

## Examination Subjects

<b>English (Required Subject)</b>	
<b>Mathematics (Required Subject)</b>	
<b>Basic Subjects (Required Subject)</b>	
	Chemical Thermodynamics
	Basic Chemistry
	Fundamentals of Transport Phenomena
<b>Specialized Subjects (Choose three subjects from the following six subjects)</b>	
	Chemical Reaction Engineering
	Fluid Dynamics
	Heat Transfer
	Process Control
	Fundamentals of Bioengineering
	Biochemical Engineering

## Contents and Keywords of Examination for Each Subject

<b>English</b>
As a rule, submit the score certificate of TOEIC or TOEFL. The score is evaluated.

<b>Mathematics</b>
<ul style="list-style-type: none"><li>• <b>Linear Algebra</b> (Vector and matrix, Determinant, Eigen value, Eigen vector, Linear mapping)</li><li>• <b>Differentiation and Integration</b> (Derivative, Indefinite integral, Definite integral, Partial derivative, Multiple integral, Vector analysis)</li><li>• <b>Ordinary Differential Equation</b> (Initial value problem, Boundary value problem)</li></ul>

<b>Chemical Thermodynamics</b>
<ul style="list-style-type: none"><li>• <b>First Law of Thermodynamics</b> (First law of thermodynamics and application, Reversible process)</li><li>• <b>Second Law of Thermodynamics</b> (Second law of thermodynamics and application, Carnot cycle)</li><li>• <b>Properties of Gases</b> (Kinetic theory of gases, Ideal gas, Real gas, Principle of corresponding states)</li><li>• <b>Phase Equilibrium</b> (Phase transition, Phase diagram, Partial molar quantity, Ideal solution, Ideal-dilute solution, Real solution, Properties of solutions, Chemical potential, Fugacity, Activity)</li><li>• <b>Chemical Equilibrium</b> (Reaction Gibbs energy, Thermodynamic equilibrium constant, Response of the equilibrium by outside condition, Acid and base)</li><li>• <b>Electrochemistry</b> (Ion activity, Electrochemical cell)</li></ul> <p><b>(Reference book)</b></p> <ul style="list-style-type: none"><li>• Atkins' Physical Chemistry, 8th Edition, P.W. Atkins, Oxford University Press</li></ul>

### 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 Edition, P.W. Atkins, Oxford University Press (2006)

### Fundamentals of Transport Phenomena

- **Molecular Diffusion and Convective Mass Transfer for Binary System** (Molar concentration and mass concentration, Fick's law, Diffusion coefficient, Convective mass transfer coefficient, A diffusing through stagnant B, Equimolar counterdiffusion)
- **Transport Phenomena of Fluid Dynamics** (Momentum balance, Newton's law of viscosity, Flow in a pipe, Velocity profile of laminar flow, Velocity profile of turbulent flow)
- **Fundamentals of Heat Transfer** (Conductive heat transfer, Convective heat transfer, Radiative heat transfer)

#### (Reference book)

- Transport Processes and Separation Process Principles, Christie J. Geankoplis, Prentice Hall College
- Transport Phenomena 2nd ed., R.B. Bird et al., John Wiley & Sons

### Chemical Reaction Engineering

- **Applied Chemical Kinetics** (Chemical reaction rate equation, Activation energy, Single reaction and complex reaction, Parallel reaction and series reaction, Steady - state approximation, Rate-determining step approximation, Kinetics of chain reaction, Kinetics of catalytic reactions, Enzyme kinetics, Half life, Differential method and integrated method)
- **Chemical Reactor Analysis and Design** (Differential reactor and integrated reactor, Limiting reactant, 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

### Fluid Dynamics

- **Incompressible flow** (Navier-Stokes equation, Boundary layer theory, Stream function, Velocity potential)
- **Particle motion in fluid** (Drag coefficient, Terminal velocity,
- **Fluid process** (Fluidized bed, Packed bed, Filtration)
- **Flow measurement** (Pressure drop, Pitot tube, Venturi meter, Orifice)

#### (Reference book)

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

### Heat Transfer

- **Advanced Heat Transfer** (Conservation equation of energy, Nondimensionalization, Heat transfer in materials, Forced and free convective heat transfers, Radiative heat transfer among more than two surfaces, Heat exchanger)

#### (Reference book)

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

### 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

### 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, Erice Conn, Paul Stumpf, Wiley
- Essential Cell Biology, Alberts et al., Garland

### Biochemical Engineering

- **Reaction Kinetics of Biocatalyst** (Biological stoichiometry, Enzyme, Coenzyme, Inhibitor, Enzymatic reaction kinetics, 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, Ligand, Receptor, Affinity chromatography, Gel filtration chromatography, Density-gradient centrifugation, Membrane separation, Electrophoresis)