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 6%

i. Analytical geometry, 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 Ed., 2003, McGraw-Hill, ISBN: 007246836.

2. Chemistry: 10%

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”, 1999.
- David R. Klein “General Chemistry as Second Language”, 2005.

3. ENGINEERING MECHANICS: 6%

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 6%

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, 1987.
- G H Ryder, “Strength of Materials”, 3rd Ed., Macmillan, 1969.

5. ELECTRICITY AND MAGNETISM 6%

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 6%

i. Thermodynamics Laws
ii. Properties and processes
iii. Properties and phase diagram
iv. Equation of state
v. Steam table
vi. phase equilibrium and phase change
vii. Chemical equilibrium
viii. Heats of reaction

ix. Cyclic processes and efficiency

x. Heats of mixing.

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 10%

i. Bernoulli equation and mechanical energy balance

ii. Hydrostatic pressure

iii. Dimensionless numbers

iv. Laminar and turbulent flow

v. Velocity head

vi. Friction losses

vii. Pipe networks

viii. Compressible and incompressible flow

ix. Flow measurement

x. Pumps, turbines, and compressors

xi. Non-newtonian flow

xii. Flow through packed beds.

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, 1985, 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 TRANSFER 10%

i. Conductive & convective heat transfer

ii. Radiation heat transfer

iii. Heat transfer coefficients

iv. Heat exchanger types

v. Flow configuration

vi. LMTU & NTU

vii. Fouling

viii. Shell and tube heat exchanger design.

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”, 1988, 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.

10. MASS TRANSFER 10%

i. Diffusion
ii. Mass transfer coefficient
iii. Equilibrium stage method
iv. Graphical method
v. differential method
vi. Separation systems
vii. Humidification and drying.

Suggested Books:

- 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”, 3rd Ed., 1990, 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

11. COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING 6%

i. Numerical methods and concepts

ii. Spread sheet for Chemical Engineering calculation

iii. Statistical data analysis.

Suggested Books:

- Bruce A. Finlayson, “Introduction to Chemical Engineering Computing”, 2006, John Wiley and Sons, Ltd.
- Norton, Peter, “Introduction to Computers, 5th Ed.”, 2010, Career Publishing.
- S.E. Lyshevski, “Engineering and Scientific Calculation using Matlab”, 2003.
- K.J. Beers, “Numerical Methods for Chemical Engineering: Application in MATLAB”, 2007, Cambridge University Press.

12. PROCESS DYNAMICS AND CONTROL 9%

i. Sensors and control valves

ii. Dynamics

iii. Feed back and feed forward control

iv. PID controller concept

v. Cascade control

vi. Control loop design

vii. Tuning PID controller and stability

viii. Open-loop and close-loop transfer functions.

Suggested Books:

- Coughanor, D.R. and Koppel, C.B., “Process system Analysis & Control”, 1991, McGraw Hill.
- Peter Harriott “Process Control”, 1984, McGraw-Hill Inc., US, ISBN: 0070993424.
- G. Stephanupolos, “Chemical Process Control”, 2002, Prentice Hall.
- Austin E. Fribance, “Handbook of Instrumentation”.

13. TRANSPORT PHENOMENON 7%

i. Newton’s Law, Fourier’s Law and Fick’s Law

ii. Generalization of basic Laws of diffusion

iii. Equations of continuity, motion, energy and continuity in multi-component system

iv. Special forms of equations of motion, energy and continuity

v. Mathematical representation of chemical engineering systems

vi. specification of initial and boundary conditions

vii. Dimensional analysis

viii. Time average transport equations for turbulent flow systems and turbulent transport properties

ix. Boundary layer approximations

x. Radiation heat transfer.

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”, 3rd Edition, 1984, John Wiley & Sons, New York.
- R. S. Brodkey and H. C. Hershey, “Transport Phenomena: A Unified Approach”, International Edition, 1988, McGraw Hill, New York.

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.

PART-II-A (FOR ALL AREAS OF PRACTICE)

This part comprises of 15 multiple choice questions and will be attempted by all the candidates.

1. HEAT TRANSFER 25%

i. Physical properties, conduction, free convective heat transfer coefficient, forced convective heat transfer coefficient (metallic and non metallic), phase change, combination of mechanics, insulation, measurement instruments,

ii. Heat exchangers, over all heat transfer coefficient, fouling factors, Reynolds numbers, LMTD, f-factor

iii. Heat exchanger types

iv. Heat exchanger design

v. Evaluation of existing and net exchanger systems

vi. Service use of heat transfer equipment, radiant and convective transfer.

Suggested Books:

- Kern Donald Q., “Process Heat Transfer” , 1997, 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
- Cengel Yunus A. “Heat Transfer-A Practical approach” , 1988, 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.

2. MASS TRANSFER 25%

i. Phase Equilibria

- Equilibrium data (e.g. VLE, LLE): equations of state
- Equilibrium data (e.g. VLE, LLE): Henry's Law and Raoult's Law
- Equilibrium data (e.g. VLE, LLE): non-ideal solutions
- Equilibrium data (e.g., VLE, LLE): zoetrope systems

- Phase equilibrium calculations: bubble and dew points
- Phase equilibrium calculations: flash calculation
- Diffusion (e.g., purification, water treatment, chip manufacturing, chemical vapor deposition)

ii. Mass Transfer Contactors: (Absorption, Stripping, Distillation, Extraction)

- Continuous contacting (packed): minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction) and reflux (distillation)
- Continuous contacting (packed): minimum number of transfer units or stages
- Continuous contacting (packed): height and number of transfer units or stages
- Continuous contacting (packed): types of packing
- Continuous contacting (packed): flooding-calculation of minimum vessel diameter
- Continuous contacting (packed): feed location for distillation column/tower
- Trayed contactors: minimum rate of flow of liquid (absorption), vapor (stripping), solvent (extraction), and reflux (distillation)
- Trayed contactors: minimum number of stages
- Trayed contactors: theoretical stages—graphical methods
- Trayed contactors: flooding—calculation of minimum vessel diameter
- Trayed contactors: stage efficiency
- Trayed contactors: feed location for distillation column/tower

iii. Miscellaneous Separation Processes

- Drying
- Adsorption (e.g., PSA, water treatment)

Suggested Books:

- 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”, 3rd Ed., 1990, 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.

3. CHEMICAL REACTION ENGINEERING 25%

i. Reaction rates and order
ii. Rate constant
iii. Conversion, yield, and selectivity
iv. Series and parallel reactions
v. Forward and reverse reactions
vi. Energy/material balance around a reactor

vii. Reactions with volume change
viii. Reactor types
ix. Homogeneous and heterogeneous reactions
x. Catalysis.

Suggested Books:

- Levenspiel Octave, “Chemical Reaction Engineering”, 2nd Ed. 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.

4. PLANT DESIGN AND OPERATION 25%

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”, 4th Ed., 1991, 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-B: (To be selected only one opted area)

This part aims to assess the depth of Chemical Engineering. This part comprises of 20 multiple choice questions and only one opted area of practice will be attempted by the respective candidates.

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 equipments 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. OPERATION AND PRODUCTION ENGINEERING

i. Introduction to Production and Operations Management

- Production and operations management
- Basic functions of business organization
- Designing and operating production systems
- Differentiating features of predictions systems
- Analysis of tradeoff system approach establishing priorities, pareto phenomena
- Recent trends in production and operations management.

ii. Productivity strategy and competitiveness

- Concept and Types of Productivity
- Factors affecting productivity
- How productivity can be improved?
- How to formulate strategy?
- Order qualifiers, order wining, mission, mission statement, aim, tactics, vision
- In how many ways organization compete with one another?
- Quality and time based strategies.

iii. Forecasting

- Features of forecasting
- Elements of a good forecasting
- Steps involved in forecasting
- Approaches to forecasting
- Qualitative techniques (judgment and opinion, delphi method, customer survey)
- Quantitative techniques (naïve, moving average, weighted average, exponential smoothing, trend adjusted exponential smoothing
- Techniques for seasonality
- Accuracy and control of forecasting
- Summarizing forecasting accuracy
- Controlling the forecasting
- Choosing forecasting techniques.

iv. Decision Making

- Decision process
- causes of poor decisions
- decision making environment
- decision theory
- decision making model
- Expected value of perfect information
- Sensitivity analysis.

v. Product and Service Design

- Reasons for product and service design
- Needs for product and service design
- Product liability

- Research and development
- Product life cycle
- Standardization
- manufacturing design
- Robust design
- Concurrent design (taguchi approach)
- Concurrent engineering
- Computer Aided Design (CAD)
- Service design
- Difference between product and service design
- Quality function deployment.

vi. Reliability

- Improving reliability
- Quantifying reliability
- Models for calculating reliabilities.

vii. Process Selection and Capability Planning

- Process selection
- Make or buy
- types of operation
- Continuous and semi-continuous processing
- Intermittent processing
- Automation
- Capacity planning
- Importance of capacity decisions
- Defining and measuring capacity
- Determination of effective capacity
- Determining capacity requirements
- Cost volume analysis.

viii. Facilities Layout

- Facilities layout
- Basics layout types
- Product layout
- Process layouts
- Fixed position layouts
- Combination layouts
- Cellular layouts
- Cellular manufacturing
- Group technology
- Flexible manufacturing
- Other service layouts
- Warehouse and storage layouts
- Retail layouts
- Office layouts
- Designing product layouts line balancing
- Designing process layouts.

ix. Project Management

- Pros and cons of project management
- Pert and CPM, difference between pert and CPM
- Slack time
- Critical time
- Gantt charts and network charts
- Project management software
- Time cost tradeoff.

Suggested Books:

- William J. Stevenson, “Production / Operations Management”, 6th Ed., 1999, ISBN 0-07-366112-0.
- William J. Stevenson, “Operations Management”, 8th Ed., 2005, ISBN 0-07-111218-9.
- Jay Heizer and Barry Render,”Production and Operations Management: Strategies and Tactics”.
- Richard J. Tersine, “Production / Operations Management: Concepts, Structure and Analysis”.

3. 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”.

PART-III-B: (To be selected only one opted area)

This part aims to assess the depth of Chemical Engineering. This part comprises of 20 multiple choice questions for 1.5 hours and only one opted area of practice will be attempted by the respective candidates.

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 Sceince: The way the world works", 3rd Ed. 1990, Prentice Hall.

5. INSTRUMENTATION AND CONTROL ENGINEERING

i. 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.

ii. 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.

iii. Control Systems

- Pneumatic control systems
- Digital control systems
- Digital data acquisition systems
- Analog and digital detectors converters
- Transducers field wiring
- Sensors and transducers
- Hardware and software for modern control system.

iv.Process Simulation

- Use of computers and Applications of process simulation.

v. Diagrams used in process instrumentation

- Use of software for drawing a process instrumentation diagram**.**

vi. Valves and their Types, selection criteria for valves

xi. Temperature, Pressure, level and Flow measuring devices

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

xii. Case Study, Designing of a control system for a process

Suggested Books:

- 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.

6. THERMAL HYDRAULICS

i. Two-Phase Flow

- Two phase flow regimes
- Two-phase flow regimes in adiabatic pipe flow, vertical, cocurrent, upward flow, cocurrent horizontal flow
- Flow regime maps for pipe flow
- Two-phase flow regimes in vertical rod bundles
- Two-phase flow models
- Flow-area averaging
- One-Dimensional Homogeneous-Equilibrium Model: single-component fluid
- One-Dimensional Homogeneous-Equilibrium Model: two-component mixture
- One-Dimensional Separated Flow Model: single-component fluid
- One-Dimensional Separated-Flow Model: two-component fluid
- The drift flux model
- Pressure drop in two-phase flow
- Two-phase frictional pressure drop in homogeneous flow and the concept of a two-phase multiplier
- Empirical two-phase frictional pressure drop methods.

ii. Boiling Heat Transfer

- Pool boiling, the pool boiling curve, heat transfer mechanisms in nucleate boiling, nucleate boiling correlations
- The hydrodynamic theory of boiling and critical heat flux, film boiling, transition boiling, flow boiling, forced-flow boiling regimes, flow boiling curves
- Flow patterns and temperature variation in subcooled boiling, onset of nucleate boiling, empirical correlations for the onset of significant void
- Hydrodynamics of subcooled flow boiling, pressure drop in subcooled flow boiling , fully developed subcooled flow boiling heat transfer correlations
- Characteristics of saturated flow boiling, saturated flow boiling heat transfer correlations
- Two-phase flow instability, static instabilities, dynamic instabilities
- Critical Heat Flux (CHF) and Post-CHF heat transfer in flow boiling, CHF mechanisms
- Experiments and parametric trends, correlations for upward flow in vertical channels, correlations for subcooled upward flow of water in vertical channels
- Models for DNB and dryout
- CHF in inclined and horizontal channels
- Post-Critical Heat Flux heat transfer 399.

iii. Choked Flow

- Physics of choking
- Velocity of sound in single-phase fluids

- Critical discharge rate in single-phase flow
- Choking in homogeneous two-phase flow
- Choking in two-phase flow with interphase slip
- Critical two-phase flow models
- The homogeneous equilibrium isentropic model
- Critical flow model of moody
- Critical flow model of henry and fauski.

Suggested Books:

- Thome Collier, John R Thome, John G Collier, “Boiling and Condensation”, 3rd Ed., Oxford University Press, USA, 1996.
- Todreas and Kaazmi, “Nuclear Systems”, Vol 1 & 2, Taylor and Francis Grouch 1989.
- S. Mostafa Ghiaasian, “Two-Phase Flow, boiling and Condensation in Conventional and Miniature Systems”, Cambridge University Press 2008.

7. 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, “Fundmentals 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.

8. BIOCHEMICAL ENGINEERING

i. Basic microbiology, biochemistry and biochemical engineering
ii. Enzymes kinetics and immobilization techniques, and their industrial applications
iii. Unit operation for bioprocesses, biochemical unit processes
iv. Design, operation and control of bio reactors, along with recovery and purification of products
v. Application of bioprocesses in pharmaceutical, food industry and waste treatment
vi. Economic analysis of biological processes.

Suggested Books:

- Shigeo Katoh, Fumitake Yoshida, quot, “Biochemical Engineering: A text book for engineers, chemists and biologists”, Wiley-VCH, 2009, ISBN: 3527325360.
- Schuler, M.L.and Kargi, F., “Bioprocess Engineering: Basic Concepts”, 2nd Ed.,Prentice Hall, New York, ISBN: 0-13-081908-5.
- Lee, J. M., “Biochemical Engineering”, 1992, Prentice Hall.
- Blanch, H. W. and Clark D. S., “Biochemical Engineering”, 2nd Ed., 1996.
- Cutlip, M. B. and Shacham, M., “Problem Solving in Chemical and Biochemical Engineering with Polymath, Excel and MatLab”, 2nd Ed., Prentice Hall.

9. ENERGY ENGINEERING

i. Energy Proem (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 (biomass).

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.

10. 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.

11. CORROSION ENGINEERING

i. Corrosion and Its Control (Theory and Practice)

- Types of corrosion
- Factors influencing corrosion
- High-temperature attack
- Combating corrosion
- Corrosion-testing methods
- Economics in materials Selection.

ii. Selection of Optimum Material of Construction

- Mechanical properties and Design considerations
- Structural Design Considerations
- Cost of Materials
- Corrosion resistance/ corrosion protection.

iii. Properties of Materials

- Materials Standards and Specifications
- Alloys, inorganic non-metallic, ceramics, organic non- metallic , polymers, plastic materials, thermoplastics, thermosetting plastics, rubber and elastomers, asphalt, carbon, graphite, wood.

iv. High and Low Temperature Materials

- Low-Temperature Metals and alloys,
- High-Temperature Materials and alloys,
- Refractories and insulation.

Suggested Books:

- Robert H. Perry, Don W. Green, “Chemical Engineer’s Handbook”, 7th Ed.,
- William D. Callister, “Introduction to Material Science”, 5th Ed.,
- Prof (R) Dr. Ijaz Hussain Khan, “Corrosion Technology”, Vol 1 and Vol 2, Institute of Chemical Engg. & Technology, PU, LHR