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]**

$$A \leftrightarrow R$$

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 m^3/hr of pure gas A (C_{A0}=95 mol/m^3) if the stoichiometry and rate are given by: **[10]**

$$A \rightarrow R;$$

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

Q.2 Ammonia oxidation takes place in a bubbling fluidized bed reactor at 1.0 atm and T = 523 K. The reactor diameter is D =12.0 cm, the gas feed contains 10% NH_3 and 90% O_2, and is fed into the reactor at 800 cm^3/s (at reaction conditions). Four kilograms of catalyst with particle size of 100 μm 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 ρ_s = 2.0 g/cm^3. The oxidation reaction is first order with respect to ammonia concentration:

$$-r_A = k_{cat}C_{NH3} \text{ mol/(s.cm}^3\text{)}$$

$$-k_{cat} = 0.086 \text{ s}^{-1}$$

The gas density is ρ_g =0.785 x 10^{-3} g/cm^3, viscosity μ_g = 2.98 x 10^{-4} g/cm.s, and diffusivity D_{AB} = 0.618 cm^2/s. Use: g = 10 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