國立成功大學 107 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：0205，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。

Problem 1 (8%)

Answer False (F) or true (T). For those "false", you **MUST** justify your answer. If the answer is incorrect, the problem is considered wrong (gain zero score). (4% each)

(1) $Q = n\Delta H$ comes merely from the result of a constant-pressure closed system (homogenous, no chemical reaction, and static (no move) are surely the assumptions as well)

(2) A Joule-Thomson process is a type of isenthalpic process where a liquid or a gas is cooled as it passes from a lower pressure state to a higher pressure state.

Problem 2 (14%)

For a polytropic process $PV^{\delta} = \text{constant}$, as you already know that

$$Q = \frac{(\delta-\gamma)\cdot RT_1}{(\delta-1)(\gamma-1)}\cdot[(\frac{P_2}{P_1})^{(\delta-1)/\delta}-1] \qquad \textbf{Eq. (1)}$$

For an ideal gas undergoes **reversible** and **constant** V (isothermal) process, we can get to the result of

$Q = \Delta U = C_v \cdot \Delta T (= C_v \cdot (T_2 - T_1)$ **Eq. (2).** Please derive **from Eq. (1)** to get to the result of **Eq. (2)**.

[Note] Besides of the two equations as above, you would need, both the equations of ideal gas and polytropics.

Problem 3 (20%)

What is the final temperature when heat in the amount of 1.0 x 10^5 Btu is added to 10 lbmol of ammonia initially at 300°F in a steady-flow process at 1 atm? The coefficients of the ideal-gas heat capacity of ammonia are listed: $A = 3.60$; $B\cdot 10^3 = 3.02$; $C = 0.0$; $D\cdot 10^{-5} = -0.16$

[Note] Please proceed the calculation **FIVE** times **EXACTLY** by using the **initial guess** of **750°F** for the final temperature.

Problem 4 (8%)

One method for the manufacture of "synthesis gas" (primarily a mixture of CO and H_2) is the catalytic reforming of CH_4 with steam at high temperature and atmospheric pressure:

The major reaction for the reforming of CH_4 with steam is

$$CH_4\,(g) + H_2O\,(g) \rightarrow CO\,(g) + 3H_2\,(g) \qquad \textbf{Eq (A)}$$

The only other reaction which occurs to an appreciable extent is the water-gas-shift reaction:

$$CO\,(g) + H_2O\,(g) \rightarrow CO_2\,(g) + H_2\,(g) \qquad \textbf{Eq (B)}$$

The reactants are supplied in the ratio of 2.5-mole steam to 2.0-mole CH_4. It is assumed that CH_4 is completely converted and the product stream contains 20 mol% CO.

Please use the above two reactions to calculate and obtain the amounts (in moles) of all species in the product stream.

Problem 5 (15%)

If the excess Gibbs energy of a binary liquid system, G^E, is expressed as a function of the mole fractions of the components as $\dfrac{G^E}{RT} = Ax_1x_2$ (A: a constant).

(1) What is the range of A, if these two liquids form two coexisting liquid phases? (7%)

(2) If $A = 2.5$, what is the composition range of species 1 leading to the observation of two coexisting liquid phases in this system? (8%)

Problem 6 (20%)

A thermodynamic power cycle consists of four sequential thermodynamic processes described as follows:

Process 1: Isentropic compression from state **A** to state **B**.

Process 2: Isobaric heating from state **B** to state **C**.

Process 3: Isentropic expansion from state **C** to state **D**.

Process 4: Isochoric cooling (constant-volume) from state **D** to state **A**.

(1) Please sketch this cycle on a P-V diagram. (5%)

(2) If air is the working fluid of this power cycle and can be regarded as an ideal gas, please estimate the thermal efficiency (η) of this air-standard power cycle. Please express the thermal efficiency (η) in terms of $\gamma = C_P/C_V$, the compression ratio ($r = V_A/V_B$), the expansion ratio ($k = V_D/V_C$), and other proper thermodynamic variables. (15%)

Problem 7 (15%)

A binary system of species 1 and 2 consists of vapor and liquid phases in equilibrium at temperature T. The overall mole fraction of species 1 is $z_1 = 0.65$. At temperature T, the activity coefficients and the vapor pressures of species 1 and 2 are given as below:

$ln(\gamma_1) = 0.67\,x_2^2$ and $ln(\gamma_2) = 0.67\,x_1^2$, and

$P_1^{sat} = 32.27\ kPa$ and $P_2^{sat} = 73.14\ kPa$.

(1) Over what range of pressures can this binary system exist as coexisting liquid and vapor phases at the given T and z_1? (10%)

(2) For a liquid phase mole fraction $x_1 = 0.75$, what is the pressure P of the system? (5%)