國立聯合大學九十八學年度碩士班考試招生

化學工程學系 入學考試試題

科目：化學動力學與化學熱力學

第1頁共1頁

1. A liquid phase reaction, \( 2A \rightarrow \text{Products} \), has been conducted in a 100-liter stirred reactor at 50°C with a feed concentration \( C_{A0} = 1 \text{ mol/liter} \). The following data has been obtained.

<table>
<thead>
<tr>
<th>Volumetric flow rate (liter/hr)</th>
<th>2.5</th>
<th>13.3</th>
<th>45.0</th>
<th>160.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion</td>
<td>0.8</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The reaction rate can be expressed as \( -r = kC_A^n \). Determine the reaction order \( n \) and rate constant \( k \). 12%

2. The competitive enzyme inhibition mechanism can be described as

\[
E + S \underset{k_s}{\rightleftharpoons} ES \underset{k_i}{\rightarrow} E + P
\]

\[
E + I \underset{k_{EI}}{\rightarrow} EI \quad \text{where } I \text{ is the inhibitor and } K_I = \frac{[E][I]}{[EI]}
\]

If \( K_m \) is an equilibrium constant and defined as \( K_m = \frac{[E]}{[ES]}[S] \), prove that the rate equation for this reaction is

\[
r_p = \frac{V_m [S]}{[S] + K_m \left(1 + \frac{[I]}{K_I}\right)}
\]

where \( V_m = k_1 [E_0] \). 12%

3. The kinetic data for a reaction \( A \rightarrow R \) is shown below

<table>
<thead>
<tr>
<th>( C_A ) (mol/liter)</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>( -r_A ) (mol/liter/hr)</td>
<td>0.06</td>
<td>0.1</td>
<td>0.25</td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

If we want to convert \( A \) from \( C_A = 10 \text{ mol/liter} \) to \( C_A = 2 \text{ mol/liter} \), what will be the optimal space time for the combination of a plug flow reactor with a mixed flow reactor? 13%

4. A liquid phase reaction, \( A + R \rightarrow \text{Products} \), with \( C_{A0} = 2 \text{ mol/liter} \), \( C_{R0} = 0 \text{ mol/liter} \), enters two mixed flow reactors in series. The reaction kinetics is \( -r_A = 1C_AC_B \) (mol/liter-min). If we wish to get 96% conversion, what optimal space time for each reactor can we process to this conversion? 13%

5. A heat engine does 1000 cal of work and removes 1500 cal of heat from the cold reservoir. If the heat engine is reversible, what is the efficiency of the heat engine? 5%

6. The Clausius equation of state is \( P(V - b) = RT \). Assume air obeys Clausius equation with \( b = -10.73 \text{ cm}^3 / \text{mol} \), and \( C_p = 29 J / \text{mol-K} \). Air at 400 bar and 40°C is steadily exhausted to the atmosphere at 1 bar, what will be the temperature of the outlet air

(a) If air expansion is at constant enthalpy? 15%

(b) If air expansion is at constant entropy? 15%

7. Prove that the constant volume heat capacity of van der Waals gas is dependent on temperature only. 15%