Course: Thermal separation processes		
Language: English		
Lecturer: Full Prof. Aleksandra Sander		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**2**	**30**
Seminar	**1**	**15**
		Overall: 90
		ECTS: 7

PURPOSE: Provide knowledge that enables evaluation and selection of the optimal separation process and basic design procedure, with overview of energy savings methods.

THE CONTENTS OF THE COURSE:

Week 1
Definition of thermal separation process; mechanism of separation; overview of thermal separation processes; concurrent, countercurrent and cross flow; theoretical stage; discontinuous and continuous processes; mass and heat balances; phase equilibria; mass transfer fundamentals; driving force

Week 2
Definition and application of heat exchangers; HE classification; modes of heat transfer; general characteristics of shell and tube HE; HE with simple and complex geometry; plate and spiral HE; fluid stream allocation; thermal analysis of HE; kinetics equation; fouling factors; driving force; HE efficiency; number of transfer units

Numerical exercises: shell and tube HE

Week 3
Extended surface HE; basic design of HE; evaluation of heat transfer coefficients and pressure drop (shell and tube side)
Numerical exercises: evaluation of heat transfer coefficients and pressure drop (shell and tube side)

Laboratory – Floating-head HE

Week 4
Evaporation: definition and scope; solutions (properties; solubility; enthalpy; latent heat of evaporation); driving force; boiling point elevation; pressure drop; heat transfer coefficient; vacuum operation; mass and heat balances; enthalpy-

concentration diagram; kinetic equation; single stage and multistage evaporation; evaporators (equipment and working principle); energy savings methods
Numerical exercises: single stage and multistage evaporation
Laboratory – batch evaporator

Week 5
Crystallization: definition, scope and classification; solution properties (physical and thermal properties of solvent; concentration; solubility; saturation, supersaturation and metastability; experimental methods); crystals (definition, crystal systems; polymorphism; crystal shape; CSD); S-L equilibrium; crystallization (supersaturation; nucleation: definition, klasification and kinetics; crystal growth; mass and heat balances);

Numerical excersises: crystallization

Week 6
Crystallizers, design basis; precipitation (basis); melt crystallization: (basis); desublimation (basis)

Numerical exercises: solving complex examples
Laboratory – cooling batch crystallization

Week 7
Written partial exam: HE, evaporation, crystallization

Week 8
Drying: definition and features, heat transfer modes (convection, conduction, radiation, MW), basic terms; sorption isotherms; psychometric charts (Y-h i Y-T); psychometric and gravimetric methods; mass and heat balances, drying curves, drying periods, dryng rate, moisture movement mechanisms; influence of the external conditions on the drying kinetics; mathematical models; energy savings steps; dryers, equipment and basic design procedure.

Numerical exercises: drying
Laboratory - Drying (fluid-bed)

Week 9
Distillation: definition and application; ideal and real mixtures; azeotropes; phase equilibria; extractive and azeotropic distillation; distillation columns; differential distillation (Rayleigh equation-graphical method; working principle; heat and mass balance); continuously operated simple distillation (mass and heat balances, working principle); flash distillation (working principle; operating line); continuous adiabatic rectification (working principle, mass and heat balances, operating lines, energy saving steps; McCabe Thile and Ponchon Savarit methods for NTU determination; q-line and feed condition; diameter and height of the column; reflux ratio);
Numerical exercises: distillation

Week 1o
Column internals (plates, packings: random and structured), selection, optimization and control of rectification column, operating conditions; discontinuous adiabatic distillation: (working principle; mass and heat balances;

operating lines; R=const and xD=const)

Numerical exercises: solving complex problems
Laboratory – Rectification

Week 11
Written partial exam: drying, distillation

Week 12
Extraction: definition and application; solvent requirements; basic terms; distribution coefficient; L-L equilibrium: ternary and distribution graph; solvent rati; single stage and multistage discontinuous extraction: mass balance, operating lines; continuous countercurrent extraction: mass balance, operating line, driving force, NTU, HTU, kinetic approach; extractors: classification and basic design

Numerical exercises: single stage, multistage and continuous extraction
Laboratory – batc extraction

Week 13
Absorption, definition; solvent selection; mass transfer; rate of absorption; local and overall mass transfer coefficients; absorption coefficients; single, multistage and continuous absorption (mass balances, operating lines); optimum L/G; absorbers: classification and general design procedure

Numerical exercises: single stage, multistage and continuous absorption

Week 14
Selection of feasible separation process; guidelines for equipment selection

Numerical exercises: solving complex problems

Week 15
Written partial exam: extraction, absorption

GENERAL AND SPECIFIC COMPETENCE:

At the end of this course students have general knowledge needed for selection of the feasible separation process, based on characteristics and properties of components and their mixture as well as separation process characteristics.
Specific competencies:
Graphical and numerical determination of number of transfer units
Definition, formulation and solving thermal separation problems using balance and kinetic equations
Calculation of heat and mass transfer coefficients for the given separation process
Selection of separation process based on phase equilibria and physical properties
Selection of solvent for extraction and absorption

KNOWLEDGE TESTING AND EVALUATION:

3 partial exams. Students who do not achieve minimum points through partial exams have to complete the written and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS: Student survey.
LITERATURE: K.Satler, H.J.Feindt, Thermal Separation Processes – Principles and Design, VCH Verlagsgesellschaft mbH, Weinheim; 1995. J.D.Seader, E.J. Henley, Separation Process Principles, John Wiley & Sons, Inc., 2006. C.J.Geankoplis, Transport Processes and Unit Operations, Allyn and Bacon, Inc., Boston, 1978. J.H.Lienhard, A Heat Transfer Textbook, Third Ed., Phlogiston Press, Cambridge, 2006.