The Faculty of Engineering and Science
The Study Board of Biotechnology, Chemistry and Environmental Engineering

AALBORG UNIVERSITY
DENMARK

Curriculum for the Bachelor's Programme in Chemical Engineering and Biotechnology

Aalborg University
September 2017

Campus Esbjerg

Preface
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Bachelor's programme in Chemical engineering and biotechnology is established. The programme also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and The Faculty of Medicine.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders
The Bachelor's programme in Chemical Engineering and Biotechnology is organised in accordance with the Ministry of Higher Education and Science's Order no. 1328 of November 15, 2016 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 257 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The Bachelor's programme falls under The Faculty of Engineering and Science

1.3 Board of Studies affiliation
The Bachelor's programme falls under the Board of Studies for Biotechnology, Chemistry and Environmental Engineering

1.4. External Evaluation Corps
The programme falls under the external evaluator corps: Ingeniøruddannelsernes landsdækkende censorkorps – kemi.

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Admission to the Bachelor's programme in Chemical engineering and biotechnology requires an upper secondary education.

The programme's specific entry requirements are:
- Mathematics A
- English B

And one of the following combinations:
- Physics B and Chemistry B
- Physics B and Biotechnology A

2.2 Degree designation in Danish and English
The Bachelor's programme entitles the graduate to the designation Bachelor (BSc) i teknisk videnskab (kemi og bioteknologi). The English designation is: Bachelor of Science (BSc) in Engineering (Chemical Engineering and Biotechnology).

2.3 The programme's specification in ECTS credits
The Bachelor's programme is a 3-year, research-based, full-time study programme. The programme is set to 180 ECTS credits.

2.4 Competence profile on the diploma
The following will appear on the diploma:

> A graduate of the Bachelor's programme has competencies acquired through an educational programme that has taken place in a research environment.
>
> A graduate of the Bachelor's programme has fundamental knowledge of and insight into his/her subject's methods and scientific foundation. These properties qualify the

graduate of the Bachelor's programme for further education in a relevant Master's programme as well as for employment on the basis of the educational programme.

2.5 Competence profile of the programme

The graduate of the Bachelor's programme:

Knowledge

- Has research-based knowledge about theory, method and practice within following natural and engineering fields: Chemistry, biology, physics, material science, mathematics and statistics.
- Analytical chemistry, instrumental methods, experimental design, data collection and method validation.
- Process engineering, including chemical reaction engineering, chemical unit operations, construction materials, process control, instrumentation and safety.
- Can understand and reflect on theory, method and practice within the scientific fields mentioned above and put them in a social context.

Skills

- Can apply the problem-based approach to analyze complex issues, identify problems and define requirements for solutions.
- Can describe processes and systems using process diagrams and also draw up and solve balance equations for this.
- Can perform chemical, microbiological, material related and process engineering experiments in the laboratory in accordance with the laboratory safety regulations.
- Can select and apply appropriate analytical methods for qualitative or quantitative analysis of composition of different products and for the purposes of process control.
- Can apply statistical tools to develop experimental designs, process data and validate analytical methods.
- Can develop mathematical models for chemical and biochemical reactions and processes, and design ideal reactors and simple unit operations.
- Can select appropriate process equipment, construction materials, safety regulations, and approach for regulation and instrumentation (including data acquisition equipment) for a given process.
- Can evaluate theoretical and practical problems associated with development, production and analysis of chemical and biotechnological products, and also reason for relevant solutions
- Can communicate chemical, biochemical, and process-technical problems and solutions to both peers and non-specialists, including collaborative partners and users, both through discussion, as well as written and oral reports.

Competencies

- Can handle complex and development-oriented situations in a study or work context
- Can independently be part of discipline-specific and interdisciplinary cooperation with a professional approach d
- Can identify own learning needs and structure own learning in different learning environments

Chapter 3: Content and Organisation of the Programme

The programme is structured in modules and organised as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. The examinations are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organised based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback

3.1 Overview of the programme

All modules are assessed through individual grading according to the 7-point scale *or* Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or assessment by the supervisor only).

Semester	Module	ECTS	Assessment	Exam
1st	Chemical and bio Industrial Products	10	7-point scale	Internal
	Chemical Engineering and Biotechnology – a Case Study	5	Pass/Fail	Internal
	Problem Based Learning in Science, Technology and Society	5	Pass/Fail	Internal
	General Chemistry	5	7-point scale	Internal
	Calculus	5	7-point scale	Internal
2nd	Chemical Reactions in Natural and Technical Systems	15	7-point scale	External
	Biological Active Molecules – Introduction to Cell Biology and Biological Chemistry	5	Pass/Fail	Internal
	Fundamental Chemical Engineering and Thermodynamics	5	7-point scale	Internal
	Linear Algebra	5	7-point scale	Internal
3rd	Analysis of Chemical Systems	15	7-point scale	External
	Methods in Quantitative Chemical Analysis	5	7-point scale	Internal
	Inorganic and Organic Chemistry	5	7-point scale	Internal
	Applied Statistics	5	7-point scale	Internal
4th	Electives • Material Science • Applied Microbiology • Petrochemical Separation Processes	15	7-point scale	External
	Chemical Thermodynamics and Separation Process Engineering	5	7-point scale	Internal
	Microbial Biotechnology	5	7-point scale	Internal
	Material Science and Material Selection	5	7-point scale	Internal
5th	Electives • Chemical Process Engineering • Bioprocess Engineering • Refinery Products and Processes	15	7-point scale	External
	Chemical Reaction Engineering	5	7-point scale	Internal
	Thermodynamics, Heat Transfer and Fluid Mechanics	5	7-point scale	Internal
	Mathematical Modelling and Numerical Methods	5	7-point scale	Internal
6th	Design of Experiments	5	7-point scale	Internal
	Process Control, Instrumentation and Safety	5	7-point scale	Internal
	BSc Project in Chemical Engineering and Biotechnology	20	7-point scale	External
Total		180		

3.2 Knowledge and Scientific Method

Science and scientific methods are included through all projects (15 ECTS modules), as these are based on problem-based learning as a scientific method. There will be teaching about this, and other scientific tools in the courses: Problem-based learning in science, technology, society, science and entrepreneurship.

3.3 Elective Courses

The Bachelor's program provides students with freedom of choice for individual profiling of their education. This freedom is achieved by the fact that both on 4th semester and 5th semester, there is an optional choice between several project modules. Also the bachelor's project provides opportunity to work on different subjects.

3.4 Descriptions of modules. 1st semester.

Title:	**Chemical Engineering and Biotechnology – a Case Study** Kemi og bioteknologi – et casestudie
Objective:	Students who complete the module must be able to: Knowledge • explain fundamental aspects of chemical engineering and biotechnology Skills • communicate the problem and results of the project in writing and orally • prepare a hypothesis that identifies a problem and forms the basis for further work within the project's area of expertise
Type of instruction	Project work
Exam format:	Oral examination based on a written report
Evaluation criteria:	As stated in the Joint Programme Regulations

Title:	**Chemical and Bio Industrial Products** Kemiske og bioindustrielle produkter
Prerequisites	The module adds to the knowledge obtained in Chemical Engineering and Biotechnology – a Case Study
Objective:	Students who complete the module must be able to: Knowledge • define and understand the concepts, methods, theories and models used in the project Skills • work safely in the laboratory, evaluate and use appropriate protectives, use relevant sources of information, handle chemicals and other materials safely, dispose of waste according to regulations and develop workplace instructions • communicate the problem and results in writing, graphically and orally in a coherent way Competencies • handle planning and implementation of a project • identify and develop own potentials for further education in the field of study

Type of instruction Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Problem Based Learning in Science, Technology and Society**
Problembaseret læring i videnskab, teknologi og samfund

Objective: Students who complete the module must be able to:

Knowledge
- explain basic learning theory
- explain techniques for planning and management of projects
- explain different approaches to problem-based learning (PBL), including the so-called Aalborg model based on problems that are part of a social and/or humanistic context
- explain different approaches to analysis and assessment of problems and solutions within engineering, natural and health sciences from a theoretical, ethical, and societal perspective

Skills
- plan and manage a problem-based study project
- analyze the project group's organization and cooperation in order to identify strengths and weaknesses, and suggest how cooperation in future groups can be improved based on this analysis
- reflect on the causes and devise possible solutions to any group conflicts
- analyze and evaluate their own study work and learning, in order to identify strengths and weaknesses, and use these reflections to consider further study and group work
- reflect upon the methods used from a theoretical perspective
- identify relevant areas of focus, concepts and methods to assess and develop technical solutions under consideration of the social and humanistic contexts that solution must be a part of

Competencies
- take part in a team-based project
- document and present work carried out in a project
- reflect upon and develop his/her own learning
- engage in and improve upon the collaborative learning processes
- reflect upon his/her professional activities in relation to the surrounding community

Type of instruction Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **General Chemistry**
Almen kemi

Objective: Students who complete the module must be able to:

Knowledge

- explain fundamental chemical and physico-chemical principles for reactions and equilibria
- explain the structure of the atom, chemical bonding and intermolecular forces
- account for atomic orbitals, the electron configuration of the elements and the physical description of the atom that form the basis of the periodic table
- describe different models for development of molecular orbitals that describe the molecular covalent bond and geometry of molecules
- explain fundamental differences on redox reactions, acid-base reactions, solubility reactions and chemical complexation
- account for fundamental thermodynamics
- account for fundamental electrochemistry, including galvanic elements and electrolysis
- explain fundamental reaction kinetics and be able to explain reaction rates and reaction orders for selected reactions

Skills

- balance chemical reactions and perform appropriate stoichiometric calculations and mass balances.
- explain the electron configurations of atoms, ions and molecules and their influence on the geometric size of the particle based on orbital and VSEPR theory.
- calculate pH and redox-potentials for relevant equilibria
- calculate enthalpy, entropy, and Gibbs free energy for chemical reactions.
- develop a Nernst equation for calculation of the electromotive force of a redox reaction
- calculate yields of electrolytic reactions
- develop rate equations describing chemical reaction kinetics, explain the order of the constituent components and the overall reaction and explain the parameters of the rate constant
- model the kinetics of simple reaction mechanisms for simulation and illustration of the time course of chemical reactions

Competencies

- plan and dimension simple chemical laboratory experiments based on knowledge of the chemical and physical conditions where these reactions happen

Type of instruction: Lectures, exercises, laboratory work, writing of laboratory journals

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Calculus**
Calculus

Objective: Students who complete the module must be able to:

Knowledge

- account for definitions, results and techniques in the theory of differentiation and integration of functions of two or more variables
- account for trigonometric functions and their inverse functions
- account for complex numbers, their accounting rules and their representations
- account for the factorization of polynomials over the complex numbers
- account for the complex exponential function, its properties, and its connection with trigonometric functions
- account for curves in the plane (both in rectangular and polar coordinates) and in space, parameterization, tangent vector and curvature for these
- account for the theory of second order linear differential equations with constant coefficients

Skills

- visualize functions of two and three variables using graphs, level curves and level surfaces
- make the determination of local and global extrema of functions of two and three variables
- determine the surface area, volume, moment of inertia and similar by using integration theory
- approximate the functions of one variable using Taylor's formula, and be able to use linear approximation for functions of two or variables
- have proficiency in arithmetic with complex numbers
- find roots in the complex quadratic equations and perform factorization of polynomials in simple cases
- solve linear second-order differential equations with constant coefficients, in general, and with initial conditions
- reason with the course concepts, results and theories in simple concrete and abstract problems

Competencies

- strengthen own knowledge, understanding and application of mathematical theories and methods in other areas
- reason and argue with mathematical concepts of linear algebra

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.5 Descriptions of modules. 2nd semester.

Title: **Chemical Reactions in Natural and Technical Systems**
Kemiske reaktioner i naturlige og tekniske systemer

Prerequisites: The module adds to the knowledge obtained in Chemical and Bio Industrial Products

Objective: Students who complete the module must be able to:

Knowledge
- explain concepts, models, theories and methods of professional relevance to the project
- account for practical laboratory work including risk safety procedures and waste management

Skills
- plan and carry out chemical experiments in the laboratory in a safe manner, keep records of the conducted experiments and draw relevant conclusions from the results obtained
- write a project report following the standards of the field of study and communicate the problem and results in writing, graphically and orally in a coherent way, including the relationship between problem formulation, project export and main conclusions
- asses the problem of the project and results in relevant professional and social contexts and identify relevant stakeholders

Competencies
- organize group work and cooperation with supervisors and undertake planning, implementation and management of a project, taking into account past experiences
- identify and develop own potentials for further education in the field of study

Type of instruction: Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Biological Active Molecules – an Introduction to Cell Biology and Biological Chemistry**
Biologisk aktive molekyler – introduktion til cellebiologi og biologisk kemi

Objective: Students who complete the module must be able to:

Knowledge
- describe the structure of the cell
- account for biologically active molecules structures, properties and functions
- explain the cellular energy metabolism
- account for DNA structure and replication
- describe biotechnological techniques
- account for protein structure and function

- account for lipids and membranes structure and function

Skills
- describe the cell's organelles and ingredients
- explain the metabolism
- explain energy conversion on a cellular level
- explain enzyme function and regulation
- describe how DNA can be used in modern recombinant technologies
- account for the interaction between chemistry and biology on a cellular level
- describe the interaction between chemistry and biology at the cellular level

Type of instruction: Lectures, tutorials, theoretical exercises, and laboratory work

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Fundamental Chemical Engineering and Thermodynamics**
Grundlæggende kemisk procesteknik og termodynamik

Objective: Students who complete the module must be able to:

Knowledge
- define and explain fundamental concepts in engineering calculations including systems, system boundaries, process classifications, process units and process variables
- explain Newton's laws
- account for the concepts of energy, energy transfer and power
- account for the laws of thermodynamics
- describe the concept of ideal gasses and their behaviour
- descibe the Boltzmann distribution
- account for heat, work and internal energy
- account for thermal properties of matter
- account for entropy
- account for enthalpy and enthalpy changes
- account for Gibbs energy and phase equilibriums
- explain chemical potentials and chemical reaction equilibriums

Skills
- read process diagrams
- solve balance equations systematically
- select a relevant control volume or control mass for a given physical, chemical or biological process and to draw a block or process diagram
- do conversions between units
- write and solve mass balance equations for nonreactive and reactive processes in steady state
- do calculations on ideal gasses and ideal gas mixtures
- use phase diagrams and steam tables
- do thermochemical calculations
- calculate the thermodynamic equilibrium composition for a reaction from thermodynamic data

- write and solve energy balance equations for stationary systems in steady state

Competencies
- use principles and theories from chemical engineering and thermodynamic on simple model systems
- apply thermodynamics and principles of chemical processes in order to understand, describe and solve problems within analytical chemistry, material science, separation processes, chemical reaction engineering and process design

Type of instruction: Lectures and theoretical exercises

Exam format: Written examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Linear Algebra**
Lineær algebra

Objective: Students who complete the module must be able to:

Knowledge
- describe definitions, results and techniques within the theory of linear equation systems
- account for linear transformations and their consistency with matrices
- describe the computer tool MATLAB and its applications in linear algebra
- account for simple matrix operations
- account for invertible matrix and invertible linear transformation
- account for the vector space Rn and the subspace thereof
- account for linear dependence and independence of vectors, dimensions and basics of the subspace
- account for the determinants of matrices
- account for eigenvalues and eigenvectors of matrices and their application
- account for projections and orthonormal bases
- account for first-order differential equations, as well as systems of linear differential equations

Skills
- apply theory and calculation techniques for linear equation systems, to determine whether it can be solved, and to determine complete solutions and their structure
- represent systems of linear equations using matrix equations, and vice versa
- determine and apply reduced Echelon Form of a matrix
- use elementary matrices for Gaussian elimination and inversion of matrices
- determine linear dependence or linear independence of small sets of vectors
- determine the dimensions of- and basis for small subspaces
- determine the matrix for a given linear mapping, and vice versa
- solve simple matrix equations
- calculate the inverse of small matrices

- determine the dimensions of- and basis for null space and column space
- calculate determinants and to use the result of the calculation
- calculate the eigenvalues and eigenvectors of simple matrices
- determine if a matrix is diagonalizable, and if so, implement a diagonalization for simple matrices
- compute the orthogonal projection onto a subspace of Rn
- solve separate and linear first-order differential equations, in general, and with initial conditions

Competencies
- develop and strengthen own knowledge, understanding and application of mathematical theories and methods in other areas
- reason and argue with mathematical concepts of linear algebra

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.6 Descriptions of modules. 3rd semester.

Title: **Analysis of Chemical Systems**
Analyse af kemiske systemer

Prerequisites: The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Fundamental Chemical Engineering and Thermodynamics

Objective: Students who complete the module must be able to:

Knowledge
- explain the fundamental physical principles that underlie the chemical analysis apparatus used in the project
- explain the fundamental physical principles underlying alternatives to the selected instrumental chemical analysis techniques
- explain the chemistry that underlies sample preparation to the instrumental chemical analysis techniques that are selected above
- describe standard statistical methods used in analytical chemistry

Skills
- perform relevant stoichiometric calculations and use ordinary glassware in the laboratory
- perform analytical chemical experiments accordance with the regulatory and achieve a reproducible result
- write down and reconcile all chemical reaction schemes that underlie the analysis regulatory
- calculate the thermodynamic affinity for the reactions used in the basis of the analysis
- perform the relevant statistical calculations on the results and select one of the analytical methods for validation
- perform general uncertainty calculations on the results obtained
- explain safety rules and phrases for the analysis and the chemicals used

- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of methods, models and other tools used in the project and asses the problem of the project and results in relevant professional contexts

Competencies

- select the best possible analytical equipment in the laboratory for a chemical analysis of a given product or a process, taking economic and temporal factors into account
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Methods in Quantitative Chemical Analysis**
Metoder til kvantitativ kemisk analyse

Objective: Students who complete the module must be able to:

Knowledge

- explain the fundamental physical principles governing selected apparatus for instrumental chemical analysis, including chromatographic and spectroscopic techniques
- explain the fundamental physical principles forming the basis for alternatives to the selected instrumental chemical analysis methods
- account for the chemistry that forms the basis of sample preparation for the above selected instrumental chemical analysis techniques
- account for spectroscopic methods that may be utilized for qualitative analysis of various organic, inorganic or organometallic substances

Skills

- perform relevant stoichiometric calculations and use common glassware in the laboratory
- perform analytical chemical experiments based on written instructions and achieve a reproducible result
- write and balance any and all chemical reaction schemes forming the foundation of the instructions for the analysis
- calculate the thermodynamic affinity for the applied reactions from the point of reference
- perform relevant statistical calculations on the results of a series of analysis on selected instruments
- perform general calculations of the uncertainty in the measurements based on the obtained results
- identify appropriate experimental methods for qualitative determination of substance properties

Competencies

- select and avalaute imaginable analysis equipment in the laboratory for a chemical analysis of a product or a given process under consideration of time and economical aspects

Type of instruction: Lectures, laboratory exercises, and theoretical exercises

Exam format: Oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Inorganic and Organic Chemistry**
Uorganisk og organisk kemi

Objective: Students who complete the module must be able to:

Knowledge

- explain the concept of activity and activity coefficients of ions in solution
- explain the fundamental thermodynamics underlying the calculation of equilibrium constants of coupled equilibria systems
- describe properties of solids that rely on the atomic structure of metals and ionic compounds
- describe stereochemistry and coordination chemistry of chemical complexation
- explain bonding of organic carbon-based compounds and stereochemistry
- account for functional groups, nomenclature, common trivial names and physical properties
- account for reactive intermediates (radicals, carbocat-ions, and anions)
- describe reaction mechanisms of organic reactions
- explain product distribution and synthesis strategy
- account for methods for the purification and isolation of organic chemicals
- account for the influence of ionic strength (non-ideality) when doing calculations on chemical reactions in solution
- explain the models for the structure of chemical complexation based on electron configuration

Skills

- couple several chemical equilibria of both homogeneous and heterogeneous nature and to perform the necessary calculations for determination of the equilibrium state of the coupled system
- explain various equilibrium diagrams with a particular focus on redox reactions
- deduce important properties of chemical compounds using the periodic table of elements
- apply the knowledge achieved in the course for analysis of the chemistry of a main group and other trends in the periodic table
- apply the fundamental concepts of isotope and nuclear chemistry
- use the nomenclature rules to read, interpret and disseminate information related to organic chemicals
- write reaction mechanisms, stereochemistry and product distributions for selected ionic, organometallic and radical reactions

- based on synthesis protocols, draw a block diagram showing all steps in the synthesis and the subsequent purification procedure

Competencies
- alter reaction pathways in order to achieve a preferred or particular outcome of a process.
- apply own knowledge of organic chemistry in technical, biological and ecological contexts.

Type of instruction: Lectures, laboratory exercises, theoretical exercises, workshops

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Applied Statistics**
Anvendt statistik

Prerequisites: The module adds to the knowledge obtained in Linear Algebra and in Calculus

Objective: Students who complete the module must be able to:

Knowledge
- describe basic concepts of probability theory, statistics and quality control
- account for relevant statistical software for solving problems in statistics and quality control

Skills
- choose the right probability model and perform calculations according to the model. This applies to both discrete and continuous distributions
- handle both one-dimensional as well as multi-dimensional random variables and the related distributions, discrete and continuous
- calculate the mean, standard deviation for one-dimensional random variables and also be introduced into the calculation and understanding of covariance for multi-dimensional random variables
- select the right statistical method and make calculations of confidence intervals and do hypothesis testing for one and two random samples, make analysis of variance and regression analysis in terms of continuous as well as discrete probability distributions
- establish and solve problems in process control and product control, this applies both within continuous as an alternative variation
- handle both traditional solution techniques as well as software based solutions
- interpret the results obtained from the correct statistical method including their application
- set up and use non-parametric tests on qualitative data

Competencies
- engage in a dialogue regarding the optimal choice of method within probability theory, statistics and quality control
- disseminate the results of the calculations to others, including

colleagues, public authorities, etc.

Type of instruction Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.7 Descriptions of modules. 4th semester.

Title: **Material Science**
Materialeteknologi

Prerequisites The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Fundamental Chemical Engineering and Thermodynamics
Methods in Quantitative Chemical Analysis
Applied Statistics

Objective: Students who complete the module must be able to:

Knowledge
- account for the fundamental structure and physical/chemical properties of materials
- account for the production and application of materials
- describe relevant methods for analysis and testing of materials

Skills
- select relevant analytical methods and approaches for a given problem
- conduct a series of experiments to gain information about key parameters
- evaluate results from experiments using statistical methods
- select materials to improve either a process or product
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of methods, models and other tools used in the project and asses the problem of the project and results in relevant professional contexts

Competencies
- interpret and evaluate knowledge about materials
- evaluate results from experimental work and their applicability to given problem
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction Project work
Access to perform laboratory experiments requires participation in laboratory

safety instructions

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Applied Microbiology**
Teknisk Microbiologi

Prerequisites The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Chemical Analysis of Homogeneous Analysis
Methods in Quantitative Chemical Analysis
Applied Statistics
Microbial Biotechnology (in parallel)

Objective: Students who complete the module must be able to:

Knowledge

- account for basic microbiology
- account for basic security in relation to the handling of microorganisms and enzymes
- describe reactor types that are relevant for Technical Microbiology, configurations thereof as well as their advantages and limitation
- account for scale-up of microbiological processes including physical conditions and limitations
- describe sterilization procedures and decimation time for microorganisms

Skills

- demonstrate basic skills in practical methods for the characterization of microorganisms, substrates and products
- select suitable microorganisms or enzymes to a specific technical problem
- set up and solve relevant mass and energy balances for microbiological processes at laboratory scale and in technical scale
- describe the necessary safety measures at all scale levels
- account for proper waste management at all scale levels
- account for suitable analytical methods for monitoring the microbiological process
- construct an experimental setup equipped with appropriate data collection
- analyze and interpret data from a fermentation process based on knowledge of the microorganism used
- report data from the technical microbiological studies using proper statistical computing
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of methods, models and other tools used in the project and asses the problem of the project and results in relevant professional contexts

Competencies

- provide technical microbiological knowledge to a broad range of people with different professional backgrounds
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work
Access to perform laboratory experiments requires participation in laboratory safety instructions

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Petrochemical Separation Processes**
Petrokemiske separationsprocesser

Prerequisites: The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Fundamental Chemical Engineering and Thermodynamics
Methods in Quantitative Chemical Analysis
Applied Statistics

Objective: Students who complete the module must be able to:

Knowledge

- describe the fundamental separation technologies used in production of oil and gas
- account for the fundamental aspects of oil and gas production
- account for fundamental types of calculations related to the separation of oil and gas
- explain fundamental knowledge thermodynamics related to oil and gas separation

Skills

- perform relevant calculations relating to oil and gas separation
- design a separation train for a given production
- evaluate which types of material are appropriate for the construction of the separation units
- set specifications for a for unit design based on the process in question
- select an appropriate separation process for a given process
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of methods, models and other tools used in the project and asses the problem of the project and results in relevant professional contexts

Competencies

- evaluate the effectiveness and applicability of different separation methods in oil and gas technology
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work
Access to perform laboratory experiments requires participation in laboratory safety instructions

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Chemical Thermodynamics and Separation Process Engineering**
Fysisk-kemiske separationsprocesser

Prerequisites: The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Fundamental Chemical Engineering and Thermodynamics
Inorganic and Organic Chemistry

Objective: Students who complete the module must be able to:

Knowledge
- account for models for non-ideal gasses
- explain theoretical and empirical models for phase equilibrium of pure species
- account for mixtures, including partial properties, chemical potentials, fugacity, activity, coefficient of activity and must know models for phase equilibrium in mixtures
- explain the theory and design of industrial separation processes, especially staged equilibrium processes as distillation, absorption and extraction
- explain the functioning of separation process equipment used in chemical equilibrium processes

Skills
- differentiate between ideal and non-ideal gasses and to use simple models of non-ideal gasses
- write equation for thermodynamic equilibrium in ideal and in non-ideal mixtures and solutions
- evaluate if a given chemical mixture can be separated and which methods could be applicable
- use thermodynamic data to dimension simple equilibrium processes
- write and use mass, energy and equilibrium relations to find the required number of equilibrium stages for a given separation of a binary mixture

Competencies
- describe, model and solve problems in separation process engineering

Type of instruction Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Microbial Biotechnology**
Mikrobiel bioteknologi

Prerequisites The module adds to the knowledge obtained in:
Biological Active Molecules – introduction to cell biology and biological chemistry
General Chemistry
Inorganic and Organic Chemistry

Objective: Students who complete the module must be able to:

Knowledge
- describe the cell as a biological entity
- account for prokaryotic and eukaryotic cell structures
- account for energy conversion in microorganisms
- describe biochemical analysis methods
- describe technically important microorganisms, their nutrition, metabolism and growth
- account for microbial genetics
- describe microbiological analysis methods
- explain good microbiological practice

Skills
- establish and calculate growth curves for microbiological growth
- perform biochemical and microbiological tests in the laboratory in a safe way
- handle experimental work with microorganisms, evaluate and use appropriate protective measures, work with sterile techniques, use relevant sources of information, and dispose of waste according to regulations

Competencies
- utilise knowledge on biochemical molecules, processes and systems, for projects in technical microbiology, food technology or for biotechnology development or production

Type of instruction Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Material Science and Material Selection**
Materialelære og materialevalg

Prerequisites The module adds to the knowledge obtained in Linear Algebra

calculus
fundamental chemical engineering and thermodynamics

Objective: Students who complete the module must be able to:

Knowledge

- explain the fundamental structure and properties of metals, polymers, ceramics and composites
- account for equilibrium and non-equilibrium diagrams
- account for the selection of materials
- account for material processing, including joining and surface treatment
- explain the fundamental mechanisms in corrosion and wear/abrasion
- describe material testing and the applicability of results gained from testing

Skills

- carry out a material selection and select an appropriate processing method for such material
- identify materials through acquired methods for material testing
- evaluate if a material is suitable for a given purpose based on the properties of the material
- select materials for a given application
- select a processing method and method for joining of materials if required

Competencies

- evaluate the properties and applicability of a given material for engineering purposes
- evaluate if a material will be subject to chemical or mechanical degradation in a given environment, and if needed subsequently select an appropriate surface treatment or substitution of the material

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.8 Descriptions of modules. 5th semester.

Title: **Chemical Process Engineering**
Kemisk procesteknologi

Prerequisites: The module adds to the knowledge obtained in Chemical and Bio Industrial Products

Objective: Students who complete the module must be able to:

Knowledge
- describe the industrial or application context, in which the project work is included in, or may affect
- describe general aspects of process engineering
- explain the main unit operations in the process relating to the project work

Skills
- determine which unit operation or reactor type is suitable in a given case
- set specifications for process equipment for a given chemical process
- analyze, model or size a selected process unit
- to perform relevant calculations for a given process
- set up mass and energy balances for a given process
- evaluate the effect of changing parameters for a given process
- evaluate the potential of the project for further development, assessing and incorporating relevant economic factors
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of literature, methods, models and other tools used in the project and asses the problem of the project and results in relevant professional and social contexts and in relation to literature

Competencies
- propose relevant laboratory experiments to allow for better modelling of a process
- evaluate if changes to a given process could be beneficial
- propose a course of action regarding a given process
- evaluate the quality of experimental data obtained and their applicability to a model of a given process
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Bioprocess Engineering**
Bioprocesteknologi

Prerequisites
The module adds to the knowledge obtained in:
Chemical and Bio Industrial Products
Microbial Biotechnology
Chemical Thermodynamics and Separation Processes
Chemical Reaction Engineering is Followed Simultaneously

Objective:
Students who complete the module must be able to:

Knowledge
- describe the industrial or application context, in which the project work is included in, or may affect
- account for general aspects of process engineering
- describe the main unit operations in the process relating to the project work

Skills
- determine which unit operation or reactor type is suitable in a given case
- set specifications for process equipment for a given chemical process
- analyze, model or size a selected process unit
- perform relevant calculations for a given process
- set up mass and energy balances for a given process
- evaluate the effect of changing parameters for a given process
- evaluate the potential of the project for further development, assessing and incorporating relevant economic factors
- propose relevant laboratory experiments to allow for better modelling of a process
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of literature, methods, models and other tools used in the project and asses the problem of the project and results in relevant professional and social contexts and in relation to literature

Competencies
- evaluate if changes to a given process could be beneficial
- propose a course of action regarding a given process
- evaluate the quality of experimental data obtained and their applicability to a model of a given process
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction
Project work

Exam format:
Oral examination based on a written report

Evaluation criteria:
As stated in the Joint Programme Regulations

Title: **Refinery Products and Processes**
Raffinaderiprodukter og processer

Prerequisites: The module adds to the knowledge obtained in Chemical and Bio Industrial Products

Objective: Students who complete the module must be able to:

Knowledge
- account for crude oil production
- account for the composition of crude oil
- describe the general structure of an oil refinery
- explain the main refinery processes such as distillation, cracking and desulphurization
- describe a given refinery process

Skills
- perform relevant calculations for a given refinery process
- set up mass and energy balances for a given refinery process
- evaluate the effect of changing parameters for a given refinery process
- evaluate the potential of the project for further development, assessing and incorporating relevant economic factors
- propose relevant laboratory experiments to allow for better modelling of a process
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of literature, methods, models and other tools used in the project and asses the problem of the project and results in relevant professional and social contexts and in relation to literature

Competencies
- evaluate if changes to a given process could be beneficial
- propose a course of action regarding a given process
- evaluate the quality of experimental data obtained and their applicability to a model of a given refinery process
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Chemical Reaction Engineering**
Kemisk reaktionsteknik

Prerequisites: The module adds to the knowledge obtained in:
Fundamental Chemical Engineering and Thermodynamics

General Chemistry
Inorganic and organic chemistry

Objective: Students who complete the module must be able to:

Knowledge
- explain fundamental concepts of chemical reaction engineering
- account for ideal and non-ideal chemical reactors and reactor systems
- describe the development of kinetic models on the basis of chemical reaction mechanisms
- explain how reactor design and process conditions can be used to optimize yield and product distribution
- explain the principles for catalysis and catalytic reactions
- describe the reaction systems for major chemical and biotechnological products

Skills
- analyze kinetic data from ideal reactors
- set up rate equations for chemical and biochemical reactions based on knowledge of reaction mechanisms
- set up and test rate equations from kinetic data
- set up and solve equations for analysis and design of ideal reactors or reactor systems operating isothermally or adiabatically
- optimize yield and selectivity of multiple reactions
- model and analyze reactors for chemical or biochemical industrial reactions

Competencies
- apply the knowledge of kinetics and reactor design to the modelling systems for e.g. natural processes

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Thermodynamic, Heat Transfer and Fluid Mechanics**
Termodynamik, varmetransmission og strømningslære

Prerequisites: The module adds to the knowledge obtained in Fundamental Chemical Engineering and Thermodynamics

Objective: Students who complete the module must be able to:

Knowledge
- account for fundamental thermodynamics, fluid mechanics and heat transfer
- account for fundamental thermodynamics
- account for fundamental fluid mechanics
- account for fundamental convection
- account for heat transfer in thermal networks
- account for heat exchangers

Skills
- apply thermodynamics to solve engineering problems
- use the energy equation on flow in piping with different components such as pumps, valves, bends and nozzles
- use fundamental fluid mechanics to analyse external flow around objects
- calculate heat transfer in thermal networks
- calculate heat transfer coefficients both at external and at internal surfaces
- analyze and select heat exchangers

Competencies
- apply the acquired knowledge and skills to describe, model and solve problems in process engineering projects
- to communicate problems and solutions to people without thorough knowledge of the subject

Type of instruction: Lectures and theoretical exercises

Exam format: Written examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Mathematical Modeling and Numerical Methods**
Matematisk modellering og numeriske metoder

Prerequisites: The module adds to the knowledge obtained in Linear Algebra and in Calculus

Objective: Students who complete the module must be able to:

Knowledge
- account for basic modeling and analysis of certain ordinary and partial differential equations
- account for basic analysis of the above ordinary and partial differential equations
- account for basic concepts of numerical methods
- explain numerically solving non-linear systems of equations, integrals, and ordinary and partial differential equations
- account for the modeling and analysis of the above ordinary and partial differential equations

Skills
- use extra- and interpolation techniques such as Taylor polynomials and Lagrange polynomials
- use Laplace transforms to solve differential equations
- apply vector analysis and integral principles for mathematical modeling
- apply methods, analytical as well as numerical, to solve the above ordinary and partial differential equations
- set up and use the correct numerical method for solving a variety of areas, such as finding the zero point, integration, interpolation, differential equations.
- set up and solve 1- and 2-dimensional heat equations by analytical and numerical methods
- set up and solve 1- and 2-dimensional wave equations by analytical and

numerical methods
- set up and solve Poisson's and Laplace's equations by numerical methods
- develop solutions of differential equations using systems of eigenfunctions
- to solve partial differential equations using Fourier series and the separation method

Competencies
- engage in a dialogue regarding the optimal choice of analytical and numerical solution methods for partial differential equations, and results from mathematical modeling in general
- disseminate setup and results of solving certain partial differential equations to others, including colleagues, government agencies and others

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.9 Descriptions of modules. 6th semester.

Title: **Design of Experiments**
Statistisk forsøgsplanlægning

Prerequisites: The module adds to the knowledge obtained in Applied Statistics

Objective: Students who complete the module must be able to:

Knowledge
- explain the establishment of experimental design with qualitative and quantitative factors
- account for complete, partial and confounding 2k and 3k factorial experiments
- explain incomplete block design and splitplot designs
- explain how to perform control experiments, including using of central points
- account for orthogonal experimental design
- describe methods of optimization of the experimental factors and minimizing noise factors
- account for regression analysis (including step-wise regression) of the drop in data
- explain response surface design

Skills
- develop study plans with qualitative and quantitative factors
- perform control experiments
- optimize the experimental factors
- minimize the noise factors

- use multiple analysis of variance and regression analyzes, including the combined variance and regression analyzes
- analyze experimental data and be able to evaluate the methods used, validity and usefulness
- use statistical design of experiments in practice within the domain of quality / process optimization and to process the results by statistical methods on a computer

Type of instruction Lectures and theoretical exercises

Exam format: Oral examination based on a prepared mini project

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Process Control, Instrumentation and Safety**
Procesregulering, instrumentering og sikkerhed

Prerequisites The module adds to the knowledge obtained in:
Mathematical Modeling and Numerical Methods
Fundamental Fluid Mechanics and Heat Transfer

Objective: Students who complete the module must be able to:

Knowledge
- account for diagrams and system interconnections
- explain modeling of physical systems , determination of operating points and linearization
- explain a system's dynamic and stationary behavior, including the effects of the type and order of the system, as well as poles and zero points and their impact on the response of the system
- account for analysis by root curves and knowledge of controller design using root curves
- account for a system's frequency response (open-loop and closed - loop)
- account for stability analyses
- describe design using frequency response techniques
- explain analog implementation of controllers
- describe measurement techniques and data collection using a PC
- account for software for building/developing applications for data acquisition and control
- account for the structure and operation of the measurement system including sensors, signal processing, and monitoring system
- explain the operation of classical sensors (pressure, temperature , position, velocity , acceleration, flow)
- account for sampling, different connections and noise from measurements

Skills
- analyze block diagrams on the basis of PI – charts
- model and analyze basic dynamical systems, including electrical, mechanical and thermal systems, and analogies between these
- develop models of dynamic systems in the form of transfer functions
- apply control theory to achieve performance criteria

- analyze a system's response and stability using the classical methods
- select appropriate regulators and predict/assess their impact
- use standard software for data acquisition, control and regulation
- connect classical sensors and conduct research with classical sensors for pressure, temperature, position, velocity, acceleration, flow
- assess the quality of the measurements and apply appropriate processing on them
- disseminate the problem, the used solution method and interpret the outcome

Type of instruction: Lectures and theoretical exercises

Exam format: Oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **BSc Project in Chemical Engineering and Biotechnology**
Bachelorprojekt i kemi og bioteknologi

Objective: Students who complete the module must be able to:

Knowledge
- explain the specific concepts, models, methods and techniques that are relevant to the professionalism of the project work
- describe the traditions of engineering, the engineer's role in society, as well as ethical issues in engineering science
- describe the scientific approaches and traditions and different theories of science and concepts of truth
- describe possible career directions in the engineering profession
- account for entrepreneurship, including opportunities for self-employment

Skills
- apply theoretical methods and concepts within the disciplines of engineering
- write a project report following the standards of the field of study, include relevant literature, use the correct terminology, and communicate the problem and results in writing, graphically and orally in a coherent way
- justify the choice of literature, methods, models and other tools used in the project and asses the problem of the project and results in relevant professional and social contexts and in relation to literature

Competencies
- handle starting up a self-motivated business and be part of the daily work in a company
- handle the planning, implementation and management of a project and handle complex and development-oriented tasks during the project work and contribute to the project group's work and results
- identify own learning needs for continued development and education in the field of study

Type of instruction: Project work
Projects are focused on one of the following themes

- development of a chemical or bio industrial product
- development, design and optimization of a chemical or bio industrial process
- development and optimization of a process analytical technology

Exam format: Oral examination based on a written report

Evaluation criteria: As stated in the Joint Programme Regulations

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of The Faculty of Engineering and Science and enters into force as of 2017.

Students who wish to complete their studies under the previous curriculum from 2016 must conclude their education by the summer examination period 2019 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Bachelor's project

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's formulation and spelling ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of good language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.
The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Bachelor's project must include an English summary. If the project is written in English, the summary must be in Danish (the Board of Studies can grant exemption from this). The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (*merit*), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad

In the individual case, the Board of Studies can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

5.3 Rules concerning the progress of the Bachelor's programme

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's programme, in order to be able to continue the programme. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor's programme.

In special cases, however, there may be exemption from the above if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

5.4 Rules for examinations

The rules for examinations are stated in the Examination Policies and Procedures published by The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and The Faculty of Medicine on their website.

5.5 Exemption
In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.6 Rules and requirements for the reading of texts
At programmes that are taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages. At programmes taught in English, it is assumed that the student can read academic text and use reference works, etc., in English.

5.7 Additional information
The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the programme, including exams.