

Contents of the curriculum Excellence in Analytical Chemistry

1	NAME OF CURRICULUM	Excellence in Analytical Chemistry
2	ACRONYM	EACH
3	EDUCATIONAL INSTITUTION(S)	University of Tartu, Estonia (UT) Uppsala University, Sweden (UU) University Claude Bernard Lyon 1, France (UCBL) Åbo Akademi University, Finland (AAU)
4	CURRICULUM TYPE	Joint Master Programme
5	LEVEL OF STUDY	Master's studies
6	CURRICULUM GROUP	Physical sciences
7	LANGUAGE(S) OF INSTRUCTION	English
8	OTHER LANGUAGES REQUIRED FOR ATTAINMENT OF THE LEARNING OUTCOMES	Swedish, French or Estonian
9	FORM OF STUDIES	Regular studies
10	NOMINAL PERIOD OF STUDY	2 years
11	AMOUNT OF CREDITS (ECTS)	120
12	QUALIFICATIONS GRANTED	- Master of Science (Excellence in Analytical Chemistry) (UT) and one of the following (according to the assigned study track): - Master of Science (UU) - Master of Physical and Analytical Chemistry (Industrial Analysis) (UCBL) - Master of Science (Technology), (Master's programme in Excellence in Analytical Chemistry (EACH)) (AAU)
13	DOCUMENTS ISSUED UPON GRADUATION	Diploma with Diploma Supplement
14	HIGHER EDUCATION INSTITUTION(S) ISSUING GRADUATION DOCUMENTS	Tartu University Uppsala University University Claude Bernard Lyon Åbo Akademi University
15	APPROVAL	This agreement describes all aspects of the programme and by signing it all participating organisations agree with it.
16	SPECIALISATION(S)	Analytical chemistry
17	VERSION OF CURRICULUM	2020/2021
18	PROGRAMME MANAGER	Ivo Leito
19	TERMS OF ADMISSION	BA degree or equivalent qualification; - Prerequisites: at least 60 ECTS in chemistry or in industrial chemistry and 20 ECTS in mathematics or physics. More detailed admission requirements: https://each.ut.ee/EACH/admission-requirements/ .
20	GOALS OF CURRICULUM	The goal of the curriculum is to provide students with in-depth knowledge and practical skills in analytical chemistry to be qualified for research and development.
21	BRIEF DESCRIPTION OF CURRICULUM STRUCTURE	I study year at the University of Tartu 1. General analytical chemistry module (21 ECTS); 2. Metrology and quality management module (9 ECTS); 3. Socio-economic module (6 ECTS) and language module (6 ECTS); 4. Internship (6 ECTS); 5. Elective courses (9 ECTS); 6. Optional courses (3 ECTS); II study year - spent in one of the partner universities: 7. Specialisation module (30 ECTS): 7.1. Uppsala University 7.1.1. Organic and bioorganic analysis and multimodal separation techniques module (30 ECTS). 7.2. University Claude Bernard Lyon 1 7.2.1. Industrial analytical chemistry module (30 ECTS). 7.3. Åbo Akademi University 7.3.1. Electroanalysis module (30 ECTS); 8. Master thesis (30 ECTS).

22	REQUIREMENTS FOR COMPLETION OF CURRICULUM	Completion of the coursework as foreseen in the curriculum.
23	LEARNING OUTCOMES OF CURRICULUM (to be attained/developed/professional knowledge and skills, general competencies, etc.)	<p>Upon completion of the curriculum, the student:</p> <ol style="list-style-type: none"> 1) Has systematic understanding of the physical, chemical and metrological foundations of analytical chemistry; factors affecting analytical results; methods for calculating and presenting of results and evaluating their quality for the widespread chemical analysis methods. 2) Has systematic understanding of laboratory quality systems (ISO 17025 and GLP), economic and legal aspects of chemical analysis and basic understanding of managing an analytical laboratory, including maintaining a quality management system. 3) Has the basic skills to work with the widespread analysis and sample preparation techniques and to tune them according to specific analysis tasks; to optimize analysis procedures; to make data evaluation and sampling. 4) Is able to define the problem, choose the methods, test them and determine their characteristics, assess their suitability for the task and apply corrective actions in one of the subfields of analytical chemistry: <ul style="list-style-type: none"> - Separation science and organic analysis, including multimodal separation techniques and complex samples of biological importance; - Industrial analytical chemistry and process control; - Electroanalysis and electrochemical sensors, including their design, miniaturization and uses for different analytical tasks. 5) Has the knowledge and skills to evaluate the adequacy of chemical analysis results obtained either by him/herself or by others. 6) Is able to apply his/her knowledge and skills for solving novel analytical chemistry problems, including in multidisciplinary context, having limited information and time. 7) Is able to work in a team (including as team leader), manage streams of information, time and resources, present results both for experts and non-experts. 8) Is able to speak Swedish; French or Estonian at least at A1 level.
24	MODULES	
	General analytical chemistry module (21 ECTS)	
	GOALS OF MODULE:	To provide the basic knowledge and skills in analytical chemistry.
	LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	<p>Upon completion of the module, the student:</p> <ol style="list-style-type: none"> 1) Has systematic understanding of analytical chemistry, its main concepts, methods of analysis and their characteristics 2) Knows the physical and chemical background of the common chemical analysis techniques and is able to apply them in practice; 3) Knows and is able to apply mathematical methods for treatment of measurement data and is able to present measurement results correctly; 4) Knows the specialisation related terminology and will be capable of explaining and defending the results of his/her research in an academic discussion; 5) Will be able to solve the problems of analytical chemistry in teamwork.
	MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students studying in the programme.</i> LOKT.06.050 Master seminar in measurement science I (6 ECTS) LOFY.01.039 Measurement data processing (3 ECTS) LOKT.06.032 Practical chemical analysis (6 ECTS) LOKT.06.033 Practical works in chemical analysis and metrology (6 ECTS)
	Metrology and quality management module (9 ECTS)	
	GOALS OF MODULE:	The goal of the module is to provide knowledge and skills on metrology and its application in analytical chemistry and on the quality assurance of measurements and analysis.
	LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	<p>Upon completion of the module, the student:</p> <ol style="list-style-type: none"> 1) Has the knowledge of the main metrological concepts (traceability, measurement uncertainty) and approaches (validation of analysis procedures, reference materials, interlaboratory comparisons) relevant to chemical analysis; 2) Has the knowledge and skills for ensuring and assessing the reliability of analysis results and expressing them correctly; 3) Knows the main principles of quality management and the main quality management systems in laboratories (ISO 17025 and GLP) and is capable of following these requirements.
	MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students studying in the programme.</i> LOKT.06.030 Metrology in Chemistry (6 ECTS) LTKT.06.015 Quality Systems (3 ECTS)
	Socio-economical module (6 ECTS) and language module (6 ECTS)	
	GOALS OF MODULE:	To provide socio-economical knowledge of analytical chemistry and language skills at level A1 in one of the following: Swedish; French or Estonian.
	LEARNING OUTCOMES OF MODULE (to be attained/developed/professional	<p>Upon completion of the module, the student:</p> <ol style="list-style-type: none"> 1) Understands the socio-economic impact of analytical chemistry, both at micro- and macro-economy level; understands the economics of functioning of an analytical laboratory; 2) Is able to communicate results of chemical analysis to a non-specialist audience;

knowledge and skills, general competencies, etc.)	3) Is able to communicate, at the level A1, in one of the three languages spoken in partner universities (Swedish, French or Estonian).	
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: The student has to choose at least two out of the three courses - LOKT.04.072, LOKT.06.034 or MJRI.10.037 - and one a foreign language course. Some of the electives of the first study-year are preparatory courses for specific study tracks and are therefore highly recommended for students assigned to the respective study track (specified in column "Preferred study track(s)" below). At UU the Swedish language course will be counted as extra credits.</i>	
	Course	Preferred study track(s)
	LTKT.06.011 Economic Aspects of Measurements (3 ECTS)	UU, UCBL, AAU
	LOKT.04.072 Environment and Measurement (3 ECTS)	UU, AAU
	LOKT.06.034 Measurements and the Law (3 ECTS)	UU, UCBL, AAU
	HVLC.03.006 French for Beginners I on the Basis of English, Level 0 > A1.1 (6 ECTS)	UCBL
	HVLC.06.010 Swedish for Beginners I (on the Basis of English), Level 0 > A1.2 (6 ECTS).	AAU, UU (extra credits at UU*)
	FLLC.09.001 Estonian for Beginners I, on the Basis of English, Level 0 > A1.1 (6 ECTS)	
* Students assigned to the UU study track must note that the HVLC.06.010 course will not be counted towards the master's degree at UU. Therefore, in addition to this course, these students have to choose another foreign language course (e.g., HVLC.03.006, FLLC.09.001, etc.).		
Internship (6 ECTS)		
GOALS OF MODULE:	Student acquires understanding of the analytical chemistry issues in a professional environment at industry, research institution or a professional laboratory as well as the knowledge and skills for performing certain tasks in that professional environment.	
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Upon completion of the module, the student: 1) Has understanding of the analytical chemistry issues in a professional environment at industry, research institution or a professional laboratory; 2) Has the knowledge and skills for performing certain tasks in professional environment and use the lab equipment; 3) Understand the quality norms and standards practiced in a particular field; 4) Has experienced working in teams and in professional non-educational setting.	
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students studying in the programme.</i>	
	LOKT.00.023 Practical Speciality Training (6 ECTS)	
Elective courses (9 ECTS)		
GOALS OF MODULE:	The objective of the module is to enhance students' knowledge in analytical chemistry according their liking and interests.	
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Upon completion of the module, the student has acquired further knowledge and skills in analytical chemistry.	
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: The student compiles the elective module independently keeping in mind the II year specialisation and the recommendations of the Programme Director. Some of the electives of the first study-year are preparatory courses for specific study tracks and are therefore highly recommended or obligatory for students assigned to the respective study track (specified in column "Preferred study track(s)" below).</i>	
	Course	Preferred study track(s)
	LTKT.02.007 Applied Electrochemistry (3 ECTS)	AAU
	LOKT.06.047 Atomic Spectroscopy (3 ECTS)	UU, UCBL, AAU
	LTKT.06.009 Chemical Analysis Lab for Beginners (3 ECTS)	UU, UCBL, AAU
	LOKT.08.005 Chemometrics (6 ECTS)	UCBL
	LTKT.06.014 Estimation of Measurement Uncertainty in Chemical Analysis (1 ECTS)	UU, UCBL, AAU
	LOKT.06.061 Introduction to Electroanalysis (3 ECTS)	AAU (obligatory)
	LTKT.06.016 Introduction to Forensic Analysis (1 ECTS)	
	LOKT.06.064 LC-MS Methods Validation (2 ECTS)	UU, AAU
	LOKT.06.016 Liquid Chromatography and Mass Spectrometry (6 ECTS);	UU (obligatory), AAU
	LTKT.06.013 Measurement Science in Chemistry Summer School (6 ECTS)	
	LOKT.10.017 Measurements in Biochemistry (3 ECTS)	UU
	LOFY.01.036 Measuring and Instrumentation (3 ECTS)	UU, UCBL, AAU
LOFY.01.037 Modern Metrology (3 ECTS)	UU	

	LOFY.01.040 Practical Works on Physical Measurement and Calibration (3 ECTS)	UU
	LTKT.06.012 Principles and Applications of Fluorescence Spectroscopy (3 ECTS)	UCBL
	LOFY.02.028 Sensors and Sensor Materials (3 ECTS)	AAU
	LOKT.09.022 Structural Analysis I (3 ECTS)	UU
Optional subjects (3 ECTS)		
GOALS OF MODULE:	The goal of the module is to learn in accordance with interests and further studies or career.	
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Upon completion of the module, the student has acquired knowledge in the areas studied.	
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Any courses taught at the University of Tartu or other HEIs that comply with the degree requirements of the involved partner universities</i>	
Specialisation module (30 ECTS)		
GOALS OF MODULE:	During the second academic year, the student studies at one of the following partner universities and specializes in the field of analytical chemistry within the competence of the specific university (the second-year university is assigned during the winter school that takes place between the first and second semesters): UU: Organic and bioorganic analysis and multimodal separation techniques - focuses on the analysis of organic, biochemical and biomedical samples with different separation methods and mass spectrometry; UCBL: Industrial analytical chemistry module - focuses on analytical chemistry applications in industry, and monitoring and controlling of industrial processes; AAU: Electroanalysis module - focuses on electroanalytical chemistry, and the applications and development of chemical sensors (incl. miniaturization). In addition to specialization, the student acquires at least basic knowledge of the local language according to the chosen module (Swedish: UU and AAU, and French: UCBL).	
Specialisation module in Uppsala (30 ECTS)		
GOALS OF MODULE:	The student acquires in-depth theoretical knowledge and practical skills in organic and bioorganic analysis and multimodal separation methods.	
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Student who has completed the module: 1) will learn and understand the fundamentals of proteomic and metabolomic approaches in complex biological samples; 2) is familiar with the chemical and physical aspects of separation methods (liquid and gas chromatography and capillary electrophoresis), optimization, detection methods, and can predict how changes in experimental conditions affect the operation of these methods; 3) is familiar with the construction of chromatography, capillary electrophoresis, and mass spectrometry instrumentation; 4) knows what type of information can be obtained from chromatograms, electropherograms and mass spectra, and is capable of interpreting and processing chromatograms and mass spectra; 5) is capable of choosing the suitable method (both, for analysis and detection) for analysis according to the properties of the analytes and matrices, and can justify their choice; 6) is able to plan and perform validation of methodologies and determine the characteristics of the methodology; 7) is able to plan and carry out both qualitative and quantitative analysis with different samples, incl. biological samples.	
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students studying in the study-track.</i> 1KB154 Applied Analysis of Complex Samples (15 ECTS); 1KB159 Advanced Mass Spectrometry (15 ECTS)	
Specialisation module at University C.B. Lyon 1 (30 ECTS)		
GOALS OF MODULE:	The student acquires the knowledge and skills of all critical parts of industrial analysis that are related to the application of analytical equipment at industrial plants.	
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Student who has completed the module: 1) is familiar with the principles of sampling during industrial analysis, knows the main approaches and constraints of it; 2) is familiar with the construction and characteristics of analytical instruments suitable for industrial analysis, and is capable of installing and using such equipment; 3) is familiar with experimental planning and data analysis, and knows the principles and tools of industrial IT and automation and is able to apply them; 4) is familiar with analytical strategies used in industry and can apply them; 5) is able to choose and implement a suitable industrial analysis and data processing system that takes into account all the limitations of the specific industrial production.	

MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students studying in the study-track.</i>
	CHM2303M Sampling on an industrial plant (6 ECTS)
	CHM2209M Instrumentation for industrial analysis (6 ECTS)
	GEP2264M Industrial IT and Automation (3 ECTS)
	CHM2304M Industrial measurement strategy (3 ECTS)
	CHM2060 Data Analysis (3 ECTS)
	CHM1045 Experimental design (3 ECTS)
	CHM2070 Communication and Management (6 ECTS).
Specialisation module at Åbo Akademi University (30 ECTS)	
GOALS OF MODULE:	The student acquires theoretical knowledge and practical skills about electrochemical analysis and chemical sensors.
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Student who has completed the module: 1) knows the most common electrochemical analysis methods, and the capabilities and limitations of them, and can apply these methods to solve different tasks; 2) is able to define an analysis problem and choose a suitable method for solving it; 3) knows the principles of constructing electrochemical sensors and is familiar with the materials used for building them, can test and characterise the sensors, knows the principles of miniaturization of sensors; 4) knows the measurement strategies and data processing capabilities based on sensors, and is able to implement them.
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Courses 410304.0, AK00BL19, 909970.0, and KE00CG27 are obligatory for all students studying in the study-track. In addition, 10 ECTS among elective courses must be chosen. The elective courses are in italics.</i>
	410304.0 Applied electrochemistry (5ECTS)
	AK00BL19 Chemical sensors and biosensors (5 ECTS)
	909970.0 Swedish as foreign language (5 ECTS)
	KE00CG27 Special project in analytical chemistry (5 ECTS)
	<i>KE00CD66 Applied analytical chemistry (5 ECTS)</i>
	<i>KEMI6429 Bioanalytical techniques (5 ECTS)</i>
	<i>KEMI6513 Functional materials (5 ECTS)</i>
	<i>KEMI6409 LC-MS and its applications (5 ECTS)</i>
Masters' thesis (30 ECTS)	
GOALS OF MODULE:	Student develops practical skills in planning, executing and reporting of scientific research in the field of analytical chemistry.
LEARNING OUTCOMES OF MODULE (to be attained/developed/professional knowledge and skills, general competencies, etc.)	Upon completion of the module, the student: 1) Is intimately familiar with one specific field of analytical chemistry and can formulate the arguments/statements to be presented at defence. 2) Is able to pose and critically analyse the arguments presented in field-specific sources and to argue and justify his/her positions; 3) Knows the general principle of research ethics and can evaluate the scientific level of the research and its degree of application linked to particular area of research; 4) Can structure and deliver a public presentation and participate in academic discussions; 5) Knows the principles and requirements for scientific work and can formulate their work results accordingly.
MODULE COURSES AND PRINCIPLES OF CHOOSING THEM BY STUDENTS	<i>Principles of module selection: Obligatory for all students.</i> <i>One of the following courses at the second-year university (depending on the assigned study track):</i>
	UU: 1KB052 Degree Project E in Chemistry (30 ECTS)
	UCBL: Master's thesis in Analytical Chemistry (30 ECTS)
	AAU: AK00BD96 Master's thesis in Analytical Chemistry (30 ECTS)
	<i>At UT, one of the above mentioned courses will be transferred as: LOKT.00.002 Master's Thesis (30 ECTS)</i>