

國立中央大學 107 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 3 頁 第 1 頁

科目： 化工熱力學及化學反應工程

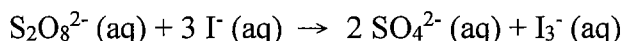
本科考試可使用計算器，廠牌、功能不拘

*請在答案卷(卡)內作答

選擇題(A1)大題請在答案卡內作答。計算題與問答題(B1)~(B5)大題請在答案卷內作答，計算題請詳列計算過程。

(A1) (25 pts)

Choose the one alternative that best completes the statement or answers the question. The peroxydisulfate ion ($S_2O_8^{2-}$) reacts with the iodide ion in aqueous solution via the reaction:



An aqueous solution containing 0.050 M of $S_2O_8^{2-}$ ion and 0.072 M of I^- is prepared, and the progress of the reaction followed by measuring $[I^-]$. The data obtained is given in the table below.

Time (s)	0.000	400.0	800.0	1200.0	1600.0
[I ⁻] (M)	0.072	0.057	0.046	0.037	0.029

1. The average rate of disappearance of I^- between 400.0 s and 800.0 s is _____ M/s.
 (A) 5.8×10^{-5} (B) 1.4×10^{-5} (C) 2.6×10^{-4} (D) 2.8×10^{-5} (E) 3.6×10^{-4}
2. A second-order reaction has a half-life of 18 s when the initial concentration of reactant is 0.71 M. The rate constant for this reaction is _____ $M^{-1}s^{-1}$.
 (A) 2.0×10^{-2} (B) 18 (C) 3.8×10^{-2} (D) 7.8×10^{-2} (E) 1.3
3. A compound decomposes by a first-order process. If 13% of the compound decomposes in 60 minutes, the half-life of the compound is _____.
 (A) -5 (B) 299 (C) 20 (D) 12 (E) -18
4. The rate constant for a particular zero-order reaction is $0.075 M s^{-1}$. If the initial concentration of reactant is 0.537 M, it takes _____ s for the concentration to decrease to 0.100 M.
 (A) 7.2 (B) 0.040 (C) 5.8 (D) -0.047 (E) -5.8
5. The reaction

$$2 NOBr (g) \rightarrow 2 NO (g) + Br_2 (g)$$
 is a second-order reaction with a rate constant of $0.80 M^{-1}s^{-1}$ at 11 °C. If the initial concentration of NOBr is 0.0440 M, the concentration of NOBr after 6.0 second is _____.
 (A) 0.0348 M (B) 0.0324 M (C) 0.0363 M (D) 0.0276 M (E) 0.0402 M

參考用

注意:背面有試題

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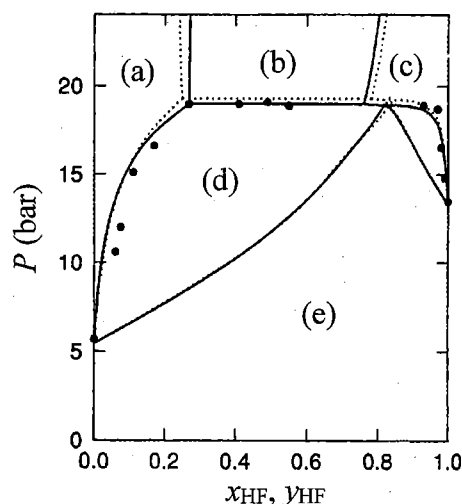
(B1) (25 pts)

The first-order, irreversible reaction ($A \rightarrow B$) takes place in a 0.3 cm radius spherical catalyst pellet at $T = 450$ K. At 0.7 atm partial pressure of A, the pellet's production rate is -2.5×10^{-5} mol/(g s). Determine the production rate at the same temperature in a 0.15 cm radius spherical pellet. The pellet density is $\rho_p = 0.85$ g/cm³. The effective diffusivity of A in the pellet is $D_A = 0.007$ cm²/s.

Hint: $R_{Ap} = -\eta k c_{As}$, $\Phi = \sqrt{\frac{k a^2}{D_A}}$, and $\eta = \frac{1}{\Phi} \left[\frac{1}{\tanh 3\Phi} - \frac{1}{3\Phi} \right]$

(B2) (10 pts)

Understanding phase diagrams of various types of fluid phase behaviors is essential for a chemical engineer. According to the vapor-liquid-liquid equilibrium phase diagram for HF/C₂F₃Cl₃ at 383.15 K [adapted from M. Lencka and A. Anderko, *AIChE J.*, 39, 533 (1993)], please write down the type of phase (solid, vapor, or liquid) or phase equilibrium (solid-liquid, solid-vapor, vapor-liquid, liquid-liquid, solid-vapor-liquid, or vapor-liquid-liquid) for regions marked as (a) - (e).



(B3) (15 pts)

Consider a liquid mixture of components 1, 2, 3, and 4. The excess Gibbs energies of all the binaries formed by these components obey relations of the form

$$g_{ij}^{EX} = A_{ij} x_i x_j$$

where A_{ij} is the constant characteristic of the i - j binary. Derive an expression for the activity coefficient of component 1 in the quaternary solution.

注意:背面有試題

參考用

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(B4) (10 pts)

In a binary liquid mixture of B and C at constant temperature and pressure, the excess Gibbs energy of mixing is given explicitly by an empirical equation in terms of the mole fractions of B and C

$$\frac{\Delta G^{EX}}{RT} = f[x_B, x_C] = x_B x_C [k_1 + k_2(x_B - x_C) + k_3(x_B - x_C)^2]$$

where for the particular conditions of interest, $k_1 = 2.0$, $k_2 = 0.2$, and $k_3 = -0.8$.

Determine if there are regions of immiscibility and any limits of essential instability.

(B5) (15 pts)

- (5 pts) Derive the Gibbs-Duhem equation for a binary solution. State clearly any assumptions made. What is the physical meaning of the Gibbs-Duhem equation?
- (5 pts) According to the Gibbs-Duhem equation, please proof that if material B in the A-B binary mixture behaves ideally, the A does also? Also, please proof that the component B obeys the Henrian behavior if the component A obeys the Raoultian behavior at $x_A \rightarrow 1$?
- (5 pts) The osmotic coefficient, ϕ , is defined as

$$\phi = -\frac{x_A}{x_B} \ln a_A$$

By writing $r = x_B/x_A$ and using the Gibbs-Duhem equation, show that we can calculate the activity (a_B) of B from the activities of A over a composition range by using the formula

$$\ln\left(\frac{a_B}{r}\right) = \phi - \phi(r=0) + \int_0^r \left(\frac{\phi-1}{r}\right) dr$$

where x_i denotes the mole fraction of component i .

參考用