Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
RUDN University

Faculty of Science

educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

Advanced Organic Synthesis

course title

Recommended by the Didactic Council for the Education Field of:

04.04.01 «Chemistry»

field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

«Bioenergies and Biorefineries»

higher education programme profile/specialisation title

2026

1. COURSE GOAL

The goal of the course "Advanced Organic Synthesis" is to provide a deep understanding of the reactivity and properties of organic compounds and cover modern synthetic methods for the synthesis of organic compounds, including modern approaches to the construction of C-C, C-N and other C-heteroatom bonds, stereoselective synthesis and mechanistic understanding, catalytic and stoichiometric approaches to various functional group interconversions as well as to train communication skills, including feedback and opposition.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the course "Advanced Organic Synthesis" is aimed at the development of the following competences:

Table 2.1. List of competences that students acquire through the course study

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
GPC-1	Ability to carry out complex experimental and computational-theoretical studies in the chosen field of chemistry or related sciences using modern equipment, software and databases for professional purposes.	GPC-1.1. Ability to use existing and develop new methods for obtaining and characterizing substances and materials for solving problems in the chosen field of chemistry or related sciences;
		GPC-1.2. Ability to use modern equipment, software and professional databases for solving problems in the chosen field of chemistry or related sciences;
GPC-2	Ability to analyze, interpret and generalize the results of experimental and computational-theoretical work in the chosen field of chemistry or related sciences.	GPC-2.1 Ability to carry out a critical analysis of the results of own experimental and computational-theoretical works and to interpret them correctly
		GPC-2.2. Ability to formulate summary and conclusions based on the results of the analysis of literature data, own experimental and computational-theoretical works in the chosen field of chemistry or related sciences
PC-1	Ability to develop a work plan and to choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry	PC-1.1. Ability to prepare a general plan of research and detailed plans for individual stages;

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course "Advanced Organic Synthesis" refers to the **variable** component of B1 block of the higher educational programme curriculum.

Within the higher education programme students also master other (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course study.

Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
GPC-1	Ability to carry out complex experimental and computational-theoretical studies in the chosen field of chemistry or related sciences using modern equipment, software and databases for professional purposes.	Actual problems of modern chemistry Bioenergy Alternative/new tools for organic synthesis	Actual problems of modern chemistry Catalyst (nanomaterials) design and applications Catalysis: from basic principles to applications. Homogeneous, Heterogeneous, Photocatalysis, Biocatalysis, Electrocatalysis Experimental lab 1: Flow synthesis and alternative technologies Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Student Scientific- Research work Pre-graduation practical training
GPC-2	Ability to analyze, interpret and generalize the results of experimental and computational-theoretical work in the chosen field of chemistry or related sciences.	Actual problems of modern chemistry Bioenergy Modern organic synthesis and pharmacology Alternative/new tools for organic synthesis	Actual problems of modern chemistry Catalyst (nanomaterials) design and applications Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis Experimental lab 1: Flow synthesis and alternative technologies Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Student Scientific-Research work Pre-graduation practical training
PC-1	Ability to develop a work plan and to choose adequate methods for solving	Modern organic synthesis and pharmacology Alternative/new tools for organic synthesis	Catalyst (nanomaterials) design and applications Experimental lab 1: Flow synthesis and alternative

Competence code	Competence descriptor	Previous courses/modules*	Subsequent courses/modules*
	research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry		technologies Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis Emerging contaminants: from fate to environmental remediation The method of working with databases Student Scientific-Research work Pre-graduation practical training

* To be filled in according to the competence matrix of the higher education programme.

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course "Advanced Organic Synthesis" is 5 credits (180 academic hours).

*Table 4.1. Types of academic activities during the periods of higher education programme mastering (**full-time training**)**

Type of academic activities		Total academic hours	Training modules			
			1	2	3	4
Contact academic hours		24		*24*		
including:						
Lectures (LC)		16		16		
Lab work (LW)		8		8		
Seminars (workshops/tutorials) (S)						
Self-studies		*120*		*120*		
Evaluation and assessment (exam/passing/failing grade)		*36*		*36*		
Course workload	academic hours	**180**		**180**		
	credits	**5**		**5**		

5. COURSE MODULES AND CONTENTS

Table 5.1. Course contents and academic activities types

Course module title	Course module contents (topics)	Academic activities types
Module 1. General principle of retrosynthesis, stereochemistry and thermochemistry	Topic 1.1 General principles of retrosynthesis, stereochemistry and thermochemistry. Introduction, examples and possibilities.	LC
Module 2. Reactions of Carbon Nucleophiles with Carbonyl Compounds	Topic 2.1 Reactions of Carbon Nucleophiles with Carbonyl Compounds, applications in synthesis. Strategies for controlling the reactivity and the stereochemistry.	LC, LW

Course module title	Course module contents (topics)	Academic activities types
Module 3. Functional Group Interconversion by Substitution, Including Protection and Deprotection	Topic 3.1 Definition of a protecting group and their classification. Strategies for the introduction and removal of protecting groups, Examples and applications. Definition of orthogonality with protecting groups.	LC, LW
Module 4. Electrophilic Additions to Carbon-Carbon Multiple Bonds	Topic 4.1 Reactivity of unsaturated compounds with electrophiles. Definition of electrophile. Reactivity, regiochemistry and stereochemistry of electrophilic additions.	LC, LW
Module 5. Organometallic Compounds of Group I and II Metals	Topic 5.1 Organolithium and organomagnesium in synthesis. Structure and reactivity relationship. Applications in modern synthesis. Generation and use tactics.	LC, LW
Module 6. Reactions Involving Transition Metals	Topic 6.1 Synthetic strategies involving transition metals. Cross coupling reactions mediated by transition metals.	LC, LW
Module 7. Carbon-Carbon Bond-Forming Methodologies.	Topic 7.1 Basic knowledge in the formation of C-C bonds. Main routes and strategy for C-C bond formation. Examples	LC, LW
Module 8. Reactions Involving Carbocations, Carbenes, and Radicals as Reactive Intermediates	Topic 8.1 Introduction to the structure and reactivity of reactive intermediates: carbocations, carbenes and radicals. Applications in synthesis.	LC, LW
Module 9. Organocatalysis	Topic 9.1 Principles of organocatalysis, strategies for planning an organocatalytic reaction, types of organocatalytic reactions.	LC, LW
Module 10. Photocatalysis	Topic 10.1 Basic principles of photocatalysis, simple examples of photocatalytic reactions	LC, LW
Module 11. Multistep Synthesis	Topic 11.1 Planning a Multistep Synthesis, strategies for multistep synthesis	LC, LW

* - to be filled in only for **full**-time training: *LC - lectures; LW - lab work; S - seminars.*

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
Lecture	A lecture hall for lecture-type classes, equipped with a set of specialised furniture; board (screen) and a set of devices for multimedia presentations.	Projector, motorized screen for projectors, wi-fi
Lab work	A classroom for laboratory work, individual consultations, current and mid-term assessment; equipped with a set of specialised furniture and machinery.	A set of specialized furniture; specialized equipment of the chemical laboratory: fume hood SHVP-4, fume hood

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
		SHVP-2, rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital melting point determination apparatus SMP10; electronic laboratory scales AND EK-610, MK-M flask heaters of different volumes, drying cabinet, magnetic stirrer MRHei-Mix S, magnetic stirrer with heating MRHei-Standart, refractometer, combined laboratory water bath, vacuum chemical station RS3001 VARIO-pro, circulation cooler Rotacool Mini, rotary plate pump vacuum RZ2.5, membrane vacuum chemical pump MZ2CNT, Steinel thermal air blower, Spectroline UV lamp, electronic vacuum controller with CVC3000 detect Vacuumbrand valve, stainless steel emergency cabin SHVV, chemical dishes, refrigerator; wi-fi
Self-studies	A classroom for self-studies (can be used for seminars and consultations), equipped with a set of specialised furniture and computers with access to the electronic information and educational environment.	**Faculty of Science Reading Room** Ordzhonikidze D.3. Coworking area Monday - Friday 10.00 – 22.00 **Reading room of the main building of the RUDN** Coworking area Monday - Saturday 9.00 - 23.00 Hall No. 2 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45 Hall No. 6 Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45

* The premises for students' self-studies are subject to **MANDATORY** mention

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main sources:

1. Jonathan Clayden, Nick Greeves, Stuart Warren · Organic Chemistry, Oxford University Press
2. Francis A. Carey and Richard J. Sundberg - Advanced Organic Chemistry, Fifth Edition, Springer

Additional sources:

1. Website of the American Chemical Society ACS Publications: Chemistry journals, books, and references https://pubs.acs.org/
2. http://www.thieme.com/journals-main
3. http://onlinelibrary.wiley.com/
4. http://www.springer.com/gp/products/journals
5. Server with the ability to search for methods for synthesizing compounds http://www.orgsyn.org/

Internet sources

1. Electronic libraries with access for RUDN students:
- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru
- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

2. Databases and search engines:
- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/
- www.scholar.google.ru

*Training toolkit for self- studies to master the course *:*

1. A set of lectures on “Advanced Organic Synthesis
2. The laboratory workshop on “Advanced Organic Synthesis”

* The training toolkit for self- studies to master the course is placed on the course page in the university telecommunication training and information system under the set procedure.

DEVELOPERS:

Organic Chemistry Department		**Renzo Luisi**
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