國立成功大學 106 學年度碩士班招生考試試題

系　所：化學工程學系

考試科目：化工熱力學

考試日期：0213，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. [17%]

One mole of an ideal monatomic gas initially at 300 K and 20 bar is expanded to a final pressure of 1 bar. What are the values of W, Q, ΔU, and ΔH in the following cases?

(1) The expansion is reversibly isothermal. **(5%)**

(2) The expansion is free isothermally. **(5%)**

(3) The gas is expanded adiabatically against an external pressure of 1 bar. **(7%)**

2. [16%]

(1) Calculate the heat of combustion for 1 mole of methane burnt completely in air at 25°C. **(4%)**

(2) Estimate the maximum temperature that can be reached by the combustion of methane with 25% excess in air. Both the methane and the air enter the burner at 25°C. Assume that heat capacities of all substances are independent of temperature. **(12%)**

***Given*:**

	ΔH_f^o (25°C) (kJ mol^{-1})	C_P^o (25°C) (J K^{-1} mol^{-1})
CH_4(g)	–74.81	35.309
H_2O(g)	–241.82	33.577
H_2O(l)	–285.83	75.291
CO_2(g)	–393.51	37.110
O_2(g)	0	29.355
N_2(g)	0	29.125

3. [20% (5% each)]

Is the statement true or false?　If the statement is false, please justify your answer.

(1) If many Carnot cycles are connected in series, supposed that the temperature difference in the heat reservoirs (T_H and T_C) of each cycle is small, then, the whole system is still considered as a Carnot cycle.

(2) The actual shaft work rate can be expressed by $\dot{W}_s = \Delta[(H + 1/2u^2 + zg)\dot{m}]_{fs} - T_\sigma \cdot \Delta(S\dot{m})_{fs}$ under the assumption of steady-state flow process.

(3) The throttling process for a flow system would result in pressure drop.

(4) For a pure species of one mole of a closed system, a reversible phase change when two phases are in equilibrium, then $T\Delta S = \Delta H$

4. [14%]

In Unit Operation, some devices are mentioned, for instance, Venturi meter. Please describe briefly what's the purpose of a Venturi meter (**4%**) and what is the correlation used for this device. (**4%**) (no need to write down the correlation equation!!)

It can be correlated to the concept of Thermodyanmics of flow processes. In the following, there are four equations, please choose those equation(s) that could be related to the concept of Venturi meter. (**6%**)

$$\frac{dP}{dx}=-\frac{T}{V}\cdot\left(\frac{1+\beta u^2/C_P}{1-M^2}\right)\cdot\frac{dS}{dx} \quad (1) \qquad u\frac{du}{dx}=T\cdot\left(\frac{\beta u^2/C_P+M^2}{1-M^2}\right)\cdot\frac{dS}{dx} \quad (2)$$

$$\frac{dP}{dx}=\frac{u^2}{VA}\cdot\left(\frac{1}{1-M^2}\right)\cdot\frac{dA}{dx} \quad (3) \qquad \frac{du}{dx}=-\frac{u^2}{A}\cdot\left(\frac{1}{1-M^2}\right)\cdot\frac{dA}{dx} \quad (4)$$

5. [20%]

Consider a liquid mixture made of x_1 moles of liquid *1* and x_2 moles of liquid *2* at a given temperature and pressure, in which $x_1 + x_2 = 1$. The van der Waals equations of state apply to both pure fluids (*1* and *2*) and the binary mixture, as follows:

$$P=\frac{RT}{V-b}-\frac{a}{V^2}$$, where ***a*** and ***b*** are two constants.

These two constants (***a, b***) for fluid *1*, fluid *2* and liquid mixture are given as (a_1, b_1), (a_2, b_2), and (a_m, b_m), respectively. Moreover, the following relation holds:

$$b_m = x_1 \cdot b_1 + x_1 \cdot b_1 \qquad \text{and} \qquad \sqrt{a_m}=x_1\cdot\sqrt{a_1}+x_2\cdot\sqrt{a_2}\,.$$

It is reasonable to expect the excess entropy S^E near zero ($S^E = 0$) in this liquid mixture. What is the excess Gibbs energy of G^E this liquid mixture? Please give G^E in terms of a_i, b_i and x_i (i = 1 and 2).

6. [13%]

If the excess Gibbs energy of a binary system at 35°C could be described as follows:

$$\frac{G^E}{RT}=Ax_1x_2$$, where *A* is a constant.

If the liquid phase at $T = 35^oC$ and $P = 108.6\ kPa$ contains liquid *1* with a mole fraction of $x_1 = 0.389$. At 35°C both fluids have saturated vapor pressure as $P_1^{sat} = 120.2\ kPa$ and $P_2^{sat} = 73.9\ kPa$, respectively.

(1) What is the value of *A* in the above equation of excess Gibbs energy? (7%)

(2) What is the corresponding mole fraction of *1* in vapor phase, y_1? (**6%**)