GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO S25 – QUESTION BANK

Subject Name & Code:

Chemical Reactions Engineering II- 3170501

Unit 1: Heterogeneous Reactions: Introduction

Repeated Questions:

1. **Give examples/Categories of heterogeneous reactions.**
   - Appeared in: S23 (Q1a, 03 marks), S25 (Q1a, 03 marks), W24 (Q1b, 04 marks)
2. **Discuss contacting patterns for two-phase systems with a neat sketch.**
   - Appeared in: S22 (Q5a, 03 marks), S24 (Q5a, 03 marks)
3. **Write in brief about Trickle Bed Reactor.**
   - Appeared in: S23 (Q3a, 03 marks), S24 (Q3a, 03 marks), W23 (Q3a, 03 marks)

Other Important Questions:

4. Discuss in brief the fluid–solid reactions in which the solid does not appreciably change in size during the reaction with a suitable example. (W22 - Q1a, 03 marks)
5. Discuss the steps to determine the volume of the reactor for mass transfer and reaction in an agitated tank contactor for mixed flow of gas and liquid. (W22 - Q4a, 03 marks)
6. State the various types of tower and tank contactors for gas–liquid reaction. (W22 - Q4a, 03 marks)
7. Give the name of the type of reactor used for fluid-fluid reactions. (S22 - Q1a, 03 marks)
8. Give examples of fluid-particle reactions (Non-catalytic). (S22 - Q1b, 03 marks)
9. What is the role of catalysts in a reaction system? How will it enhance the rate of reaction? (S22 - Q2a, 03 marks)
10. Discuss advantages and disadvantages of solid heterogeneous catalysts. (W24 - Q1a, 03 marks)
11. Suggest suitable contactor for a fluid-fluid reaction having bulk liquid resistance as a controlling resistance. Justify your recommendation. (S25 - Q3a, 03 marks)
12. For fluid-fluid reaction, under which circumstances a high f_i value is desired? Justify with a suitable example. (S25 - Q3a (OR), 03 marks)
13. Suggest suitable justification for the selection of a packed tower for a non-catalytic fluid-fluid reaction. (W24 - Q3a, 03 marks)
14. Give three examples of heterogeneous fluid-fluid reactions. (W24 - Q3a (OR), 03 marks)

Unit 2: Fluid-Fluid Systems

Repeated Questions:

1. **Derive the rate equation for straight mass transfer / physical absorption.**
   - Appeared in: S22 (Q2b, 04 marks), W23 (Q2c, 07 marks)
2. **Discuss how solubility data/Henry's constant can help predict the kinetic regime.**
   - Appeared in: S22 (Q5a, 03 marks), S24 (Q5a, 03 marks), W23 (Q4a, 03 marks)
3. **Derive the rate equation for a fast reaction with a high concentration of liquid reactant.**
   - Appeared in: S22 (Q5c, 07 marks), S24 (Q5b, 04 marks)

Other Important Questions:

4. Explain the significance of the Hatta modulus in fluid–fluid reaction. (S23 - Q4a, 03 marks)
5. Derive the rate equation for a fast reaction with a low concentration of liquid reactant in a fluid–fluid reaction. (S23 - Q4b, 04 marks)
6. What is the film conversion parameter? State various criteria for it which are used in the study of fluid-fluid reactions. (S23 - Q4c, 07 marks)
7. How can the Hatta number be used to decide the type of contacting device for fluid–fluid reactions? (S22 - Q5b, 04 marks)
8. With a neat schematic diagram, explain the salient features of a packed column reactor used for a fluid-fluid reaction. (S25 - Q3b, 04 marks)
9. With a neat schematic diagram, explain the salient features of a tray column and agitated tank reactor used for a fluid-fluid reaction. (S25 - Q3b (OR), 04 marks)
10. Gaseous A absorbs and reacts with B in liquid according to $A(g) + B(l) \rightarrow R(l)$ in a packed bed under given conditions. (i) calculate the rate of reaction, (ii) describe the kinetics characteristics. (S25 - Q3c, 07 marks)
11. The rate of CO_2 absorption into an alkaline buffered solution. Find the fraction of entering CO_2 absorbed. (S25 - Q3c (OR), 07 marks) *[Numerical]*
12. Hydrogen sulfide is absorbed by a solution of methanolamine (MEA) in a packed column. (i) Find the rate of absorption, (ii) Compare with absorption in pure water. (W24 - Q3c, 07 marks) *[Numerical]*
13. Discuss the significance of the Enhancement factor and Hatta Modulus for heterogeneous fluid-fluid reactions. (W24 - Q3b, 04 marks)
14. Discuss eight special cases of non-catalytic fluid-fluid heterogeneous reactions. (W24 - Q3c (OR), 07 marks)
15. Gaseous A absorbs and reacts with B in liquid according to $A(g \rightarrow l) + B(l) \rightarrow R(l)$ in a packed bed. (i) Calculate the rate of reaction. (ii) Determine the location of major resistance and behavior in the liquid film. (S23 - Q4c, 07 marks) *[Numerical]*
16. It is proposed to remove CO_2 from air by counter-current contact with water. (i) Calculate the resistances offered by the gas and liquid film (ii) Suggest the simplest form of the rate equation for tower design. (W22 - Q4c, 07 marks) *[Numerical]*
17. Hydrogen sulfide (H_2S) is to be absorbed by a solution containing methanolamine (MEA). Calculate the enhancement factor. (W22 - Q4c, 07 marks) *[Numerical]*
18. Air with gaseous A bubbles through a tank containing aqueous B. (a) locate the resistance to reaction, (b) locate the reaction zone, (c) determine the behavior in the liquid film, (d) calculate the rate of reaction. (S24 - Q5c, 07 marks) *[Numerical]*
19. Dilute A diffuses through a stagnant liquid film onto a plane surface consisting of B, reacts there to produce R which diffuses back into the mainstream. Derive the overall rate expression for the L/S reaction. $A(l) + B(s) \rightarrow R(l)$ (S24 - Q5b, 04 marks)
20. The four PA versus CA sketches represent various possible ideal contacting schemes of gas with liquid. Sketch the contacting scheme for straight physical absorption. (S24 - Q5c, 07 marks)

Unit 3: Fluid-Particle Systems

Repeated Questions:

1. **Explain the Shrinking Core Model (SCM) with a neat sketch/concentration profile.**
   - Appeared in: W23 (Q1b, 04 marks), S23 (Q1b, 04 marks), W24 (Q2b, 04 marks)
2. **Calculate the time needed for complete conversion of a particle (e.g., ZnS, Graphite) using the Shrinking Core Model.**
   - Appeared in: W22 (Q2c, 07 marks), S23 (Q2c, 07 marks), W23 (Q3c, 07 marks), S25 (Q2a, 03 marks)
3. **Discuss the limitations of the Shrinking Core Model.**
   - Appeared in: S24 (Q4a, 03 marks), S25 (Q2c (OR), 07 marks)

Other Important Questions:

4. Write limitations of a shrinking core model for solid-fluid non-catalytic system. (S24 - Q4a, 03 marks)
5. Discuss with a neat sketch the selection of a model for fluid–particle reactions. (S24 - Q4b, 04 marks)
6. A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non-flaking product according to the shrinking-core model. Conversion is about 7/8 for a reaction time of 1 h; conversion is complete in two hours. What mechanism is rate controlling? (W22 - Q1b, 04 marks) *[Numerical]*
7. Gas containing A contacts and reacts with a semi-infinite slab of the solid B as $A_{(g)} + B_{(s)} \rightarrow R_{(g)} + S_{(s)}$. If diffusion through the ash layer controls, show that $t_{AshLayer} = \frac{L^2}{2MD_eC_{Ag}}$. (W22 - Q1c, 07 marks)
8. An instantaneous reaction takes place between gas A and spherical solid B. Show that the flux of gas A through the exterior surface of solid is $Q_{AS} = \frac{D_e r_C (C_{Ag} - C_{Ac})}{R(R - r_C)}$. How is this simplified when the reaction goes to completion? (W22 - Q2c, 07 marks)
9. Explain Stokes' regime in a fluid-particle reaction system. (W23 - Q2a, 03 marks)
10. Discuss the effect of time for the determination of the rate-controlling step for fluid-solid reactions. (W23 - Q2b, 04 marks)
11. In a uniform environment, 4 mm solid particles are 87.5% converted to product in 5 min. What mean conversion is obtainable in a fluidized bed reactor using a feed of 2 mm and 1 mm particles with a mean residence time of 30 minutes? (S23 - Q2c (OR), 07 marks) *[Numerical]*
12. Draw a plot to show the progress of the reaction of a single spherical particle of constant size with surrounding fluid measured in terms of time for complete conversion for all the different resistances. (S24 - Q4a (OR), 03 marks)
13. Analyze the role of temperature and particle size for experimentally determining the rate-controlling step of a fluid-particle noncatalytic reaction. (S24 - Q4b (OR), 04 marks)
14. In a gas-phase environment, particles of B are converted to solid product. Find the weight of solids in the reactor to treat 1 ton/hr of solids to 90% conversion. (S24 - Q4c, 07 marks) *[Numerical]*
15. Spherical solid particles containing B are roasted isothermally. From the conversion data, determine the rate-controlling mechanism. (W24 - Q2a, 03 marks) *[Numerical]*
16. Solids of unchanging size are reacted with gas in a fluidized reactor. Design a commercial-sized fluidized bed reactor to treat 4 metric tons/hr of solid feed to 90% conversion. (W24 - Q2c, 07 marks) *[Numerical]*

17. Derive rate expression for ash film controlled non-catalytic solid-fluid reaction. (W24 - Q2c (OR), 07 marks)
18. Suggest a suitable model for solid-fluid reactions for different situations (e.g., burning of cotton, corrosion of iron). (S25 - Q2b, 04 marks)
19. A solid feed consisting of different particle sizes passes through a reactor. (1) Find residence time for 100% conversion. (2) Find mean conversion for 15 min residence time. (S25 - Q2c, 07 marks) *[Numerical]*
20. With a neat schematic diagram, explain reactant gas and solid concentration profile for SCM and PCM models. (S25 - Q2c (OR), 07 marks)
21. A feed consisting of different particle sizes is to be reacted in a fluidized-bed reactor. Find the conversion of solids for a feed rate of 1 kg solids/min. (W23 - Q5c, 07 marks) *[Numerical]*

Unit 4: Introduction to Catalysis

Repeated Questions:

1. **Define/Explain: Catalyst Promoters, Inhibitors, and Poisons.**
    - Appeared in: W22 (Q3c, 07 marks), W23 (Q2a, 03 marks), S23 (Q2a, 03 marks), S24 (Q1a, 03 marks), S25 (Q4c, 07 marks), W24 (Q4a, 03 marks)
2. **List and explain the methods of catalyst preparation.**
    - Appeared in: S22 (Q2c (OR), 07 marks), S23 (Q3b, 04 marks), S24 (Q1b, 04 marks), S25 (Q1b, 04 marks)
3. **Discuss the physical properties of catalysts and/or methods for surface area determination (BET, Nitrogen desorption).**
    - Appeared in: S22 (Q4c, 07 marks), S23 (Q3c, 07 marks), S25 (Q4a, 03 marks), W24 (Q4c, 07 marks)

Other Important Questions:

4. Explain in brief about monolithic catalyst and molecular sieves. (W22 - Q2a, 03 marks)
5. Discuss about the Monolithic catalyst. (S22 - Q4a, 03 marks)
6. Define: 1) Catalysts 2) Accelerator 3) Coking 4) Sintering (S22 - Q4b, 04 marks)
7. Discuss various physical properties of a catalyst. (S22 - Q4a (OR), 03 marks)
8. Give classification of catalysts. (W23 - Q1b, 04 marks)
9. Discuss in detail about the nature and mechanism of catalytic reactions. (W23 - Q1c, 07 marks)
10. What are the carriers or supports used and why are they used with catalysts? Name the three categories of Industrial catalysts. (S23 - Q3a, 03 marks)
11. Name the methods of preparing solid catalyst. Discuss any one method in detail. (S23 - Q3b, 04 marks)
12. Discuss catalyst preparation through the wet impregnation method. (W24 - Q4a, 03 marks)
13. Discuss the sol-gel method for heterogeneous catalyst preparation. (W24 - Q4b, 04 marks)
14. Discuss XRD, SEM, and TPD analysis. (W24 - Q4c, 07 marks)
15. Discuss the significance of XRD, SEM, and TPD analysis in the characterization of catalysts. (S25 - Q4a, 03 marks)
16. Discuss the importance of surface area and thermal stability characteristics of a catalyst. Also, suggest suitable techniques to measure these characteristics. (S25 - Q4b, 04 marks)
17. Nitrogen was employed to determine the surface area of a silica gel sample. Calculate the specific surface area by the BET method. (S24 - Q1c, 07 marks) *[Numerical]*
18. Derive the Langmuir adsorption isotherm for molecular adsorption of hydrogen on a catalyst surface. (S22 - Q4c (OR), 07 marks)
19. Discuss the spectrum of kinetic regimes for a porous catalyst surrounded by a reactant. (W22 - Q3a, 03 marks), (S23 - Q3a (OR), 03 marks)
20. Distinguish between van der Waal's adsorption and activated adsorption with a suitable example. (W22 - Q3a (OR), 03 marks)

Unit 5: Solid-Catalyzed Reactions

Repeated Questions:

1. **Derive/Explain the LHHW (Langmuir-Hinshelwood-Hougen-Watson) model for a surface reaction.**
   - Appeared in: S22 (Q2c, 07 marks), W23 (Q3c (OR), 07 marks), S23 (Q5b, 04 marks)
2. **Define and explain the Significance of the Effectiveness Factor and Thiele Modulus.**
   - Appeared in: S22 (Q3a, 03 marks), S23 (Q5a, 03 marks), S24 (Q3a, 03 marks), S24 (Q3b, 04 marks), W24 (Q5b, 04 marks)
3. **Discuss/Predict a rate law and mechanism consistent with experimental data for a catalytic reaction.**
   - Appeared in: W22 (Q2b, 04 marks), S24 (Q2c, 07 marks), S25 (Q5c, 07 marks)

Other Important Questions:

4. Discuss steps involved in a catalytic reaction with a neat sketch. (W22 - Q3b, 04 marks)
5. The desorption of gaseous species C from the active site "S" of a catalyst is given as $C.S \rightleftharpoons C + S$. Derive the rate law for the desorption phenomena. (W22 - Q3b (OR), 04 marks)
6. State the mass transfer correlations for a fluidized bed catalytic reactor. (W22 - Q5a, 03 marks)
7. Write merits and demerits of fixed bed reactors. (W22 - Q5b, 04 marks)
8. Discuss the experimental methods for finding a rate law consistent with experimental data with a suitable example. (W22 - Q5c, 07 marks)
9. What is meant by the interphase effectiveness factor for an isothermal catalytic reaction? (W22 - Q5a (OR), 03 marks)
10. Write an algorithm for determining the reaction mechanism, rate-limiting step, and rate law for the isomerization of n-pentene to i-pentene over alumina as a catalyst. (W22 - Q5b (OR), 04 marks)
11. Derive the design equation for a packed bed catalytic reactor. (W22 - Q5c (OR), 07 marks)
12. Explain Turn over frequency and Selectivity of catalysts. (S22 - Q3a (OR), 03 marks)
13. Explain poison and promoter for catalyst with example. (S22 - Q3b, 04 marks)
14. Explain accelerators and promoters in detail. (W23 - Q5a, 03 marks)
15. Explain turn over frequency and Effectiveness factor for catalysts. (W23 - Q5b, 04 marks)
16. Write in brief about catalyst deactivation. (W23 - Q5a (OR), 03 marks)
17. Give details about Monolayer & Multilayer adsorption. (W23 - Q5b (OR), 04 marks)
18. Gaseous reactant A diffuses through a gas film and reacts on the surface of a solid according to a reversible first-order rate. Develop an expression for the rate of reaction of A accounting for both mass transfer and reaction steps. (S23 - Q1c, 07 marks)
19. For kinetics of fluid-solid catalytic reaction, write about "Adsorption isotherm". (S23 - Q3c, 07 marks)
20. Develop the overall rate expression for a gas-phase heterogeneous reaction: A⇌M+N, assuming the surface reaction is the rate-controlling step. (S23 - Q3b (OR), 04 marks)
21. List out steps involved in solid catalyzed fluid-phase reactions in converting reactants to products. (S23 - Q5a, 03 marks)
22. Justify: For a given treatment rate, the conversion of a reacting fluid, flowing through a batch of deactivating catalyst, decreases with time during the run. (S23 - Q5c, 07 marks)
23. Answer the following in brief: (i) Effectiveness factor (ii) Pore diffusion Resistance (iii) Thiele modulus. (S23 - Q5a (OR), 03 marks)
24. Derive the Performance Equations for a Plug flow Reactor containing porous catalysts. (S23 - Q5c (OR), 07 marks)

25. Write the assumption for the Langmuir Hinshelwood Hougen Watson model. (S24 - Q2a, 03 marks)
26. Explain the mechanism of solid catalysed reactions. (S24 - Q2b, 04 marks)
27. The catalytic reaction A → B takes place within a fixed bed. From the data, determine if the reaction is limited by external diffusion, internal diffusion, or reaction rate. Estimate effectiveness factors. (S24 - Q2c (OR), 07 marks) *[Numerical]*
28. Write a brief note on the working of a fluidized bed reactor. (S24 - Q3b (OR), 04 marks)
29. The catalytic reaction A→4R is run in a plug flow reactor. Find a rate equation to represent this reaction. (S24 - Q3c (OR), 07 marks) *[Numerical]*
30. Cl_2 is removed from a waste stream in a PBR. If flow rate, particle size, and tube length are changed, what percentage of Cl_2 would be removed? (S24 - Q3c, 07 marks) *[Numerical]*
31. Discuss the concept of pore diffusion in solid catalyzed reactions. (W24 - Q5a, 03 marks)
32. A first-order catalytic reaction is run in a reactor. The catalyst particles shrink over time. What should be the conversion after a few months for (i) no pore diffusion resistance, (ii) strong pore diffusion resistance? (W24 - Q5b, 04 marks) *[Numerical]*
33. Explain a detailed reaction mechanism on a solid surface considering the LHHW model. (W24 - Q5c, 07 marks)
34. Define Thiele modulus and Enhancement factor and discuss its significance. (W24 - Q5b (OR), 04 marks)
35. To build a packed bed reactor filled with porous catalyst particles to treat feed gas to 80% conversion. How much catalyst must be used? (W24 - Q5c (OR), 07 marks) *[Numerical]*
36. Discuss salient features of the LHHW model for solid catalysed reactions. (S25 - Q5b, 04 marks)
37. Gaseous A reacts (A → B) in an experimental plug flow reactor. From the conversion data, find a rate equation to represent the reaction. (S25 - Q5c, 07 marks) *[Numerical]*
38. The first-order decomposition of A is run in an experimental mixed flow reactor. Determine the role played by pore diffusion in these runs. (S25 - Q5b, 04 marks) *[Numerical]*
39. To build a packed bed reactor to treat 1 m^3/s of feed gas to 80% conversion of A. How much catalyst must be used? (S25 - Q5c, 07 marks) *[Numerical]*
40. Draw a schematic diagram of three different types of industrial fixed bed catalytic reactors with heat removal arrangements for different exothermic reactions. (S25 - Q4a (OR), 03 marks)
41. Discuss salient features of a fluidized bed reactor. Also, list various industrial applications of fluidized bed reactors. (S25 - Q4b (OR), 04 marks)
42. Discuss experimental reactors for solid catalyzed reactions. (S25 - Q4c (OR), 07 marks), (W24 - Q4c (OR), 07 marks)
43. Write a short note on Slurry reactors. (S23 - Q5b, 04 marks), (W22 - Q4b, 04 marks)
44. Write a short note on a trickle bed reactor. (W22 - Q5a (OR), 03 marks)

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