國立中央大學94學年度碩士班考試入學試題卷　共3頁 第1頁

所別：化學工程與材料工程學系碩士班 科目：輸送現象與單元操作

所別：藝術學研究所碩士班　乙組 科目：西洋音樂史

1. Momentum Transfer (25%)

In a gas absorption experiment a viscous fluid with constant viscosity μ and constant density ρ flows upward through a small circular tube and then downward in laminar flow on the outside (Fig. P1).

(a) Find the velocity distribution in the falling film (neglecting end effect).

(b) Obtain an expression for the mass rate of flow in the film.

Note: $d\{-x^2/4 + x^2(\ln x)/2\} / dx = x \ln x$

2. Heat Transfer (25%)

A spherical catalyst pellet has a radius R and a thermal conductivity k (which may be assumed constant). Because of the chemical reaction occurring within the porous pellet, heat is generated at a rate of Q cal/m^3.s. Heat is lost at the outer surface of the pellet to a gas stream at constant temperature T_∞ by convective heat transfer with heat transfer coefficient h. Find the steady-state temperature profile, assuming that Q is constant throughout.

(a) Set up the differential equation by making a shell energy balance.

(b) State the proper boundary conditions and determine the temperature at the outer surface of the sphere.

(c) Integrate the differential equation to get the temperature profile.

(d) To reduce the temperature in the spherical catalyst pellet, what can you do?

3. Unit Operation (25%)

(a) (5%) Which statement is ***FALSE*** on the x-y diagram?

A. For the countercurrent process of gas absorption, the operating line must lie above the equilibrium line in order for absorption to take place.

B. For both the co-current and countercurrent processes of gas absorption, the operating line can intersect with the equilibrium line.

C. For the countercurrent process of gas absorption, the equilibrium line can concave away from the operating line.

D. For the countercurrent process of gas absorption, the operating line can be curved.

E. For the countercurrent process of gas desorption, the operating line could lie above the equilibrium line.

(b) (5%) Which statement is ***FALSE***?

A. On the x-y diagram, the McCabe-Thiele construction method can be started at either end of the distillation column.

B. The definition of the minimum reflux ratio for a distillation column is based on the situation that when either the rectifying line or the stripping line or both lines touch the equilibrium curve on the x-y diagram.

C. The fixed charges for the distillation column first increase and then decrease with reflux ratio.

D. The fixed charges on the reboiler and condenser increase steadily with the reflux ratio.

E. In leaching, the equilibrium line is always straight.

注意：背面有試題

(c) (5%) Which statement is *FALSE*?

A. The falling-rate period of the drying rate curve may decrease linearly with time or may give plots that are concave upward or concave downward.

B. The critical moisture content is a property of the material being dried.

C. The distribution coefficient is the ratio of eth equilibrium concentration of the solute in the extract to that in the raffinate.

D. Neither crystal growth nor formation of nuclei from the solution can occur in a saturated or unsaturated solution.

E. The operating temperature in membrane separation processes is determined by balancing the needs for high flux and high selectivity because an increase in temperature usually increases the membrane selectivity and decreases the membrane permeability.

(d) (5%) Suppose that a feed containing 60 % *A* and 40 % *B* is to be fractionated. The overhead product is to contain 95 % of component *A* and the bottom product is to contain 87 % of component *B*. If 100 mol/h of feed enters the distillation column, determine the quantities of (a) the distillate and (b) bottom products.

Please use the following notations for all your work.

F = total flow rate of the feed, mol/h, B = total flow rate of the bottom product, mol/h, D = total flow rate of the distillate, mol/h.

(e) (5%) Prove that the slope of the operating line in the stripping section of a distillation column is always greater than one on the x-y diagram.

Please use the following notations for all your work.

B = Flow rate of bottoms product, mol/h, L_m = Flow rate of liquid from plate m of stripping column, mol/h, V_{m+1} = Flow rate of vapor from plate m+1 in stripping column, mol/h, y_{m+1} = Mole fraction in vapor from plate m+1 in stripping column, x_m = Mole fraction in liquid from plate m of stripping column, x_B = Mole fraction in liquid in bottoms product.

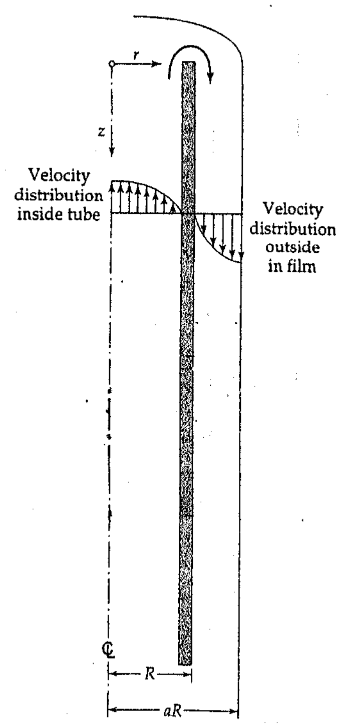

Fig. P1 Velocity distribution for the flow of a falling film on the outside of a circular tube.

4. Unsteady State Mass transfer (25%)

Ants, and some other insects, apparently communicate a wide range of messages (Danger! Food over here! Let's start a family!) by releasing and detecting volatile substances called *pheromones* (費洛蒙) that diffuse from the source insect to the recipients through diffusion and convection. E. O. Wilson, an entomologist (昆蟲學家) at Harvard University, has spent his life studying the behavior of ants. One of his experiments provides an opportunity for us to apply "**limited source**" diffusion theory.

The harvester ant (收穫蟻) communicates danger through an alarm substance, a volatile liquid, secreted from a gland (腺體) in its head. While convection can disperse this substance, in certain circumstances diffusion is the only mechanism of transmittal of the message. Wilson devised a series of experiments for measuring the diffusion coefficient of the alarm pheromone. In one such experiment (see Fig. P4) a group of harvester ants were acclimated to (適應) a tube of inside diameter 2.6 cm and length approximately 1 m. At some initial instant of time a small vial (小玻璃瓶) containing crushed heads of several ants was coupled to one end of the main tube. Sufficient time prior to this had been allowed to permit evaporation of the volatile substance into the small vial. Wilson's observations consisted of the determination of the time t at which the ants at a distance x from the pheromone source began to display behavior characteristic of alarm (running in circles). The following set of data is available:

Time of observation of alarm responses, t(s)	60	360
Distance from source of alarmed, x(cm)	3.16	32.5

To analyze these data, we must begin with the assumption that "alarm" occurs when the ant senses a critical or threshold level of concentration C^*.

(8%) Write down the governing equation and boundary conditions.

(8%) Obtain the concentration profile. [Hint: Fourier transform, $F[c(x,t)]=c'(\omega,t)$]

(4%) Diffusion coefficient D can be expressed in terms of two pairs of (distance, alarm time) measurements.

(3%) Calculate the diffusion coefficient from these data.

[Hint: $F^{-1}[\exp(-a\omega^2)]=\exp(-x^2/4a)/(4\pi a)^{1/2}$; $\int_0^\infty \exp(-x^2)dx=(\pi/4a)^{1/2}$]

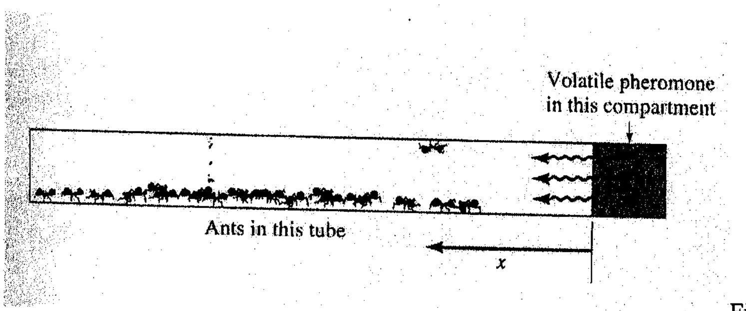

Fig. P4