國立中正大學
111 學年度碩士班招生考試
試 題

[第 3 節]

科目名稱	化工熱力學與化工動力學
系所組別	化學工程學系

－作答注意事項－

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1.預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

2.考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。

3.入場後於考試開始 40 分鐘內不得離場。

4.全部答題均須在試卷（答案卷）作答區內完成。

5.試卷作答限用藍色或黑色筆（含鉛筆）書寫。

6.試題須隨試卷繳還。

國立中正大學 111 學年度碩士班招生考試試題

科目名稱：化工熱力學與化工動力學　　本科目共 3 頁　第 1 頁

系所組別：化學工程學系

第一部分: 選擇題 (單選題，每題 7 分，共 10 題)

[考生作答須知]　務必閱讀後，再進行作答

本試卷選擇題不使用答案卷上之選擇題作答區(1~80 題)進行作答，請在下方作答區中自行標示選擇題題號，依題號順序作答。每題選擇題除作答正確選項外，必須於答案卷上提供您的完整計算過程，並與作答答案相符才計分。若答案為猜測、無計算過程或湊出答案，即使作答選項正確，仍不予計分。若(A)~(E)選項中無適合之正確選項，則作答(F)以上皆非，並寫下正確答案。

1. A rigid vessel of 0.1 m^3 volume contains an ideal gas (C_p = 3.5 R) at 400 K and 1 bar. If heat in the amount of 20000 J is transferred to the gas, determine its entropy change.
(A) 52.5 J/K (B) 36.7 J/K (C) 22.7 J/K (D) 38.9 J/K (E) 45.8 J/K

2. One mole of a monatomic ideal gas at 500 K and 2000 kPa expands adiabatically to four times its initial volume. Assuming these processes are mechanically reversible, the work done by the gas is
(A) 2178 J (B) 4207 J (C) 1984 J (D) 3761 J (E) 5322 J.

3. At 25°C, the standard heats of formation of HCl(g) and H_2O(g) are –92370 J and –241818 J, respectively. The standard heat of reaction for $4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g)$ is
(A) –114408 J (B) –334188 J (C) –149448 J (D) –127662 J (E) –391266 J.

4. Calculate the internal energy change for 1 kg of water when it is vaporized at 100°C and 1 atm. The specific volumes of liquid and vapor water at theses conditions are 0.00104 and 1.673 m^3/kg, respectively. For this change, heat in the amount of 2256.9 kJ is added to the water.
(A) 2051.6 kJ (B) 2256.9 kJ (C) 2436.3 kJ (D) 2165.8 kJ (E) 2087.5 kJ

5. For a binary solution at 1 atm, the excess Gibbs energy is given by $G^E / RT = x_A x_B(-4x_A - 2x_B)$
The Gibbs free energies of species A and B at 500K are 2250 J/mol and 3670 J/mol, respectively. Determine the total Gibbs energy of this binary system at 500K and x_A = 0.3.
(A) –1785 J/mol (B) –1565 J/mol (C) –1680 J/mol (D) –1455 J/mol (E) –1835 J/mol

6. For a bimolecular reaction, the reaction rate at 500 K is 10 times faster than that at 400 K. Please calculate the activation energy by collision theory.
(A) 38287 cal/mol (B) 9150.5 cal/mol (C) 36432 cal/mol (D) 8707 cal/mol (E) 4354 cal/mol

7. A first-order liquid phase reaction A → B is carried out in a batch reactor. The reaction is exothermic. An inert coolant (C) is added to the reaction mixture to control the temperature. The temperature is kept constant by varying the flow rate the coolant. At initial, vessel contains only A (no B or C present) and the initial volume is 50 ft^3. The concentration of C_{A0} is 0.5 lb·mol/ft^3. What is the flow rate of the coolant 2 h after the start of the reaction?

(A) 1.58 lb/s (B) 3.16 lb/s (C) 4.93 lb/s (D) 6.32 lb/s (E) 7.39 lb/s

Additional information:

- Temperature of reaction: 100°F
- Value of k at 100°F: 1.2×10^{-4} s^{-1}
- Heat capacity of all components: 0.5 Btu/lb·°F
- Temperature of coolant: 80°F
- Density of all components: 50 lb/ft^3
- ΔH_{RX}^{o}: –25000 Btu/lb·mol

8. A liquid phase reaction of A (2^{nd} order) is conducted in a batch reactor. 25% of A is converted in 3 min. How many minutes would it take to reach 80% conversion?

(A) 6 (B) 12 (C) 18 (D) 24 (E) 36

9. For the 1^{st}-order reactions in series $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ with $k_1 = k_2 = 0.4$ min^{-1}, calculate the time required to reach the maximum concentration of B.

(A) 2.5 (B) 4 (C) 4.5 (D) 5 (E) 6

10. A second-order liquid phase reaction, A → products, is carried out in a CSTR reactor and the conversion is 0.5. If the volume of the reactor is enlarged to 6 times the original size and other conditions are unchanged, what is the conversion of A?

(A) 0.25 (B) 0.5 (C) 0.75 (D) 0.8 (E) 0.85

第二部分：計算題（每題 15 分，共 2 題）

[考生作答須知] 計算題需有完整計算過程，並清楚標示各小題答案。

1. Consider a binary mixture (A and B) system at vapor-liquid equilibrium at 25°C and 12 bar. The molar fraction of component A in the liquid phase is 0.05. The molar fraction of component B in the vapor phase is only 0.08. The compressibility factor of pure component A gas at 25°C is given by $Z = 1 - 3\times10^{-3} P$ (P: bar).

   (a) Calculate the fugacity of component A in the liquid phase. (7%)
   (b) Calculate the Henry's constant of component A dissolved by component B liquid. (4%)
   (c) Assumed the species B follows the Lewis/Randall rule, calculate the saturated pressure of B. (4%)

2. Consider the following system of gas-phase reactions:

$$A \rightarrow X \qquad r_X = k_1 C_A^{0.5} \qquad k_1 = 0.004\ (\text{mol/dm}^3)^{1/2}\cdot\text{min}$$
$$A \rightarrow B \qquad r_B = k_2 C_A \qquad k_2 = 0.3\ \text{min}^{-1}$$
$$A \rightarrow Y \qquad r_Y = k_3 C_A^2 \qquad k_3 = 0.25\ \text{dm}^3/\text{mol}\cdot\text{min}$$

   B is the desired product, and X and Y are foul pollutants that are expensive to get rid of. The specific reaction rates listed above are at 27°C. The reaction system is to be operated at 27°C and 4 atm. Pure A enters the system at a volumetric flow rate of 10 dm^3/min.

   (a) Consider a series of reactors for maintaining the selectivity ($S_{B/X+Y}$) as high as possible. What should be the volume of the first reactor? (10%)
   (b) What is the effluent concentration of B from the first reactor? (3%)
   (c) What is the conversion of A in the first reactor? (2%)