平成３０年度第２次募集

新潟大学大学院自然科学研究科博士前期課程入学者選抜試験問題

外国人留学生特別入試

材料生産システム専攻

素材生産科学（化学工学系）

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専門科目（化学工学）

Specialized Subject (Chemical Engineering)

注意事項
General Instructions

1　この問題冊子は，試験開始の合図があるまで開いてはならない。
Do not see the contents of these question sheets before the start of examination is announced.

2　問題冊子は，表紙を含めて全部で５ページある。
There are five pages including this cover page.

3　問題はⅠ～Ⅳの４問ある。これらのすべてに解答すること。
There are four questions from I to IV. Answer all of these questions.

4　解答は，出題科目に対応する解答用紙に記入すること。別の問題の解答用紙に記入した場合は無効となる。
Write your answer on the designated answer sheet corresponding to each question. If you use a wrong answer sheet, no marks will be awarded to the question.

5　解答用紙の表だけで解答スペースが足りない場合は，その用紙の裏に続けて解答してよい。ただし，「(裏面に続く)」と解答用紙の表面の一番下に明記すること。
If you cannot complete the answer on the front side of an answer sheet, you may use also the back side of the answer sheet. When you use the back side, write "continued on the back" clearly at the bottom of the front side.

6　受験番号は，各解答用紙と下書用紙の指定された箇所に記入すること。
Enter your examinee number in the designated blanks of all answer sheets and the draft sheet.

7　解答時間は，１２０分である。
The duration of examination is 120 minutes.

8　下書きには，下書用紙を使用すること。下書用紙は試験後に回収する。
Use the draft sheet for making a draft if necessary. It will be collected at the end of examination.

9　辞書や電子機器類の使用は認められない。
Using any dictionary or electronic device is prohibited.

[I] Answer the following questions (1) and (2).

(1) The following table includes chemical terms ①–⑤. Select a person's name to be mostly related to each term in the word group and answer in the right column.

	Term	Person's name
①	light absorption	
②	activation energy	
③	adsorption isotherm	
④	acid and base	
⑤	intermolecular force	

(2) Fill the appropriate word in each ( ) appearing in the following sentences by using a word, a number or a molecular-formula in the word group.

Acid rain is a general term for rain, snow, fog of pH less than (⑥). This pH value is based on the pH at which the equilibrium is attained when atmospheric (⑦) is dissolved in water. One of the main reasons of low pH value rain is the dissolution of (⑧) and (⑨) generated from (⑩).

Word group
Lambert, Lewis, van der Waals, Arrhenius, Langmuir,
SO_2, NO_x, CO_2, NH_3, O_3,
combustion, synthesis,
7, 5.6

[II] Answer the following questions (1) and (2).

(1) Explain the following terms.

① Density

② Viscosity of fluid

③ Kinematic viscosity of fluid

④ Laminar flow in fluid

⑤ Turbulent flow in liquid

⑥ Reynolds number in the fluid flow through a cylindrical tube

(2) As shown in Fig.II-1, a Newtonian fluid flows along the flat surface vertically. If the flow is laminar and the liquid surface is flat and free from ripples, the fluid motion can be analyzed mathematically. Here, we consider the viscosity and density of fluid to be constant. We focus our attention on a region of length L [m] in x direction, sufficiently far from the ends of the wall that the entrance and exit disturbances are not included in L [m]. Let's consider a region with the thickness B [m] in y direction and distance W [m] in the z direction. In this distance W [m], neglect the end effect for velocity.

Answer the following questions by using following symbols; shear stress: τ_{yx} [Pa], viscosity : μ [Pa・s], density: ρ [kg/m^3], gravitational acceleration: g [m/s^2], time: t [s], velocity of x direction: u [m/s], distance of y direction: y [m], distance of x direction: x [m], distance of z direction: z [m], volume flow rate : Q [m^3/s] , Newton's law of viscosity : $\tau_{yx} = -\mu \dfrac{du}{dy}$.

① If the velocity distribution of the flow in a viscous isothermal liquid film is $u = \dfrac{\rho g B^2}{2\mu}\left[1-\left(\dfrac{y}{B}\right)^2\right]$, determine the maximum velocity u_{max} [m/s] using boundary condition.

② Determine the volume flow rate (Q) by integration of the velocity distribution.

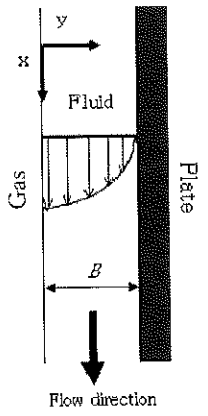

Fig.II-1 Flow direction of Newtonian fluid.

[III] Read next sentences and answer the following questions ①－⑥.

Substance A produces R (A → R). This reaction is the first order reaction with respect to the concentration of substance A. The feed (C_{A0}=1.0 mol/m^3, C_{R0}=0 mol/m^3) enters an ideal steady-state flow reactor with the volume flow rate Q [m^3/s]. Knowing that the first order reaction rate constant is given by k, answer the following questions.

Note that C_{A0} and C_{R0} show the inlet concentration of substance A and R, and C_{Ae} and C_{Re} show the outlet concentration of substance A and R, respectively. V [m^3] shows the total volume of reactor, and θ is the hydraulic retention time of liquid in the reactor. The substance of A and R is in the liquid phase, and there is no total volume change.

① Write the algebraic form of the rate equation for A → R, as a function of concentration.

② Explain the CFSTR (constant flow stirred tank reactor).

③ Explain the PFR (plug flow reactor).

④ Explain the hydraulic retention time.

⑤ If the conversion of substance A into R is 0.5 in the single CFSTR (as shown in the Fig.III-1), determine the first order reaction rate constant k as a function of θ after the deriving the material balance equation of substance A.

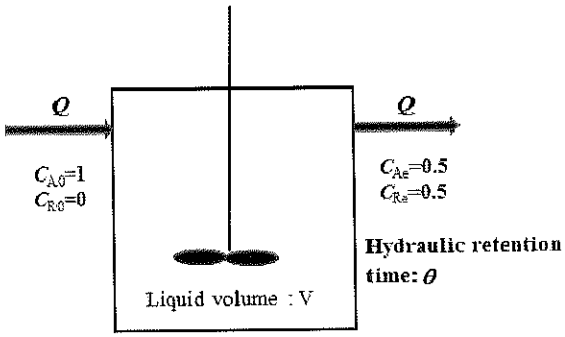

Fig. III-1 CFSTR (constant flow stirred tank reactor)

⑥ Find the overall conversion of substance A in the PFR as shown in the Fig.III-2, when the volume and the feed rate are the same with the CFSTR (question ⑤). Notations are L: total length of PFR [m], S: cross sectional area [m^2], u: superficial velocity of liquid in the PFR, t: time [s], l: distance from the reactor inlet [m], respectively. Also, you may use the flowing numerical values if necessary; ln2 = 0.693, exp(−1) = 0.368, exp(0.5) = 1.65.

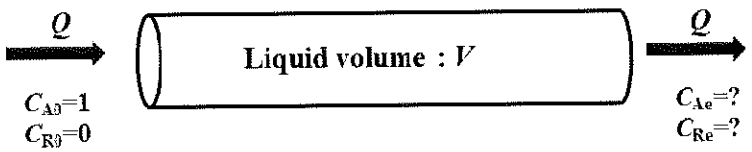

Fig. III-2 PFR (plug flow reactor)