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

Chemistry of coordination compounds

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

1. INTERNSHIP GOAL(s)

The Internship aims at mastering fundamental knowledge in the field of modern coordination chemistry, systematization of ideas about the formation of chemical bonds, synthesis methods, studies of the composition, structure, and physicochemical properties of coordination compounds for those students who strive to obtain modern ideas about coordination compounds, the relationship between structure and reactivity, as well as the scope of their possible application, and to prepare for research work in the field of coordination chemistry; acquire professional skills and abilities of independent research and search work.

- gain an understanding of workplace dynamics, professional expectations.
- build proficiency in a range of research skills appropriate to the field of the internship placement, including learning to critically analyse and evaluate modern scientific achievements, and generate new ideas.
- refine and clarify professional and career goals through critical analysis of the internship experience or research project.
- introduce students to a professional environment of coordination chemistry.

2. REQUIREMENTS FOR LEARNING OUTCOMES

The internship implementation is aimed at the development of the following competences (competences in part):

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 analyse 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 internship refers to the elective component of B1 block of the higher educational programme curriculum.

Underline whatever applicable. The core component includes all introductory field internships, the variable component includes all advanced field internships, except for research and pre-graduate types of the internship. The elective module includes all research and pre-graduation types of the internship (if any).

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

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	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.	Current problems 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 Undergraduate practice
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.	Organization and planning of scientific research Scientific seminar Completing a master's thesis	Research work Undergraduate practice

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

4. INTERNSHIP WORKLOAD

The total workload of the internship is 3 credits (108 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		36			*36*	
Lectures (LC)		36			36	
Lab work (LW)						
Seminars (workshops/tutorials) (S)						
Self-studies		*54*			*54*	
Evaluation and assessment (exam/passing/failing grade)		*18*			*18*	
Course workload	academic hours	**108**			**108**	
	credits	**3**			**3**	

5. INTERNSHIP CONTENTS

Table 5.1. Internship contents

Course module title	Course module contents (topics)	Academic activities types
Module 1. Basic principles of the theory of the structure of coordination compounds	1.1. Coordination and complex compounds. Basic concepts and definitions. Structure of complex compounds. Nomenclature. Main types of classification.	LC
	1.2. Stereochemistry of coordination compounds. Spatial interpretation of coordination numbers. Factors influencing the structure of coordination polyhedra. Factors contributing to the distortion of regular coordination polyhedra.	LC
	1.3. Isomerism of coordination compounds. Types of isomerism. Ligand isomerism. Bond isomerism. Stereoisomerism: geometric, optical, and conformational isomerism. Solvate and ionization isomerism.	LC
Module 2. Electronic structure of coordination compounds. Chemical bonding in coordination compounds.	2.1 Electronic structure of transition metal atoms. Ionic-covalent and electrostatic representations. Effective atomic number concept. The theory of repulsion of electron pairs of the valence shell of compounds.	LC
	2.2. Valence bond method. Dative and donor-acceptor interactions. Hybridization of atomic orbitals. External orbital and intraorbital complexes. Magnetic properties of coordination compounds in the light of the theory of valence bonds. Advantages and disadvantages of the valence bond method.	LC
	2.3. Crystal field theory (CFT). Basic provisions. Methods for splitting d-sublevels of a	LC

Course module title	Course module contents (topics)	Academic activities types
	complexing agent in fields of different symmetries. Splitting parameter. High- and low-spin complexes. Energy of stabilization by the ligand field. Explanation of the spectral and magnetic properties of coordination compounds. Irving–Williams's series. Electronic spectra of coordination compounds. Colour of complex compounds. Tanabe-Sugano diagrams. Structural and thermodynamic effects of level splitting. Jahn-Teller effects. Disadvantages of crystal field theory.	
	2.4. Molecular orbital (MO) method. Energy level diagrams of molecular orbitals for an octahedral complex with a central d-element atom and ligands that do not have π orbitals. Effect of π-bonding on Δ_0 parameters. Nephelauxetic effect. Spectrochemical series of ligands.	LC
	2.5. Magnetic and optical properties of coordinate compounds. Low-spin and high-spin complexes. Comparison of crystal field theory and ligand field theory.	LC
Module 3. Mutual influence of ligands in the inner sphere of coordination compounds.	3.1. Mutual influence of ligands. The concept of trans influence. The pattern of trans-influence. Trans-influence mechanisms: electrostatic theory, polarizability concept, π-bond theory. Using the law of trans-influence for the synthesis of geometrically isomeric coordination compounds. Dynamic trans-influence. Qualitative and quantitative characteristics of trans influence. Cis influence of ligands. Mutual influence effects and X-ray electron spectroscopy. Chugaev's cycle rule.	LC
Module 4. Reactions involving coordination compounds.	4.1. Concept and criteria for the stability of coordination compounds. Nature of the complexing agent. Nature of ligands. Chelation effect. Macrocyclic and cryptate effects.	LC
	4.2. Acid-base properties of complex compounds. Lewis concept of acids and bases. Theory of hard and soft acids and bases.	LC
	4.3. Redox properties of coordination compounds. Types of redox transformations of coordination compounds. Intra-sphere and outer-sphere mechanisms. Oxidative addition and reductive elimination reactions. Stabilization of unusual oxidation states of the central ion at coordination.	LC
Module 5. Kinetics of reactions of complex formation.	5.1. Mechanisms of substitution reactions of coordination compounds. Dissociative and associative substitution. Radical and ionic	LC

Course module title	Course module contents (topics)	Academic activities types
	mechanisms. Intermediates and transition states. Labile and inert coordination compounds. Agreed addition. Cascade transformations.	
Module 6. Studies of complex formation in solutions.	6.1. Primary and secondary dissociation of coordination compounds. Instability constants and stability constants. Formation constants. Functions characterizing complex formation in solutions. Formation function and formation curves. Experimental methods for studying equilibria in solutions of coordinate compounds.	LC
Module 7. Synthesis and application of coordination compounds.	7.1. Strategy for the synthesis of coordination compounds. Direct and indirect routes of synthesis. Examples of the synthesis of coordination compounds. π-complexes. Macrocyclic complexes. Metal organic frameworks (MOFs). Coordination polymers.	LC
	7.2. Natural coordination compounds, their biological significance for life. Applied aspects of the use of synthetic coordination compounds.	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
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.	

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

7. RECOMMENDED RESOURCES FOR COURSE STUDY

Main readings:

1. Birgit Weber. Coordination Chemistry. Basics and Current Trends. Springer, 2023.

2. Joan Ribas Gispert. Coordination Chemistry. WILEY-VCH, 2008.

3. Vasishta Bhatt. Essentials of Coordination Chemistry. A Simplified Approach with 3D Visuals. Academic Press, 2016.

Additional readings:

1. Geoffrey A. Lawrance. Introduction to Coordination Chemistry 1st Edition. Wiley, 2010.
2. Comprehensive Coordination Chemistry III. Editors Edwin Constable, Gerard Parkin, Lawrence Que. Elsevier, 2021.
3. G. J. Leigh, N. Winterton. Modern Coordination Chemistry. The Royal Society of Chemistry 2002.

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 database http://www.elsevierscience.ru/products/scopus/

The training toolkit and guidelines for a student to do an internship, keep an internship diary and write an internship report:

1. Safety regulations to do the internship (safety awareness briefing).
2. Machinery and principles of operation of technological production equipment used by students during their internship; process flow charts, regulations, etc. (if necessary).
3. Guidelines for keeping an internship diary and writing an internship report.

*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.

DEVELOPER:

Professor, Department of General and Inorganic Chemistry		**Kovalchukova O.V.**
position, educational department	signature	name and surname.

HEAD OF EDUCATIONAL DEPARTMENT:

General and Inorganic Chemistry Department		**Khrustalev V.N.**
name of department	signature	name and surname

HEAD OF HIGHER EDUCATION PROGRAMME: Dean of Faculty of Science, Head of Organic Chemistry Department		**Voskressensky L.G**
position, department	signature	name and surname