GUJARAT TECHNOLOGICAL UNIVERSITY

BE-6 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:

CHEMICAL REACTION ENGINEERING I (3160506)

Unit 1: Overview of chemical reaction engineering

Repeated Questions:

1. **Define/Explain elementary and non-elementary reactions with a suitable example.**
   (W25 - Q1a, 03 marks)
   (W23 - Q1b, 04 marks)
   (S23 - Q1b, 04 marks)
2. **Define molecularity and order of reaction. State the difference between them.**
   (S22 - Q1b, 04 marks)
   (S23 - Q1a, 03 marks)
   (W24 - Q1a, 03 marks)
   (S25 - Q1a, 03 marks)
3. **Discuss the variables affecting the rate of reaction.**
   (S23 - Q1c, 07 marks)
   (S24 - Q1b, 04 marks)
   (S25 - Q3a, 03 marks)
4. **Why can molecularity never be more than three? Why can the order of reaction be zero, but the molecularity cannot?**
   (W24 - Q1a, 03 marks)
   (W23 - Q1A.1 & A.2, 03 marks)
5. **Explain homogeneous and heterogeneous reactions with a suitable example.**
   (S23 - Q2b, 04 marks)
   (W24 - Q1a, 03 marks)

Other Important Questions:

1. **Classify reactions and give a suitable industrial example of such a reaction.** (W25 - Q1a, 03 marks)
2. **Define rate constant. Derive the unit of rate constant.** (S24 - Q1a, 03 marks)
3. **Define rate constant with its significance.** (S25 - Q1a, 03 marks)
4. **Define rate of reaction considering unit volume, mass, and surface of solid in a fluid-solid system.** (S25 - Q1b, 04 marks)
5. **Give a detailed classification of reactions with an example.** (S25 - Q2c, 07 marks)
6. **Give a detailed classification of chemical reactions.** (S22 - Q4a, 03 marks)
7. **Define an intermediate. What are the different types of intermediates suggested by the chemistry of the materials?** (W23 - Q1A.3, Part of 03 marks)
8. **Discuss the conditions required for the steady-state approximation.** (W24 - Q2a, 03 marks)
9. **What do you mean by constant volume and variable volume system?** (S23 - Q2a, 03 marks)
10. **Write a short note on 'Variable volume batch reactor'.** (W24 - Q2b, 04 marks)
11. **Define extent of reaction and conversion.** (Inferred from Unit 1 content - No direct question found in scanned papers matching exact phrasing for marks)
12. **Define selectivity and product distribution.** (S23 - Q4a, 03 marks)

Unit 2: Kinetics

Repeated Questions:

1. **The first-order reversible liquid reaction $A \rightleftharpoons R$, $C_{A0} = 0.5$ mol/lit, $C_{R0} = 0$ takes place in a batch reactor. After 8/9 minutes, conversion of A is 33.3%/30% while equilibrium conversion is 66.7%/70%. Find/Devise the rate equation for this reaction.**
   (W25 - Q2c, 07 marks) [Diagram or Table given - refer Question paper of W25]
   (S23 - Q3c, 07 marks)
   (S22 - Q2c OR, 07 marks)
2. **Explain/Discuss the integral and differential method of analysis.**
   (S23 - Q2c, 07 marks)
   (W24 - Q3a, 03 marks)
   (W23 - Q3A, 04 marks)
3. **Explain with example autocatalytic reaction.**
   (S23 - Q2c OR, 07 marks)
   (W24 - Q3a, 03 marks)
   (S24 - Q3b, 04 marks)
   (S22 - Q3a OR, 03 marks)
   (S25 - Q3b, Part of question)
4. **Discuss autocatalytic reaction with conversion-time and rate-concentration curves.**
   (W24 - Q3a, 03 marks)
   (S24 - Q3b, 04 marks)
   (S25 - Q3b, Part of question)
5. **Derive the equation for a unimolecular type first-order reaction for a constant volume batch reactor using the integral method.**
   (S25 - Q2a, 03 marks)
   (S22 - Q3a, 03 marks)

Other Important Questions:

1. **For the decomposition $A \rightarrow R$, $C_{A0} = 1$ mol/liter, in a batch reactor conversion is 75% after 1 hour, and is just complete after 2 hours. Find a rate equation to represent this kinetics.** (S25 - Q2c OR, 07 marks)
2. **Derive the equation for half-life using the overall order of an irreversible reaction.** (W24 - Q2c OR, 07 marks) (S25 - Q3c, 07 marks)
3. **List various theories of temperature dependency on the rate of reaction and discuss any one in detail.** (W24 - Q2c, 07 marks)
4. **Give a brief about shifting order reaction.** (S25 - Q2b, 04 marks)
5. **Analyze total pressure data obtained in a constant-volume system and establish the relation used to calculate the partial pressure of a gaseous component in the reaction mixture.** (S24 - Q2c, 07 marks)
6. **Show that: $\ln[(M - X_A) / (M(1 - X_A))] = C_{A0} (M - 1) k t$, for $M \neq 1$ for a second-order irreversible bimolecular reaction $A + B \rightarrow$ Products with different initial concentrations.** (S24 - Q2c OR, 07 marks)
7. **Explain the theory - Analysis of total pressure data obtained in a constant-volume system.** (W23 - Q2C OR, 07 marks)
8. **A certain reaction has a rate given by $-r_A = 0.005 C_A^2$ (mol/cm³.min). If the concentration is expressed in mol/l and time in hours, what would be the value and units of the rate constant?** (W24 - Q3c, 07 marks)
9. **In a homogeneous isothermal liquid polymerization, 20% of the monomer disappears in 34 minutes for an initial monomer concentration of 0.04 and also for 0.8 mol/liter. What rate equation represents the disappearance of the monomer?** (S23 - Q3c, 07 marks)
10. **Define and write about the advantages and disadvantages of an Ideal Batch Reactor and also give its industrial application.** (S22 - Q3c, 07 marks)
11. **Phosphine decomposes when heated: $4PH_3(g) \rightarrow P_4(g) + 6H_2(g)$. At a given instant, the rate of decomposition is 2.4×10^{-3} mol/(L.s). (a) Express the rate in three ways. (b) What is the rate of formation of P_4 and H_2?** (W24 - Q3c, 07 marks)

12. **What is a biochemical reaction? Explain with an example.** (S22 - Q3a, 03 marks)
13. **Derive the rate of reaction for a homogeneous catalytic reaction.** (W24 - Q3a, 03 marks)
14. **Explain homogeneous and heterogeneous catalytic reactions with a suitable example.** (S23 - Q2b, 04 marks)

Unit 3: Homogeneous Single Reactions

Repeated Questions:

1. **Derive the performance/design equation for a steady-state Plug Flow Reactor (PFR).**
   (S25 - Q1c, 07 marks)
   (S23 - Q3b, 04 marks)
2. **Derive the performance/design equation for a steady-state Mixed Flow Reactor (CSTR).**
   (S24 - Q1c, 07 marks)
   (W23 - Q3C, Part of question)
   (S22 - Q3b OR, 04 marks)
3. **Given a gaseous feed, $C_{A0}=100$, $C_{B0}=200$, $A+B \rightarrow R+S$, $X_A=0.8/0.9$. Find X_B, C_A, C_B.**
   (W25 - Q3a, 03 marks)
   (W24 - Q3a OR, 03 marks)
4. **Show/Prove that N number of plug flow reactors connected in series with total volume V gives the same conversion as a single PFR of volume V.**
   (W24 - Q4b, 04 marks)
   (W23 - Q3C, 04 marks)
5. **Discuss equal-sized mixed flow reactors (CSTRs) in series.**
   (S24 - Q4a, 03 marks)
   (W23 - Q4B, 04 marks)
   (S22 - Q4a, 03 marks)
6. **What is a recycle reactor? Write its uses.**
   (S23 - Q3a OR, 03 marks)
   (W24 - Q3a, 03 marks)

Other Important Questions:

1. **Justify: Performance of PFR is better than CSTR for all positive order reactions.** (W25 - Q1c, 07 marks) [Diagram or Table given - refer Question paper of W25]
2. **Derive the performance equation for an ideal batch reactor.** (W24 - Q4a, 03 marks) (S25 - Q4c, 07 marks)
3. **Derive the performance equation of a recycle reactor.** (S22 - Q5c, 07 marks) (W23 - Q5C, Part of question)
4. **Derive performance equation for PFR with recycle.** (W24 - Q1c, 07 marks)
5. **Explain recycle ratio and the performance equation of recycle plug flow reactors.** (S25 - Q4a OR, Part of question)
6. **What is multiple-reactor systems? Explain its importance.** (S23 - Q3a, 03 marks)
7. **Discuss the working of PFR in series and parallel connection.** (S22 - Q4b, 04 marks)
8. **Explain Plug Flow Reactors in Series and in Parallel with equation.** (S24 - Q4b, 04 marks)
9. **Write a short note on Multiple CSTRs in series.** (W24 - Q3b OR, 04 marks)
10. **Discuss different sizes of mixed flow reactors in series.** (S25 - Q5b OR, 04 marks)
11. **For multiple reactors, justify with a suitable diagram that for all positive order reactions, PFR + small CSTR + large CSTR is the best choice.** (W24 - Q3c OR, 07 marks)
12. **Show that performance of multiple PFRs in series is equal to the performance of a single PFR having the same total volume and volumetric flow rate.** (W24 - Q3c, 07 marks)
13. **Define: Space time, Space velocity, Holding time, Mean residence time.** (W23 - Q3B, Part of question) (S24 - Q2a, 03 marks)
14. **Define space time and space velocity.** (W24 - Q3a, 03 marks)
15. **At present, the elementary liquid-phase reaction $A+B \rightarrow R+S$ takes place in a PFR using equimolar A and B. Conversion is 96%, $C_{A0}=C_{B0}=1$ mol/lit. If a mixed flow reactor ten times as large as the PFR is hooked up in series, which unit should come first and by what fraction could production be increased?** (W25 - Q3c, 07 marks)
16. **When elementary 2nd order liquid reaction $2A \rightarrow 2R$ is carried in a PFR with a recycle ratio of unity, conversion is 66.67%. Determine the conversion if the recycle stream is shut off.** (S24 - Q3c OR, 07 marks)

17. **An aqueous reactant stream with $C_{A0}=4$ mol/lit passes through a mixed flow reactor followed by a plug flow reactor. The reaction is 2nd order w.r.t A. The volume of the PFR is 3 times that of the MFR. Find the concentration of A at the exit of the PFR if the concentration in the MFR is 1 mol/lit.** (S24 - Q3c, 07 marks)
18. **A liquid reactant stream (1 mol/liter) passes through two mixed flow reactors in series. Concentration at the exit of the first reactor is 0.5 mol/liter. Find the concentration at the exit of the second reactor. The reaction is second-order w.r.t A and V2/V1 = 2.** (W25 - Q4a OR, 03 marks)
19. **A liquid reactant stream (2 mol/liter) passes through two mixed flow reactors in series. Concentration at the exit of the first reactor is 0.7 mol/liter. Find the concentration at the exit of the second reactor. The reaction is second-order w.r.t A and V2/V1 = 1.5.** (W24 - Q4c OR, 07 marks)
20. **Define and write about the advantages and disadvantages of an Ideal Plug Flow Reactor and also give its industrial application.** (S22 - Q3c OR, 07 marks)
21. **Discuss merits and demerits of batch and continuous modes of reactor operation.** (W23 - Q1B, 04 marks)
22. **Explain the advantages, disadvantages, and applications of batch reactors and continuous reactors.** (W24 - Q4a OR, 03 marks)
23. **Define conversion, yield, space time.** (S25 - Q5a, 03 marks)
24. **Give criteria for the best arrangement of a set of ideal reactors.** (S22 - Q4b OR, 04 marks)

Unit 4: Multiple Reactions

Repeated Questions:

1. **Discuss qualitative product distribution for reactions in parallel.**
   (W23 - Q5C, Part of question)
   (S25 - Q5c, 07 marks)
   (S22 - Q5c OR, 07 marks)
2. **Define yield, selectivity, and product distribution.**
   (S23 - Q4a, 03 marks)
   (S25 - Q5a, Part of question)
3. **Discuss parallel reactions with examples.**
   (S25 - Q4a, 03 marks)
   (S22 - Q5c OR, Related concept)

Other Important Questions:

1. **Derive a relation for overall fractional yield in a PFR for the following parallel reactions: A → R and A → S.** (W25 - Q4c, 07 marks) (W24 - Q4c, 07 marks)
2. **Discuss fractional yield, overall yield, and selectivity for parallel reactions.** (S24 - Q3a, 03 marks)
3. **Define Overall Fractional yield and Instantaneous fractional yield for the decomposition of A into product R.** (S24 - Q4b OR, 04 marks)
4. **Consider the parallel decomposition of A of different orders. Determine the maximum concentration of desired product obtainable in (a) plug flow, (b) mixed flow.** (W25 - Q4b OR, 04 marks) [Diagram or Table given - refer Question paper of W25]
5. **Using separate feeds of A and B, sketch the contacting pattern and reactor conditions which would best promote the formation of product R for the elementary reactions: A+B→R and A→S (Continuous flow reactor).** (W24 - Q4a OR, 03 marks)
6. **Differentiate between contacting patterns in continuous flow operations and non-continuous operations for various combinations of high and low concentration of reactants for maximizing the desired product.** (S25 - Q5c OR, 07 marks)
7. **Explain selectivity with its equation.** (S25 - Q5a OR, 03 marks)
8. **First-order unimolecular irreversible reaction in series A → R → S takes place with specific reaction rates k1 and k2. Express the variation of concentration of A, R, and S with time. Find the expression for the time when the formation of R becomes maximum.** (S24 - Q4c OR, 07 marks)
9. **Draw a schematic diagram of concentration vs. time for the following series reactions: A → R → S.** (W25 - Q4c OR, 07 marks) (W24 - Q4b OR, Part of question)
10. **Discuss in detail about product distribution for parallel reactions.** (S24 - Q4c, 07 marks)

Unit 5: Temperature Effects for Single and Multiple Reactions

Repeated Questions:

1. **Discuss/Optimum temperature progression and its application.**
   (W25 - Q4a, 03 marks)
   (S23 - Q5a, 03 marks)
   (S25 - Q3c, 07 marks)
2. **Derive the relation/find the equation between conversion and temperature for adiabatic operation.**
   (S23 - Q5c, 07 marks)
   (S22 - Q4c OR, 07 marks)
3. **What is the effect of temperature and pressure on equilibrium conversion from thermodynamics?**
   (S22 - Q5b OR, 04 marks)
   (W23 - Q4C, Part of question)
   (W23 - Q4A OR, Related concept)

Other Important Questions:

1. **Suggest selection of maximum operating temperature for: i) exothermic irreversible reaction, ii) exothermic reversible reaction, iii) endothermic reversible reactions.** (W24 - Q4a, 03 marks)
2. **Draw a schematic diagram for optimal temperature progression for adiabatic reactions in a CSTR and explain its salient features.** (W24 - Q4b, 04 marks)
3. **Derive the equation for complete conversion for adiabatic operation.** (S22 - Q4c OR, 07 marks)
4. **Between 0°C and 100°C, determine the equilibrium conversion of A for the aqueous reaction A ⇌ B. ΔG°298 = -3375 cal/mol; ΔH°f,298 = -18,000 cal/mol. Plot a graph between conversion and temperature. What restrictions should be placed on an isothermal reactor to obtain a fractional conversion of 75% or higher?** (S24 - Q5c OR, 07 marks)
5. **Show the graphical representation of the energy balance equation for adiabatic operation.** (S25 - Q4b OR, 04 marks)
6. **Discuss the effect of pressure on equilibrium conversion as predicted by thermodynamics keeping temperature fixed.** (W23 - Q4C, Part of question)
7. **Discuss the effect of temperature on equilibrium conversion as predicted by thermodynamics keeping pressure constant.** (W23 - Q4C OR, Part of question)
8. **Discuss the effect of temperature on the heat of reaction.** (W23 - Q4A OR, Part of question)
9. **Define an equilibrium state and discuss the characteristics of chemical equilibrium.** (W23 - Q4A, Part of question)
10. **Classify chemical reactions on the basis of (a) number of phases involved and (b) heat of reaction with a suitable example.** (W23 - Q5A, Part of question)
11. **Write a short note on equilibrium constants from thermodynamics clearly indicating the equations.** (S24 - Q5c, 07 marks)
12. **What is equilibrium conversion? Discuss.** (S22 - Q5a OR, 03 marks)
13. **The pyrolysis of ethane proceeds with an activation energy of about 300 kJ/mol. How much faster is the decomposition at 650°C than at 500°C?** (W25 - Q3b, 04 marks)
14. **At 1100K n-nonane thermally cracks 20 times as rapidly as at 1000K. Find the activation energy for this decomposition.** (S23 - Q1c, 07 marks)
15. **At 500K the rate of a bimolecular reaction is ten times the rate at 400K. Find the activation energy from (a) Arrhenius law, (b) collision theory. What is the % difference in rate at 600K predicted by these two methods?** (W24 - Q4c, 07 marks)
16. **The activation energy of a reaction is 17982 cal/mol without a catalyst and 11980 cal/mol with a catalyst. By how many times will the rate grow at 25°C in the presence of the catalyst?** (W24 - Q4c OR, 07 marks)
17. **Milk is pasteurized if heated to 63°C for 30 min, but if heated to 74°C it only needs 15**

sec for the same result. Find the activation energy of this sterilization process. (S25 - Q4b, 04 marks)

18. **The activation energy of a bimolecular reaction is about 9150 cal/mol. How much faster does this reaction take place at 500K than at 400K?** (W23 - Q2A, 03 marks)
19. **Discuss the temperature dependence term from the Arrhenius Law.** (S22 - Q1c, 07 marks)
20. **Write a short note on the temperature dependency of the reaction rate constant from the Arrhenius law. Compare with transition state and collision theories.** (W23 - Q2B, 04 marks)

Unit 6: RTD theory and analysis of non-ideal reactors

Repeated Questions:

1. **Discuss various non-idealities that can be present in a CSTR/PFR.**
   (W25 - Q5a, 03 marks)
   (W25 - Q5a OR, 03 marks)
   (S23 - Q4b, 04 marks)
   (S25 - Q3b, 04 marks)
2. **Sketch and explain RTD curves (E and/or C curves) for Ideal PFR and Ideal Mixed Flow Reactor (CSTR).**
   (W23 - Q4B OR, Part of question)
   (S22 - Q5a, 03 marks)
3. **Discuss earliness and lateness of mixing in RTD.**
   (S23 - Q4a, 03 marks)
   (W24 - Q5a OR, 03 marks)
4. **Draw C and E curves for an ideal PFR for a pulse input.**
   (W25 - Q5b, 04 marks)
   (W24 - Q5b OR, 04 marks)

Other Important Questions:

1. **Define Residence Time Distribution (RTD) and explain the E-Curve.** (S24 - Q5a, 03 marks)
2. **Discuss the significance of RTD studies.** (W24 - Q5a, 03 marks) (W24 - Q5a, 03 marks)
3. **Write a short note on the uses of RTD studies.** (W24 - Q5a, 03 marks)
4. **RTD of all components for an ideal PFR is the same. Justify this statement.** (W24 - Q5a OR, 03 marks)
5. **Draw and discuss C, E, and F curves for an ideal PFR for a pulse input.** (W24 - Q5b OR, 04 marks)
6. **Draw C and E curves for an ideal CSTR, PFR with bypass, and PFR with dead zone for a pulse input.** (W24 - Q5b OR, 04 marks)
7. **How can you identify dead zone and bypass non-idealities present in a CSTR? Explain with suitable schematic diagrams.** (W24 - Q1b, 04 marks)
8. **Suggest relative changes in t_bar value for various non-idealities present in a CSTR. Explain with a schematic diagram of the C curve for all such cases.** (W25 - Q5b OR, 04 marks)
9. **Which are the various non-idealities that can exist in a reactor? Also suggest solutions to remove such non-idealities.** (W23 - Q5B, Part of question)
10. **Discuss the non-ideal flow patterns which may exist in a reactor and how a reactor deviates from an ideal flow reactor.** (S22 - Q5b, 04 marks) (W24 - Q5b, 04 marks)
11. **A closed vessel has flow for which the dispersion number is 0.3. We wish to represent this vessel by the tanks-in-series model. What value for the number of tanks should be selected?** (S24 - Q5b, 04 marks)
12. **From first principles, prove that for a backmix reactor (i) E(θ) = e^(-θ) and (ii) F(θ) = 1 - e^(-θ).** (S24 - Q5b OR, 04 marks)
13. **List out the characteristics of a good tracer.** (S24 - Q5a OR, 03 marks)
14. **What is the use of a tracer? Discuss the desired characteristics of a tracer.** (W23 - Q4B, Part of question)
15. **A pulse of concentrated NaCl solution is introduced as tracer into the fluid entering a vessel (V=1 m^3, v=1 m^3/min). The concentration of tracer is measured in the fluid leaving the vessel. Develop a flow model to represent the vessel from the tracer output data.** (W25 - Q5c OR, 07 marks) [Diagram or Table given - refer Question paper of W25]
16. **A pulse input to a vessel gives the results shown in a figure. (a) Check the material balance. (b) If consistent, determine t_bar, V, and sketch the E curve.** (W24 - Q5c OR, 07 marks) [Diagram or Table given - refer Question paper of W24]
17. **The concentration readings in a table represent a continuous response to a pulse input into a closed vessel. Calculate the mean residence time (t_bar) of fluid in the vessel and**

tabulate and plot the exit age distribution E. (S23 - Q5c, 07 marks) [Diagram or Table given - refer Question paper of S23]

18. **The concentration readings in a table represent a continuous response to a pulse input. Calculate the mean residence time of fluid in the vessel.** (S25 - Q3a OR, 03 marks) [Diagram or Table given - refer Question paper of S25]
19. **A pipeline (10 cm I.D., 19.1 m long) simultaneously transports gas and liquid. The volumetric flow rates are 60,000 cm^3/s and 300 cm^3/s, respectively. Pulse tracer tests give results as shown in a figure. What fraction of the pipe is occupied by gas and what fraction by liquid?** (W25 - Q5c, 07 marks) (W24 - Q5c, 07 marks) [Diagram or Table given - refer Question paper of W25 & W24]
20. **Dispersed non-coalescing droplets [C_{A0} = 2 mol/liter] react as per $A \rightarrow R$ with $-r_A = k C_A^2$, k=0.5 lit/(mol.min) as they pass through a contactor. Find the average concentration of A leaving the contactor. (Use E = 0.50 for $1 < t < 3$).** (S22 - Q5c OR, 07 marks)

****