國立成功大學
110學年度碩士班招生考試試題

編　號：76

系　所：化學工程學系

科　目：化學反應工程

日　期：0203

節　次：第 3 節

備　註：可使用計算機

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※ 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。

1. **(23%)** The elementary and gaseous reaction, $2A \rightarrow B + C$, with specific reaction rate of 9.5 dm^6/mol/g cat/min at 200°C is carried out in a packed bed reactor (PBR) isothermally at 200°C with pressure drop parameter, α, equals to 0.01 g^{-1}. Pure A is fed at pressure of 10 atmospheres and at temperature of 200°C, and a production rate of 120 g/min of B is required.

   (a) The pressure drop in this PBR could be evaluated by the analytical solution of Ergun equation,

   $$(P/P_0) = (1 - \alpha W)^{0.5}.$$

   Please provide the necessary conditions to solve the Ergun equation analytically. (3%)

   (b) Please determine the catalyst weight if the conversion of A is to be 80%? Assume ideal gas law. (20%)

   Additional information: R = 0.082 [(atm · dm^3)/(mol · K)]

   The molecular weight of B is 60.

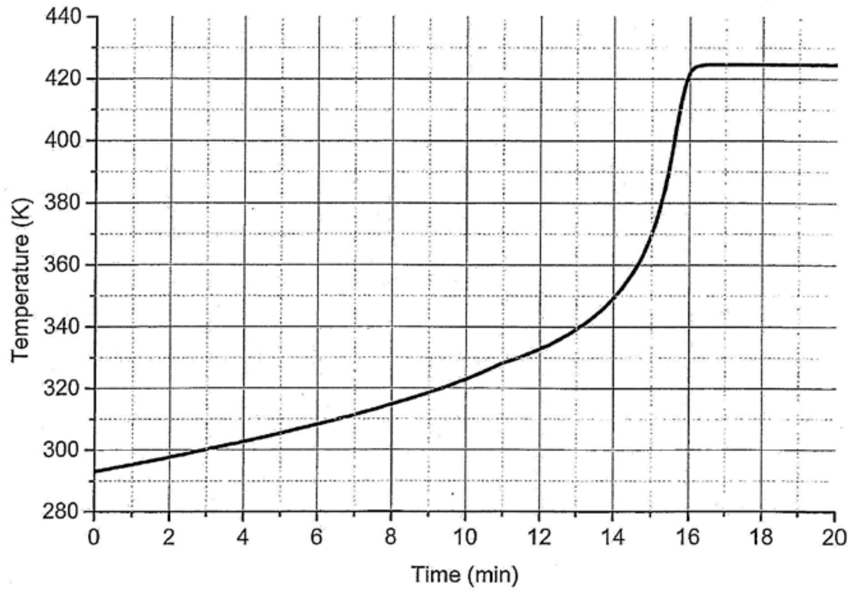
2. **(10%)** For liquid-phase reaction, $A \rightarrow B$, please use the integral method to analyze the rate data shown below to obtain reaction order, specific reaction rate, and half-life of reactant A.

t (min)	0	20	40	60	80	100	120
C_A (mol/dm^3)	3.000	0.097	0.049	0.033	0.025	0.020	0.017

3. **(20%)** The elementary irreversible gas-phase reaction (A => B + C) is performed in an adiabatic reactor without pressure drop. Pure A is fed with a 20 dm^3/s volumetric flow rate at a pressure of 10 atm and a temperature of 450 K. What catalyst weight is needed to obtain 80% conversion in (a) a CSTR **(10%)** and (b) a PBR **(10%)**?

   Additional information:
   C_{PA} = 40 J/mol/K; C_{PB} = 25 J/mol/K; C_{PC} = 15 J/mol/K; H_A^o = -70 kJ/mol; H_B^o = -50 kJ/mol; H_C^o = -40 kJ/mol. All heats of formation are referenced to 273 K.
   $k = 0.133 \exp[(E/R)*(1/450-1/T)]$ dm^3/kg/cat/s with E_a = 31.4 kJ/mol

4. **(13%)** An advanced reactive system screening tool (ARSST) system is used to test an elementary reaction of A + B => 2C. The temperature-time trajectory of this reaction is as below:
   (a) At what temperature the reaction is ignited (T_{onset})? Please explain. **(3%)**
   (b) What is the heat of reaction? Assuming $\Delta C_p = 0$; C_{PA} = 187.9 J/mol/K; C_{PB} = 75.4 J/mol/K; $F_{A0} = F_{B0}/3$. **(10%)**



5. **(16%)** Experimental data for the gas-phase catalytic reaction: A + B → C is shown below. The limiting step in the reaction is known to be irreversible, so that the overall reaction is irreversible. The reaction was carried out in a differential reactor to which A, B, and C were all fed.

Run	P_A (atm)	P_B (atm)	P_C (atm)	Reaction Rate (mol)/(g cat·s)
1	0.1	1	2	0.073
2	1	10	2	3.42
3	10	1	2	0.54
4	1	30	2	6.80
5	1	30	10	2.88
6	20	1	2	0.56
7	1	1	2	0.34
8	1	30	5	4.50

(a) Suggest a rate law consistent with the experimental data. **(8%)**

(b) Suggest a mechanism and rate-limiting step for this reaction. **(8%)**

6. **(18%)** The elementary irreversible gas phase catalytic reaction

$$A + B \xrightarrow{k} C + D$$

is to be carried out in a moving-bed reactor at constant temperature. The reactor contains 5 kg of catalyst. The feed is stoichiometric in A and B. The entering concentration of A is 0.2 mol/dm^3. The catalyst decay law is zero-order with k_D = 0.2 s^{-1}. The volumetric flow rate is v_0 = 1.0 dm^3/s and k = 1.0 dm^6/(mol·kg cat·s).

(a) What is the maximum conversion that could be achieved (i.e., at infinite catalyst loading rate)? **(6%)**

(b) What catalyst loading rate is necessary to achieve 40% conversion? **(8%)**

(c) At what catalyst loading rate (kg/s) will the catalyst activity be exactly zero at the exit of the reactor? **(4%)**