(Table 5.2) Course unit description

Study program: Chemistry
Type and level of studies: Master academic studies
Course unit: Green chemistry
Teacher in charge: Vladimir Mihailović
Language of instruction: English
ECTS: 5
Prerequisites: Enrolled semester
Semester: Winter semester
Course unit objective Introducing students to new, more environmentally friendly chemical processes enabled by green chemistry (and engineering), and directing them towards new approaches in chemistry and its applications, in order to understand the importance and scope of chemistry in meeting the demands of modern society. Through learning about the 12 principles of green chemistry and the principles of green engineering, students will develop an understanding of the importance of sustainable development in the chemical industry and in the broader context of environmental protection.
Learning outcomes of Course unit Students will gain theoretical and practical knowledge on improving chemical processes and applying bioengineering to reduce and prevent chemical pollution at its sources. They will understand, adopt, and be able to apply the knowledge and techniques necessary for implementing the 12 principles of green chemistry. Students will become familiar with methods and techniques of green chemistry for designing products and processes that minimize or eliminate the use of hazardous and toxic chemicals harmful to humans and the environment (so-called "green" products). They will develop the ability to adapt to continuous advancements in the fields of green chemistry and green chemical technology, with an emphasis on designing processes and producing from renewable raw materials that contribute to sustainable development. The acquired knowledge can be applied in education, research and development, as well as in environmental protection and conservation.
Course unit contents *Theoretical classes:* The relationship between chemistry and the environment. The limited availability of non-renewable resources and the importance of recycling. Sustainable development and the circular economy. Agenda 2030 and the Sustainable Development Goals. Fundamentals and subject matter of green chemistry. The twelve principles of green chemistry with practical examples. Principles of green engineering and their application. Renewable and sustainable sources of raw materials. Alternative starting materials, reagents, and solvents in green chemistry (e.g., water-based paints, ionic liquids). Solvent-free reactions. Solvents in green chemistry. Catalysis as the foundation of green processes – heterogeneous and homogeneous catalysis, enzymatic catalysis. Use of microwave radiation in chemical reactions. Nanomaterials and nanotechnologies in green chemistry. Environmental biotechnology as an element of green chemistry. *Practical classes:* Use of microwave radiation in organic synthesis. Ionic liquids as green solvents. Synthesis of organic molecules in ionic liquids. Application of water as a green solvent in organic transformations. Isolation and application of biopolymers (starch and chitosan). Production of biofuels (bioethanol, biodiesel, and biogas) from renewable raw materials. Green synthesis of metal nanoparticles. Catalysts in the degradation of pollutants. Microbial transformation of pollutants. Microbial production of industrially important molecules.
Literature

1. M. Lancaster, *Green Chemistry - An Introductory Text*, RSC, Cambridge, 2002.
2. M. Doble, A. K. Kruthiventi, *Green Chemistry and Engineering*, Elsevier, Amsterdam, 2007.
3. J. Clark, D. Macquarrie, *Handbook of green chemistry and technology*, Blackwell Science Ltd, 2002.

Materials from lectures and laboratory exercises.

Number of active teaching hours				
Lectures: 2	Practice: 2	Other forms of classes:	Independent work:	Other classes:

Teaching methods

Lectures, consultations, seminars, laboratory exercises.

Examination methods (maximum 100 points)

Exam prerequisites	**No. of points**	**Final exam**	**No. of points**
Practical classes	10	Written examination	30
Tests		Oral examination	30
Homework	5	Other	
Seminars	20		
Project	5		

Grading system

Grade	**No. of points**	**Description**
10	>= 91	Excellent
9	81-90	Exceptionally good
8	71-80	Very good
7	61-70	Good
6	51-60	Passing
5	<=50	Failing