國立中正大學104學年度碩士班招生考試試題

系所別：化學工程學系　　科目：輸送現象與單元操作

第2節

1. Using the Navier-Stokes equation, determine the velocity profile (u) for the incompressible steady flow of fluid between two horizontal-parallel plates at rest with distance h. Assume one dimensional laminar flow with constant viscosity (μ), and the variation of pressure (p_y) in the vertical direction is negligible for small h. (20 points)

2. In order to transport liquid metal, the liquid metal flows through a pipe imbedded in a wall at a point where the temperature is 600K. A 1.0-m-thick wall constructed of a material having a thermal conductivity varying with temperature according to k= 0.094(1+0.004T), where T is in K and k is in W/m · K, has its inside surface maintained at 900K. The outside surface is exposed to air at 350K with a convective heat-transfer coefficient of 18 $W/m^2 \cdot K$.
   (a) How far from the hot surface should the pipe be located? (15 points)
   (b) What is the heat flux for the wall? (15 points)

3. For a binary mixture of A and B, show that
   $$\mathbf{j}_A + \mathbf{j}_B = 0$$
   where **j** is the mass flux related to the mass-average velocity. (5 points)

4. Leaching or extraction is a separation process involving the use of solvent *S* on the feed *F*, two streams leaving from the separator are extract (*E*) and raffinate (*R*). Define the nomenclatures of extract and raffinate, and make a mass balance to yield **an operation line for single-stage extraction**. Please note that *F, S, E*, or *R* represents the amount of total mass in each stream and the mass fractions of target solute in *F*, *E* and *R* streams are x_F, x_E, and x_R. (10 points)

5. Ammonia is to be absorbed from air at 20 ℃ and atmospheric pressure in a **countercurrent** packed tower, 15 cm in diameter, using ammonia-free water as the absorbent. The inlet gas rate is 661 m^3/h (ideal gas can be assumed) and the inlet water rate is 666 kg/h. Under these conditions, the overall mass transfer coefficient, $K_y a$, is assumed to be 75 kg mole/h · m^3. The ammonia concentration will be reduced from 0.083 mole fraction to 0.003 mole fraction. The molecular mass of ammonia (NH_3) is 17, and the gas constant is R = 0.08205 m^3 · atm/kg mol · K. The tower is cooled, the operation thus takes place essentially at 20 ℃. The equilibrium relationship is linear and can be represented as:
   Y (kg mole NH_3/kg mole air) = 1.15 × X (kg mole NH_3/kg mole H_2O)
   (a) Determine the height of the absorption tower. (20 points)
   (b) Define number of transfer unit (NTU). (5 points)
   (c) Define two-film theory. (5 points)
   (d) Describe how packed and wetted wall tower (column) be used for the absorption. (5 points)