UiT

NORGES ARKTISKE UNIVERSITET

PROGRAMME DESCRIPTION

Master Degree in Molecular Sciences

120 credits

Campus Tromsø

Based on <name of National Curriculum Regulations> of <dd.mm.yyyy>

The programme description has been approved by the board of Faculty of Science and Technology on <dd.mm.yyyy>

<table>
<tr><td>Study programme name</td><td>Master in Molecular Sciences</td></tr>
<tr><td>Obtained degree</td><td>Master of Science in Molecular Sciences</td></tr>
<tr><td>Target group</td><td>Students wanting to participate in solving grand challenges of the future; efficient use of resources, health and environment, food, etc. Students wanting to learn how properties of molecules can explain phenomena occurring 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 knowledge can be used to improve health, industry and environment.</td></tr>
<tr><td>Admission requirements, required prerequisite knowledge, recommended prerequisite knowledge</td><td>Admission requires the following:
A Bachelor’s Degree (180 ECTS credits) 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 program in Molecular Sciences; Biological and Structural Chemistry, Inorganic and Materials Chemistry, Organic Chemistry, Theoretical and computational Chemistry, Bioinformatics, of which a minimum of 30 ECTS must be traditional chemistry courses.
By "one of the natural sciences OR an equivalent degree" means one of the degrees mentioned in the table below, where the admission requirement for the various disciplines is outlined. Biochemistry is considered traditional chemistry for the discipline Biological and structural chemistry.
Table 1 Overview over admission requirements for the various disciplines within molecular sciences.
<table>
<tr><td></td><td></td><td colspan="5">Discipline</td></tr>
<tr><td rowspan="10">Bachelor degree</td><td></td><td>Organic Chemistry</td><td>Inorganic- and materials chemistry</td><td>Theoretical and computational chemistry</td><td>Biological and structural chemistry</td><td>Bioinformatics</td></tr>
<tr><td>Chemistry</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>Biochemistry*</td><td></td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>Biomedicine*</td><td></td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>Biotechnology*</td><td></td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>Molecular sciences*</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>Pharmacy*</td><td>x</td><td>x</td><td></td><td>x</td><td></td></tr>
<tr><td>Matematics*</td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>Physics*</td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>Informatics*</td><td></td><td></td><td></td><td></td><td>x</td></tr>
</table>
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</td></tr>
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Academic content and description of the study programme	*Molecular sciences* has in recent years emerged as a field exceeding the traditional field of Chemistry since its activities include methods and technologies which previously often were linked to i.e 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 offers a Master of Science Degree in Molecular Sciences. Projects for the Master's thesis in Molecular Sciences can be chosen from one of Department of Chemistry's five thematic focus areas: 1) *Chemistry of the cell*, 2) *Drug discovery and design*, 3) *Scientific Computing in Chemistry and Biology*, 4) *Functional materials*, and 5) *Catalysis*. Experimental laboratory projects, scientific computing-oriented projects, as well as highly transdisciplinary projects encompassing a combination of these can be accomplished during the master program. 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 (http://www.ctcc.no), an internationally recognized research centre in Structural Biology (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 of Science Degree in Molecular Sciences, will provide specialization within five different disciplines: i. biological and structural chemistry ii. inorganic and materials chemistry iii. organic chemistry iv. theoretical and computational chemistry v. bioinformatics The student will choose a project within the thematic areas present 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 be possible. Eligibility to projects may depend on the student's background. **Thematic areas for thesis projects** The Master's programme in Molecular Sciences offers graduate 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 theoretically or experimentally 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; *Biological and Structural Chemistry, 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 ageing 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 specialization 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: *Organic Chemistry, Biological and Structural Chemistry, Theoretical and Computational Chemistry, Inorganic and Materials 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 in 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 programming, high-performance computing, scripting, and computational modeling as research methods. Available disciplines: *Theoretical and Computational Chemistry, Bioinformatics, Inorganic and Materials chemistry*. *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 unusual 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: *Organic Chemistry, Theoretical and Computational Chemistry, Inorganic and Materials 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, Biological and Structural Chemistry, Organic Chemistry, Inorganic and Materials Chemistry*.

Table: programme structure

The Master of Science Program in Molecular Sciences at UiT has a duration of 2 years and equals a total of 120 ECTS. Each Master's candidate works on a research project to complete an independent scientific dissertation (thesis, 60 ECTS). In addition, the program includes topical coursework, where 20 ECTS are obligatory for all students admitted to the program, and 40 ECTS are to expand on the students chosen discipline and other special curricula (total 60 ECTS). Within each discipline, certain courses are mandatory.

	Theoretical			Inorganic			Organic			Biological and structural			Bioinformatics		
First term (autumn)	KJE-3001		KJE3101 or Opt*	KJE-3001		Opt	KJE-3001		KJE3301	KJE-3001		KJE3402	KJE-3001		KJE3402
Second term (spring)	KJE3106 or Opt*	Opt	Opt	KJE3201	Opt	Opt	Opt	KJE3303		KJE3403 or KJE3603	Opt	Opt	KJE3323	Opt	Opt
Third term (autumn)	Thesis			Thesis			Thesis			Thesis			Thesis		
Fourth term (spring)	Thesis			Thesis			Thesis			Thesis			Thesis		

* Depends on specialization within *the discipline*

Figure 1 *Program structure for disciplines within the Master of Science Program in Molecular Sciences*

Optional courses (40 ECTS) should be chosen from the list below. Exceptions can be made for other relevant courses at Master's levels at UiT or other Universities. Exceptions have to be approved by the Department of Chemistry. Some courses may be mandatory for certain areas of specialization. For example, a project directed towards organic synthetic chemistry will require *KJE-3301 Organic chemistry II*, a project in biocatalysis will require *KJE-3402 Protein structure,* etc.

Table 1 List of Master courses at Department of Chemistry

KJE-3001	Interdiciplinary 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-3309	Reaction Mechanisms
KJE-3313	Advanced Organic Chemistry
BIO-3323	Bioinformatics: Genomes and genomics
KJE-3402	Protein Structure
KJE-3403	X-ray Crystallography 1
KJE-3501	Introduction to research methodology in organic chemistry
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)

The study programme's Learning Outcome

After completion of the program, the candidate has the following learning outcome:

Knowledge

- Has an overview of scientific approach to understand, analyse and treat phenomena and challenges occurring in nature, using theory and methods within molecular sciences.
- Has thorough knowledge of theory and methods within at least one of the disciplines offered in the Master of Molecular Sciences programme.
- Has advanced insight into international frontier research and development within the field of specialization.
- Has acquired advanced knowledge in order to be able to obtain a profound understanding and ability to treat phenomena occurring in her or his field of specialization.

Skills

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

- Can critically produce, analyse and evaluate the quality of data, products and results generated within the chosen field of molecular sciences.
- Can use sophisticated and advanced methods and instrumentation relevant for the chosen specialization, and interpret the results generated. The candidate is able to:
  - *Biological and structural biology*
    - Perform biological, chemical and enzymatic assays.
    - Perform analysis of the relationship between protein structure and function on sequence or amino acid level.
  - *Organic Chemistry, Inorganic and materials chemistry*
    - Perform chemical synthesis of organic or inorganic molecules
    - Perform molecular analysis using traditional methods and advanced state of the art spectroscopic and chromatographic instruments.
    - Perform molecular modelling and visualization of chemical compounds
  - *Theoretical and computational chemistry*
    - Perform computer programming
    - Perform algorithm development
    - Perform computing and modelling on chemical small molecule systems*
    - Perform computing and modelling on biological molecules*
  - *Bioinformatics*
    - Perform computer programming
    - Perform biological big data analysis
- Has become proficient within the chosen specialization of molecular sciences, and has acquired basic tools needed to carry out independent research and to complete an advanced research project under the supervision of a supervisor.

General competence

- Can analyse and judge the reliability of information obtained from different sources and has a sound critical attitude towards the knowledge from all sources.
- Can apply the obtained knowledge in molecular sciences to solve problems in other natural sciences.
- Can accomplish some independent research 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-program in molecular sciences, chemistry or related areas.

* Depending on specialization

The study programme's relevance	A Master of Science Degree in Molecular Sciences provides the graduates with the qualifications to work as professionals in chemical or biotechnology industries, or to apply for Ph.D. programs in relevant scientific fields. The scientific computing projects can also qualify the graduates for positions in computational modelling and data handling and analysis, software development or high-performance computing. The program 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 medicine, biology, geology, material science, nanotechnology, pharmacy and environmental studies. 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 and learning activities	The Master's candidates become full 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. Courses are taught as classes, some in combination with experimental laboratory exercises, and some purely through laboratory work. Fronter is used as the electronic learning portal in all 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. Each Master's candidate works on a research project to complete an independent scientific dissertation (thesis, 60 ECTS). In addition, the program includes topical coursework, where 20 ECTS are obligatory for all students admitted to the program, and 40 ECTS are to expand on the student's chosen discipline and other special curricula (total 60 ECTS). Within each discipline, certain courses may be mandatory. To achieve the learning goals, students are expected to work 40 hours per week on the project and courses, including lectures, lab and seminars.
Examination and assessment	Coursework will be evaluated according to the study plans for the individual courses. The Master thesis will be evaluated by an internal and an external censor/referee, and the final grade will be based on the thesis, the student's oral presentation of the thesis and an oral examination.
For master's theses/	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.

independent work in master’s degrees	
Language of instruction and examination	The language of instruction is English and all syllabus material is in English. The Master's thesis may be written in either English or a Scandinavian language. Examination questions will be given in English, but may be answered in either English or a Scandinavian language.
Internationalisation and student exchange	The master's programme is structured such that the student can spend shorter or longer periods studying abroad, preferably in the second or third semester. Courses must be approved in advance. Formal exchange programs with Universities in Europe (Umeå, Stockholm, Copenhagen, Pisa) and overseas (Auckland, New Zealand) are under development.
Supervised professional training	Not relevant
Administrative responsibility and academic responsibility	Faculty of Science and Technology, Department of Chemistry
Quality assurance	The study programme is evaluated every second year according to the University´s quality assurance system. The courses constituting the programme are evaluated following every third offering, as a minimum. 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	