

國立高雄應用科技大學  
106 學年度研究所碩士班招生考試  
化學工程與材料工程系碩士班  
單元操作及輸送現象

試題 共 2 頁，第 1 頁

- 注意： a.本試題共 5 大題，滿分為 100 分。  
b.作答時不必抄題，務必依序作答。  
c.考生作答前請詳閱答案卷之考生注意事項。  
d.可能會用到的方程式：

(1) Differential equation of mass transfer:  $\bar{\nabla} \cdot \bar{N}_A + \frac{\partial c_A}{\partial t} - R_A = 0$

(2) Fick's law:  $N_{Az} = -cD_{AB} \frac{dy_A}{dz} + y_A(N_{Az} + N_{Bz})$

(3) Chilton-Colburn analogy:  $\frac{h}{\rho v_{\infty} c_p} \text{Pr}^{2/3} = \frac{k_c}{v_{\infty}} \text{Sc}^{2/3} = \frac{C_f}{2} \quad (j_D = j_H = \frac{C_f}{2})$

(4)  $f_f = -3.6 \log \left[ \frac{6.9}{\text{Re}} + \left( \frac{e}{3.7D} \right)^{10/9} \right] \quad (4 \times 10^4 \leq \text{Re} \leq 10^8 \text{ and } 0 \leq e/D \leq 0.05)$

1. Briefly answer the following questions. (40%)

- (1) 有一含有二氧化矽粒子的酒精懸浮液，欲分離二氧化矽粒子與酒精，可以選擇那幾種單元操作？(6%)
- (2) 動量傳送(momentum transfer)的驅動力為何？(3%)
- (3) 欲估計對流熱傳速率可以使用牛頓冷卻定律(Newton's law of cooling)，請寫出牛頓冷卻定律方程式，說明方程式中每一項符號代表的物理量與單位。(4%)
- (4) 說明熱交換器對數平均溫度差(logarithmic mean temperature difference)之定義。(6%)
- (5) List the driving forces for natural convective mass transfer process. (6%)
- (6) List the types of heat exchangers. (6%)
- (7) Explain the physical meaning of the following dimensionless groups. (9%)
  - (a) Reynolds number
  - (b) Nusselt number
  - (c) Sherwood number

【下頁尚有試題】

2. 某種 Non-Newtonian fluid 以層流(laminar flow)流經一半徑為  $R$  且長度為  $L$  的圓管，流動方向為  $z$  方向。該流體剪應力和剪應速率之關係可表示為

$$\tau_{rz} = K \left( \frac{dv_z}{dr} \right)^2。若忽略入口效應，根據 shell momentum balance，可推導出$$

$$\text{governing equation: } -r \frac{dP}{dz} + \frac{d}{dr}(r\tau_{rz}) = 0 \quad \text{亦即} \quad \frac{d}{dr}(r\tau_{rz}) = \left( \frac{dP}{dz} \right) r。$$

- (1) 寫出推導管內流體速度分布(velocity profile)需要之邊界條件。(4%)
  - (2) 根據 governing equation，推導出速度分布方程式。(8%)
  - (3) 推導出計算最大流速的方程式。(3%)
3. A well-stirred storage vessel contains 1000 kg of brine containing 5% salt by mass. A constant flow rate of 10 kg/min of salt solution consisting of 20% salt is suddenly introduced into the tank and a constant withdrawal rate of 10 kg/min is also started. These two flows remain constant thereafter. Answer the following questions.
- (1) Determine the total mass of brine after 30 min. (5%)
  - (2) Derive the equation relating the mass of salt in the tank as a function of time. (8%)
  - (3) Calculate the mass of salt in the tank after 100 min. (2%)
4. A 0.10 m-thick-brick wall with a thermal conductivity of 1.5 W/m·K separates the combustion zone of a furnace from its surrounding air at 30°C, with a convective heat transfer coefficient of 10 W/m<sup>2</sup>·K. In addition, inside the furnace the gas is at 300°C, with a convective heat transfer coefficient of 30 W/m<sup>2</sup>·K. The effect of radiation can be neglected.
- (1) What will be the inner and the outer wall surface temperatures at steady state? (10%)
  - (2) If you would like to add a thermal insulation layer (asbestos, 石棉) on the outer wall for reducing the heat flux to 400 W/m<sup>2</sup>, please calculate the thickness of asbestos required. The thermal conductivity of asbestos can be taken as 0.1 W/m·K. (5%)
5. 有一片長效型藥布可釋放水溶性蛋白質表皮生長因子(hEGF)，用於治療皮膚創傷。藥布與皮膚接觸的界面是一層藥物擴散層，擴散層以介孔性高分子材料作為介質，材料孔隙中充填水。當 hEGF (A 成分)從藥物負載層進入擴散層時，先溶解於水(B 成分)，再從材料孔隙擴散至皮膚表面，hEGF 擴散至皮膚表面時，幾乎立即被細胞吸收。在 37°C 之下，hEGF 在水中的溶解度為 1.0 mole/m<sup>3</sup> (相當於負載層與擴散層界面間之 hEGF 濃度)，hEGF 在孔隙材料的有效擴散係數( $D_{AB}$ )為  $2.85 \times 10^{-11}$  m<sup>2</sup>/s，藥布與皮膚接觸的面積有 4 cm<sup>2</sup>，但是能夠釋放藥物的微孔隙截面積僅佔藥布面積之 25%。藥布設計目標為每一天 hEGF 的釋放量至少達到 0.5 μmole 以上，請估計介孔性高分子層的厚度不得高於多少公分？(15%)