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ФИО: Ястребов Олег Александрович  
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**Federal State Autonomous Educational Institution of Higher Education  
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA named after Patrice Lumumba  
RUDN University**

**Faculty of Science**

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

**COURSE SYLLABUS**

Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, Photocatalysis,  
Biocatalysis, Electrocatalysis

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course title

**Recommended by the Didactic Council for the Education Field of:**

04.04.01 «Chemistry»

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field of studies / speciality code and title

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

«Bioenergies and Biorefineries»

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higher education programme profile/specialisation title

**2025**

## 1. COURSE GOAL

The goal of the course “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, Photocatalysis, Biocatalysis, Electrocatalysis” is to provide the basis for the different types of catalytic processes from homogeneous to heterogeneous, photo, electro and biocatalysis from the basics to a number of examples illustrating the concepts.

## 2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the course “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis” 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-1.3. Ability to use modern computational and theoretical methods of chemistry to solve professional problems
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

## 3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis” 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 Advanced Organic Synthesis	Actual problems of modern chemistry Advanced Organic Synthesis 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 Bioproducts, Biomaterials and Biorefineries Advanced Organic Synthesis	Actual problems of modern chemistry History and philosophy of science Experimental lab 2: Biorefineries and Bioproducts Experimental lab 3: Advanced Organic Synthesis 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 “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis” is 4 credits (144 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
<i>Contact academic hours</i>		27			27	
including:						
Lectures (LC)		18			18	
Lab work (LW)		9			9	
Seminars (workshops/tutorials) (S)						
<i>Self-studies</i>		72			72	
<i>Evaluation and assessment (exam/passing/failing grade)</i>		9			9	
<b>Course workload</b>	academic hours	<b>108</b>			<b>108</b>	
	credits	<b>3</b>			<b>3</b>	

## 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. Introduction to Catalysis	Topic 1.1 Introduction to Catalysis. Catalysis as a pillar of our future society. Types of catalysis. Examples.	LC
Module 2. Homogeneous catalysis. Basics, principles and examples	Topic 2.1 Homogeneous catalysis. Basics, principles and examples. Catalyst design. Applications.	LC, LW
Module 3. Heterogeneous catalysis. Basics, principles and examples	Topic 3.1 Heterogeneous catalysis. Basics, principles and examples. Catalyst design. Applications.	LC, LW
Module 4. Photocatalysis. Basics, principles and examples	Topic 4.1 Photocatalysis. Basics, principles and examples. Photocatalyst design. Applications.	LC, LW
Module 5. Biocatalysis. Basics, principles and examples	Topic 5.1 Biocatalysis. Basics, principles and examples. Biocatalyst design. Applications.	LC, LW
Module 6. Electrocatalysis. Basics, principle and examples	Topic 6.1 Electrocatalysis. Basics, principle and examples. Electrocatalyst design. Applications.	LC, LW
Module 7. Differences and similarities. A comparison between Catalysis types	Topic 7.1 Differences and similarities. A comparison between Catalysis types. Pros and cons. Possibilities and combinations of catalytic processes (e.g. chemo-biocatalysis). Perspectives and combination with modern tools (e.g. flow chemistry)	LC, LW
Module 8. Conclusions and prospects	Topic 8.1 Conclusions and prospects	LC

\* - 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	A set of specialized furniture; specialized equipment of the chemical

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
	furniture and machinery.	laboratory: fume hood SHVP-4, fume hood SHVP-2, rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital devices for determining the melting point 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.	<b>Faculty of Science Reading Room</b> Ordzhonikidze D.3. Coworking area Monday - Friday 10.00 – 22.00 <b>Reading room of the main building of the RUDN</b> 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

Type of academic activities	Classroom equipment	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
		Monday - Thursday 10.00 - 17.45 Friday 10.00 - 16.45

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

## 7. RECOMMENDED RESOURCES FOR COURSE STUDY

### *Main sources:*

1. Catalysis Series, RSC publishing, Series DOI: 10.1039/1757-6733; Print ISSN: 1757-6725; Electronic ISSN: 1757-6725, <https://books.rsc.org/collection/79/Catalysis-Series>
2. Heterogeneous Catalysis; Eds. R. Luque, A. Burange, American Chemical Society, 2022. DOI: 10.1021/acsinfocus.7e5032
3. Heterogeneous Catalysts: Advanced Design, Characterization and Applications
4. Eds. W-Y. Teoh, A. Urakawa, Y. H. Ng, P. Sit, 2021, Wiley-VCH, ISBN:9783527344154 DOI:10.1002/9783527813599

### *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](http://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/](https://www.yandex.ru/)

- Google search engine <https://www.google.ru/>
- Scopus abstract database <http://www.elsevierscience.ru/products/scopus/>
- [www.scholar.google.ru](http://www.scholar.google.ru)

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

1. A set of lectures on “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis”
2. The laboratory workshop on “Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis”

\* 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**

position, department

signature

**Rafael Luque**

name and surname

**HEAD OF EDUCATIONAL  
DEPARTMENT:**

**Organic Chemistry Department**

name of department

signature

**Voskressensky L.G.**

name and surname

**HEAD  
OF HIGHER EDUCATION  
PROGRAMME:**

**Dean of Faculty of Science,**

**Head of Organic Chemistry**

**Department**

position, department

signature

**Voskressensky L.G.**

name and surname