

國立中央大學101學年度碩士班考試入學試題卷

所別：化學工程與材料工程學系碩士班 甲組(一般生) 科目：化工熱力學及化學反應工程 共 2 頁 第 1 頁
 本科考試可使用計算器，廠牌、功能不拘 *請在試卷答案卷(卡)內作答

1. (10%)

A steam turbine in a small electric power plant is designed to accept 4000 kg/h of steam at 30 bar and 500 °C and exhaust the steam at 10 bar. Assuming that the turbine is adiabatic and has been well designed ($\dot{S}_{gen} = 0$), compute the exit temperature of the steam and the power generated by the turbine.

Superheated Vapor (Continued)

| T (°C) | P = 1.00 MPa (179.91) | | | | Sat. | P = 2.50 MPa (223.99) | | | | P = 3.00 MPa (233.90) | | | |
|--------|-----------------------|-----------|-----------|-----------|------|-----------------------|-----------|-----------|-----------|-----------------------|-----------|-----------|-----------|
| | \hat{V} | \hat{U} | \hat{H} | \hat{S} | | \hat{V} | \hat{U} | \hat{H} | \hat{S} | \hat{V} | \hat{U} | \hat{H} | \hat{S} |
| Sat. | 0.194 44 | 2583.6 | 2778.1 | 6.5865 | 225 | 0.079 98 | 2603.1 | 2803.1 | 6.2575 | 0.066 68 | 2604.1 | 2804.2 | 6.1869 |
| 200 | 0.2060 | 2621.9 | 2827.9 | 6.6940 | 250 | 0.080 27 | 2605.6 | 2806.3 | 6.2639 | — | — | — | — |
| 250 | 0.2327 | 2709.9 | 2942.6 | 6.9247 | 300 | 0.087 00 | 2662.6 | 2880.1 | 6.4085 | 0.070 58 | 2644.0 | 2855.8 | 6.2872 |
| 300 | 0.2579 | 2793.2 | 3051.2 | 7.1229 | 350 | 0.098 90 | 2761.6 | 3008.8 | 6.6438 | 0.081 14 | 2750.1 | 2993.5 | 6.5390 |
| 350 | 0.2825 | 2875.2 | 3157.7 | 7.3011 | 400 | 0.109 76 | 2851.9 | 3126.3 | 6.8403 | 0.090 53 | 2843.7 | 3115.3 | 6.7428 |
| 400 | 0.3066 | 2957.3 | 3263.9 | 7.4651 | 450 | 0.120 10 | 2939.1 | 3239.3 | 7.0148 | 0.099 36 | 2932.8 | 3230.9 | 6.9212 |
| 500 | 0.3541 | 3124.4 | 3478.5 | 7.7622 | 500 | 0.139 98 | 3112.1 | 3462.1 | 7.1746 | 0.107 87 | 3020.4 | 3344.0 | 7.0834 |
| 600 | 0.4011 | 3296.8 | 3697.9 | 8.0290 | 600 | 0.159 30 | 3288.0 | 3686.3 | 7.5960 | 0.132 43 | 3108.0 | 3456.5 | 7.2338 |

\hat{V} [=] m³/kg; \hat{U}, \hat{H} [=] J/g = kJ/kg; \hat{S} [=] kJ/kg K

2. (15%)

From experimental data it is known that at moderate pressures the volumetric equation of state may be written as $Pv = RT + BP$. Show that the van der Waals equation ($P = \frac{RT}{v-b} - \frac{a}{v^2}$) leads to the following expression for the virial coefficient $B = b - a/RT$. The temperature at which $B = 0$ is called the Boyle temperature. Show that for the van der Waals fluid, $T_{Boyle} = 3.375T_C$. State the physical significance of Boyle temperature.

3. (12%)

Vapor-liquid equilibrium data for the A-B system at a constant temperature of 350 K shows that component B follows Henry's law in the range $0 < X_B \leq 0.05$. At this temperature the following data point has been reported $X_A = 0.975$, $y_A = 0.942$, $P = 1035$ mmHg, and the vapor pressures are $P_A^0 = 1000$ mmHg, $P_B^0 = 800$ mmHg. Calculate y_B and P when $X_B = 0.04$.

4. (13%)

In the system A-B, activity coefficients can be expressed by

$$\ln \gamma_A = 0.5 X_B^2 \text{ and } \ln \gamma_B = 0.5 X_A^2$$

The vapor pressure of A and B at 80°C are $P_A^0 = 900$ mmHg, $P_B^0 = 600$ mmHg.

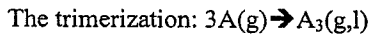
Is there an azeotrope in this system at 80°C, and if so, what is the azeotrope pressure and composition?

注意：背面有試題

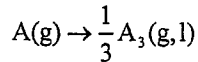
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5. (10%)



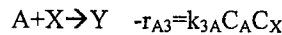
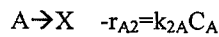
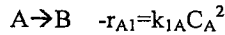
is carried out isothermally and without pressure drop in a PFR at 298 K and 2 atm. As the concentration of A_3 increases down the reactor and A_3 begins to condense. The vapor pressure of A_3 at 298K is 0.5 atm. If an equal molar mixture of A and inert, I, is fed to the reactor at what conversion of A will A_3 begin to condense?



$$\text{Condensation begins at } y = \frac{P_V}{P_T} = \frac{0.5 \text{ atm}}{2 \text{ atm}} = 0.25$$

6. (15%)

The following reactions were found to occur while trying to make a desired product B



Species X and Y are both foul pollutants

(a) What is the instantaneous selectivity of B with respect to the foul pollutant X and Y?

(b) How would you carry out this reaction to maximize the formation of B?

Additional Information

$$k_{1A} = 0.5e^{-10,000/T} \text{ min}^{-1}, T \text{ in degree Kelvin}$$

$$k_{2A} = 50e^{-20,000/T} \text{ min}^{-1}, T \text{ in degree Kelvin}$$

$$k_{3A} = 100e^{-5,000/T} \text{ min}^{-1}, T \text{ in degree Kelvin}$$

7. (10%)

The gas-phase decomposition: $3A \rightarrow 2B + C$ was carried out in a constant volume batch reactor. $t_{1/10}$ was the time necessary for the concentration of A to fall to 1/10 of its initial concentration. Run1 through 4 were carried out at 80°C, while run 5 was carried out at 28°C. Please determine the reaction order, specific reaction rate, and the activation energy.

| Run | 1 | 2 | 3 | 4 | 5 |
|---|-------|-------|-------|------|-------|
| Initial concentrations C_{A0} (g-mol/L) | 0.090 | 0.150 | 0.245 | 0.41 | 0.245 |
| $t_{1/10}$ (min) | 109.2 | 40.2 | 14.8 | 5.4 | 90.2 |

8. (15%)

A second-order gas reaction $3A \rightarrow 2B + C$ is taking place in 40 meters of a pipe packed with catalyst. The diameter of the pipe is 2 cm. The pellet size is 3 mm in diameter and the porosity is 50%. The density of catalyst is 4 g/cm³. The specific reaction rate is 1 (m⁶/kmol·kg cat·h). There is 1 kg/h of gas passing through the bed and the entering concentration of A is 0.1 kmol/m³. The entering pressure is 2 atm. The properties of the gas are similar to air that the density is 1 kg/m³ and the viscosity is 1.82×10⁻⁵ kg/m·s.

(a) What is the conversion if there is no pressure drop?

(b) What is the conversion if there pressure drop is considered?

Hint. The Ergun equation:
$$\frac{dP}{dz} = -\frac{G}{\rho g_c D_p} \left(\frac{1-\phi}{\phi^3} \right) \left[\frac{\text{Term 1}}{D_p} + \frac{\text{Term 2}}{1.75G} \right]$$

注意：背面有試題