Thermodynamics

1. Explain briefly the following terms: (12)
   (a) Azeotrope.
   (b) Retrograde condensation.
   (c) Joule-Thomson expansion.
   (d) Regular solution, athermal solution, and ideal solution.

2. Determine the number of degrees of freedom F for each of the following system: (8)
   (a) a gaseous mixture of N_2, H_2, and NH_3 with no catalyst present (so that the rate of reaction is zero);
   (b) a gaseous mixture of N_2, H_2, and NH_3 with a catalyst present to establish reaction equilibrium;
   (c) a system formed by adding a catalyst to pure $NH_3(g)$ so as to establish reaction equilibrium between N_2, H_2, and NH_3;
   (d) a system consisting of a rigid, permeable, thermal conducting walls separate all the phases of the system, expressing F (the degree of freedom) in terms of C (the number of independent components) and p (the number of phase).

3. In the study of an equipment, one cycle consists of the following steps is used:
   a. An isothermal compression from P_1, T_1, V_1, to P_2, T_1, V_2
   b. A constant-volume path from P_2, T_1, V_2, to P_3, T_2, V_2
   c. An isothermal expansion from P_3, T_2, V_2, to P_4, T_2, V_1
   d. A constant-volume path from P_4, T_2, V_1, to P_1, T_1, V_1

   Sketch this cycle on a PV diagram, and calculate ΔU, ΔS, Q, and W for each of the steps and for the entire cycle. What is the efficiency of the cycle? Assume reversible operation, and take the working substance to be an ideal gas with constant heat capacities. (16)

4. A system maintained at constant volume has a constant C_v, heat capacity at constant volume. The system is initially at a temperature T_1, and a heat reservoir at the lower temperature T_o is available. Show that the maximum work recoverable, as the system is cooled to the temperature of the reservoir, is

   $$W = C_v [(T_1 - T_o) - T_o \ln(T_1/T_o)].$$ (6)

5. Calculate the fugacity, Φ, for a gas at 27 °C and 10 atm, whose PVT behavior is given by the Virial equation,

   $$Z = 1 + \frac{B P}{R T},$$

   where B is the second Virial equation with a value of -246 cm^3 $(g\ mole)^{-1}$, and R = 82 cm^3 atm $(g\ mole)^{-1}$ K^{-1}. (8)

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國立中正大學八十三學年度碩士班考試試題

所　別：化學工程研究所　　科　目：化工熱力學與化工動力學

化　工　動　力　學

2-P.2

一. 解釋名詞　20分（每小題各4分）

1. Activation Energy
2. Half Life of Reaction
3. RTD(Residence Time Distribution)
4. Elementary Reactions
5. Effectiveness Factor

二. 對一不均相觸媒異構化反應 $A \rightleftharpoons R$，其反應步驟可以以下列三式表示

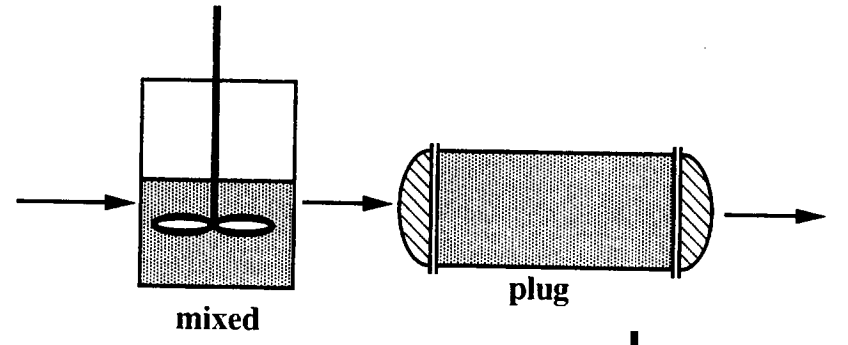
Adsorption:	$A + S \rightleftharpoons AS$		(1)
Surface Reaction:	$AS \rightleftharpoons RS$		(2)
Desorption:	$RS \rightleftharpoons R + S$		(3)

S：觸媒表面活性基(Active Site)，其總量爲 C_t

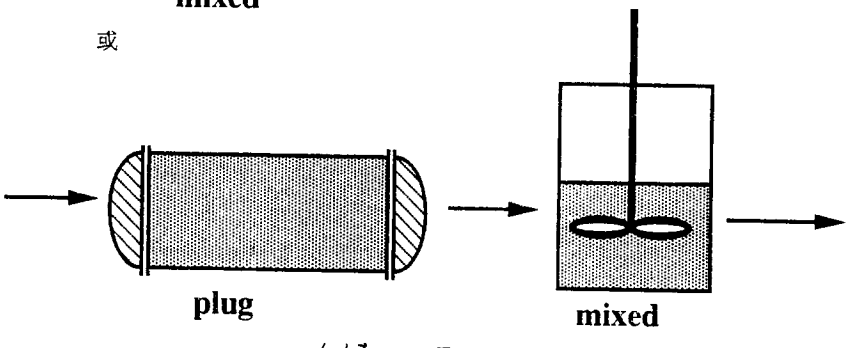
1. 若此催化反應是屬於表面反應控制(surface reaction controlling)則總反應速率式(rate expression)爲何?

2. 若上述反應中 surface reaction 及 desorption 均不可逆，則反應速率式又爲何?　10 分

三. 爲了減少反應器容量，我們經常考慮將兩種不同反應器組合成一反應系統如下圖所示



或



(續下頁) 2.

3-P.3

對一自催反應 A + R ——— R + R ，從實驗我們得到以下的數據

C_A	C_R (mol/liter)	$-1/r_A$ (liter.min/mol)
0.99	0.01	40.21
0.95	0.05	11.56
0.90	0.10	7.01
0.70	0.30	3.74
0.60	0.40	3.46
0.50	0.50	3.48
0.40	0.60	3.76
0.30	0.70	4.43
0.10	0.90	10.88

若進料流量爲 100 liter/min 且含 90% A 、10% R ,欲得到 10% A ，90 % R 的產品則兩種不同反應器該如何組合才能使總反應器體積爲最小？請圖示兩種不同反應器的相對體積　10 分

四. 簡答題 ：

1.比較CSTR(continuous flow stirred tank reactor),PFR(plug-flow reactor), 及batch reactor 在工業應用上的優缺點. 5 分

2.什麼是 differential reactor, 如何利用此反應器求得反應動力參數 . 5 分