

Chapter 9

The programme-specific part of the curriculum for the programme:

MASTER OF SCIENCE (MSc) IN ENGINEERING (CHEMISTRY)

CIVILINGENIØR, CAND. POLYT. I KEMI

Curriculum 2016, Version 1.1

Applicable to students admitted September 2016 onwards

Please note that this version is a translation from Danish. In the event of discrepancies or ambiguity between this translation and the Danish version, the Danish version shall prevail.

The Curriculum is divided into general provisions (Chapters 1-8), a programme-specific section (Chapter 9), and descriptions of the programme's individual course modules. Students should familiarise themselves with all three parts in order to get a complete overview of the provisions regulating the programme.

§1 Job profile

Graduates in Master of Science in Engineering (Chemistry) are trained to perform a variety of important vocational functions. The typical fields of work include:

- Design, planning and commissioning of new process engineering plants, as well as development, optimisation and operation of existing plants, such as plants in chemical and biochemical production, environmental upgrading, food production, pharmaceutical production, etc.
- Research related to the development of products and processes where chemical or biotechnological aspects play a significant role, such as products and/or processes of chemical production, biorefining, energy conversion, food processing or handling of residual and waste products from industry and agriculture.
- Research related to the development and optimisation of processes of chemical synthesis and their associated catalysts.
- Research within the development of new materials with specific functional properties.
- Counselling and consultancy in private and public organisations working within the areas of chemistry, environment and biosystems.

§2 Competence profile

Learning objectives for the programmes are determined on the basis of the legislation and other regulation applicable to the area. Furthermore, emphasis is on the vocational functions that newly graduated engineers are expected to perform, and on the requirements regarding their continued personal and professional development after completion of the programmes.

A wide range of non-chemical engineering competences are required of newly graduated engineers, as described in the general section of the Curriculum.

Graduates in chemical engineering are expected to have acquired the following:

Knowledge and understanding

- Specific technical knowledge within the academic profiles of the programme, rooted in advanced research with an international perspective.
- Ability to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.

Based on this knowledge, graduates must be able to solve complex technical problems and design and implement complex technological products and systems in a social context. To graduates in chemical engineering, this means that they are expected to have the following:

Skills

- Ability to use the methods and tools associated with the specific disciplines of the programme's academic profiles in relation to the job profile for the programme as described in §1.
- Ability to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences.
- Ability to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on consideration of chemical engineering, biotechnical, resource and environmental aspects.
- Ability to develop analytical methods for research and development.

Competences

- Ability to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering.
- Ability to head the establishment and management of analytical laboratories and quality and risk management systems.
- Ability to head the development and implementation of quality and risk management systems.

- Ability to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering.
- Ability to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for own assignments.
- Ability to plan and pursue own professional and personal development.

The above competences are based partly on the general engineering competences acquired under the DSMI educational concept, and partly on an academic foundation of competences within a range of technical, scientific and social disciplines described in the following under subject columns.

Qualifications matrix – Academic profile in Biotechnology and biorefining

GRADUATES WITH AN ACADEMIC PROFILE IN BIOTECHNOLOGY AND BIOREFINING WILL HAVE ACQUIRED ...	XC-ANUM	XC-FYK1	K-MDA	XC-RIS1	XC-VIM	EM-BEM	XC-SP30 /XC-SP40	XC-PRO1	XC-TM1	XC-BRT
RESEARCH BASED KNOWLEDGE										
Specific knowledge within the academic profiles and rooted in advanced research with an international perspective	x	x	x				x	x	x	x
Ability to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.					x		x		x	x
THE FOLLOWING SKILLS (ON A SCIENTIFIC BASIS)										
Ability to use the methods and tools associated with the specific disciplines of the programme's academic profiles in relation to the job profile for the programme as described in §1	x		x	x	x	x	x	x	x	x
Ability to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences	x				x		x			x
Ability to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on consideration of chemical engineering, biotechnical, resource and environmental	x						x		x	x

aspects.										
Ability to develop analytical methods for research and development		x	x				x	x	x	
THE FOLLOWING COMPETENCES (ACADEMIC AND INTERDISCIPLINARY)										
Ability to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering	x				x		x	x	x	
Ability to head the establishment and management of analytical laboratories and quality and risk management systems							x		x	
Ability to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering				x	x	x	x			x
Ability to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for own assignments	x				x	x	x	x	x	x
Ability to plan and pursue own professional and personal development					x	x	x		x	

Qualifications matrix – Academic profile in Functional materials

GRADUATES WITH AN ACADEMIC PROFILE IN FUNCTIONAL MATERIALS WILL HAVE ACQUIRED ...	XC-ANUM	XC-FYK1	K-MDA	XC-RIS1	XC-VIM	EM-BEM	XC-SP30 /XC-SP40	KE801	KE830	XC-MSC1	XC-MSC2	XC-MSM3	XC-MSC4
RESEARCH BASED KNOWLEDGE													
Specific knowledge within the academic profiles and rooted in advanced research with an international perspective	x	x	x				x	x	x	x	x	x	x
Ability to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.					x		x					x	x
THE FOLLOWING SKILLS (ON A SCIENTIFIC BASIS)													
Ability to use the methods and tools associated with the specific disciplines of the programme's academic profiles in relation to the job profile for the programme as described in §1	x		x	x	x	x	x		x		x		X
Ability to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences	x				x		x					x	x
Ability to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on	x						x						

consideration of chemical engineering, biotechnical, resource and environmental aspects													
Ability to develop analytical methods for research and development		x	x				x		x				x
THE FOLLOWING COMPETENCES (ACADEMIC AND INTERDISCIPLINARY)													
Ability to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering	x				x		x	x			x		x
Ability to head the establishment and management of analytical laboratories and quality and risk management systems							x						
Ability to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering				x	x	x	x					x	x
Ability to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for own assignments	x				x	x	x					x	
Ability to plan and pursue own professional and personal development					x	x	x				x		x

Qualifications matrix – Academic profile in Chemical engineering

GRADUATES WITH AN ACADEMIC PROFILE IN CHEMICAL ENGINEERING WILL HAVE ACQUIRED ...	XC-ANUM	XC-FYK1	K-MDA	XC-RIS1	XC-VIM	EM-BEM	XC-SP30 /XC-SP40	XC-CAT1	XC-MEM1	XC-CRY1	XC-REA3	XC-SEP2
RESEARCH BASED KNOWLEDGE												
Specific knowledge within the academic profiles and rooted in advanced research with an international perspective	x	x	x				x	x	x	x	x	x
Ability to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.					x		x				x	
THE FOLLOWING SKILLS (ON A SCIENTIFIC BASIS)												
Ability to use the methods and tools associated with the specific disciplines of the programme's academic profiles in relation to the job profile for the programme as described in §1	x		x	x	x	x	x	x	x	x	x	x
Ability to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences	x				x		x					
Ability to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on	x						x	x	x		x	x

consideration of chemical engineering, biotechnical, resource and environmental aspects												
Ability to develop analytical methods for research and development		x	x				x	x		x		
THE FOLLOWING COMPETENCES (ACADEMIC AND INTERDISCIPLINARY)												
Ability to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering	x				x		x	x	x	x	x	x
Ability to head the establishment and management of analytical laboratories and quality and risk management systems							x			x		
Ability to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering				x	x	x	x				x	x
Ability to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for own assignments	x				x	x	x				x	
Ability to plan and pursue own professional and personal development					x	x	x			x	x	

Qualifications matrix – Academic profile in Eco-efficient Engineering

GRADUATES WITH AN ACADEMIC PROFILE IN ECO-EFFICIENT ENGINEERING WILL HAVE ACQUIRED ...	XC-ANUM	XC-FYK1	K-MDA	XC-RIS1	XC-VIM	EM-BEM	XC-SP30 /XC-SP40	EM-LCA1	EM-IWT	EM-WAM1
RESEARCH BASED KNOWLEDGE										
Specific knowledge within the academic profiles and rooted in advanced research with an international perspective	x	x	x				x	x		x
Ability to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.					x		x		x	
THE FOLLOWING SKILLS (ON A SCIENTIFIC BASIS)										
Ability to use the methods and tools associated with the specific disciplines of the programme's academic profiles in relation to the job profile for the programme as described in §1	x		x	x	x	x	x	x	x	x
Ability to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences	x				x		x	x		x
Ability to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on	x						x		x	x

consideration of chemical engineering, biotechnical, resource and environmental aspects										
Ability to develop analytical methods for research and development		x					x			x
THE FOLLOWING COMPETENCES (ACADEMIC AND INTERDISCIPLINARY)										
Ability to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering	x					x	x	x	x	x
Ability to head the establishment and management of analytical laboratories and quality and risk management systems							x			x
Ability to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering				x		x	x	x	x	x
Ability to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for own assignments	x			x		x	x	x	x	x
Ability to plan and pursue own professional and personal development				x		x	x			

§3 Subject columns

The technical competences of graduates in chemical engineering are attributable mainly to the following subject columns, which apply to both the bachelor and master levels of the programme.

The bachelor level comprises the following eight subject columns:

- Chemical Engineering
- General, inorganic and organic chemistry
- Biotechnology
- Physical chemistry and materials
- Environment and project management
- Mathematic and physical models
- IT and experimental methodology
- Personal and learning competences

as described in Chapter 9 for the bachelor level of the chemical engineering programmes.

§4 Academic profiles

The master level of the programme consists of constituent courses and academic profile courses. In combination, the constituent courses provide the common technical foundation for graduates in chemical engineering.

At the master level, the following four academic profiles are offered:

- Biotechnology and biorefining
- Functional materials
- Chemical engineering
- Eco-efficient Engineering

§5 Structure and modules (by academic profile)

5.1 Academic profile: Biotechnology and biorefining

Semester	STRUCTURE																													
4.	XC-SP30/XC-SP40 Thesis																													
3.	XC-VIM Methods in Science					XC-BIO3 Advanced Natural Product Chemistry										Elective course					Elective courses/XC-SP40* Thesis									
2.	XC-RIS1 Risk Management in Chem. and Biochem. Engineering					XC-TM1 Technical Microbiology										XC-BRT Biorefinery Technology					Elective course					Elective course				
1.	XC-ANUM Advanced Numerical Methods and Modelling for Chem. and Biochem. Engineers					XC-FYK1 Advanced Physical Chemistry					K-MDA Multivariate Data Analysis and Chemometrics					XC-PRO1 Protein Technology					EM-BEM Business Economics and Management					Elective course				
ECTS POINT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. A student on a 4+4 PhD programme may use 15 ECTS electives on third semester together with the 30 ECTS on fourth semester on a 45 ECTS master thesis. The student may also choose to spend 15 ECTS elective courses on an In-company Period.

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses (if a 30 ECTS thesis)	30

5.2 Academic profile: Functional materials

Semester	STRUCTURE																													
4.	XC-SP30/XC-SP40 Thesis																													
3.	XC-VIM1 Methods in Science					KE801 Inorganic Chemistry B					XC-MSC4 Materials Characterization II					Elective course					Elective courses/XC-SP40* Thesis									
2.	XC-RIS1 Risk Management in Chem. and Biochem. Engineering					KE830 Materials Characterization I					XC-MSC2 Preparative Solid State Chemistry					XC-MSM3 Chemical Metallurgy					Elective course					Elective course				
1.	XC-ANUM Advanced Numerical Methods and Modelling for Chem. and Biochem. Engineers					XC-FYK1 Advanced Physical Chemistry					K-MDA Multivariate Data Analysis and Chemometrics					EM-BEM Business Economics and Management					XC-MSC1 Basic Solid State Chemistry					Elective course				
ECTS POINT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. A student on a 4+4 PhD programme may use 15 ECTS electives on third semester together with the 30 ECTS on fourth semester on a 45 ECTS master thesis. The student may also choose to spend 15 ECTS elective courses on an In-company Period.

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses (if a 30 ECTS thesis)	30

5.3 Academic profile: Chemical Engineering

Semester	STRUCTURE																													
4.	XC-SP30/XC-SP40 Thesis																													
3.	XC-VIM Methods in Science					EM-BEM Business Economics and Management					Elective courses/XC-SP40 Thesis										Elective course					Elective course				
2.	XC-RIS1 Risk Management in Chem. and Biochem. Engineering					XC-CRY1 Crystallization and Processing of Pharmaceuticals					XC-REA3 Modelling and Simulation of Non-ideal Reactors					XC-SEP2 Industrial Separation Technology					Elective course					Elective course				
1.	XC-ANUM Advanced Numerical Methods and Modelling for Chem. and Biochem. Engineers					XC-FYK1 Advanced Physical Chemistry					K-MDA Multivariate Data Analysis and Chemometrics					XC-CAT1 Heterogenous Catalysis					XC-MEM1 Industrial Membrane Technology					Elective course				
ECTS POINT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. A student on a 4+4 PhD programme may use 15 ECTS electives on third semester together with the 30 ECTS on fourth semester on a 45 ECTS master thesis. The student may also choose to spend 15 ECTS elective courses on an In-company Period.

Explanation	ECTS, total
Constituent courses	30
Profile courses	25
Elective courses (if a 30 ECTS thesis)	35

5.4 Academic profile: Eco-efficient Engineering

Semester	STRUCTURE																													
4.	XC-SP30/XC-SP40 Thesis																													
3.	XC-VIM Methods in Science					EM-BEM Business Economics and Management					Elective courses/XC-SP40 Thesis										Elective course					Elective course				
2.	XC-RIS1 Risk Management in Chem. and Biochem. Engineering					EM-IWT Industrial Water Technology										EM-WAM1 Waste Management – From Waste to Resources										Elective course				
1.	XC-ANUM Advanced Numerical Methods and Modelling for Chem. and Biochem. Engineers					XC-FYK1 Advanced Physical Chemistry					K-MDA Multivariate Data Analysis and Chemometrics					EM-LCA1 System Analysis - Life Cycle Assessment										Elective course				
ECTS POINT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

* If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS. A student on a 4+4 PhD programme may use 15 ECTS electives on third semester together with the 30 ECTS on fourth semester on a 45 ECTS master thesis. The student may also choose to spend 15 ECTS elective courses on an In-company Period.

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses (if a 30 ECTS thesis)	30

§6 Common constituent courses

PURPOSE

The common constituent courses serve a two-fold purpose: The first is to provide the students with a set of advanced tools within numerical methods, chemometrics and scientific working methods in general. These tools will enable them, on the basis of physical/chemical data, to solve complex technical problems within their chosen academic profile, and to implement the often complex technical solution to the problem. The second is to provide the students with the required tools to implement solutions in a financially sound manner and with the least possible production and environmental risk for the surrounding society.

The objectives and content of the common constituent modules allow students with different academic backgrounds (bachelor degrees) to acquire the learning objectives of the master programme.

Subjects:

- Numerical methods
 - Numerical methods in linear algebra.
 - Iterative procedures for solving sets of algebraic equations.
 - Statistical methods for parameter estimation.
 - Data filtering and processing methods.
 - Numerical methods for solving ordinary and partial differential equation systems.
 - Fundamental structured programming exemplified by using MatLab.
- Chemometrics
 - Multivariate data analysis.
 - Multiple linear regression (MLR).
 - Principal component analysis (PCA).
 - Partial least squares regression (PLSR).
 - Data modelling and model validation.
 - Model optimisation and determination of significant parameters.
 - Experimental test designs.
- Physical chemistry
 - Statistical thermodynamics.
 - Thermodynamics of mixtures.
 - Thermodynamic properties of macromolecules.
- Scientific methodology
 - Working hypotheses for research assignments.
 - Scientific integrity and ethics.

- Critical literature searches and source criticism.
- Preparation of scientific reviews in article form.
- Preparation of working documents: Method descriptions, testing and time schedules.
- Use of GLP in connection with record-keeping and scientific documentation.
- Risk assessment
 - Applicable Danish and EU legislation and standards relating to chemical and biochemical production and food production
 - Methods for identifying hazards related to production facilities
 - Creation of event trees for identified accident scenarios
 - Development of fault/failure trees for production facilities and processes
 - Calculation of probabilities for identified accident scenarios
 - Emissions calculations
 - HAZOP analyses of production facilities and laboratories
 - Risk and safety management and its integration into the general enterprise management
- Finances
 - Business management and finances
 - Creation of a business plan
 - Methods for comparing and assessing investment proposals
 - Methods for comparing and assessing funding options
 - Activity, capacity and cash flow budgeting
 - Analysis of profitability, earnings capacity, capital adjustment and solvency based on annual reports

§7 Academic profile: Biotechnology and biorefining

PURPOSE

The academic profile must ensure that graduates in biotechnology and biorefining are able to develop and produce technological and system engineering solutions within the biotechnical and environmental area. More specifically, the competences may be used in connection with biotechnological and microbial production, in the processing of vegetable raw materials to make foods and feedstuffs, in pharmaceutical production, in energy production and in the accomplishment of environmental assignments. The academic profile aims for a high level of international research-based knowledge in protein technology and bio-refining technology, technical microbiology and natural product chemistry as well as enabling the graduate to apply and further develop the scientific methods within these areas.

In combination with the competences acquired at the bachelor level, the academic profile ensures that the graduate based on the profession's scientific foundation and practice is able to:

- Develop methods and processes for biotechnological and microbial production, including production of foods, natural medicines and bioenergy.
- Develop processes and technologies for energy conversion to ensure optimum utilisation of various types of biomass.
- Participate actively in research to develop new products and technologies within biotechnological production, energy conversion and environmental upgrading.
- Develop and apply models for developing and managing process plants for biotechnological production, energy conversion and environmental upgrading.
- Advise authorities and enterprises on the production of bioenergy and other technologies for environmental upgrading.

STRUCTURE OF THE ACADEMIC PROFILE

In addition to the 30 ECTS worth of constituent courses, the academic profile Biotechnology and Biorefining consists of 30 ECTS in profile courses defining the academic profile, elective courses totalling 30 ECTS, and a 30 ECTS Master's Thesis.

If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

Protein chemistry

- Protein synthesis and protein folding
- Links between the structure and function of proteins
- Recombinant DNA technology and analysis of genes and proteins
- Chromatographic and biochemical methods for the purification, identification, quantification and characterization of proteins
- Industrial enzymes and pharmaceutical proteins

Technical microbiology

- Mathematical models for microbial growth and product formation
- Batch, fed-batch, continuous, multi-stage, recirculating and immobilised systems
- Metabolism and product formation
- Purification of microbial products
- Regulatory mechanisms and genetic modification
- Reactor engineering: Design, agitation and aeration, sterilisation, measurement and regulation
- Fermentation on the laboratory scale: Establishment of fermentors with data collection and control, experimental measurements for characterisation of growth and product formation, calculations using computer-based models.

Biorefining technology

- Theoretical characterisation of plant and biomass material
- Selection and evaluation of process technologies for biorefining
- Simulation of biorefining processes, including the development of mass and energy balances and kinetic considerations
- Identification of potentially high-value products from and/or energy potential for different bio mass
- Assessment and evaluation of the financial aspects of selected biorefining processes

Advanced natural product chemistry

- Biosynthesis of secondary metabolites from plants, micro-organisms and aquatic organisms.
- Bioactivity of secondary metabolites
- Cell-based and biochemical assays
- Isolation, characterisation and quantification of secondary metabolites by means of chromatographic and spectroscopic techniques.

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

The biotechnical progression in the academic profile consists mainly of the courses in protein technology, technical microbiology, advanced natural product chemistry and biorefining technology. The course in protein technology, together with the biotechnology competences acquired at the bachelor level, provides the basis for the courses in technical microbiology and advanced natural product chemistry. The course in advanced natural product chemistry is also supported by the bachelor level courses in general and organic chemistry. The course in biorefining technology is also supported by the competences in separation processes and biotechnology acquired at the bachelor level.

The constituent courses in numerical methods and multivariate data analysis provide the basis for modelling, analysis and calculation assignments in the courses in technical microbiology and biorefining technology as well as in the Master's Thesis.

Together with the courses in scientific working methods and finances, the biotechnical progression forms the basis for the final Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points thesis.

During the third semester it is possible to choose an in-company period (15 ECTS) or to complete the entire semester at a foreign university.

§8 Academic profile: Functional materials

PURPOSE

The academic profile aims to ensure that graduates in engineering who have completed a programme in materials chemistry are able to develop and deliver solutions to complex problems of material technology within the chemical, petrochemical, energy technology and materials technology industries, as well as to implement these solutions. The academic profile aims to provide a high level of international research-based knowledge within the area of classic solid state chemistry and metallurgy, technical electrochemistry and energy conversion, as well as enabling the graduate to apply and further develop the scientific methods within these areas.

In combination with the competences acquired at the bachelor level, the academic profile ensures that with a basis in the profession's scientific foundation and practice, the Master of Science in Chemical Engineering is able to:

- Design, synthesise and characterise materials with specific catalytic, electrocatalytic, ion-conducting, dielectric, magnetic or optical properties.
- Make optimum selections of materials, based on chemical, financial and technological criteria.
- Develop components or devices such as sensors or catalytic reactors (including fuel cells and batteries) that use these materials.
- Design and implement relevant characterisation and testing methods for these components and devices.
- Contribute to develop models for and make model calculations of these devices and, if required, provide the necessary input parameters.
- Contribute to integrating the devices in large technical or chemical engineering plants, and manage operation of these.

STRUCTURE OF THE ACADEMIC PROFILE

In addition to the 30 ECTS worth of constituent courses, the academic profile Functional materials consists of 30 ECTS in profile courses defining the academic profile, elective courses totalling 30 ECTS and a 30 ECTS Master's Thesis. If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

- Material chemistry:
 - Selected technologically important structural types with electric, dielectric, magnetic or optical properties
 - Selected synthesis methods for the above compounds
 - Phase equilibrium
 - Defects chemistry
- Chemical metallurgy
 - Financially significant minerals and ores

- Chemical aspects of extractive recovery of Cu, Ni, Zn, Pb, Sn, Al and Fe as well as a metal of choice for independent studies
- Characterisation of solids
 - Powder X-ray diffraction
 - Electron microscopy
 - UV-VIS absorption spectroscopy
 - Electrochemical methods
 - Thermal characterisation
 - Particle size distribution
 - Solid-state NMR
 - Element analysis by ICP
 - Particle size

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

Together with the profile courses in Inorganic chemistry and Materials chemistry, the constituent course in Physical chemistry provides a solid chemical engineering foundation for the more application-oriented subjects in Synthetic solid state chemistry and Materials characterisation. Together with the introductory courses in chemistry, the bachelor level courses in materials science provide the required qualifications for understanding the specialised chemistry subjects of the academic profile. The common constituent courses' content of mathematics, statistics, risk assessment and finance, combined with the bachelor level's chemical engineering courses, provide the students with the required qualifications to develop, model and implement products and processes involving solids with specific chemical and physical properties. Along with the academic profile's other theoretical and practical courses, the constituent course in Scientific working methods provides the basis for the final Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

During the third semester it is possible to choose an in-company period (15 ECTS) or to complete the entire semester at a foreign university.

§9 Academic profile: Chemical Engineering

PURPOSE

The academic profile aims to ensure that graduates in engineering who have completed a chemical engineering programme are able to develop and deliver technical solutions to complex production problems within the chemical, pharmaceutical, petrochemical and biochemical industries, as well as to implement these solutions. The academic profile aims to provide a high international level of research-based knowledge within the area of classic separation methods, membrane technology and reactor engineering, as well as enabling the graduate to apply and further develop the scientific methods within these areas.

In combination with the competences acquired at the bachelor level, the academic profile ensures that with a basis in the profession's scientific foundation and practice, the Master of Science in Chemical Engineering is able to:

- design new plants and sub-plants for use in the chemical, biochemical and pharmaceutical industries.
- develop new processing equipment for the chemical, biochemical and pharmaceutical industries.
- manage the operation of production facilities within the chemical, biochemical and pharmaceutical industries.
- participate actively in research and development within the chemical, biochemical and pharmaceutical industries.
- develop new models based on chemical, biochemical, physical and mathematical principles for the design of new processes and processing equipment.

STRUCTURE OF THE ACADEMIC PROFILE

In addition to the 30 ECTS worth of constituent courses, the academic profile Chemical engineering consists of 25 ECTS in profile courses defining the academic profile, elective courses totalling 35 ECTS and a 30 ECTS Master's Thesis. If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

- Separation engineering
 - Selection and characterisation of membranes for separating fluids, gasses and micro-particles
 - Description, modelling and simulation of mass and energy transport across membranes
 - Design, modelling and simulation of membrane modules
 - Design, modelling and simulation of entire membrane plants
 - Modelling, simulation and design of plants for non-stationary separation methods, e.g. chromatography, adsorption and ion exchange
 - Modelling, simulation and design of multi-component distillation plants
 - Optimisation and simulation of multi-column distillation plants

- Catalysis
 - Heterogeneous catalysis
 - Methods for examining the surface properties of solids
 - Methods for describing reaction mechanisms and reaction kinetics
 - Methods for estimating reaction rates
 - Experimental methods for determining reaction rates
 - The impact of internal and external mass and heat transport on reaction rates in heterogeneous catalysis.
- Crystallisation
 - Principles and mechanisms for crystallisation of pharmaceutical products
 - Thermal dynamics of solid state phases (amorphous, polymorphous, salts) for pharmaceutical products
 - Principles and mechanisms for phase transformation between solid state phases
 - Methods of analysis for identifying pure solids and mixtures of solids
- Reactor engineering:
 - Methods for developing models for quantitative description of conversion and heat generation in chemical and biochemical reactors
 - Modelling of fixed and fluid bed reactors
 - Modelling of multi-phase reactors
 - Modelling of membrane reactors
 - Designing and solving reactor models in MatLab.

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

The constituent courses in numerical methods and modelling and statistics provide the mathematical basis for the profile courses in reactor science and separation processes. Similarly, the courses in Physical chemistry and Heterogeneous catalysis combined with the competences acquired at the bachelor level provide the basis for the course in Reactor science. In addition to these technical elements, the course in Separation processes is supported by the course in Membrane technology and Crystallisation. This academic chemical engineering progression, combined with the constituent courses in Scientific working methods, Finances and Risk assessment, form the basis for the Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

During the third semester it is possible to choose an in-company period (15 ECTS) or to complete the entire semester at a foreign university.

§10 Academic profile: Eco-efficient Engineering

PURPOSE

The academic profile aims to ensure that graduates in eco-efficient technology are able to develop solutions to issues related to chemical engineering and environmental engineering within the chemical, pharmaceutical and biochemical industries, as well as contribute to the planning, problem solving and counselling in the public sector. The academic profile aims to provide a high international level of research-based knowledge within the area of water technology, systems analysis and waste management, as well as enabling the graduate to apply and further develop the scientific methods within these areas.

Combined with the competences acquired as bachelor students the academic profile aims to ensure that graduates, based on the profession's scientific foundations and practice, can:

- Analyse and assess environmental problems and apply research based methods to develop solutions.
- Develop processes and technologies for chemical engineering and biotechnological production with focus on environmental and energy efficiency, incl. water treatment technologies.
- Apply systems analysis, including plan and carry out an LCA
- Develop and apply decision models for waste management and recycling.

STRUCTURE OF THE ACADEMIC PROFILE

In addition to the 30 ECTS worth of constituent courses, the academic profile Eco-efficient Engineering consists of 30 ECTS profile courses, which define the academic profile, 30 ECTS elective courses and a 30 ECTS Master's Thesis.

If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

Systems analysis

- Life cycle analysis (LCA) of products and systems using advanced methods
- Setting objectives and scope and locate data for systems analysis

Water technology

- Physical methods (filtering, sedimentation, radiation, evaporation)
- Chemical methods (oxidation, separation, adsorption)
- Biological methods
- Management of end products from water treatment

Waste

- Systems and hierarchy for waste management
- Innovative methods for waste treatment
- Application of LCA for analysis of waste management and treatment

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and the profile courses.

The constituent courses in numerical methods and multivariate data analysis enable graduates to solve mathematical problems and analyse complex data. The profile courses in systems analysis and waste management allow graduates to, based on the master and bachelor courses in chemistry and chemical engineering, solve problems in environmental technology and to carry out life cycle analyses on systems and products. The course in water technology contributes, together with the courses in process technology and separation processes, to the graduate's competences in process development. The academic progression in environmental technology and systems analysis, together with the constituent courses in scientific methods, risk analysis and economy, form the basis for the Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

During the third semester it is possible to choose an in-company period (15 ECTS) or to complete the entire semester at a foreign university.

§11 Programme language

The programme's common constituent courses and profile courses are offered in English. In classes where all students and the teacher master Danish, teaching may be provided in Danish, whereas the written material will be available in English. If warranted by special circumstances, certain elective courses may be offered exclusively in Danish.

§12 Qualifying degrees

Qualifying degrees

Based on 12.2 – 12.4 the university has assessed that the below degrees qualify for admission to Master of Science in Engineering (Chemistry). The list is not exhaustive.

- BSc in Engineering (Chemistry and Biotechnology) – University of Southern Denmark (legal entitlement for admission)
- BSc in Chemistry – University of Southern Denmark provided
 - o Module X-REA1 Design of Ideal Reactors is passed
- BEng in Chemical Engineering – University of Southern Denmark provided
 - o Module X-REA1 Design of Ideal Reactors is passed
- BSc in Chemical Engineering – Aalborg University
- BSc in Engineering (Chemistry and Technology) – DTU (excluding the academic profile in Biotechnology and biorefining)
- BEng in Biotechnology (previously Bioprocess Technology) – Aarhus University

12.2 Level and content of qualifying degrees

Qualifying bachelor and professional bachelor degrees in the scientific and technical area where the level and content of the scientific and technical courses correspond to a bachelor of science degree or a bachelor of engineering degree in the subject area of the MSc in Engineering (Chemistry) programme.

12.3 Academic content of qualifying degree

MSc in Engineering (Chemistry) admits applicants with a bachelor degree or a professional bachelor degree in the subject area of chemistry and biotechnology cf. 12.2 provided that the degree covers:

<u>Subject knowledge</u>	<u>Extent</u>
Chemical engineering	10 ECTS
Reactor design	5 ECTS
Process and product design	5 ECTS
General and analytical chemistry, organic and inorganic chemistry	20 ECTS
Biotechnology, incl. Technical microbiology	10 ECTS
Laboratory practice	10 ECTS
Physical chemistry	5 ECTS
Mathematic and physical models	15 ECTS
Statistics	5 ECTS

12.4 Additional courses

Should the applicant's degree fail to meet the requirements mentioned in 12.1-12.3, it is possible to acquire the necessary skills through additional courses offered at the University of Southern Denmark. The extent of additional courses cannot exceed 15 ECTS.

Additional courses have to be taken after admission to the programme. The courses can be taken during the first two semesters of the programme and must be passed by the end of the first year of study. Additional courses are restricted to courses offered by the University of Southern Denmark as summer courses or parallel to the first year of the master programme.

12.5 Admission with a foreign degree

Applicants with a bachelor degree or professional bachelor degree from a foreign university who meet the requirements of §12.2 and §12.3 are eligible for admission subject to an academic assessment and comparison of whether the applicant's academic qualifications correspond to those of qualifying Danish degree.

12.6 Possible exemptions

Applicants whose bachelor degree or professional bachelor degree fails to meet the terms stated in 12.1 – 12.5 are not eligible for admission.

Applicants who do not hold a bachelor degree or a professional bachelor degree but who have the academic qualifications equivalent thereto are eligible for admission should their qualifications, based on an academic assessment and comparison, correspond to those of a qualifying Danish degree.

Two-year transitional arrangement regarding additional courses:

Completed and passed additional courses, i.e. single courses from existing bachelor programmes, may be included in the application for admission until 31 August 2016.

§13 Corps of Censors and Board of Studies

The programme belongs under the Board of Studies of the programmes at the Faculty of Engineering and the Danish national Corps of censors for the Engineering programmes. Modules offered by the Faculty of Science belong under the Corps of Science censors.

§14 Entry into Force and Amendments

1. Approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 14 September 2010.
2. Admission 2012 approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 13 September 2012 (Version 1.0).
3. Curriculum 2013 approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 19 June 2013 (Version 1.0).
4. Curriculum 2014 approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 29 April 2014 (Version 1.0).
5. Curriculum 2015 approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 10 October 2014 (Version 1.0).
6. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 15 April 2015 (Version 1.1).
7. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 22 May 2015 (Version 1.1).
8. Curriculum 2016 approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 17 March 2016 (Version 1.0).
9. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 20 June 2016 (Version 1.1).