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CHEMISTRY DEPARTMENT

Information Booklet

Master Studies

BANJA LUKA, 2020

The program of chemistry study was established at the Faculty of Natural Sciences and Mathematics in 1997. By accepting the principles of the Bologna process, in 2007, chemistry studies at first cycle are organized within two directions: *Chemistry* and *Chemistry Education*. Since its establishment, 238 students have graduated at Chemistry Department (including the pre-Bologna period), of which 102 as a Bachelor of Science in Chemistry and 136 graduated as Teacher of Chemistry (December 2020). To this day, nine doctoral dissertations in the field of Chemical Sciences have been defended at the Chemistry Department, according to the conditions from the pre-Bologna period, which refers to Masters in Chemical Sciences. Currently, 97 students are studying at the first cycle of studies at the Chemistry Department. The classroom and laboratory space of the Faculty of Natural Sciences and Mathematics is available to chemistry students, and in addition, experimental classes partly take place at other appropriate laboratories of the University.

Chemistry Department is organized by model 4+1+3. This model implies that studies at first cycle are performed in eight semesters or four years. The number of ECTS credits per year of study is 60, so that a student achieves 240 ECTS credits upon completion of undergraduate studies. Undergraduate studies of chemistry consist of required and elective courses, which provide knowledge and skills necessary for obtaining diploma for the first cycle of academic studies. Studies at Chemistry Department are organized within two programs: *Chemistry* and *Chemistry Education*.



Master studies last two semesters, the number of ECTS credits is 60. The program includes six subjects, four are elective. All subjects are in the winter semester, while the summer semester is reserved for master's theses.

The first generation of students was enrolled in academic year 2016/17. Second cycle of chemistry studies at Chemistry Department was licensed in July 2016. Since the beginning of the second cycle, 40 students have been enrolled, 23 are currently studying, and

14 students have completed the second cycle of studies. Currently, initiation is being done on establishing the III cycle - Doctoral studies in chemistry at the Faculty of Natural Sciences and Mathematics. The Department employs seven full-time teachers, four assistants, four laboratory technicians and four professional associates, and teachers and associates form other faculties of the University of Banja Luka, as well as visiting professors from University of Belgrade and University of East Sarajevo. Head of the Department Professor Milica Balaban.



Until the beginning of the academic 2019/20, 40% of graduated Master in Chemistry, enrolled doctoral studies at prestigious world universities including the University of Belgrade, the University of Aachen, Germany, the Technical University of Bratislava, Slovakia and the ETH University in Zurich, Switzerland. All students enrolled doctoral studies with full scholarships for their studies, which include project positions or assistant positions during the doctoral studies. These data unequivocally indicate that

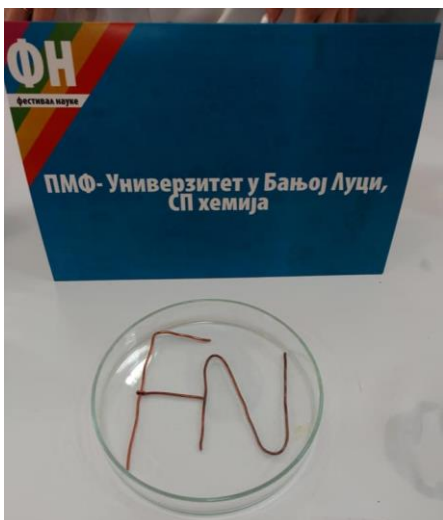
the quality of the Chemistry Department is unquestionable, and that a high standard has been reached in both study cycles, with Master's studies fully training our students for top scientific research work in accordance with the latest trends in science and further education.

Simultaneously, with the launch of the second cycle of studies at the Chemistry Department, the first generation of students enrolled at the innovated Curricula at the first cycle of studies, in order to complete the logical unity and enable the accordance with the Bologna Declaration. At the moment, after four years of implementation, the Chemistry Department plans to propose innovating both cycles of studies and further modernization of curricula, and their harmonization with the latest trends in chemical sciences, as soon as possible, having in mind the adopted new Law of Higher Education. Changes in the Curriculum for the first cycle of studies in 2016 were designed to enable students to acquire both fundamental and disciplinary knowledge in accordance with accepted norms at the European level, and the basics of specific knowledge in the most current areas of chemistry such as: synthesis and characterization of new of inorganic and organic compounds with targeted properties, increasing energy efficiency, analytics and, in general, environmental chemistry, design of modern inorganic and organic materials, including polymers and nanomaterials, modern biochemical research, as well as knowledge of domestic and European standards in chemistry and related disciplines. Also, an effort was made to introduce a certain number of contents that lead to the improvement and increase of the competencies of chemistry teachers in the second cycle of chemistry studies with minimal human and material resources.

The next step will be the design of a special module for chemistry teachers at the second cycle of studies, as well as a substantial innovation of the first cycle of chemistry studies – Teaching program in terms of fully training future teachers for curricular approach and education based on learning outcomes.



One of the key steps in the coming period will be the introduction of compulsory study practice at the first cycle of chemistry studies for both programs, which will be done in cooperation with industrial partners, businesses, national educational and other institutions or students will be included in research teams or projects realized at the Chemistry Department. Until now, a significant number of students have independently, i.e., in the organization of Chemistry Department, performed various types of professional practice or improved their studies through study exchange in the country and abroad.



The analysis of the past period through real indicators and the Report on self-evaluation of Chemistry Department from 2018 showed that the concept of teaching at the II cycle (Master) of studies at the Chemistry Department, where students are enabled to cooperate with the future mentor, they largely create their own curriculum, very successfully. In this way, one study field: Master in Chemistry, offers students a personalized study program, which is possible to deepen existing and acquire new knowledge in very current areas within the narrower scientific fields in the field of Chemistry, but also other, interdisciplinary fields. Also, in this way, the personal affinities of students and the needs of their jobs are taken into consideration.

LEARNING GOALS

of Master studies in Chemistry at Faculty of Natural Sciences and Mathematics

1. Education of highly professional staff in the field of chemistry.
2. Education of experts competent to work in laboratories engaged in research in the field of chemistry and related sciences, capable of working in interdisciplinary teams.
3. Education of experts who can be involved in the teaching-scientific process at universities, capable of independent scientific-research work and team work.
4. Education of chemistry teachers for work in primary and secondary schools by introducing, in addition, to chemical programs and specific programs of chemistry teaching methodology.
5. Education of experts for work in institutions and industry where expert knowledge, advice and recommendations in the field of chemistry are needed.
6. Providing a modern educational program with an emphasis on the adoption of fundamental knowledge, but also the latest scientific and applied achievements in the field of chemistry and related sciences.
7. Encouraging creative thinking, problem-solving methodologies and the use of the most modern information technologies in the process of learning and presenting the acquired knowledge.

COMPETENCIES

expected from graduate master students in Chemistry at Faculty of Natural Sciences and Mathematics

1. They are capable of adopting, analyzing and synthesizing basic knowledge in chemistry and related fields of natural sciences;
2. Acquire abilities for practical application of knowledge of chemistry by:
 - They are able to work in chemical laboratories of general type and quality control departments of various industries;
 - They are able to work in development departments of different types of chemical industry;
 - They are able to start working in scientific research laboratories;

- They can effectively transfer appropriate chemical knowledge and information to students in primary and secondary schools and other uninformed audiences.
- 3. Skills for collection and processing, as well as evaluation and interpretation of chemical data and other information;
- 4. The ability to exchange information, ideas, problems and solutions;
- 5. The ability for teamwork;
- 6. The ability to form scientifically based and reasoned judgments based on knowledge of basic chemical laws;
- 7. The ability of effective professional communication in the field of chemistry;
- 8. They have built the learning skills they need to engage in further and higher education in chemistry.

Graduate Master in Chemistry who obtained their degree at the Chemistry Department can respond to the demands, by the introduction of new standards in the workplace in various scientific, academic, industrial and administrative institutions, but also to train for independent scientific research and continue their education at the third cycle of chemistry studies.

The process of self-evaluation at the Chemistry Department has shown that chemistry students in the final years of the first cycle and students of master studies are very interested in scientific research work. During the last five years, a large number of students of both cycles have presented scientific papers at scientific conferences, including, among other things, the student scientific-professional conference StES, where chemistry students have won four first places in the field of natural sciences since 2015, or were in second- or third-place.

A large number of international and national research projects are being implemented at the Chemistry Study Program. Almost all of the teachers and assistants from Chemistry Department participate in the realization of projects. The Chemistry Department is currently implementing four international projects funded by the European Institute of Innovation and Technology (EIT Raw Materials, Horizon 2020) and one UNESCO Fund for Green Chemistry (UNESCO International Basic Sciences Program (IBSP) -Green Chemistry for Life) project. SP Chemistry teachers also participate in the implementation of two COST actions (CA18210 and CA 18112) and in one bilateral exchange project with the Republic of Slovenia. In the last few years, great attention has been paid to projects with industrial partners, and in the period 2018-2019, is realized a project with the company R-S Silicon d.o.o. Mrkonjić Grad, while the project with the company "Destilacija" a.d. Teslić is currently underway, within the call "Synergy". The value of these two industrial projects is over 125,000.00 KM. At this point, 10 national projects are being implemented at Chemistry Department. In June 2020, participation was approved in another project funded by the EIT RawMaterials Fund and an Erasmus + staff and student exchange with the Technical University of Bratislava, Slovakia. The beginning of the

realization of these projects is expected in October this year. Also, during this year, a number of project proposals were submitted under international calls, including one Horizon 2020 project. It should be noted that the implementation of a large number of projects involves final year students and master's students, who are thus enabled to do the experimental part of their bachelor and master's theses, as well as gain valuable experience in international and / or industrial environments.

For two years in a row, the team of the Chemistry Department has won the Award for Scientific Achievements, awarded by the Ministry of Scientific and Technological Development, Higher Education and Information Society in the Government of the Republic of Srpska (2018 and 2019). In the period of the previous ten years, the scientific productivity of Chemistry Department has multiplied (while the number of employed teachers and associates has not changed significantly). Thus, in the period of seven years, from 2010 to 2016, a total of 11 papers were published at the Chemistry Department in international journals (with IF), while the same number of papers was published only in 2019. This year, more than ten papers have already been published or accepted, while almost as many are in various stages of the review and publication process. Considering that a total of 11 full-time teachers and assistants are employed at Chemistry Department, the mentioned increase in scientific productivity is respectable.



A large part of scientific and teaching activities takes place through cooperation with universities in the region, Europe and the world, both through postdoctoral research, study stays, and through participation in international project teams, encouraging the mobility of researchers. Two Chemistry Department teachers have won the prestigious Fulbright Scholarship for postdoctoral research stay in the United States in the last five years, while Chemistry Department teachers have also been awarded two Matsumae International Fellowship Scholarships for their stay in Tokyo, Japan, which is ranked in the top ten universities in the world in the field of natural sciences.

CURRICULUM

Master in Chemistry (MSc in Chemistry) - 300 ECTS

FIRST YEAR					
Course	Status	I semester	ECTS	II semester	ECTS
Research Methodology in Chemistry	R	2+1	4		
Measurement Data Processing	R	2+1	4		
Elective course 1	E		6		
Elective course 2	E		6		
Elective course 3	E		5		
Elective course 4	E		5		
Study and research – Seminar work	R			0+5	10
Study and research – Master thesis	R			0+20	20

R – Required course

E – Elective course

List of elective courses	Class per week	ECTS
Environmental Samples Analysis	3+2	6
Chemical Contaminants of Food and Water	2+2	5
Chemical Analysis of Food	2+2	5
Chromatographic Methods	2+3	5
Sampling and Sample Preparation for Chemical Analysis	2+3	6
Synthesis and Characterization of Polymers	3+2	5
Organic Synthesis	3+2	6
Organic Geochemistry	3+2	6
Applied Organic Chemistry	2+2	5
Modern Structural Methods	2+2	5
Computational Chemistry	3+0	5
Organic Chemistry Didactics	2+2	5
Multimedia Resources for Teaching Chemistry	2+2	5
Selected Topics of Physical Chemistry	3+2	5
Selected Topics of Instrumental Methods	3+2	6
Chemical Kinetics and Catalysis	2+2	5
Colloidal Chemistry	2+2	5
Photochemistry	2+2	5
Inorganic Synthesis	2+2	5
Advanced Inorganic Chemistry	3+2	6
Solid State Chemistry	3+2	6
Coordination Chemistry	3+2	6
Mechanisms of Inorganic reactions	3+2	6
Experimental Biochemistry	2+2	5

Biochemistry of Free Radicals	2+3	6
Biochemical Toxicology	2+3	5
Enzyme Kinetics	2+2	5
Nanochemistry	2+2	5
Contemporary Materials	3+2	5
Standards and Standardization	2+2	5
Surface Active Substances	2+2	5
Alternative Fuels and Lubricants	2+2	5

Qualification exam for second cycle studies at Chemistry Department

Qualification exam for the second cycle of studies at the Chemistry Department carries 50 points and includes test in chemistry (40 points) and English (10 points), which are taken in writing before the appointed Commission. The minimum number of points that allows ranking candidates and enrollment in the first year of the second cycle of studies is 15. Candidates for the entrance exam should bring an identification document (ID card or passport) and show it at the request of members of the Commission, who also acquaint candidates with the procedure taking exams. The average grade of the previous cycle of studies multiplied by 5 represents the other 50 points for ranking the candidates on the final list. Data on the average grade are taken from the documents that candidates bring when applying for the qualification exam. The results of the entrance exam and the procedure for enrolling candidates are prescribed by the competition.

Example of qualification exam in Chemistry

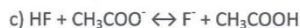
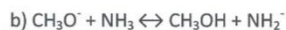
ПРИРОДНО-МАТЕМАТИЧКИ ФАКУЛТЕТ
 СП ХЕМИЈА, ДРУГИ ЦИКЛУС СТУДИЈА
 БАЊА ЛУКА, 04.11.2020.



КВАЛИФИКАЦИОНИ ИСПИТ

1. По растућем редосљеду поредати једињења на основу њихових киселости: H_2O , HF , HI , CH_3OH , CH_3COOH , NH_3 , CH_4 .

2. Одредите која се од датих честица понаша као Bronsted-ова киселина и база и означите их:



3. Разврстати дате честице према Луисовој теорији киселина и база и означити електрофиле и нуклеофиле: H_2O , I^- , NH_3 , H^+ , Fe^{2+} , ZnCl_2 , BF_3 , Mg^{2+} , CH_3^- , Cl^- , OH^- .

4. Допунити изразе:

Силицијум се у природи налази у виду минерала: _____ . Стакло је по саставу _____ и растворљиво је у _____ киселини те се због тога чува у _____ боцама.

5. Израчунати рН вриједности 0,5 М раствора натријум хидроксида и 0,5 М раствора сирћетне киселине ако је константа дисоцијације ове киселине $1,85 \cdot 10^{-5}$.

6. Оксидација амонијака може се приказати једначином:

$4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$. Стандардне моларне енталпије и моларни топлотни капацитети учесника реакције су следећи:

	$\Delta_f H_m^\circ / \text{kJ mol}^{-1}$	$C_{p,m} / \text{J mol}^{-1} \text{K}^{-1}$
$\text{NH}_3(\text{g})$	-44,024	$24,77 + 3,750 \times 10^{-2} T - 7,381 \times 10^{-6} T^2$
$\text{O}_2(\text{g})$	-	$26,19 + 1,149 \times 10^{-2} T - 3,222 \times 10^{-6} T^2$
$\text{NO}(\text{g})$	-90,374	$25,98 + 1,019 \times 10^{-2} T - 2,651 \times 10^{-6} T^2$
$\text{H}_2\text{O}(\text{g})$	-242,044	$28,83 + 1,374 \times 10^{-2} T - 1,435 \times 10^{-6} T^2$

Израчунати промјену моларне енталпије реакције при 427°C .

7. Дефинисати појам и врсте екстракције.

8. Који елемент у периодном систему има највећи атомски радијус:

a) Zn b) Na c) Sc d) Cs

9. Изједначити редокс реакцију:



10. Допунити израз:

Инсулин је хормон _____ и учествује у _____. Састоји се од _____

Example of qualification exam in English

Други циклус студија школске 2020/21. године
Студијски програм Хемија
Квалификациони испит из енглеског језика



Име и презиме кандидата _____

Biochemistry, sometimes called biological chemistry, is the study of chemical processes within and relating to, living organisms. By controlling information flow through biochemical signaling and the flow of chemical energy through metabolism, biochemical processes give rise to the complexity of life. Over the last 40 years, biochemistry has become so successful at explaining living processes that now almost all areas of the life sciences from botany to medicine are engaged in biochemical research. Today, the main focus of pure biochemistry is in understanding how biological molecules give rise to the processes that occur within living cells, which in turn relates greatly to the study and understanding of whole organisms. Biochemistry focuses on processes happening at a molecular level. It focuses on what's happening inside our cells, studying components like proteins, lipids and organelles. It also looks at how cells communicate with each other, for example during growth or fighting illness. Biochemists need to understand how the structure of a molecule relates to its function, allowing them to predict how molecules will interact.