

國立臺灣科技大學 108 學年度碩士班招生試題

系所組別：化學工程系碩士班
 科目：化工熱力學與動力學

(總分為 100 分)

1. (17%) The liquid phase reaction $A + B \rightarrow C + D$ was carried at 25 °C in a solution of B ($C_{B0}=0.5 \text{ mol/dm}^3$). The reaction is made irreversible by precipitating one of the products. The reaction is first order in B. The concentration of A was measured as a function of time as shown below. Please find the rate law expression, $-r_A$, of this reaction.

Time (min)	0	50	100	150	200	250
C_A (mmol/ dm^3)	50	38	30.6	25.6	22.2	19.5
$-dC_A/dt$	3.0	1.86	1.2	0.8	0.5	0.47

2. (17%) The data of $C_{A0}/-r_A$ versus X_A for a liquid phase decomposition of reactant A is shown below. The volumetric flow rate is 30 L/min. Please design a configuration of reactor(s) connected in series with a minimum reactor volume for the 0.9 final conversion. Please use Simpson's rule to evaluate the integrals in your calculation.

$C_{A0}/-r_A$ (min)	15	20	40	60	45	25	10	15	40	70
X_A	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Simpson's rule: $\int_{X_0}^{X_2} f(x)dx = \frac{h}{3}[f(X_0) + 4f(X_1) + f(X_2)]$, where $h = \frac{X_2 - X_0}{2}$,
 $X_1 = h + X_0$

3. Considering to design a reactor to run a gas-phase, elementary and reversible reaction, $2C_6H_6 \rightleftharpoons C_{12}H_{10} + H_2$. At equilibrium, the rate of reaction is identically zero for all species. The rate of the above reaction doubles for a 10 °C increase in temperature (T) occurs only at a specific temperature for a given activation energy.
- (a) (8%) Develop a relationship between the temperature and activation energy (Ea) for the above reaction. Please show your answer with the form of Ea as a function of T.
- (b) (8%) Determine the activation energy and the pre-exponential factor from the following data. Where k is a rate constant.

k	0.001	0.005
T (°C)	00.0	100.0



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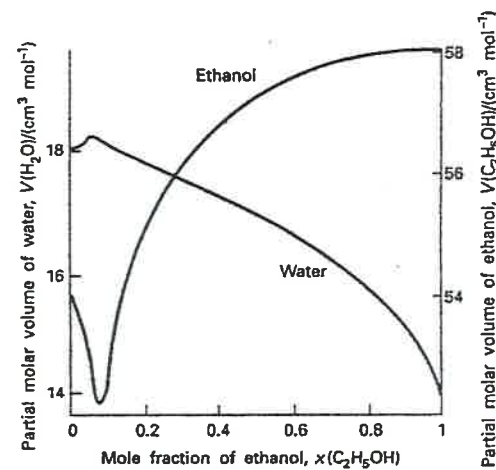
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(總分為 100 分)

- 4.(5%) Frequently the first law of thermodynamics is expressed as $\Delta U = Q - W$. Explain the limitations, i.e., assumptions, of this equation.
- 5.(20%) A flow process produces CO₂ as 75 mol % liquid CO₂ and the rest vapor at 60 °F for use in fire extinguishers. In this process, CO₂ at 20 psia and 60 °F is compressed in two steps: first to 100 psia and then to its final pressure. The gas is cooled to 60 °F before entering the second compressor. Assume both compressors operate adiabatically and reversibly. Using the attached P-H diagram for CO₂, estimate the amount of work required in the process and the required cooling capacity. Compare your results with those obtained when assuming CO₂ as an ideal gas?
- (5%) For putting out fire, a CO₂ fire extinguisher (75 mol % liquid CO₂ and the rest vapor, stored at 60 °F) is discharged to atmospheric pressure (14.7 psia), what is the state of the exit stream?
- 6.(10%) Derive the Clayperon equation for describing phase equilibrium starting from the equilibrium criteria. The sublimation pressure of dry ice (CO₂) as a function of temperature is shown below and its molar volume is $2.8 \times 10^{-5} \text{ m}^3/\text{mol}$. Determine the heat of sublimation of dry ice at 190 K. Estimate the fugacity of solid CO₂ at 190 K and 200 bar.

T (K)	130	155	185	194.5	205
P (kPa)	0.032	1.674	44.02	101.3	227

- 7.(10%) What volumes of pure ethanol and pure water must be mixed in order to produce 100 cm³ mixture containing 50 % (mass) ethanol? If an extra 1 cm³ pure ethanol is added to the mixture due to a careless measurement, by how much will the volume of this mixture change?



P-H diagram of CO₂

