**Chemical Engineering**

**(Compulsory English Preparatory Class)**

**Course Contents**

**FIRST YEAR**

**I. SEMESTER**

**PHYS101 - Physics-I 4 / ECTS: 6**

Physics and measurements. Vectors; motion in one and two dimensions; the laws of motion; circular motion and other applications of Newton's Laws; work and energy; conservation of energy; linear momentum and collisions; rotational motion; angular momentum; equilibrium; gravitation.

**MATH101-** **Calculus –I 4 / ECTS: 6**
Foundations, coordinates and vectors, functions, limits, continuity, derivative, tangent lines, the mean value theorem, graphing, extreme values, optimization problems, linearization and differentials, integration, Riemann sums and definite integrals, the fundamental theorem of calculus, natural logarithm, exponential functions, inverse trigonometric functions, L'Hospital's rule, methods of integration, applications of integrals.

**CHEM101-General Chemistry-I 4 / ECTS: 6**

Structure of matter, Fundamentals of chemistry (matter and measurements), atoms, molecules and ions, atomic theory, chemical compounds, stoichiometry in chemical reactions and calculations, aqueous solution reactions, oxidation-reduction reactions, thermochemistry, gases, physical properties of solutions, chemical reactions, chemical kinetics and chemical equilirium.

**CHE105 – Computer Aided Engineering Graphics 3 / ECTS : 4**

Introduction to Technical Drawing, Drawing tools, Paper dimensions, Line types, Filing operations, Drawing aids, Drawing geometric shapes, Arrangement of objects, Projections and Views, Image control systems, Dimensioning, Isometric drawing, Working with blocks, 3D drawing and its applications.

**RPSC109 – Positive Psychology and Communication Skills 3 / ECTS: 5**

The course includes subjects like the general framework of the basic concepts of communication sciences, solutions and recommendations to strengthen communication skills, interpersonal communication, group communication, organizational communication, mass communication, public communication, international communication and intercultural communication.

**RCUL101 – University Culture - I 1 / ECTS : 1**

The course consists of reports on seminars and conferences organized by the university.

**FIRST YEAR**

**II. SEMESTER**

**PHYS102- Physics -II 4 / ECTS: 6**
Topics in Electricity and Magnetism: Electric charges and matter, Coulomb's law, electric fields, electric field calculations, motion of a charged particle in electric field. Gauss's law, electric flux and Gauss's law, applications of Gauss's law. Electric potential and electric potential difference, electric potential energy, electric potential due to point charges and charge distributions. Capacitance and dielectrics, definition and calculations of capacitances, energy stored in capacitors, capacitors with dielectrics. Current and resistance, electric current, resistance, electrical conduction. Direct-current circuits, electromotive force, Kirchhoff's rules, applications. Magnetic fields, definition and properties of Magnetic fields. Magnetic forces on charges and currents, applications of magnetic fields. Sources of magnetic fields, the Biot-Sawart Law, Ampere's law. Faraday's law, Lenz's law, induced electric fields, generators and motors. Inductance, mutual and self inductance, RL circuits, energy in magnetic fields.

**MATH102-Calculus -II 4 / ECTS: 6**
Sequences and series, Taylor and Maclaurin series, lengths of plane curves, polar coordinates and complex numbers, lines, planes and quadric surfaces in space, functions of several variables, limits and continuity, partial derivatives, differentiability, the chain rule, directional derivatives, extreme values, multiple integrals, integrals in polar, cylindrical and spherical coordinates, line integrals and surface integrals.

**CHE102- Introduction to Chemical Engineering 3 / ECTS: 4**

Introduction to chemical engineering and history of chemical engineering. Chemical industries and industrial applications in Turkey. Principles and applications of material balance calculations of continuous steady-state processes. Introduction to process flowsheet simulation, computational techniques and software applications. Introduction to chemical engineering design and economics.

**CHEM102-General Chemistry-II 4 / ECTS: 6**

Continuation of CHEM 101. Discussion of physical properties of solutions in aqueous solution, chemical kinetics, chemical equilibrium, chemical thermodynamics and electrochemistry.

**MBG154- General Biology 3 / ECTS: 4**

Key biological concepts will be covered in this course. The topics include; the origin of living organisms and cellular basis, the chemical structural components of the cell, cell biology, the structure of cell membrane, functions of sub-cellular organelles, energy metabolisms, the basis of cellular information flow and cell signalling, DNA structure, chromosomes and nucleus.

**COME 102 – Introduction to Algorithms and Programming 3 / ECTS: 4**

Basic computer literacy: terminology, system components and operation. Fundamentals of computer programming: sequence, decision, repetition, syntax, compilation, debugging and maintenance, procedures, parameters, arrays, searching, sorting, top-down structured design, and style. Recursion, pointers and dynamic memory allocation; strings and string processing; advanced file processing; programmer-defined types; Introduction to Object Oriented Programming; classes and data abstraction: behaviour/state (data) model, member scope and access, constructors/destructors, object assignment.

**RCUL102 – University Culture** **-II 1 / ECTS: 1**

The course consists of reports on seminars and conferences organized by the university.

**SECOND YEAR**

**III. SEMESTER**

**RPRE104- Entrepreneurship and Project Culture 2 / ECTS:3**

This course introduces students to the world of entrepreneurship through the development of the entrepreneurial mindset. The focus will be on both starting a new business as well as on the advancement of entrepreneurial thinking within a large corporation. Students will analyze the entrepreneurial process of formulating, planning, and implementing new business ventures and opportunities from domestic and international viewpoints.

**CHEM203 – Physical Chemistry 3 / ECTS:4**

Basic terms at physical chemistry, perfect gases, real gases, the compressibility factor, the van der Waals Equation, the kinetics gas model, isothermal and adiabatic reversible-irreversible processes, zeroth, first, second and third laws of thermodynamics, basic equations of thermodynamics, Maxwell relations, chemical thermodynamics, thermochemistry and the chemical equilibrium.

**BEN205 - Stoichiometry 3 / ECTS:4**

Definitions, Measurements, Introduction to Engineering Calculations, Process and Process Variables, Process Classifications and Balances, Balances on Multiple-Unit Processes, Recycle and Bypass Balances on Reactive Systems, Combustion Reactions, Gases, Single Component Phase Equilibrium, Gibbs Phase Rule and Gas-Liquid Systems, Multicomponent Gas-Liquid Systems, Energy Balance for Closed and Open Systems.

**COME211-Introduction to Programming for Engineers 2 / ECTS: 3**

Main objective is to support students’ programming abilities using Matlab. The content will be presented as follows; Use of workspace and the interface, Arrays: basic data structure, Basic plotting in Matlab, Simple data analysis, Introduction to automation of tasks, More program flow control, Writing your own functions and project applications, Simulink applications.

**ATA101-** **Principles of Atatürk and History of Revolutions-I 2 / ECTS: 3**

Türk İnkılâbının tarihi anlamı ve önemi; Türk inkılâbını hazırlayan koşullar, ortam ve gelişmeleri; Mustafa Kemal Paşa önderliğinde Ulusal Kurtuluş Savaşı; Ulus egemenliğine dayalı tam bağımsız yeni Türk Devleti'nin kuruluşu; Atatürk'ün dahi asker, büyük devlet adamı ve İnkılâpçı kişiliği ile teşkilatçılığı.

**TURK101-Turkish Language-I 2 / ECTS: 3**
“Dil” tanımı, dilin sosyal bir unsur olarak millet hayatındaki yeri ve önemi, dil-kültür münasebeti, Türk dilinin dünya dilleri arasındaki yeri, Türk dilinin gelişmesi ve tarihi evreleri, bugünkü durumu ve yayılma alanları, Türkçe’de sesler ve sınıflandırılması, Türkçe’nin ses özellikleri ve ses bilgisi ile ilgili kurallar, hece bilgisi, imla kuralları ve uygulaması, noktalama işaretleri ve uygulaması, Türkçe’nin yapım ekleri ve uygulaması, kompozisyonla ilgili genel bilgiler, kompozisyon yazmada kullanılacak plan ve uygulanması, isim ve fiil çekimleri, kompozisyonda anlatım şekilleri ve uygulanması, zarfların ve edatların kullanılış şekilleri.

**ENG101-English-I 3 / ECTS: 3**
Reading texts and exercises. Listening exercises. Translation exercises. Writing essay. Speaking exercises, conversations.

**MATH202 - Linear Algebra and Differential Equations 3 / ECTS:4**

Matrices, Concept of Differential Equation and Fundamental Definitions, Ordinary Differential Equations of the First Order, Existence and Uniqueness Theorems, Exact 11 Differential Equations and Integrating Factors, Second-Order Differential Equations, High Order Linear Differential Equations, Series Solutions of Linear Differential Equations, Laplace Transform Solutions of Linear Differential Equations, Systems of First-Order Linear Differential Equations, Non-linear Differential Equations, Sturm-Liouville Problems.

**XXXXXXX-Social Elective-I 3 / ECTS: 5**

**SECOND YEAR**

**IV. SEMESTER**

**BEN210 – Fluid Mechanics 3 / ECTS: 5**

Introduction to Fluid Mechanics (Dimensions and Units). Newton's law of viscosity. Fluid Statics (Pressure at a Point, Hydrostatic Pressure). Incompressible and compressible fluids. Buoyancy, Flotation and Stability. Fluid Dynamics: Conservation of Mass, Conservation of Momentum, and Conservation of Energy. Friction Loss. Bernoulli Equation. Inviscid Flow, Viscous Flow. Mixing and Agitation. Dimensional analysis.

**CHE204 - Chemical Engineering Thermodynamics 3 / ECTS:5**

Law of thermodynamics, work and heat concepts, thermodynamic properties of pure substances and state equations, second law of thermodynamics and entropy, processes applied to the ideal gas, generalized state properties, stability criterion, fugacity and activity concepts, mixtures and thermodynamic concepts, Gibbs free energy and Gibbs Duhem equation, multi-component systems.

**ATA102- Principles of Atatürk and History of Revolutions-II 2 / ECTS: 3**

Türk ulusunun bütün kurumları ve değerleriyle çağdaş uygarlığın da üstüne çıkma çabaları, Atatürk İlke ve İnkılâpları; Atatürk düşünce sistemi; Atatürk döneminde Türkiye'nin iç ve dış politikası; İkinci Dünya Savaşı ve Türkiye; Türkiye'de çok partili döneme geçiş.

**TURK102-Turkish Language–II 2 / ECTS: 3**
Cümlenin unsurları, cümle tahlili ve uygulanması, edebiyat ve düşünce dünyası ile ilgili eserlerin okunup incelenmesi ve retorik uygulaması, yazılı kompozisyon türleri ve uygulanması, anlatım ve cümle bozuklukları ve bunların düzenlenmesi, ilmi yazıların hazırlanmasında uyulacak kurallar.

**ENG102-English-II 3 / ECTS: 3**
Reading texts about profession, grammar exercises, word activities, translation activities, listening and speaking exercises.

**CHE282 – Summer Practice-I 0 / ECTS:5**

The aim of summer practice is to recognize the work area of chemical and biological engineering and apply theoretical knowledge from university to practical work area. The students practice in the fields that they are interested.

**CHEM104 - Organic Chemistry 4 / ECTS: 6**

Atoms and Molecules, Orbitals and Bonding, structural isomerism, stereochemistry, Halides, Free Radical Reactions, Alcohols, Alkenes and Alkynes.

**THIRD YEAR**

**V. SEMESTER**

**IE211- Engineering Economics 3 / ECTS: 4**

This course emphasizes the strong correlation between engineering design and manufacturing of products/systems and the economic issues they involve. The basic concepts of the time value of money and economic equivalence are applied throughout the course. Each assignment progressively incorporates different cash flows, the cost of funds, capital, operational and maintenance costs, salvage value, depreciation, and taxation. Students learn to apply different economic analysis methods – like discounted cash flow analysis, present worth, annual-equivalent worth, rate-of-return, cost/benefit etc. – in evaluating the economic viability of a project, as well as the comparison of mutually exclusive alternatives. The course also introduces concepts of replacement decisions, a few methods of describing project risk, and exposes students to specific issues of economic analysis of the private sector versus the public sector. Applications to a variety of engineering fields’ actual cases are stressed throughout the course.

**CHE304- Chemical Reaction Engineering 3 / ECTS: 5**

This course applies the concepts of reaction rate, stoichiometry and equilibrium to the analysis of chemical reacting systems, derivation of rate expressions from reaction mechanisms and equilibrium or steady state assumptions, design of chemical reactors via chemical kinetics, transportphenomena,and mass and energy balances. Topics covered include: chemical pathways, kinetics; batch, semi-batch and plug flow reactors for chemical reactions and heat and mass transport in reactors.

**CHE301- Heat Transfer 3 / ECTS: 5**

Mechanisms of heat transfer. Steady and transient heat conduction in solids, solution methods. Laminar and turbulent forced convection, natural convection. Heat exchangers. Radiation heat transfer.

**CHEXXX – Departmental Elective-I 3 / ECTS: 5**

**XXXXXX – Elective (2nd Foreign Language) 3 / ECTS: 5**

**XXXXXX – Field Elective-I 3 / ECTS**

**THIRD YEAR**

**VI. SEMESTER**

**BEN320 – Mathematical Modeling 3 / ECTS: 5**

Description of Mathematical Modeling and Simulation/Graphical and Numerical Solutions of Equations/Solutions of Equations by MATLAB/Presentation of Data and Deep Considerations/Plotting Nonlinear Functions in Linear Form. Mathematical Formulations of Processes/Multivariable Systems/Modeling of Steady-State and Dynamic Systems/Development of Ordinary and Partial Differential Equations and Their Solution Methods/Modeling of Bioengineering Processes and Applications.

**CHE310- Mass Transfer 3 / ECTS: 5**

General and special forms of the mass transfer equations. Steady-state molecular diffusion. Convective mass transfer. Continuous and stagewise contacting of immiscible and partially miscible phases: gas absorption, desorption and liquid-liquid extraction. Distillation of binary mixtures.

**CHEXXX – Departmental Elective-II 3 / ECTS: 5**

**CHE326- Chemical Engineering Laboratory I 2 / ECTS: 5**

Conducting experiments to apply the principles of fluid mechanics, reaction kinetics, heat transfer, mass transfer, thermodynamics and process control.

**MATH204- Statistics 3 / ECTS: 5**

Introduction to Statistics, Descriptive Statistics, Probability, Random Variables and Expectation, Discrete Probability Distributions, Continuous Probability Distributions, Distributions of Sampling Statistics, Parameter Estimation, Hypothesis Testing, Simple Linear Regression and Correlation, Analysis of Variance.

**CHE382 – Summer Practice-II 0 / ECTS:5**

Application of the theoretical knowledge, which the students acquired during the semester, into the practice. The students practice in the fields that they are interested.

**FORTH YEAR**

**VII. SEMESTER**

**CHE491-Graduation Project 3 / ECTS: 5**

Studies on a project, which requires synthesis of knowledge gained
in the chemical engineering program. The content may vary depending on the research interest of student and supervisor.

**CHEXXX-** **Departmental Elective-III 3 / ECTS: 5**

**CHEXXX-** **Departmental Elective-IV 3 / ECTS: 5**

**BEN409-** **Process Dynamics and Control 3 / ECTS: 5**

Incentives for Chemical/Biochemical Process Control, Design Aspects of a Process Control System, Hardware of a Process Control System, Development of Mathematical Modeling, Modeling Consideration for Control Purposes, Computer Simulation and Linearization of Non-linear Systems, Laplace Transforms and Use of Them in Process Control, Solution of Linear Differential Equations Using Laplace Transform, Transfer Functions and Input-Output Models, Dynamics of First-Order Systems, Introduction to Feedback Control and Design of Feedback Controllers, Frequency Response Analysis of Linear Systems, Design of Feedback Control Systems Using Frequency Response Technique.

**XXXXXX-** **Field Elective-II 3 / ECTS: 5**

**CHE426- Chemical Engineering Laboratory II 2 / ECTS: 5**

Experiments aiming to integrate theory and practice on Chemical Engineering fundamental topics such as fluid mechanics, reaction kinetics, heat transfer, mass transfer, thermodynamics and process control.

**OHS401- Occupational Health and Safety-I 2 / ECTS: 2**

**FORTH YEAR**

**VIII. SEMESTER**

**CHE492-Graduation Thesis 5 / ECTS: 5**
Complete production and test procedure of the project that is designed conceptually in CHE491.

**CHEXXX-** **Departmental Elective-V 3 / ECTS: 5**

**CHEXXX-** **Departmental Elective-VI 3 / ECTS: 5**

**XXXXXX-** **Field Elective-III 3 / ECTS: 5**

**XXXXXX-** **Field Elective-IV 3 / ECTS: 5**

**OHS402- Occupational Health and Safety-II 2 / ECTS: 2**

**XXXXXX-** **Social Elective-II 3 / ECTS: 5**

**ELECTIVE COURSES**

**CHE303- Introduction to Nanobiotechnology**  **3 / ECTS: 5**

Micro-electro-mechanical systems (MEMS) have been broadly used for biochemical, medical, RF, and lab-on-a-chip applications. This course will cover both MEMS technologies (e.g., micro- and nanofabrication) and devices. For example, MEMS technologies include anisotropic wet etching, RIE, deep RIE, micro/nano molding and advanced packaging. This course will also cover various MEMS devices used in microsensors and actuators. Examples will include pressure sensors, accelerometers, gyros, FR filters, digital mirrors, microfluidics, micro total-analysis system, biomedical implants, etc.

**CHE305- Sustainable and Renewable Energy 3 / ECTS: 5**

This class assesses current and potential future energy systems, covering resources, extraction, conversion, and end-use technologies, with emphasis on meeting regional and global energy needs in the 21st century in a sustainable manner. Instructors and guest lecturers will examine various renewable and conventional energy production technologies, energy end-use practices and alternatives, and consumption practices in different countries. Students will learn a quantitative framework to aid in evaluation and analysis of energy technology system proposals in the context of engineering, political, social, economic, and environmental goals. Students taking the graduate version, *Sustainable Energy*, complete additional assignments.

**CHE306- Fermentation Technology 3 /ECTS: 5**

Biotechnology-advantages and limitations. Isolation of microorganisms (extremophiles, thermophiles, osmophiles) selection, breeding and storage of production microorganisms. Limitation of the microbial metabolites production, permeabilization of cells, importance of membrane transport during overproduction. Use of classical and alternative substrates, nutritional components. Equipments and isolation techniques used in biotechnological processes - bioreactors, and other membrane separation techniques, finalization and stabilization of the product. The microbial biomass-disintegration, stabilization, purification techniques for the isolation of metabolites and cellular components. Microbial enzyme preparation - purification, stabilization, immobilization and industrial applications. Differences for the fermentative preparation of primary and secondary metabolites and their isolation. New trends in the preparation of biofuels - producers, new substrates and use of the products. Waste in biotechnological processes and their use.

**CHE308- Data Mining in Chemical and Biological Engineering 3 / ECTS: 5**

This course will serve as an introduction to the fundamental principles of data mining, R language and its application in data mining.

**CHE311- Transport Phenomena in Chemical Engineering 3 / ECTS: 5**

Analytical and approximate solutions to mass, momentum and energy transport equations in one direction.

**CHE314 - Separation Processes 3 / ECTS: 5**

Principles of stagewise and continuous contact operations. Absorption, distillation, extraction, and simultaneous heat and mass transfer. Applications and design of units.

**CHE405- Biotechnology and Special Applications 3 / ECTS: 5**

The topics of the course include: introduction to biotechnology, the principles of bioreactors and fermentation, biotechnological products, plant, animal, medical, food, environmental biotechnologies and biofuel cell technologies will be generally covered.

**CHE406- Bioinformatics for Engineers 3 / ECTS: 5**

The objective of this course is to help the students use the bioinformatics tools to solve the problems on their own research in molecular biology. Topics include (but not limited to) bioinformatics databases, sequence and structure alignment, protein structure prediction, protein folding, protein-protein interaction. The course involves student application during which emphasis will be put on the understanding and utilization of these concepts.

**CHE408- Special Topics in Chemical Engineering 3 / ECTS: 5**

Advances in Chemical Engineering, new applications and technologies in the field.

**CHE409- Principles and Practice of Drug Development 3 / ECTS: 5**

This course will serve as a description and critical assessment of the major issues and stages of developing a pharmaceutical or biopharmaceutical. Topics covered include drug discovery, preclinical development, clinical investigation, manufacturing and regulatory issues considered for small and large molecules, and economic and financial considerations of the drug development process. A multidisciplinary perspective will be provided by the faculty, who represent clinical, life, and management sciences.

**CHE414- Drug Design 3 / ECTS: 5**

Drug design consists of identifying a target (DNA, RNA, proteins) that is known to cause a certain disease and selectively inhibiting or modifying its activity by binding a drug molecule to a specified location on that target. In this course, computational techniques for designing such a drug molecule will be taught. The topics to be covered are: Identification of the active part. Forces involved in drug-receptor interactions. Screening of drug libraries. Use of different software to determine binding energies. Identifying a lead molecule. Methods of refining a lead molecule for better suitability. Case studies: A survey of known drugs, success and failure stories.

**CHE323- Introduction to Biological Science - II 3 / ECTS: 5**

This course will be carried out as the continuation of general biology. Topics include; Biodiversity and Evolution, Plant structure and functions, Animal systems, Introduction to ecology.

**CHE202- Organic Chemistry – II 3 / ECTS: 5**

The course includes alcohols, diols and ethers. Aromatic compounds; chemistry of aromatic compounds. Carbonyl compounds; Aldehydes and ketones. Carboxylic acids and their derivatives. In addition, Laboratory work is an essential part of organic chemistry courses.

**CHE313- Structural Biology 3 / ECTS: 5**

Structures of biological macromolecules. Structure determination techniques such as NMR-spectroscopy and X-ray crystallography. Folding and maintenance of biological structures. Structure-function relationships. Structural databases, visualization and analysis of structures. Applications in pharmaceutical industry.

**CHE416- Protein Engineering for Chemical Engineers 3 / ECTS: 5**

Recombinant DNA technology is fundamental to genetic engineering and molecular biotechnology applications which have been founded on the ground of multiple disciplines such as molecular biology, microbiology, biochemistry, immunology, genetics, and cell biology. The course includes the recombinant DNA techniques which involve the utilization of prokaryotic and eukaryotic organisms and the manipulation of DNA in order to generate relevant clones, examine gene regulation, and express proteins. Relevant application of some of these techniques (cloning, and in detail- the restriction and ligation of DNA fragments, transformation of competent cells with recombinant DNA vectors, screening of positive bacterial clones, PCR, site directed mutagenesis...) will be exposed to students besides to their applications in the industry (drugs, vaccines, crops,...).

**CHE433- Chemical Engineering Design-I 3 / ECTS: 5**

Application of chemical engineering principles and methods to open ended process and/or product design problems. Use of computer programming and/or design packages in iterative decision making and optimization.

**CHE434- Chemical Engineering Design-II 3 / ECTS: 5**

Continuation of Design-I equipment selection and design. Cost estimation, project evaluation process and product safety and ethical issues.

**CHE213- Physical Chemistry Laboratory 3 / ECTS: 5**

Experimental techniques and analysis of data in physicochemical systems. Experiments related to the properties of pure gases, liquids and mixtures, phase diagrams, electrochemistry, rate of chemical reactions and catalysis.

**CHE325- Nanostructured Materials 3 / ECTS: 5**

The basic principles of nanoscience and nanotechnology, fabrication, synthesis and characterization of nanostructured materials, and properties of materials at nanometer length scales and their applications.

**CHE461- Petroleum Refinery Engineering 3 / ECTS: 5**

Oil production. Surface operations. Characterization and classification of crude oils. Physical properties of oils. Refinery operations; atmospheric and vacuum distillation, treatment processes, catalytic cracking, reforming, alkylation, coking, asphalt production and lubricating oil production. Blending of refinery products. Waste treatment**.**

**CHE462- Natural Gas Engineering 3 / ECTS: 5**

Characterization and properties of natural gas. Gas gathering systems. Gas-oil multistage separation. Gas treatment and liquefaction. Gas transportation through pipelines.

**CHE463- Petrochemical Technology 3 / ECTS: 5**

Production technologies of synthesis gas, olefins and aromatic. Manufacture of important petrochemicals derived from base chemicals and synthesis gas. Production technologies of important polymers and plastics.

**CHE464- Catalysis 3 / ECTS: 5**

Conservation laws in heterogeneous systems. Effectiveness factor and application to heterogeneous catalytic reactor design. Catalysis principles and mechanism; surface chemistry and surface structure. Physical properties of porous catalyts, reaction mechanisms.

**CHE465- Photocatalysis 3 / ECTS: 5**

Homogeneous and heterogeneous photocatalysis. Photocatalytic materials. Applications to industry.

**CHE321- Fundamentals of Biochemistry 3 / ECTS: 5**

Chemical nature of cellular components; enzymes and mechanism of enzyme activity; energy interconversions and biosynthetic reactions, including template dependent reactions, and some aspects of control mechanisms.

**CHE451- Water Treatment Technology 3 / ECTS: 5**

Water and impurities in water and their harmful effects. Removal of nonionic suspended and colloidal impurities. Softening by precipitation. Ion exchange. Demineralization process and systems. Demineralizer equipments.

**CHE471- Polymer Technology 3 / ECTS: 5**

Chemistry of polymerization and mechanisms. Production, properties and fabrication of plastic materials. Rheology of polymers and polymer solutions. Polymer composites, new polymers.

**CHE453- Chemical Technology 3 / ECTS: 5**

A general study of chemical process industries, considering raw materials, energy, intermediate chemicals, and final products, Future trends.

**CHE455- Gas Purification Technology 3 / ECTS: 5**

Principles of adsorption, absorption and chemical conversion. Gas dehydration and purification by adsorption. Catalytic conversion of gas impurities.

**CHE457- Recycling Technology 3 / ECTS: 5**

Recyclable materials include many kinds of glass, paper, cardboard, metal, plastic, tires, textiles, batteries, and electronics. Recycling industrial wastes, recycling technologies currently used in different fields.