國立臺北科技大學

九十二學年度工程科技研究所博士班入學考試

化學工程（化學工程組）試題

填准考證號碼

注意事項：

1. 本試題共【6】題，配分共 100 分；第 1~4 題為 17 分，第 5~6 題每題為 16 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在答案卷之答案欄內，否則不予計分。

1. Air at 1 atm and 30℃ is compressed in a staged reciprocating compressor (with intercooling) to a final pressure of 60 atm. For each stage, the inlet gas temperature is 30℃ and the maximum allowable outlet temperature is 180℃. Mechanical power is the same for all stages, and isentropic efficiency is 70% for each stage. The volumetric flowrate of air is 0.60 m^3/s at the inlet to the first stage. Assume air is an ideal gas with $C_P = (7/2)R$
   (a) How many stages are required ?
   (b) .What is the mechanical-power requirement per stage ?
   (c) What is the heat duty for each intercooler ?
   (d) Water is the coolant for the intercoolers. It enters at 25℃ and leaves at 40℃. What is the cooling-water rate per intercooler ? (C_{Pwater} = 4.184 kJ/kg)

2. A binary system of species 1 and 2 consists of vapor and liquid phases in equilibrium at temperature T. The overall mole fraction of species 1 in the system is z_1 = 0.60. At temperature T,

   $ln\,\gamma_1 = 0.667\,x_2^2$, $\quad ln\,\gamma_2 = 0.667\,x_1^2$

   $P_1^{sat} = 32.17\ kPa$, $\quad P_2^{sat} = 73.86\ kPa$

   (a) Over what range of pressures can this system exist as two phases at given T and z_1 ?
   (b) For a liquid-phase mole fraction x_1 = 0.70, what is the pressure P and what molar fraction of the system is vapor ?
   (c) Show whether or not the system exhibits an azeotrope ?

3. Equimolar quantities of A, B, and D are fed continuously to a CSTR reactor where they combine by the elementary reactions

$$A + D \xrightarrow{k_1} R$$

$$B + D \xrightarrow{k_2} S$$

where $k_1/k_2 = 2.5$

(a) If 60% of the incoming A is consumed find what fraction of the products formed is R ?

(b) If 60% of the incoming D is consumed find what fraction of the products formed is S ?

4. Chemical R is to be produced by the decomposition of A in a given CSTR reactor. The reaction proceeds as follows:

$$A \rightarrow R, \qquad r_R = k_1 C_A$$

$$2A \rightarrow S, \qquad r_S = k_2 C_A^2$$

Let the molar cost ratio $\$_R/\$_A = M$ (S is waste material of no value), and for convenience let $k_1 = N k_2 C_{A0}$. In the feed C_{A0} is fixed.

(a) Ignoring operating costs, find what conversion of A should be maintained in the reactor to maximize the gross earnings and therefore the profits.

(b) Repeat part (a) with the hourly operating cost dependent on the feed rate and given by $a+bF_{A0}$.

5. A drop of water, 0.75 mm in diameter, is falling freely through dry, still air at 1 atm and 60 ℃. The velocity of the falling drop is 2.5 m/s. The surface temperature of the drop is 22℃. The vapor pressure of water is 0.0249 atm at 22℃. Assuming pseudo-steady-state behavior and a small mass-transfer rate, compute the rate of change of the drop diameter in cm/s. Assume that the "film properties" of dry air are $\mu = 1.91\times10^{-4}$ g/cm·s and $D_{AB} = 0.292$ cm^2/s.

6. By extraction with kerosene, 1000 kg of waxed paper per day is to be dewaxed in a continuous countercurrent extraction system that contains a number of ideal stages. The waxed paper contains, by weight, 20% paraffin wax and 80% paper pulp. The extracted pulp is put through a dryer to evaporate the kerosene. The pulp, which retains the unextracted wax after evaporation, must not contain over 0.2 kg of wax per 100 kg of wax-free pulp. The kerosene used for the extraction contains 0.05 kg of wax per 100 kg of wax-free kerosene. Experiments show that the pulp retains 2.0 kg of kerosene per kilogram of kerosene- and wax-free pulp as it is transferred from cell to cell. The extract from the battery is to contain 5 kg of wax per 100 kg of wax-free kerosene. How many stages are required ?