Questions for examining Unit Operations of Chemical Engineering II – academic year 2015/2016

1. Settling. Balance of forces acting on a particle. Rewrite the balance using dimensionless numbers. The use of dimensionless numbers in obtaining terminal velocity or size of a particle. Design of settlers – determination of the volume of the device.
2. Discuss two limiting cases of idealized fluid flow through an apparatus and describe the corresponding residence time distribution (RTD) and its density. Explain the principle of experimental techniques serving to determine the RTD. Write down differential balance of a component in a mixture flowing through an ideal mixer and determine the RTD and its density.
3. Write down enthalpy balance for a finite-size system within a finite-time interval with chemical reaction. Explain the way of introducing fictitious streams. How are the enthalpies of a real and fictitious streams determined? Alternatively, explain the use of extent in enthalpy balance.
4. Introduction to reactors: stoichiometry, extent and conversion, their mutual relation. Explain the terms: reaction enthalpy, equilibrium constant. Define extensive and intensive reaction rate, relation to extent. Give examples of kinetic expressions in the case of irreversible and reversible reactions. Temperature dependence of reaction rates.
5. Stirred batch reactor – mass and enthalpy balances for the case of a single reaction. Calculation of reaction time at constant temperature. Reaction time for first order reaction. Indicate problems when there are two reactans.
6. Continuous stirred tank reactor – mass and enthalpy balances for the case of a single reaction. Calculation of mean residence time. Discuss stability of the reactor with exothermic reaction and cooling.
7. Cascade of CSTRs – mass and enthalpy balances. Graphical determination of the number of reactors, algebraic solution in the case of an isothermal reaction of first order.
8. Tubular reactor – mass and enthalpy balances. Calculation of the mean residence time. Relations to the batch reactor. Indicate problems occurring when gas phase is used instead of liquid.
9. Show the use of triangle diagram in describing equilibrium in the case of partially miscible solvents. Write down mass balance equations for a single extraction stage. Explain the lever rule and show how to use it to determine the composition of the raffinate and extract in the triangle diagram.
10. Write all the necessary equations describing repeated (or cross-flow) extraction with partially miscible solvents. Explain how these equations are represented in the triangle diagram and show its use in determining the number of stages.
11. Write all the necessary equations describing counter-current extraction with partially miscible solvents. By using the difference form of the balance equations explain how these equations are represented in the triangle diagram and show its use in determining the number of stages.
12. Describe diffusion within one phase. Discuss Fick's law. Diffusion and convection fluxes.. What is mass transfer and overall mass transfer? Formulate the corresponding rate equations for the molar flux. Resistances and relations between mass transfer and overall mass transfer coefficients. Explain how to calculate mass transfer coefficients. Show various types of driving forces in the x-y diagram.
13. Staged absorption. Describe graphical method for determining the number of equilibrium and real stages in a counter-current absorber. Assuming a linear equilibrium line outline the concept of effectiveness factor to determine the number of equilibrium stages?
14. Absorption with continuous contact of phases. Differential mass balance. Describe how to calculate the height of a packed absorption column using the concept of height and number of transfer units. Logarithmic mean of driving force, conditions of use.
15. Classify various membrane processes according to main driving force. Types of membranes, membrane modules. Mass and enthalpy balance of a module. What is concentration polarization?
16. Quantitative description of reverse osmosis and ultrafiltration.
17. Quantitative description of gas permeation, pervaporation.