北京化工大学 2014——2015 学年第一学期

《CHEMICAL REACTION ENGINEERING》期中考试试卷

课程代码	C	H	E	3	2	5	0	2	T

班级： **姓名：** **学号：** **分数：**

题号	1	2	3	4	5	6	7	总分
得分								

1. Choose the most suitable one from the four answers (5 points for each one, 25 points in total)

(1) A reaction conversion reaches 30% at t=10min and 45% at t=15min, the reaction may be (　　)

A.Zero-order reaction B.First-order reaction

C.Second-order reaction D.Third-order reaction

(2) The first order reactions in series $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ proceed in an ideal reactor. Which one of the following four conditions makes the fractional yield of product R maximum? (　　)

A. k_1/k_2=1, batchreactor **B. k_1/k_2=10, batch reactor**

C. k_1/k_2=1, mixed flow reactor D. k_1/k_2=10, mixed flow reactor

(3) If $-r_A=-(dC_A/dt)$ =0.1mol/liter·sec when C_A=1mol/liter, what is the rate of reaction when C_A=10 mol/ liter? Note: the order of reaction is not know. (　　)

A.0.1mol/liter·sec B.0.5mol/liter·sec C. 1mol/liter·sec **D. Not know**

(4) Gaseous reaction A→3R is allowed to proceed to completion, equal molar A and inerts present at the start, what is the value of expansion factor ε ? (　　)

A. 1 B. 2 C.3 D.4

(5) The second order reactions in series $A \xrightarrow[t_1]{\triangle H_1<0} R \xrightarrow[t_2]{\triangle H_2>0} S$ proceed in a plug reactor. Which one of the following four conditions makes the concentration of product R maximum? (　　)

C. $t_1=500°C$; $t_2=300°C$ **B. $t_1=300°C$; $t_2=300°C$**

C. $t_1=300°C$; $t_2=500°C$ D.$t_1=500°C$; $t_2=500°C$

2. Write your answers in the blanks (5 points for each one, 20points in total)

(1) Liquid A (C_{A0}=1mol/liter) decomposes by second-order kinetics in a batch reactor, 50% of A will be converted in a 5-minute run. How much time would it take to reach 75% conversion? __15min__

(2)Time required to process one reactor volume of feed is called__space time__

(3)A reaction proceeds with an activation energy of 100kJ/mol. The reaction rate is 1 at 500°C, the reaction rate is 2 at__536__°C.

(4) Liquid phase reactions $A + B \xrightarrow{k_1} R + S$ and $R + B \xrightarrow{k_2} P + S$ are allowed to proceed to completion, an equimolar feed of $C_{A0} = C_{B0} = 1 mol / liter$ is introduced into a batch reactor , the final concentrations of A and R are 0.3mol/liter, 0.4mol/liter, respectively, the value of k_1/k_2 is **1.25**

Note: you may use the following figure.

3. A catalytic reaction $C_{20}H_{42} \rightarrow R$ is proceed in a batch reactor, the reactor unit contains 100 tons of ρ=1000 kg/m^3 porous catalyst, 2820m^3 of ρ=1000 kg/m^3 reactants are treated per day, if 72% of the reactants turn into products, what is the rate of reaction, expressed as $-r$ (mols reacted/kg cat·hr)? (8points) **3 mols reacted/kg cat·hr**

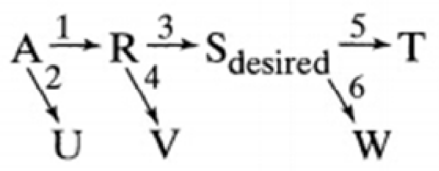
4. A liquid reactant(1mol/liter) passes through two mixed flow reactors in series.The concentration of A in the exit of the first reactor is 0.5mol/literand 0.2mol/liter of the second reactor exit. The reaction is of first-order with respect to A, what is the value of the reactor volume ratio V_2/V_1? (10 points)

1.5

5. A first order gas decomposes reaction $A \rightarrow 2R$ proceeds in a plug flow reactor isothermally. The inlet stream with 60% A and 40% inerts. The volume of outlet stream is 1.2 times as inlet one and the mean residence time is 10 sec. Please find the conversion of reactant A and the rate constant k. (12points)

x_A=1/3 **k=0.04sec^{-1}**

6.Qualitatively find the optimum temperature progression to maximize C_S for the reaction scheme



Data: E_1=10, E_2=25, E_3=15, E_4=10, E_5=20, E_6=25 (10 points)

Low-high-low

7. Liquid reactant A decomposes as follows:

$$A \rightarrow R \qquad r_R = k_1 C_A^2 \qquad k_1 = 0.4 m^3 \cdot mol^{-1} \cdot \min^{-1}$$

$$A \rightarrow S \qquad r_S = k_2 C_A \qquad k_2 = 2 \min^{-1}$$

A feed of aqueous A ($C_{A0}=10 mol \cdot m^{-3}$) enters a reactor, decomposes, and a mixture of A, R, and S leaves. Find C_R and C_S and τ for $X_A = 0.9$ in a plug flow reactor. (15 points)

C_R=4.42mol/m^3 **C_S=4.58mol/m^3** **t=0.693min**

北京化工大学 2014——2015 学年第一学期

《CHEMICAL REACTION ENGINEERING》

期中考试试卷答案

1

(1) A (2) B (3) D (4) A (5) B

2

1. 15 minutes
2. space time
3. 536
4. 1.25

3.

$n = (2820*1000) / 0.282 = 10^7$ mol

$-r = (0.72*10^7) / (10^5*24) = 3$ mols reacted/kg cat·hr

4.

$$\tau=\frac{C_{A0}\Delta x_A}{-r_A}=\frac{C_{A0}\Delta x_A}{kC_{A0}(1-x_A)} \qquad k\tau=\frac{\Delta x_A}{(1-x_A)}$$

For $x_A=0.5 \qquad k\tau_1=\frac{0.5}{(1-0.5)}=1$

For $x_A=0.8 \qquad k\tau_2=\frac{0.8-0.5}{(1-0.8)}=1.5$

$$\frac{k\tau_2}{k\tau_1}=1.5$$

$V_2/V_1=1.5$

5.

$$\delta_A=\frac{2-1}{1}=1 \qquad y_{A0}=0.6 \qquad \varepsilon_A=1\times0.6=0.6$$

$$V=V_0(1+\varepsilon_A x_A) \qquad 1.2=1\times(1+0.6x_A) \qquad x_A=1/3$$

$$\bar{t}=C_{A0}\int_0^x\frac{dx_A}{-r_A(1+\varepsilon_A x_A)} \qquad k\bar{t}=-\ln(1-x_A)$$

$$k=\frac{-\ln(1-x_A)}{\tau}=\frac{-\ln(1-1/3)}{10}=0.0405\,\mathrm{sec}^{-1}$$

6.

low-high-low

7.

$$\varphi_R = \frac{dC_R}{dC_A} = \frac{k_1 C_A^2}{k_2 C_A + k_1 C_A^2} = \frac{0.4C_A}{2+0.4C_A}$$

$$C_R = \int_{C_A}^{C_{A0}} \varphi_R dC_A = \int_1^{10} \frac{0.4C_A}{2+0.4C_A} dC_A$$

$$\varphi_S = \frac{dC_S}{dC_A} = \frac{k_2 C_A}{k_2 C_A + k_1 C_A^2} = \frac{2}{2+0.4C_A}$$

$$C_S = \int_{C_A}^{C_{A0}} \varphi_S dC_A = \int_1^{10} \frac{2}{2+0.4C_A} dC_A = \frac{2}{0.4}\ln(2+0.4C_A)\Big|_1^{10}$$

$$= \frac{2}{0.4}\ln\frac{2+0.4\times 10}{2+0.4\times 1} = 4.58 mol\cdot m^{-3}$$

$$C_R = (C_{A0} - C_A) - C_S = (10-1) - 4.58 = 4.42 mol\cdot m^{-3}$$

$$\tau = \int_1^{10} \frac{1}{-r_A} dC_A = \int_1^{10} \frac{1}{k_2 C_A + k_1 C_A^2} dC_A = \int_1^{10} \frac{1}{2C_A + 0.4C_A^2} dC_A = \int_1^{10} \frac{1}{10} \times \frac{1}{0.2C_A(1+0.2C_A)} dC_A$$

$$= \frac{1}{10}\int_1^{10} \left(\frac{1}{0.2C_A} - \frac{1}{1+0.2C_A}\right) dC_A = \frac{1}{10}\left[\frac{1}{0.2}\ln C_A\Big|_1^{10} - \frac{1}{0.2}\ln(1+0.2C_A)\Big|_1^{10}\right] = 0.693\min$$