The Faculty of Engineering and Science
Board of Studies for Chemistry, Environmental
Engineering and Biotechnology


# Curriculum for Bachelor (BSc) in Chemical Engineering and Biotechnology

Aalborg University
September 2014

Campus Esbjerg

**Preface:**
Pursuant to Act 367 of May 25, 2013 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 Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science.

Godkendt af Studienævnet for Kemi, Miljø og Bioteknologi
Aalborg Universitet, 2014

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Godkendt af dekanen 2014

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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 Science, Innovation and Higher Education's Order no. 814 of June 29, 2010 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 666 of June 24, 2012 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 1487 of December 16, 2013 (the Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

### 1.2 Faculty affiliation

The Bachelor's programme falls under the Faculty of Engineering and Science, Aalborg University.

### 1.3 Board of Studies affiliation

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

# 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, Physics B and Chemistry B *or* Biotechnology A.

### 2.2 Degree designation in Danish and English

The Bachelor's programme entitles the graduate to the designation Bachelor (BSc) i kemi og bioteknologi. The English designation is: Bachelor of Science (BSc) in 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

Knowledge base

- 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.
- Understanding and thought level
- Can understand and reflect on theory, method and practice within the scientific fields mentioned above and put them in a social context.

Skills

Type of 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.

Assessment and decision making

- Can evaluate theoretical and practical problems associated with development, production and analysis of chemical and

biotechnological products, and also reason for relevant solutions.

Communication skills

- 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

Working competencies

- Can handle complex and development-oriented situations in a study or work context

Cooperation and responsibility

- Can independently be part of discipline-specific and interdisciplinary cooperation with a professional approach
- Learning

- 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
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- Laboratory work
- Supervisor sessions

### 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 |
| | Chemistry, Environment and Health – a Case study | 5 | Pass/Fail | Internal |
| | Problem Based Learning in Science, Technology and Society | 5 | Pass/Fail | Internal |
| | Organic Chemistry | 5 | 7-point scale | Internal |
| | Linear Algebra | 5 | 7-point scale | Internal |
| 2nd | Chemical Reactions in Natural and Technical Systems | 15 | 7-point scale | External |
| | Bioactive Molecules – an Introduction to Biological, Physiology and Toxicology | 5 | Pass/Fail | Internal |
| | Introduction to Chemical Engineering and Thermodynamics | 5 | 7-point scale | Internal |
| | Calculus | 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 Physical Chemistry | 5 | 7-point scale | Internal |
| | Applied Statistics | 5 | 7-point scale | Internal |
| 4th | Material Science | 15 | 7-point scale | External |
| | Applied Microbiology | | | |
| | Petrochemical Separation Processes | | | |
| | Chemical Thermodynamics and Separation Process Engineering | 5 | 7-point scale | Internal |
| | Biological Chemistry | 5 | 7-point scale | Internal |
| | Material Science and Material Selection | 5 | 7-point scale | Internal |
| 5th | Chemical Process Engineering | 15 | 7-point scale | External |
| | Bioprocess Engineering | | | |
| | Refinery Products and Processes | | | |
| | Chemical Reaction Engineering | 5 | 7-point scale | Internal |
| | Fundamental Fluid Mechanics and Heat Transfer | 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 |
| | Theory of Science and Entrepreneurship | 5 | Pass/Fail | Internal |
| | BSc Project | 15 | 7-point scale | External |
| Total | | 180 | | |

### 3.2 Knowledge and Scientific Method

In the above modules, 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

Bachelor's degree 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, that there in the bachelor project is an opportunity to work with an optional subject, and that it is possible to put together an individual semester (see section 5.5).

## Descriptions of modules

### 3.4 Module description for 1. Semester

**Title:** **Chemistry, Environment and Health – a Case Study**
(Kemi, miljø og sundhed – et casestudie)

Prerequisites: Admission to the programme

Objective: Students who complete the module:

Knowledge

- Must have knowledge of some basic concepts in the relevant project angle/ professionalism
- Must have a basic knowledge of work processes in a project, knowledge acquisition and cooperation with the supervisor

Skills

- Must be able to define the objectives of the project, and be able to write a conclusion that answers the problem of the project
- Must be able to describe and analyze one or more project angles
- Must be able to disseminate the results of the project work in writing, graphically and verbally in a coherent way

Competences

- Must be able to reflect on the problem-oriented and project-organized study form and workflow
- Must be able to disseminate the obtained results from the project work in a project report
- Must be able to cooperate in a project group about the problem, and make a presentation of the obtained results from the project together.
- Must be able to reflect on ways to disseminate information to others (written, verbally and graphically)

Education form: Project with guidance
The students work with a chosen case within the theme of chemistry, environment and health.
The selected problems will be worked out from several angles on the basis of available knowledge.
A project report will be prepared, and presented on a presentation seminar.

Exam format: Individual oral examination based on a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Chemical and Bio Industrial Products**
(Kemiske og bioindustrielle produkter)

Prerequisites: Chemistry, Environment and health – a Case Study
Problem-based learning in science, technology and society is followed simultaneously

Objective: Students who complete the module:

Knowledge

- Must be able to define and understand the applied concepts as well as having a basic understanding of the applied methods, theories and / or models

Skills

- Must be able to define the objectives of the project and a strategy for problem-processing and be able to analyze and draw conclusions with the involvement of relevant contexts
- Must be able to write a conclusion that answers the problem in the project
- Must be able to assess the relevance of collected information in connection with the project.
- Must be able to include and describe relevant concepts, models, theories and methods used to analyze the problem.
- Must be able to disseminate the results in the project work in an organized and understandable way both written, graphic and oral
- Must be able to analyze own learning process
- Must be able to use a method for organizing project work

Competences

- Must be able to disseminate the obtained results from the project work in a report
- Must be able to cooperate around the problem field in the project and make a presentation of the project results
- Must be able to use the project work as a study form
- Must be able to reflect on own experiences with project work and problem processing
- Must be able to use the methods / theories used in the project for analysis of a problem of similar academic nature

Education form: Project work with guidance, if necessary, supplemented by lectures, workshops, presentation seminars, laboratory experiments, company visits etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

The students work with a problem within the theme of chemical and bio-industrial products. The specific problems will be chosen from a catalog with project subjects developed by the supervisors.
The selected problem is analyzed from multiple angles and a solution proposal or requirement specifications are presented. A project report is prepared and presented at a presentation seminar.

Exam format: Individual oral examination based on a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

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

Objectives: Students who complete the course module will obtain the following qualifications:

Knowledge

- Shall be able to explain basic learning theory
- Shall be able to explain techniques for planning and management of projects
- Shall be able to 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
- Shall be able to explain different approaches to analysis and assessment of problems and solutions within engineering, natural and health sciences from a theoretical, ethical, and societal perspective
- Shall be able to explain how these methods can be applied within Electronics and Computer Science

Skills

- Must be able to plan and manage a problem-based study project
- Must be able to 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
- Must be able to reflect on the causes and devise possible solutions to any group conflicts
- Must be able to 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
- Must be able to reflect upon the methods used from a theoretical perspective
- Must be able to 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

- Shall be able to take part in a team-based project
- Shall be able to document and present work carried out in a project
- Shall be able to reflect upon and develop his/her own learning
- Shall be able to engage in and improve upon the collaborative learning processes

- Shall be able to reflect upon his/her professional activities in relation to the surrounding community

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written examination

Evaluation criteria: Stated in the Framework Provisions

**Title:** **Organic Chemistry**
(Organisk kemi)

Prerequisites: Admission to the programme

Objective: Students who complete the module:

Knowledge

- Must have knowledge about atomic structures, electronegativity, molecular bonding , polarity, formal charges , resonance
- Must have knowledge about- and be able to explain intermolecular interactions and their implications for physical properties of substances
- Must have knowledge about the functional groups and their physical properties
- Must have knowledge about IUPAC nomenclature and knowledge of common trivial names
- Must have knowledge about stability and energy issues, including bond-dissociation energy, activation energy and transition state and to understand energy diagrams for reactions
- Must have knowledge about- and be able to explain reaction mechanisms and stereochemistry
- Must have knowledge about- and be able to explain product distribution and synthesis strategy
- Must have knowledge about methods for the purification and isolation of organic chemicals
- Must have knowledge about general safety rules for laboratory work and be able to explain how chemicals, equipment and laboratory waste must be handled

Skills

- Must be able to use the nomenclature rules to read, interpret and disseminate information relating to organic chemicals
- Must be able to write the chemical equations, balancing those, make stoichiometric calculations and be able to convert between units
- Must be able to write reaction mechanisms, stereochemistry and product distribution for selected ionic, organometallic and radical reactions
- Must be able to, based on a synthesis regulation, record a block diagram showing all steps in the synthesis and the subsequent purification procedure
- Must be able to use chemical safety data sheets to assess risk and safety for a given laboratory task.

Competences

- Must be able to understand the relationship between molecular structure, physical properties, chemical reactivity and biological activity

- Must be able to apply your knowledge of organic chemistry in the technical, biological and ecological contexts

Education form: Lectures, exercises, laboratory work.

Exam format: Internal individual written or oral examination in the examination system.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Linear Algebra**
(Linear algebra)

Prerequisites: High school mathematics at level A

Objective: Students who complete the module:

Knowledge

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

Skills

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

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

Competences

- Must develop and strengthen your knowledge, understanding and application of mathematical theories and methods in other areas
- Must, based on given assumptions, be able to reason and argue with mathematical concepts of linear algebra

Education form: Lectures with exercises.

Exam format: *Internal* Individual oral or written examination under the examination policies

Evaluation criteria: As stated in the Framework Provisions

### 3.5 Module descriptions for 2. Semester

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

Prerequisites: Chemistry and bio industrial products
Problem-based learning in science, technology and society
Organic chemistry

Objective: Students who complete the module:

Knowledge

- Must have knowledge to- and understanding of concepts, models, theories and methods within the professionalism being relevant for the project
- Must have knowledge about practical laboratory work including risk safety procedures and waste management
- Must have knowledge about various methods of knowledge acquisition, and methods for processing a problem

Skills

- Must be able to define the goal or vision of the project and analyze different solution proposals and take academically based conclusions
- Must be able to apply and select relevant concepts, terminology, models, theories and methods in the appropriate professionalism for processing a problem
- Must be able to 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
- Must be able to disseminate results of the project in a clearly structured, coherent and concise manner, both written, graphic and oral
- Must be able to analyze their own learning process
- Must be able to plan and manage a project, and be able to analyze the project groups organization of the project work
- Must be able to perform systematic choice of methods for knowledge acquisition in the context of problem analysis and problem processing
- Must be able to make a critical assessment regarding the relevance of knowledge obtained in relation to the project work, and evaluate the models, theories and / or suitability of methods

Competences

- Must be able to participate in and manage different forms of organization of the project work in the further study
- Must in a structured way be able to acquire skills and knowledge in the further course of study (individually and in groups)
- Must be able to use the methods/theories applied in the project in connection with the design or analysis of a problem of similar academic nature

Education form: Project work with guidance, if necessary, supplemented by lectures, laboratory experiments, workshops etc.

Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: *O*ral or written examination on the basis of the submitted project

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Bioactive Molecules – an Introduction to Biological, Physiology and Toxicology**
(Biologisk aktive molekyler – introduktion til biologisk kemi, fysiologi og toksikologi)

Prerequisites: Organic Chemistry

Objective: Students who complete the module:

Knowledge

- Must have knowledge about structure of the cell
- Must have knowledge about biologically active molecules structures, properties and functions
- Must have knowledge about the cellular energy metabolism
- Must have knowledge about human organs, their structure and function, including musculoskeletal, circulatory, respiratory, digestive and urinary systems
- Must have knowledge about the organism's regulatory systems, including the nervous, sensory, endocrine and immune systems
- Must have knowledge about the concept of toxicology/ecotoxicology, including sources, types and characteristics of toxic substances, as well as distribution and transformation of some chemicals in the environment
- Must know dosis-/respons contexts, toxicity testing and organism response, including the determination of LC50
- Must have knowledge about the toxicological and ecotoxicological safety and risk assessment
- Must have knowledge about risk and safety in handling biological materials and waste

Skills

- Must be able to describe the cell's organelles and ingredients.
- Must be able to explain the metabolism
- Must be able to account for toxic substances, sources, types and characteristics.
- Must be able to describe the distribution and transformation of some chemicals in the environment.
- Must be able to explain the organism response and dosis-/respons-contexts.
- Must be able to describe bio monitoring and ecological risk assessment.
- Must be able to handle biological material and waste from laboratory tests in a safe manner
- Must be able to use the correct terms, notations and symbols in the above mentioned areas.

Competences

- Must be able to describe the interaction between chemistry and biology at the cellular, organ, organism or ecosystem level

- Must be able to apply the knowledge acquired in the context of the project
- Must be able to understand parts of literature about cell biological, physiological, toxicological and ecotoxicological issues

Education form: Lectures, tutorials and laboratory work

Exam format: Internal written examination according to the examination policies

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Introduction to Chemical Engineering and Thermodynamics**
(Grundlæggende kemisk procesteknik og termodynamik)

Prerequisites: Admission to the programme

Objective: Students who complete the module:

Knowledge

- Must be able to define and explain fundamental concepts in engineering calculations including systems, system boundaries, process classifications, process units and process variables
- Must have knowledge about Newton's laws
- Must know and understand the concepts of energy, energy transfer and power
- Must know an be able to read process diagrams
- Must know how to write and solve balance equations systematically
- Must know the laws of thermodynamics
- Must know the concept of ideal gasses and their behaviour
- Must know the Boltzmann distribution
- Must have knowledge about heat, work and internal energy
- Must have knowledge of thermal properties of matter
- Must have knowledge about entropy
- Must have knowledge about enthalpy and enthalpy changes
- Must have knowledge about Gibbs energy and phase equilibriums
- Must have knowledge about chemical potentials and chemical reaction equilibriums

Skills

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

Competencies

- Must be able to use principles and theories from chemical engineering and thermodynamic on simple model systems
- Must be able to 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 problem solving classes

Exam format: Internal written examination according to the examination rules

Evaluation criteria: Are stated in the Framework Provisions

**Title:** **Calculus**
(Calculus)

Prerequisites: Linear algebra

Objective: Students who complete the module:

Knowledge

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

Skills

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

- Must be able to reason with the course concepts, results and theories in simple concrete and abstract problems.

Competences

- Must develop and strengthen your knowledge, understanding and application of mathematical theories and methods in other areas
- Must, based on given assumptions, be able to reason and argue with mathematical concepts of linear algebra

Education form: Lectures with exercises.

Exam format: *Internal* Individual oral or written examination under the examination policies

Evaluation criteria: As stated in the Framework Provisions

### 3.6 Module Description for 3. Semester

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

Prerequisites: Basic chemical process engineering and thermodynamics

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the fundamental physical principles that underlie the chemical analysis apparatus used in the project.
- Must have knowledge about the fundamental physical principles underlying alternatives to the selected instrumental chemical analysis techniques.
- Must have knowledge about the chemistry that underlies sample preparation to the instrumental chemical analysis techniques that are selected above
- Must have knowledge about standard statistical methods used in analytical chemistry.

Skills

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

Competences

- Must be able to pick out 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.
- Must be able to choose alternative solutions for the analysis.
- Should be able to communicate the outcome of the deliberations and the results of the performed laboratory work for students at the same level and to laypeople.

Education form: Project work with guidance, if necessary, supplemented by lectures, laboratory experiments, workshops etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: *O*ral or written examination on the basis of the submitted project

Evaluation criteria: As stated in the Framework Provisions

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

Prerequisites: Fundamental Chemical Engineering and Thermodynamics

Objective: Students who complete the module:

Knowledge

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

Skills

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

Competencies

- Must be able to select the best imaginable analysis equipment in the laboratory for a chemical analysis of a product or a given process under consideration of time and economical aspects.
- Must be able to select alternative solutions for the analysis.
- Should be able to communicate the result of these considerations as well as the results of the work in the laboratory to students at the same level as well as laymen.

Type of instruction: Lectures, laboratory problems and theoretical exercises

Exam format: Oral examination

**Title:** **Inorganic and Physical Chemistry**
(Uorganisk og fysisk kemi)

Prerequisites: Organic Chemistry
Fundamental Chemical Engineering and Thermodynamics

Objective: Students who complete the module:

Knowledge

- Must have knowledge of the fundamental differences on redox reactions, acid-base reactions, precipitation and dissolution reactions, complexation reactions.
- Must have knowledge of the fundamental thermodynamics underlying the calculation of equilibrium constants of coupled equilibria systems.
- Must have knowledge of fundamental electrochemistry, including galvanic elements, electrolysis and the principles of the use of electrodes in potentiometry.
- Must have knowledge of fundamental reaction kinetics.
- Must have knowledge of the electron configuration of the elements and the physical description of the atom that form the basis of the periodic table.
- Must have knowledge of different models for development of molecular orbitals that describe the molecular covalent bond.
- Must have knowledge of properties of solids that rely on the atomic structure of metals and ionic compounds.

Skills

- Must be able to balance chemical reactions and perform appropriate stoichiometric calculations and mass balances of chemical reactions.
- Must be able to couple a large number of chemical equilibria of both homogeneous and heterogeneous nature and to perform the necessary calculations for determination of the equilibrium state of the coupled system, taking account of ionic strength effects.
- Must be able to 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.
- Must be able to develop a Nernst equation for calculation of the electromotive force of a redox reaction and account for all chemical activities involved.
- Must be able to calculate the yields of electrolytic reactions.
- Must be able to explain the function of an electrode used for chemical analysis and convert its signal to a concentration of a compound.
- Must be able to explain the electron configurations of atoms and ions and their influence on the geometric size of the particle.
- Must be able to explain the structure of molecules, metals and ionic compounds based on electron configurations and the size of atoms and ions.
- Must be able to explain the models for the structure of chemical complexation based on electron configuration.
- Must be able to explain various equilibrium diagrams with a particular focus on redox reactions.
- Must be able to apply the knowledge achieved in the course for analysis of the chemistry of a main group and other trends in the periodic table.

Competencies

- Must have the ability to scrutinize the chemistry behind any reaction carried out in connection with any future project, so that a physic-chemical model can be developed for explanation of obtained experimental data.
- Must have the ability to select alternate reaction pathways in order to achieve a particular outcome of a process.
- Must have the ability to communicate the results of the above considerations to students at the same level and laymen.

Type of instruction: Lectures, experimental laboratory exercises, theoretical exercises, workshops. Potentially supplemented with presentation seminars and guest lectures.

Exam format: Individual written or oral examination.

Evaluation criteria: Are stated in the Framework Provisions

**Title:** **Applied Statistics**
(Anvendt statistic)

Prerequisites: Linear algebra
Calculus

Objective: Students who complete the module:

Knowledge

- Must have knowledge about basic concepts of probability theory, statistics and quality control
- Must have knowledge about using MATLAB, including the Statistic TOOLBOX for solving problems in statistics and quality control

Skills

- Must be able to choose the right probability model and perform calculations according to the model. This applies to both discrete and continuous distributions.
- Must be able to handle both one-dimensional as well as multi-dimensional random variables and the related distributions, discrete and continuous.
- Must be able to 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.
- Must be able to 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.
- Must be able to establish and solve problems in process control and product control, this applies both within continuous as an alternative variation.
- Must be able to handle both traditional solution techniques as well as MATLAB solutions.
- Must be able to interpret the results obtained from the correct statistical method including their application
- Must be able to set up and use non-parametric tests on qualitative data

Competences

- Must be able to engage in a dialogue regarding the optimal choice of method within probability theory, statistics and quality control.
- Must be able to disseminate the results of the calculations to others, including colleagues, public authorities, etc.

Education form: A combination of lectures, exercises

Exam format: Individual written or oral test.

Evaluation criteria: As stated in the Framework Provisions

### 3.7 Module Descriptions for 4. Semester

**Title:** **Material Science**
(Materialer)

Prerequisites: Fundamental Chemical Engineering and Thermodynamics
Methods in Quantitative Chemical Analysis
Applied Statistics

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the fundamental structure and physical/chemical properties of materials.
- Must be able to account for the production and application of materials.
- Must have knowledge about relevant methods for analysis and testing of materials.

Skills

- Must be able to determine relevant analytical methods and approaches for a given problem.
- Must be able to conduct a series of experiments to gain information about key parameters.
- Must be able to evaluate results from experiments using statistical methods.
- Must be able to select a material to improve either a process or product.

Competencies

- Must be able to interpret and evaluate the gained knowledge about materials.
- Must be able to evaluate results from experimental work and their applicability to given problem.
- Must be able to participate in group work and disseminate results and knowledge obtained

Type of instruction: Project work. Discussions and ad hoc study circles. Instruction in laboratory.

Admission to the laboratory requires participation of the laboratory safety instruction.

Exam format: Oral examination based on a written report and the project closing

Evaluation criteria: are stated in the Framework Provisions

**Title:** **Applied Microbiology**
(Teknisk Microbiology)

Prerequisites: Chemical analysis of homogeneous analysis
Methods in quantitative chemical analysis
Applied statistic

Objective: Students who complete the module:

Knowledge

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

Skills

- Must have basic skills in practical methods for the characterization of microorganisms, substrates and products
- Must be able to select suitable microorganisms or enzymes to a specific technical problem
- Must be able to set up and solve relevant mass and energy balances for microbiological processes at laboratory scale and in technical scale
- Must be able to describe the necessary safety measures at all scale levels
- Must be able to account for proper waste management at all scale levels
- Must be able to account for suitable analytical methods for monitoring the microbiological process
- Must be able to construct an experimental setup equipped with appropriate data collection
- Must be able to analyze and interpret data from a fermentation process based on knowledge of the microorganism used

Competences

- Must be part of a working group and provide technical microbiological knowledge to a broad range of people with different professional backgrounds
- Must be able to report data from the technical microbiological studies using proper statistical computing

Education form: Project work with guidance, if necessary, supplemented by lectures, laboratory experiments, workshops etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: Individual oral examination on the basis of a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Petrochemical Separation Processes**
(Petrokemiske separationsprocesser)

Prerequisites: Fundamental Chemical Engineering and Thermodynamics
Methods in Quantitative Chemical Analysis
Applied Statistics

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the fundamental separation technologies used in production of oil and gas.
- Must have knowledge of the fundamental aspects of oil and gas production.
- Must have knowledge of fundamental types of calculations related to the separation of oil and gas.
- Must have fundamental knowledge thermodynamics related to oil and gas separation.

Skills

- Must be able to perform relevant calculations relating to oil and gas separation.
- Must be able to design a separation train for a given production.
- Must be able to evaluate which types of material are appropriate for the construction of the separation units.
- Must be able to set specifications for a for unit design based on the process in question.

Competencies

- Must be able to select an appropriate separation process for a given process.
- Must be able to evaluate the effectiveness and applicability of different separation methods.
- Must be able to participate in group work and disseminate results and knowledge obtained.

Type of instruction: Project work. Discussions and ad hoc study circles. Instruction in laboratory.

Admission to the laboratory requires participation of the laboratory safety instruction.

Exam format: Oral examination based on a written report and the project closing

Evaluation criteria: are stated in the Framework Provisions

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

Prerequisites: Fundamental chemical Engineering and Thermodynamics
Physical and Inorganic Chemistry

Objective: Students who complete the module:

Knowledge

- Must have knowledge about models for non-ideal gasses
- Must know theoretical and empirical models for phase equilibrium of pure species
- Must have knowledge about mixtures, including partial properties, chemical potentials, fugacity, activity, coefficient of activity and must know models for phase equilibrium in mixtures
- Must have knowledge about the theory and design of industrial separation processes, especially staged equilibrium processes as distillation, absorption and extraction

Skills

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

Competencies

- Must be able to apply the acquired knowledge to describe, model and solve problems in separation process engineering

Type of instruction: Lectures and problem solving

Exam format: Internal oral or written examination according to the examination rules

Evaluation criteria: Are stated in the Framework Provisions

**Title:** **Biological Chemistry**
(Biologisk kemi)

Prerequisites: Biological Active Molecules – Elements of Biological Chemistry, Physiology and Toxicology
Inorganic and physical chemistry

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the cell as a biological entity
- Must be able to account for prokaryotic and eukaryotic cell structures
- Must be able to explain the structure and function of biomolecules (proteins, nucleic acids, carbohydrates, lipids)
- Must have knowledge about enzymes, co-enzymes and enzyme kinetics
- Must have knowledge about bioenergetics
- Must be able to explain the anabolic and catabolic metabolisms and their regulatory mechanisms
- Must have knowledge about genetic information and be able to explain the concepts of replication, transcription and translation
- Must have knowledge about- and be able to explain protein synthesis
- Must have knowledge about biochemical analysis methods
- Must have knowledge about technically important microorganisms, their nutrition, metabolism and growth
- Must have knowledge about microbial genetics
- Must have knowledge about microbiological analysis methods

Skills

- Must be able to calculate the energy yield of biological metabolisms
- Must be able to perform kinetic calculations on enzyme-catalyzed reactions using Michaelis-Menten kinetics
- Must be able to establish and calculate growth curves for microbiological growth
- Must be able to perform biochemical and microbiological tests in the laboratory in a safe way

Competences

- Must be able to apply the knowledge gained about biochemical molecules, processes and systems, for projects in technical microbiology, food technology or for biotechnology development or production

Education form Lectures with exercises, possibly supplemented by laboratory tests

Exam format: Individual written examination

Evaluation criteria: As stated in the Framework Provisions

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

Prerequisites: Linear Algebra
Calculus
Fundamental Chemical Engineering and Thermodynamics

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the fundamental structure and properties of metals, polymers, ceramics and composites.
- Must have knowledge about equilibrium and non-equilibrium diagrams.
- Must have knowledge about selection of materials.
- Must have knowledge about material processing, including joining and surface treatment
- Must have knowledge about the fundamental mechanisms in corrosion and wear/abrasion.
- Must have knowledge about material testing and the applicability of results gained from testing.

Skills

- Must be able to carry out a material selection and select an appropriate processing method for such material.
- Must be able to identify materials through acquired methods for material testing.
- Must be able to evaluate if a material is suitable for a given purpose based on the properties of the material.

Competencies

- Must be able to evaluate the properties and applicability of a given material for engineering purposes.
- Must be able to 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.
- Must be able to select a material for a given application.
- Must be able to select a processing method and method for joining of materials if required.

Type of instruction: Lectures supplemented with project work

Exam format: Written examination

Evaluation criteria: Are stated in the Framework Provisions

### 3.8 Module Descriptions for 5. Semester

**Title:** **Chemical Process Engineering**
(Kemisk procesteknologi)

Prerequisites: Material science and material selection
Chemical thermodynamics and separation processes
Chemical reaction engineering is followed simultaneously
Fundamental fluid mechanics and heat transfer

Objective: Students who complete the module:

Knowledge

- Must be able to understand and describe the industrial or application context, in which the project work are included in, or may affect.
- Must have specific knowledge, and be able to explain the process engineering and process equipment, including reactors, unit operations and principles for the management, regulation and monitoring, which are or may be relevant for the given project problems
- Must be able to account for suitable analytical chemistry reference methods for monitoring the process.

Skills

- Must be able to specify requirements for process equipment and materials for a given chemical process
- Must, based on requirement specifications for a given process either be able to choose appropriate process equipment, construction materials and surveillance equipment or to evaluate and possibly make suggestions for improvement of an existing process
- Must be able to establish a risk analyses
- Must be able to analyze, model or size a selected process unit
- Must be able to document the work performed in a technical report and convey the main points in an oral presentation

Competences

- Must be able to handle situations with inconsistent data or discrepancies between theory and practice
- Must be able to participate in a professional and interdisciplinary cooperation with technical staff and any external parts

Education form: Project work with guidance, if necessary, supplemented by lectures, workshops, presentation seminars, laboratory experiments etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: *O*ral examination on the basis of a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Bioprocess Engineering**
(Bioprocesteknologi)

Prerequisites: Biological chemistry
Chemical thermodynamics and separation processes
Chemical reaction engineering is followed simultaneously
Fundamental fluid mechanics and heat transfer is followed simultaneously

Objective: Students who complete the module:

Knowledge

- Must have knowledge about methods for bioindustrial production, including fermentation and purification and downstream processing
- Must have knowledge about basic security in relation to the handling of microorganisms and enzymes
- Must have knowledge about unit operations that are relevant for Technical Microbiology

Skills

- Must be able to identify microorganisms or enzymes to a specific technical problem based on literature studies
- Must be able to set up and solve mass and energy balances relevant to microbiological processes at laboratory scale as well as technical scale
- Must be able to describe the necessary safety measures at all scale levels
- Must be able to account for proper waste management at all scale levels
- Must be able to account for suitable analytical chemistry reference methods for monitoring the microbiological process
- Must be able to account for equipping and instrumentation of unit operations in industrial scale
- Must be able to establish an experimental reactor properly equipped with appropriate data collection, safety instrumentation and sampling mechanisms
- Must be able to analyze and interpret data from a fermentation process based on knowledge of the microorganism used
- Must be able to explain the choice of the relevant unit operations for solving a specific technical problem
- Must be able to develop a model that covers a selected technical microbiological unit operation
- Must be able to explain the benefits and limitations of using different reactor configurations to solve a specific technical microbiological problem

Competences

- Must be able to engage in an interdisciplinary working group and provide technical microbiological knowledge to a broad range of people with different professional backgrounds
- Must be able to report data from the technical microbiological studies using proper statistical computing
- Must be able to reason from data material originating from a technical microbiological process and be able to draw statistically valid conclusions on the basis of this.

Education form: Project work with guidance, if necessary, supplemented by lectures, workshops, presentation seminars, laboratory experiments etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: Individual oral examination on the basis of a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Refinery Products and Processes**
(Raffinaderi produkter og processer)

Prerequiutes: Chemical Thermodynamics and Separation Process Engineering
Organic chemistry
Reaction Engineering

Objective: Students who complete the module:

Knowledge

- Must have knowledge of the historical crude oil production and the worldwide development of petroleum use.
- Must have knowledge of organic and inorganic components of crude oil.
- Must have knowledge of some additives applied in connection with the production of crude oil.
- Must have knowledge of the general structure of a Danish oil refinery.
- Must have knowledge of separation processes, especially distillation, and the plants used in these processes.
- Must have knowledge of cracking and hydro-cracking processes.
- Must have knowledge of reforming processes.
- Must have knowledge of desulphurization processes, including the Claus process.

Skills

- Must be able to set up laboratory equipment and perform model experiments corresponding to a selected refinery process.
- Must be able to perform analytical-chemical work to identify the transformations that may have occurred in the selected refinery process.
- Must be able to provide examples of reactions for some of the processes that take place in the reaction setup.
- Must be able to select appropriate catalysts for the processes and provide an explanatory model of how the catalyst works.
- Must be able to draw up kinetic rates expressions and calculate reaction rates in Matlab for selected conversion processes under different conditions.
- Must be able to calculate mass and energy balances of the selected processes.

Competences

- Must be able to decide if any selected characteristics of the laboratory products could be the subject of further experimental studies in the laboratory.
- Must be able to account for the necessary precautions in relation to the above described experimental laboratory studies.

- Must be able to communicate the outcome and conclusions of the completed project to both the students at the same level, as well as to the business community and laymen.

Education form: Project work with guidance, if necessary, supplemented by lectures, workshops, presentation seminars, laboratory experiments etc.
Access to perform laboratory experiments requires participation in laboratory safety instructions.

Exam format: Individual oral examination on the basis of a presentation seminar and a project report.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Chemical Reaction Engineering**
(Kemisk reaktionsteknik)

Prerequisites: Introduction to Chemical Engineering and Thermodynamics
Physical and Inorganic Chemistry

Objective: Students who complete the module

Knowledge

- Must be able to reason from data material originating from a technical microbiological process and be able to draw statistically valid conclusions on the basis of this.
- Must have knowledge about and be able to explain chemical reaction engineering concepts
- Must know ideal reactors and types of non-ideal reactors and reaction systems
- Must know methods to extract and analyse kinetic data from ideal reactors
- Must know methods to model kinetics of chemical reactions from given reaction mechanisms
- Must know how chemical reactor design and process variables can be used to design and optimize yield and product distribution
- Must know principles for catalysis and catalytic reactions
- Must know reaction systems for important chemical and biochemical products
- Must be able to understand and explain how natural processes and systems can be modelled as reactor systems

Skills

- Must be able to write rate equations for chemical and biochemical reactions based on known reaction mechanisms
- Must be able to write and test rate equations from kinetic data
- Must be able to write and solve systems of design equations for isothermal or adiabatic ideal reactors or reactor systems

Competencies

- Must be able to use the acquired knowledge about kinetics and reactor design to model and analyse reactors used in industrial chemical or biochemical reactions
- Must be able to use the acquired knowledge about kinetics and reactor design to model systems of natural occurring processes

Type of instruction: Lectures and problem solving

Exam format: Internal oral or written examination according to the examination rules

Evaluation criteria: Are stated in the Framework

**Title:** **Fundamental Fluid Mechanics and Heat Transfer**
(Varmetransmission og strømningsmekanik)

Prerequisites: Introduction to Chemical Engineering and Thermodynamics

Objective: Students who complete the module

Knowledge

- Must have knowledge about fundamental technical thermodynamics, fluid mechanics, heat transfer
- Must be able to understand fundamental technical thermodynamics, fluid mechanics, heat transfer

Skills

- Must be able to apply technical thermodynamics to solve engineering problems
- Must be able to use fundamental fluid mechanics to solve problems connected to internal flow in piping networks with components such as pumps, turbines, valves, bends and nozzles
- Must be able to use fundamental fluid mechanics to analyse external flow around objects
- Must be able to calculate heat transfer in thermal networks
- Must be able to calculate heat transfer coefficients both at external and at internal surfaces
- Must be able to analyse and select heat exchangers

Competencies

- Must be able to apply the acquired knowledge and skills to describe, model and solve problems in process engineering projects

Type of instruction: Lectures and problem solving

Exam format: Written examination according to the examination rules

Evaluation criteria: Are stated in the Framework Provisions

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

Prerequisites: Linear Algebra
Calculus

Objective: Students who complete the module:

Knowledge

- Must have knowledge about basic modeling of 1. order and second order differential equations.
- Must have knowledge about basic modeling of elliptic, hyperbolic and parabolic partial differential equations.
- Must have knowledge about basic analysis of the above ordinary and partial differential equations
- Must have a basic knowledge about solving 1. order and second order differential equations, including Euler Cauchy-equations.
- Must have knowledge about basic concepts of numerical methods.
- Must have knowledge about numerically solving non-linear equation systems, integrals, and ordinary and partial differential equations
- Must have an understanding about- and be able to use interpolation techniques as, Taylor polynomial, LaGrange polynomial and Newton 's Divided.
- Must have an understanding about- and be able to use Laplace transforms to solve differential equations.
- Must have knowledge about divergence and rotation of vector fields
- Must have an understanding about- and be able to use Gauss' divergence, Stokes - and Greens phrases

Skills

- Must demonstrate understanding of the modeling and analysis of the above ordinary and partial differential equations
- Must be able to apply vector analysis and integral principles for mathematical modeling
- Must be able to apply methods, analytical as well as numerical, to solve the above ordinary and partial differential equations
- Must be able to set up and use the correct numerical method for solving a variety of areas, such as finding the zero point, integration, interpolation, differential equations.
- Must be able to set up and solve 1. - and 2.-dimensional heat conduction equations by analytical and numerical methods
- Must be able to set up and solve 1. - and 2.-dimensional wave equations by analytical and numerical methods
- Must be able to set up and solve Poisson's and Laplace 's equations by numerical methods
- Must be able to develop solutions of differential equations for the system of eigen functions
- Must be able to solve the above partial differential equations using Fourier series and the separation method
- Must be able to use the Finite Element Method and the Finite Volume method for solving partial differential equations

Competences

- Must be able to 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
- Must be able to disseminate setup and results of solving certain partial differential equations to others, including colleagues, government agencies and others.

Education form: Lectures supplemented with project

Exam format: Written evaluation

Evaluation criteria: As stated in the Framework Provisions

### 3.9 Module Descriptions for 6. Semester

**Title:** **Design of Experiments**
(Statistisk forsøgsplanlægning)

Prerequisites: Applied Statistics

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the establishment of experimental design with qualitative and quantitative factors
- Must have knowledge about complete, partial and confounding 2k and 3k factorial experiments
- Must have knowledge about incomplete block design, splitplot designs and incremental test plans
- Must have knowledge about optimization experiments (Box-Wilson / Simplex)
- Must have knowledge about performing control experiments, including using of central points
- Must have knowledge about orthogonal experimental design
- Must have knowledge about the methods of optimization of the experimental factors and minimizing noise factors
- Must have knowledge about analysis of "drop in"[Sk1] data (eg. Production data, emission data, etc.)
- Must have knowledge about regression analysis (including step-wise regression) of the drop in data.

Skills

- Must be able to develop study plans with qualitative and quantitative factors
- Must be able to perform control experiments
- Must be able to optimize the experimental factors
- Must be able to minimize the noise factors
- Must be able to use multiple analysis of variance and regression analyzes, including the combined variance and regression analyzes
- Must be able to analyze experimental data and be able to evaluate the methods used, validity and usefulness

Competences

- Must be able to 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.

Education form: Lectures supplemented with project work

Exam format: Oral examination on the basis of prepared mini project.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Process Control, instrumentation and Safety**
(Procesregulering, instrumentering og sikkerhed)

Prerequisites: Mathematical Modeling and Numerical Methods

Fundemental Fluid Mechanics and Heat Transfer

Objective: Students who complete the module:

Knowledge

- Must have knowledge about about diagrams and system interconnections.
- Must have knowledge about modeling of physical systems , determination of operating points and linearization
- Must have an understanding of 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
- Must have an understanding of analysis by root curves and knowledge of controller design using root curves
- Must have an understanding of a system's frequency response ( open-loop and closed - loop)
- Must have an understanding of stability analyses
- Must have an understanding of design using frequency response techniques
- Must have knowledge about analog implementation of controllers
- Must have knowledge about measurement techniques and data collection using a PC
- Must have knowledge about software for building/developing applications for data acquisition and control
- Must have knowledge about the the structure and operation of the measurement system including sensors, signal processing, and monitoring system.
- Must have knowledge about the operation of classical sensors (pressure, temperature , position, velocity , acceleration, flow)
- Must have knowledge about sampling, different connections and noise from measurements

Skills

- Must be able to analyse block diagrams on the basis of PI – charts
- Must be able to model and analyze basic dynamical systems, including electrical, mechanical and thermal systems, and analogies between these
- Must be able to develop models of dynamic systems in the form of transfer functions
- Must be able to apply control theory to achieve performance criteria
- Must be able to analyze a system's response and stability using the classical methods
- Must be able to select appropriate regulators and predict/assess their impact
- Must be able to use standard software for data acquisition, control and regulation
- Must be able to connect classical sensors and conduct research with classical sensors for pressure, temperature, position, velocity, acceleration, flow
- Must be able to assess the quality of the measurements and apply appropriate processing on them.
- Must be able to disseminate the problem, the used solution method and interpret the outcome

Competences

- Must be able to apply the field in interdisciplinary collaboration with other fields

Education form: The teaching is organized in accordance with the general teaching methods of the program.

Exam format: Individual oral exam based on a prepared mini project.

Evaluation criteria: As stated in the Framework Provisions

**Title:** **Theroy of Science and Entrepreneurship**
(Videnskabsteori og entrepreneurskab)

Prerequisites: None

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the traditions of engineering, the engineer's role in society, as well as ethical issues in engineering science
- Must have knowledge about scientific approaches and traditions. Must have knowledge about different theories of science and concepts of truth
- Must have knowledge about possible career directions in the engineering profession, including construction, production and design engineer, project manager, researcher etc.
- Must have knowledge about entrepreneurship, including opportunities for self-employment

Skills

- Must be able to apply theoretical methods and concepts within the disciplines of engineering
- Must be able to plan their own careers
- Must be able to handle starting up a self-motivated business
- Must be able to analyze the organizational forms of companies.
- Must be able to assess and reflect on their own learning in the context of job training

Competences

- Must be part of the daily work in a company

Education form: Lectures supplemented with project work and workshops. The course will be taught in English if foreign students are enrolled.

Exam format: Continuously evaluated on the basis of active participation according to the examination policies

Evaluation criteria: As stated in the Framework Provisions

**Title:** **BSc Project**
(Bachelorprojekt)

Prerequisites: Completed 1-5 semester of the Bachelor's degree in chemistry and biotechnology

Objective: Students who complete the module:

Knowledge

- Must have knowledge about the specific concepts, models, methods and techniques that are relevant to the professionalism of the project work

Skills

- Must be able to develop a problem analysis which clarifies the "critical points" of the problem
- Must be able to set specifications and goals for solving the problem
- Must be able to set up and use realistic test plans for experimental work
- Must be able to apply appropriate standards in solving the problem
- Must be able to use appropriate modeling and calculation tools
- Must be able to set time, resources, and management plans for the preparation of the solution
- Must be able to assess the extent to which the problem is solved

Competences

- Must be able to independently engage in a professional and interdisciplinary collaboration between research groups and external partners on solving a specific chemical or biotechnological issue
- Must be able to perform project work comprising experimental, empirical and / or theoretical studies of one or more issues within the central themes of the education
- Must be able to document the issues, methods, results and conclusions in the project as a technical report
- Must be able to select and disseminate the essentials in a project by oral presentation

Education form and Content: Project with guidance, if necessary. supplemented by lectures, workshops, presentation seminars, laboratory experiments, etc.

The student must work with a chemical or biotechnological research essay or a systematic solution of a problem within method-, product- or process development.

The project can be carried out in cooperation with or related to a company or other external partners.

There is focused on one of the following issues

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

a research problem within chemical engineering or industrial biotechnology

Exam format: Internal individual written or oral examination in the examination system.

Evaluation criteria: As stated in the Framework Provisions

**Workshop courses in Chemical Engineering Practice**

In addition to the prescribed courses, intensive short workshop courses in chemical engineering practices are offered concerning practical laboratory skills, health and safety for the handling of chemicals, biological materials, waste, instruments and technical equipment, and software.
In the courses A and D focus is on basic laboratory safety when doing experimental work in chemical and biological laboratories. Proof of completion of workshop courses A and D is a condition for approved access to and use of the chemical and biological laboratories.
In the other workshop courses (workshop courses B, C, and E) handling of experimental equipment and software is practiced. Proof of completion of one or more workshop courses may be a condition for using specific laboratory facilities and equipment in relation to projects.
Students with relevant practical laboratory background may be exempted from participation in one or more of the courses.
Proof of approved participation in workshop courses or exemption is issued by the study board in collaboration with the laboratory responsible of the institute.

| | Workshop course | | ECTS | Assessment | Exam |
|---|---|---|---|---|---|
| Autumn | A | Basic Laboratory Techniques and Safety (Grundlæggende Kemisk Laboratoriepraktik) | 2 | Pass/Fail | Internal |
| | C | Laboratory Course in Analytical Chemistry (Instrumentel Kemisk Laboratoriepraktik) | 2 | Pass/Fail | Internal |
| | E | Laboratory Course in Data Acquisition (Praktisk Måleteknik og Dataopsamling) | 2 | Pass/Fail | Internal |
| Spring | B | Introduction to Computational Software (Introduktion til Beregningssoftware) | 2 | Pass/Fail | Internal |
| | D | Laboratory Course in Microbiology (Mikrobiologisk Laboratoriepraktik) | 2 | Pass/Fail | Internal |
| | F | Risk Assessment (Risiko vurdering) | 2 | Pass/Fail | Internal |

**Optional free study activities**
The Study Board of Biotechnology, Chemistry and Environmental Engineering can set up and offer optional free study activities. The objectives of the free study activities are:

- To give students the opportunity to supplement their knowledge in areas that complements the core areas of the selected profession.
- To give students the opportunity to supplement their knowledge to a level that exceeds the objectives of the programme.

Free study activities are assessed and evaluated in line with other modules. The result will appear on the diploma.
The student can, as a free study activity, follow courses offered by other educations and specialization, if the student complies with the prerequisites.
The Study Board of Biotechnology, Chemistry and Environmental Engineering can cancel free study activities depending on capacity and the number of enrolled students.

## *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 September 2014.

Students who wish to complete their studies under the previous curriculum from 2010 must conclude their education by the summer examination period 2016 at the latest, since examinations under the previous curriculum are not offered after this time.

In accordance with the Framework Provisions for the Faculty of Engineering and Science and The Faculty of Medicine at Aalborg University, the curriculum must be revised no later than 5 years after its entry into force.

## *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.[1] If the project is written in English, the summary must be in Danish.[2] 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 Framework Provisions 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.

[1] Or another foreign language (French, Spanish or German) upon approval by the Board of Studies.
[2] The Board of Studies can grant exemption from this.

### 5.4 Rules concerning the completion of the Bachelor's programme
The Bachelor's programme must be completed no later than six years after it was begun.

### 5.5 Special project process
In the 3rd, 4th and 5th semesters, the student can upon application, design an educational programme where the project work is replaced by other study activities; cf. the Framework Provisions section 9.3.1.

### 5.6 Rules for examinations
The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

### 5.7 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.

### 5.8 Rules and requirements for the reading of texts
It is assumed that the student can read academic texts in his or her native language as well as in English and use reference works etc. in other European languages.

### 5.9 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.