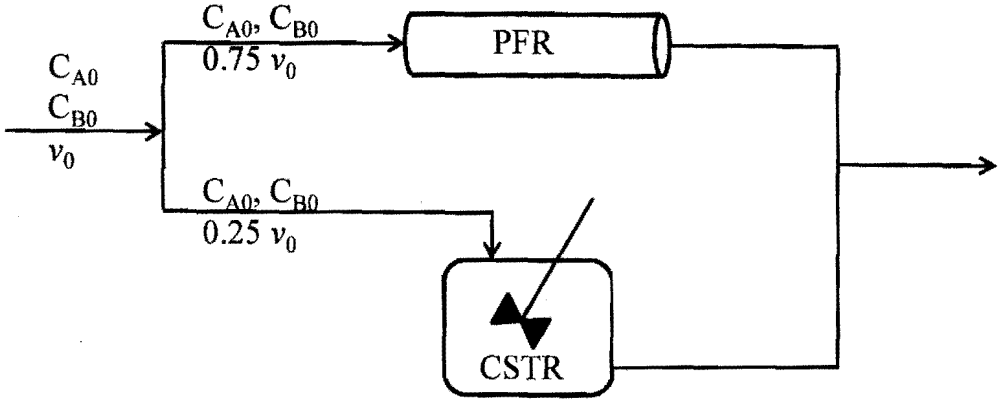
系所組別： 化學工程學系甲組

考試科目： 化學反應工程

考試日期：0225，節次：3

※ 考生請注意：本試題可使用計算機，並限「考選部核定之國家考試電子計算器」機型

1. The elementary and liquid-phase reaction A + B → C + D is carried out isothermally in an ideal reactor system as shown in the figure with v_0 = 1 m^3/min, and C_{A0} = C_{B0} = 2.0 kmol/m^3. The rate constant is 0.56 m^3/kmol · min^{-1}. The space time (reactor volume/feed flow rate) of the plug flow reactor and the continuous-stirred tank reactors are τ_{PFR} = 2 min and τ_{CSTR} = 8 min, respectively. Please determine the conversion of species A at exit the system (20%).



2. The gaseous reaction, A → B, is a first-order reaction and has a specific reaction rate of 0.2 dm^3/g cat · min^{-1} when carried out in a packed bed reactor at 200°C. Pure A at 10 atm is fed, and a production rate of 3600 kg/hr of B is required. Determine the catalyst weight if the conversion of A is to be 90%? Assume perfect gas laws. (14%)

Additional information: R = 0.082 [atm · dm^3/mol · K]

The molecular weight of B is 60.

The pressure drop in PBR can be estimated by $(P/P_0) = (1 - 0.01W)^{0.5}$.

$$\int_0^W (1-\alpha W)^{1/2} dW = \frac{2}{3\alpha}[1-(1-\alpha W)^{3/2}]$$

(背面仍有題目,請繼續作答)

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3. Titanium nitride (TiN) films are used in decorative coatings as well as in wear-resistant tools. There is increasing interest in TiN because of its thermal stability, good diffusion barrier properties, and its low electrical resistivity. Titanium nitride films were formed by CVD from a mixture of $TiCl_4$, NH_3, H_2 and Ar. The following observations can be made from the experiment:

   - **Observation 1**: The rate of deposition is independent of Ar and H_2.
   - **Observation 2:** At low partial pressures of both $TiCl_4$ and NH_3, the deposition rate appears to be first-order in $TiCl_4$ and second-order in NH_3.
   - **Observation 3:** At high partial pressures of NH_3, the rate varies inversely with $TiCl_4$.

   The following mechanism has been suggested for the reaction:

   $$\mathbf{TiCl_4 + 2NH_3 \rightleftarrows TiCl_4(NH_3)_2 \text{ gas phase}}$$

   $$\mathbf{TiCl_4(NH_3)_2 + S \rightleftarrows TiCl_4(NH_3)_2{\cdot}S}$$

   $$\mathbf{TiCl_4(NH_3)_2{\cdot}S + S \longrightarrow TiN + S + \text{gas products (HCl, } H_2\text{, etc.)}}$$

   It is believed that the gas-phase reaction to form the complex $TiCl_4(NH_3)_2$ is in equilibrium.

   (a) Determine the rate expression for the suggested mechanism. (8%)

   (b) Evaluate if the rate expression obtained in (a) agree with each experimental observation? (5%)

   (c) Determine the reaction rate parameters from the data given below. (5%)

$r_{Dep} \times 10^8$ (mol TiN/cm^2·min)	15	10	6	8.5	16
P_{NH3} (mT)	79	79	79	60	100
P_{TiCl4} (mT)	1	3	10	2.3	2.3

4. A powder is to be completely dissolved in an aqueous solution in a large, well-mixed tank. An acid must be added to the solution to make the spherical particle soluble. The particles are sufficiently small (negligible shear stress) that they are unaffected by fluid velocity effects in the tank. For the case of excess acid, please derive an equation for the diameter of the particle as a function of time when mass transfer limits the dissolution: $W_A = k_c C_{A0}$ (15%)

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5. The following data were obtained in the production of dextrose from corn starch using glucoamylase in a fully agitated CSTR.

$$\text{corn starch} \xrightarrow{\text{glucoamylase}} \text{dextrose}$$

T = 60 °C, $[S_o]$ = 168 mg starch/ml, $[E_o]$ = 11600 units, reactor volume = 1000ml.

Space Time (min)	0	15	30	45	60	75	90
Dextrose concentration (mg/ml)	12.0	40.0	76.5	94.3	120.0	135.5	151.2

When different temperature was used to produce dextrose, the following maximum reaction rates were obtained:

Temperature (°C)	25	35	45	55	65
$V_{max} \times 10^6$ (m mol/min·unit of enzyme)	12.0	76.5	120.0	151.2	155.7

(a) Derive the relationship between the concentration of corn starch and the space time of CSTR. (4 %)

(b) Determine the maximum reaction velocity, V_{max} (mg/ml-min·unit of enzyme), and the Michaelis constant, K_M (8 %)

(c) Determine the activation energy (ΔE, cal/gmol) for this enzyme reaction. (6 %)

6. A first order irreversible reaction S → P is carried out in a capillary tube (radius = R, length = L) with a reaction rate of $r_P = kC_S$. The product P adsorbs onto the tube wall and the adsorption process is rapid and reversible:

$$P + W \underset{k_d}{\overset{k_a}{\rightleftarrows}} PW$$

(a) Please derive the relationship between the amount of P adsorbed on the wall (PW) and the amount of P in the solution. The total amount of W in the tube is Wt. (6 %)

(b) Since the surface to volume ratio is large in a capillary tube, the amount of adsorbed P cannot be neglected. Please derive the mass balance equation for P in the capillary tube (using [P] or C_p as the variable). The inlet concentration of S is S_0. (9 %)