

國立臺灣科技大學
八十八學年度碩士班招生考試試題

系所別：化學工程系碩士班

組別：

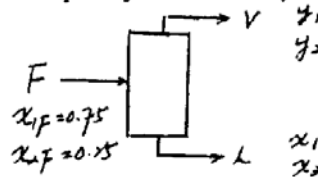
科目：化工熱力學與動力學

Part I：化工熱力學

- (15%) Steam at 600°C and 10 MPa undergoes a Joule-Thomson expansion to 0.1MPa. Please determine the temperature of the steam after the expansion. The enthalpy can be obtained from the Mollier diagram shown in Figure 1.
- (20%) An engineer claims to have invented a steady flow device that will take air at 4 bar and 40°C and separate it into two streams of equal mass, one at 1 bar and -20°C and the second at 1 bar and 100°C. Furthermore, the inventor states that his device operates adiabatically and does not require (or produce) work. Is such a device possible? Why? (Air can be assumed to be an ideal gas with constant heat capacity of $C = 29.3 \text{ J/mol K}$)
- (15%) It is desired to condense 50 mol percent of vapor containing 25 mol percent ethyl alcohol in 75 percent water. The condensation is to be performed at 78.15°C. At what pressure must the condenser be operated? At 78.15°C the vapor pressures of pure water and alcohol are 329mmHg and 755mmHg, respectively. Although the gaseous solutions may be assumed to be ideal, the liquid solutions clearly are not. The liquid activity coefficients may, however, be adequately described by the van Larr equations:

$$\text{Water: } \ln \gamma_1 = A/[1+(Ax_1/Bx_2)]^2$$

$$\text{Alcohol: } \ln \gamma_2 = B/[1+(Bx_2/Ax_1)]^2$$



Where $A = 1.00$ and $B = 0.845$ and the standard states are pure liquids at the temperature of the system. The subscript 1 represents water, and subscript 2 ethanol.

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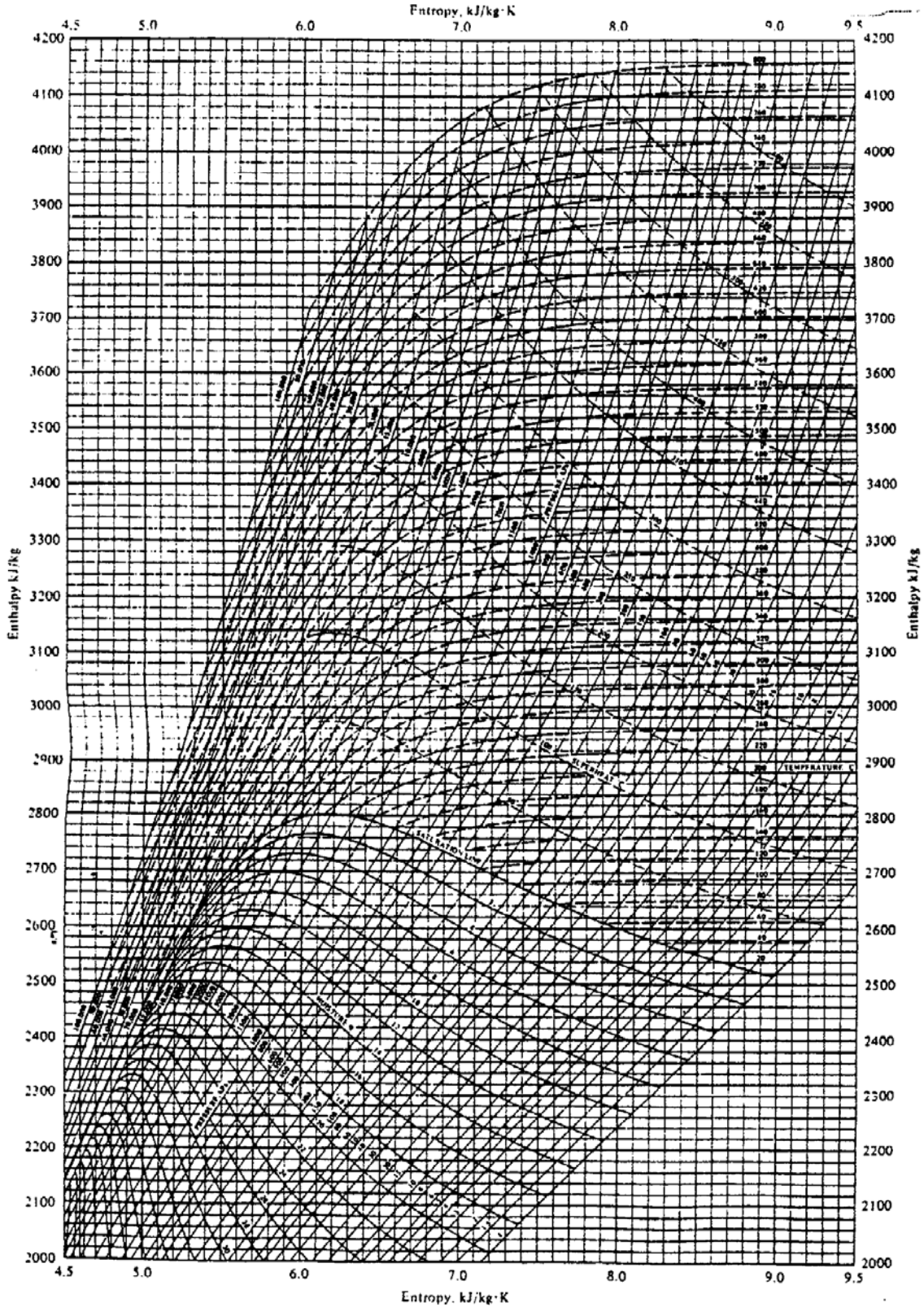


Figure 1. Enthalpy-entropy or Mollier diagram for steam.

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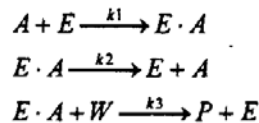
Part II 化工動力

4. Consider the reaction $A \rightarrow R$ with reaction rate

$$-r_A = -\frac{dC_A}{dt} = \frac{k_1 C_A}{K_2 + C_A}$$

(1) Please plot the behavior of reaction rate with respect to concentration of A, i.e. $-r_A$ versus C_A (7 %); (2) How do you determine the constant k_1 and K_2 by applying the integral method? (8 %)

5. The mechanism of a reaction $A + W \rightarrow P$ catalyzed by a homogenous catalyst E in aqueous solution is as following:



Use the assumption that the concentration of EA complex is nearly constant throughout the reaction to find the rate expression ($-r_A$) of the reaction in terms of reactant A, W, and the total catalyst concentration Et. (Note: $[Et] = [E] + [EA]$) (20 %).

6. How do you prove that a liquid reaction ($A \rightarrow R$) process of using two equal size CSTRs in series (each CSTR has a volume of V) is better than the process using one CSTR of volume 2V or not? If (1) reaction rate is zero order (6 %); (2) reaction rate is first order (9 %). (Note: derive the proof in terms of outlet concentration or conversion).