國立臺灣科技大學 107 學年度碩士班招生試題

系所組別：化學工程系碩士班

科　　目：工程數學與輸送現象

總分 100 分，請依序作答，並詳列計算過程。

1. Solve the Bernoulli differential equation: $xy' + y = 3x^2y^4$ with IC: $y(1)=0.5$. (10%)

2. Solve the initial value problem: $y'' + 9y = f(t)$; $y(0) = 0$, $y'(0) = 1$, where $f(t) = 0$ for $t < 2$ and $f(t) = t$ for $t \geq 2$. (15%)

3. Solve the boundary value problem using the method of separation of variables:
$\nabla^2 u(x, y, z) = 0$ for $0 < x < 1$, $0 < y < 2$, $0 < z < 4$,
$u(0, y, z) = u(1, y, z) = 0$ for $0 < y < 2$, $0 < z < 4$,
$u(x, 0, z) = u(x, 2, z) = 0$ for $0 < x < 1$, $0 < z < 4$,
$u(x, y, 0) = 0$, $u(x, y, 4) = f(x, y) = xy$ for $0 < x < 1$, $0 < y < 2$ (17%)

4. Write the function value in the form $a + b\,i$ for $\sqrt[3]{2i}$. (8%)

5. Laminar flow of water goes through a tube of inner diameter 0.25 cm, the maximum velocity (u_{max}) is 1.2 cm s^{-1}. Calculate the shear stress on the tube wall. The water viscosity at room temperature is 0.01 poise (g cm^{-1} s^{-1}), and the velocity profile of laminar flow is parabolic; expressed as $u_x = u_{max}[1-(r/R)^2]$, with R: tube radius; r: radial position; u_x: water velocity at position r. (10%)

6. One way to separate the uranium isotope (鈾同位素)is to take advantage of the mass difference between $U^{235}F_6$ and $U^{238}F_6$ which diffuse through a porous membrane with different Knudsen diffusivity (D_{KA}) at elevated temperatures. Please estimate the ratio of Knudsen diffusivity $D_{KA\text{-}U235F6}/D_{KA\text{-}U238F6}$. (10%)

Molecular weight of $U^{235}F_6$ is 349.028, that of $U^{238}F_6$ is 352.038, and

$D_{KA} = 97.0\bar{r}\sqrt{\frac{T}{M_A}}$ T : temperature in K; M_A : molecular weight of species A; $\bar{r}$: pore radius in m.

7. Select the most appropriate answer to the following questions (one choice only), explain your choice. Engineers have designed a short flow manifold, as shown in Figure 1, to achieve certain effects on the water flow. The flow manifold is featured with a large pipe (diameter 8 in.) filled with many straws (5-6 mm in diameter, 15-20 cm in length). We connect the manifold at the end of pipe and allow water flow through; (5%)

(A) The flow type changes from laminar into turbulent flow, the pressure drop decreases.
(B) The flow type changes from turbulent into laminar flow, the pressure drop decreases.
(C) The flow type changes from laminar into turbulent flow, the pressure drop increases.
(D) The flow type changes from turbulent into laminar flow, the pressure drop increases.

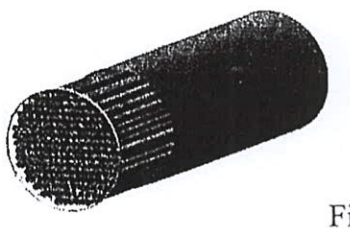

Figure 1. Laminar flow manifold

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8.A heat exchanger of one shell pass and two tube passes is designed to warm up the cold water flow 12.6 kg s^{-1} from 15.5 to 46.5 °C, while the hot water enters at 98.5 °C and leaves at 49.0 °C, calculate (A) ΔT_{lm} and ΔT_m; (B) the required inside heat transfer area of the heat exchanger (m^2). The specific heat of water is 4180 J kg^{-1} K^{-1}, overall heat-transfer coefficient based on inside surface area U_i is 3500 W m^{-2} K^{-1} (A:10% ; B:5%) (15%)

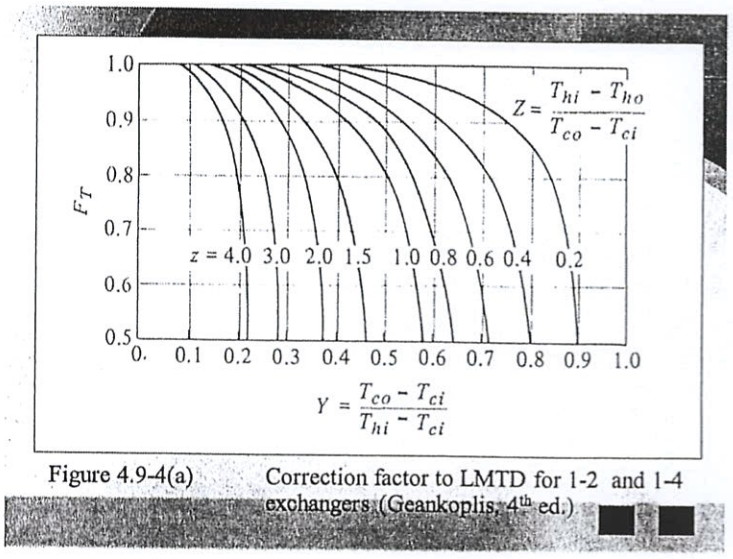

Figure 4.9-4(a) Correction factor to LMTD for 1-2 and 1-4 exchangers (Geankoplis, 4th ed.)

Figure 2 Correction factor F_T.

$$q = U_i A_i \Delta T_m$$

$$\Delta T_m = F_T \Delta T_{lm}$$

$$\Delta T_{lm} = \frac{(T_{hi} - T_{co}) - (T_{ho} - T_{ci})}{\ln[(T_{hi} - T_{co})/(T_{ho} - T_{ci})]}$$

9.A binary mixture of A and B, 100 kg mol in total, containing 55 mol% A and 45 mol% B, undergoes equilibrium (or flash) distillation, and 58 kg mol is distilled. Estimate the molar fraction of A in the vapor (y_A) and in the liquid (x_A). Relative volatility (α_{AB}) is 2.86.

$$\alpha_{AB} = \frac{y_A / x_A}{y_B / x_B} = \frac{y_A / x_A}{(1 - y_A)/(1 - x_A)}$$ (10%)