國立中央大學 106 學年度碩士班考試入學試題

所別： 化學工程與材料工程學系 碩士班 甲組(一般生) 共 2 頁 第 1 頁

科目： 化工熱力學及化學反應工程

本科考試可使用計算器，廠牌、功能不拘 *請在答案卷內作答

須有計算過程

This two-page, 100-min examination contains six big questions and the perfect scores are 100. Please write down all units and circle your final answers in the booklet.

參考用

1. **(10 pt)** Given this reaction: $CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow 2H_2O_{(g)} + CO_{2\,(g)}$ what are the ΔG values at standard conditions and at 477°C ?

	$CH_{4\,(g)}$	$2O_{2\,(g)}$	$2H_2O_{(g)}$	$CO_{2\,(g)}$
$H_f°$ ($^{kJ}/_{mol}$)	-74.87	0	-241.83	-393.509
S° ($^{J}/_{K\cdot mol}$)	186.26	205.07	188.84	213.74
$G_f°$ ($^{kJ}/_{mol}$)	-50.8	0	-288.59	-394.359

2. **(15 pt)** The reversible (elementary) reaction $2A \leftrightarrow C + D$ is conducted in a CSTR at a feed rate of 100 liters/min with an inlet concentration C_{A0}=1.5 mol/L. The specific rate in the forward direction is 10 L/mol-min and the equilibrium constant is 16. 80% of the equilibrium conversion is required. Find the size of a CSTR to achieve this conversion.

3. There is an elementary liquid-phase reaction $A+B \rightarrow C$, in which k = 0.07 dm^3/mol-min at 300 K and E = 20 kcal/mol. The concentration of the A and B streams are 2 M before mixing and the volumetric flow rate of each stream is 5 dm^3/min.
   (a) **(5 pt)** What conversion would be obtained if the 200 dm^3 CSTR and 800 dm^3 PFR were operated at 300 K and connected in series?
   (b) **(5 pt)** This reaction is originally carried out isothermally in an 800 dm^3 PFR at 300 K. If you want to use another CSTR which can be operated at 77°C isothermally, what size should this CSTR be to achieve the same conversion?
   (c) **(5 pt)** How long would it take to achieve 90% conversion in a 200 dm^3 batch reactor with $C_{A0} = C_{B0}$ = 1 M after mixing at a temperature of 77°C?

4. **(10 pt)** There are two elementary gas reactions carried out isothermally:

$$A \xrightarrow{k_1} R \xrightarrow{k_2} S, \quad R + S \xrightarrow{k_3} RS$$

Pure A is charged to the reactor at a pressure of 117 kPa at 700 K. The specific reactions are $k_1 = 1.0\times10^{-3}$ (s^{-1}), $k_2 = 1.2\times10^{-3}$ (s^{-1}), and $k_3 = 1.6\times10^{-3}$ (dm^3/mol-s). What would be the exit concentrations from a CSTR operated a space time of 1000 s?

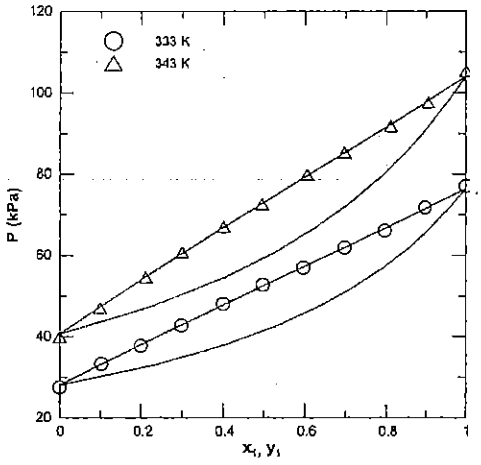
注意：背面有試題

5. The phase diagram of the vapor-liquid equilibrium (VLE) is one of important information for the analysis of vapor-liquid separation processes, such as distillation. Thus, it is essential for a chemical engineer to understand how to read a VLE phase diagram and how to estimate the composition of the vapor and liquid in equilibrium.

   (a) **(5 pts)** According to the following *P-x-y* diagram of the binary mixture of hexane(1) + heptane(2) at 333 and 343 K, [adapted from K. J. Lee, et al., *J. Taiwan Inst. Chem. Eng.*, 40, 573 (2009).] please write down the dew point pressure and the bubble point pressure at 343 K under equimolar condition.

   (b) **(10 pts)** A stream contains 50 mol% *n*-hexane (C6), 25 mol% *n*-heptane (C7), and 25 mol% *n*-octane (C8) and is to be processed at 343 K. What is the bubble point pressure of this mixture and the vapor phase composition that results?

   (c) **(10 pts)** What is the dew point pressure of the mixture in (b) and the liquid phase composition that results?



   The following data are available: $P_{C6}^{vap} = 1.049$ bar, $P_{C7}^{vap} = 0.402$ bar, and $P_{C8}^{vap} = 0.157$ bar at 343 K.

6. Consider the cell: $Co(s)|Co^{2+}(C_1)||Ni^{2+}(C_2)|Ni(s)$ at 25°C

   (a) **(5 pts)** Write the cathode reaction, anode reaction and net cell reaction.

   (b) **(5 pts)** Calculate $\Delta\varepsilon_{cell}°$, $\Delta G°$, and K_{eq}.

   (c) **(5 pts)** Calculate Q, $\Delta\varepsilon_{cell}$, ΔG when $C_1 = 1.00$ M and $C_2 = 0.0010$M.

   (d) **(5 pts)** Will the reaction proceed spontaneously from left to right when all substances are in their standard states?

   (e) **(5 pts)** Will the reaction proceed spontaneously from left to right when $C_1 = 1.00$ M and $C_2 = 1.0 \times 10^{-3}$M?

Useful Information: Gas constant = $R = 8.3144$ J·mol^{-1}K^{-1}; Faraday constant = $F = 96485$ C·mol^{-1}; Reaction quotient = Q; Equilibrium constant = K_{eq}; Number of moles = n; $\Delta G = RT \ln (Q/K)$ and $\Delta G = -nF\Delta\varepsilon_{cell}$; $Ni^{2+} + 2e^- \rightarrow Ni(s)$, $\varepsilon° = -0.25$ volts; $Ni(OH)_2(s) + 2e^- \rightarrow Ni(s) + 2OH^-$, $\varepsilon° = -0.72$ volts; $Co^{2+} + 2e^- \rightarrow Co(s)$, $\varepsilon° = -0.28$ volts; $2H^+(aq) + 2e^- \rightarrow H_2(g)$, $\varepsilon° = 0.0000$ volts; $2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-$, $\varepsilon° = -0.8277$ volts.

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