

Birla Institute of Technology and Science, Pilani – Pilani Campus

Semester-II, 2022-23

CHE G641: Reaction Engineering

Comprehensive Examination (Regular)

Date: 08/05/2023

Max. Marks: 90

Day: Monday

Duration: 3 Hours

Instructions: 1) Attempt all questions; 2) Take suitable assumptions wherever necessary.

Closed Book (Max. Marks: 60)

- Q.1.** Give examples of two industrially important reactions (stoichiometric balance) of type E. Stating their application. [4]
- Q.2.** Discuss the following terms: [4]
a) Bulk diffusion; b) Knudsen diffusion; c) Configurational diffusion; d) Effective diffusivity
- Q.3.** The observed rate of reaction for a Gas-Solid catalytic and non-catalytic reaction is given by: [4]

$$-r_A = \frac{C_A}{\frac{1}{k_g} + \frac{1}{k_s}}$$

Does it mean the catalyst does not have any effect on the rate of reaction?

- Q.4.** Discuss how would you determine experimentally the rate-controlling step among film control, ash control, and reaction control for G-S reaction (Type A). [4]
- Q.5.** What is a pseudo-steady-state assumption? Derive an expression to justify the pseudo-steady-state assumption. Also, discuss its limitations. [8]
- Q.6.** What do you understand by effectiveness factor? Derive an expression to establish the relationship between the effectiveness factor and Damkohler number for a non-porous catalyst. [8]
- Q.7.** Consider the LHHW model to derive a rate expression, assuming adsorption of A is rate controlling, for the following catalytic reaction: [8]

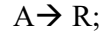


- Q.8.** Write a note on the development of fluidized bed reactor models. [8]
- Q.9.** Derive the general equations for the design of packed bed reactors assuming a pseudo-homogeneous model. Discuss the significance of each term in the expression. Also, mention all the boundary conditions. [12]

P.T.O

Open Book (Max. Marks: 30)

- Q.1** Determine the amount of catalyst required in a packed bed reactor for 80% conversion of 1200 m³/hr of pure gas A ($C_{A0}=95 \text{ mol/m}^3$) if the stoichiometry and rate are given by: **[10]**



$$-r_A' = \frac{50C_A}{1 + \frac{C_A}{50}} \text{ mol.kg}^{-1}.\text{hr}^{-1}$$

- Q.2** Ammonia oxidation takes place in a bubbling fluidized bed reactor at 1.0 atm and $T = 523 \text{ K}$. The reactor diameter is $D = 12.0 \text{ cm}$, the gas feed contains 10% NH_3 and 90% O_2 , and is fed into the reactor at $800 \text{ cm}^3/\text{s}$ (at reaction conditions). Four kilograms of catalyst with particle size of $100 \mu\text{m}$ is used in the reactor, and the initial height of settled bed is 40 cm . The catalyst has a sphericity of 0.6 and density $\rho_s = 2.0 \text{ g/cm}^3$. The oxidation reaction is first order with respect to ammonia concentration:

$$-r_A = k_{\text{cat}} C_{\text{NH}_3} \text{ mol}/(\text{s.cm}^3)$$
$$-k_{\text{cat}} = 0.086 \text{ s}^{-1}$$

The gas density is $\rho_g = 0.785 \times 10^{-3} \text{ g/cm}^3$, viscosity $\mu_g = 2.98 \times 10^{-4} \text{ g/cm.s}$, and diffusivity $D_{AB} = 0.618 \text{ cm}^2/\text{s}$. Use: $g = 10 \text{ m/s}^2$.

Determine the following in (SI units):

- a) Pressure drop across the bed of solids **[2]**
- b) Pressure drop due to perforated plate for a fluidized bed height of 55 cm **[2]**
- c) Minimum fluidization velocity **[6]**
- d) Terminal velocity of the particles **[6]**
- e) Comment on the fluidization achieved: good/shallow/slugging **[2]**
- f) j-factor for mass transfer. **[2]**

Note: There may be additional data in the problem, which is not needed to determine the asked parameters.

Best Wishes