國立中正大學
113學年度碩士班招生考試
試題
[第2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

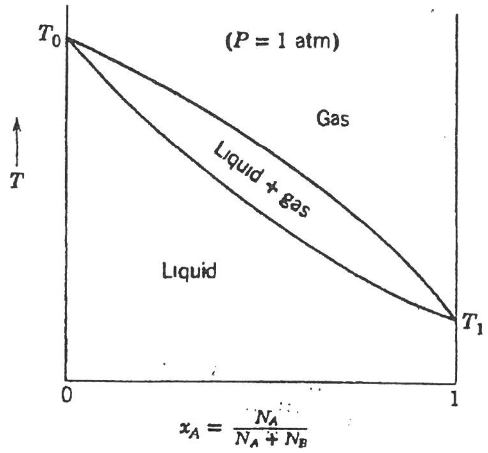
—作答注意事項—

※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。

(1) It is found that a certain liquid boils at a temperature of 90°C at the top of a mountain, and boils at a temperature of 110°C at the bottom of the mountain. The latent heat is 1000cal/mole. What is the approximate height of the hill? (12%)

(2) The phase diagram of a solution of A in B, at a pressure of 1 atm, is as shown.



The upper bounding curve of the two-phase region can be represented by

$T = T_0 - (T_0 - T_1)\, X_A^2$

The lower bounding curve can be represented by

$T = T_0 - (T_0 - T_1)\, X_A^2\,(2 - X_A)$

A beaker containing equal mole number of A and B is brought to its boiling temperature. What is the composition of the vapor as it first begins to boil? (10%) Does boiling tend to increase or decrease the mole fraction of A in the remaining liquid? (4%)

(3) Ten mole of an idea gas with Cp = 36(J/gmole·K) is compressed isobarically but irreversibly at 5bar from 500K to 300K in a piston cylinder device. The work required in 35% greater than the work of reversible, isobaric compression. The heat transferred from the gas during compression flows to a heat reservoir at 300K. Please calculate (24%)

(a) What is the ΔW (under a reversible process);
(b) What is the ΔW (under an irreversible process);
(c) What is the ΔU of the gas;
(d) What is the ΔS of the gas;
(e) What is the ΔS of the heat reservoir;
(f) What is the total ΔS of the system

(4) An elementary irreversible liquid-phase reaction $2A \rightarrow B$ takes place with 92 % conversion in an isothermal plug flow reactor. If the plug flow reactor is replaced by a CSTR of the same size, what will be the conversion? All the other conditions remain unchanged. (15 %)

(5) The oxidation of compound A to form compound B is carried out on a catalyst. However, compound B is also oxidized on this catalyst to form compound C. The reactions are irreversible and first order in compounds A and B, respectively. The reaction is carried out in a three-fold excess of oxygen and in dilute concentrations (ca. 0.1 % compound A, 1% O_2, and 98.9% N_2). The volume change with the reaction can be neglected. Please determine the concentration of compound B as a function of space-time. (20%)

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

(6) For the elementary and gas-phase reaction, $A + B \rightarrow C + D$, being carried out isothermally in a packed bed reactor (PBR), reactants A and B are fed in equal molar with the total molar rate of 10 mole·min^{-1}. The initial pressure is 12 atm, the temperature is 423 K, and the pressure drop parameter is 0.01 g^{-1}. Please determine the catalyst weight to achieve 85% conversion. (15 %)

Additional information:

(i) The pressure inside PBR should be kept above 1 atm.

(ii) Specific reaction rate at 423 K, k = 50 liter^2·(mole·g catalyst·min)$^{-1}$.

(iii) Differential form of Ergun equation for the pressure drop in packed beds:

$$\frac{dy}{dW} = -\frac{\alpha}{2y}(1+\epsilon X)\frac{T}{T_0}$$

where α is the pressure drop parameter and $y = P/P_0$

Useful Integrals in Reactor Design

$$\int_0^x \frac{dx}{1-x} = \ln\frac{1}{1-x}$$

$$\int_{x_1}^{x_2} \frac{dx}{(1-x)^2} = \frac{1}{1-x_2} - \frac{1}{1-x_1}$$

$$\int_0^x \frac{dx}{(1-x)^2} = \frac{x}{1-x}$$

$$\int_0^x \frac{dx}{1+\varepsilon x} = \frac{1}{\varepsilon}\ln(1+\varepsilon x)$$

$$\int_0^x \frac{(1+\varepsilon x)dx}{1-x} = (1+\varepsilon)\ln\frac{1}{1-x} - \varepsilon x$$

$$\int_0^x \frac{(1+\varepsilon x)dx}{(1-x)^2} = \frac{(1+\varepsilon)x}{1-x} - \varepsilon\ln\frac{1}{1-x}$$

$$\int_0^x \frac{(1+\varepsilon x)^2dx}{(1-x)^2} = 2\varepsilon(1+\varepsilon)\ln(1-x) + \varepsilon^2 x + \frac{(1+\varepsilon)^2 x}{1-x}$$