

國立中央大學 110 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4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

一、單選題(佔 24 分，每題 2 分)

1. A first order gaseous phase reaction is catalyzed by a non-porous solid. The kinetic rate constant and the external mass transfer coefficients are k and k_g respectively. The effective rate constant (k_{eff}) is given by
 - A. $k_{eff} = k + k_g$
 - B. $k_{eff} = (k + k_g)/2$
 - C. $k_{eff} = (kk_g)^{1/2}$
 - D. $1/k_{eff} = 1/k + 1/k_g$
2. The half-life period of a first order reaction is given by (where k = rate constant).
 - A. $1.5/k$
 - B. $2.5/k$
 - C. $0.693/k$
 - D. $6.93/k$
3. The eddy diffusivity for a liquid in plug flow must be
 - A. 1
 - B. 0
 - C. ∞
 - D. Between 0 and 1
4. The most suitable reactor for carrying out an auto-thermal reaction is a
 - A. Batch reactor
 - B. CSTR
 - C. Semi-batch reactor
 - D. Plug-flow reactor
5. In an ideal tubular-flow reactor
 - A. There is no mixing in longitudinal direction.
 - B. Mixing takes place in radial direction.
 - C. There is a uniform velocity across the radius.
 - D. All of the above.
6. A batch reactor is suitable for:
 - A. Achieving 100 percent conversion of reactants into products
 - B. Large scale gaseous phase reactions
 - C. Liquid phase reactions
 - D. Obtaining uniform polymerization products in highly exothermic reactions

注意:背面有試題

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7. If Thiele modulus is _____, then the pore diffusion resistance in a catalyst may be considered as negligible.
- A. 0
 - B. ∞
 - C. < 0.5
 - D. > 0.5
8. Which of the following chemical reactions will be favored by low pressure?
- A. $2\text{HI} = \text{H}_2 + \text{I}_2$
 - B. $\text{N}_2\text{O}_2 = 2\text{NO}$
 - C. $\text{N}_2 + \text{O}_2 = 2\text{NO}$
 - D. None of these
9. In an exothermic chemical reaction, the reactants compared to the products have:
- A. Higher temperature
 - B. More energy
 - C. Less energy
 - D. Same energy
10. In Langmuir treatment of adsorption,
- A. Whole surface of the catalyst does not have the same activity for adsorption and there is attraction between the adsorbed molecule
 - B. Whole surface of the catalyst is essentially uniform and the adsorbed molecule has no effect on the rate of adsorption per site
 - C. All the adsorption does not take place by the same mechanism
 - D. Extent of adsorption is more than one complete monomolecular layer on the surface
11. Conversion increases with increase in temperature in case of a/an _____ reaction.
- A. Autocatalytic
 - B. Irreversible
 - C. Reversible endothermic
 - D. Reversible exothermic
12. Half life period of decomposition of a liquid "A" by irreversible first order reaction is 12 minutes. The time required for 75% conversion of "A" is _____ minutes.
- A. 18
 - B. 24
 - C. 6
 - D. 12

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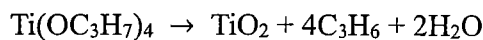
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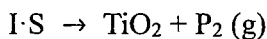
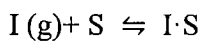
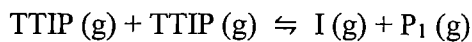
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二、計算題(佔 76 分)

1. Titanium dioxide is a wide-bandgap semiconductor that is considered as an insulating dielectric in VLSI capacitors and for use in solar applications such as solar cells and photocatalyst. Thin films of TiO_2 can be prepared using chemical vapor deposition from gaseous titanium tetra-isopropoxide (TTIP). The overall reaction is



The reaction mechanism in a CVD is believed to be



Where I is an active intermediate, S is an active site, P_1 is one set of reaction products (e.g. H_2O , C_3H_6) and P_2 is another set. Assuming the homogeneous gas-phase reaction for TTIP is in equilibrium, please answer the following question

- (a) (18%) Derive a rate law for the deposition of TiO_2
- (b) (8%) The experimental results show that at 200°C the reaction is second order at low partial pressure of TTIP and zero order at high partial pressures. While at higher temperature (300°C) the reaction is second order in TTIP over the entire pressure range. Discuss these results based on the rate law derived above. [Hint: adsorption is exothermic in general]
2. (10%) The intensive state of a PVT system containing N chemical species and π phases is in equilibrium. Show that the phase rule is: $F = 2 - \pi + N$, where F is the degree of freedom of the system.
3. For the steady-state, adiabatic, irreversible flow of an incompressible liquid in a horizontal pipe of constant cross-sectional area, show that:
- (a) (5%) The velocity is constant,
- (b) (5%) The temperature increases in the direction of flow, and
- (c) (5%) The pressure decreases in the direction of flow
- (Hint: $dH = C_P dT + (1 - \beta T) V dP$ and $dS = C_P (dT/T) - \beta V dP$ where β is defined as the volume expansivity and C_P is the heat capacity at constant pressure).

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4. It is necessary to determine the vapor-liquid equilibrium composition for designing a separation process for a binary mixture of perfluoro-*n*-heptane and *n*-heptane at 25 °C. At this temperature, the vapor pressure of pure perfluoro-*n*-heptane is 0.1101 bar, and the vapor pressure of pure *n*-heptane is 0.0601 bar.

(a) (6%) Calculate the composition of the vapor in equilibrium with a liquid containing 60 mol % perfluoro-*n*-heptane and 40 mol % of *n*-heptane at 25 °C and 0.6 bar, assuming the solution is ideal.

(b) (10%) Please derive the expressions of the activity coefficient for both components in a binary mixture, assuming the solution obeys the regular solution theory. The excess Gibbs energy equation of the regular solution theory is as following: $G^{ex} = (x_1V_1 + x_2V_2)\Phi_1\Phi_2(\delta_1 - \delta_2)^2$, where δ_i is solubility parameter of component *i* and Φ_i is volume fraction of component *i*: $\Phi_i = x_iV_i / \sum_i x_iV_i$

(c) (6%) Recalculate the composition in part (a), assuming the solution obeys the regular solution theory. The regular solution parameters are

Compound	V^L (cm ³ /mol)	δ (cal/cc) ^{1/2}
perfluoro- <i>n</i> -heptane	226	12.3
<i>n</i> -heptane	148	7.4

(d) (3%) Which model (ideal solution or regular solution) provides better estimation of gas phase compositions? Please give the reason according to the gas phase composition results in (a) and (c).

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