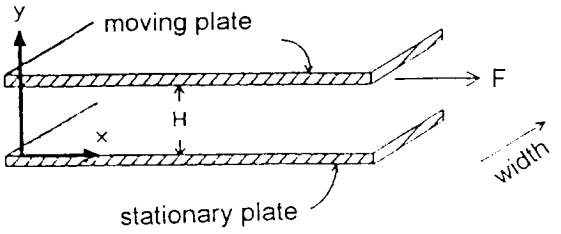
國立中正大學八十五學年度碩士班考試試題

所　別：化學工程研究所　　科　目：輸送現象與單元操作

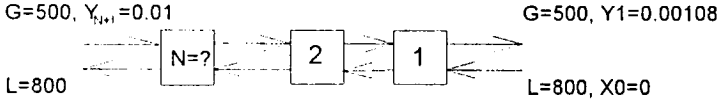
（可攜帶電子計算器）

1. Consider a steady-state flow of an incompressible Newtonian fluid between two horizontal parallel plates separated by a small distance H. The top plate is constantly pulled by a force F and the bottom plate is held stationary.
   (1) Calculate and plot the velocity profile of the fluid; (10 points)
   (2) Calculate the total volumetric flow rate per unit width. (10 points)



2. An air stream contains 0.01 mole fraction of methanol vapor. It is proposed to remove the methanol in consecutive equilibrium stages by absorption into a water stream. The solubility of methanol vapor in water follows the relation Y=1.0X where Y and X are the mole fractions of methanol in the gas phase and the liquid phase, respectively. For simplicity, the total gas-phase flow rate and liquid-phase flow rate can be approximated as constant at 500 moles/hr and 800 moles/hr, respectively.
   (1) what would be the % of methanol removal after two equilibrium stages? (15 points)

   (2) How many stages are required to achieve 89.2% methanol removal? (15points)



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3. A furnace wall is made up of three layers, 10 cm of firebrick (thermal conductivity is 1.6 W/m•K), followed by 20 cm kaolin insulating brick (thermal conductivity is 0.2 W/m•K), and finally 5 cm of masonry brick (thermal conductivity is 0.7 W/m•K). Assume that the temperature of the inner surface, T_1, and the temperature of the surrounding air (far away from the furnace), T_∞, are constant and known. The rate of energy loss per unit area of the outer surface is described by the Newton rate equation

$$\text{heat flux at the outer surface} = h\,(T_s - T_\infty)$$

where T_s is the temperature at the outer surface of masonry brick.

It is assumed that perfect contact is made between adjacent layers; i.e., adjacent surfaces are considered to be at the same temperature.

(a) Obtain the steady temperature profiles in every layers as functions of the coordinate emerging from the inner surface of the wall, x.

(b) Calculate the value of T_s and the heat loss per hour per square meter of the outer surface to the air, if T_1 = 1298 K, T_∞ = 298 K, and h = 35 W/m^2•K.

(c) If the convective heat transfer coefficient can be represented by

$$h = 0.19\,(\Delta T)^{1/3}$$

where $\Delta T = (T_s - T_\infty)$. Please calculate the value of T_s and the rate of heat loss again with T_1 and T_∞ as stated in part (b).

（本大題25分）

4. In a hot combustion chamber, oxygen diffuses through air to a carbon surface where it reacts to make CO_2 as shown in the following figure. The carbon surface is flat. The reaction at the surface may be assumed to be instantaneous (very quick). No reaction occurs in the gas film. The molar fraction at z = 0 is 0.22. If only carbon dioxide is produced at the carbon surface and the rate of oxygen consumption per hour per square meter is 10 moles. The total concentration of the gas phase is c = 4.09 X 10^{-5} mol/cm^3 and the diffusivity of oxygen is $D_{O_2\text{-air}}$ = 1.3 X 10^{-4} cm^2/sec.

(a) Find the thickness of the gas film, δ, and the distribution of CO_2 concentration in the gas film.

(b) Estimate the time that is required to reduce the thickness of the carbon plate from 0.1 m to 0.06 m. The density of carbon plate is 1.2 g/cm^3.

(c) Obtain an expression for relating the mass transfer coefficient and the thickness of the gas film.

(State your assumptions clearly !)

（本大題25分）