110BE03

國立臺北科技大學 110 學年度碩士班招生考試

系所組別：3510 化學工程與生物科技系化學工程碩士班甲組

第二節　化工熱力學與反應工程　試題

注意事項：

1. 本試題共 4 題，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1.One hundred moles per minute of a binary mixture of 50% A and 50% B are separated in a two-stage (serial) process. In the first stage, the liquid and vapor flow rates exiting from the stage are each 50 mol/min. The liquid stream is then passed into a second separator that operates at the same temperature as the first stage. The temperature is the same for each stage, and at that temperature, the vapor pressure of A is 10 kPa and the vapor pressure of B is 100 kPa. Treat the liquids and vapors as ideal. Calculate the compositions of the vapor and liquid streams, and the pressure in the first stage. (30%)

2. One mole of a gas is placed in a closed system with a 0.02 m^3 vessel initially at T = 300 K. The vessel is then isothermally expanded to 0.04 m^3. The gas follows the equation of state:

$$P = \frac{RT}{\overline{V}} + \frac{a}{\overline{V}^2}$$

where a=–4.053 m^6 Pa/mol^2 and R=8.314 J/mol K.

(1) Derive an expression relating $(\partial \overline{H} / \partial \overline{V})_T$ to measurable properties. (10%)

(2) Find $\Delta \overline{H}$ for the gas in this process. (10%)

<Hint> Expansion rule: $\left(\frac{\partial X}{\partial Y}\right)_Z = \left(\frac{\partial X}{\partial K}\right)_L \left(\frac{\partial K}{\partial Y}\right)_Z + \left(\frac{\partial X}{\partial L}\right)_K \left(\frac{\partial L}{\partial Y}\right)_Z$

3. Consider a second-order reaction 2A→B+C, which is occurred in 20 meters of $1\frac{1}{2}$ schedule 40 pipe packed with catalyst. There is 104.4 lb_m/h of gas flowing through the bed with the entering pressure of 101300 Pa. Temperature was kept at 260°C. Entering volumetric flow rate (v_0) is 6.5 m^3/h. Cross-sectional area of pipe is 0.0013 m^2. Catalyst pellet size is 6 mm; catalyst bulk density is 1800 kg/m^3. Pressure drop parameter (β_0) is 2580 Pa/m. Assume specific reaction rate constant (k) is independent of particle size; k = 0.012 m^6/mol· kg cat.·h. Calculate the conversion with and without pressure drop. (20%) If the catalyst size increases by a factor of 2, what is the conversion with pressure drop? (10%)

4. Consider the reaction mechanism:

$X + S \rightleftharpoons X \cdot S$ (A)

$X \cdot S + Y \rightleftharpoons Z \cdot S$ (B)

$Z \cdot S \rightleftharpoons Z + S$ (C)

(1) Derive a rate law assuming surface reaction is rate-limiting. (10%)

(2) Derive a rate law assuming adsorption of X is rate-limiting. Let Y adsorb on catalyst surface and react with X · S. (10%)

<Hint> Modified (B) and add one extra adsorption reaction.