506002

國立臺灣科技大學 110 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. (15%) The pressure derivative of entropy at the constant temperature is written in terms of $-(\frac{\partial V}{\partial T})_P$. If liquid ammonia at 350 K is compressed from saturation pressure of 270 kPa to 1000 kPa, determine its enthalpy (ΔH, kJ/kg) and entropy (ΔS, kJ/kg·K) changes. For saturated liquid ammonia at 350 K, liquid volume and volume expansivity (β) are 1.551×10^{-3} $m^3 \cdot kg^{-1}$ and 2.095×10^{-3} K^{-1}, respectively.

2. (15%) Air (molar mass = 28.851 g/mol) enters a compressor through a 5-cm-radius tube with an average velocity of 10 $m \cdot s^{-1}$ at the initial conditions [P_1 = 1 bar and T_1 = 10°C], and is discharged through a 1.5-cm-radius tube at the final conditions [P_2 = 36 bar and T_2 = 90°C]. The shaft work supplied to the compressor is 25.0 $kJ \cdot mol^{-1}$. Determine the heat-transfer rate (kJ/sec) from the compressor? Assume enthalpy and specific volume at initial condition are 30.68 $kJ \cdot mol^{-1}$ and 31.40 $L \cdot mol^{-1}$, respectively, while enthalpy and specific volume at final condition are 33.97 $kJ \cdot mol^{-1}$ and 0.5438 $L \cdot mol^{-1}$, respectively.

3. (10%) If volumetric equation of state ($P = \frac{RT}{V} - \frac{a - bRT^{3/2}}{\sqrt{T}V^2}$) can be expanded in the form of Virial equation of state, show that Boyle temperature (T_B) for the volumetric equation of state is written in terms of ***a***, ***b***, and ***R***.

4. (10%) A refrigeration system cools a steel casting from 25°C to −15°C at a rate of 15 $kg \cdot s^{-1}$. Assume that heat flows from the refrigeration system to the surroundings at a temperature of 45°C and the specific heat capacity of the steel casting is 7.6 $kJ \cdot kg^{-1} \cdot °C^{-1}$. If the thermodynamic efficiency of the process is 31%, determine the power (kJ/kg) requirement of the system?

5. (12%) A liquid-phase reaction A→2R was performed in a CSTR with a volume of 5 L. In the reaction, the reactant A was fed to the CSTR at a concentration of 1 mol/L. The researcher intended to find a rate expression for this reaction by carrying out the experiments at different conditions, which were summarized in the following Table. Please determine the **reaction order** and the **activation energy** of this reaction.

Run	Feed rate (cm^3/s)	Reaction temperature (°C)	Concentration of R in effluent (mol/L)
#1	2	13	1.8
#2	15	13	1.5
#3	15	84	1.8

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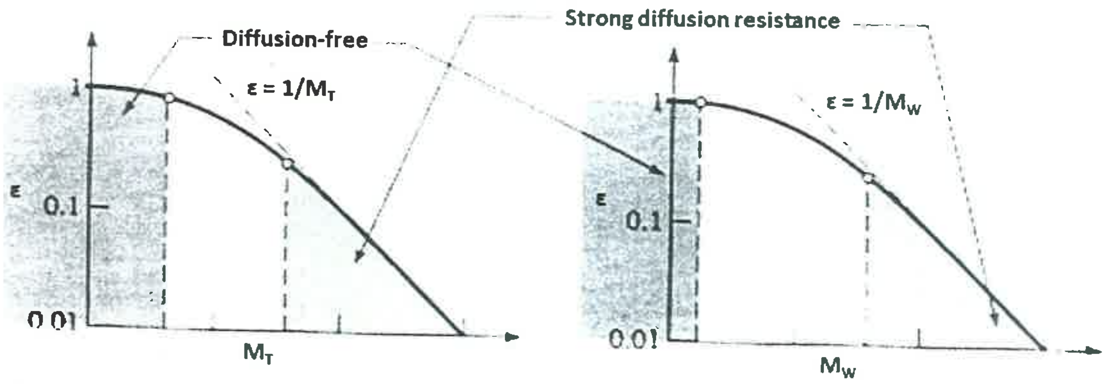
6. (15%) An experimental rate measurement on the decomposition of A is made with a particular catalyst. For the spherical particle: $\boldsymbol{d_p}$ = 2.4 mm, $\boldsymbol{D_e}$ = 5 × 10^{-5} m^3/hr-m cat (Effective mass conductivity), $\boldsymbol{k_{eff}}$ = 1.6 kJ/hr-m cat-K (Effective thermal conductivity), for the gas film surrounding the pellet: $\boldsymbol{h}$ = 160 kJ/hr-m^2 cat-K (heat transfer coefficient), $\boldsymbol{k_g}$ = 300 m^3/hr-m^2 cat (mass transfer coefficient), for the reaction: ΔH_r = -160 kJ/mol A (exothermic), C_{Ag} = 20 mol/m^3 (at 1 atm, 336 °C), $-r'''_{A,obs}$ = 10^5 mol/hr-m^3 cat.

(a) Is it likely that film resistance to mass transfer influence the rate? **(5%)**

(b) Could this run have been made in the regime of strong pore diffusion? **(5%)**

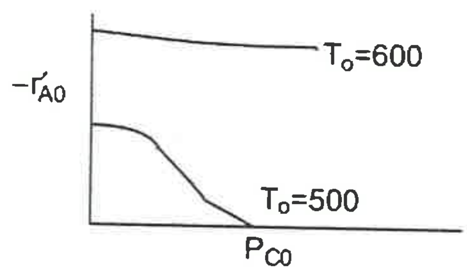
(c) Would you expect to have temperature variations within the pellet or across the gas film? **(5%)**



M$_T$: Thiele modulus, **M$_W$** = Wagner-Weisz-Wheeler modulus, **ε** = effectiveness factor, (actual mean reaction rate within pore)/(rate if not slowed by pore diffusion)

7. (11%) In an ammonia decomposition reaction to generate N_2 and H_2 on a Platinum catalyst ($2NH_3 \rightarrow N_2 + 3H_2$) the rate can be expressed as $-r = kK_AP_A/K_HP_H$, where k is the rate constant, P_A and P_H indicate the pressures of ammonia and hydrogen, and K_A and K_H are the adsorption constants for ammonia and hydrogen. Suggest a **<u>mechanism</u>** and the **<u>assumptions</u>** consistent with the rate equation and prove it.

8. (12%) The irreversible gas phase reaction of A and B to form C and D was carried out in a packed bed reactor in which there is no catalyst decay. The following figure shows the rate of reaction at the reactor entrance as a function the partial pressure of C for various entering temperatures, T$_o$ (K).



Choose the one best answer from the information given for the above system:

A) The reaction is exothermic: (1) Ture, (2) False), (3) Cannot tell (3%)

B) The reaction is endothermic: (1) Ture, (2) False), (3) Cannot tell (3%)

C) Species C is adsorbed on the catalyst surface at 400 K: (1) Ture, (2) False), (3) Cannot tell (3%)

D) Species C is adsorbed on the catalyst at 700 K: (1) Ture, (2) False), (3) Cannot tell (3%)