國立成功大學
111學年度碩士班招生考試試題

編　號：75

系　所：化學工程學系

科　目：化工熱力學

日　期：0219

節　次：第 2 節

備　註：可使用計算機

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※ 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　(13%)

A process consists of two steps: (Ⅰ) one mole of gas (CO_2 : steam = 4 : 1 by mole) at T = 560 K and P = 4 bar is heated at constant volume to T = 840 K, and (Ⅱ) this gas is then cooled at constant pressure until its temperature reaches 560 K. If this two -step process is replaced by a single isothermal expansion of the gas from 560 K and 4 bar to the final pressure P. Please answer the following questions:

(1) What is the value of P which the work of the two processes (two-step process and single-step process) is the same? (5%)

(2) Heat, work, ΔU, and ΔH for each process. (8%)
Assume (a) gas is an ideal gas; (b) heat capacity of linear gaseous C_{pm}= 7R /2 and heat capacity of nonlinear gaseous C_{pm}= 4R; and (c) all the processes are reversible.

Problem 2　(20%)

A reversible compression of 1 mole of an ideal gas in a cylinder device results in a pressure change from 0.5 bar to P_2 and a temperature increasing from 300 K to 750 K by an adiabatic process.
Please determine the P_2, work, ΔU, and ΔH. (20%)

Assume: $\frac{C_p}{R} = 3.8 + 0.5 \times 10^{-3}\ T$ (T is in unit of Kelvin, K.)

Problem 3　(17%)

(1) Please write down the fundamental property relation for dA for a closed system. (5%)
[Note] For one mole of a homogeneous fluid of constant composition.

(2) In a closed system, based on one mole of a homogeneous fluid of constant composition, please derive to obtain $\left[\frac{\partial(A/RT)}{\partial V}\right]_T = -\frac{P}{RT}$ and $\left[\frac{\partial(A/RT)}{\partial T}\right]_V = -\frac{1}{T}\cdot\left(\frac{U}{RT}\right)$. (12%)

[Note] $A \equiv U - TS$ where A is the Helmholtz energy

Problem 4　(16%)

An inventor claims to have devised a heat pump which exchanges heat with reservoirs at 30°C and 260°C, and which has a thermal efficiency (or ***COP***) of 0.5. Please answer the following.

(1) Write down the definition for the thermal efficiency (or ***COP***, coefficient of performance) of a heat pump. (5%)

(2) Is this claim believable? Please prove to get the answer. (11%)

... Continued on the next page.

Problem 5 (14%)

The excess Gibbs energy for a binary system consisting of two liquids is given as $\frac{G^E}{RT} = A \cdot x_1 x_2$, where ***A*** is a function of temperature only and x_i is the mole fraction of the component ***i***. If this binary system always phase-separates into two coexisting phases during $0.3 \le x_1 \le 0.7$, please determine the value of ***A***. (14%)

Problem 6 (20%)

Reverse osmosis has become the primary separation technique for producing purified water from sources such as seawater. Let us consider the idealized physical system, shown below as Figure A. The left compartment contains a binary liquid mixture of solute (1) and solvent (2), and the right contains pure solvent (2). The partition separating these two compartment is permeable to solvent (2) only. An additional pressure, in excess of the osmotic pressure (Π), is applied on the left compartment to transfer solvent molecules into the right one.

(1) Please show the osmotic pressure of the solution as $\prod = \frac{m \cdot x_1 \cdot RT}{V_2} \approx c\mathrm{RT}$, i.e., the van't Hoff equation, where x_1 is the mole fraction of solute (1), V_2 is the molar volume of solvent (2), ***c*** is the molar concentration of solute (1), and ***m*** is the number of dissociated ions per solute molecule ($m = 1$ for nonelectrolyte). (14%)

(2) On average, seawater has a salinity of 3.5% (3.5 g/L). If NaCl is assumed as the only salt present in seawater, what is the minimum Π that must be overcome to produce fresh water from seawater? The molar mass of NaCl is 58.443 g/mol. (6%)

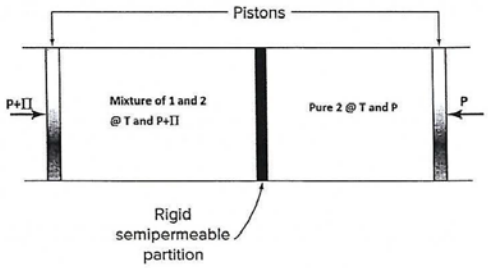

Figure A

The end.