國 立 清 華 大 學 命 題 紙

95 學年度_____化學工程學____系（所）_____組碩士班入學考試

科目_化工熱力學及化學反應工程_ 科目代碼__1402__共_3_頁第_1_頁 *請在【答案卷卡】內作答

1. (a) An ideal gas enters a valve at 500 K and 3 MPa at a steady-state rate of 3 mol/min. It is throttled to 0.5 MPa. What is the rate of entropy generation? $C_p = 7R/2$. (10%)

   (b) For a gas obeying the van der Waals equation of state show that C_v depends only on T. (10%)

2. (a)(i) For a pure substance, please draw a schematic T-S (temperature-entropy) diagram consisting of solid, liquid and vapor phases. Please label all the phase regions and the triple-point line.
   (ii) For a pure substance, please draw a schematic Mollier diagram (an H-S, enthalpy-entropy diagram) consisting of solid, liquid and vapor phases. Please label all the phase regions and the triple-point line. (10%)

   (b)(i) Please draw a T-X (temperature-composition) phase diagram consisting of liquid phase, vapor phase, and an azeotrope (minimum) for an A-B binary system at a constant pressure, P_1. (ii) For the A-B binary system, please draw a schematic G-X (Gibbs free energy-composition) diagram at the azeotropic temperature and pressure P_1 for both the liquid and vapor phases. (iii) Substances C and D are ideal gases in their vapor phases, and in their liquid phases C and D form an ideal solution. At a constant pressure P_1, the temperature of the boiling point of C is lower than that of substance D. Please draw a T-X (temperature-composition) phase diagram consisting of liquid phase and vapor phase for the C-D binary system at a constant pressure, P_1. (10%)

3.(a) Consider an ideal gas phase reaction carried out in an isothermal batch reactor. The reaction is given by the following stoichiometry:

$A+B \rightarrow C$

The rate equation and rate constant are:

$(-r_A)=kC_AC_B \quad k=1\times10^{-5}m^3/(mol\bullet s)$

The reactor is initially filled with a mixture of 40 mol % *A*, 40 mol % *B* and 20 mol % inert. The temperature is held constant at 100°C. **The initial reactor pressure is 500 kPa. The reactor** is controlled during the course of reaction such that the following relationship is valid

$P_T=P_{T0}-at, \quad a=1Pa/s$

Where t is time in seconds and P_T and P_{T0} are the total pressure and initial total pressure in Pa, respectively. Determine the time required to achieve 80% conversion of reactant A and the total reactor pressure at that time. (10%)

(b)The decomposition of hexaphenylethane to triphenylmethyl radicals in liquid chloroform has been studied at 0°C,

$$(C_6H_5)_3CC(C_6H_5)_3 \rightarrow 2(C_6H_5)_3$$

The following results were obtained.

Time, t (sec)	C/C_0 for hexaphenylethane
0	1.000
17.4	0.941
35.4	0.883
54.0	0.824
174	0.530
209	0.471
313	0.324
367	0.265
434	0.206
584	0.118
759	0.059

Determine the reaction order and rate constant for the reaction by differential method of analysis. For orders other than one, C_0 will be needed. If so, incorporate this term into the rate constant. (10%)

4. (a)The elementary liquid-phase reaction

$$A + 2B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R$$

with rate equation

$-r_A = (12.5\ \text{liter}^2/\text{mol}^2\cdot\text{min})C_A C_B^2 - (1.5\ \text{min}^{-1})C_R \qquad \left[\ \frac{mol}{liter\cdot\text{min}}\ \right]$

is to take place in an 8-liter steady-state mixed flow reactor. Two feed streams, one containing 2.8 mol A/liter and the other containing 1.6 mol B/liter, are to be introduced at equal volumetric flow rates into the reactor, and 80% conversion of liming component is desired. What should be the flow rate of each feed stream? Assume a constant density throughout. (10 %)

(b)The homogeneous gas decomposition of phosphine

$$4\ PH_3\ (g) \rightarrow P_4\ (g) + 6\ H_2$$

proceeds at 649 °C with the first-order rate

$$-r_{PH3} = (10/\text{hr})\ C_{PH_3}$$

What size (in m^3) of plug flow reactor operating at 649 °C and 430 kPa can produce 75% conversion of a feed consisting of 50 mol of pure phosphine per hour?

Note:

(i). $k\tau = -(1 + \varepsilon_A)\ln(1 - X_A) - \varepsilon_A X_A$

where k is the rate constant, τ is the space time, ε_A is the expansion factor (the fractional volume change on complete conversion of A), A denotes PH_3, and X_A is the fraction of A converted.

(ii). Gas constant = 8.314 $Pa\cdot m^3/mol\cdot K$ (10 %)

5. (a) Plot approximately the exit concentration of the tracer versus time for a plug-flow reactor and a CSTR if a pulse trace input is used to measure the residence time distribution of the reactor. (10%)

(b)Derive the residence time distribution function for n CSTRs in series if a tracer pulse is injected into the first CSTR. Explain every term used in the function. (10%)