國立台灣科技大學九十九學年度碩士班招生試題

系所組別： 化學工程系碩士班

科　　目： 化工熱力學與動力學

（總分為100分）

總分 100 分 (100%)

Part I. 化工熱力學 (50%)

1. (25%) Since the gas pumping is usually quick compared with heat transfer, the operation of a compressor can be regarded as adiabatic. Knowing that the inlet to a compressor is air at 5 mol/s (which we will assume to be an ideal gas with C_p = 29.3 J/mol K) at 1 bar and 27°C and the discharge is at a pressure of 10 bar, please:
   a) Define the system and formulate the mass, energy, and entropy balance equations (4%)
   b) Estimate the temperature of the exit gas (8%)
   c) The rate at which work is done on the gas (8%)
   d) How can we assess if the compression is indeed an adiabatic process? (5%)

2. (25%) Concerns over food shortage and biofuel have driven scientists to look for ways to increase plant growth rate. To assess if plants grow faster under high pressure, scientists designed experiments to find out. A perfectly insulated pressurized room at 4 bar and 27 °C containing 10 m^3 of 50 %CO_2, and 50 % O_2 (assumed ideal gas) was used. The gases need to be vented down to 1 bar during routine sampling and maintenance once every three months. The gases therefore need to be pumped in afterwards. It was found that early experiments failed since the temperature in the room could not be kept constant at 27 °C during inflow of gas. A chemical engineer involved in the research project came up with the idea of adding a cooler in the room. Thus, a 100 W (J/s) electric cooler is switched on when the gas is flowing into the pressurized room. A control valve is used to adjust gas flow rate so that the temperature in the room is constant at 27 °C. Please:
   a) Define the system and formulate the mass, energy, and entropy balance equations (4%)
   b) Give us some reasons why the electric cooler is needed to keep the temperature constant? (5%)
   c) What is the flow rate of gas into the room that you recommend based upon chemical engineering thermodynamics? (8%)
   d) How long will it take to increase the pressure from 1 bar to 4 bar? (8%)

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Part II. 化工動力學**(50** 分**)**

1.今於 PFR (plug flow reactor)中進行下列氣相反應：

$$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$$

已知反應溫度爲 227°C，壓力爲 16.4 atm，進料只有 A 及 B，其莫耳流率皆爲 1 mol/s，試問當 H_2的轉化率達 60%時，氮、氫及氨的濃度各爲若干？(16 分)

2. 磷化氫(phosphine)的分解爲一階不可逆(first order and irreversible)，

$$4PH_3(g) \rightarrow P_4(g) + 6H_2(g)$$

在 650°C 時，其反應速率常數爲 $3.28\times10^{-3}\ s^{-1}$，今以定容批式反應器在 650°C 進行磷化氫的分解，初時反應器中只有磷化氫，其壓力爲 1 atm (650°C)，試問在反應 100 秒後反應器的壓力爲何？(17 分)

3. 今使用一個 CSTR (continuous stirred tank reactor)進行下列液相反應：

$$A \xrightarrow{k_1=0.1/min} B \xrightarrow{k_2=0.1/min} C$$

已知進料中只有 A，其濃度爲 C_{A0}= 1 mol/dm^3，試証明在滯留時間(residence time)爲 $1/k_1$時，反應器中 B 的濃度爲最大，並計算此濃度值。(17 分)