Faculty of Science & Technology

UNIVERSITEIT TWENTE.

Programme-specific appendix of the programme part of the students' charter including the Education and Examination Regulations for the bachelor's programme in Chemical Science and Engineering

(art. 7.13 and 7.59 of the Higher Education and Research Act)

Contents

Preamble

1. The rules in this appendix apply to the full-time bachelor's programme in Chemical Science and Engineering.
2. This programme-specific appendix and the general section (TNW19280/vdh) together constitute the programme part of the students' charter, including the Education and Examination Regulations for the bachelor's programme in Chemical Science and Engineering at the University of Twente.
3. The rules established by the Chemical Science and Engineering Board of examiners with regard to the performance of its duties and powers in accordance with 7.12b of the Law are included in the 'Rules and Guidelines of the Chemical Science and Engineering Board of examiners'.

Reference: TNW/19283/ate/lk/vdh
Date: 19 July 2019

Article 1 Programme objectives

The objectives of the bachelor's programme in Chemical Science and Engineering are as follows:

a) to educate students theoretically and practically at a basic level and to provide them with skills needed for research, design and organisation in the areas of chemistry, materials science and process technology,
b) to offer a broad curriculum which enables students to orientate themselves within the discipline and beyond the boundaries of the discipline,
c) primarily, it aims at the preparation for a master's programme in the field of chemical engineering and related disciplines,
d) optionally, there is a possibility to prepare for a direct entrance to the labour market for technical positions at a bachelor's level in the field of chemical engineering research, design and teaching.

The competence areas and intended learning outcomes for the holder of a bachelor's degree in Chemical Science and Engineering are elaborated in article 3.

Article 2 Connecting master's degree programme

Successful completion of the bachelor's exam grants access to the master's programme in Chemical Engineering at the Faculty of Science & Technology.

Article 3 Intended learning outcomes for the programme

The intended learning outcomes for this programme have been described on the basis of the 3TU Academic Competencies, better known as the Meijers' criteria[1]. These criteria have been approved by the Dutch-Flemish Accreditation Organisation (NVAO)[2] and provide an excellent framework that systematically defines the general intended learning outcomes for an academic master's programme, in which specific aspects for individual programmes may also be included.

A university graduate in a technical field can be characterised using seven competence areas. He or she:

1. is competent in one or more scientific disciplines
2. is competent in doing research
3. is competent in designing
4. has a scientific approach
5. possesses basic intellectual skills
6. is competent in cooperating and communicating
7. takes account of the temporal and the social context

These competences can be divided into three groups (see Fig. 1):

(a) programme domain (1,2,3)
(b) academic approach to thinking and acting (4, 5, 6)
(c) context of conducting scientific research (7)

Each competence area comprises a combination of knowledge, skills and attitude

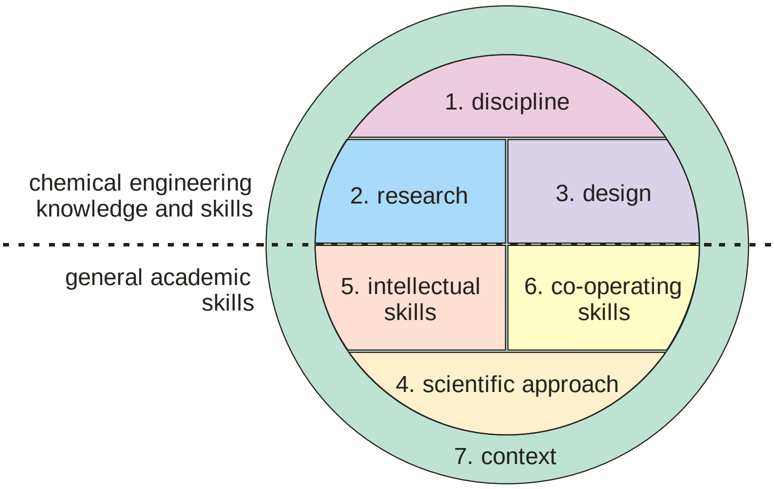

Figure 1. Seven competence areas of Chemical Science and Engineering according to Meijers' criteria

[1] A.W.M. Meijers, C.W.A.M. van Overveld, J.C. Perrenet, Criteria for Academic Bachelor's and Master's Curricula, TU/e 2005 (also available via http://www.jointquality.org/ descriptors special descriptors).

[2] Dutch-Flemish Accreditation Organization.

The competence areas are elaborated on in the various competences. For each competence, it is indicated whether its emphasis is on knowledge (k) and/or skills (s) and/or attitude (a).

The bachelor graduate Chemical Science and Engineering (CSE):

1. *understands the basics of and has some skills in the field of chemical engineering.* A CSE bachelor graduate is (1) familiar with the basics of existing scientific knowledge and has some skills to increase and develop this through study [a, b, e, f], and (2) has developed basic experimental skills [c, d].

1a.	Understands the knowledge base and the structure of the relevant fields in chemical engineering: • chemistry: analytical chemistry, inorganic chemistry (properties), organic chemistry (synthesis and properties), bio-chemistry, physical chemistry, catalysis, • inorganic and organic materials science (synthesis and properties), • process technology: physical transport phenomena, chemical reactors, separation technology, process design of existing processes, • the supporting disciplines: applied mathematics, physics and applied computer science. The BSc-CSE understands the relevant key-concepts, theories, methods, and techniques. [ks]
1b.	Understands the structure of these relevant fields, and the connections between sub-fields. [ks]
1c.	Has knowledge of and some skill in the way in which the following activities take place in chemical engineering: [ks] • truth-finding and the development of theories and models, • interpretations of texts, problems, data, and results, • experiments, gathering of data and modelling, • decision-making based on data and modelling.
1d.	Has some experimental skills in the relevant fields [ks]: • chemistry and materials science: synthesis and qualitative and quantitative determination of properties of chemical substances, • process technology: qualitative and quantitative characterisation of chemical processes.
1e.	Is aware of both the presuppositions of the standard methods and their importance. [ksa]
1f.	Is able (with supervision) to reflect on his/her own knowledge, and to revise and extend knowledge through study. [ks]

2. *has the basic knowledge and skills for doing research in the field of chemical engineering.* A bachelor graduate CSE can, under supervision of a senior researcher, contribute to increasing scientific knowledge.

2a.	Is aware of the research methodology in the field of chemical engineering [ksa]
2b.	Is, under supervision, able to do research at bachelor's level: • analyse research problems in the field of chemical engineering with a limited complexity, • use the relevant knowledge base, • formulate the research objectives and, if relevant, the appropriate hypothesis, • formulate a research plan including the required theoretical and experimental steps, assumptions and approaches, • execute the different activities of the research plan, • analyse and evaluate the research results in respect to the defined problem, • assess research results on its usefulness, • defend this results against the parties involved. [ksa]
2c.	Is observant, and has the creativity and the capacity to discover certain connections and new viewpoints. [ksa]
2d.	Is able to work at different levels of abstraction and detail. [ks]
2e.	Is able to recognise, systematically collect, analyse, select and process relevant scientific information [ks]
2f.	Understands, where necessary, the importance of other disciplines (interdisciplinarity). [ka]
2g.	Is aware of the changeability of the research process through external circumstances or advancing insight. [ka]
2h.	Is, under supervision, able to contribute to the development of scientific knowledge in one or more areas of the disciplines involved in chemical engineering. [ks]

3. *has the basic skills for designing a chemical product or process in the field of chemical engineering.* A bachelor graduate CSE is familiar with the steps of the design process and able to carry them out in a not-complex situation.

3a.	Is aware of the design methodology in the field of chemical engineering and is aware of design being a cyclic process. [ksa]
3b.	Is, under supervision, able to design at bachelor's level: • analyse design problems in the field of chemical engineering with a limited complexity, • integrate the relevant knowledge base in a design, • formulate the design requirements, objectives and boundaries, taking into account some safety, sustainability, environmental and economic aspects, • formulate and execute the different activities of the design plan, • defend the results against the parties involved. [ksa]
3c.	Is able to integrate existing knowledge in a design. [ks]
3d.	Is able to systematically collect, analyse, select and process relevant design information from literature, patents, databases and web-sites and is able to estimate lacking information [ks]
3e.	Has creativity and synthetic skills with respect to design problems. [ksa]
3f.	Is able to work at different levels of abstraction and detail including the system design level. [ks]
3g.	Is aware of the changeability of the design process through external circumstances or advancing insight. [ka]
3h.	Understands the importance of other disciplines (interdisciplinarity) and their contribution to the design process. [ks]

4. *has knowledge of a scientific approach.*

A bachelor graduate CSE has a systematic approach characterised by the use of theories, models and coherent interpretations.

4a.	Is inquisitive and has an attitude of lifelong learning. [ka]
4b.	Has a systematic approach characterised by the application of theories, models and coherent interpretations. [ksa]
4c.	Has the knowledge and the skill to justify and use models for research and design and assess their value ('model' is understood broadly: from mathematical model to scale-model). [ks] Is able to adapt models for his/her own use. [ks]
4d.	Has the ICT skills to process data and models.
4e.	Has insight into the nature of sciences and technology (purpose, methods, differences and similarities between scientific fields, nature of laws, theories, explanations, role of the experiment, objectivity etc.) [k]
4f.	Has some insight into scientific practice (research system, relation with clients, publication system, importance of integrity etc.) [k]
4g.	Is able to document adequately the results of research and design. [ksa]

5. *possesses some basic intellectual skills such as reasoning, reflecting and forming a judgment.* A bachelor graduate CSE has some skills in reasoning, reflecting, and forming a judgment.

5a.	Is able (with supervision) to reflect critically on his/her own thinking, decision making and acting, and able to adjust his/her behaviour on the basis of this reflection. [ks]
5b.	Is able to reflect on his/her more strong and weak capabilities with regard to his/her role as researcher, designer, organiser, and teacher/advisor and is able to adjust on the basis of this reflection. [ks]
5c.	Is able to reason logically and apply methods of reasoning. [ks]
5d.	Is able to ask adequate questions, and has a critical yet constructive attitude towards analyzing and solving simple problems in chemical engineering. [ks]
5e.	Is able to form a well-reasoned opinion in the case of incomplete or irrelevant data or uncertainty. [ks]
5f.	Is able to take a standpoint with regard to a scientific argument in chemical engineering. [ksa]
5g.	Possesses basic numerical skills and has an understanding of orders of magnitude. [ks]

6. *is able to cooperate in projects and communicate.*

A bachelor graduate CSE is able to work with and for others. This requires not only adequate interaction, a sense of responsibility, and leadership, but also good communication with colleagues and other stakeholders.

6a.	Is able to communicate in writing (logbook, research and design report, poster), and verbally in Dutch (scientific presentation) about the results of learning, thinking and decision-making with colleagues, non-colleagues and managers. [ks]
6b.	Is able to interpret English written scientific literature and textbooks and to understand discussions and scientific debates in English. [s]
6c.	Is characterised by professional behaviour. This includes: reliability, commitment, accuracy, perseverance and independence as well as respect for others irrespective of their age, social economic status, education, culture, philosophy of live, gender, race or sexual nature. [ksa]
6d.	Is able to perform project-based work: is pragmatic and has a sense of responsibility; is able to deal with limited sources; is able to deal with risks, is able to make compromises. [ksa]
6e.	Is able to work and communicate within an interdisciplinary team. [ks]
6f.	Has insight into, and is able to deal with, team roles and social dynamics. [ks]

7. *is aware of the social, environmental, sustainability and safety context.*

A bachelor graduate CSE is aware that beliefs and methods have origins and that decisions have social consequences in time.

7a.	Is aware of the social, environmental, sustainability and safety aspects of the chemical and related industries and is familiar with Life Cycle Analysis. [ks]
7b.	Has an eye for the different roles of chemical engineering professionals in society: researcher, designer, organiser, teacher/advisor. [ks]
7c.	Is able to analyse the place of chemical engineering in society and to discuss the social, environmental, sustainability and safety consequences of new developments in relevant fields with colleagues and non-colleagues. [ks]
7d.	Is able to analyse and to discuss the ethical and the normative aspects of the consequences and assumptions of scientific thinking and acting with chemical engineering colleagues and non-colleagues (in research, designing and applications). [ks]
7e.	Optional: is familiar with and has experience with the technological organisational processes of a chemical engineering company. [ksa]

Article 4 Language

1. The bachelor's degree programme in Chemical Science and Engineering is an English-taught programme as of September 2018. This implies for 2019-2020 that the B1 and B2 programmes will be English-taught. The B3 programme is still Dutch-taught and will be English-taught in 2020-2021.
2. All study materials are in English (in the first and second year), or in English and Dutch (in the third year).
3. Units of study for the third year of the programme, or parts thereof, may be taught and tested in English if:
   a) The lecturer or tutor for the unit of study in question does not speak Dutch, or
   b) Students of the bachelor's degree programme in Chemical Science and Engineering are taught alongside students of an English-taught bachelor's degree programme, or if

c) The faculty deems this necessary in order to meet one of its learning objectives with regard to communication skills in the English language. In accordance with article 4.4 paragraph 2 sub d of the general section, the module descriptions included in article 5 of this programme-specific appendix specify which language or languages will be used in teaching and testing.

4. In module evaluations and student panel meetings the English language proficiency of teaching staff will be a standard subject. If evaluation results indicate that improvement is necessary, the programme board will urgently appeal for the involved staff member to improve his/her English proficiency.

Article 5 Bachelor's final examination

The bachelor's final examination consists of the programme taught in the first, second and third years of study (B1, B2 and B3). The core programme consists of the B1 and B2 programmes.

The B1 programme has a study workload of 60 EC and consists of 4 modules of 15 EC each. The components of the B1 programme are:

Name	Module components & content	Education design[3] and assessment	EC
Chemistry (201300067)	Foundations of chemistry, theory and project (8.5 EC): chemistry project, (in-)organic structures, reactions classes, reaction mechanisms, polymers Foundations of chemistry, practice (2.5 EC): experiment 1, incl. safety, error theory / MATLAB and basic skills & practical on organic synthesis. Mathematics (4 EC): Introduction to Maths: logic, proofs, combinatorics & Calculus 1A: functions, limits, derivatives, vectors	Project: in groups. Assessment based on group report and individual presentation. Mathematics and chemistry: lectures and tutorials, supervised self-study. Assessment based on written test. Practical: Assessment based on participation, lab journals, and error theory test. All teaching and tests for this module are in English.	15
Process technology (2019xxxxx)	Thermodynamics & Process technology project (9.5 EC): mass and energy balances, process diagram, basic equipment; 1st and 2nd law, free energy equations Experiments 2 (2.5 EC): practical on process technology, including error theory / MATLAB. Mathematics (3 EC): Calculus 1B: integration, differential equations, complex numbers	Project: in groups. Assessment based on a group report and individual oral test. Mathematics, thermodynamics and process technology: lectures and tutorials. Assessment based on written test. Practical: Assessment based on participation and lab journals. All teaching and tests for this module are in English.	15
Materials science (201800133)	Material science, theory and project (9.5 EC): quantum phenomena, inorganic materials science, polymers, materials science case study Experiments 3 (2.5 EC): practical on materials science Mathematics (3 EC): Linear algebra: linear equations, matrix algebra	Project: in groups. Assessment based on group report and poster presentation. Mathematics and materials: lectures and tutorials. Assessment based on written test. Practical: assessment based on participation and lab journals. All teaching and tests for this module are in English.	15
Physical and analytical chemistry (201900xxx)	Analytical chemistry (9.5 EC): Analytical chemistry, theory, chemical equilibria, electrochemistry, phase diagrams, project. Analytical Chemistry practical (2.5 EC) Mathematics (3 EC): Calculus 2: partial derivatives, multiple integrals	Project: in groups. Assessment based on group report. Mathematics, equilibria and analytical chemistry (theory): lectures and tutorials. Assessment based on written test Practical: in groups; individual assessment based on participation, lab journals and reports. All teaching and tests for this module are in English.	15
Total B1			60

[3] This table seeks to present the programme as accurately as possible. No rights can be derived from the contents specified here. For more detailed information, please refer to the Osiris education catalogue and the Canvas sites of the respective modules or educational units. The appendix to this programme-specific appendix provides a list of learning objectives for each individual module.

The B2 programme has a study workload of 60 EC. The components of the B2 programme are:

Name	Module components & content[2]	Education design and assessment[4]	EC
Industrial processes (201900xxx)	Industrial chemistry and processes, sustainable industrial chemistry project (8.5 EC) Catalysis and reaction kinetics (4.5 EC) Mathematics (2 EC): Vector calculus: vector fields, integral theorems	Project: in groups. Assessment based on report and presentation. Lectures and tests in English. Mathematics, catalysis and reaction kinetics, industrial chemistry and processes: lectures and tutorials. Assessment based on written test. Lectures and tests in English.	15
Physical transport (201900146)	Theory (7.5 EC): flow theory, energy transport, substance transport + practical on transport phenomena Numerical methods/modelling (4 EC) Transport phenomena project (3.5 EC)	Project: in groups. Assessment based on report and presentation. Option to take module in English. Theory: lectures and tutorials. Assessment based on written test. Lectures and tests in English if there are non-Dutch students present. Practical: assessment based on participation and reports. Option to take module in English. Numerical methods/modelling: lectures and tutorials. Assessment based on assignments. Lectures and tests in English	15
Molecules and materials (201900xxx)	Organic and bioorganic chemistry (6 EC): (bio)organic chemistry theory on synthesis. Organic and bioorganic chemistry practical (2 EC) Colloid & Nanochemistry (7 EC): Colloid & nanochemistry theory and project on nanochemistry.	Project: in groups. Assessment based on report/poster. In English. Organic chemistry, colloid and nanochemistry: lectures and tutorials. Assessment based on written test. Nanochemistry lectures and tests are in English. Organic chemistry and colloid chemistry lectures and tests are in Dutch. Practical: assessment based on participation and reports Dutch.	15
Process design (201400164) Or	Chemical technology project (7 EC): designing an industrial process Separation methods (4 EC): theory of industrial separation techniques and practical on distillation, absorption or adsorption . Introduction to chemical reactor science (4 EC): theory of basic reactors for 1-phase systems and residence time distribution	Project: in groups. Assessment based on (group) report and individual oral examination. Option to take English-taught module. Introduction to Chemical reactor science, separation methods: lectures and tutorials. Assessment based on written test. Practical: assessment based on participation and reports.	15
Materials science & Technology (201900xxx)	Advanced materials: theory and project, incl. 2 practicals (7 EC) Chemistry and technology of inorganic materials (4 EC) Chemistry and technology of organic materials (4 EC)	Project: in groups, assessment based on (group) report. AM, CTOM and CTIM: lectures and tutorials. Assessment based on written test.	15
Total B2			60

This programme applies to students belonging to the 2015 generation and later cohorts.
For students belonging to the 2014 and earlier generations, different B1, B2, and B3 programmes apply. Further information on transitioning between the programmes for these generations can be found on the website of the programme in question, in accordance with Article 9 of this appendix.

[4] This table seeks to present the programme as accurately as possible. No rights can be derived from the contents specified here. For more detailed information, please refer to the Osiris education catalogue and the Canvas sites of the respective modules or educational units. The appendix to this programme-specific appendix provides a list of learning objectives for each individual module.

The B3 programme has a study workload of 60 EC. The components of the B3 programme are:

Name	**Education design**[2]	**EC**
Minor / optional course profile (xxxxxxxx)	Differs per minor. Please refer to the Osiris education catalogue and https://www.utwente.nl/en/education/electives/minor (The 'options matrix' on the website shows which minors CSE students are eligible to take.)	30
Preparations for CSE final bachelor's assignment (201800425)	Module components: Research/Science (2.5 EC): lectures and tutorials. Assessment based on assignments and written test; lectures and tests are in English., Ethics (2.5 EC): lectures and tutorials. Assessment based on group assignments and written tests; lectures and tests may be in English. Preparations for the final bachelor's assignment (2 EC): tutorials. Assessment based on assignments. Test may be in English. Statistics (3 EC): lectures and tutorials. Assessment based on assignments and written test. Lectures, tutorials and tests in English. Elective (5 EC): choice between biochemistry (Dutch), process equipment design (English) and study tour preparation (English)	15
Final bachelor's assignment CSE (20150466)	Assessment based on report and presentation. Approval to start the final bachelor's assignment must be requested from the Board of examiners by submitting the form 'Agreement final bachelor's assignment CE' in a timely fashion (no later than 1 month before starting the project). The bachelor's project must address a topic belonging to the field of chemical engineering. If the project is not carried out with a research group affiliated with the Chemical Science and Engineering department within the Faculty of Science and Technology, the student in question must specify in the proposal which components of the project will be of a Chemical Science and Engineering-related nature. If one of the assessors for the project does not speak Dutch, the report and presentation of the final bachelor's assignment must be in English.	15
Total B3		60

N.B. As of 1 September 2012, the final bachelor's assignment was redesigned, scheduling the project for fixed quarters, in the final week of which the project is completed by means of cluster-specific colloquia about the bachelor's project. Starting from 2014, the project will be scheduled for the fourth quarter. Conditions for participation in the final bachelor's assignment module are specified in Article 7.4 of this programme-specific appendix.

An internship may be included in the study programme as a replacement for the final bachelor's assignment if the student wishes to continue in a social/civic role after completing his or her degree. The purpose of such an internship is to acquire relevant experience in a business or institution external to the university. Students who will continue to the master's programme after obtaining their bachelor's degree, will find an internship included in the master's programme. Replacing the final bachelor's assignment with an internship requires the approval of the Board of examiners.

Article 5a Resits and validity of test results

1. In addition to Article 4.4 paragraph 5f of the general section of the bachelor's Education and Examination Regulations, students must always be permitted to participate in resits scheduled within the module. With regard to resits scheduled outside the module (repairs), students may only participate by invitation. The module examiner must indicate the minimum conditions for eligibility for an invitation in the test schedule, in consultation with the Board of examiners.
2. In the event that a module has not been completed satisfactorily, all modules from the B1 and B2 programme, and module 11 from the B3 programme are subject to the following rules with regard to the validity of test results registered in Osiris:
   a) The validity of all module components as defined in Article 5 that have been completed is unlimited.
   b) A math component in one of the modules 1-4 that was completed with a grade 5.0 counts as a pass and has un unlimited validity when at least 1 other math component in another module (from module 1-4) was completed with a grade > 6.0.
   c) Individual students who qualify for the Fobos regulations due to special circumstances, activism, participation in top sports or top cultural activities, may deviate from the additional requirement stipulated under c, with the aim of limiting study delays as much as possible. This exception may be granted if the student in question has submitted and had approved a multi-year study plan. This study plan must be drawn up in consultation with the study adviser and must be approved by the programme board, prior to the period in which the exception is to apply, see also Article 6.2.4 of the general section of the Education and Examination Regulations.

Article 6 Safety

There are certain safety requirements for working in a laboratory. Students are obliged to take note of these rules[5] and to comply with them.

Article 7 Order of study units

1. Before the start of a unit of study, the student must meet the prior knowledge requirements for that unit of study. The prior knowledge requirements can be found in the Osiris education catalogue.
2. When starting a minor, the student must have amassed at least 90 EC (6 modules) from the B1 and B2 programmes of the bachelor's programme in Chemical Science and Engineering.
3. For students wishing to start the final bachelor's assignment in the fourth quarter and belonging to the 2012-2013 and earlier cohorts, who have not been transferred to the 2013/2014 programme (or later), the following conditions apply:
   - the student has passed the propaedeutic exam and has completed all exam components, adding up to 60 EC, in the B1 phase;
   - the student has failed to pass no more than 1 course in the entire B2 programme and in the B3 programme up to and including the second quarter, and has completed no more than 2 courses with a 5, which must meet the criteria for compensated 5s as specified in the rules and guidelines of the Chemical Science and Engineering Board of examiners;
   - at the time of application, the courses from the third quarter of the B3 programme have not yet been completed with a passing grade, but they have been completed.
4. For students from the 2013/2014 cohort and later, and students from earlier cohorts who were transferred to the 2013/2014 or later programmes who wish to begin the final bachelor's assignment in the fourth quarter, the following conditions apply:
   - The student has completed all exam components, totalling 60 EC, in the B1 phase;
   - The student is yet to complete no more than 2 modules in the B2 and B3 programmes, excluding the final bachelor's assignment, but including the module that must be completed in the quarter prior to the final bachelor's assignment.
5. The Board of Examiners is authorised to grant exemptions from the conditions stated in paragraphs 2,3 and 4 of this article, in the event that the strict application of the conditions included therein would entail an unjustifiable delay in the studies of the student in question. To this end, the student must submit a request to the Board of Examiners.

Article 8 Student guidance

a) When starting a degree programme, all students are assigned a mentor.

b) The mentor must follow the progress of all students assigned to him or her, providing them with advice when asked or when deemed necessary. The mentor must actively stay in touch with students who have a pace of study of less than 75% of the nominal pace of 60 EC per year.

c) The mentor must invite students for a progress meeting at least once per year after their first year at university.

d) The study advisor is tasked with advising individual students about all aspects of their degree programmes, as well as informing the programme director about the progress of the students in question.

Article 8a (Binding) recommendation (BSA)

The additional requirements that students must meet, as intended in article 6.3 paragraph 3c of the general section of the Education and Examination Regulations, include no fewer than 3 of the mathematical components of modules 1-4:

- must have been completed with a passing grade (grade recorded in Osiris ≥ 5.5) or,
- must be compensated by another grade/other grades within the module.

[5] See the Health & Safety and Environmental Regulations at and the information provided by the Practical Department of the Faculty of Science & Technology, at http://www.tnw.utwente.nl/onderwijs_overig/practica.

Article 8b Quality assurance

1. The programme board is responsible for evaluating the programme.

2. The quality assurance coordinator of the Faculty of Science & Technology (Science & Technology cluster), and the quality assurance officer are tasked with providing internal quality assurance for the degree programme in Chemical Science and Engineering. They are supported by the CSE Education Quality Committee, consisting of students and the quality assurance coordinator. The quality assurance coordinator is the chairperson of the CSE Education Quality Committee.

3. The following instruments are used for internal quality assurance:
   a) panel discussions with students;
   b) the UT Student Experience Questionnaire (UT-SEQ);
   c) web surveys about entire modules or module components[6];
   d) drawing up overviews of quantitative results, such as pass rates;
   e) lecturer panel discussions with module lecturers and representatives of the student panels, in which all evaluation results in sections a-d are discussed.

4. The results of internal quality assurance efforts are published as follows:
   a) An evaluation report is drawn up for each module, based on the report of the lecturer panel discussion specified in paragraph 3e. This evaluation report is shared with the relevant lecturers, staff members involved in the study programme, and the programme committee;
   b) overviews of quantitative results, summaries of web surveys and evaluation reports will be published on the Canvas organisation quality assurance and evaluation ChE, which is accessible to all students and lecturers of the Chemical Science and Engineering degree programme.

5. The following internal and external evaluations are used to evaluate the curriculum and the degree programme as a whole:
   a) the exit survey for the entire bachelor's programme;
   b) the National Student Survey (NSE);

   The programme board must respond to these evaluations and submit an improvement plan. The evaluation and the improvement plan are then submitted to the programme committee.

6. The programme board and programme committee agree which improvements will be made to modules, module components, or the entire curriculum. These improvements will be recorded in the quality assurance action plan.

7. The programme board must draw up an improvement plan annually, based on internal and external evaluations, as well as new insights.
   a) the improvement plan is then discussed with the programme committee;
   b) the improvement plan is included in the faculty's annual plan.
   c) the dean and the portfolio holder for education will discuss the faculty's annual plan with the Executive Board in their autumn meeting.

Article 9 Changes and transitional arrangement

1. If the study programme included in article 5 of this appendix is altered or one of the other articles included in the general section or this programme-specific appendix is changed, the programme director will draw up and publish a transitional arrangement.

2. Article 8.4 of the general section sets out the conditions and requirements that a transitional arrangement must meet.

3. The transitional arrangement will also be published on the website of the Chemical Science and Engineering degree programme.

4. In the event that changes are made to this programme-specific appendix, the provisions set out in articles 8.3 and 8.4 of the general section apply.

Article 10 Entry into force

This programme-specific appendix will come into effect on 1 September 2019 and will replace the appendix dated 1 September, 2018.

Adopted by the board of the faculty in consultation with the Programme Committee for Chemical Science and Engineering, with the consent of the Faculty Council with articles 5a and 8a, and with the consent of the Programme Committee for Chemical Science and Engineering with articles 3, 5, 6 and 8b.

Enschede, 19 July 2019.

[6] New or largely renewed modules will be followed by web surveys. This also applies to entire modules or module components which were awarded an average grade below 6.0 by students in the UT-SEQ or in a previous web survey.

Appendix: Intended learning outcomes per module

These learning outcomes have been copied from the module-specific test schedules, as known at the time at which this programme-specific appendix was published. For the most recent version of the learning outcomes, please refer to the education catalogue or the test schedule of the module in question.

Module 1 – Chemistry

Learning outcomes
1) Insight into the relationship between the structure and reactivity of molecules; the student is able to predict the reactivity of organic molecules on the basis of electronegativity, Lewis structure and electron distribution.
2) Drawing up and rationalising reaction mechanisms; dealing with concepts such as electrophilic, nucleophilic, resonance, acidity and basicity; interrelating the concepts of the kinetics, mechanism and selectivity of organic reactions and accurately drawing up reaction equations
3) Insight into polymerisation types
4) Handling standard lab equipment and performing organic reactions
5) Becoming acquainted with basic techniques for the purification and characterisation of organic compounds
7) Learning to work in a project-based fashion and to communicate about facts, findings, and activities.
8) Drawing up and solving differential equations
9) Capable of formal, logically consistent reasoning

Module 2 – Process technology

Learning outcomes
1) Explaining the following thermodynamic concepts: differences between ideal gas and a real gas, the Van der Waals equation; triple point & critical point in PV/PT plots; specific heat CP and CV; differences between enthalpy & internal energy
2) Explaining and applying the first and second law of thermodynamics,
3) Explaining and evaluating thermodynamic cycles (Carnot efficiency, Joule Thomson expansion)
4) Deriving thermodynamic identities (e.g., dU, dH, dG, and dF and determining changes in Gibbs and Helmholtz free energy.
5) Explaining research methodology and applying this on a chemical experiment, using a lab journal to lay down the experiment and data, selecting and using the appropriate technical equipment. Applying error analysis
6) Developing a mass and energy balance for (non)reactive processes, using the theory of distillation and the appropriate methods (e.g., McCabe-Thiele) for the design of a distillation columns and applying this knowledge in the design of an industrial process.
7) Working with limits, definitions of continuity and differentiability and applications, elementary properties of integrals and calculate integrals using different techniques, power series and Taylor series
8) Investigating functions in two variables; can apply partial differentiation

Module 3 - Materials science

Learning outcomes
1) Explaining, from a historical point of view, the evolvement of Quantum Mechanics and giving examples of applications of QM in modern Science & Technology
2) Explaining the Copenhagen interpretation of QM and using the Schrodinger equation to solve simple problems
3) Explaining the 3 main classes of materials on different levels (molecular to macroscopic), their mechanical properties in relation to the underlying structure.
4) Explaining electrical properties of different materials (metals, insulators, semiconductors) in relation to the underlying structure, and predicting the flow of electrons during chemical reactions.
5) Identifying basic chemical structures, functional groups and connecting chemical functions to molecular materials
6) Explaining basic structure-property relationships of polymers explaining their mechanical, optical and electronic properties.
7) Identifying characteristic structural motifs of polymers leading to specific properties and estimating properties from given problems and examples
8) Searching systematically for information, following a search strategy & writing a group essay and presenting a poster on a given topic, and discussing findings
9) Setting up and carrying out scientific research systematically, including experimental skills such as use of equipment, documentation and safe practices.
10) Working with systems of linear equations, vectors, matrices, linear transformations and explaining the connections between these concepts
11) Working with subspaces of Rn and determinants and connecting them with the previous concepts

Module 4 – Physical and analytical chemistry

Learning outcomes: After completing the module, the student is capable of: ...
1) Applying the basic principles, equations and relationships of equilibrium thermodynamics to simple physical processes (phase transitions) and chemical/electrochemical reactions
2) Using data pertaining to a reference state and thermodynamic and mathematical equations and relations to predict whether an (electrochemical) reaction/process will take place and to calculate the conditions (pressure, temperature, electrical potential, composition) in a state other than the reference state; calculating solubility products, equilibrium constants and other thermodynamic quantities from data of the standard redox and cell potentials
3) Reading, applying, sketching and interpreting phase diagrams, naming the phases of a phase diagram, calculating the relative quantity of phases using the lever rule, explaining the "phase rule" (binary, ternary, Pourbaix), and applying it to phase equilibria.
4) Explaining and calculating the "activity" for given thermodynamic data, making estimations of the mixing enthalpy for non-ideal mixtures; calculating ion activity in an electrolyte solution
5) Explaining the thermodynamic basis of an electrochemical cell, as well as that of kinetic processes and phenomena that occur at the surface of electrodes; calculating the current flow of an electrochemical cell, and determining whether or not certain electrochemical reactions occur, e.g. during electrolysis
6) Describing the basic principle of the spectroscopic/spectrometric techniques IR, NMR, UV-Vis, MS, as well as the analytical separation techniques HPLC, GC and electrophoresis, identifying the parameters that determine the quality of a chromatographic separation, and based on this, deciding on a specific chromatographic technique and associated materials (column, solvent)
7) Predicting the structure of a molecule based on the spectral data (e.g., from HPLC, GC, electrophoresis, tables, graphs)
8) Formulating, in a scientific way, a sound advice on one or more analytical techniques that can be used to solve a given analytic-chemical problem.
9) Performing a chemical analysis in a systematic way, setting up a calibration curve.
10) Identifying an unknown material, based on spectral / chromatographic / thermal data and writing a scientific report on the experiment
11) Working with partial derivatives and applications
12) Defining and evaluating double and triple integrals over bounded regions

Module 5 - Industrial chemistry and processes

Learning outcomes: After completing the module, the student is capable of: ...
1) Explaining the most important industrial processes and products, while paying attention to the scale, feed streams and process flow diagrams, catalysis, separations and selectivity. Determining thermodynamic equilibrium, calculate the mass and energy balances.
2) Transport: Explaining the following concepts and calculate their influence on reaction kinetics: molecular and Knudsen diffusion, internal and external mass transport limitations, thiele modulus
3) Mechanism: Explaining Langmuir-Hinshelwood, Eley-Rideal, Michaelis-Menten (for bio-catalysis) and models and calculate the effect of these models on reaction kinetics.
4) Adsorption: Describing the Langmuir adsorption model for associative, dissociative and competitive adsorption.
5) Applying the Arrhenius equation and explain a wide range of characterization techniques.
6) Looking at processes from multiple perspectives (energy, mass balance, social-ecologic life cycle analysis); applying these perspectives in studying an industrial process in more detail and coming up with alternative / improved processes with regard to sustainability. Presenting the results in a report and oral presentation
7) Calculating line integrals and surface integrals
8) Applying the theorems of Gauss, Green and Stokes

Module 6 – Physical Transport

Learning outcomes
1)Formulating and solving a macroscopic balance for mass, momentum and/or energy in case of flow through a control volume
2) Applying concepts such as Bernoulli's law, Reynolds number, laminar and turbulent flow in the right context
3) Determining the velocity and shear stress profile for fluid flow through simple geometries (2D, 3D tube flow), starting from the micro-balance for momentum, for different boundary conditions (gas-solid, liquid-solid, liquid-gas). Able to calculate the flow rate and force exerted to the wall by the fluid.
4) Determining the flow resistance for piping systems and for flow past objects of simple geometry (spheres, cylinders)
5) Formulating and solving integral and differential thermal energy balances for steady state and non-stationary operation of open and closed systems.
6) Solving problems of coupled heat and mass transport, applying appropriate Nusselt/Sherwood correlations
7) Analysing and solving problems on thermal energy and molar transport in exchange equipment. Formulating and solving integral and differential, stationary (component) mass and energy balances.
8) Using MATLAB to solve Ordinary Differential Equations and solving partial differential equations. Using different numerical solution methods to solve non-linear equations.
9) Measuring the rate of heat or mass transfer in a 'engineering–type of set up (practical)
10) Given a problem statement, making an analysis of the relevant transfer processes for the problem statement, describing these processes quantitatively in a (mathematical) model, using fundamentals of transport phenomena using a (mathematical), solving the model (e.g., by making a design for a novel system), coming up with and carrying out dedicated experiments, comparing results and model, reporting about findings.

Module 7 - Molecules and materials

Learning outcomes
After the module, the student is capable of:
1) Predicting the reactivity of (bio) organic molecules on the basis of electronegativity, Lewis structure and electron distribution in more complex (bio) organic compounds
2) Drawing up and rationalizing reaction mechanisms of organic reactions; dealing with concepts such as electrophilic, nucleophilic, resonance, acidity and basicity; relating the concepts of the kinetics, mechanism and selectivity of organic reactions to each other and drawing up accurate reaction equations
3) Carrying out organic reactions according to standardised procedures, including the application of safety and reporting protocols, with a thorough analysis of structure and purity
4) Describing physical properties of interfaces, colloidal systems and adsorption processes
5) Applying mathematical formulas to colloidal systems
7) Recognising nano aspects and characteristics in different material classes
8) Describing, characterising and placing a nano/colloidal system in a social context

Module 8a - Process design

Learning outcomes: after completing the course, the student is capable of:
1) Defining and applying model reactors for single phase reaction systems using self-formulated mass-, mole and energy balances.
2) Given a system/reactor, calculating the residence time distribution, and analysing the behaviour of a reactor and predict the reactor performance.
3) Explaining the principles of equilibrium separations, velocity based separations, mechanical separations and performing calculations for simple systems.
4) Using a separation technique in a systematic way, reporting about the research and findings.
5) Project: For a chemical process, systematically search for information (e.g., historical context, application, chemistry, thermodynamics, kinetics, and description of the process scheme). Estimate unknown physical and chemical data. Design a reactor and separation apparatus (e.g., a column), draw up a process scheme, make an economic analysis of the process (CAPEX, OPEX), describe and quantify the safety and environmental aspects of the process. Report in oral and written manner about this group project.

Module 8b – Materials science & technology

Learning outcomes, after completing the course, the student is capable of:
1) Advanced Materials: explaining the relation between microstructure and properties of materials.
2) Describing the functional properties of materials used in any device, connecting these with basic material properties in relation to the ability to synthesize these materials.
3) CTIM: explaining the relation between properties, structure/composition and synthesis for inorganic materials; Explain epitaxial growth and strain within materials.
4) Describing the principles of the commonly used physical vapour deposition techniques and chemical vapour deposition techniques for films; describe the principles of sol gel and sintering techniques for bulk
5) CTOM: Polymer Chemistry, explaining the basic properties of polymers, polymer synthesis techniques, and polymerization mechanisms and kinetics.
6) CTOM: Polymer Physics part, explaining structure-property relations, amorphous and semi crystalline polymers, mechanical properties, viscoelasticity, chain dimensions, networks and properties in solution
7) Groups of 4 students will study a specific, technologically relevant material system for a given project: study a specific, technologically relevant material system with respect to its physical properties, and the way it is synthesized. Determining the structure with X-ray diffraction and another physical property by a measurement. Reporting and present the results of this group project.

Module 11 - Preparation for the final bachelor´s assignment

Learning outcomes
A professional chemical engineer and/or scientific researchers is capable of:
1) Explaining, from a philosophical perspective, what scientific research looks like, how problems are solved in chemistry, what roles models do play in Chemical Science and Engineering, and how we evaluate a problem solution in Chemical Science and Engineering.
2) Explaining concepts: code of conduct, whistle blowing dispersed responsibility and the three main theories (utilitarianism, deontology, virtue ethics)
3) Using the ethical cycle in analysing an ethical problem in a systematic way.
4) Finding a bachelor’s assignment related to own interests and skills, formulating the research plan including research question, research set up, research techniques and research planning
5) Cell biology and molecules, protein chemistry, cytoskeleton, cellular membrane, cellular respiration, polymer chemistry, nanomedicine
6) Designing a compressor or pump, a heat exchanger and a distillation column including mechanical aspects for a given industrial process.

Module 12 – Final bachelor´s assignment

Learning outcomes
The student is capable of:
1. Obtaining, selecting and processing scientific information for research purposes, in which process the student makes adequate use of latest relevant concepts and theories of the field in question. Using Endnote (or similar programs) to save and scientifically format all used references.
2. Conducting bachelor-level research in the field of chemical engineering. They have the knowledge and skills to conduct systematic scientific research, consisting of: problem analysis, research objectives, theoretical and experimental approach, execution, and result analysis. They make well-founded decisions when carrying out the investigation.
3. Efficiently designing and planning an investigation, ranging from problem analysis to feedback.
4. Demonstrating a certain degree of independence in the preparation and execution of a research project and adopting a critical, scientific attitude.
5. Functioning properly in a professional environment: this involves communicating clearly with the supervisor, collaborating in a research group and communicating with others within and outside the Chemical-Engineering community.
6. Producing an adequate written report of scientific research
7. Giving an adequate oral presentation of scientific research, discussing it with fellow students and colleagues.
8. Considering the social context, any potential safety and environmental implications and scientific and ethical aspects when forming an opinion of scientific results.