

# Chemical engineering syllabus

## Chemical engineering examinations

### Group A - Compulsory examinations (six required)

#### 23-Chem-A1 Process Balances and Chemical Thermodynamics

The analysis of industrial and chemical processes; mass conservation and energy conservation; thermochemistry; properties of pure substances; properties of solutions; energy and the first law of thermodynamics; the second law of thermodynamics and entropy; applications of the laws of thermodynamics to problems in the behaviour of fluids, flow processes, power cycles, refrigeration and heat pumps, phase equilibria and chemical reaction equilibria.

*Textbooks (most recent edition is recommended):*

- J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, latest edition. McGraw-Hill.
- R.W. Felder, R.W. Rousseau, Elementary Principles of Chemical Processes, latest edition. John Wiley.

#### 23-Chem-A2 Unit Operations and Separation Processes

Incompressible and compressible fluid flow. Flow through packed beds, fluidization. Particle size distribution. Mechanical operations such as mixing and blending, filtration and sedimentation. Thermal operations such as evaporation and crystallization. Application of equilibrium theory and rate considerations for absorption, adsorption, distillation, drying, extraction, membrane separation, leaching.

*Textbooks (most recent edition is recommended):*

- C.J. Geankoplis, Transport Processes and Unit Operations, latest edition. Prentice Hall.
- W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, latest edition. McGraw-Hill.
- F.P. Incropera, D.P. DeWitt, Fundamentals of Heat and Mass Transfer, latest edition. John Wiley.

#### 23-Chem-A3 Heat and Mass Transfer

Theory and practice of conductive, convective, and radiative heat transfer; design of heat exchangers; heat transfer involving phase change. Diffusion and permeability; mass transfer through stagnant and moving films; the concept of equilibrium stages; estimation and use of overall heat and mass transfer coefficients in the design of process equipment.

*Textbooks (most recent edition is recommended):*

- R.E. Treybal, Mass Transfer Operations, latest edition. McGraw-Hill.
- P.H. Wankat, Equilibrium Staged Separations. Elsevier.
- J.D. Seader, E.J. Henley, Separation Process Principles. John Wiley.
- W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, latest edition. McGraw-Hill.

#### 23-Chem-A4 Chemical Reactor Engineering

Application of the principles of chemical kinetics and other rate phenomena to the design of chemical reactors. Dynamics in chemical systems, including chemical kinetics, catalysis and transport processes. Theory of idealized isothermal reactors including batch, plug flow, and continuous stirred tank reactors for single and multiple reactions. Residence time distributions and their effect on conversion. Simple adiabatic and non-isothermal reactors with homogeneous and heterogeneous reactions; thermal run-away reactions.

*Textbooks (most recent edition is recommended):*

- H.S. Fogler, Elements of Chemical Reaction Engineering, latest edition. Prentice Hall.

### **23-Chem-A5 Chemical Plant Design and Economics**

Structure of chemical process systems and systematic methods for capital and operating cost calculations. Economic factors in design, economic balances, capital and operating cost estimation techniques, assessment of alternative investments and replacements, and application of compound interest calculations. Simple optimization theory. Evaluation of process alternatives. Equipment and materials selection. Factors such as energy, safety, hygiene, and environmental protection. Familiarity with computer process simulation. Intrinsically safe design. Risk analysis. The use of heuristics in design of chemical processes.

*Textbooks (most recent edition is recommended):*

- M.S. Peters, K.D. Timmerhaus, R.E. West, Plant Design and Economics for Chemical Engineers, latest edition. McGraw-Hill.
- W.D. Seider, J.D. Seader, D.R. Lewin, Process Design Principles: Synthesis, Analysis and Evaluation. John Wiley.
- R. Turton, R.C. Bailie, W.B. Whiting, J.A. Shaeiweitz, Analysis, Synthesis, and Design of Chemical Processes, latest edition, Prentice Hall.

### **23-Chem-A6 Process Dynamics and Control**

Concept of transfer functions. Response of simple chemical processes to step, ramp, and sinusoidal inputs. Transient response of interacting elements in series. Frequency response analysis of simple systems. On-off control, cascade control, ratio control, proportional, integral, derivative, and combinations of these control actions, single-input/single-output control and multiple-input/multiple-output control. Closed-loop response. Feedback and feedforward control. Controller tuning and algorithms. Simple stability analysis. Dynamics and control of common chemical process units such as heat exchangers, simple reactors, and agitated vessels. Hardware implementation, analog and digital, of simple control algorithms and designs.

*Textbooks (most recent edition is recommended):*

- D.E. Seborg, T.F. Edgar, D.A. Mellichamp, Process Dynamics and Control. John Wiley, latest edition.
- T. Marlin, Process Control, Designing Processes and Control Systems for Dynamic Performance, latest edition. McGraw-Hill.
- B.W. Bequette, Process Control: Modeling, Design and Simulation. Prentice Hall.
- C.A. Smith, A.B. Corripio, Principles and Practice of Automatic Process Control, latest edition John Wiley.

## **Group B - Optional examinations (three required)**

### **23-Chem-B1 Transport Phenomena**

The application of integral and differential techniques for solving problems involving mass, energy and/or momentum transport through solids and within fluids. Steady and unsteady state processes. Molecular transport. Convective transfer of heat and mass involving laminar and turbulent fluid flows.

*Textbooks (most recent edition is recommended):*

- R.S. Brodkey, H.C. Hershey, Transport Phenomena: A Unified Approach. McGraw-Hill.
- R.B. Bird, W.E. Stewart, E.N. Lightfoot, Transport Phenomena. latest edition, John Wiley.

### **23-Chem-B2 Environmental Engineering**

Engineering aspects of air and water pollution abatement and effluent treatment. Characterization of water contaminants and their measurement, biological oxygen demand, sedimentation, flotation, aeration, and activated sludge processes, pH control, ion exchange, oxidation-reduction, electrodialysis, reverse osmosis. Sources and dispersion of atmospheric pollutants. Control methods for particulates, gases, and vapours.

Photochemical reactions, noxious pollutants, and odour control. Contaminated soil remediation. Measurement techniques.

*Textbooks (most recent edition is recommended):*

- G. Kiely, Environmental Engineering. McGraw-Hill Ryerson.

### 23-Chem-B3 Simulation, Modelling, and Optimization

The analysis and modelling of chemical processes using either a mechanistic or an empirical input/output approach. Subsystem modelling to reduce complex processes to simpler component parts. Linearization of non-linear processes. Optimization methods; direct search, climbing and elimination techniques, linear and non-linear programming.

*Textbooks (most recent edition is recommended):*

- S.M. Walas, Modelling with Differential Equations in Chemical Engineering. Butterworth-Heinemann.
- D. Basmadjian, The Art of Modeling in Science and Engineering. Chapman & Hall.
- B.W. Bequette, Process Dynamics: Modeling, Analysis and Simulation. Prentice Hall (first 12 chapters and all modules).
- P. Venkataraman, Applied Optimization with Matlab Programming. John Wiley.
- T.F. Edgar, D.M. Himmelblau, L.S. Lasdon, Optimization of Chemical Processes. Latest edition. McGraw-Hill.

### 23-Chem-B4 Biochemical Engineering

Basic applied microbiology and chemistry of cells, biochemical kinetics, enzymes, metabolic pathways, energetics, transport phenomena and reactor design as applied to biochemical reactors, scale-up and control of bioreactors, downstream processes.

*Textbooks (most recent edition is recommended):*

- J.E. Bailey, D.F. Ollis, Biochemical Engineering Fundamentals, latest edition. McGraw-Hill.

### 23-Chem-B5 Pulp and Paper Technology

Papermaking raw materials: wood anatomy and chemistry. Pulping processes: mechanical pulping, chemi-thermo-mechanical processes, chemical pulping (sulphite, Kraft). Pulp treatment: refining and bleaching. Papermaking equipment and processes. Environmental protection. Structure and properties of paper and paperboard.

*Textbooks (most recent edition is recommended):*

- J.P. Casey, Pulp and Paper: Chemistry and Chemical Technology, latest edition, Volumes 1 and 2. Wiley Interscience.
- G.A. Smook, Handbook for Pulp and Paper Technologists, latest edition, Angus Wilde Publ, Inc.

### 23-Chem-B6 Petroleum Refining and Petrochemicals

The composition and classification of petroleum. Crude oil evaluation in relation to product quality. Refinery products: properties, specifications, and testing. The petroleum refinery: crude oil distillation, catalytic cracking, alkylation, hydrogen production, catalytic reforming, hydrotreating, amine processes, sulphur production, isomerization, polymerization, oxygen compounds. Lubricating oil and asphalt manufacturing. Synthesis of primary products; ethylene, methanol, glycols, aromatics.

*Textbooks (most recent edition is recommended):*

- J.H. Gary, G.E. Handwerk, Petroleum Refining, Technology and Economics, latest edition. Marcel Dekker.
- J.G. Speight, The Chemistry and Technology of Petroleum, latest edition. Marcel Dekker.

### 23-Chem-B7 Extractive Metallurgy

Thermodynamics and reaction kinetics of extractive metallurgical processes. Electrolytic reduction of molten salts. Metal refining processes. Heat transfer, mass transfer, and materials preparation in the metallurgical industry. Comparison of processes. Equipment selection and operation.

*Textbooks (most recent edition is recommended):*

- T. Rosenqvist, Principles of Extractive Metallurgy, latest edition. McGraw-Hill.
- C. Bosworth, The Extraction and Refining of Metals. CRC Press.

### 23-Chem-B8 Polymer Engineering

Basic polymer structures and characterization of polymer physical, chemical, and mechanical properties. Polymerization reactions and kinetics; chain formation and co-polymerization. Polymerization processes: bulk, suspension, solution, and emulsion polymerizations. Polymer flow behaviour describing non-Newtonian and visco-elastic effects. Polymer processing including extrusion, moulding and film production. Polymer systems: additives, blends, composites, and fibre reinforcement.

*Textbooks (most recent edition is recommended):*

- A. Rudin, The Elements of Polymer Science and Engineering, latest edition. Academic Press.
- J. Fried, Introduction to Polymer Science and Technology. Prentice Hall.

### 23-Chem-B9 Advanced Materials

Properties, production of and uses of composites, engineered plastics, biopolymers, special coatings, and nanostructured materials with emphasis on structure property relationships.

*Textbooks (most recent edition is recommended):*

- No Referenced Textbooks

### 23-Chem-B10 Life Cycle Assessment (LCA)

Concepts of life cycle assessment. Applications to energy utilization, environment, sustainable development and process analysis and optimisation.

*Textbooks (most recent edition is recommended):*

- No Referenced Textbooks

### 23-Chem-B11 Nuclear and Nuclear Chemical Processes

The properties of actinides; radioactivity; processes of mining, refining and enrichment of uranium; reactor materials and design; reprocessing chemistry; waste management.

*Textbooks (most recent edition is recommended):*

- No Referenced Textbooks