國立臺灣科技大學
九十四學年度碩士班招生考試試題
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 100 分

Part I. 化工熱力學（50%）

（1）For a gas at a pressure low enough so that the virial expansion may be truncated to $Z = 1 + B'P$, where Z is the compressibility factor, B' is the second virial coefficient and P is the pressure. What is the work (W) required in a reversible isothermal compression process operated at a temperature of T (K) from the initial state (P_i, $\underline{V}_i$) to the final state (P_f, $\underline{V}_f$)? P_i (or P_f) and $\underline{V}_i$ (or $\underline{V}_f$) are the pressure and molar volume of the gas in the initial (or final) state, respectively. What would happen to the work done on the gas if the process is operated at a higher temperature? (15%)

（2）Two rigid tanks are connected by a valve. One tank contains 2 kg of CO at 77 ℃ and 0.7 bar and the other holds 8 kg of the same gas at 27 ℃ and 1.2 bar. The valve is then opened and the gases are allowed to mix while receiving energy by heat transfer from the surroundings. The final equilibrium temperature is 42 ℃. Using the ideal gas model, determine the final equilibrium pressure and the heat transfer for the process. $C_v = 0.745$ kJ/kg-K (20%)

（3）A brilliant chemical engineer claims to have developed a power cycle capable of delivering a net work output of 450 kJ for an energy input by heat transfer of 1000 kJ. The system undergoing the cycle receives the heat transfer from hot gases at a temperature of 227 ℃ and discharges energy by heat transfer to the atmosphere at 27 ℃. Evaluate the validity of this claim. (7%)

（4）An adiabatic compressor is used to compress air that can be

80

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regarded as an ideal gas from 1 bar and 17 ℃ to 10 bar and 302 ℃. What is the entropy change for this process? How much work per mole of air is needed for the compression? C_p = 29.3 J/mol-K, R = 8.314 J/mol-K (8%)

81

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Part II 化工動力學

(5) (a) Please derive **a general mole balance equation** for a reactor system. (5%)
(b) Please give the **conditions or assumptions** to get the reactor design equation of a **batch** reactor **in terms of conversion**. (5%)
(c) Please give **the conditions or assumptions** to get the reactor design equation of a continuously stirred tank reactor **(CSTR) in terms of conversion**. (5%)
(d) Please give the conditions or assumptions to get the reactor design equation of a plug flow reactor **(PFR) in terms of conversion**. (5%)

(6)(a) Please make **a general stoichiometric table** for the gas reaction $A + (b/a)B \rightarrow (c/a)C + (d/a)D$ in a flow system. In order to reduce the concentration of reactants inert gas (I) is also fed into the system. Assume that A is the limiting reactant. (10%)
(b)Please derive the C_A and volumetric flow rate (v) in terms of conversion (X) of species A in the case of ideal gases. (5%)

(7)You are designing a CSTR for the following gas-phase reaction:

$$A \rightarrow B \qquad r_B = k_1 C_A^2 \quad \text{where } k_1 = 2\ dm^3/mol\ s$$

Unfortunately, there is also a side reaction:

$$A \rightarrow C \qquad r_C = k_2 C_A \quad \text{where } k_2 = 1\ s^{-1}$$

C is a pollutant and costs money to dispose of; B is the desired product. **What size of reactor** will provide an effluent stream **for the conversion of A = 0.6** and what is **the overall selectivity of B** at this condition? If the volumetric flow rate is 10 dm^3/s and the concentration of species A in the entering stream is 1 mol/dm^3。(15%)

82