中原大學104學年度碩士班考試入學

104/3/4　8:00 AM~9:30 AM

誠實是我們珍視的美德，
我們喜愛「拒絕作弊，堅守正直」的你！

化學工程學系

科目：輸送現象及單元操作　　　　（共3頁，第1頁）

☑可使用計算機(僅限於四則運算、三角函數及對數等基本功能，可程式之功能不可使用)
☐不可使用計算機

Problem 1 (15%)

Please explain the following terms:

(a) porosity　　(b) Newtonian fluid　　(c) venturi meter

(d) Henry's law　　(e) Schmidt number

Problem 2 (15%)

A centrifugal fan is to be used to take a flue gas (density=1.4 kg/m^3) at rest (zero velocity) and at a pressure of 750 mm Hg and discharge this gas at a pressure of 800 mm Hg and a velocity of 30 m/s. The volumetric flow rate of gas is 55 m^3/min. Calculate the power of the fan if its efficiency is 65%. Assume incompressible turbulent flow and no friction loss.

Problem 3 (20%)

Water (ρ =1000 kg/m^3, μ =1 cp) is flowing from a tank with either a vertical or a horizontal outlet capillary tube, shown as **Figure 1**. In both cases the capillary tube has a diameter of 2 mm and a length of 0.3 m. The liquid head in the tank, *H*, remains constant at *H*=0.5 m. The tank is a cylinder with a diameter of 0.4 m. Please find the ratio of the volumetric flow rates for the two systems.

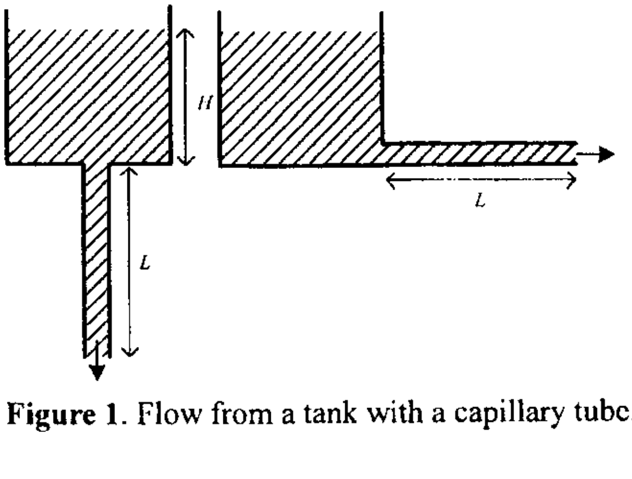

Figure 1. Flow from a tank with a capillary tube.

Problem 4 (18%)

An aqueous solution at 25℃ and a rate of 0.3 kg/sec enters a thin-wall tube which has a surface temperature of 100 ℃ maintained by condensing a saturated steam. If the tube has a surface area of 0.35 m^2 and the heat transfer coefficient, h, from the tube wall to the solution is 600 W/m^2.K，estimate

(a) the outlet temperature of aqueous solution,　(10 %)

(b) the amount of steam required in kg/hr.　(8 %)

Data: Heat capacity , c_p, of the aqueous solution is 4.18 x 10^3 J/kg.°C

Latent heat of condensation of steam at 100℃ is 2.10 x10^6 J/kg

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科目：輸送現象及單元操作　　　　（共 3 頁，第 2 頁）

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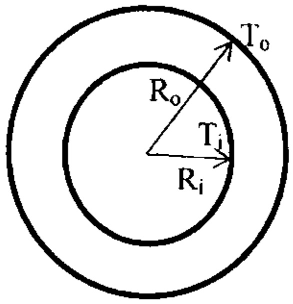
Problem 5 (12%)

A spherical (球形) shell with inner radius R_i and outer radius R_o is made of a material with a thermal conductivity of $k=a+bT$, where a and b are constants, and T is temperature. Derive an expression for the steady heat transfer rate when the inner surface temperature is kept T_i and outer surface temperature T_o.

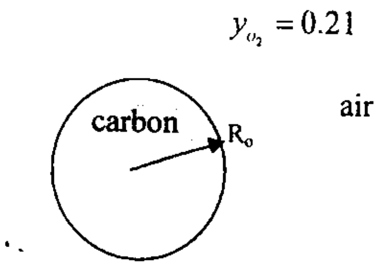


Problem 6 (20%)

Consider a carbon sphere of radius R_o is fed into a hot combustion chamber(燃燒室) and oxidized by oxygen as:

$$6\,C + 5\,O_2 \rightarrow 4CO_2 + 2\,CO$$

The molar fraction of oxygen in the bulk gas of the chamber is 0.21 and the oxidized reaction is assumed to be instantaneous. How long will it take for the sphere to disappear. Express your result in terms of ρ_c(density of the sphere), D_{AB}(diffusivity of oxygen in air), M_c(molecular weight of carbon), R_o and other pertinent quantities.



**Units and conversion factors may be used in calculation:

Viscosity: $1\text{cp}=1\times10^{-3}$ kg/m.sec

Energy, Power: 1W=1 J/sec=1 N.m/sec

Force: 1 N=1 kg.m/s^2

Gravitational acceleration: 1 g=9.8 m/s^2

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**The equations that may be used in calculation:

(1) Stoke's law: $F_D = 3\pi\mu v d_p$

(2) Hagen-Poiseuille equation: $Q = \dfrac{\pi R^4 \Delta P}{8\mu L}$

(3) Mechanical-energy-balance equation: $\dfrac{1}{2\alpha}\left(v_2^{\,2} - v_1^{\,2}\right) + g\left(z_2 - z_1\right) + \int_{P_1}^{P_2} \dfrac{dP}{\rho} + W_S + \sum F = 0$

(4) Friction loss in a pipe: $\sum F = 4 f_F \dfrac{L}{D}\dfrac{v^2}{2}$

(5) Ergun equation: $\Delta P = 150 \dfrac{\mu v L}{d_p^2}\dfrac{(1-\varepsilon)^2}{\varepsilon^3} + 1.75 \dfrac{\rho_f v^2 L}{d_p}\dfrac{(1-\varepsilon)}{\varepsilon^3}$