1. What is a chemical reaction?
2. What is reaction stoichiometry?
3. Single versus multiple reactions, what is the difference?
4. What is (molar) extent of reaction?
5. What is the concept of the limiting reactant?
6. What is fractional conversion?
7. How are molar extent of reaction and conversion related?
8. How is molar concentration of any species related to conversion? Is there a difference between constant volume and constant pressure systems?
9. How is molar concentration of a species related to extent?
10. How is mole fraction related to extent? Conversion?
11. How is the thermodynamic equilibrium constant calculated at standard condition? Does this constant have units?
12. How do we correct the value of the thermodynamic equilibrium constant for temperature? Is this constant a function of pressure?
13. How is the thermodynamic equilibrium constant, $K$, related to $K_y$, for ideal gases, $K_c$ for liquids?
14. What information is needed to calculate the equilibrium composition of the system? What is the procedure?
15. How is the rate of reaction defined? What is it a function of?
16. Write down the representation of an n-th order reaction rate for an irreversible reaction and show what the Arrhenius representation of the rate constant looks like. What is the meaning of activation energy?
17. What is an elementary reaction? Can we infer its order from its molecularity?
18. What is a mechanism of reaction?
19. Using PSSA how do we develop a rate equation from the proposed mechanism?
20. Using RLSA how do we develop a rate equation from the proposed mechanism?
21. How does a catalytic mechanistic sequence differ from the non-catalytic one?
22. What is the Lindemann’s mechanism for ‘unimolecular’ gas phase reactions? At what conditions is the expected first order rate observed? At what conditions is the rate second order?
23. What is the Michaelis-Menten reaction mechanism for enzyme promoted reactions? Show the expected rate form and discuss apparent reaction order at low and high reactant (substrate) concentrations.
24. Write the basic mass balance for an isothermal batch reactor, list key assumptions, and relate reaction time to conversion.
25. How do you relate production rate in a batch reactor, reaction time and conversion?
26. Develop the basic design equation for an isothermal continuous flow stirred tank reactor (CSTR).
27. Develop the basic design equation for an isothermal plug flow reactor (PFR).
28. What is the meaning of space time?
29. Represent graphically the space time for a CSTR and PFR on a plot of the reciprocal of the reaction rate versus conversion.
30. What is the mean residence time (mean holding time)? How does it relate to the space time?
Part 2

1. For a reaction with $20 \text{ kcal}$ activation energy a $10^\circ C$ temperature rise from 300 to 310K raises the rate how many times?

2. For a zeroth order reaction in a batch complete conversion is reached in 1 hour. If we doubled the initial reactant concentration what happens to the time required for complete conversion?

3. For n-th order ($n > 0$) reaction at fixed feed conditions and fixed desired conversion we need a larger space time in a PFR than in a CSTR. True or false?

4. For an autocatalytic reaction the largest reactor volumetric productivity is achievable in a) PFR, b) CSTR c) reactor combination.

5. True or false. For consecutive reactions $A \rightarrow R \rightarrow S$ the highest yield of intermediate $R$ can be expected in a PFR not in a CSTR.

6. True or false. For competitive reactions $A \rightarrow P, A \rightarrow S$, the reaction of higher order is promoted in a PFR.

7. Sketch the relationship between point yield and overall yield in a) CSTR, b) PFR.

8. For multiple reactions $A + 2B = R; \quad 2A + R = S$ develop the relationship for the molar concentration of each species, feed concentrations and the molar extents per unit volume $(\xi_1, \xi_2)$ for each reaction.

9. What is the design equation for a) CSTR, b) PFR, c) an isothermal recycle reactor for a homogeneous single reaction?

10. Write for a single reaction $A \rightarrow$ products a species mass balance and energy balance for a) CSTR, b) PRF?

11. In an adiabatic CSTR how many steady states are possible for an n-th order reaction $(n \geq 0)$ which is a) endothermic, b) exothermic?

12. What are the necessary conditions for stability of a steady state in a CSTR?

13. Wall cooled tubular reactors are prone to hot spot formation. Can you describe why? What do we need to do to prevent a hot spot?

14. True or false. Hot spots in wall cooled tubular reactors are more likely when the reactor is operated at high conversion.

15. What is the effectiveness factor for nonporous catalysts? Can it be larger than one for n-th order $(n \geq 0)$ reaction that is a) exothermic, b) endothermic?
16. How should adiabatic plug flow reactors be operated to ensure safety?

17. If a reaction on a nonporous catalyst is completely mass transfer controlled what can be assumed for the reactant concentration at the catalyst surface? Can you express catalyst surface temperature in terms of mass transfer coefficient, heat transfer coefficient and bulk gas phase reactant concentration in the vicinity of the catalyst surface?

18. What is the effectiveness factor for a porous catalyst particle that accounts for internal transport effects? What is the Thiele modulus? How are they related?

19. What do we mean by “strong pore diffusion limitation regime”? What is the relationship between the effectiveness factor and the Thiele modulus in such regime?

20. What is the value of the catalyst effectiveness factor in absence of internal and external transport effects?

21. At very high temperatures the catalytic reaction rate is limited by external mass transfer. To enhance the reaction rate per unit mass of catalyst should we use larger or smaller particles?

22. What is the residence time distribution (RTD) of a reactor?

23. How is E-curve obtained from a tracer impulse response?

24. What is the mean of the E-curve equal to?

25. What is a segregated flow model and how does it use the E-curve?

26. What is the maximum-mixedness model for a CSTR and what is the segregated flow model for the CSTR? For n-th order reactions do they predict different reactor performance? What can you tell us about it?

27. In order to predict isothermal reactor performance for a first order reaction in a homogeneous system what do we need to know?

28. How should a fluidized bed reactor be modeled? Can its performance be bracketed by a CSTR and PFR model?

29. To maximize productivity how should packed bed adiabatic reactors be operated for exothermic reaction?

30. What information can you obtain from the breakthrough curve (step response) of an adsorber?