

**NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES  
OF UKRAINE**

Chair of Analytical and Bioinorganic Chemistry & Water Quality

**APPROVED**

by the Dean of the Faculty of Plant Protection,  
Biotechnology and Ecology  
“22” June 2026

**CURRICULUM OF ACADEMIC DISCIPLINE  
CHEMISTRY (INORGANIC AND ANALYTICAL)**

Area of knowledge E «Natural Sciences, Mathematics and Statistics»

Specialty E2 Ecology

Faculty of Plant Protection, Biotechnology and Ecology

Developed by: Larysa VOITENKO, Docent, Candidate of Chemical Sciences  
(*position, academic degree, academic rank*)

Kyiv – 2026

## **Description of the discipline Chemistry (inorganic and analytical)**

Inorganic chemistry studies the theoretical foundations of the modern inorganic chemistry, including the chemical properties and transformations of macronutrients, micronutrients, toxic elements and their compounds. Chemical properties are described in terms of atomic-molecular studies, acid-base chemistry, redox processes and complexation. The laboratory course involves the preparation and study of a number of types of inorganic and complex compounds. Analytical chemistry (chemical analysis) is the area of chemistry responsible for characterizing the composition of matter, both qualitatively (what is present) and quantitatively (how much is present). Course includes: (1) the qualitative tests of cations and anions; (2) methods of identification of soluble and insoluble substances; (3) gravimetric analysis; (4) volumetry (neutralization, RedOx methods, precipitation titrimetry; complexonometry).

<b>Area of knowledge, specialty, academic programme, academic degree</b>		
Academic degree	<i>Bachelor's</i>	
Specialty	<i>E2 Ecology</i>	
Academic programme	<i>Ecology</i>	
<b>Characteristics of the discipline</b>		
Type	Mandatory	
Total number of hours	150	
Number of ECTS credits	5	
Number of modules	4	
Form of assessment	<i>exam</i>	
<b>Indicators of the discipline for full-time and part-time forms of university study</b>		
	<b>University study</b>	
	<b>Full-time</b>	<b>Part-time</b>
Year of study	1	No
Term	15 weeks	
Lectures	45 <i>hours</i>	<i>hours</i>
Practical classes and seminars	<i>hours</i>	<i>hours</i>
Laboratory classes	45 <i>hours</i>	<i>hours</i>
Self-study	60 <i>hours</i>	<i>hours</i>
Number of hours per week for full-time students	6 <i>hours</i>	

### **1. Aim, competences and expected learning outcomes of the discipline**

Aim is to develop an understanding of the range and uses of inorganic chemistry and analytical qualitative and quantitative methods for the application in monitoring and research of the environmental objects, and formation of skills in chemical experiment performing.

*List of academic disciplines preceding the study of "Chemistry (inorganic and analytical)": secondary school level in Chemistry*

***Competences acquired:***

Integral competence (IC): The ability to solve complex specialized tasks and solve practical problems in the field of ecology, environmental protection and sustainable use of nature, or in studies that involve the application of basic theories and methods of environmental sciences and are characterized by the complexity and uncertainty of conditions.

General competence (GC):

GC08. Ability to conduct research at an appropriate level.

GC11. Ability to evaluate and ensure the quality of work performed.

Special (professional) competence (SC):

SC16. Ability to critically reflect on the basic theories, methods and principles of the natural sciences.

**Expected learning outcomes (ELO):**

ELO03. Understand the basic concepts, theoretical and practical problems in the field of natural sciences, which are necessary for analysis and decision-making in the field of ecology, environmental protection and optimal nature use.

ELO21. Be able to choose the optimal methods and tools for conducting research, collecting and processing data.

## 2. Programme and structure of the discipline

Modules and topics	Number of hours					
	full-time					
	weeks	total	including			
lec			lab	ind.	s.st.	
<b>Module 1. <i>Quantum-chemical foundations of periodicity and chemical bonding</i></b>						
Topic 1. Epistemology and conceptual framework of inorganic chemistry. System of chemical elements as a natural-scientific paradigm. Stoichiometric laws and their role in environmental analytics	1	6	2	2		2
Topic 2. Quantum-mechanical model of multielectron atoms. Electron configuration, energy hierarchy, and spectroscopic terms		4	2			2
Topic 3. Periodic law in the light of quantum theory. Periodicity of atomic radii, ionisation energy, electron affinity, electronegativity. Anomalies and trends	2	8	2	4		2
Topic 4. Quantum-chemical approaches to chemical bonding. Molecular orbital (MO), valence bond (VB), and crystal field theories. Molecular geometry, hybridisation, and intermolecular interactions	3	6	4			2
Total for module 1, hours		24	10	6		8

Modules and topics	Number of hours					
	full-time					
	weeks	total	including			
lec			lab	ind.	s.st.	
<b>Module 2. <i>Physicochemical equilibria in homogeneous and heterogeneous systems</i></b>						
Topic 1. Chemical kinetics and thermodynamics of reversible reactions. Le Chatelier principle. Equilibrium constants. Solutions as multicomponent systems. Electrolytic dissociation	4	8	2	2		4
Topic 2. Proton transfer equilibria. Brønsted-Lowry theory. Hydrolysis of salts. Buffer systems. pH as an environmental parameter	5	12	4	4		4
Topic 3. Redox equilibria. Standard electrode potentials. Nernst equation. Eh-pH diagrams (Pourbaix diagrams) for environmental assessment	6	12	2	4		6
Topic 4. Coordination chemistry and complexation equilibria. Ligand field theory. Stability constants. Role of complexation in metal speciation in natural waters	7	6	2	2		2
Total for module 2, hours		38	10	12		16
<b>Module 3. <i>Analytical chemistry: qualitative identification and systematic analysis of inorganic matrices</i></b>						
Topic 1. Foundations of chemical analysis. Analytical signal, sensitivity, selectivity. Semimicro qualitative analysis technique	7-8	20	4	8		8
Topic 2. Systematic qualitative analysis of cations and anions. Analytical groups. s-, p-, d-elements. Analysis of salts, acids, bases, oxides. Validation of results	9	16	4	4		8
Total for module 3, hours		36	8	12		16
<b>Module 4. <i>Quantitative chemical analysis: gravimetric and titrimetric methods for environmental monitoring</i></b>						
Topic 1. Heterogeneous equilibria in analytical chemistry. Solubility product ( $K_{sp}$ ). Gravimetric analysis	10	12	4	2		6
Topic 2. Acid-base titrimetry (neutralisation method). Titration curves, equivalence point, indicators. Alkalinity of natural waters	11	12	4	4		4

Modules and topics	Number of hours					
	full-time					
	weeks	total	including			
lec			lab	ind.	s.st.	
Topic 3. Redox titrimetry. Permanganometry, iodometry. Applications in environmental analysis (COD, dissolved oxygen, heavy metals)	12-13	13	4	5		4
Topic 4. Complexometric titrimetry and metrology. EDTA titrations. Water hardness. Error, uncertainty, statistical processing	14-15	15	5	4		6
Total for module 4, hours		52	17	15		20
<b>Total hours</b>		150	45	45		60

### 3. Topics of lectures

No.	Topic	Hours
1	<b>Epistemology and conceptual framework of inorganic chemistry.</b> The system of chemical elements as a natural-scientific paradigm. Stoichiometric laws and their role in environmental analytics. Classification of inorganic substances.	2
2	<b>Quantum-mechanical model of multielectron atoms.</b> Electron configuration, energy hierarchy, and spectroscopic terms. Pauli exclusion principle, Hund's rule, and the Aufbau principle. Atomic orbitals and quantum numbers.	2
3	<b>Periodic law in the light of quantum theory.</b> Periodicity of atomic radii, ionisation energy, electron affinity, and electronegativity. Anomalies and trends across periods and groups. Relativistic effects for heavy elements.	2
4-5	<b>Quantum-chemical approaches to chemical bonding.</b> Molecular orbital (MO), valence bond (VB), and crystal field theories. Molecular geometry, hybridisation, and intermolecular interactions (hydrogen bonding, van der Waals forces).	4
6	<b>Chemical kinetics and thermodynamics of reversible reactions.</b> Reaction rates, activation energy, and catalysis. Le Chatelier principle. Thermodynamic functions (enthalpy, entropy, Gibbs free energy). Equilibrium constants and their environmental significance.	2
7	<b>Solutions as multicomponent systems.</b> Concentration units and their interconversion. Concentration units in analytical chemistry: molarity (M), molality (m), normality (N), mole fraction ( $\chi$ ), percentage concentration (w/v, w/w, v/v), parts per million (ppm), parts per billion (ppb). Interconversion of	2
	concentration units using density and molar mass. Electrolytic dissociation. Strong and weak electrolytes. Ionic strength and activity coefficients. Ionic equations in analytical practice.	
8	<b>Proton transfer equilibria.</b> Brønsted–Lowry theory of acids and bases. Autoionisation of water. pH scale and its environmental significance. Hydrolysis of salts. Buffer systems and buffer capacity.	2

No.	Topic	Hours
9	<b>Redox equilibria.</b> Standard electrode potentials. Nernst equation. Eh-pH diagrams (Pourbaix diagrams) for environmental assessment. Disproportionation and comproportionation reactions.	2
10	<b>Fundamentals of electrochemistry.</b> Galvanic cells and electrolysis. Corrosion as an electrochemical process. Redox indicators. Applications in environmental monitoring.	2
11	<b>Coordination chemistry and complexation equilibria.</b> Ligand field theory. Stability constants of complexes. Stepwise and overall formation constants. Chelate effect. Role of complexation in metal speciation in natural waters and soils.	2
12	<b>Foundations of chemical analysis.</b> Analytical signal, sensitivity, detection limit, selectivity, and accuracy. Classification of analytical methods (classical and instrumental). Organisation of semimicro qualitative analysis. Analytical reactions and requirements.	2
13	<b>Systematic qualitative analysis of cations.</b> Analytical groups of cations. s-elements (IA, IIA), p-elements (IIIA, IVA), d-elements (IIIB, VB). Separation and identification strategies. Group reagents and selective reactions.	2
14	<b>Systematic qualitative analysis of anions.</b> Analytical groups of anions. p-elements (VIIA, VIA, VA, IVA). Specific and characteristic reactions. Interfering anions and their elimination.	2
15	<b>Qualitative analysis of inorganic substances.</b> Analysis of salts, acids, bases, and oxides. Systematic analytical scheme for unknown solid samples. Validation and documentation of results.	2
16	<b>Introduction to quantitative chemical analysis.</b> Classification of quantitative methods. Gravimetric analysis: principles, procedures, and calculations. Precipitation and ignition techniques.	2
17	<b>Metrological foundations of chemical analysis.</b> Measurement uncertainty, systematic and random errors. Precision, accuracy, and bias. Statistical processing of analytical results (mean, standard deviation, confidence intervals)	2
18	<b>Heterogeneous equilibria in analytical chemistry.</b> Solubility product ( $K_{sp}$ ) and its applications. Conditions for precipitation and dissolution. Fractional precipitation. Relationship between $K_{sp}$ and molar solubility. Recalculation of concentration units (M, N, ppm) in gravimetric analysis.	2
19	<b>Acid-base titrimetry (neutralization method).</b> Titration curves for strong and weak acids/bases. Equivalence point and titration jump. Choice of acid-base indicators. Alkalinity and acidity of natural waters. Buffer solutions in analytical practice.	2
20	<b>Redox titrimetry.</b> Classification of redox methods: permanganometry, iodometry, iodimetry, dichromatometry, bromatometry. Theoretical basis. Applications in environmental analysis (COD, dissolved oxygen, determination of heavy metals).	2
21	<b>Permanganometry and iodometry in detail.</b> Principles, standard solutions, indicators, and typical analytical procedures. Advantages and limitations. Calculation of equivalence points and concentrations.	2

No.	Topic	Hours
23	<b>Applications of complexometry in environmental monitoring.</b> Determination of total water hardness ( $\text{Ca}^{2+}$ and $\text{Mg}^{2+}$ ). Analysis of soil extracts and industrial wastewater. Comparison of titrimetric methods.	2
24	<b>Integrated approach to quantitative analysis of environmental samples.</b> Selection of analytical method based on matrix, concentration range, and regulatory requirements. Quality control and quality assurance (QC/QA). Documentation and reporting.	3
	Total	45

#### 4. Topic of laboratory classes

No.	Topic	Hours
1	Introduction. Lab Safety rules. Semimicro qualitative lab techniques. The introduction testing. Synthesis and property analysis of inorganic compounds. Qualitative observations of physical and chemical transformations.	2
2	Electron formulas compiling. Determination of valence and	2
No.	Topic	Hours
	oxidation number of the chemical elements as a function of their electron configuration. Electron configuration simulation (i.e., <a href="https://www.wolframalpha.com/widgets/gallery/view.jsp?id=bd4637e2261cbcdda20d9077e61c712f&amp;reportprob=1">https://www.wolframalpha.com/widgets/gallery/view.jsp?id=bd4637e2261cbcdda20d9077e61c712f&amp;reportprob=1</a> )	
3	Periodicity as an expression of electron shell structures. Visualization of the periodicity (i.e., <a href="https://www.behance.net/gallery/46554621/Visualizing-the-Periodic-System-of-Chemical-Elements">https://www.behance.net/gallery/46554621/Visualizing-the-Periodic-System-of-Chemical-Elements</a> ). Systematic analysis of s- and p-block element compounds. Comparative study of oxide and hydroxide behaviour across periods	2
4	Qualitative assessment of chemical bonding types and molecular structure of acids, bases, salts, oxides. Virtual simulation of chemical bonds and visualization of molecules (i.e. "Avogadro" tool <a href="https://sourceforge.net/projects/avogadro/files/avogadro/">https://sourceforge.net/projects/avogadro/files/avogadro/</a> )	2
5	Experimental studding of strong and weak electrolytes from viewpoint of Avogadro's electrolytic dissociation theory. How to compile the ionic equations. How to use the net ionic calculator (i.e., <a href="https://www.chemicalaid.com/tools/netionicequation.php?hl=en">https://www.chemicalaid.com/tools/netionicequation.php?hl=en</a> ).	2
6	Experimental studding of hydrolysis of salts in water medium. How to predict and to measure of a pH. How to use a Hydrolysis calculator (i.e., <a href="https://www.calculatoratoz.com/en/anionic-salt-hydrolysis-Calculators/CalcList-2611">https://www.calculatoratoz.com/en/anionic-salt-hydrolysis-Calculators/CalcList-2611</a> ).	2
7	Experimental studding of RedOx processes; chemical nature of Reducing and oxidizing agents. RedOx potential and its measuring in water medium. Electron balance and half-reaction methods. How to use a RedOx calculator (i.e., <a href="https://calculator-online.net/redox-reaction-calculator/">https://calculator-online.net/redox-reaction-calculator/</a> ).	2
8	Experimental studding of complexing processes. How to isolate and decompose the coordinative compounds. IUPAC nomenclature of coordinate compounds ( <a href="https://unacademy.com/content/jee/study-material/chemistry/iupac-nomenclature-of-coordination-compounds/">https://unacademy.com/content/jee/study-material/chemistry/iupac-nomenclature-of-coordination-compounds/</a> )	2
9	Introduction to chemistry of elements and their qualitative analysis. The action of general group reagents on metal cations.	4
10	Analytical classification of the main bioactive cations. Separation and identification of I-IV cation groups according to the ammine-phosphate classification.	2

11	Studying of chemical-analytical properties and qualitative tests of s-element cations (on the example of $\text{Na}^+$ , $\text{K}^+$ , $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Mg}^{2+}$ ) and ammonia cation $\text{NH}_4^+$ . Studying of chemical-analytical properties and qualitative tests of p-element cations (on the example of $\text{Al}^{3+}$ , $\text{Pb}^{2+}$ ).	4
No.	Topic	Hours
12	Analytical classification of the main bioactive anions. Separation and identification of anions $\text{SO}_4^{2-}$ , $\text{SO}_3^{2-}$ , $\text{CO}_3^{2-}$ , $\text{PO}_4^{3-}$ , $\text{Cl}^-$ , $\text{Br}^-$ , $\text{I}^-$ , $\text{NO}_2^-$ , $\text{NO}_3^-$ .	2
13	The identification methods of the inorganic substances qualitative analysis. Two experimental control tasks for the analysis of inorganic substances.	5
14	Experimental strategies of quantitative analysis: weighing, measuring vessels, filtering. Volumetric analysis. Calculations in volumetric analysis. Neutralization method. Preparation of primary and secondary standard solutions. Experimental control tasks: - Concentration of alkali in water solution; - Determination of temporary water hardness of water sample.	4
15	RedOx volumetric methods of quantitative analysis. Preparation of primary and secondary standard solutions of Permanganometry and Iodometry. Experimental control tasks: - The permanganometric determination of Fe(II) concentration in water solution of Mohr's salt; - The iodometric determination of Cu(II) content in solid copper vitriol.	4
16	Complexometric volumetric method of quantitative analysis. Preparation of primary and secondary standard solutions of Trilonometry method. Experimental control tasks: - Determination of total water hardness of water sample; - Determination of Calcium content in water solution.	4
	Total	45

### 5. Topics of self-study

No.	Topic	Hours
1	Stoichiometric Laws. Application and limitation	2
2	History of atomistic theory developing.	2
3	The foundations of condensed matter chemistry	2
4	Chemical reactions rate and chemical equilibrium in the environmental systems	4
5	Solutions and expression of their concentrations	4
6	Intramolecular hydrolysis	2
7	Redox potentials. Standard electrode potentials of metals. Galvanic elements. The direction of redox reactions. Electrolysis as a redox process. Corrosion of metals as a redox process	4
8	Isomerism of complex compounds. The state of complex compounds in solution.	2
9	Special chemical properties and structure of water as medium of life origin. Features of the biological action and chemistry of selenium and its compounds	2
9	Special chemical properties and structure of water as medium of life origin. Features of the biological action and chemistry of selenium and its compounds	2
10	Inorganic chemistry of Arsenic subgroup	2
11	Silicon compounds in the biosphere. Borides and borates, polyborates. Aluminates and aluminosilicates.	2
12	Strontium and barium as Calcium analogues; their role in living nature. Lithium, Rubidium and Caesium and their compounds in plant and animal	2

	metabolism	
13	Biological functions of Copper(II), Zinc, Manganese. Toxic effects of Cadmium and Mercury and their compounds as correlation of their atomic structure.	4
14	Types of analytical reactions and reagents, their characteristics; classification of analytical reagents and calculations of reaction sensitivity indicators.	4
15	Experimental techniques of qualitative inorganic analysis. Dry and wet reactions. Semimicro apparatus and semimicro analytical operations. Micro apparatus and microanalytical operations. Spot test analysis.	2
16	Training calculations of concentration units recalculations in the environmental application (heavy metals analysis, salty waters mineralization, etc.)	2
17	The ionic strength of natural water systems (salty sea waters, blood, cell juice etc.). Osmosis and ionic strength. Calculation of common ion effect and environmental problems (how to immobilize the heavy metals in soils etc.). Ionic strength calculator ( <a href="https://www.omnicalculator.com/chemistry/ionic-strength">https://www.omnicalculator.com/chemistry/ionic-strength</a> )	4
18	pH graphic method determination. How to prepare of buffer solutions. TRIS solution – preparation and application. How to calculate titration curves of acid mixture titration. Choice of the best acid-base indicators and their preparation.	2
20	Assessment of reliability of analytical data. Reproducibility and correctness of experimental data. Types of systematic errors. Individual and instrumental systematic errors. Determination of systematic error and its influence on the results of the analysis. Random error. Basic concepts of classical statistics.	4
21	RedOx calculation of ionic species of metals of changing valences in natural systems (iron, manganese). RedOx potential of natural waters and soils. Chemical oxygen demand (COD) of natural waters as application of RedOx volumetric methods in the environmental analysis.	4
22	Chelates as food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	2
23	Correct sampling procedures of the environmental objects for qualitative analysis.	2
	Total	60

### 6. Methods of assessing expected learning outcomes:

- Oral or written survey;
- Interview;
- Test;
- Defending laboratory works;
- Peer-to-peer assessment.

### 7. Teaching methods:

- Problem-based method;
- Practice oriented studying method;
- Case method;
- Research based method;
- Learning discussions and debates method.

### 8. Results assessment

The student's knowledge is assessed by means of a 100-point scale converted into the national grades according to the "Exam and Credit Regulations at NULES of Ukraine" in force

### 8.1. Distribution of points by types of educational activities

Educational activity	Results	Assessment
<b>Module 1. Quantum-chemical foundations of periodicity and chemical bonding</b>		
Lab work 1. Introduction. Lab Safety rules. Semimicro qualitative lab techniques. The introduction testing.	<b>ELO03</b> For understanding of the basic concepts, theoretical and practical problems in the field of natural sciences: to know and understand the subject area and professional activity: to be able to work and analyze scientific and educational literature on the Chemistry; Gain practical skills and be able monitor and evaluate current condition of environment based on chemical concepts; to have skills for the stoichiometric calculations for analysis and decision-making in the field of ecology, environmental protection and balanced nature management	<b>5</b>
Lab work Report. General chemical properties of main classes of inorganic substances		<b>15</b>
Lab work 2. Electron formulas compiling. Determination of valence and oxidation number of the chemical elements as a function of their electron configuration		<b>10</b>
Lab work 3. Periodicity as an expression of electron shell structures		<b>5</b>
Lab work 4. Qualitative assessment of chemical bonding types and molecular structure of acids, bases, salts, oxides.		<b>5</b>
Module control work		<b>50</b>
Self-study 2 Testing via Elern		<b>10</b>
<b>Total for module 1</b>		<b>100</b>
<b>Module 2. Physicochemical equilibria in homogeneous and heterogeneous systems</b>		
Lab work 5. Experimental studding of Avogadro's electrolytic dissociation theory on the examples of the interactions in aqua solutions. Lab work Report.	<b>ELO 03, ELO 21:</b> For understanding of the basic concepts and principles of acid-base chemistry; chemical kinetics and equilibrium, theory of complex compounds for the analysis and decision-making in the field of ecology, environmental protection and balanced nature management; for analyzing the influence of acid base processes on the water systems state; acid-base equilibrium and complexing for monitoring and evaluate current condition of environment; the concept of strong and weak electrolytes, complexing processes for the description of water ecosystems; to calculate the degree of electrolytic dissociation and a pH values; to calculate a RedOx potential	<b>5</b>
Control work. Ionic equations compilation.		<b>10</b>
Lab work 6. Experimental studding of hydrolysis of salts in water medium. Lab work Report.		<b>5</b>
Control work. Compilation of molecular and ionic equations of the salt hydrolysis; prediction of a pH of salt solutions.		<b>10</b>
Lab work 7. RedOx processes. Lab work Report.		<b>5</b>
Control work. Compilation of RedOx processes; balancing using method of electron balance		<b>20</b>
Lab work 8. Experimental studding of complexing processes. Lab work Report.		<b>5</b>
Control work. Compilation of complexing equations. Structure of complexes and their naming		<b>15</b>
Module control work 2.		<b>20</b>
Self-study 1 Testing via Elern		<b>5</b>

	in natural water bodies and its influence of the alive matter.		
<b>Total for module 2</b>		<b>100</b>	
<b>Module 3. Analytical chemistry: qualitative identification and systematic analysis of inorganic matrices</b>			
Lab work 9. Introduction to chemistry of elements and their qualitative analysis. Lab work Report.	<b>ELO 03, ELO 21:</b> For understanding of the basic concepts and principles of qualitative analysis of chemical compounds and separate ions in water medium, soils, air at the organizing of the environmental monitoring; how to realize the lab and field techniques of semimicro qualitative tests; understand the importance of sensitivity and selectivity of test analytical reactions; to understand the experimental pathway of inorganic substances qualitative analysis; the importance of the chemical analysis in the environmental sciences and planning of the environment monitoring strategy.	<b>5</b>	
Lab work 10. Studying of chemical-analytical properties and qualitative tests of d-element cations (on the example of $Zn^{2+}$ , $Cu^{2+}$ , $Mn^{2+}$ , $Fe^{2+}$ , $Fe^{3+}$ , $Ag^{+}$ ). Lab Work Report.		<b>5</b>	
Control work. Chemical properties and transformation of the main biogenic chemical elements		<b>10</b>	
Lab work 11. Studying of analytical classification of the main bioactive cations. Separation and identification of I-IV cation groups according to the ammine-phosphate classification. Lab Work Report.		<b>10</b>	
Lab work 12. Experimental examination of analytical classification of the main bioactive anions. Separation and identification of anions $SO_4^{2-}$ , $SO_3^{2-}$ , $CO_3^{2-}$ , $PO_4^{3-}$ , $Cl^{-}$ , $Br^{-}$ , $I^{-}$ , $NO_2^{-}$ , $NO_3^{-}$ Lab Work Report.		<b>5</b>	
Lab work 13. Two experimental control tasks for the analysis of inorganic substances. Lab Work Report.		<b>20</b>	
Module control work 3.		<b>40</b>	
Self-study 3 Testing via Elern		<b>5</b>	
<b>Total for module 3</b>			<b>100</b>
<b>Module 4. Quantitative chemical analysis: gravimetric and titrimetric methods for environmental monitoring</b>			
Lab work 14. Experimental strategies of quantitative gravimetric analysis. Volumetry. Neutralization method. Preparation of primary and secondary standard solutions. Experimental control tasks: - Concentration of alkali in water solution; - Determination of temporary water hardness of water sample. Lab Work Report	<b>ELO03</b> for understanding of the basic concepts, theoretical and practical problems in the field of natural sciences: monitoring of the hydrosphere, pedosphere parameters, soil properties etc. such as waterhardness, content of calcium, magnesium, chemical oxygen demand, soil organic matter.	<b>10</b>	
Lab work 15. RedOxmetric titration in quantitative analysis. Experimental control task: Determination of Iron(II) content in Mohr's salt. Lab Work Report		<b>10</b>	
Lab work 16. Complexometric titration in quantitative analysis. Experimental control tasks: - Determination of Calcium content in		<b>10</b>	

model solution; - Determination of total water hardness. Lab Work Report		
Module control work 4.		<b>60</b>
Self-study 4 Testing via Elern		<b>10</b>
<b>Total for module 4</b>		<b>100</b>
<b>Class work</b>	<b><math>(M1 + M2 + M3 + M4)/4 \times 0,7 \leq 70</math></b>	
<b>Exam/credit</b>	<b>30</b>	
<b>Total for year</b>	<b><math>(\text{Class work} + \text{exam}) \leq 100</math></b>	

## 8.2. Scale for assessing student's knowledge

Student's rating, points	National grading (exam/credits)
90-100	excellent
74-89	good
60-73	satisfactory
0-59	unsatisfactory

## 8.3. Assessment policy

<i>Deadlines and exam retaking rules</i>	Works that are submitted late without valid reasons will be assessed with a lower grade. Module tests may be retaken with the permission of the lecturer if there are valid reasons (e.g. a sick leave).
<i>Academic integrity rules</i>	Cheating during tests and exams is prohibited (including using mobile devices). Term papers and essays must have correct references to the literature used
<i>Attendance rules</i>	Attendance is compulsory. For good reasons (e.g. illness, international internship), training can take place individually (online by the faculty dean's consent)

## 9. Teaching and learning aids:

*E-learning course of the discipline:*

<https://elearn.nubip.edu.ua/enrol/index.php?id=4107>

*Links for digital educational resources:*

1. ScienceLab 3D

Lab works #1-3 (Module 1)

Direct link: <https://sciencelab-two.vercel.app>

GitHub: <https://github.com/rudra496/sciencelab3d>

An interactive 3D platform with virtual experiments. For chemistry, experiments include atomic structure, chemical bonding, electrolysis, acid-base titration, crystal lattices, and the periodic table.

2. All-Science Sims

Lab works #2-4, #6-7, #15 (Modules 1-4)

GitHub (main access): <https://github.com/listyantidewi1/all-science-sims>

Valuable simulations include VSEPR (molecular geometry), acid-base titration with real-time indicator colour change, galvanic cells, and collision theory - for lab works #2, 4, 6, 7, and 15.

3. CurTiPot (Acid-Base pH and Titration Curves)

Lab works #5, #9, #16 (Modules 2-4)

Official download site: [https://www.iq.usp.br/gutz/Curtipot\\_.html](https://www.iq.usp.br/gutz/Curtipot_.html)

A free Excel-based program for pH calculation, modelling acid-base and complexometric titration curves, buffer capacity calculation, and distribution diagram construction.

5. Virtua Chem Sim

Lab work #12 (Module 3 qualitative analysis of inorganic substances)

<https://play.google.com/store/apps/details?id=com.iTechUstad.VirtuaChemSim>

A 3D laboratory on a mobile device with realistic reagent mixing and reaction observation, audio and written instructions, built-in tests. No internet or data transmission required after installation. Particularly useful for lab work #12 (qualitative analysis of unknown inorganic substances).

6. Model ChemLab Lite for iPad

Lab work #13 (Module 4 - gravimetric analysis)

<https://apps.apple.com/kz/app/model-chemlab-lite-for-ipad/id1564190767>

A chemistry laboratory simulation with interactive experiments: acids/bases, gravimetric analysis, fractional crystallisation, etc. For lab work #13 (gravimetric determination of barium).

7. Orange Data Mining

Lab work #16 (Module 4 - statistical processing of analytical data)

Official download site: <https://orangedatamining.com/download/>

An open-source visual programming environment for data analysis, statistical processing, machine learning, and graphing. For processing quantitative analysis results - calculating means, standard deviations, and confidence intervals.

*Lecture notes and presentations (in electronic form)*

Digital learning resources (lecture notes, presentations, lab simulations):

E-learning course at NULES portal: <https://elearn.nubip.edu.ua/course/view.php?id=4107>

The course contains: full lecture notes (PDF), lecture presentations (PowerPoint/PDF), video recordings of key experiments, interactive tests, and links to external simulations.

*Textbooks, manuals*

1. Methodological guidelines "Inorganic and analytical chemistry for bachelor students specialty 101 Ecology / Voitenko L.V., Kopilevich V.A., Prokopchuk N.M., Savchenko D.A., Kravchenko O.O. Kyiv: Експо-Друк., 2023. - 219 p.
2. Laboratory manual on Inorganic and Analytical Chemistry. Savchenko D.A., Voytenko L.V., Prokopchuk N.M.- Kyiv: Експо-Друк., 2017. - 216 p.
3. Неорганічна та аналітична хімія: підручник / В.А. Копілевич, Д.А. Савченко, Т.І. Ущапівська. К.: Редакційно-видавничий відділ НУБіП України. 2020. 596 с.
4. Неорганічна та аналітична хімія: навчальний посібник у формі лабораторного практикуму// Д.А. Савченко, В.А. Копілевич, Т.І. Ущапівська, Н.М. Прокопчук. К.: ДДП «Експо-Друк». 2021. 329 с.

*Methodological materials for studying the academic discipline for applicants*

1. Навчальне видання Робочий зошит до вивчення дисципліни Хімія (неорганічна і аналітична) для студентів 1 курсу спеціальності Е 2 Екологія - Workbook for studying the discipline Chemistry (Inorganic and Analytical) for the 1st year students of the specialty Е 2 Ecology Kyiv: NUBiP Publ., 2025. 90 pp.

## 10. Recommended sources of information

1. PhET Interactive Simulations – <https://phet.colorado.edu>
2. Khan Academy Chemistry – <https://www.khanacademy.org/science/chemistry>
3. ChemCollective (Carnegie Mellon) – <http://chemcollective.org>
4. Chemistry Around Us (Open Textbook) – <https://open.umn.edu/opentextbooks/textbooks/chm-151-chemistry-around-us>
5. RSC Education – <https://edu.rsc.org/resources>
6. ScienceLab 3D – <https://sciencelab-two.vercel.app>