

## 淡江大學 96 學年度碩士班招生考試試題

系列：化學工程與材料工程學系

科目：輸送現象與單元操作

准帶項目請打「V」

V

簡單型計算機

本試題共 2 頁

1. Answer the following questions: (36%)

- (a) What's the definition of *Reynolds number* used in boundary layer flow? Briefly describe the velocity profile in a boundary layer and the variation of drag coefficient in the flow direction.
- (b) Plot a figure and briefly describe the relationship between friction factor and Reynolds number for a Newtonian fluid flow in a circular tube.
- (c) What is the hydraulic diameter of a concentric tube annulus with inner diameter of  $d_i$  and outer diameter of  $d_o$ ?
- (d) What is the definition of *Nusselt number* for heat transfer? Which dimensionless group used in a mass transfer system can be analogous with Nusselt number?
- (e) When a fluid flows across banks of tubes, what is the log-mean temperature difference,  $\Delta T_{lm}$ ? Express  $\Delta T_{lm}$  using tube surface temperature,  $T_s$ , fluid temperatures at inlet,  $T_i$ , and outlet,  $T_o$ .
- (f) What is the Fick's law of diffusion? Define the parameters used in this law.

2. A single-effect evaporator is concentrating a feed solution of organic colloids from 5 to 50 wt%. The solution has a negligible boiling-point elevation. The heat capacity of the feed is  $c_p=4.06$  kJ/kg·K and the feed enters at 15.6 °C. Saturated steam at 101.32 kPa (saturated temperature=100 °C; heat of evaporation=2257.1 kJ/kg) is available for heating, and the pressure in the vapor space of the evaporator is 15.3 kPa. A total of 4536 kg/h of water is to be evaporated. The overall heat-transfer coefficient is 1988 W/m<sup>2</sup>·K. What is the required surface area in m<sup>2</sup> and the steam consumption? The saturated temperature of steam at 15.3 kPa is 54.3 °C and the heat of evaporation in such a condition is 2372.4 kJ/kg. (22%)

3. Determine the velocity distribution  $v_\theta(r)$  between two coaxial cylinders of radii  $R_i$  and  $R_o$  rotating at angular velocities  $\Omega_i$  and  $\Omega_o$ , respectively. Assume that the space between cylinders is filled with an incompressible Newtonian fluid in laminar flow. (20%)

本試題雙面印製

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4. A solid steel sphere ( $\rho=7832 \text{ kg/m}^3$ ,  $c=559 \text{ J/kg}$ ,  $k=48.8 \text{ W/m}\cdot\text{K}$ ), 300 mm in diameter, is coated with a dielectric material layer of thickness 2 mm and thermal conductivity 0.04 W/m·K. The coated sphere is initially at a uniform temperature of 500 °C and is suddenly quenched in a large oil bath for which  $T_\infty=100 \text{ °C}$  and  $h=3300 \text{ W/m}^2\cdot\text{K}$ . Estimate the time required for the coated sphere temperature to reach 140 °C.

[Hint] Neglect the effect of energy storage in the dielectric material, since the thermal capacitance ( $\rho c V$ ) is small compared to that of steel sphere. (22%)