The National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of Ecology and Plant Polymers Technology

Environmental monitoring.

Part 2. Instrumental methods of environmental analysis

Work program of the educational component (Syllabus)

Details of the educational component	
Level of higher education	***first (bachelor's)***
Field of knowledge	*10 Natural sciences*
Speciality	*101 Ecology*
Educational program	*Environmental safety*
Status of the educational component	*Normative*
Form of study	*full-time (day)/remote/mixed*
Year of preparation, semester	*3rd year, 5 semester, autumn*
Scope of the educational component	*4 (120)*
Semester control/ control measures	*exam*
Schedule of classes	*3,6 hours a week (1,2 hour of lectures and 2,4 hours of laboratory classes)*
Language of instruction	*Ukrainian*
Information about tothe eminent course / teachers	Lecturer: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky/krisenko-tamara-volodimirivna-2.html Laboratory: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky/krisenko-tamara-volodimirivna-2.html
Course placement	*https://do.ipo.kpi.ua/*

The program of the educational component

1. Description of the educational component, its purpose, subject of study and learning outcomes

The intensive development of scientific and technological progress has led to the emergence of a number of global environmental problems, each of which can lead to the destruction of our civilization. Among these problems, the most priority are: shortage of fresh water, reduction of species biological and landscape diversity of the planet, greenhouse effect, ozone holes, acid rain, pollution of the World Ocean, desertification, loss of forests, etc.

Reducing the level of anthropogenic impact on the biosphere can be achieved by high-quality management of socio-economic systems of all levels by implementing a scientifically based

system of environmental and socio-economic management, which would be based on objective data of the corresponding system of environmental and socio-economic monitoring.

The monitoring system should, in terms of information, ensure the organization of the necessary information flows and improve monitoring of the main processes and phenomena in the biosphere.

The subject of the educational component is the processes of quality control of environmental components, methods for determining the content of pollutants in air, water and soil, programs for processing measurement results and sampling frequency.

The purpose of the educational component is to form in students the following competencies:

- the ability to assess the impact of technogenesis processes on the state of the environment and identify environmental risks associated with production activities;

- the ability to conduct environmental monitoring and assess the current state of the environment;

- the ability to apply modern methods and means of monitoring the state of atmospheric air, natural waters, soils and biota, to determine the level of contamination of natural and industrial materials with radioactive elements, to possess methods for assessing the impact of adverse factors on living organisms, to determine the adaptive capabilities of the human body in environmental conditions.

According to the requirements of the educational component program "Environmental Monitoring", after mastering it, students must demonstrate the following program learning outcomes:

- use the management principles on which the environmental safety system is based;

- know the conceptual foundations of monitoring and standardization of anthropogenic load on the environment;

- be able to predict the impact of technogenic processes and production on the environment;

- participate in the development and implementation of projects aimed at optimal management and treatment of industrial and municipal waste;

- preserve and multiply the achievements and values of society based on understanding the place of the subject area in the general system of knowledge, use various types and forms of physical activity to lead a healthy lifestyle.

2. Pre-requisitions and post-requisitions of *educational component* (place in the structural and logical scheme of education according to the relevant educational program)

Studying the educational component "Environmental Monitoring. Part 2. Instrumental Methods of Environmental Analysis" requires knowledge that is formed on the basis of studying such educational components as "Chemistry with Fundamentals of Biogeochemistry", "Special Sections of Biogeochemistry", "Organic Chemistry". The educational component "Environmental Monitoring. Part 2. Instrumental Methods of Environmental Analysis" is a fundamental basis that should provide such educational components as "Modeling and Forecasting of the State of the Environment", "Ecological and Natural and Technogenic Safety", and diploma design.

3. The content of the *educational component*

Section 1. Tasks and methods of instrumental methods of analysis

Section 2. Spectroscopic methods

Topic 2.1. Fundamentals of spectroscopy.

Topic 2.2. Methods of optical molecular spectroscopy.

Topic 2.3. Methods of atomic spectroscopy.

Section 3. Electrochemical methods of analysis

Topic 3.1. Fundamentals of electrochemical processes. Classification of electrochemical methods of analysis.

Topic 3.2. Potentiometry.

Topic 3.3. Voltammetry.

Topic 3.4. Coulometry.
Section 4. Chromatographic methods
Topic 4.1. Theoretical foundations of chromatographic methods of analysis.
Topic 4.2. Technique of chromatographic analysis.
Topic 4.3. Liquid chromatography.
Topic 4.4. Planar chromatography.
Topic 4.5. Gas chromatography.
Section 5. Kinetic methods of analysis

***Basic r*eferences**

1. Gab A.I., Shakhnin D.B., Malyshev V.V. Analytical chemistry and instrumental methods of analysis. – Kyiv: "Ukraine", 2018. – 396 p.
2. Instrumental methods of chemical analysis [Electronic resource]: a teaching aid for students of specialty 161 "Chemical technologies and engineering" of specialization "Chemical technologies of inorganic ceramic materials" / Igor Sikorsky Kyiv Polytechnic Institute; compilers: L.M. Spasyonova, V.Yu. Tobilko, I.V. Pylypenko. – Electronic text data (1 file: 1.85 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2019. – 69 p.
3. Instrumental methods of food product analysis / inc.: A.V. Sachko, V.V. Diychuk, M.M. Vorobets, O.V. Sema. Chernivtsi: Chernivtsi. National University named after Yu. Fedkovych, 2020. – 80 p.
4. Analytical chemistry. Quantitative analysis: a workshop for students of the Faculty of Chemistry and Pharmacy / O. M. Chebotaryov, S. V. Toporov, O. M. Guzenko, R. E. Khoma, D. V. Snigur. – Odesa: Odessa National University named after I. I. Mechnikov, 2019. – 80 p.
5. Fundamentals of chemistry and methods of food product analysis: a textbook / N. K. Cherno, O. O. Antipina, O. V. Malinka, S. I. Vikul. – Kherson: Oldi-plus, 2019. – 360 p.
6. Thermodynamic and kinetic aspects of chemical reactions: a textbook / comp. O. M. Shved, K. S. Yutilova, S. L. Bogza, G. M. Rozantsev. Vinnytsia: Vasyl Stus DonNU, 2021. 144 p.

***Supporting* references**

7. Methods of analytical chemistry in environmental research: methodological guidelines for studying the discipline "Methods and means of environmental control". Part II. Physical, physico-chemical and biological methods of analysis / L.I. Butchenko, O.M. Tereshchenko, O.P. Khokhotva. - K: NTUU "KPI", 2011. - 58 p.

8. Methods of analytical chemistry in environmental research: methodological guidelines for studying the discipline "Methods and means of environmental control". Part III. Physical, physico-chemical and biological methods of analysis / L.I. Butchenko, O.M. Tereshchenko, O.P. Khokhotva. - K: NTUU "KPI", 2011. - 56 p.

9. Methodological guidelines for solving typical problems / L.I. Butchenko, O.M. Tereshchenko, O.P. Khokhotva. – K: NTUU "KPI", 2010. – 56 p.

10. Maslenko S.N., Velichko V.V., Velikonskaya N.M., Pereskoka V.V. Analytical chemistry and methods of analysis: Textbook. – Dnipropetrovsk: NMetAU, 2011. – 162 p.

11. Methodical instructions for solving typical problems from the course "Instrumental methods of analysis" for students of the direction of training 6.040106 "Ecology, environmental protection and balanced nature management" / Compiled by: L.I. Butchenko, O.P. Khokhotva, O.M. Tereshchenko, O.V. Glushko. – K.: "Polytechnica", 2012. – 62 p.

Information resources on the Internet

1. Library named after V.I. Vernadsky – www.nbuv.gov.ua
2. Center for Electronic Educational Materials, access mode: https://do.ipo.kpi.ua/
3. Scientific Electronic Library of Periodicals of the NAS of Ukraine http://dspace.nbuv.gov.ua/.

Educational content

5. Methods of mastering the educational component

Lectures are aimed at: providing modern, holistic, interdependent knowledge on the educational component "Environmental Monitoring. Part 2. Instrumental Methods of Environmental Analysis", the level of which

– is determined by the target setting for each specific topic; ensuring creative work of students together with the teacher during the lecture;

– educating students in professional and business qualities and developing their independent creative thinking;

– forming the necessary interest in students and providing a direction for independent work;

– determining the current level of development of science in the field of analytical chemistry, forecasting its development for the coming years;

– reflecting the methodical processing of the material (highlighting the main ideas and provisions, emphasizing conclusions, repeating them in different formulations);

– teaching in a clear and understandable language, explaining all newly introduced terms and concepts;

– accessibility for perception by the given audience.

Title of the lecture topic and list of main questions (list of didactic means, references to literature and tasks for* IWS*)	***Hours***
Section.1. Tasks and methods of instrumental methods of analysis Classification of physicochemical methods of determination and separation of elements. Features of use and significance of physicochemical methods for the development of science, technology, production control and economy. **References:** [1]. P. 225-236; [2] P. 5-8; [3] P. 3-7. Tasks for IWS. Metrological and analytical characteristics of analysis methods.	2
Section 2. Spectroscopic methods Topic 2.1. Fundamentals of spectroscopy. Electromagnetic spectrum. Apparatus for optical spectroscopy. Topic 2.2. Methods of optical molecular spectroscopy. 2.2.1. UV-visible spectroscopy. Theoretical foundations of the method. Origin of absorption spectra. The Bouguer-Lambert-Beer law. Reasons for deviation from the basic law of photometry. Physicochemical foundations of the formation of colored compounds. Reactions that can be used in photometric analysis. Methods for measuring color intensity. Photometry and spectrophotometry. 2.2.2. Nephelometric and turbidimetric methods of analysis. 2.2.3. IR-spectroscopy. Vibrational spectra. Apparatus for vibrational spectroscopy. 2.2.4. Fluorescence and phosphorescence spectroscopy. Excitation mechanisms in fluorescence and phosphorescence. Quantitative analysis. Apparatus in luminescent analysis. Practical application. **References:** [1] P. 270-318; 328-335; [3] P. 33-45. Tasks for IWS. Refractometric methods of analysis. Polarimetric methods of analysis.	4
Topic 2.3. Atomic spectroscopy methods 2.3.1. Atomic absorption spectroscopy. Origin of atomic spectra. Radiation sources. Hollow cathode lamps. Atomizers. Quantitative analysis.	*4*

2.3.2. Atomic emission spectroscopy. Sources of atomization and excitation. Types of spectrometers. Quantitative and qualitative analysis. 2.3.3. X-ray and electron spectroscopy. Mechanism of excitation of internal electrons. X-ray fluorescence analysis. Radiation sources for X-ray diffraction, crystal analyzer, detectors. Qualitative and quantitative analysis. **References:** [1] P. 318-328; [3] P. 33-45. Tasks on the IWS. X-ray diffraction methods of analysis. Nuclear magnetic resonance spectroscopy. Mass spectrometry. Methods of analysis based on radioactivity.	
Section 3. Electrochemical methods of analysis Topic 3.1. Fundamentals of electrochemical processes. Classification of electrochemical methods of analysis. Electrodes and electrochemical cell. Classification of electrodes. Topic 3.2. Potentiometry. Direct potentiometry. Measurement of pH using a glass electrode. Ion-selective electrodes. Potentiometric titration. Topic 3.3. Voltammetry. Electrochemical processes. Construction of voltammograms. Classical polarography. Qualitative and quantitative polarographic analysis. Reversal voltammetry. Amperometric titration. Topic 3.4. Coulometry. Direct coulometry. Coulometric titration. **References**: [2] P. 5-13; [3] P. 53-69. Tasks for the IWS. Mechanisms of charge transfer in solutions. Electrical conductivity of electrolytes. Conductometry. Electrogravimetric method of analysis.	**3**
Section 4. Chromatographic methods Topic 4.1. Theoretical foundations of chromatographic methods of analysis Classification of chromatographic methods of analysis. Chromatographic parameters. Theory of chromatographic separation, processing of chromatograms. Concept of gas and liquid column chromatography. Topic 4.2. Technique of chromatographic analysis. Chromatographic column and its preparation for analysis. Obtaining a chromatogram on a column and its analysis. Chromatography in a thin layer of a sorbent. Topic 4.3. Liquid chromatography. Basic mechanisms of separation in liquid chromatography. Partition chromatography. Liquid adsorption chromatography. Ion chromatography. Topic 4.4. Planar chromatography. Stationary and mobile phases. Detection. Rf value and capacity coefficient. Topic 4.5. Gas chromatography. Retention characteristics, partition coefficients. Separation processes in the gas phase. **References**: *[1] C. 151-182;* [5] P. 285-296. Tasks for IWS. Extraction and ion exchange	**4**
Section 5. Kinetic methods of analysis Kinetic equations. Zero, first and second order reactions **References:** [6] P. 48-69.	**1**
Just	***18***

Laboratory classes

In the system of professional training of students, laboratory classes occupy 30% of the classroom load.

Laboratory work allows students to gain the ability to work with chemical reagents, dishes and devices, to carry out a chemical experiment and conduct primary scientific research.

The subject of laboratory work covers the main sections of quantitative analysis. When conducting a laboratory workshop, conditions are created for maximum independent performance of laboratory work by students. Therefore, laboratory classes begin with an express survey on the theoretical material necessary for the work (with assessment), checking the plans for laboratory work prepared by students as part of independent work and ends with an assessment of the student's work in the laboratory and the results obtained by them.

Laboratory work content	***Hours***
Photometric determination of titanium (IV) by comparison method.	2
Photometric determination of copper (II) by addition method.	2
Photometric determination of iron (III) in aluminum using sulfosalicylic acid by calibration graph method.	4
Extractive-photometric determination of trace amounts of copper.	4
Extractive separation of cobalt or nickel.	4
Potentiometric determination of chromic acid.	2
Determination of iron (III) by potentiometric titration method.	2
Adsorption separation of cobalt (II), iron (III) and copper (II) metal cations on aluminum oxide. Separation on paper of a mixture of iron (III) and copper (II) ions. Determination of the concentration of KNO3 solution by cation exchange method	6
Chromatographic separation and determination of cadmium and zinc.	4
Kinetic-photometric determination of molybdate	4
MTW	2
Just	**36**

6. Independent work of the student

Independent work of students takes 55% of the time of studying the educational component, also includes preparation of calculation and graphic work and preparation for the exam. The main task of independent work of students is mastering scientific knowledge in the field of analytical chemistry, which is not included in the list of lecture questions, through personal search for information, formation of active interest in a creative approach in educational work and when performing calculation and graphic work.

N⁰	*The name of the topic submitted for independent study*	*Number of hours of IWS*
Section.1. Tasks and methods of instrumental methods of analysis		
1	Metrological and analytical characteristics of methods of analysis. **References:** [1]. P. 8-12.	4

	Section 2. Spectroscopic methods	
2	Refractometric methods of analysis. Polarimetric methods of analysis. **References:** [1]. P. 338-348; [3]. P. 8-33. X-ray diffraction methods of analysis. Nuclear magnetic resonance spectroscopy. Mass spectrometry. Methods of analysis based on radioactivity. **References:** [10] P. 123-144.	4
	Section 3. Electrochemical methods of analysis	
3	Mechanisms of charge transfer in solutions. Electrical conductivity of electrolytes. Conductometry. Electrogravimetric method of analysis. **References:** [1]. P. 212-257.	4
	Section 4. Chromatographic methods	
4	Extraction and ion exchange **References:** [1] P. 321 – 339.	4
5	Calculation and graphic work References: 1 - 11.	15
6	Test work on sections 1-5	5
7	Exam	30
	Total hours	*66*

Individual tasks

According to the curriculum, the student must complete an individual task in the form of a calculation and graphic work.

Calculation and graphic work (CGW) is an independent study of the student. The essence of this type of work is to provide not only theoretical, but also practical material. By performing the GW, the student improves the knowledge and skills obtained in the process of studying the educational component "Environmental Monitoring. Part 2. Instrumental Methods of Environmental Analysis", namely: firstly, the calculation and graphic work highlights in a more specific form those issues that were briefly considered by the teacher; secondly, the student acquires skills in working with scientific literature and the ability to analyze a certain problem and find ways to solve it (so, the GW contains certain calculations, graphs, tables, diagrams); Thirdly, working on the RGR, the student acquires skills and abilities that will be useful in the future when performing more complex tasks (diploma thesis, dissertation, scientific research, etc.).

The RGR should be based on the study of sources of basic and auxiliary literature. In addition, it is recommended to use monographs, special articles, textbooks for university students and periodicals as auxiliary literature.

The requirements for the implementation of the RGR are given in Appendix A.

Ensuring program outcomes through educational component components

Name EC	*Lectures*	*Practical and laboratory classes, individual assignments*
Use the management principles on which the environmental safety system is based.	*Fundamentals of spectroscopy. Methods of optical molecular spectroscopy. Nephelometric and turbidimetric methods of analysis.*	*Photometric determination of titanium (IV) by comparison method.* *Photometric determination of copper (II) by addition method.*

	IR spectroscopy. Fluorescence and phosphorescence spectroscopy. *Methods of atomic spectroscopy* *Electrochemical methods of analysis.*	*Photometric determination of iron (III) in aluminum using sulfosalicylic acid by calibration graph method.* *Potentiometric determination of chromic acid.* *Determination of iron (III) by potentiometric titration method.*
Be able to predict the impact of man-made processes and production on the environment.	*Kinetic methods of analysis.*	*Kinetic-photometric determination of molybdate.*
Know the conceptual foundations of monitoring and regulating anthropogenic load on the environment.	*Tasks and methods of instrumental methods of analysis. Classification of physicochemical methods of determination and separation of elements.*	
To preserve and multiply the achievements and values of society based on an understanding of the place of the subject area in the general system of knowledge, to use various types and forms of physical activity to lead a healthy lifestyle.	*Chromatographic methods.*	*Adsorption separation of metal cations cobalt (II), iron (III) and copper (II) on aluminum oxide.* *Separation on paper of a mixture of iron (III) and copper (II) ions.* *Determination of the concentration of a KNO3 solution by the cation exchange method.* *Chromatographic separation and determination of cadmium and zinc.*
Participate in the development and implementation of projects aimed at optimal management and treatment of industrial and municipal waste		*Iindividual assignments (CGW)*

Policy and control

7. Policy of the educational component

Rules for Attendance and Behavior in Classes

For objective reasons (e.g., illness, international internship), training may be conducted individually (online, in agreement with the dean of the faculty). Students are required to actively participate in the educational process, not be late, and not be distracted by actions not related to the educational process.

Rules for Assigning Reward and Penalty Points

The semester certification is conducted in the form of an exam. A 100-point rating system and university scale are used to evaluate learning outcomes.

Reward points may be awarded by the teacher exclusively for performing creative works from the educational component or additional completion of online specialized courses with obtaining the appropriate certificate (in agreement with the teacher):

- https://www.coursera.org/learn/spectroscopy;
- https://www.edx.org/course/basic-analytical-chemistry;
- https://istl.org.ua/module-1-1.

A certificate that was previously awarded in the previous semester is not taken into account. The sum of the bonus points cannot exceed 10% of the rating scale.

Deadline and rescheduling rules

Modules can be rescheduled with the permission of the lecturer if there are valid reasons (for example, sick leave).

Laboratory work is evaluated based on the results of the work and its defense.

Academic Integrity Policy

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the lack of links when using printed and electronic materials, quotes, opinions of other authors. Unacceptable hints and write-offs when writing tests, conducting classes; passing the exam for another student; copying materials protected by the copyright system without the permission of the author of the work.

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute https://kpi.ua/code".

Academic Conduct and Ethics Policy

Students should be tolerant, respect the opinions of others, formulate objections in the correct form, constructively maintain feedback in the classroom.

The norms of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute https://kpi.ua/code".

8. Types of control and rating system for evaluating learning outcomes (RS)

Distribution of study time by types of classes and tasks in the educational component in accordance with the working curriculum:

Semester	*Educational time*		*Distribution of study hours*				*Control measures*		
	Credits	*Acad. H.*	*Lecture**	*Practical**	*Lab. Work**	*IWS*	*MTW*	*CGW*	*Semester control*
5	*4*	*120*	*18*	*-*	*36*	*66*	*1*	*1*	Exam

* - in accordance with the number of students in the group, the number of lectures, practical and laboratory classes can be proportionally changed, taking into account individual classes

The student's rating for the credit module consists of the points he receives for:

1) four tests (the *MTW* is divided into 4 tests lasting 22 minutes each);

2) completing 10 laboratory works;

3) completing calculation and graphic work;

4) answering the exam.

The system of rating points and evaluation criteria

1. Modular test.

Weighted score – 5. The maximum number of points for all tests is:
5 points x 4 tests = 20 points.

Criteria for evaluating test papers

Completeness of the answer	***Points***
"excellent" - a complete answer (at least 90% of the required information);	5
"good" - a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies;	4
"satisfactory" - an incomplete answer (at least 60% of the required information) and minor errors;	3
"unsatisfactory" - the task was not completed, the TW was not credited.	*2-0*

2. Laboratory work.

Weighted score – 3.0 points. The maximum number of points for all laboratory work is:
3 points x 10 works = 30 points.

Laboratory work evaluation criteria

Evaluation criteria	*Points*
the experiment was performed independently in full, the error of determination does not exceed 3%, the calculations were performed in full, a conclusion was made on the laboratory work, the work was formalized (the protocol and calculations were submitted on time), the theory of the laboratory work was fully mastered	3
the experiment was performed independently in full, the relative error of determination is more than 3%, but does not exceed 5%, the calculations were performed in full, the answer is correct, a conclusion was made on the laboratory work, the work was formalized (the protocol was submitted on time and the calculations were made with some delay), the theory of the laboratory work was not fully mastered, minor errors or inaccuracies were made during the defense of the work	2
the experiment was performed with the help of a teacher or laboratory assistant, the relative error of determination is more than 5%, but does not exceed 10%, the calculations were performed in full, the answer is correct, a conclusion was made on the laboratory work, the work is formalized (the protocol and calculations were submitted late), the theory behind the laboratory work is partially mastered, a significant error or inaccuracy was made during the defense of the work	1
the experiment was not performed, the relative error of the determination exceeds 10%, the theory behind the laboratory work is not mastered, during the defense of the work there is no understanding of the theoretical foundations and work methodology	0

3. Calculation and graphic work.

Weighting point – 10 points.

Criteria for evaluating calculation and graphic work

Points	*Evaluation criteria*
10-9	impeccable, creative execution of the work
8-7	the work was completed with minor flaws
6-5	the work was completed with certain errors
4-0	the work was not credited (the task was not completed or there are gross errors)

The condition for the first certification is to obtain at least 10 points and complete all laboratory work by the time of certification. The condition for the second certification is to obtain at least 22 points, complete all laboratory work by the time of certification and pass the calculation and graphic work.

The condition for admission to the exam is to pass all control, laboratory work, calculation and graphic work and a starting rating of at least 36 points.

During the exam, students complete a written test. Each task contains four questions (tasks). Each question (task) is evaluated out of 10 points according to the following criteria

Points	*Completeness of the answer*
10-9	complete answer (at least 90% of the required information);
8-7	sufficiently complete answer (at least 75% of the required information), or complete answer with minor inaccuracies;
6-5	incomplete answer (at least 60% of the required information) and minor errors;
4-0	work not counted (task not completed or there are gross errors)

Thus, the semester rating scale for the educational component is:

$$R_S = 4 \cdot 5 + 10 \cdot 3 + 10 = 60 \text{ points}$$

The exam component is 40% of R:

$$R_{ex} = 40 \text{ points}$$

Thus, the rating scale for the educational component is:

$$R = R_S + R_{ex} = 60 + 40 = 100 \text{ points}$$

The sum of the starting points and the points for the examination test is converted into the examination grade according to the table.

Points	***Examination score***
100...95	*Perfectly*
94...85	*Very good*
84...75	*Well*
74...65	*Satisfactory*
64...60	*Enough*
R<60 points	*Disappointing*
There are uncredited laboratory work or uncredited computational and graphic work or $R_S < 36$	*Not allowed*

9. **Additional information on the educational component**

Приблизний перелік питань, які виносяться на семестровий контроль

1. *Представити переваги інструментальних методів в порівнянні з хімічними.*
2. *Представити класифікацію спектральних методів аналізу.*
3. *Пояснити природу поглинання світла речовиною та хімізм виникнення забарвлення.*

4. *Розкрити зміст поняття електромагнітний спектр.*
5. *Розкрити зміст поняття хромофори, ауксохроми, батохромний та гіпсохромний зсуви.*
6. *Навести умови використання основного закону фотометрії та причини відхилення.*
7. ***Представити методи визначення концентрації забарвлених сполук.***
8. *Розкрити фізичний зміст поняття молярний коефіцієнт світлопоглинання. Навести чинники, що впливають на величину ε.*
9. *Сформулювати ІІ закон світлопоглинання (закон адитивності оптичних густин).*
10. *Сформулювати основні положення атомно-емісійного спектрального аналізу.*
11. *Представити основні вузли спектральних приладів та їх характеристики.*
12. *Розкрити зміст атомно-абсорбційного спектрального аналізу.*
13. *Представити основні вузли приладів для атомно-абсорбційного спектрального аналізу. Охарактеризувати кількісний атомно-абсорбційний аналіз.*
14. *Представити порівняльну характеристику методів атомно-емісійної та атомно-абсорбційної спектроскопії.*
15. *Розкрити зміст рентгеноспектрального аналізу.*
16. *Представити основні вузли приладів для рентгеноспектрального аналізу та їх характеристики.*
17. *Пояснити проведення якісного та кількісного рентгеноспектрального аналізу.*
18. *Розкрити сутність рентгенофлуоресцентного аналізу.*
19. *Розкрити зміст вольтамперометричного аналізу.*
20. *Пояснити проведення якісного та кількісного вольтамперометричного аналізу, навести розрахункові формули.*
21. *Розкрити зміст хроматографічного методу аналізу.*
22. *Представити хроматографічний пік.*
23. *Представити якісний та кількісний хроматографічний аналіз.*
24. *Розкрити зміст іонообмінної хроматографії.*
25. *Представити класифікацію іонообмінних сорбентів, навести приклади.*
26. *Розкрити зміст газо-твердофазної хроматографії, представити принципову схему установки.*
27. *Розкрити зміст газорідинної хроматографії, представити принципову схему установки.*
28. *Представити площинну хроматографію, її якісний і кількісний аналіз.*
29. *Розкрити зміст хеміохроматографії.*
30. *Представити загальну характеристику кінетичних методів аналізу.*

The work program of the educational component (syllabus):

Compiled *by Ph.D., assoc. prof. Krysenko T.V.*

Approved *by the department _E and PPT_ (protocol N^0 17 from 29.05.2025 p.)*

Approved by the Methodical Commission Faculty (protocol N^0 11 from _27.06.2025_)