UiT

NORGES
ARKTISKE
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PROGRAMME DESCRIPTION

Master degree in Molecular Sciences

120 credits

Trømsø

The programme description has been approved by the Faculty of Natural Sciences on 28.11.2018

Study programme name	Engelsk: Master in Molecular Sciences
Degree obtained	Master of Science in Molecular Sciences
Target group	Target group is students wanting to participate in molecular studies to address the grand challenges of the future, among them: efficient use of natural resources, health and medicine, environment and climate, and global food production. Students aiming to learn how properties of molecules can explain phenomena in nature, how synthesis, discovery and analysis of new molecules can be used to design new drugs, medicine and materials with improved functionality, and how molecular studies can be used to improve health, industry and environment. A Master of Science Degree in Molecular Sciences provides the graduates with the qualifications to work as professionals in chemical, biochemical or biotechnology industries, or to apply for Ph.D. programmes in relevant scientific fields. The scientific computing projects may also qualify the graduates for positions in computational modelling and data handling and analysis, software development or high-performance computing. The programme is also relevant for students who wish to strengthen their knowledge about chemical and biochemical processes, in order to apply it in fields such as biology and biotechnology, medicine and pharmacy, geology, material science, nanotechnology and environmental studies, either in academia, or in the industry or public sector.
Admission requirements, required prerequisite, recommended prerequisite knowledge	Admission requires the following: • A **Bachelor's Degree** (180 ECTS credits) in one of the natural sciences OR an equivalent degree following a programme of study of minimum 3 years, or a similar education approved in accordance with the Norwegian Universities Act section 3-4. • The Bachelor's Degree must contain a minimum of 80 ECTS (or equivalent) specialization within the fields specific to the disciplines within the Master's degree programme in Molecular Sciences; *Biomolecular Chemistry and Bioinformatics*, *Chemical Synthesis and Spectroscopy*, *Theoretical and Computational Chemistry*, of which a minimum of 30 ECTS must be chemistry courses on bachelor level. By "one of the natural sciences OR an equivalent degree" means one of the degrees mentioned in Table 1 below, where the admission requirement for the various disciplines is outlined.

Table 1 Overview over admission requirements for the various disciplines within Molecular Sciences.

		Discipline		
		Theoretical and Computational Chemistry	**Chemical Synthesis and Spectroscopy**	**Biomolecular Chemistry and Bioinformatics**
Bachelor degree	Chemistry	x	X	x
	Biochemistry*	x		x
	Biomedicine*			x
	Biotechnology*			x
	Molecular sciences*	x	X	x
	Pharmacy*		X	x
	Mathematics*	x		
	Physics*	x		
	Informatics*			x

*Admission to the Master programme in Molecular sciences requires a minimum of 30 ECST in chemistry

- The minimum average grade requirement is
  - C - for Bachelor's degree or equivalent issued in Europe, Canada, USA, Australia and New Zealand
  - B - for Bachelor's degree or equivalent issued in all other countries
- International students from non-Nordic countries (except students with English as their mother tongue), must meet the Department of Chemistry's English proficiency with minimum scores as outlined below.

	IELTS	TOEFL
Reading	6.5	22
Listening	6.5	22
Speaking	6.5	22
Writing	6.5	25

The study programme's Learning Outcome

Knowledge

The candidate:

- Has an overview of scientific approaches to analyse and understand natural phenomena, using theory and methods of molecular sciences.
- Has thorough knowledge of theory and methods used in molecular sciences.
- Has advanced insight into international research and development within molecular sciences.
- Has acquired advanced knowledge and understanding sufficient to contribute to innovation and discovery within her or his discipline.

Skills

The candidate:

- Can independently and critically produce, analyse and evaluate the quality of data, products and results generated within the chosen field of molecular sciences.
- Can independently use various sources of information to structure and formulate scientific arguments.
- Has become proficient within the chosen discipline of molecular sciences, and has acquired basic tools needed to carry out independent research in accordance with applicable norms for research ethics, and to complete advanced research under supervision.
- Can independently use sophisticated and advanced methods and instrumentation relevant for the chosen discipline, and interpret the results generated. The candidate can:

  Biomolecular Chemistry and Bioinformatics

  - Manipulate and study biological macromolecules at DNA and amino acid levels experimentally (recombinant protein production) and/or computationally (bioinformatics).
  - Study structural, functional, and biophysical properties of biological macromolecules experimentally (crystal structure determination, intermolecular interactions, enzyme function) and/or computationally (molecular modelling, drug design).
  - Apply informatics tools to analyse biological macromolecules and their properties at genetic sequence and/or amino acid and/or structural levels.

  Chemical Synthesis and Spectroscopy

  - Plan and carry out chemical syntheses of organic or inorganic molecules
  - Analyze synthetic and natural substances with advanced chromatographic, spectroscopic and/or crystallographic methods.

  Theoretical and Computational Chemistry

  - Use state of the art software to model molecular structure, molecular properties or chemical processes
  - Develop and implement computational protocols to model chemical systems
  - Predict or interpret the behavior of chemical systems by making use of advanced computational infrastructure.

General competence

The candidate:

- Can critically read, cite, analyse and understand scientific literature
- Can independently communicate scientific information clearly and precisely, both written and oral forms.

	• Can independently analyse and judge the reliability of information obtained from different sources and has a sound critical attitude towards knowledge from all sources. • Can independently conduct research activities and communicate the research questions and results in both written and oral forms. • Can carry out knowledge-based evaluations of general problems in science and communicate this to the public. • Can accomplish research projects under guidance, e.g. under a PhD-programme in molecular sciences, chemistry or related areas. • Can apply the obtained knowledge to independently solve new problems in natural sciences and to contribute to research and innovation.
Academic content and discription of the study programme	The Department of Chemistry at UiT offers a *Master of Science Degree in Molecular Sciences*. *Molecular Sciences* has in recent years emerged as a field somewhat broader than Chemistry, as its activities include methods and technologies which previously were linked to e.g. physics and biotechnology. *Molecular Sciences* includes the analysis of molecules at all levels, ranging from physical properties, through chemical reactivity, to interactions in larger assemblies, such as in a biological cell. The Department of Chemistry at UiT provides excellent research environments, with state-of-the-art laboratories and experimental equipment, and access to advanced computer facilities for computer-oriented work. The Department hosts a Centre of Excellence (CoE) in Theoretical and Computational Chemistry, *Hylleraas Centre for Quantum Molecular Science* (http://www.ctcc.no), an internationally recognized research centre in structural biology, *NorStruct*, (http://norstruct.uit.no), and a national and international facility for bioinformatics (http://SfB.cs.uit.no). The Department also participates in the *Arctic Biodiscovery Centre* (http://arcticbc.no), where our expertise in structure elucidation and molecular analysis (http://smallstruct.uit.no), biocatalyst research, synthetic chemistry, and biotechnology is utilized. The Master Degree programme in Molecular Sciences, will provide programme options within three different disciplines: i. Biomolecular Chemistry and Bioinformatics ii. Chemical Synthesis and Spectroscopy iii. Theoretical and Computational Chemistry The student will choose a Master's project within the thematic areas available at the Department, and the student will make use of the methodological tools relevant for the thematic specializations. Combination of different specializations to acquire a wider expertise is also possible. Eligibility to projects may depend on the student's background.

Thematic areas for Master projects

The Master's programme in Molecular Sciences offers Master projects within five different thematic areas:

1. *Chemistry of the Cell*
2. *Drug Discovery and Design*
3. *Scientific Computing in Chemistry and Biology*
4. *Functional materials*
5. *Catalysis*

These projects can be theoretical or experimental in nature, or a combination of these, and might be applied to basic and applied research questions.

1. Chemistry of the Cell

This thematic area is for students that wish to focus their master studies on research questions relevant to understanding cellular processes. Understanding the function of cellular macromolecules, individually and in complex intermolecular interactions, is essential to understand the regulation of processes in living cells and, the origins of disease; this in turn inspires the innovation of new eco-friendly catalysts or diagnostic tools for medicine or industry. Recent advances enable new approaches to study the total set of cellular macromolecules in single experiments, promising new and exciting discoveries.

Projects may be chosen from among a diverse set of topics, ranging from cell communication networks in marine bacteria, to the extraction of biologically active compounds from living marine cells, to development of algorithms, software solutions and e-infrastructure for studying cellular macromolecules (for example, DNA and specific genes, cellular RNA, enzymes or other proteins). Project technologies may involve one or more of: molecular biotechnology techniques, macromolecular crystallography, NMR-spectroscopy, protein chemistry, enzymology and chemo- and bioinformatics. Thus, projects offered in this thematic area can be theoretical or experimental in nature, or a combination of these, with a focus ranging from pure basic research to highly applied industrial product development.

Available disciplines; *Biomolecular Chemistry and Bioinformatics*

2. Drug Discovery and Design

This thematic area offers opportunities to focus on research questions relevant to the discovery and design of new medicines. The development of new medicines, new applications of medicines, and new methods of drug discovery is essential to sustain and improve human health, especially in the context of aging populations and drug resistance. The increasing knowledge of the molecular mechanisms behind disease, high-resolution structural data of molecular drug targets, and binding data for large sets of compounds has resulted in novel interdisciplinary ways of approaching drug discovery.

A Master’s degree with in Drug Discovery and Design will involve research projects with inter- or intradepartmental collaborations, under the guidance

of thesis advisors with interdisciplinary expertise. Coursework providing a survey of drug design methods will guide the choice of a project with potential application in disease areas (e.g. anticancer or antimicrobial therapeutics). Project technologies may typically include chemical synthesis, synthetic method development, protein crystallography, spectroscopic studies, chem- and bioinformatics, medical imaging and diagnostics, and computational modeling. The commercial potential of this area of applied research is high, with the generation of novel intellectual property. Thus, projects offered in this thematic area may involve a high degree of confidentiality, depending on patenting strategies.

Available disciplines: *Chemical Synthesis and Spectroscopy, Biomolecular Chemistry and Bioinformatics, Theoretical and Computational Chemistry.*

3. Scientific Computing in Chemistry and Biology

This thematic area is for students who wish to focus their master studies on research questions in chemistry and biological chemistry that can be addressed by a variety of scientific computing tools, such as the development and/or application of novel computational tools to simulate chemically and biologically relevant processes or to develop tools relevant for bioinformatics. Scientific computing is an indispensable tool in scientific research and is broadly applied to assist in making new compounds, interpreting chemical reactivity, explaining molecular properties and increasing our understanding of biological data. With modern software and high-performance computers and data storage, realistic simulations or data analysis of chemical and biomolecular systems as well as bacterial genomics and metagenomics can be obtained, achieving deep insight, which might otherwise be inaccessible, difficult or expensive to obtain through experimental techniques.

Within this thematic area, the department offers research projects ranging from theoretical development in quantum chemistry, to the implementation of novel computational tools in the form of high performance code (Fortran/C/C++) or scripting tools (Python), or purely applied projects. Specific projects might involve simulation of chemical processes, bioinformatics, biocatalysis and enzyme design, homogenous catalysts, complex molecular environments such as metalloenzymes and nanoparticles, development of methods for simulating established and novel spectroscopies, as well as heavy and superheavy elements.

The specialization will provide the candidate with competence in advanced programmeming, high-performance computing, scripting, and computational modeling as research methods.

Available disciplines: *Theoretical and Computational Chemistry, Chemical Synthesis and Spectroscopy, Biomolecular Chemistry and Bioinformatics*.

	4. Functional materials This thematic area is for students that wish to focus their master studies on research questions involving analysis and design of functional, often nanostructured, materials. Within this area, nanoscale (i.e. 1-100 nm) structures are of special interest. A variety of nanostructured materials are synthesized, characterized, and theoretically modeled at the Department of Chemistry. Specific systems being studied include dye-sensitized solar cells, liquid crystals, metal-organic frameworks, and biofilms. Theoretical modeling of such materials is challenging, given their large scale relative to atoms and molecules, and typically involve multiscale modeling methods including quantum, classical, and continuum mechanics. Available disciplines: *Chemical Synthesis and Spectroscopy, Theoretical and Computational Chemistry*. *5. Catalysis* This thematic area is for students that wish to focus their master studies on research questions involving analysis and design of catalysts for biochemical and industrially relevant reactions. Catalysts are able to increase the rate of chemical reactions, resulting in chemical processes that otherwise might be too slow to occur or might be too costly. Many industrial processes are dependent on the use of catalysts, and most biochemical reactions in the body can only occur because they are catalyzed by protein catalysts (enzymes). Research into catalysis is a large activity at the Department of Chemistry, and involves diverse applications, including homogeneous catalysts, biomimetic catalysts modeled after metalloenzymes, light-catalyzed reactions, and analysis and design of industrially relevant biocatalysts for reactions. A variety of tools are applied in the research of catalytic reactions and their mechanisms, ranging from laboratory work (enzyme cloning and expression, organic and inorganic synthesis, spectroscopic studies) to molecular modeling techniques (quantum chemical and molecular dynamics analysis of reaction pathways). Highly interdisciplinary projects involving a combination of theoretical and experimental methods are also available. Available disciplines: *Theoretical and Computational Chemistry, Biomolecular Chemistry and Bioinformatics, Chemical Synthesis and Spectroscopy*.
Table: programme structure	The Master Degree Programme in *Molecular Sciences* at UiT has a duration of 2 years and equals a total of 120 ECTS (Table 2). Each Master's candidate works on a research project to complete an independent scientific dissertation (thesis, 60 ECTS) under supervision. In addition, the programme includes topical coursework, where 20 ECTS are obligatory for all students admitted to the programme, 20 ECTS are obligatory within each discipline, and 20 ECTS are to expand on the students chosen discipline and other special curricula (total 60 ECTS).

Table 2 Programme structure for disciplines within the Master Degree Programme in Molecular Sciences

	Theoretical and Computational Chemistry*			Chemical Synthesis and Spectroscopy**			Biomolecular Chemistry and Bioinformatics***		
1st sem	KJE3001		KJE3102	KJE3001		KJE3301 or Opt	KJE3001		KJE3402
2nd sem	KJE3101 or KJE3106	Opt	Opt	KJE3303#, KJE3308#, or KJE3201	Opt		KJE3403#, KJE3603, or BIO3323	Opt	Opt
3rd sem	Thesis			Thesis			Thesis		
4th sem	Thesis			Thesis			Thesis		

* In addition to KJE-3001 and KJE-3102,at least 10 ECTS chosen among KJE-3101, KJE-3106 or KJE-3201, depending on specialization

** KJE-3001 and KJE-3301 are obligatory, the remaining courses are optional

*** In addition to KJE-3001 and KJE-3402, at least 10 ECTS chosen among KJE-3403, KJE-3603 or BIO-3323, depending on specialization

Course given only every 2nd year

Optional courses (30 ECTS) should be chosen from the list below and from other relevant Master level courses at UiT or other institutions. Courses not on the list must be approved in advance by the Department of Chemistry. Some courses may be mandatory for certain areas of specialization.

Table 3 List of Master courses at Department of Chemistry

KJE-3001	Interdisciplinary molecular sciences: From quantum mechanics to medicine (new)
KJE-3101	Quantum chemistry
KJE-3102	Computational chemistry
KJE-3103$	Quantum chemical methods
KJE-3106	Molecular modelling (new)
KJE-3201	Bioinorganic chemistry
KJE-3301	Organic Chemistry 2
KJE-3303#	Nuclear Magnetic Resonance spectroscopy
KJE-3308#	Metal-Organic Compounds in Organic Synthesis
KJE-3313$	Advanced Organic Chemistry
BIO-3323	Bioinformatics: Genomes and genomics
KJE-3402	Protein Structure
KJE-3403#	X-ray Crystallography 1
KJE-3603	Protein Production Technology
KJE-3805	Individual special curriculum – Master degree (5 ECTS)
KJE-3810	Individual special curriculum – Master degree (10 ECTS)
KJE-3815	Individual special curriculum – Master degree (15 ECTS)
KJE-3820	Individual special curriculum – Master degree (20 ECTS)

Course given only every 2nd year

$ Course given at irregular intervals or as special curriculum

Learning activites, examination and assessement	Courses are taught as classes or as individual curriculum. Some courses are theoretical, some in combination with experimental laboratory exercises, and some are purely through laboratory work with a final exam or a written report. The University electronic learning portal is used for regular courses. Various assessment methods are applied. Courses are assessed through oral

	or written exams, some through assessment of a laboratory or project report, and some as a combination of methods. To achieve the learning outcomes, students are expected to work 40 hours per week on the project and courses, including lectures, lab and seminars. To achieve the learning outcomes, students are expected to work 40 hours per week on the project and courses, including lectures, lab and seminars.
The study programme's relevance	A Master of Science Degree in Molecular Sciences can provide a stepping-stone for exciting careers in a variety of fields, in Norway or abroad. The fields of study are crucial in the development of new sources of renewable energy (e.g. biofuels, solar cell materials), new solutions for the treatment of pollutants and waste (e.g. biomass conversion), and new technological tools which improve the efficiencies and reduce the costs of industrial processes (e.g. design of novel biocatalysts). A Master's in Molecular Sciences from UiT is also well suited for work in the pharmaceutical industry or academia in topics related to life sciences and drug discovery and development.
Work scope	The Master students become members of one of the research groups at the Department, with an assigned thesis supervisor. Throughout the project, the Master´s students may work closely in teams with PhD students, post doctoral fellows and senior scientists.
For master's theses/independent work in master's degrees	The Master's thesis must be an independent scientific dissertation, completed under the supervision of a scientific staff member or a postdoctoral fellow affiliated to Department of Chemistry, UiT.
Language of instruction and examination	The language of instruction and examination is English and all syllabus material is in English. The Master's thesis must be written in English.
Internationalisation	The research groups, to which the Master students become members, consist of staff and students of different nationalities. The scientific staff have international collaborators, providing opportunities for obtaining knowledge about the international research frontier through visits, lectures and workshops by national and international scientists. International collaboration also provides opportunities for research visits abroad.
Student exchange	The master's programme is structured such that the student can spend periods of their study abroad, preferably in the third semester. Student exchange can be formal courses, or visits to other labs and institutions to learn new techniques. Formal exchange programs with international Universities exist, (see university web pages for more information). However, visits abroad are generally arranged individually, depending on what is relevant for the Master's project, and on the collaborations of the supervisor. Courses must be approved in advance.
Administrative responsibility and academic responsibility	Faculty of Science and Technology, Department of Chemistry

Quality assurance	The study programme is evaluated according to the University´s quality assurance system. Course evaluation consists of both student and teacher reports. An overview of which courses are to be evaluated each semester is found on the faculty's quality assurance pages.
Other regulations	