國立成功大學 107 學年度碩士班招生考試試題

系　所：化學工程學系

考試科目：化學反應工程　　考試日期：0205，節次：3

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Multiple-Choice Question (Q1-Q3) with Single Answer (單選題): (9%)

1. What assumptions were made in the derivation of design equation for batch reactor: (3%)
   (a) open system
   (b) constant volume
   (c) constant temperature
   (d) steady state
   (e) all above correct

2. What assumptions were made in the derivation of design equation for CSTR: (3%)
   (a) non-steady state
   (b) No radial variation in reaction rate of the system
   (c) No spatial variation in concentration of the system
   (d) No radial variation in pressure of the system
   (e) all above wrong

3. An irreversible, liquid-phase or gas phase, second order reaction, A ➔ B, proceeds to 50% conversion in the PFR operating isothermally, isobarically and at steady state. What conversion would be obtained if the PFR operated at half the original pressure? (3%)
   (a) > 50% for liquid and gas phase
   (b) < 50% for liquid and gas phase
   (c) = 50% for gas phase and >50% for liquid phase
   (d) = 50% for liquid phase and < 50% for gas phase
   (e) > 50% for liquid phase and < 50% for gas phase

4. The reaction 2A + B ➔ 2C is irreversible. At 50°C the specific rate constant is 10 $(mol/dm^3)^2\ s^{-1}$ with an activation energy 500 J/mol. What is the rate of reaction at 100°C when the concentrations of A and B are 3 and 1.5 mol/dm^3 when the rate law for the reaction is: (10%)
   (A) second order in A and overall third order;
   (B) second order in B and overall third order.

5. Nitric oxide is produced by the gas-phase oxidation of ammonia as:
   $4NH_3 + 5O_2$ ➔ $4NO + 6H_2O$
   The rate equation is followed by $-r_A = k\,[NH_3]\,[O_2]^{1/2}$. The feed consists of 15% ammonia in air at 9 atm and 276°C. The kinetic constant k is 0.1 $(dm^3/mol)^{1/2}$ and flow rate v_0 is 2 dm^3/s. Calculate the reactor volume necessary to achieve 65% conversion in CSTR. (15%)

6. Please answer the followings: (10%)
   (a) Draw the four stages of cell growth as a function of time and give explanation for what happen at each stage.
   (b) For an exothermic, reversible reaction in an adiabatic reactor, please sketch the profiles of equilibrium conversion and conversion calculated based on energy balance as functions of temperature.
   (c) Using the graphical solution provided above, how to increase the conversion, which is limited by the thermodynamics, at the outlet of reactor. Any strategy? Please explain.
   (d) Please draw the temperature as a function of time of an Advanced Reaction System Screening Tool (ARSST) system. Please explain the temperature trajectory you provided in detail.

7. The reaction A + B => C was conducted in a CSTR with a volume of 20 m^3. The feed is at 295 K, containing propylene oxide (A), water (B), and methanol (M), each at a flow rate of 91 mol h^{-1}. The product (C) is propylene glycol and methanol is inert. The volumetric flow rate to the reactor is 25 m^3 h^{-1}. The heat capacities in J mol^{-1} K^{-1} are C_{PA} = 146, C_{PB} = 75, C_{PC} = 192, and C_{PM} = 79.
The reaction is first order in A, zero order in B, k = $6.9\times10^{10}\exp(-75000/(R\,T))$ h^{-1}, where the activation energy is in unit of J mol^{-1}. The heat of reaction is -56800 J mol^{-1}. The CSTR is surrounded by a cooling jacket and the heat transfer coefficient times the heat transfer area is 1 x 10^4 J h^{-1} K^{-1}. The cooling water temperature is assumed constant at 305 K. What is the unstable steady-state operating temperature and conversion in the range of 298 to 438 K? (23%)

8. Methyl ethyl ketone (MEK) is an important industrial solvent that can be produced from the dehydrogenation of butan-2-ol (Bu) over a zinc oxide catalyst:

$$Bu \rightarrow MEK + H_2$$

The following data giving the reaction rate for MEK were obtained in a differential reactor at 490°C.

Data Set	**1**	**2**	**3**	**4**	**5**	**6**
P_{Bu} (atm)	2	0.1	0.5	1	2	1
P_{MEK} (atm)	5	0	2	1	0	0
P_{H2} (atm)	0	0	1	1	0	10
r'_{MEK} (mol/h·gcat)	0.44	0.040	0.069	0.060	0.044	0.059

(a) Suggest a rate law consistent with the experimental data. (10%)
(b) Suggest a reaction mechanism and rate-limiting step consistent with the rate law. (8%)

9. The following externally mass transfer-limited reaction was carried out in a packed-bed reactor. (15%)

$$A + \frac{b}{a}B \rightarrow \frac{c}{a}C + \frac{d}{a}D$$

Please show that the conversion is

$$\ln\frac{1}{1-X} = \frac{k_c a_c}{U}L$$

where U is the superficial molar average velocity through the bed; L is the reactor length.

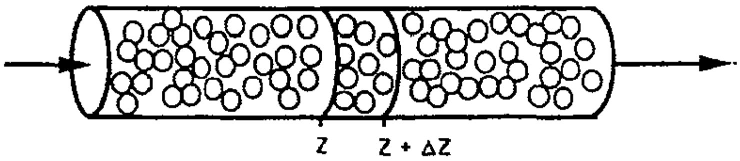

Figure. Packed-bed reactor.