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

INTERNSHIP SYLLABUS

Physical research methods in catalysis
internship title

Recommended by the Didactic Council for the Education Field of:

04.04.01 «Chemistry»
field of studies / speciality code and title

The student's internship is implemented within the professional education programme of higher education:

Modern integrative chemistry
higher education programme profile/specialisation title

2025 г.

1. INTERNSHIP GOAL(s)

The purpose of mastering the discipline "Physical research methods in catalysis" is to provide students with theoretical and practical knowledge on the application of physico-chemical methods to study catalytic processes at the modern level and in conjunction with other sciences. The discipline "Physical research methods in catalysis" is aimed at studying the basics of the theory and practice of physico-chemical analysis of substances, the main experimental patterns underlying physico-chemical research methods, their connection with modern technologies, as well as the formation of students' competencies that allow for the experimental determination of patterns of change in physico-chemical properties and numerical calculations calculations of the corresponding physico-chemical quantities.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Table 2.1. List of competences that students acquire during the internship

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
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;
		PC-1.2. Ability to select experimental and calculation-theoretical methods for solving the problems based on the available material and time resources
PC-2	Ability, based on a critical analysis of the results of research and development, to evaluate the prospects for their practical application and continuation of work in the chosen field of chemistry, chemical technology or sciences related to chemistry.	PC-2.1. Ability to systematize information obtained in the course of research and development, to analyze it and compare it with literature data;
		PC-2.2. Ability to determine possible directions for the development of work and prospects for the practical application of the results obtained

3. INTERNSHIP IN HIGHER EDUCATION PROGRAMME STRUCTURE

The discipline "Physical methods of research in catalysis" refers to the elective component of the B1 block of the EP of HE.

Within the framework of the EP, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline "Physical research methods in catalysis".

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

Competence code	Competence descriptor	Previous courses/modules, internships*	Subsequent courses/modules, internships*
PC-1	The ability to plan work and choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or related sciences	Actual tasks of modern chemistry Organization and planning of scientific research Theory and problems of physical chemistry Data analysis in chemistry Chemistry of nanostructured systems Module: Selected chapters of the main areas of chemistry Module: Modern problems of chemistry Scientific seminar Completing a Master's thesis	Research work Pre-graduate practice
PC-2	He is able, based on a critical analysis of the results of research and development, to assess the prospects for their practical application and continuation of work in the chosen field of chemistry, chemical technology or related sciences	Organization and planning of scientific research Scientific seminar Completing a Master's thesis	Research work Pre-graduate practice

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

4. INTERNSHIP WORKLOAD

The total labor intensity of the discipline "Physical research methods in catalysis" is 5 credit units.

Table 4.1. Types of educational work by periods of mastering the educational program for FULL-time education

Type of educational work		TOTAL, ac.h.	Semester(s)			
			1	2	3	4
Contact work, ac.h.		*72*			*72*	
including:						
Lectures		36			36	
Laboratory work		36			36	
Practical / seminar classes						
Independent work of students, ac.h.		*72*			*72*	
Control (exam / test with assessment), ac.h.		*36*			*36*	
Total labor intensity of the discipline	ac.h.	**180**			**180**	
	c.u.	**5**			**5**	

5. INTERNSHIP CONTENTS

*Table 5.1. Internship contents**

Name of the discipline section	Content of the section (topics)	Type of educational work
Section 1. General characteristics and classification of physical research methods.	Topic 1.1. General characteristics and classification of physical research methods. Direct and inverse problems, characteristic time of the methods.	LC, LW
	Topic 1.2. Possibilities of physical methods and their applications	
Section 2. X-ray spectral methods of analysis of catalytic systems	Topic 2.1. Determination of the crystal and electronic structure, surface condition of catalytic nanosystems before and after catalysis. LC, LR	LC, LW
	Topic 2.2. The influence of the composition of the catalyst surface on the nature of the processes occurring on it	
Section 3. Atomic adsorption methods for studying the chemical composition of catalysts	Topic 3.1. The theoretical and practical foundations of the atomic absorption method of analysis, the main components of atomic absorption spectrometers, including radiation sources, atomizers, etc. are considered	LC, LW
	Topic 3.2. Types of interfering influences and ways to eliminate them, basic methodological approaches to the analytical determination of elements in various objects of catalytic systems using flame and electrothermal atomization methods, metrological characteristics of the method	
Section 4. Application of IR, UV and visible spectroscopy methods in the study of adsorption-catalytic systems.	Topic 4.1. Classification and assignment of electronic transitions and corresponding bands in the UV and visible spectra.	LC, LW
	Topic 4.2. Application of electronic spectra. Application of IR and UV spectroscopy methods in analysis, investigation of equilibria and kinetics of reactions.	
	Topic 4.3. Application of IR, UV and visible spectroscopy methods in the study of adsorption-catalytic systems.	
Section 5. Mass spectrometry and resonance methods in catalysis	Topic 5.1. Mass spectrometers, mass spectrum, principles of operation of mass spectrometers and possibilities of their application. Determination of the structure of a molecule by chemical shifts and spin-spin splits in the NMR spectra.	LC, LW

	Topic 5.2. The structure of EPR spectra. Diffraction methods, their features and possibilities for studying adsorbate-adsorbent systems.	
Section 6. Surface determination by adsorption of specific and non-specific absorbates	Topic 6.1. Surface determination by adsorption of specific and non-specific absorbates.	LC, LW
	Topic 6.2. Determination of specific surface area, pore size distribution, as well as pore shape and volume.	
	Topic 6.3. The use of various approaches in qualitative, structural and quantitative analyses of pores of catalytic systems.	
	Topic 6.4. Experimental methods for determining surface acidity.	

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

6. INTERNSHIP EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Type of audience	**Equipment of the audience**	**Specialized educational /laboratory equipment, software and materials for the development of the discipline** (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; a blackboard (screen) and technical means of 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 chemical laboratory equipment: computer, Crystal Chromatograph 2000 M Crystal 5000 Chromatograph Catalytic plant "Fischer–Tropsch synthesis" Catalytic plant "Carbon dioxide conversion of methane" Thermal desorption unit, TLT T23D centrifuge, Water thermostat, Chromatograph Color, Infrared spectrometer FT-02, Gas chromatograph with quadrupole mass detector, flame ionization detector, thermal conductivity detector, electronic capture detector. Catalytic atmospheric pressure unit, Catalytic unit "Dehydration of alcohols"

Type of audience	Equipment of the audience	Specialized educational /laboratory equipment, software and materials for the development of the discipline (if necessary)
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.	

7. RESOURCES RECOMMENDED FOR INTERNSHIP

Main readings:

1. Physico-chemical fundamentals of materials science: Textbook / G. Gottstein; Edited by V.P.Zlomanov; Translated from English by K.N.Zolotova, D.O.Charkin. - M.: BINOM, 2016. - 400 p.: ill. - (The best foreign textbook). - - - - ISBN 978-5-94774-769-0: 400.00 p. http://lib.rudn.ru/MegaPro/Web/SearchResult/ToPage/1 34.2 - G 74
2. Physical methods of analysis of changes: trans. S.A.Belyaev and V.V.Yakovlev; edited by I.P.Alimarin. - M.: Mir, 1967. - - 416 p. - 2.75. http://library of RUDN .ru/MegaPro/Web/Search result/Topage/1

Additional readings:

1. Methods of studying genetic changes: A large number for researchers / A.V. Novoselova. - M.: Higher School, 1980. - 166 p.: ill. - 0.25. http://lib.rudn.ru/MegaPro/Web/SearchResult/ToPage/1
2. Methods of research of materials and processes: A textbook for universities / V.Yu. Konyukhov, I.A. Gogoladze, Z.V. Murga. - 2nd ed., ispr. and add. - M.: Yurayt, 2018. - 226 p. - (Universities of Russia). - ISBN 978-5-534-05475-0: 459.00 p. http://lib.rudn.ru/MegaPro/Web/SearchResult/ToPage/1 24.4 - K 65
3. Physical research methods in chemistry: Resonant and electro-optical methods: Textbook for universities / L.V. Vilkov, Yu.A. Pentin. - M.: Higher School, 1989. - 288 p.: ill. - - - - In 5-06-00071-0 number ISBN: 0.95. http://lib.rudn.ru/MegaPro/Web/SearchResult/ToPage/124.4 - B44

Internet sources

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:

- 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 databasehttp://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for students' independent work during the development of the discipline/module:*

1. A course of lectures on the discipline "Physical research methods in catalysis".
2. Laboratory workshop on the discipline "Physical research methods in catalysis"

*The training toolkit and guidelines for the discipline are placed on the discipline page in the university telecommunication training and information system under the set procedure.

DEVELOPERS:

Associate Professor, Department of Physical and Colloidal Chemistry		**Markova E.B.**
position, educational department	signature	name and surname.

THE HEAD OF DEPARTMENT:
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		Cherednichenko A.G.
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HEAD OF HIGHER EDUCATION PROGRAMME:
Dean of Faculty of Science, Head of Organic Chemistry Department **Voskressensky L.G**

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