國立聯合大學 101 學年度 碩士班考試招生

化 學 工 程 學 系 入學考試試題

科 目： 單 元 操 作 第 1 頁共 1 頁

(Data: assume that the density of water keeps constant = 998 kg/m^3)

1. Explain the following terms in detail : (24 pts)
   (a) Prandtl number (b) Fick's law (c) absorption (d) Stefan-Boltzmann law (e) flux
   (f) NTU (in heat exchanger) (g) Reynolds number (h) NPSH

2. Water at 300 K flows into a process unit through a 2-in ID pipe at a rate of 80.00 ft^3/hour. Calculate the mass flow rate (in kg/s) and the kinetic energy flow rate (in J/s) for this stream. (10 pts)

3. At 100℃ and 1 atm, the vapor pressures of benzene (A) and toluene (B) are 179.2 and 74.3 kPa, respectively. Assume that the binary system is an ideal system. Please calculate (a) the vapor y_A and the liquid x_A compositions and (b) the relative volatility α_{AB}. (10 pts)

4. List (DO NOT proof) the major assumptions to achieve that the flow rate for a flowmeter is

$$\dot{Q} = C_i \cdot \frac{\pi D_i^2}{4} \cdot \sqrt{\frac{2g_c(-\Delta p/\rho)}{1-\beta_i^4}} \quad \text{where } \beta = D_i/D \quad (4 \text{ pts})$$

5. A pump takes water from a river at the night and pumps it to a hilltop 200 m above the river. The water is returned through a turbine in the daytime. The friction loss is estimated to be 20 m of water. For ten 50-cm pipes, each carrying 80,000 liters per minute.
   (a) What is the total mass flow rate (in kg/s) for the water at the night? (4 pts)
   (b) What pumping power (in J/s) is needed if the pump efficiency is 75 %? (6 pts)
   (c) How much power (in J/s) can be generated by the turbine using the same total flow rate if the turbine efficiency is 70 %? (5 pts)

6. An electric wire having a diameter of 4.0 mm covered with a plastic insulation (k = 0.5 W/m K, thickness = 2.5 mm) is exposed to air at 320 K and h_{air} = 25 W/m^2 K. Assume that the wire surface temperature keeps constant at 420 K.
   (a) Calculate the value of the critical radius (in cm). (4 pts)
   (b) Calculate the heat loss per unit length of wire without insulation. (6 pts)
   (c) Calculate the heat loss per unit length of wire with insulation. (5 pts)

7. Oxygen gas (A) is stored at elevated pressure in a rectangular container having rubber (B) walls 10 mm thick. The concentrations of oxygen in the rubber at the inner and outer surface are 200 and 0.5 mol/m^3, respectively. The binary diffusion coefficient for the system is 0.21x10^{-9} m^2/s. Compute the molar and mass diffusive flux for oxygen through the rubber. (10 pts)

8. A concentric parallel heat exchanger is to cool 0.3 kg/s of benzene from 350 K to 300 K with 1.0 kg/s of water at 283 K. If the inner tube outside is 6.0 cm and the overall heat transfer coefficient based on the outside area is 700 W/m^{2}K, estimate the required length of the exchanger. (12 pts) (Hint: Cp(water)=4180 J/kgK; Cp(benzene)=1900 J/kgK)