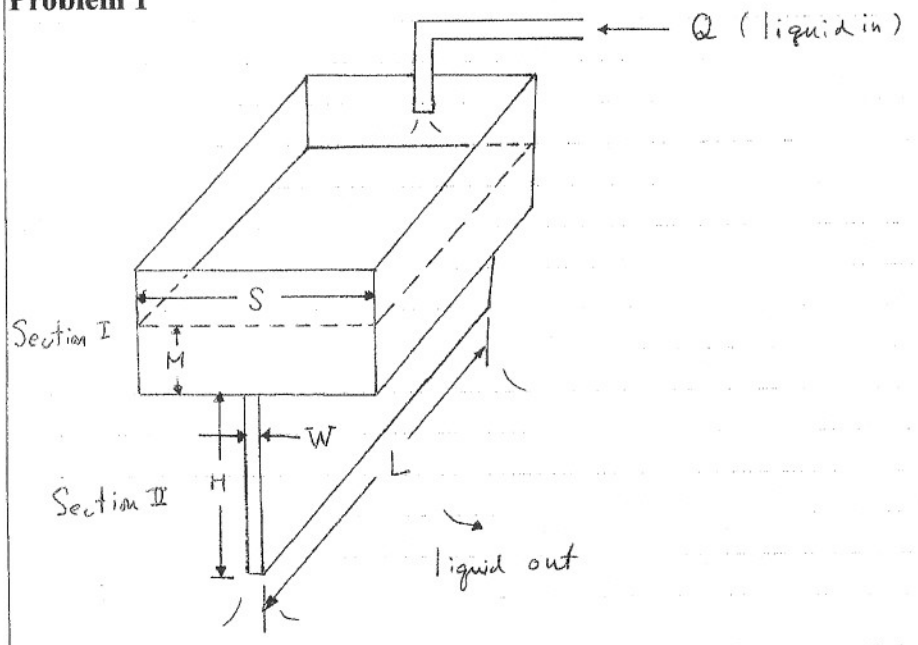
國　立　清　華　大　學　命　題　紙

96 學年度___化學工程學__系（所）_____組碩士班入學考試

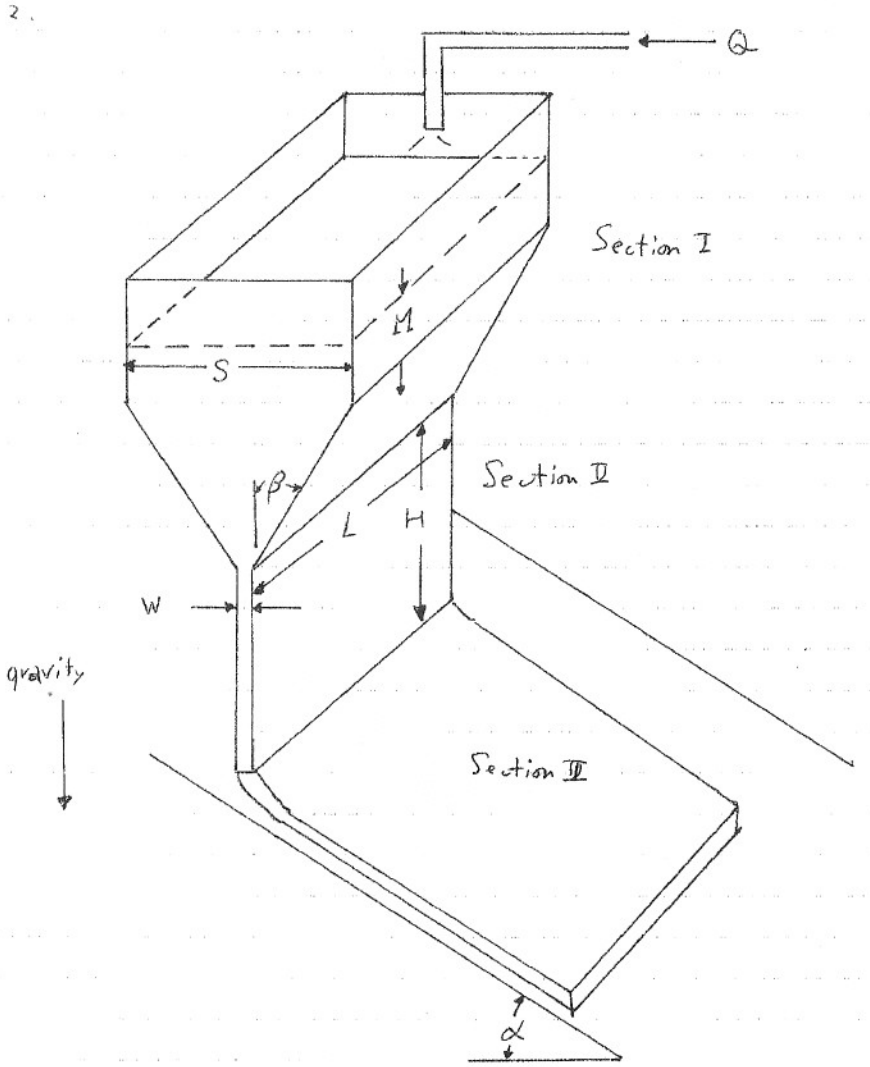
科目_輸送現象及單元操作_ 科目代碼__0701__共___5__頁第___1__頁 *請在【答案卷卡】內作答

Problem 1



A dilute aqueous Newtonian liquid with constant viscosity μ and density ρ flows into an open rectangular tank with two sections. The dimensions of both sections I and II are shown in the figure. Assuming L>>W, H>>W, S>>W, steady one-dimensional fully developed flow exists in Section II, you may also neglect edge and entrance effects. What should be the inlet volumetric flow rate Q to maintain the liquid level at a constant level M in section I? List your assumptions. (10%)

Problem 2



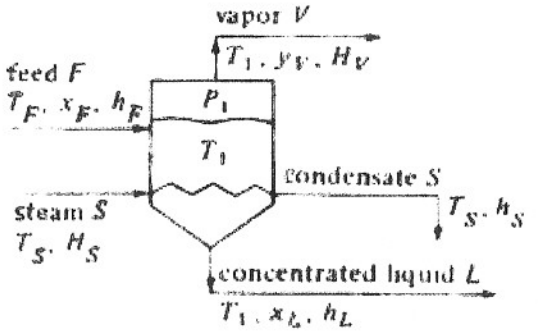
The same liquid in the above problem now flows into a tank with a converging section as shown in the figure, the angle β is less than 15°. All the dimensions are shown in the figure. Assuming steady, one-dimensional fully developed flow exists in sections II and III, what is the maximum velocity in Section III? List your assumptions. Note that L>>W, H>>W, S>>W, you may neglect end effects. (10%)

Problem 3

1. For isothermal and adiabatic flow of gases in a horizontal pipe, please derive the equation to relate the pressure drop (p1 – p2) after flowing for a length of ΔL. Start with the differential equation: v dv + dp/ρ+ dF = 0, where dF is the shear frictional term at wall, $dF = 4 f v^2 dL/(2D)$, with f = friction factor, D = diameter of pipe, v = velocity, L pipe length, and ρ the gas density. (10%)

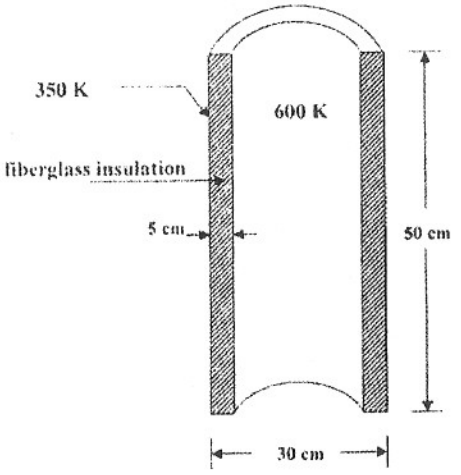
Problem 4

2. For single effect evaporator (as shown in the figure), part of the water in the feed (F) is removed as vapor (V) to obtain a concentrated solution (L), which utilizes steam (S) as the heating source. Let's now use such an evaporator to concentrate 4560 kg/h 20% NaOH at 60°C (its enthalpy h_F = 214kJ/kg) to a product of 50% NaOH solids. [The boiling point of 50% NaOH is about 89.5°C, its enthalpy h_L = 505 kJ/kg]. For the saturated steam used here, its temperature is 115.6°C and a latent heat of 2214 kJ/kg. As for the vapor, its enthalpy is 2667 kJ/kg. The overall heat transfer coefficient is 1560 $W/m^{2o}K$. Please calculate the steam used, the steam economy (kg vaporized/kg steam) and the heating surface area. (10%)



Problem 5

A small furnace is in the form of a tube with a length of 50 cm and a outer diameter of 30 cm. The wall is 5 cm thick, insulated with fiberglass. Assuming the heat flow resistance is dominated by this insulation, calculate the power required for steady operation at 600 K inside the furnace with 350 K at the outer casing. The thermal conductivity of the fiberglass at 475 K is 0.11 W/m K. (10%)



Problem 6

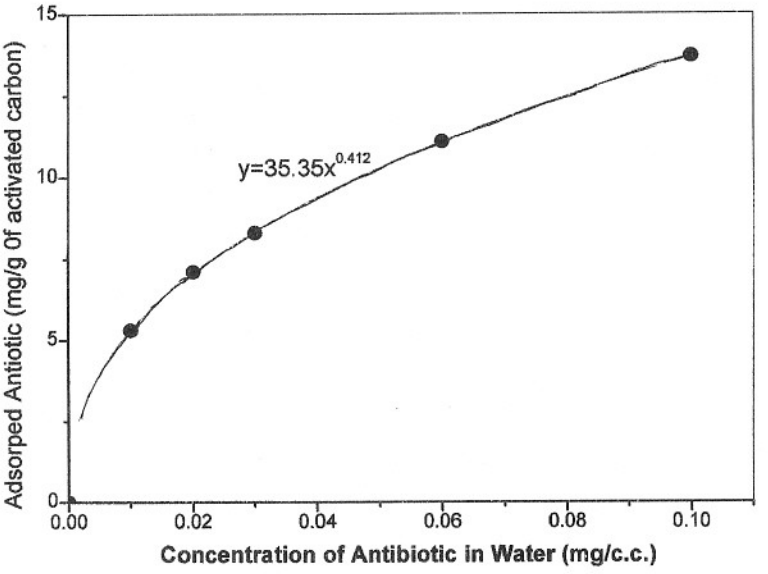
Electronic components are often mounted with finned plate, which is exposed to a stream of cooling air from a fan. The total mass times specific heat for such a component is 5000 J/K, and the effective heat transfer coefficient times surface area is 10 W/K. The initial temperature of the component and cooling air is 295 K. Find the component temperature after 300 W of power is turned on for 10 minutes. (10%)

Problem 7

Water containing 10 mg/L of a steroid is extracted with the solvent methylene chloride. The ratio of equilibrium concentration of steroid in methylene chloride to that in water is 100. Water and methylene chloride are mutually immiscible.

- How many liters of methylene chloride per liter of water, is required to remove 90% of steroid from water.
- How many liters of methylene chloride per liter of water, is required to remove 99% of steroid from water. (10%)

Problem 8



The adsorption isotherm of an antiobotic on an activated carbon is given above. A water solution contains 0.1 mg/c.c. of antiobotic. Suppose 0.01 g of activated carbon is added to 1 c.c. of such a solution. How much antibiotic is left in the liquid solution after the adsorption has reached equilibrium. (10%)

Problem 9

(a)How is the binary diffusivity defined? How is self-diffusion defined? Give typical orders of magnitude of diffusivities for gases, liquids, and solids.

(b)Show that only one diffusivity is needed to describe the diffusional behavior of a binary mixture. (10%)

Problem 10

(a)Under what conditions is $\nabla \cdot \mathbf{v}=0$ and $\nabla \cdot \mathbf{v}^* =0$. ($\mathbf{v}$ is the local mass average velocity. $\mathbf{v}^*$ is the local molar average velocity.)

(b)How does the size of a bubble change as it moves upward in a liquid. (10%)