PAKISTAN ENGINEERING COUNCIL
Syllabus for Engineering Practice Examination (EPE)
Chemical & Polymer Engineering

Total Marks: 60

PART-II

This is an open book breadth and depth examination, comprising 60 Multiple Choice Questions (MCQs) of one mark each (total 60 marks) with a duration of three hours. There shall be two sections of Part-II for each major discipline of EPE. Qualifying Marks for this part shall be ***sixty per cent***.

SECTION-A / BREADTH

This section will generally confirm to latest (updated) B.E./equivalent qualification of Chemical & Polymer Engineering. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. MATHEMATICS, PROBABILITY & STATISTICS 5%

i. Differential and integral calculus
ii. Matrix operation
iii. Roots of equation
iv. Vector and tensor analysis
v. Differential equation, differential calculus
vi. Measurement of central tendencies and dispersions
vii. Probability distributions, conditional probabilities
viii. Estimation of regression and curve fitting
ix. Testing of hypothesis
x. Laplace transform

Suggested Books:

- Erwin Kreyszig, "Advanced Engineering Mathematics," Ninth Edition, 2005, International Edition, John Wiley & Sons, ISBN: 0471728977.
- Stephen Goode, "Differential Equations and Linear Algebra," 2nd Ed., 2000, Prentice Hall, ISBN: 013263757X.
- Susan Milton and Jesse C Arnold, "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences", 4th Edition, 2003, McGraw-Hill, ISBN: 007246836.

2. APPLIED CHEMISTRY 8%

i. Nomenclature
ii. Oxidation & reduction
iii. Periodic table
iv. States of matter
v. Acids and bases
vi. Equations, equilibrium
vii. Metals & nonmetals

Suggested Books:

- R Gopalan et al, “Engineering Chemistry”, 4th Edition 2018.
- David R. Klein “General Chemistry as Second Language”, 2005.

3. ENGINEERING MECHANICS 5%

i. Statics

- Resultants of force systems
- Concurrent force systems
- Equilibrium of rigid bodies
- Frames & trusses
- Centroid of area
- Area moments of inertia
- Friction

ii. Dynamics

- Linear motion
- Angular motion
- Mass moment of inertia
- Impulse & Momentum applied to particles & rigid bodies
- Work energy & power applied to particles & rigid bodies
- Friction.

Suggested Books:

- Hibler, R.C. “Engineering Mechanics”, 11th Ed, Prentice Hall, 2006
- Khurmi, R. S. “Engineering Mechanics”, 19th Ed, S. Chand, 1990
- J. L. Meriam & L.G.Kraige, “Engineering Mechanics” 6th Ed., John Wiley & Sons

4. STRENGTH OF MATERIAL/MATERIAL PROPERTIES 5%

i. Fundamental Laws and principles of stress and strain
ii. Shear Force (SF), Bending Moment (BM), SF and BM diagrams
iii. Stress types
iv. Strain caused by axial load, bending load, torsion & shear
v. Deformations
vi. Plastic verses elastic deformations
vii. Combined stresses
viii. Columns.

Suggested Books:

- Pytel, A. & F.L.Singer, “Strength of Materials”, 4th Ed, Harper & row Publishers, 1997.
- G H Ryder, “Strength of Materials”, 3rd Ed., Macmillan, 1975.

5. ELECTRICITY AND MAGNETISM

5%

i. Charge, energy, current, voltage, power
ii. Work done in moving a charge in an electric field, force between charges

iii. Current & voltage laws
iv. Equivalent circuits
v. Capacitance & inductance
vi. Reactance & impedance
vii. Susceptance & admittance viii.AC circuits
ix. Basic complex algebra.

Suggested Books:

- Halliday, Resnick, "Krane, “Physics, Volume 2”, 5th Ed.
- Kittle C, “Introduction to Solid State Physics”, Willey New York,2000
- Stan Gibilisco, “Applied Physics”, McGraw-Hill, 2002, ISBN 0071382011

6 MATERIAL/ ENERGY BALANCES 8%

i. Mass balance
ii. Energy balance
iii. Control boundary concept
iv. Steady-state process
v. recycle process
vi. Bypass process
vii. Combustion.

Suggested Books:

- Himmelblau David M. “Basic Principles and Calculations in Chemical Engineering”, 7th Ed. 2003, Prentice Hall PTR
- Felder Richard M., Rousseau Ronald W., “Elementary Principles of Chemical Processes”, 3rd Ed., 2001, John Willey & Sons.
- Reklaitis G.V., Schneider Daniel R., “Introduction to Material and Energy Balances”, 1983, John Wiley & Sons.
- Hougen Olaf A., Watson Kenneth M., “Chemical Processes Principles”, 2004, John Wiley and Sons & CBS Publishers.
- Chopy & Hicks, “Handbook of Chemical Engineering Calculations”, 2nd Ed., 1994, McGraw-Hill Professional Publishing.

7. CHEMICAL ENGINEERING THERMODYNAMICS 5%

i. Laws of thermodynamics
ii. Closed and open systems
iii. Entropy
iv. Properties and processes
v. Properties and phase diagram
vi. Equation of state
vii. phase equilibrium and phase change
viii. Chemical equilibrium
ix. Heats of reaction

Suggested Books:

- Smith J.M., Van Ness H.C., Abbott M.M., “Chemical Engineering Thermodynamics”, 6th Ed., 2001, McGraw Hill International Ed.

- Daubert Thomas E., “Chemical Engineering Thermodynamics”, 1st Ed., 1985, McGraw Hill Book Company.
- Sandler Stanley I., “Chemical and Engineering Thermodynamics”, 3rd Ed., John Wiley and sons, Inc.

8. FLUID DYNAMICS 8%

i. Bernoulli equation and mechanical energy balance
ii. Hydrostatic and dynamic pressure
iii. Dimensionless numbers
iv. Laminar and turbulent flow
v. Friction losses in pipes, fittings and bends
vi. Pipe networks
vii. Turbo machinery
viii. Non-newtonian flow

Suggested Books:

- McCabe Warren L., Smith Julian C., Harriott peter, “Unit Operations of Chemical Engineering”, 6th Ed., 2001, McGraw Hill, Inc.
- Coulson J.M., Richardson J.F., “Chemical Engineering”, Vol-I, 1999, The English Book Society and Pergamon Press.
- Holland, F.A. & Bragg, R., “Fluid flow for Chemical Engineers”, 2nd Ed., Butterworth & Heinemann, 1995.
- White, F.M., “Fluid Mechanics”, 4th Ed., McGraw-Hill, 1999.
- Noel Noel-de-Nevers, “Fluid Mechanics for Chemical Engineers”, McGraw Hill.

9. HEAT & MASS TRANSFER 8%

i. Modes of Heat Transfer
ii. Heat transfer coefficient
iii. Thermal and hydrodynamic boundary layers
iv. LMTD & NTU
v. Fouling
vi. Heat exchanger design
vii. Diffusion
viii. Mass transfer coefficient
ix. Equilibrium stage method
x. Graphical method
xi. Separation processes including distillation, leaching, extraction and gas absorption
xii. Humidification and drying

Suggested Books:

- Kern Donald Q. “Process Heat Transfer” , 1997, McGraw Hill Book Co.
- James R. Welty, Charles E**.** Wicks**,** Robert E**.** Wilson, and Gregory L. Rorrer , “Heat, Mass and Momentum Transport”, 5th Ed., 2008, John Wiley & Sons,. Inc., ISBN: 978-0-470-12868-8
- Cengel Yunus A. “Heat Transfer-A Practical approach”, 2nd Edition 2002, McGraw Hill, Book Company.

- Incropera Frank P., De Witt David P., “Fundamentals of Heat and Mass Transfer” 5th Ed., 2002, John Wiley and Sons.
- Coulson J.M., Richardson J.F., “Chemical Engineering” Vol-I, 1999, The English Book Society and Pergamon Press
- Coulson J.M., Richardson J.F., “Chemical Engineering” Vol-II, 5th Ed., 2002, The English Book Society and Pergamon Press
- J.P. Holman, “ Heat Transfer”, 2002, McGraw Hill Book Company.
- James R. Welty, Charles E**.** Wicks**,** Robert E**.** Wilson, and Gregory L. Rorrer , “Heat, Mass and Momentum Transport”, 5th Ed., 2008, John Wiley & Sons,. Inc., ISBN: 978-0-470-12868-8
- MeCabe Warren L., Smith Julian C., Harriott peter, “Unit Operations of Chemical Engineering”, 7th Ed., 2005, McGraw Hill Inc.
- Coulson J.M., Richardson J.F., “Chemical Engineering”, Vol-II, 5th Ed., 2002., The English Book Society and Pergamon Press.
- Incropera Frank P., De Witt David P., “Fundamentals of Heat and Mass Transfer”, 8th Ed., 2018, John Wiley and Sons.
- Schweitzer, “Handbook of Separation Techniques for Chemical Engineers”, 1979, McGraw Hill Book Co.
- Coulson J.M., Richardson J.F., “Chemical Engineering”, Vol-I, 1999. The English Book Society and Pergamon Press

10. PROCESS DYNAMICS AND CONTROL 8%

i. Sensors and control valves
ii. Dynamics, lag and transfer function
iii. Feed back and feed forward control
iv. P, I and PID controllers
v. Control loop design
vi. Tuning PID controller and stability

Suggested Books:

- G. Stephanupolos, “Chemical Process Control”, 2002, Prentice Hall.
- Coughanor, D.R. and Koppel, C.B., “Process system Analysis & Control”, 3rd Edition 2009, McGraw Hill.
- Peter Harriott “Process Control”, 2nd Edition 2003, McGraw-Hill Inc., US, ISBN: 0070993424.
- Austin E. Fribance, “Handbook of Instrumentation”.

11. TRANSPORT PHENOMENON 5%

i. Transport processes
ii. Generalization of basic Laws of diffusion
iii. Diffusion of mass, momentum and heat
iv. Special forms of equations of motion, energy and continuity
v. Specification of initial and boundary conditions
vi. Dimensional analysis
vii. Reynolds averaging

Suggested Books:

- R. B. Bird et al, “Transport Phenomena”, 2nd Edition, 2002, John Wiley & Sons, New York.

- J. R. Welty et al, “Fundamentals of Momentum, Heat and Mass Transfer”, 5th Edition, 2007, John Wiley & Sons, New York.
- R. S. Brodkey and H. C. Hershey, “Transport Phenomena: A Unified Approach”, International Edition, 2003, McGraw Hill, New York.

12. CHEMICAL REACTION ENGINEERING 15%

i. Reaction rates and order of reaction
ii. Rate constant
iii. Conversion, yield, and selectivity
iv. Series and parallel reactions
v. Equilibrium reactions
vi. Energy/material balance around a reactor
vii. Reactions with volume change
viii. Reactor types
ix. Homogeneous and heterogeneous reactions
x. Reactions with heat effects

Suggested Books:

- Levenspiel Octave, “Chemical Reaction Engineering”, 3rd Edition 1999, John Willey & Sons Inc.
- Smith J.M., “Chemical Engineering Kinetic”, 2001, McGraw Hill Book Co.
- Fogler H. Scott, “Elements of Chemical Reaction Engineering”, 2nd Ed., 2001, Prentice Hall
- E Bruce Naumen, “Chemical Reactor Design, Optimization and Scale up”, 2002, McGraw Hill.

13. PLANT DESIGN AND OPERATION 15%

i. Economic Consideration
- Equipment-cost correlations /economic calculations
- Operating costs
- Time value of money.

ii. Design and Operation
- Process equipment design
- Process flow sheet development
- Design optimization
- Operating manuals (e.g., startup, shutdown, maintenance)
- Equipment testing, troubleshooting, and analysis.

iii. Safety
- Emergency venting devices (e.g., safety valves, blowout walls)
- Performance of scheduled audits (e.g., testing safety valves, checking rupture, disks)
- Flares and vents
- Plant layout considerations (e.g., equipment arrangement, pipe racks, and layouts)
- Fire protection
- Emergency ingress and egress
- Process hazard analysis.

iv. Environmental

- Evaluation and permitting of gas discharges and liquid discharges
- Solid waste management (non-hazardous and hazardous)
- Industrial hygiene (e.g., MSDS, TLV, noise control, ventilation, personal protective equipment)
- Pollution prevention.

Suggested Books:

- Peters Max S., Timmerhaus Klaus D., “Plant Design and Economics for Chemical Engineers”, 5th Edition, 2003, McGraw Hill Inc.
- Ludwig Ernest E., “Applied Process Design for Chemical and Petrochemical Plants”, Voll 1,2 & 3, 3rd Ed.2002, Gulf Publishing Company.
- Walas Stanley M., “Chemical Process Equipment Selection and Design”, 1999, Butterworth Heinemann.
- Coulson J.M, and Richardson, “Chemical Engineering”, 1999, Vol VI, Butterworth Heinemann.
- Wells G. L. Rose L.M., “The art of Chemical Process Design”, 1986. Elsevier.
- Smith Robin, “Chemical Process Design”, 1995, McGraw Hill Inc.
- Backhurst & Harker, “Chemical Process Design”, John Willey.
- Evans, “Handbook of Chemical Equipment Design

PART-II

SECTION-B / DEPTH

This section shall be based on practical concepts framed to judge the practical experience and field- based knowledge of Registered Engineers (REs). The examination of this section shall comprise 35 MCQs. Each candidate may attempt the only opted area of practice, among the followings.

1. PROCESS SYNTHESIS, DESIGN AND OPTIMIZATION

i. Process Design

a. Fundamentals

- Process design steps, primary considerations in process design
- Development of base-case design.

b. Detailed

- Equipment sizing, separation equipment's design
- Pumps, compressors, and expanders, optimal design of batch processes.

ii. Process Synthesis

- Objectives of process synthesis, reactor network synthesis
- Synthesis of separation trains, sequencing of columns.

iii. Process Flow Diagram: (tool for synthesis and optimization)

- Reactor section, separator section, feed preparation sections for reactor and separation sections, important process control loops
- Process simulation, instrument for process synthesis
- What is a process simulator?, simulator input data
- Selection of chemical components, thermodynamic models, feed stream properties, equipment parameters and convergence criteria
- Case Studies.

iv. Analysis of a Process

- The Input-Output Structure of a Process Flow Diagram, The Block Flow Process Diagram
- Equipment classification as function Block in PFD.
- Interpretations of a Process Flow Diagram
- Tracing chemicals in PFD, Tracing Primary Paths Taken by Chemicals in Process
- Recycle and Bypass Streams, Inert Chemicals path.
- Reactor Performance
- Reactor-Separator-Recycle Network

v. Process Optimization

- Starting point for optimization, selection of objective function
- Key decision variables, heat and power integration
- Topological optimization
- Eradication of hazardous waste, equipment rearrangement

- Alternative separation schemes and reactor configurations
- Enhancement in heat integration
- Parametric optimization
- Single variable optimization, two variable optimization
- Process flexibility and the sensitivity of the optimum.

Suggested Books:

- Richard Turton, Richard C. Bailie at el., "Analysis, Synthesis, and Design of Chemical Processes", 3rd Ed., 2008, Prentice Hall , PIR,
- Ian C Kemp, Pinch, "Analysis and Process Integration", Elsevier Publishers, 2007
- Kai Sundmacher, "Integrated Chemical Processes", WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2005,

2. UTILITIES AND SERVICES ENGINEERING

i. Offsite/ Utilities & Support Services

- Raw water treatment
- Seawater treatment (desalination)
- Boiler feed water treatment (demineralization, softening, reverse osmosis, deaeration)
- Steam generation and distribution
- Condensate recovery and treatment (polishing, deaeration, deoiling)
- Other water systems (chilled water, electronic grade, Water For Injection (WFI), purified water)
- Cold/hot oil belt systems
- Water reuse/recycle.

ii. Plant Operations Support Processes / Services & Offsites

- Safety relief systems (flares)
- Blow down (open, closed)
- Fuel systems (oil, gas, solids)
- Storage (tankage, tank,)
- Loading and unloading facilities
- Blending (in-line, in-tank)
- Shipping (jetty, rail, road)
- Air supply (plant and instrument air storage, drying, delivery, distribution)
- Inert gas supply
- Cooling water systems (open, closed, reduced plume)
- Firewater system
- Potable water system
- Refrigerant systems
- Materials handling
- Sulfur storage, handling
- Flushing oil systems

- Chemical handling and distribution
- Slop systems
- Hot oil system
- Power generation system
- Waste heat recovery & power generation
- Chemical injection system
- Waste disposal
- Produced water disposal system / treatment.

Suggested Books:

- Jack Broughton, “Introduction to Design, Operation and Maintenance”,
- Charles C. Patton, “Applied Water Technology”, 2nd Ed., 1995, ISBN: 10: 9998157234.
- Eastop, Allan McConkey, “Applied Thermodynamics for Engineering Technologists”, 1997, Harlow : Longman, ISBN**:** 0582091934
- A.H. Hewllet “Thermodynamics Applied for Heat engines”.

3. ENVIRONMENT AND PROCESS SAFETY ENGINEERING

i. Chemical process safety fundamentals

ii. Toxicology and industrial hygiene, toxic and flammable releases and dispersion models, process hazards identification and analysis techniques, toxic chemicals and ground water pollution

iii. Process risk assessment and management, process safety management systems and standards, accident investigation and reporting

iv. Industrial personal protection equipment, emergency planning and response

v. International conventions for safe use of chemicals, clean development mechanism

vi. Solid, water, air and noise pollution and their control

vii. Global environmental problems, ecosystem and sustainable development viii. Environmental impact assessment techniques

ix. Converting refuse to resources, environment friendly green energy policy, risk and economics of pollution.

Suggested Books:

- CCPS, “Guidelines for Chemical Process Quantitative Risk analysis”, 1989, AIChE, New York, Vol 32, 1989.
- Crowl, D.A. and Louvar, J.F., “Chemical Process Safety: Fundamentals with applications”, 2nd Ed., Prentice Hall**,** Englewood Cliffs, New Jersey, 2001.
- Jonthan, T., “Occupational safety and health management”, 2nd Ed., 2006, Mcgraw Hill.
- Davis, M.L. and Cornwell, D.A., “Introduction to Environmental Engineering”, 3rd Ed., 1998, McGraw-Hill, ISBN**:** 0-07-015918-1.
- Nebel, B.J., “Environmental Science: The way the world works”, 3rd Ed. 1990, Prentice Hall.

4. PROCESS MODELING, INSTRUMENTATION AND CONTROL ENGINEERING

i. Process Modeling

- Initial and boundary value problems
- Linear vs nonlinear systems
- Application to simple systems (tank, reactor, heat exchanger)
- Degrees of freedom analysis
- Lumped vs distributed parameter models
- Algebraic models of process units
- Series and parallel process systems
- Recycle, bypass, and purge calculations
- Transient balances for batch reactor, CSTR and PFR
- Step-change and response interpretation
- Time constant and physical meaning
- First-order ODE solutions

Error estimation

ii. Principles of Measurement

- Accuracy, Precision/repeatability, error, tolerance, range or span, bias, linearity, sensitivity of measurement, sensitivity to disturbance, hysteresis, dead space, threshold resolution, noise and filtering
- Units for Measurement of Physical Variables: temperature, level, flow, pressure, force, length, acceleration, velocity, frequency, time.

iii. Process Dynamics, Modeling and control

- Process variables, first order and second order systems, closed loop control systems, feedback, feed forward, cascade, override control proportional
- Proportional Integrative (PI)
- Proportional Integrative Differential (PID) controls
- Time constant, transfer functions
- Steady state design and dynamic controllability.

iv. Valves and their Types, selection criteria for valves

v. Temperature, Pressure, level and Flow measuring devices

- Design, selection criteria, types, calibration, accuracy, sensitivity.

Suggested Books:

- Rawlings, J. J. B., and Ekerdt, J. G., “Chemical Engineering Process Modeling and Simulation”, 1st Ed., Nob Hill Publishing, 2002.
- Upreti, S. R., “Process Modeling and Simulation for Chemical Engineers: Theory and Practice”, 1st Ed., Wiley, 2017.
- Luyben, W. L., “Process Modeling, Simulation and Control for Chemical Engineers”, 3rd Edition, McGraw-Hill, New York, 1990.

- Coughner D R and Koppel C.B, “Process System Analysis and Control”, McGraw Hill, 1991.
- William L. Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2nd Ed., 1996, McGraw Hill Publishers.
- Carlos A.Smith, Armando B.C., “Principles and Practice of Automatic Process Control”, 3rd Ed., 2006, John Wiley and Sons.
- ISA - International Society of Automation, http://www.isa.org
- Tony R. Kuphaldt, “Lessons In Industrial Instrumentation”, Creative Commons, 2009.
- Marlin T.E., “Process Control”, 2nd Ed., Mc Graw Hill, 2000.
- Ogunnaike, B.A. et al, “Process Dynamics Modelling and Control”, Oxford University Press, 1997.

5. POLYMER ENGINEERING

i. Polymer, classification and properties, application of thermo plastic
ii. Polymerization techniques
iii. Role of additives & fillers with their applications
iv. Thermal behavior and degradation of polymers
v. Major polymer processing methods
vi. Rheological properties
vii. Analytical, physical, mechanical and thermal testing viii. Fundamentals of mould & die design.

Suggested Books

- Fried Joel R. “Polymer Science and Technology”, 2000, Prentice Hall.
- Stanley Middlean, “Fundamentals of Polymer Engineering”, 3rd Ed., 1996
- Tim A. Ossworld, Georg Menges, Hanser, “Material Science of Polymer for Engineering”, 2003.
- I.M. Ward & D.W. Hadley, Wiley, “An Introduction to the Mechanical Properties of Solid Polymer”, 3rd Ed., 1998.

6. ENERGY ENGINEERING

i. Energy Problem (Trends & Classifications)

- Energy supply and demand analysis
- Types and forms of energy
- Worldwide/countrywide energy scenario
- Futuristic sustainable energy approaches
- Statistical energy demand speculation.

ii. Non-renewable Energy Sources

- Fossil fuels, generation, processing and consumption of fossil fuels
- Value addition by chemical and physical treatment of fossil fuels
- Isomerization, cracking, reforming, vis-breaking and hydrogenation treatment
- Fuel conversion, gasification, carbonization, liquefaction and fuel pulverization
- Nuclear processes and power plants
- Combustion & flammability.

iii. Renewable/Sustainable Energy Sources

- Alternative energy resources
- Power systems operating on wind energy, solar energy, tidal energy
- Pressure retarded osmosis
- Water (hydel) energy
- Geothermal energy
- Bio-chemical energy

iv. Energy systems and Industry

- Optimization of energy systems
- Audit and conservation of energy in chemical and process industries
- Energy resource utilization
- Simulation and hazard analysis of energy systems
- Operational troubleshooting
- Thermal power plants
- Turbines / expanders
- Nuclear power plants.

Suggested Books

- Boyle, G., Everett, B., and Ramage, J.,"Energy Systems & Sustainability", First Edition, Oxford University Press, 2003.
- Hinrichs, R. A., and Kleinbach, M. H.," Energy: Its Use and the Environment", 4th Ed., Brooks, 2005.
- Vanek, F., and Albright, L. D.," Energy Systems Engineering Evaluation and Implementation", 1st Ed., McGraw Hill Professional, 2008.
- Capehart, B. L., "Encyclopedia of Energy Engineering and Technology", 1st Ed., CRC Press, 2007.

7. SEPARATION PROCESS ENGINEERING

i. Separation Processes

- Difference between conventional and novel separation processes
- Advantages and classification of novel separation processes
- Analysis and design of following novel separation processes
- Reverse osmosis
- Ultra-filtration
- Dialysis / electro-dialysis / donnan dialysis
- Liquid membranes / polymeric membranes
- Foam fractionation
- Adsorption / parametric pumping
- Freezing processes.

ii. . Optimization of Separation Processes

- Application of optimization techniques to separation process engineering
- linear programming for optimization of multi-component distillation columns
- Dynamic optimization for separation systems in transient state.

iii. . Separation Processes in Industry

- Operational procedures regarding separation processes
- Hazard Analysis
- Safety and Environmental Issues
- Effect of various process control parameters (temperature, flow, level, pressure, composition) on separation processes
- Troubleshooting and Operational problems.

Suggested Books:

- Rousseau, R. W., "Handbook of Separation Process Technology", 1st Ed., Wiley Inter-Science Publication, 1987.
- Khoury, F. M., "Multistage Separation Processes", 3rd Ed., CRC Press, 2005.
- Scott, K., "Handbook of Industrial Membranes", 2nd Ed., Elsevier Science & Technology Books, 1999.
- Sinaiski, E. G. and Lapiga E. J., "Separation of Multiphase, Multi-component Systems" 1st Ed., Wiley – VCH, 2007.
- Tarleton, E. S. and Wakeman, R. J., "Solid Liquid Separation: Equipment Selection and Process Design", 1st Ed., Elsevier, 2007.
- Petlyuk, E. B., "Distillation Theory and Its Application to Optimal Design of Separation Units", 1st Ed., Cambridge University Press, 2004.