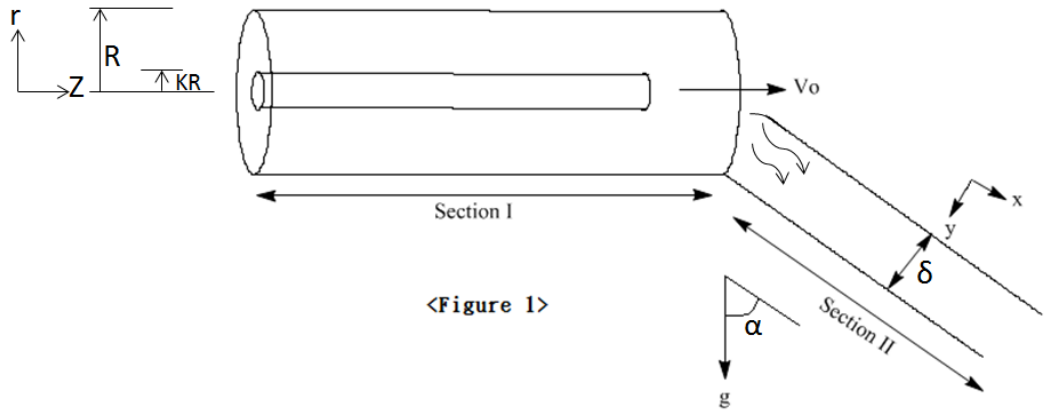
國立高雄大學 102 學年度研究所碩士班招生考試試題

科目：輸送現象與單元操作
考試時間：100 分鐘

系所：化學工程及材料工程學系
（甲組）
本科原始成績：100 分

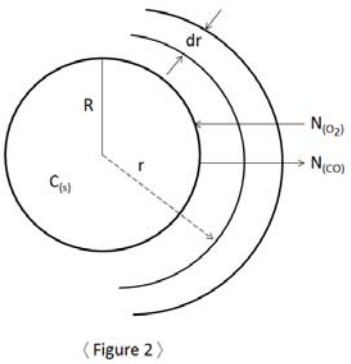
是否使用計算機：是

1. A Newtonian fluid with viscosity μ and density ρ is flowing out of an annular tube and onto a slide as shown in Figure 1. A cylindrical rod of radius κR moves axially with velocity V_o along the axis of a cylindrical cavity of radius R. The pressure at both ends of the cavity is the same, so the fluid flows through the annular region I only because of the rod movement. And, the angle between the slide wall and the direction of gravity is α. (i) Find the velocity distribution in the region I and II, respectively. (ii) What is the relation between V_o and δ? (Note) Assume that the shell balance is available in both regions I and II. Neglect the end effect. **(25%)**



<Figure 1>

2. At steady state, a spherical particle of coal with original radius of R performs a heterogeneous reaction in air atmosphere at 1 atm as shown in Figure 2: $2\ C_{(s)} + O_{2(g)} \rightarrow 2\ CO_{(g)}$ Find mass transfer rate of O_2(g) for the following two cases (i) if the oxidation is instantaneous and (ii) if the oxidation is slow and 1st-order reaction, respectively. Where $N_{(\ )}$ represents molar flux. **(20%)**



〈Figure 2〉

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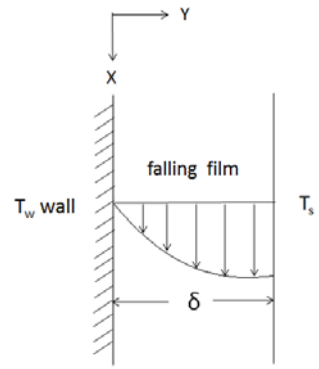
3. At short contact time, heat transfer to a falling film of Newtonian fluid with viscosity μ and density ρ as shown in Figure 3.
   (i) Derive that $V_x = \rho g \delta^2/2\mu [2(y/\delta) - (y/\delta)^2]$
   (ii) At near the wall, show that $V_x \fallingdotseq \rho g \delta y/\mu$
   (iii) Derive that $\rho C_p V_x(\sigma T/\sigma x) = k(\sigma^2 T/\sigma y^2)$ where C_p: heat capacity of fluid; T: temperature at y; k: heat conductivity; σ **:** partial derivative symbol .
   (iv) Find temperature distribution for short contact time. **(30%)**



〈Figure 3〉

4. A methanol (A) and H_2O (B) mixture containing 20 mol% of methanol is distilled at 1 atm. A column with a total condenser and a reboiler are used. The top product contains 90 mol% methanol and the bottom product contains 10 mol%. The feed contains 50% liquid and 50% vapor. The equilibrium line is given. Please directly plot this graph on your answer sheet. Explain how you determine the following quantities using the construction method.
   (a) Determine the minimum reflux ration.
   (b) Determine the number of ideal stages needed at 1.5 times of the minimum reflux ratio.
   (c) Determine the position of the feed plate in case (b).
   (d) Determine the number of ideal stages needed at total reflux. **(25%)**