

Examination Subjects (all subjects are required)

English	
Mathematics	
Chemical Engineering I	
	Chemical Thermodynamics
	Basic Chemistry
	Fundamentals of Bioengineering
Chemical Engineering II	
	Fluid Dynamics
	Heat Transfer
	Mass Transfer
Chemical Engineering III	
	Process Control
	Chemical Reaction Engineering
	Biochemical Engineering

✓ Calculator is provided on examinations of Chemical Engineering I – III.

Contents and Keywords of Examination for Each Subject

English
As a rule, submit the score certificate of TOEIC or TOEFL. The score is evaluated.
Mathematics
<ul style="list-style-type: none"> • Linear Algebra (Vector and matrix, Determinant, Eigen value, Eigen vector, Linear mapping) • Differentiation and Integration (Derivative, Indefinite integral, Definite integral, Partial derivative, Multiple integral, Vector analysis) • Ordinary Differential Equation (Initial value problem, Boundary value problem)
Chemical Engineering I: Chemical Thermodynamics
<ul style="list-style-type: none"> • First Law of Thermodynamics • Second Law of Thermodynamics • Properties of Gases (Kinetic theory of gases, Ideal gas, Real gases, Principle of corresponding states) • Phase Equilibria (Phase transitions, Phase diagrams, Partial molar quantities, Ideal solutions, Real solutions, Chemical potentials, Fugacities, Activities) • Chemical Equilibria (Gibbs energies of reactions, Thermodynamic equilibrium constants, Acids and bases) • Electrochemistry (Ion activities, Electrochemical cells) <p>(Reference book)</p> <ul style="list-style-type: none"> • Atkins' Physical Chemistry, 8th Edition, P.W. Atkins, Oxford University Press

Chemical Engineering I: Basic Chemistry

- **Organic Chemistry** (Structure and bond of organic molecules, acid-base reaction, properties of organic reactions, reaction and reaction mechanism of alkene, alkyne, aromatic compounds, alkyl halide, alcohol, aldehyde, ketone, carboxylic acid and their derivatives)
- **Inorganic Chemistry** (Structure of solid (Closed-packed structure, Metal structure, Ionic solid structure), Molecular orbital theory for solid (Band structure of metal and semiconductor))
- **Quantum Chemistry** (The Schrödinger equation, The structure of atoms and molecules, Molecular orbital theory)

(Reference book)

- Fundamentals of Organic Chemistry 7th Edition, Brooks Cole
- Atkins' Physical Chemistry, 8th and 10th Edition, P.W. Atkins, Oxford University Press (2006)

Chemical Engineering I: Fundamentals of Bioengineering

- **Biomolecules** (Amino acid, Sugar, Nucleic acid, Protein, Lipid)
- **Gene Expression System** (Transcription, Translation, Regulation of transcription)
- **Cell Organization and Function** (Organelle, Membrane structure)
- **Cell Metabolism** (Glycolysis, Pentose phosphate pathway, TCA cycle, Fatty acid metabolism, Electron transport chain, Photosynthesis)
- **Cell Division** (Cell cycle, Mitosis, Meiosis)
- **Fundamentals of Biotechnology** (PCR, Restriction enzyme Hybridization, Hybridoma, Monoclonal antibody, Transgenic animal, Stem cell)

(Reference book)

- Biochemistry, Eric Conn, Paul Stumpf, Wiley
- Essential Cell Biology, Alberts et al., Garland

Chemical Engineering II: Fluid Dynamics

- **Incompressible Flow** (Newton's law of viscosity, Navier-Stokes equation, Boundary layer theory, Stream function, Velocity potential, Velocity distribution)
- **Fluid Process** (Pressure drop, Drag coefficient, Fluidized bed, Packed bed)
- **Momentum Transport Phenomena** (Conservation equation of momentum, Analogy in transport phenomena)

(Reference book)

- Transport Phenomena (revised. 2nd ed.), R.B. Bird et al., John Wiley & Sons

Chemical Engineering II: Heat Transfer

- **Conductive Heat Transfer** (Fourier's law, Heat transfer in solids, Heat transfer in composite walls, Thermal resistance)
- **Convective Heat Transfer** (Newton's law of cooling, Overall heat transfer coefficient, Boiling heat transfer, Condensation heat transfer)
- **Radiative Heat Transfer** (Planck's law, Stefan-Boltzmann law, Black body, Gray body, Heat transfer among more than two surfaces)
- **Heat Exchanger** (Double-pipe heat exchanger. Correction factor, Fin efficiency)
- **Heat Transfer Phenomena** (Conservation equation of energy, Analogy in transport phenomena, Forced and free convective heat transfers)

(Reference book)

- Transport Phenomena (revised 2nd ed.), R.B. Bird et al., John Wiley & Sons

Chemical Engineering II: Mass Transfer

- **Molecular Diffusion** (Molar concentration and mass concentration, Fick's law, Equimolar counter diffusion)
- **Convective Mass Transfer** (Mass transfer coefficient, A diffusing through stagnant B, Film theory, Dimensionless number and experimental correlation)
- **Mass Transfer Phenomena** (Diffusion equation, Analogy in transport phenomena, Mass transfer with chemical reaction)
- **Gas Absorption** (Gas-liquid equilibrium, Overall mass transfer coefficient, Absorption equipment, Packed tower)
- **Distillation** (Gas-liquid equilibrium, Continuous rectification, Distillation tower)

(Reference book)

- Transport Processes and Separation Process Principles, C.J. Geankoplis, Pearson New International Edition
- Transport Phenomena (revised 2nd ed.), R.B. Bird et al., John Wiley & Sons

Chemical Engineering III: Process Control

- **Process Dynamics** (Transfer function, Block diagram, First-order system, Second-order system, System with dead time)
- **Dynamic Response and Frequency Response** (Step response, Nyquist plots, Bode diagram)
- **Feedback Control System** (Stability analysis, Offset, Gain and phase margins, PID controller)
- **Advanced Control System** (Cascade Control, Feedforward Control)

(Reference book)

- Chemical Process Control: An introduction to theory and practice, George Stephanopoulos, Prentice-Hall International Editions

Chemical Engineering III: Chemical Reaction Engineering

- **Applied Chemical Kinetics** (Activation energy, Steady-state approximation, Rate-determining step approximation, Kinetics of catalytic reactions, Half life, Differential method and integrated method)
- **Chemical Reactor Analysis and Design** (Conversion, Constant volume system and variable volume system, Space time, Batch reactor (BR), Continuous stirred-tank reactor (CSTR), Plug flow reactor (PFR), Recycle reactor)

(Reference book)

- Chemical Reaction Engineering and Kinetics, R.W. Missen et al., John Wiley & Sons

Chemical Engineering III: Biochemical Engineering

- **Reaction Kinetics of Biocatalyst** (Biological stoichiometry, Enzymatic reaction, Michaelis-Menten equation, Cell growth kinetics, Anabolism/Catabolism, Monod equation)
- **Bioprocess Design and Operation** (Bioreactor, Immobilized enzyme, Microbial culture, Animal/plant cell culture, Sterilization, Biological wastewater treatment)
- **Bioseparation** (Pretreatment, Precipitation, Affinity chromatography, Gel filtration chromatography, Density-gradient centrifugation, Membrane separation, Electrophoresis)