NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"APPROVED"

Dean of Facultyof Plant Protection, Biotechnology and Ecology,
Dr.Agr.Sc., Prof._____Y.V.KOLOMIEC
"23"_05_2024

"REWIED AND APPROVED"
At the meeting of the department of Analytical and Bioinorganic Chemistry & Water Quality
Protocol#11"23_"05 _2024__
Head of the Department
Dr.Chem.Sc., Prof._____V.A. Kopilevich

"REWIED"
Guarantor of EP
Cand. Of Sc., Assoc. Prof._____O.Y.Kvasko

CURRICULUM OF ACADEMIC DISCIPLINE

ANALYTICAL CHEMISTRY

Field of knowledge 16-Chemistry and Biotechnology
Specialty –162"Biotechnology and Bioengineering"
Education program Biotechnology and Bioengineering
Faculty of the Plant Protection, Biotechnology and Ecology
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Kyiv-2024

Description of the discipline

ANALYTICAL CHEMISTRY

Branch of knowledge, direction, specialty, education and qualification level		
Educational and Qualification level qualification	Bachelor	
Branch of knowledge	16 Chemical and Bio-engineering	
Speciality	162 Biotechnologies and Bio-engineering	
Characteristics of training programme		
Type	Ordinary (standard)	
The total number of academic hours	180	
Number of ECTS credits allocated	6	
Number of modules	2	
Forms of control	Exam	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	Part-time
Year of study (course)	2	No
Semester	3	
Number of lecture, hours	30	
Number of seminars, practical classes	-	
Laboratory sessions (activities)	60	
Independent study	90	
Individual lessons	-	
Number of weekly in-class academic hours for full-time forms of training	6	
Course work (separate program)	40	
Study workshop (separate program)	36	

1. Aim, objectives, competenteces and expected learning outcomes of the discipline

Aim of Analytical Chemistry is the Chemistry of the differences. From an analytical point of view, analogies of elements, of a same column or period of the periodic table, are left aside in the same way that analogy of organic compounds, having the same functional groups, in order to pay more attention to the specific identity of elements and compounds. In this sense, Analytical Chemistry is closer to the evidences of the life

experiences than other chemical disciplines and it can be well understood by our students, who appreciate the different effects of sodium and potassium on soil fertility, in spite of the fact that both are alkaline elements, or the tremendous differences between the toxicity of methanol and ethanol, which have the small difference of a carbon and two hydrogen atoms.

Analytical chemistry is often described as the area of chemistry responsible for characterizing the composition of matter, both qualitatively (what is present) and quantitatively (how much is present). This description is misleading. Almost all chemical disciplines routinely make qualitative or quantitative measurements (Figure 1). The argument has been made that analytical chemistry is not a separate branch of chemistry, but simply the application of chemical knowledge.

The **Objects** of Analytical chemistry research:

- To empower students to obtain a skills orientated qualification - laboratory technician:
- To train natural scientists to be employed in various sectors of the economy;
- To train specialists in natural sciences;
- To create further opportunities in research and for post-graduate studies;
- To make a national and international contribution to the promotion of research.

Requirements to the knowledge and skills

Student must to know:

- Safety technique in analytical laboratory;
- Bases of the qualitative analysis;
- Qualitative reactions of cations and anions;
- Methods of masking for prevent ions;
- Methods of ions separation in solution at qualitative determination;
- Bases of gravimetry (mass analysis) and titrimetry (volume analysis).

Competentions:

Competencies of the educational programme:

Integrative competency (IC): The ability to solve complex specialized problems and practical problems characterized by complexity and uncertainty in biotechnology and bioengineering, or in the learning process, which involves the application of theories and methods of biotechnology and bioengineering.____

General competencies (GC):

GC3.Ability to communicate in a foreign language.

GC5. Ability to learn and master modern knowledge.

Professional (special) competencies (SC):__

- SC2. Ability to use thorough knowledge of chemistry and biology to the extent necessary to achieve others results of the educational program
- SC5. The ability to conduct experimental research with improvement of biological agents, including to cause changes in the structure of the hereditary apparatus and functional activity of biological agents.

Program learning outcomes (ELO) of the educational programme: _

- ELO2. To be able to carry out qualitative and quantitative analysis of substances of inorganic, organic and biological origin, using appropriate methods.
- ELO22. Be able to take into account social, ecological, ethical, economic aspects, labor and industrial safety requirements sanitation and fire safety during the formation of technical solutions. Be able to use different types and forms of motor activities for active recreation and healthy living way of life.

2. **Programme and structure of the discipline**

for full-time form of training

Topic	Hours (lect./labor. prac/ self)	Learning outcomes	Tasks	Assessment
1 semestr				
Module1				
Lecture # 1. Subjects and objects of the chemical analysis (analytical chemistry).	2/2/4	What is necessary to know , What one should be able to do, What one should be concerned in: Methods of quantitative analysis – chemical and physical-chemical. Subjects of qualitative and quantitative analyses. Methods of qualitative analysis – macro-, semimicro-, micro-, and ultramicromethods.	LABORATORY TRAINING № 1. lab works preparation;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 2. Analytical reactions and requirements to analytical reactions. Examples of	2/4/4	What is necessary to know , What one should be able to do, What one should be concerned in: “Dry” and “wet” qualitative tests.	LABORATORY TRAINING № 2. Examples of qualitative reactions. lab works preparation;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;

qualitative reactions of different visual effects (sedimentation, colorizing etc.).		Pyrochemical methods (idea of borax bead tests, flame tests), microcrystalline analysis, analysis in drops in filter paper. Notions of specific, selective, and group reactions and reagents. Examples.		
Lecture # 3. Principles of cations classification – acid-base, sulfide, ammine-phosphate.	2/4/4	What is necessary to know , What one should be able to do, What one should be concerned in: The main group reagents. Analytical purity of reagents. Ukrainian and international degrees of purity (classification техн, ч, чда, хч, осч; Analytical reagent AR, Guaranteed Reagent (GR) etc.).	LABORATORY TRAINING № . lab works preparation;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 4. The methodology of cation mixture analysis.	2/4/4	What is necessary to know , What one should be able to do, What one should be concerned in:	LABORATORY TRAINING № .lab works preparation; tests;	-Control of lab works preparation ; -Theoretical control tests;

		Partial and Systematic analysis. Centrifugation, fullness testing.		-Control experimental problems;
Lecture # 5. Expression of Concentration:	2/4/4	What is necessary to know , What one should be able to do, What one should be concerned in: percent (mass) concentrations (percentage weight by weight; volume by volume etc; Molar, Normal (equivalent), and Titr.	Module2 LABORATORY TRAINING	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 6. Formulas of recalculations of concentration units.	2/4/4	What is necessary to know , What one should be able to do, What one should be concerned in: Preparation of solutions. Calculation in quantitative analysis.	LABORATORY TRAINING № .lab works preparation;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 7. Heterogeneous	2/4/4	What is necessary to know , What one should be able to	LABORATORY TRAINING № lab works preparation;	-Control of lab works preparation ;

equilibrium.		do, What one should be concerned in: Equilibrium In Saturated Solutions of Slightly Soluble Substances. Solubility product. Molar and mass solubility. Examples of calculations.	experimental problems; tests; Control experimental problems;	-Theoretical control tests; -Control experimental problems;
Lecture # 8. Factors effecting solubility	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: temperature, common ion effect, pH effect. Notion of ionic power (strength), active coefficients, and active concentrations.	LABORATORY TRAINING № lab works preparation; experimental problems;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 9. Subject of gravimetric analysis.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in:	LABORATORY TRAINING № lab works preparation; lab works preparation;	-Control of lab works preparation ; -Theoretical control tests;

		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. Rules of sedimenting.		-Control experimental problems;
Lecture # 10. Homogeneous equilibrium. Ionic product of water.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: pH notion. Biological function depending pH. Measuring pH. pH calculations of strong acids and bases, weak acids and bases.	LABORATORY TRAINING № gravimetric analysis. lab works preparation; experimental problems; tests;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 11. Hydrolysis and pH	2/4/8	What is necessary to know , What one should be able to	LABORATORY TRAINING № Ionic product of water. lab works	-Control of lab works preparation ;

calculations of different salts solutions. Buffer solutions.		do, What one should be concerned in: Calculate of a pH of buffer solutions. Titration curves, equivalent points, titration jump. Acid-base indicators. Choice of indicators. Equivalent law in volumetry.	preparation; experimental problems;	-Theoretical control tests; -Control experimental problems;
Lecture # 12. Neutralization method.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: Standard and working solutions, possibilities of method. Determination of water temporary hardness.	LABORATORY TRAINING № lab works preparation; experimental problems;	-Control of lab works preparation ; -Theoretical control tests; -Control experimental problems;
Lecture # 13. RedOx volumetry. Nernst equation.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: Electrode potential	LABORATORY TRAINING № Neutralization method. lab works preparation; tests;	-Control of lab works preparation ; -Theoretical control tests; -Control

		of redox systems. Electromoving force (EMF) of redox systems. RedOx indicators.		experimental problems;
Lecture # 14. Foundations of permanganatometry and iodometry.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: Bases of method of permanganatometry and iodometry.	LABORATORY TRAINING № RedOx volumetry. Nernst equation. lab works preparation; experimental problems;	-Control of lab works preparation; -Theoretical control tests; -Control experimental problems;
Lecture # 15. Complexonometry. Bases of method.	2/4/8	What is necessary to know , What one should be able to do, What one should be concerned in: Standard and working solutions, possibilities of method. Metal-lochromic indicators. Determination of total temporary hardness. Precipitation titration. Mohr' method of chloride determination. Fixation of equivalent point. Experimental	LABORATORY TRAINING № permanganatometry and iodometry. lab works preparation; experimental problems;	-Control of lab works preparation; -Theoretical control tests; -Control experimental problems;

		strategy.		
Total	30/60 /90		LABORATORY TRAINING № Complexonometry. lab works preparation; experimental problems; tests;	
Course work	40			(70/30) 100
Study work				70
Exam				30
Total				100

3. Topic of laboratory classses

#	Chapter	Hours
1	Introduction. Lab Safety rules. Semimicro qualitative lab techniques. Basic characteristics of Qualitative tests (sensitivity, selectivity.	4
2	Qualitative classification of cations. Qualitative tests of the I cation group (NH_4^+, K^+, Na^+)	4
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.	4
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.	4
5	Partial and Systematic analyses of cation mixture. Idea 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
8	*Experimental module test.* Determination of barium content in the barium chloride hydrate.	8
9	Neutralization method. Standard and working solutions, possibilities of method. *Experimental module test.*	4

	Determination of alkali content in solution, and water temporary hardness.	
10	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.	6
11	Iodometry method. Standard and working solutions, possibilities of method. *Experimental module test.* Iodometric determination of copper content in copper vitriol.	6
12	Complexonometry. Bases of method. Standard and working solutions, possibilities of method. *Experimental module test.* Complexonometric determination of Calcium content in solution.	8
	Змістовий модуль 2	60

4. Topic for self-study

#	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.	8
2	Principles of sulfide-free methods of cation classifications. Dissolving of the sample. "Soda" extracting. Methods of heterogeneous mixture separating.	8
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	10
4	Analytical methods of environmental item qualitative tests	10
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.).	18
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.	10
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	8

	methods in the environmental analysis.	
8	Chelates as a food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	8
	Total	90

5.Tools for assessing expected learn outcomes:

- Exam;
- Module test;
- Referates;
- Laboratory works;
- Abstracts.
- Presentation of laboratory works.

- 6. Teaching Methods

- **-** Verbal methods (lecture, interview)
- - Practical methods (Laboratory works)
- - Visual methods(demonstration methods)
- - Independent work (task performance)

- 7. Assessment methods

- Forms of control:
- -exam
- -test
- -control work
- -module test
- -laboratory work.

- 8. Distribution of points received by students

- The assessment of students' knowledge and skills is conducted by means of a 100-point scale and is converted into national grades according to Table 1 of the current *Exam and Credit Regulations at NULES of Ukraine*.

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Student's rating, points	National grading of exams and credits	
	exams	credits
90-100	excellent	pass
74-89	good	
60-73	satisfactorily	
0-59	unsatisfactorily	fail

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- To determine a student's rating in the discipline **RDIS** (up to 100 points), the received assessment rating **RA** (up to 30 points) is added to the academic performance raiting **RAP** (up to 70 points): **RDIS** = **RAP** + **RA**.

9. Technology and methodological requirements

1. Analytical Chemistry: Tutorial : [for students of higher educational institutions III-IV accreditation level, speciality 162 Biotechnologies and Bio-engineering»] / Voitenko L.V., Prokopchuk N.M., Lavrik R.V.,– Kyiv: NULES Publ., 2018. – 402 p.
2. Introduction in General, Organic and Analytical Chemistry, 7th Edition, by Morris Hein, Leo R. Best, Scott Pattison and Susan Arena, Brooks/Cole Publishing Co., 2020, 872 pp.
3. Chemistry: the Molecular Nature of Matter and Change, 2nd ed. Martin S. Silberberg, McGraw-Hill Companies, 2020, 1086 pp.
4. Analytical Chemistry, second edition, D. F. Shriver, P. W. Atkins, and C.H. Langford; W. H. Freeman and Co., New York, 2020, 913 pp.
5. https://elearn.nubip.edu.ua/course/view.php?id=2590

10. Recommended sources of information

1. Introduction in General, Organic and Biochemistry, 7th Edition, by Morris Hein, Leo R. Best, Scott Pattison and Susan Arena, Brooks/Cole Publishing Co., 2020, 872 pp.
2. Inorganic an analytical Chemistry, second edition, D. F. Shriver, P. W. Atkins, and C.H. Langford; W. H. Freeman and Co., New York, 2023, 913 pp.

3. https://elearn.nubip.edu.ua/course/view.php?id=1185
4. http://www.informika.ru/text/database/chemy/Enu/Data/Ch1-7.html