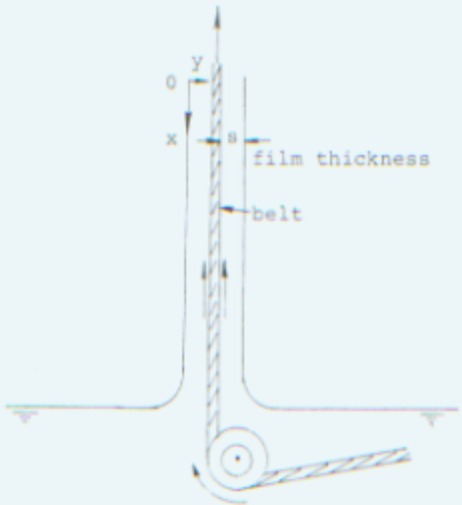
國立中正大學八十七學年度碩士班考試試題

所　別：化學工程學系　　科　目：輸送現象與單元操作

1. State and explain the questions in the following: (16 points)
   (a) Newton's law of viscosity.
   (b) Newton's law of cooling.
   (c) Fourier's law of heat transfer.
   (d) What is the main assumptions of boundary layer theory?
   (e) State the relation between gaseous viscosity and temperature.
   (f) Physical meaning of Prandtl number (Pr).
   (g) Physical meaning of $\nabla \cdot \vec{v}$ ($\vec{v}$ is the fluid velocity).
   (h) Physical meaning of Reynolds number (Re).

2. A belt of conveyer, which is immersed in a viscous Newtonian fluid, is vertically moving upward steadily with a constant velocity v_o (as shown in the figure). Then, a fluid film with thickness (s) is thus accompanied moving upward along with the belt of the conveyer. Assume that the belt is flat with width w. The physical properties of the flowing fluid are assumed to be constants. Please answer the questions in the following. (16 points)
   (b) Using the momentum and mass shell balances, and assumptions, find the governing equation of the flowing fluid in the liquid film.
   (c) List out the necessary boundary conditions, and explain the use of boundary conditions.
   (d) Find the velocity profile of the flowing fluid in the liquid film.
   (e) Find the average velocity of the flowing fluid.



3. A Newtonian fluid flows within a circular heated pipe at steady state. Suppose that the pipe wall provides a constant heat flux to the flowing fluid. Please find the Nusselt number for heat transfer to the fluid from pipe wall at far down stream (far from entrance). A constant velocity v_o within the pipe is assumed. Also, the physical properties of the fluid are assumed to be constants. You can make necessary assumptions in order to solve the problems. (18 points)

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4. Briefly define the following terms and when there is more than one, compare and contrast their general characteristic with those of others in the same groups: (15 points)
(a) crushers, grinders
(b) adiabatic humidification, dehumidification
(c) ideal plates (ideal contact stages).

5. Acetone is being absorbed by water in a countercurrent packed tower having a cross-sectional area of 2 ft^2 (= 0.186 m^2) at 20 °C and 1 atm. The inlet air contains 2.5 mol % acetone and outlet 0.5 mol % acetone. The air flow rate (acetone-free basis) is 30 lb-mol /h. The pure water inlet flow is 100 lb-mol/h. Equilibrium data are given in the following table. Consider the effect of one-way diffusion in the gas film. The effect of absorption heat is neglected. The following equations are available for the mass-transfer coefficients based on mole-fraction differences.

$$k_x a = 0.04\ G_x$$

$$k_y a = 5 \times 10^{-5}\ G_y G_x$$

where G_x and G_y are respectively mass velocities of the liquid and gas streams based on tower cross section, lb/(ft^2 h). The molecular weights of acetone and air are 58 and 28, respectively. Answer the following questions: (23 points)

(a) Calculate the tower height（要求作法正確，數字誤差可接受）.
(b) Describe the structure of a typical packed tower for acetone absorption, including the properties of packing materials, the locations of input and output for liquid and gas streams, and the position where the mass transfer takes place.

Table: Equilibrium data for acetone-water system at 20 °C (293K)

Mole fraction of acetone in liquid, x_A	Partial pressure of acetone in vapor, p_A (atm)
0	0
0.015	0.02
0.03	0.04
0.07	0.083
0.12	0.11
0.17	0.135

6. Component A diffuses through a stagnant film to the catalytic surface where it is instantaneously converted to B by the reaction

$$A \rightarrow 4B$$

B diffuses away from the catalytic surface, back through the stagnant film. The catalyst is considered a flat surface. The thickness of the stagnant film is δ and the mole fraction of A outside the stagnant film is y_{A0}. Determine the rate at which A enters the gas film if this is a steady-state process and evaluate the concentration profile, that is, the distribution of mole fraction of A in the stagnant film. (12 points)