NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"CONFIRMED"
Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr. Agr. Sci, Prof. _____ Yu. V. Kolomiets
"___" _____, 2023

"APPROVED"
at the meeting of the department of
Analytical and Bioinorganic Chemistry & Water Quality
Protocol № 8 dated "24" 04 2023.
Head of Department
_____ (Prof. Volodymyr Kopilevich)

"REVIEWED"
Program Coordinator of Ecology Bachelor
Prof. _____ (Volodymyr Bogolyubov)

PROGRAM OF THE COURSE

CHEMISTRY(ANALYTICAL)

Specialization 101 – Ecology
Educational program – Ecology
Faculty of of Plant Protection, the Biotechnologies, and Ecology
Developer: Associate Professor, Cand Chem Sci Larysa Voitenko
(position, academic degree, academic title)

Kyiv – 2023

Academic discipline description

Chemistry (analytical)

(назва)

Field of knowledge, specialization, educational program, educational degree		
Educational degree	*Bachelor's*	
Specialization	*101- Ecology*	
Educational program	*Ecology*	
Characteristics of the course		
Type	Compulsory	
Total number of hours	120	
Number of ECTS credits	4	
Number of content modules	3	
Course project (work)	Applicable	
Form of assessment	*Exam*	
Indicators of the course for full-time and part-time forms of study		
	Full-time form of study	Part-time form of study
Course (year of study)	The 2d	No
Semester	The 2d	
Lecture classes	*30 hr.*	*hr.*
Practical, seminar classes	*hr.*	*hr.*
Laboratory classes	*45 hr.*	*hr.*
Self-study	*45 hr.*	*hr.*
Individual assignments	*hr.*	*hr.*
Number of weekly classroom hours for the full-time form of study	*5 hr.*	

2. Purpose, objectives, and competencies of the course

Purpose is to develop an understanding of the range and uses of analytical qualitative and quantitative methods in analysis of the environmental objects, and formation of skills in chemical analytical experiment performing.

Objective is to acquire basic concepts, principles, and techniques of modern analytical chemistry (qualitative analysis, gravimetry, titrimetry) that would empower students with an analytical mind set and the abilities to solve diverse analytical problems for environmental assessment in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

Tasks:

1. to develop an understanding of the range and uses of analytical methods in environmental analytical chemistry;
2. to establish an appreciation of the role of chemistry in quantitative analysis;
3. to develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks;

4. to provide an understanding of chemical methods employed for elemental and compound analysis;
5. to provide experience in some scientific methods employed in analytical environmental chemistry;
6. to develop some understanding of the professional and safety responsibilities of ecologist residing in working on chemical analysis.

Competence acquisition:

Integral competence (IC): The ability to solve complex specialized problems and solve practical problems in the field of ecology, environmental protection, and sustainable environmental management, which involves the application of basic theories and methods of science about environments that are characterized by complexity and uncertainty of conditions.

General competences (GC):
GC1. Knowledge and understanding of the subject area and professional activity
GC8. Ability to conduct research at the appropriate level
GC10. The ability to evaluate and ensure the quality of performed works.

Professional (special) competences (PC):
PC2. Ability to critically understand basic theories, methods and principles of natural sciences.
PC 3. Ability to understand basic theoretical concepts regulations, concepts and principles of natural and of social and economic sciences.
PC7. Ability to monitor and evaluate current condition of environment based on analytical monitoring data.

Programmatic learning outcomes (PLO):
PLO 3. 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 balanced nature management.
PLO14. Be able to create texts, make presentations and messages for professional audiences and the general public with observance of professional integrity and impossibility plagiarism.
PLO18. Combine the skills of independent and teamwork to achieve results with an emphasis on professional integrity and responsibility for decision-making.
PLO19. Increase the professional level by continuing education and self-education.
PLO21. To be able to choose optimal methods and tools for research, collection and data processing.

Program and structure of the subject
- for full-time English-speaking students

Modules naming and chapters	Hours						
	Full-time						
	weeks	total	included				
			lectures	Practice training	Lab works	Individual tasks	Independent work
1	2	3	4	5	6	7	8
Content Module 1. The Foundations of the Qualitative Analysis							
Chapter the 1st. Subjects and objects of the chemical analysis (analytical chemistry). Methods of quantitative analysis. Subjects of qualitative and quantitative analyses. Methods of qualitative analysis (macro-, semimicro-, micro-, and ultramicro-methods). Analytical reactions and requirements to analytical reactions. Examples of qualitative reactions of different visual effects (sedimentation, colorizing etc.). "Dry" and "wet" qualitative tests. Pyrochemical methods, microcrystalline analysis, drop analysis. Notions of specific, selective, and group reactions and reagents.	1	10	4		2		4
Chapter the 2d. Sulfide, acid-base, and ammine-phosphate classification of cations. Qualitative tests of I-IV cation groups. The main group reagents. Analytical classification of anions.	2-3	8	2		4		2
Chapter the 3d. Analytical purity of reagents. Ukrainian and international degrees of purity. The methodology of cation mixture analysis. Partial and Systematic analysis. Centrifugation, fullness testing. *Experimental test.* To analyze and determine the composition of cation mixture. *Theoretical quiz.* Qualitative analysis of cations.	4-5	16	4		8		4
Chapter the 4th. Qualitative tests of anions. *Experimental module test.* Qualitative analysis of soluble salts, and insoluble substances (salts, free metals, oxides). *Theoretical quiz.* Qualitative analysis of inorganic substances.	6	11			6		5
Totally the module 1st:	**6**	**45**	**10**		**20**		**15**

1	2	3	4	5	6	7	8
Content Module 2. The Foundations of the Gravimetric Quantitative Analysis							
Chapter the 1st. Expression of Concentration: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titr. Formulas of recalculations of concentration units. Preparation of solutions.	7	11	4				7
Chapter the 2d. Analytical techniques and procedures of Quantitative mass analysis (gravimetry). Subject of gravimetric analysis. Equipment and tools (filter paper series). The experimental strategy. Calculations in gravimetric analysis. Tananaev's rule. Amorphous and crystalline sediments. Requirements to sediments in gravimetric analysis. Experimental strategies of sedimentation. *Experimental module test.* Determination of barium content in the barium chloride hydrate. *Theoretical quiz.* The foundations of mass analysis, heterogeneous equilibrium.	8-9	20	4		8		8
Totally the module 2d:	**3**	**31**	**8**		**8**		**15**
Content Module 3. The Foundations of the Volumetric Quantitative Analysis (titrimetry)							
Chapter the 1st. Ionic product of water. pH notion. Biological function depending pH. Measuring pH. pH calculations of strong acids and bases, weak acids and bases. pH calculations of different salts solutions. Buffer solutions. Calculation of a pH of buffer solutions. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.	10	6	4				2
Chapter the 2d. Neutralization method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of alkali content in solution, and water temporary hardness. *Theoretical quiz.* Units of concentration.	11	8	2		4		2
Chapter the 3d. RedOx volumetry. Nernst equation. Electrode potential of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators. Bases of permanganatometry and iodometry. RedOx volumetric methods. Permanganatometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of iron(II) content in Mohr's salt solution.	12-13	14	4		6		4

1	2	3	4	5	6	7	8
Iodometry method. Standard and working solutions, possibilities of method. *Experimental module tests.* Permanganatometric determination of iron(II) content in Mohr's salt solution. Iodometric determination of copper content in copper vitriol.		7			2		5
Chapter the 4th. Complexonometry. Bases of method. Standard and working solutions, possibilities of method. Metallochromic indicators. Determination of total temporary hardness. Precipitation titration. Mohr' method of chloride determination. Fixation of equivalent point. Experimental strategy. *Experimental module test.* Complexonometric determination of Calcium content in solution. *Theoretical quiz.* Foundations of Redox and complexonometric methods.	14-15	9	2		5		2
Totally the module 3d:	**6**	**44**	**12**		**17**		**15**
Hours:		**120**	**30**		**45**		**45**

3. Seminars – do not planned.

4. Practical class – do not planned.

5. Laboratory class topics

#	Title	Hours
1	Introduction. Lab Safety rules. Semimicro qualitative lab techniques. Basic characteristics of Qualitative tests (sensitivity, selectivity.	2
2	Qualitative classification of cations. Qualitative tests of the I cation group (NH_4^+, K^+, Na^+)	2
3	Qualitative tests of the II cation group (Mg^{2+}, Ca^{2+}, Sr^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, and Al^{3+}). Action of group, selective, and specific reagents.	2
4	Qualitative tests of the III cation group (Zn^{2+}, Cu^{2+}, Co^{2+}, and Ni^{2+}), and the IV cation group (Ag^+, Pb^{2+}). Action of group, selective, and specific reagents.	2
5	Partial and Systematic analyses of cation mixture. Stategy of cation separation. *Experimental test.* Determine the composition of cation mixture.	4
6	Qualitative classification of anions. Qualitative tests and methods of separations of anions SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, PO_4^{3-}, SiO_3^{2-}, MoO_4^{2-}, BO_2^-, Cl^-, Br^-, I^-, NO_3^-, NO_2^-, and CH_3COO^-	4
7	*Experimental module test.* Qualitative analysis of soluble salt (1 item), and insoluble substance (1 item) (salts, free metals, oxides).	4
	The 1st module	**20**
8	*Experimental module test.* Determination of barium content in the barium chloride hydrate.	8
	The 2d module	**8**
9	Neutralization method. Standard and working solutions, possibilities of method. *Experimental module test.* Determination of alkali content in solution, and water temporary hardness.	5
10	RedOx volumetric methods. Permanganatometry method. Standard and working	4

	solutions, possibilities of method. *Experimental module test.* Determination of iron(II) content in Mohr's salt solution.	
11	Iodometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Iodometric determination of copper content in copper vitriol.	4
12	Complexonometry. Bases of method. Standard and working solutions, possibilities of method. *Experimental module test.* Complexonometric determination of Calcium content in solution.	2
	The 3d module	**17**
	Total	**45**

6. Independent work topics

#	Chapter	Hours
1	Application of chemical analysis. Sampling. Types of analysis. Use of literature. Common techniques. Factors affecting the choice of analytical methods. Data acquisition and treatment.	4
2	Principles of sulfide-free methods of cation classifications. Dissolving of the sample. "Soda" extracting. Methods of heterogeneous mixture separating.	4
3	Determination of analytical purity of the chemicals for the different purposes of environmental analysis (air, fresh water, soils, foods, microbiological analysis etc.). Methods of analytical separation of cations in natural systems	5
4	Analytical methods of environmental item qualitative tests	3
5	Training calculations of concentration units recalculations in the environmental application (heavy metals analysis, salty waters mineralization, etc)	10
6	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.).	7
6	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.	5
7	RedOx calculation of ionic species of metals of changing valencies 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
8	Chelates as a food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	3
	Total	**45**

7. Examples of control questions, tests for the assessment of student' knowledge level.

1. Subjects and objects of the chemical analysis (analytical chemistry).
2. Methods of quantitative analysis – chemical and physical-chemical.
3. Subjects of qualitative and quantitative analyses.
4. Methods of qualitative analysis – macro-, semimicro-, micro-, and ultramicromethods.
5. Analytical reactions and requirements to analytical reactions. Examples of qualitative reactions of different visual effects (sedimentation, colorizing etc.)
6. "Dry" and "wet" qualitative tests. Pyrochemical methods (idea of borax bead tests, flame tests), microcrystalline analysis, analysis in drops in filter paper.
7. Notions of specific, selective, and group reactions and reagents. Examples.
8. Principles of cations classification – acid-base, sulfide, ammine-phosphate. The main group reagents.

9. Analytical purity of reagents. Ukrainian and international degrees of purity (classification техн, ч, чда, хч, осч; Analytical reagent AR, Guaranteed Reagent (GR) etc.)
10. Expression of Concentration: 1. percent (mass) concentrations; 2. Molar, 3. Normal (equivalent), and 4. Titr.
11. Formulas of recalculations of concentration units.
12. Heterogeneous equilibrium. Equilibrium In Saturated Solutions of Slightly Soluble Substances. Solubility product. Molar and mass solubility. Examples of calculations.
13. Factors effecting solubility: temperature, common ion effect, pH effect. Notion of ionic power (strength), active coefficients, and active concentrations.
14. Subject of gravimetric analysis. Equipment and tools (filter paper series). The experimental strategy. Calculations in gravimetric analysis.
15. Tananaev's rule. Amorphous and crystalline sediments. Requirements to sediments in gravimetric analysis. Rules of sedimenting.
16. Ionic product of water. pH notion. Biological function depending pH. Measuring pH.
17. pH calculations of strong acids and bases, weak acids and bases.
18. pH calculations of different salts solutions.
19. Buffer solutions. Calculate of a pH of buffer solutions.
20. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.
21. Neutralization method. Standard and working solutions, possibilities of method. Determination of water temporary hardness.
22. RedOx volumetry. The Nernst equation. How to calculate the electrode potential of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators.
23. Theoretical foundations of permanganatometry and iodometry/iodatometry.
24. Complexonometry. Bases of method. Standard and working solutions, possibilities of method. Metallochromic indicators.
25. Determination of total temporary hardness.

Test questions

	Question 1. Group qualitative reactant of Cu^{2+} cations is (according to ammonium-phosphate classification):
A	Red blood salt;
B	Yellow blood salt;
C	Ammonium hydrophosphate;
D	Concentrated ammonia.
	Question 2. Qualitative reaction of CH_3COO^- anion with strong acid is accompanied by visual effect of:
A	Blue colorizing of solution;
B	Brown ring;
C	Special odour;
D	Crimson colorizing of solution.
	Question 3. For semimicro qualitative analysis it is used:
A	Near 100 g of solid and 100 mL of liquid reactants;
B	Near 10 g of solid and 1 L of liquid reactants;
C	Near 0,001 g of solid and 0,1 mL of liquid reactants;
D	Near 0,05 g of solid and 1 mL of liquid reactants.
	Question 4. Solution of potassium permanganate in the burette is levelled on:
A	The highest point of the meniscus;
B	The lowest point of the meniscus;
C	The middle point of the meniscus;
D	The zero point of the meniscus.
	Question 5. Accuracy of weighting of analytical balances is:
A	±0,0001 g;

B	±5 g;
C	±0,01 g;
D	±0,1 g.
	Question 6. Mass of H_2SO_4 (M=98,00 g/mol), dissolved in 2000 mL of solution, if for titration of 10 mL of this solution it was used 12,3 mL of 0,01 N NaOH):
A	1,2054 g;
B	2,4108 g;
C	3,4567 g;
D	0,1205 g.
	Question 7. What mixture has buffer properties:
A	$NH_4Cl + NH_4HCO_3$;
B	$NH_4Cl + NH_4OH$;
C	$HCl + NH_4Cl$;
D	$NH_4Cl + NH_4H_2PO_4$.
	Question 8. For qualitative determination of Mg^{2+} ion of Ammonia or Sodium Hydrophosphate it is prevented the presence in solution:
A	Cations of alkali metals;
B	Anions;
C	Cations of the 2d group;
D	All cations of the 2^d, 3^d and 4^{th} groups (according to ammonia-phosphate classification).
	Question 9. In analytical determinations it doesn't use chemicals of such purity:
A	Technical grade;
B	Extra Pure grade;
C	Pharmacopoeia grade;
D	For Analytical Purpose.
	Question 10. Mass of $CaCl_2 \cdot 6H_2O$ (M=219,08 g/mol) for precipitation of Calcium in the form of $CaC_2O_4 \cdot H_2O$ (M=146,11 g/mol) is:
A	1,4994 g;
B	0,7497 g;
C	0,4998 g;
D	0,9996 g.
	Question 11. Buffer solution has such main property:
A	To stabilize ionic strength or pH of solution;
B	To stabilize density of solution;
C	To stabilize temperature of solution;
D	To stabilize color of solution.
	Question 12. It is necessary for preparation of coarse-crystalline precipitate:
A	To precipitate of hot diluted solutions;
B	To precipitate of cold diluted solutions;
C	To precipitate of hot concentrated solutions;
D	To precipitate of cold concentrated solutions.
	Question 13. pH of 0,01 N HIO_3 (pK=10,64) is:
A	6,32;
B	10,64;
C	7,00;
D	1,12.
	Question 14. ppm – this is…:
A	Percent per mass;
B	Parts per million;
C	Parts per mass;
D	Percent per million.

	Question 15. Equivalent mass of H_3BO_3 (M=61,83 g/mol) in neutralization processes is equal to:
A	61,83 g/g-eq;
B	10,31 g/g-eq;
C	20,61 g/g-eq;
D	122,66 g/g-eq.
	Question 16. Such system of cation classification doesn't exist:
A	Acid-base;
B	Phosphate;
C	Hydrochloride;
D	Buffer.
	Question 17. Qualitative reaction of Pb^{2+} anion with KI after re-crystallization in presence of acetic acid is accompanied by visual effect of:
A	Blue colorizing of solution;
B	Brown ring;
C	Yellow-goldish precipitation ("Gold rain");
D	Crimson colorizing of solution.
	Question 18. Equivalent concentration is shown:
A	Quantity of moles of soluble substance per 1 L of solution;
B	Quantity of equivalents of soluble substance per 1 L of solution;
C	Quantity of moles of soluble substance per 1 kg of solution;
D	Quantity of moles of soluble substance in per 100 mL of solution.
	Question 19. According to Tananaev's recommendations, mass of amorphous precipitate is the best of all would be:
A	Near 0,2 g;
B	Near 0,5 g;
C	Near 1 g;
D	Near 1 mol.
	Question 20. Sign of heterogeneous system is:
A	Presence of precipitate and solution simultaneously;
B	One aggregate state of all phases;
C	Absence of separated surfaces between phases;
D	Mixing of all components.
	Question 21. SO_3^{2-} and SO_4^{2-} anions may be separated one from other by adding:
A	Concentrated ammonia;
B	Silver nitrate;
C	Sulphate acid;
D	Barium chloride and action of diluted HCl into formed precipitates.
	Question 22. Equivalent mass of Ca^{2+} cation (A (Ca)=40,08) in reaction with Trilon B is:
A	40,08 g-eq/g;
B	20,04 g-eq/g;
C	10,02 g-eq/g;
D	5,01 g-eq/g.
	Question 23. Metallochromic indicators in complexonometry are:
A	Weak bases;
B	Weak acids;
C	Red-Ox systems;
D	Ligands, formed colored unstable compexes with metal cations.
	Question 24. The most sensitive reactant of Na^+ determination is:
A	$K[Sb(OH)_6]$;
B	$Zn(UO_2)_3(CH_3COO)_8$ in presence of acetic acid;

C	Chugaev's reactant;
D	$NH_4H_2PO_4$.
	Question 25. Red-Ox potential of the system MnO_4^-/Mn^{2+} at pH=3 ($E^0(MnO_4^-/Mn^{2+})$=+1,52V), when $[MnO_4]=[Mn^{2+}]$=1 mol/L, is:
A	+1,80 V;
B	-1,80 V;
C	+1,24 V;
D	-1,52 V.
	Question 26. The best indicator for titration of 0,1 N acetic acid by 0,1 N Sodium hydroxide is ($pH_{equivalent\ point}$=8,16):
A	Methyl Violet (pT=1,4);
B	Cresol red (pT=7,5);
C	Methacresol purple (pT=8,2);
D	Orange G (pT=12,8).
	Question 27. Equivalent mass of $KMnO_4$ for titration in acidic medium is ($M(KMnO_4)$=158 g/mol):
A	158 g/g-eq;
B	52,7 g/g-eq;
C	79,0 g/g-eq;
D	31,6 g/g-eq.
	Question 28. Percent concentration is shown:
A	Mass of solute in 100 mL of solution;
B	Mass of solute in 100 g of solution;
C	Mass of solute in 1 kg of solution;
D	Mass of solute in 1000 mL of solution.
	Question 29. Equivalent point of titration in neutralization reaction corresponds to:
A	Starting of indicator color change;
B	Finishing of indicator color change;
C	pH in the starting of titration jump;
D	pH in the centre of titration jump;
	Question 30. The most sensible test for borate anion determinations is:
A	Reaction with Sodium hydroxide;
B	Flame test with concentrated sulphate acid and alcohol;
C	Test with $BaCl_2$;
D	Test with $AgNO_3$.

8. Teaching methods

Before teaching a course, the instructor must identify what she or he intends for the students to learn. For most analytical chemistry instructors, this usually involves an assessment of what methods and techniques to include and at what depth to cover them. There are many other skills, though, that will be important to students for their future success. Most university classes in analytical chemistry are taught in a lecture format. An alternative to lecturing is the use of cooperative learning. Cooperative learning offers the potential to develop skills such as teamwork, communication, and problem-solving that are more difficult to impart in a lecture format. The laboratory component of analytical chemistry courses is often an underutilized learning resource. More often than not, the lab is used to demonstrate fundamental wet and instrumental analysis techniques and develop rudimentary laboratory skills. The analytical lab should also be

used to develop meaningful problem-solving skills and to demonstrate and have students participate in the entire analytical process.

A teaching method comprises the principles and methods used for students teaching. Commonly used teaching methods for studding subject "Analytical chemistry" include on-time participation, demonstration, recitation, memorization, or combination of these. The choice of teaching method or methods to be used depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students.

Explaining, or lecturing, is the process of teaching by giving spoken explanations of the subject that is to be learned. Lecturing is often accompanied by visual aids to help students visualize an object or problem.

Demonstrating is the process of teaching through examples or experiments. For example, a chemistry teacher must teach an idea by performing an experiment for students. A demonstration may be used to prove a fact through a combination of visual evidence and associated reasoning.

Demonstrations in analytical chemistry and own experiment are permit to obtain experimental skills needed for environmental monitoring etc. Memorization of a list of facts is a detached and impersonal experience, whereas the same information, conveyed though demonstration, becomes personally relatable. Demonstrations help to raise student interest and reinforce memory retention because they provide connections between bacts and real-world applications of those facts. Lectures, on the other hand, are often geared more towards factual presentation than connective leaning.

Collaboration allows students to actively participate in the leaning process by talking with each other and listening to other points of view. Collaboration establishes a personal connection between students and the topic of study and it helps students think in a less personally biased way. Group projects and discussions are examples of this teaching method. Teachers may employ collaboration to assess students' abilities to work as a team, leadership skills, or presentation abilities.

Collaborative discussions can take a variety of forms, such as fishbowl discussions. After some preparation and with clearly defined roles, a discussion may constitute most a lesson, with the teacher only giving short feedback at the end or in the following lesson.

Learning by teaching in the method, when students assume the Lecturer'r role and teach their peers. Students who each other's as a group or as individuals must study and understand a topic well enough to teach it to their peers. By having students participate in the teaching process, they gain self-confidence and strengthen their speaking and communication skills.

9. Forms of assessment

The main forms of knowledge control are control works and tests that are executed by students using E-learn platform.

They include:

1. Lab work protocols assessment;
2. Tests;
3. Module control works.

The point rating of each kind of activity is established depends on it's complexity.

Examinations. Exam is a final step in the study of the whole or part of the discipline and are designed to test students' knowledge on the theory and identify the skills apply the acquired knowledge in solving practical problems, as well as independent work skills with educational and scientific literature.

Student's rating of knowledge of an academic discipline consists of training work rating – 70 points and final attestation – 30 points. Thus, rating of content modules, that are constituents of an academic discipline, makes 70 points. Rating of content modules as well as attestation rating are also measured by 100-point-scale.

10. Distribution of grades received by students. Evaluation of student knowledge is carried out on a 100-point scale and is converted to national grades according to Table 1 "Regulations and Examinations and Credits at NULES of Ukraine" (order of implementation dated 26.04.2023, protocol № 10)

Student rating, points	**National grade based on exam results**	
	Exams	**Credits**
90-100	**Excellent**	**Passed**
74-89	**Good**	
60-73	**Satisfactory**	
0-59	**Unsatisfactory**	**Not passed**

In order to determine the rating of a student (listener) in the discipline $\mathbf{R_{dis}}$ (up to 100 points), the rating from the exam $\mathbf{R_{ex}}$(up to 30 points) is added to the rating of a student's academic work $\mathbf{R_{aw}}$ (up to 70 points): $\mathbf{R_{dis} = R_{aw} + R_{ex}}$ **.**

11. Educational and methodological support.

The training materials for educational components were published in a related course and can be accessed at the following link:
https://elearn.nubip.edu.ua/course/view.php?id=2667

1. Analytical Chemistry. Manual for Bachelor's Students // Voytenko l.V., Kosmaty V.E., Kopilevich V.A. – Kyiv: NAUU publ., 2007. – 199 pp.
2. Analytical Chemistry. Workbook for Bachelor's Students // Voitenko l.V., Kosmaty V.E., Savchenko D.A., Kopilevich V.A. – Kyiv: NUBiP Publ., 2014. – 140 pp.

12. Recommended sources of information

1. Harvey D. Modern Analytical chemistry (electron copy). McGraw-Hill Education, 2000. – 556 pp.
2. Ф.Г. Жаровський, А.Т. Пилипенко, І.В. П'ятницький. Аналітична хімія. – К.: "Вища школа", 1982. – 543 с.
3. Vogels' Textbook of Macro and semimicro qualitative inorganic analysis https://archive.org/details/VogelsQantitativeChemicalAnalysis

4. Harvey D. An Ecectronic Textbook for Introductory Cources in Analytical chemistry. http://www.freebookcentre.net/chemistry-books-download/An-Electronic-Textbook-for-Introductory-Courses-in-Analytical-Chemistry.html
5. Quantitative Analysis Analytical Chemistry by Dr. Michael J. Prushan http://www.freebookcentre.net/chemistry-books-download/Quantitative-Analysis-Analytical-Chemistry.html
6. Prof. Clemens F Kaminski Analytical Chemistry Notes http://www.freebookcentre.net/chemistry-books-download/Analytical-Chemistry-Notes-(PDF-55P).html
7. ISO 6353-2:1983 Reagents for chemical analysis – Part 2: Specifications – First series.
8. ISO 6353-2:1983/Add.2:1986(en) Reagents for chemical analysis — Part 2: Specifications — First series ADDENDUM 2.
9. ISO 6058:1984. Water quality – Determination of calcium content – EDTA titrimetric method.
10. ISO 6059:1984 Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method.
11. Periodical Table - http://www.webqc.org/periodictable.php.
12. Calculator of Molar weight (FW)
http://www.graphpad.com/quickcalcs/Molarityform.cfm
13. Units convertor - http://www.webqc.org/unitconverters.php.
14. pH calculator - http://www.webqc.org/phsolver.php.
15. Calculating titrating curves -
http://chemwiki.ucdavis.edu/Core/Physical_Chemistry/Equilibria/Acid-Base_Equilibria/pH_Titration_Curves.
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https://www.youtube.com/watch?v=FdVO1zX6doA – phosphate test