國立中央大學九十學年度碩士班研究生入學試題卷

所別：化學工程與材料工程系　科目：輸送現象與單元操作　共 2 頁 第 1 頁

1. (5%)
   Write the definition of Reynolds number and explain its physical meaning.
2. (25%)
   Find the velocity profile and the average velocity of the isothermal flow of a power-law fluid through a circular pipe of radius R and length L. (If you don't know how to handle this problem for a power-law fluid, solve this problem for a Newtonian fluid instead. However you will only get partial points for solving Newtonian flow.)

3. (20%) A plane wall of thickness L and the thermal conductivity k having uniform volummetric heat generation of $\dot{q}$ is insulated on one side, while the other side is exposed to a fluid at T_∞. The convection heat transfer coeffieient between the wall and the fluid is h.

(a) Determine the outer surface temperature T_s. (5%)

(b) Write the conservation equation and boundary conditions for this system, and solve this equation to obtain the temperature distribution T(x). (15%)

4. (15%) The friction coefficient for turbulent flow over a plate is

$C_{f,x} = 0.0592 \mathrm{Re}_x^{-1/5}$

Estimate the local Nusselt number and Sherwood number by using
(a) the Reynolds analogy; (5%)
(b) the modified Reynolds analogy (Colburn analogy). (10%)

5. Control of Organism Growth (20%)
As a consequence of a search for intelligent life in bio-lab at the National Central University, a small spherical organism is discovered. It has a respiration (呼吸) rate of R_A = 7 g O_2/L-h, and this respiration rate appears to be independent of external oxygen concentration in the surrounding air. Controlled tests indicate that the organism will not reproduce as long as an organ located at the center of the organism is exposed to a concentration of oxygen $C(r=0)$ below $C_R = 10^{-7}$ mol/cm^3. Assume that the diffusion coefficient of O_2 through the organism is $D = 10^{-5}$ cm^2/s. The organism has a radius of R = 100 μm (10^{-2} cm).
(a)Write the diffusion equation and obtain the concentration profile. (10%)
(b)What surface concentration of oxygen (exterior to the organism) must be maintained to permit reproduction? Give your answer in units of atmospheres of oxygen (i.e., as a partial pressure). (10%)
[Hint] (i) We know that at 25°C the solubility of oxygen in water that is in equilibrium with normal air with 21% oxygen is $C = 2.7\times10^{-7}$ mol/cm^3. (ii) The Henry's law is $p = HC$.

注意：背面有試題

6. A Steady State Convection/Diffusion Problem (15%)

Two gases are initially separated into two bulbs connected by a narrow diameter capillary. Pure N_2 then flows from right to left with a velocity v, as shown in Fig. P6. We wish to know to what degree O_2 can diffuse upstream, against the N_2 flow. The diffusion coefficient of O_2 is D. We assume that the system has achieved some steady state. The domain is the connecting tube $z = [0, L]$. Assume that the volumes at the two ends are so large that each maintains nearly pure, even though some exchange takes place. This will be a good approximation in the early stages of this process, before much N_2 has gone into the left-hand bulb.

(a) Write down the convective-diffusion equation and obtain the concentration profile. (10%)

(b) How large must $\phi = vL/D$ be to obtain $C/C_0 = 0.01$ at $z/L = 0.99$? (5%)

[Hint] $\phi \gg 1$.

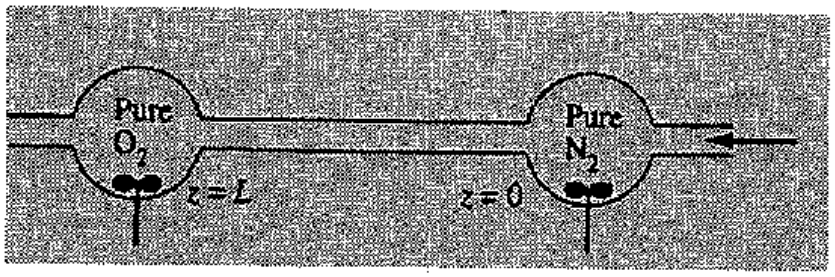

Fig. P6