

國立臺灣科技大學
九十一學年度碩士班招生考試試題

系所組別：化學工程系

科目：化工熱力學與動力學

總分 100 分

Part I. 化工熱力學

1. (20%) Please give short , quick, and concise definition or explanations to:
 - a) compressibility factor
 - b) principle of corresponding states
 - c) partial molar property
 - d) *UNIQUAC* model

2. (10%) Historically, chromium (Cr) has been widely used in numerous industrial processes, including leather tanning and metal plating operations. In these applications, if the water is mildly acidic, the Cr is typically present as bichromate (HCrO_4^-) and/or dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ions. These ions can be interconverted by the equation



The standard Gibbs free energies of formation of HCrO_4^- , $\text{Cr}_2\text{O}_7^{2-}$ and H_2O are -764.8 , -1301.0 , and -237.2 kJ/mol, respectively. Please compute the equilibrium constant for the conversion of HCrO_4^- to $\text{Cr}_2\text{O}_7^{2-}$.

3. (20%) As proposed by Arrhenius in 1896, "greenhouse effect" stands for the phenomenon that certain gases such as CO_2 , CH_4 , and N_2O trap heat in the troposphere. The effect is critical for the birth of life on earth. Without our current heat-trapping blanket of gases, the earth's temperature would be -18°C instead of its current 15°C . However, people nowadays are concerned about global warming by the enormous input of greenhouse gases as fossil fuels are burned. To understand the forest turnover rate, scientists set up experiments to study how plants grow under high concentration of CO_2 . A perfectly insulated pressurized room at 4 bar and 27°C containing 1 m^3 of 90 % CO_2 , and 10 % O_2 (assumed ideal gas) was used. The gases need to be vented down to 1 bar during routine sampling and maintenance once every two month. The gases therefore need to be pumped in



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afterwards. A 100 W (J/s) electric cooler is switched on when the gas is flowing into the room. A control valve is used to adjust gas flow rate so that the temperature in the room is unchanged.

- a) What is the flow rate of gas into the room that you recommend?
- b) How long will it take to increase the pressure from 1 bar to 4 bar?
- c) Give us some reasons why the electric cooler is used? What are possible consequences if the flow rate varies?



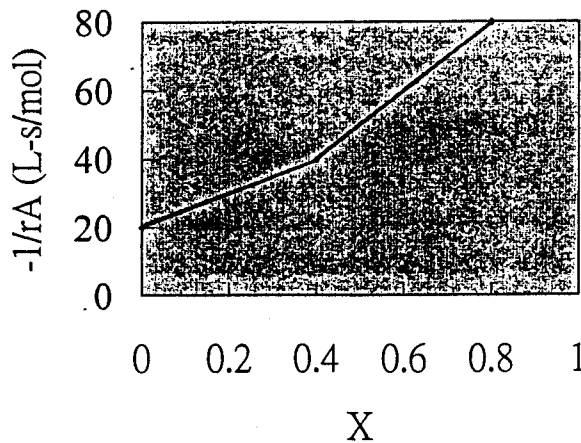
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Part II. 化工動力學

1. (a) Briefly list the characteristics (e.g., advantages, disadvantages, etc.) of continuous stirred tank reactors (CSTR) and plug flow reactors (PFR). (10%)
- (b) For the CSTR and PFR with exactly the same space time (mean residence time), which one has the broader residence time distribution? (2%)
- (c) The inverse of reaction rate ($-1/r_A$, L-s/mol) as a function of conversion (X) is shown below. For reaction systems of CSTR-PFR in series and PFR-CSTR in series, which one is better? Explain briefly. The levels of conversion at the exit of the first and second reactors are 0.4 and 0.8, respectively. (10%)



- (d) The reaction in part (c) is carried out in a system comprising N identical CSTRs in series. N is a very large number, the molar flow rate to the first reactor is 10 mol/s and a conversion level of 0.8 is achieved at the exit of the last reactor. Estimate the total volume of these N CSTRs. (10%)



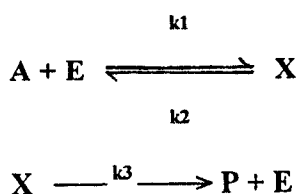
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2. (a) Briefly explain the physical meaning of $\exp[-E/(RT)]$ appearing in the Arrhenius equation $k = A \exp[-E/(RT)]$. The parameter k is the specific reaction rate (constant), A is frequency factor, E is activation energy, R is gas constant, and T is absolute temperature. (3%)
- (b) The elementary reaction $A + B \xrightarrow{k} P$ is carried out in a constant volume batch reactor. Propose a method to determine the specific reaction rate (constant) k . (5%)
3. Considering the enzymatic reaction $A \rightarrow P$ and the reaction mechanism shown below, derive an expression for the rate of disappearance of A ($-r_A = -dC_A/dt$).



E and X represent the enzyme and very active intermediate, respectively, and k_i ($i = 1, 2$ or 3) is the specific reaction rate (constant) of step i . (10%)

