_c} c_A v_x \, dy \bigg|_x$$

$$W_{A_2} = \int_0^{\delta_c} c_A v_x \, dy \bigg|_{x+\Delta x}$$

$$W_{A_3} = c_{A,\infty} \left[\frac{\partial}{\partial x} \int_0^{\delta_c} v_x \, dy \right] \Delta x$$

and

$$W_{A_4} = k_c (c_{A,s} - c_{A,\infty}) \, \Delta x$$

Please derive the integral expression as the approximate analysis of the concentration boundary layer by von Kármán.

3. (12%) Benzylamid is the product obtained from the liquid-phase of ammonia and benzoyl chloride:

$$C_6H_5COCl + 2\,NH_3 \rightarrow C_6H_5CONH_2 + NH_4Cl$$

(a) Taking C_6H_5COCl as your basis of calculation, set up a stoichiometric table for a batch system.

(b) If the initial mixture consisted solely of NH_3 at a concentration of 6 g mol/liter and C_6H_5COCl at a concentration of 2 g mol/liter, calculate the concentrations of NH_3 and C_6H_5COCl when the conversion is 25%.

4. (13%) The mechanism for hydrogen adsorbing as atoms on the surface of the catalyst is

$$H_{2(g)} + 2\,S \leftrightarrow 2\,H \bullet S \qquad (dissociative\ adsorption)$$

where S represents an active (vacant) site, $H \bullet S$ represents that one unit of H is adsorbed on the site S. Derive an equilibrium isotherm equation ($C_{H\bullet S}$ as a function of P_{H2}) for this adsorption.

5. Initially at 300 K and 1 atm pressure, 1mol of an ideal gas undergoes an irreversible isothermal expansion in which its volume is doubled, and the work it performs is 500 J mol^{-1}. What are the values of q, $\triangle$U, $\triangle$H, $\triangle$G and $\triangle$S ? What would q and w be if the expansion occurred reversibly? (17 %)

6. The equilibrium constant for the reaction A + 2B $\rightleftharpoons$ Z is a 0.25 $dm^6\ mol^{-2}$. In a volume of 5 dm^3, what amount of A must be mixed with 4 mol of B to yield 1 mol of Z at equilibrium ? (16 %)

7. Calculate the solubility product and the solubility of AgBr at 25 ℃ on the basis of the following standard electrode potentials: (17 %)

$$AgBr_{(s)} + e^- \longrightarrow Ag_{(s)} + Br^-_{(aq)} \qquad E^0 = 0.0713\ V$$
$$Ag^+_{(aq)} + e^- \longrightarrow Ag_{(s)} \qquad E^0 = -0.7991\ V$$