所別：化學工程與材料工程學系碩士班 不分組 科目：輸送現象與單元操作

1.(25%)

Consider the velocity profile for laminar flow over a flat plate to be of the form

$$\frac{v_x}{v_\infty} = c_0 + c_1\left(\frac{y}{\delta}\right) + c_2\left(\frac{y}{\delta}\right)^2 + c_3\left(\frac{y}{\delta}\right)^3.$$

(a). (15%) Apply proper boundary conditions to obtain an expression for the velocity profile v_x in terms of the velocity boundary-layer thickness δ and the free stream velocity v_∞.

(b). (10%) The velocity boundary-layer thickness of this system is known as $\delta = 5\sqrt{\mu x/\rho v_\infty}$.

Obtain an expression for the friction coefficient $C_f = 2\tau|_{y=0}/\rho v_\infty^2$. Expressing your result in terms of the local Reynolds number Re_x.

2. (25%)

Two large flat porous horizontal plates are separated by a relatively small distance L. The upper plate at y = L is at temperature T_L, and the lower one at y = 0 is to be maintained at a lower temperature T_0. To reduce the amount of heat that must be removed from the lower plate, an ideal gas at T_0 is blown upward through both plates at a steady rate. Develop an expression for the temperature distribution and the amount of heat q_0 that must be removed from the cold plate per unit area per unit time as a function of the fluid properties and gas flow rate. Use the abbreviation $\phi = \rho\hat{C}_p v_y L/k$, where the velocity v_y and fluid properties can be assumed constant.

3. (15%)

For the special case of ideal binary mixtures of components A and B, a simple method called Fenske equation is available for calculating the minimum number of plates, N_{min}, in a continuous distillation from the terminal concentrations of bottoms and overhead products, x_B and x_D respectively, and based on the relative volatility of the two components α_{AB}.

(a). (5 %) Define α_{AB} mathematically and all terms you use clearly.

(b). (10%) Derive the Fenske equation and define all terms you use clearly.

注意：背面有試題

4. (10%)

Which statement is definitely FALSE?

(A) Tie lines connect the equilibrium phases of the binodal curve on an equilateral-triangle diagram in extraction,

(B) Tie lines could slope upward from the extract side to the raffinate side of the equilateral-triangle diagram in extraction,

(C) Distillation, extraction, crystallization, evaporation and dialysis are all mass transfer techniques,

(D) The McCabe-Thiele method could only be applied to distillation and gas absorption.

(E) The slope of the stripping line has to be equal to or greater than the slope of the rectifying line in a continuous distillation.

5. (25%)

A "spinning disk" mass transfer device is designed as suggested in Fig. 1. A solid disk rotates about an axis normal to its circular face and is immersed in a large volume of fluid. Except for the motion induced by the rotation of the disk, there is no imposed convective flow in the system. The surface of the disk is coated with a solid film of a material that is soluble in the surrounding fluid. A significant motion is induced by the rotation of the disk, and this motion gives rise to significant convective mass transfer from the disk surface. Studies have shown that the convective mass transfer coefficient is given by

$$k_c = 0.62\, D^{2/3}\, \nu^{-1/6}\, \omega^{1/2} \qquad (1)$$

where k_c = convective mass transfer coefficient, D = diffusion coefficient of the solute in the fluid, ν = kinematic viscosity of the fluid, and ω = rotational speed of the disk. Convert Eq. (1) into a nondimensional format of the form

$$Sh = A\, Re^{n}\, Sc^{m} \qquad (2)$$

(a). (10%) Give the values for the coefficients A, n, and m.

(b). (10%) Define each of the dimensionless groups in terms of the parameters that appear in Eq. (1) and/or the figure.

(c). (5%) Explain what each of the numbers represents.

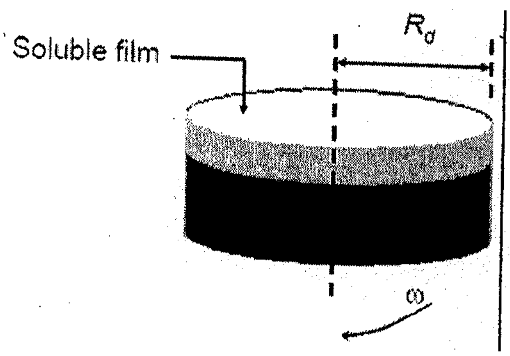

Figure 1 Spinning disk test device.