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

Department of Ecology and Plant Polymers Technology

Environmental monitoring – 2. Instrumental methods of analysis

Working program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***First (Bachelor)***
Branch of knowledge	*10 Natural Sciences*
Speciality	*101 Ecology*
Educational program	*OPP Environmental Safety*
Status of discipline	*Normative*
Form of training	*full-time/remote/mixed*
Year of preparation, semester	*3rd year, spring semester*
Volume of discipline	*4(120)*
Semester control/ control measures	*Exam*
Schedule of classes	*3 hours per week (1 hour lecture and 2 hours of laboratory classes)*
Language of instruction	*Ukrainian*
Information about the course /teachers	Lecturer: *Ph.D., Assoc., Oksana Tereshchenko, okter789@gmail.com* Laboratory: *Ph.D., Assoc., Oksana Tereshchenko, okter789@gmail.com*
Course placement	https://do.ipo.kpi.ua/course/view.php?id=2514

Program of discipline

1. Description of the discipline, its purpose, subject of study and learning results

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: fresh water shortage, reduction of species biological and landscape diversity of the planet, greenhouse effect, ozone holes, acid rain, pollution of the oceans, desertification, death of forests, etc.

Reducing the level of anthropogenic impact on the biosphere can be achieved by qualitative management of socio-economic systems of all levels by introducing a scientifically based system of environmental and socio-economic management, which would be based on objective data of the relevant system of environmental and socio-economic monitoring.

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

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

The purpose of the discipline is to form competencies for students:

- the ability to assess the impact of technogenesis processes on the state of the environment and to 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 up-to-date 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 master methods for assessing the impact of adverse factors on living organisms, to determine the adaptive capabilities of the human body in environmental conditions.

In accordance with the requirements of the program of the discipline "Environmental Monitoring", students after its assimilation must demonstrate the following programmatic learning results:

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

- to know the conceptual basis of monitoring and regulation of anthropogenic load on the environment;

- to be able to predict the impact of technological processes and industries on the environment;

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

- to carry out laboratory researches with use of modern devices, to provide sufficient accuracy of measurement and reliability of results, to process the obtained results.

2. Prerequisitions and requisition of disciplines (place in the structural and logical scheme of training according to the relevant educational program)

Study of the discipline "Environmental Monitoring-2. Instrumental methods of analysis" requires knowledge that is formed on the basis of the study of such disciplines as "Chemistry and Fundamentals of Biogeochemistry", "Specific Topics of Biogeochemistry", "Organic chemistry". Discipline "Environmental Monitoring-2. Instrumental methods of analysis" are the fundamental basis that should provide such disciplines as "Modeling and forecasting of the environment", "Ecological and natural-technogenic safety", diploma design.

3. Contents of the discipline

Module 2. Instrumental methods of analysis

Section 1. Tasks and methods of instrumental methods of analysis

Topic 1.1. Classification of physico-chimihnyh stages of determination and separation of elements.

Section 2. Spectroscopic methods

Topic 2.1. Basics of spectroscopy.

Topic 2.2. Methods of optical molecular spectroscopy.

Topic 2.3. Methods of atomic spectroscopy.

Section 3. Electrochichnyh methods of analysis

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

Topic 3.2. Potentiometry.

Topic 3.3. Voltamperometry.

Topic 3.4. Pendantry.

Section 4. Chromatographic methods

Topic 4.1. Theoretical foundations of chromatographic methods of analism.

Topic 4.2. Technique of chromatographic analysis.

Topic 4.3. Liquid chromatography.
Topic 4.4. Plane chromatography.
Topic 4.5. Gas chromatography.
Section 5. Kinetic methods of analysis

4. Training materials and resources

Basic literature

1. Gab A.I., Shahnin D.B., Malyshev V.V. Analytical chemistry and instrumental methods of analysis. – K.: "Ukraine", 2018. – 396 p.

2. Instrumental methods of chemical analysis [Electronic resource] : teaching aid for stud. specialty 161 "Chemical technologies and engineering" specialization "Chemical technologies of inorganic ceramic materials"/ KPI them. Igor Sikorsky Kyiv Polytechnic Institute: L.M. Spasyonov, V.Y. Tobilko, I.V. Pylypenko. – Electronic text data (1 file: 1.85 MB). – Kyiv: Igor Sikorsky Kpi, 2019. – 69 p.

3. Instrumental methods of food analysis / incl.: A.V. Sachko, V.V. Diychuk, M.M. Vorobets, O.V. Sema. Chernivtsi: Chernivets. national un-t named after Y. Fedkovych, 2020. – 80 p.

4. Analytical chemistry. Quantitative analysis: workshop for students of f-th chemistry and pharmacy / O.M. Chebotaryov, S.V. Toporov, O.M. Guzenko, R.E. Khoma, D.V. Snigur. – Odessa: Odessa.

5. Fundamentals of chemistry and methods of food analysis: textbook / N.K. Cherno, O.O. Antipina, O.V. Malynka, S.I. Vikul. – Kherson : Aldi-plus, 2019. – 360 p.

6. Thermodynamic and kinetic aspects of chemical reactions: teachings. / compiled by O. M. Shved, K. S. Yutilov, S. L. Bogza, G. M. Rozantsev. Vinnytsia: Vasyl Stus DonNU, 2021. 144 p.

Secondary

7. Methods of analytical chemistry in environmental researches: methodical instructions for the study of 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. Hohotva. – K: NTUU "KPI", 2011 – 58 p.

8. Methods of analytical chemistry in environmental researches: methodical instructions for the study of 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. Khohotva. – K: NTUU "KPI", 2011 – 56 p.

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

10. Otto M. Sovremennye methods of analistic chimima (in 2 volumes).

11. Otto M. Sovremennye methods of analistic chimney (in 2 volumes).

12. Maslenko S.N., VelychkoV.V., Velikonska N.M., Pereskoka V.V. Analytical chemistry and methods of analysis: Teaching manual. – Dnipropetrovsk: NMetAU, 2011. – 162 p.

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

Information resources on the Internet

1. Center for Electronic Learning Materials, access mode: http://193.108.240.69/moodle/

2. Journal of inorganic chemistry, access mode: http://www.geokhi.ru/~zhakh

3. Electronic Library of Literature on General Chemistry: website. URL: https://techemy.com (hit date: 25.05.2019).

4. Center for Electronic Learning Materials: website. URL: http://193.108.240.69/moodle/ (date of appeal: 25.05.2019).

5. Bubliotek Academy of Sciences. Information on English Language: website. URL: http://ban.yu.ru (hit date: 25.05.2019).

6. Povnotective journals on chemistry in English and Russian: website. URL: http://abc.chemistry.bsu.by/free-journals/ (hit date: 25.05.2019).

Program of discipline

5. Methods of mastering the discipline (educational component)

Lectures are aimed at: providing modern, holistic, interdependent knowledge in the discipline "Environmental Monitoring – 2. Instrumental methods of analysis", the level of which

– determined by the target installation for each specific topic; ensuring in the process of lecturing the creative work of students together with the teacher;

– education of students of professional and business qualities and development of their independent creative thinking;

– formation of the necessary interest in students and providing direction for independent work;

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

– reflection of methodical processing of the material (allocation of main thoughts and provisions, underlining conclusions, repeating them in different formulations);

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

– accessibility for perception of this audience.

s/p	*Title of the lecture topic and list of main questions (list of didactic means, references to literature and tasks on the IWS)*
1	***Section 1. Tasks and methods of instrumental methods of analysis*** *Topic 1.1. Classification of physico-chimihnyh metods of definition and separation of elements.* *Features of the use and importance of physical and climatic methods for the development of science, technology, control of production and economy.* ***Literature: [1]. 225-236; [2] P. 5-8; [3] P. 3-7.*** *Tasks on the IWS. Metrological and analytical characteristics of analysis methods.*

2-3	***Section 2. Spectroscopic methods*** *Topic 2.1. Basics of spectroscopy.* *Electromagnetic spectrum. Equipment for optical spectroscopy.* *Topic 2.2. Methods of optical molecular spectroscopy.* *2.2.1. UV-visible spectroscopy. The origin of absorption spectra. Law of Buger-Lambert-Behr. Reasons for deviation from the basic law of photometry.* *2.2.2. Nefelometric and turbidymetric methods of analysis.* *2.2.3. IR spectroscopy and spectroscopy of combination scattering. Oscillations of multiatomic molecules. Osc swinging spectra. Equipment for oscival spectroscopy.* *2.2.4.Fluorescent and phosphorescent spectroscopy. Excitation mechanisms for fluorescence and phosphorescence. Quantitative analysis. Equipment in fluorescent analysis. Practical application.* ***Literature: [1]. 270-318; 328-335; [3] 33-45**.* *Tasks on the IWS. Refractometric methods of analysis. polarimetric methods of analysis.*
4	*Topic 2.3. Methods of atomic spectroscopy* *2.3.1. Atomic absorption spectroscopy. Origin of atomic spectra. Sources of radiation. Doppler expansion. Lamps with a broken cathode. Atomizers. Quantitative analysis.* *2.3.2. Atomic emission spectroscopy. Sources of atomization and excitation. Types of spectrometers. Quantitative and qualitative analysis.* *2.3.3. X-ray and electronic spectroscopy. Excitation mechanism of internal electrons. X-ray fluorescent analysis. Radiation sources for rfa, crystal analyzer, detectors. Qualitative and quantitative analysis.* ***Literature: [1]. 318-328; [3] 33-45**.* *Tasks on the IWS. X-ray diagnostic methods of analysis. Spectroscopy of nuclear magnetic resonance. Mass spectrometry.*
5	***Section 3. Electrochic methods of analiz*** *Topic 3.1. Basics 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. Jonselective electrodes. Potentiometric titration.* *Topic 3.3. Voltamperometry. Electrochemical processes. Construction of volts of ampere curves. Classical polarography. Qualitative and quantitative polarographic analysis. Inversion voltamperometry. Amperometry and volametry.* *Topic 3.4. Pendantry. Potentiostatic pendantry. Galvanostatic pendantry.* ***Literature: [2]. p. 5-13; [3]. CC 53-69; [10]. 340-347; 357-392; [12]. 84-111**.* *Tasks on the IWS. Mechanisms of charge transfer in solutions. Electroconductivity of electrolytes. Conductometry. Electrogravimetric method of analysis.*
6-7	***Section 4. Chromatographic methods*** *Topic 4.1. Theoretical foundations of chromatographic methods of analism* *Classification of chromatographic methods of analism.* *Chromatographic parameters. Theory of chromatographic separation, processing of chromatograms.* *The concept of gas and liquid column chromatography.* *Topic 4.2. Technique of chromatographic analysis* *Chromatographic column and its preparation for analysis. Obtaining chromatographs on the column and its analysis. Chromatography in a thin layer of*

	sorbent. *Topic 4.3. Liquid chromatography. The main mechanisms of separation in liquid chromatography. Distributive chromatography. Liquid adsorption chromatography. Yonne chromatography.* *Subject 4.4. Plane chromatography. Fixed and moving phases. Detection.* *Topic 4.5. Gas chromatography. Characteristics of retention, distribution coefficients. Separation processes in the gas phase. Flowchart of gas chromatograph.* ***Literature: [5] P. 285-296; [12] CC 8-81**.* *Tasks on the IWS. Extraction and ion exchange*
8	***Section 4. Kinetic methods of analysis*** *Kinetic equations. Zero, first and second order reactions* ***Literature: [6] P. 8-69; [12] CC 8-81**.*

Laboratory classes (computer workshop)

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

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

The topics of laboratory work cover the main sections of quantitative analysis. During the laboratory workshop, conditions are created for the most independent performance of laboratory work by students. Therefore, laboratory classes begin with an express survey on the theoretical material necessary for the performance of work (with evaluation), verification of plans for laboratory work prepared by students in the framework of independent work and ends with an assessment of the student's work in the laboratory and the results obtained by them.

Number Work	*Content of laboratory work*	*Number of hours*
1	*Photometric definition of titanium (IV) by comparison.*	*2*
2	*Photometric determination of copper (II) by additives.*	*2*
3	*Photometric determination of iron (III) in aluminum using sulphosalicylic acid by the method of graded graph.*	*4*
4	*Extraction-photometric determination of the micronuities of the cuprum.*	*4*
5	*Extraction separation of cobalt or nickel.*	*4*
6	*Potentiometric determination of chromic acid.*	*2*
7	*Determination of iron(III) by potentiometric titration.*	*2*
8 *9*	*Adsorption separation of cations of metals cobalt (II), iron (III) and copper (II) on aluminum oxide.* *Separation on paper of a mixture of iron ions (III) and copper (II).*	*4*
10	*Determination of the concentration of solution KNO_3 by cationic metabolism*	*2*
11	*Chromatographic separation and determination of cadmium and zinc.*	*4*
12	*Kinetic-photometric determination of molybdate*	*4*
13	*FDM*	*2*
Total hours		*36*

6. Independent work

Independent work of students takes 55% of the time of study of the course, also includes the preparation of calculation and graphic work and preparation for the exam. The main task of independent work of students is the mastery of scientific knowledge in the field of analytical chemistry, which are not included in the list of lecture questions, through personal search for information, the formation of an active interest in creative approach in educational work and in the implementation of calculation and graphic work.

No s/p	*Name of the topic submitted for IWS*	*Number of hours of IWS*
	Section 1. Tasks and methods of instrumental methods of analysis	
1	*Metrological and analytical characteristics of analysis methods.* ***Literature: [1]. C. 8-12.***	*4*
	Section 2. Spectroscopic methods	
2	*Refractometric methods of analysis. Polarimetric methods of analysis.* ***Literature: [1]. C. 338-348; [3]. C. 8-33.*** *X-ray methods of analysis. Spectroscopy of nuclear magnetic resonance. Mass spectrometry. Methods of analysis based on radioactivity.* ***Literature: [10]. C. 223-224; 287-339.***	*4*
	Section 3. Electrochic methods of analiz	
3	*Mechanisms of charge transfer in solutions. Electrical conductivity of electrolytes. Conduktometry. Electrogravimetric analysis method.* ***Literature: [10]. 347-357; [10]. 102-104.***	*4*
	Section 4. Chromatographic methods	
4	*Extraction and ion exchange* ***Literature: [10]. C. 121 – 139.***	*4*
5	*Calculation and graphic work* *Literature: 1 - 13.*	*15*
6	*Control work from sections 1-5*	*5*
7	*Exam*	*30*
Total hours		*66*

Politics and control

6. Policy of discipline (educational component)

Rules for attending classes and behavior in classes

For objective reasons (for example, illness, international internship), training can take place individually (online in agreement with the dean of the faculty). Students are obliged to take an active part in the educational process, not to be late, not to be distracted by actions that are not related to the educational process.

Rules for assigning incentive and penalty points

Semester certification is carried out in the form of an exam. To assess the results of training, a 100-point rating system and a university scale are used.

Encouraging points can be credited by the teacher only for the performance of creative works in the discipline or additional passage of online specialized courses with the receipt of the appropriate certificate (in agreement with the teacher):

- *https://orgchem. nuph. edu. ua;*
- *https://mgri.ru;*
- *https://www.coursera.org/learn/biosensory.*

The certificate was not re-issued (previously granted last semester). The amount of incentive points may not exceed 25% of the rating scale.

Deadline and overlay rules

The transfer of modules takes place with the permission of the lecturer if there are valid reasons (for example, sick leave).

Evaluation of laboratory work is carried out on the basis of the result of the work and its protection.

Academic Integrity Policy

Write-offs during control works and exams are prohibited (including using mobile devices). Works should have correct text links to the literature used.

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

Policy of academic behavior and ethics

Students should be tolerant, respect the opinion of others, object to form in the correct form, constructively maintain feedback in the classroom.

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

7. Types of control and rating system for assessing learning outcomes (RCOs)

Distribution of teaching time by types of classes and tasks from the credit module according to the working curriculum

Semester	School time		Training hours				Control measures		
	Loans	akad.h	Lectz.*	Pract.*	L/r*	IWS	MCT	HCW	Semester certification
6	4	120	18	-	36	66	1	1	Exam

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

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

1) four control works (MKR is divided into 4 works lasting 22 minutes);
2) performing 10 laboratory works;
3) performing of HCW;
4) answer to the exam.

System of rating (weight) points and evaluation criteria:

1. Modular control.

Weight point – 5. The maximum number of points for all control works is equal to:
5 points x 4 robots = 20 points.

Criteria for evaluation of control works

Mark	*Completeness of the answer*
5	*"excellent" – a complete answer (at least 90% of the necessary information);*
4	*"good" – a sufficiently complete answer (at least 75% of the required information), or a complete response with minor inaccuracies;*
3	*"satisfactory" – incomplete response (at least 60% of the required information) and minor errors;*
2 - 0	*"unsatisfactory" – the task is not completed, the MCT is not counted.*

2. Laboratory work.

Weight point – 3 points.

Point	*Completeness of the answer*
3	*impeccable work, the relative error of determination does not exceed 3%, defense - unerring knowledge of the theoretical foundations and methods of work performance*
2	*the relative error of determination does not exceed 5%, insignificant errors or inaccuracies were made when protecting the work*
1	*the relative error of determination exceeds 10%, a significant error or inaccuracy was made when protecting the work*
0	*the relative error of determination exceeds 10%, when defending the work there is no understanding of the theoretical foundations and methods of work*

3. HCW.

Weight point – 10 points.

Point	*Повнота відповіді*
10 - 9	*impeccable, creative performance of work*
8 – 7	*a sufficiently complete answer (at least 75% of the required information), with minor shortcomings*
6 – 5	*work done with certain errors*
4 - 0	*work is not counted (task not completed or there are gross errors)*

The condition for the first certification is to receive at least 8 points and perform all laboratory work at the time of certification. The condition of the second certification is the receipt of at least 22 points, the implementation of all laboratory works at the time of certification and the enrollment of settlement and graphic work.

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

At the exam, students perform a written test. Each task contains four questions (tasks). Each question (task) is evaluated with 10 points according to the following criteria

Point	*Completeness of the answer*
10 – 9	*"excellent" – a complete answer (at least 90% of the necessary information);*
8 – 7	*"good" – a sufficiently complete answer (at least 75% of the required information), or a complete response with minor inaccuracies;*

6	*"satisfactory" – incomplete response (at least 60% of the required information) and minor errors;*
5 - 0	*"unsatisfactory" – the task is not completed, the CD is not counted.*

Thus, the rating semester scale of the credit module is:

R_C=4*5+10*3+10=60.

The component of the exam is equal to 40% of R:

$R_{екз}$ = 40 points.

Thus, the rating scale of the credit module is:

$R = R_C+R_{EK3}$ = 60 + 40 =100 points

The sum of starting points and points for the examination test is transferred to the examination score in accordance with the table.

Points. $R = R_C + R_{EK3}$	*Examination assessment*
100…95	*Perfectly*
94…85	*Very good*
84…75	*Fine*
74…65	*Satisfactorily*
64…60	*Enough*
Less than 60	*Unsatisfactorily*
There are not credited laboratory work or not credited calculation and graphic work or R_C <26	*Not allowed*

8. Additional information on the discipline (educational component)

An approximate list of questions that are submitted for semester control

1. Formulate the classification of physico-chemical methods of determining and separating elements. Formulate the features of use and significance of physico-chemical methods for the development of science, technology, production control and economy.
2. To characterize spectroscopic methods of analysis.
3. Describe the method of absorption spectroscopy.
4. To characterize photometric and spectroscopic methods of analysis. Give the theoretical foundations of the method.
5. Explain the origin of absorption spectra.
6. Derive the Bouguer-Lambert-Behr law. Show the reasons for the deviation from the basic law of photometry.
7. Explain the physicochemical basis of the formation of colored compounds. Give reactions that can be used in photometric analysis.
8. Describe the methods of measuring the color intensity. Explain what photometry and spectrophotometry are.
9. Describe the methods of fluorescence and phosphorescence spectroscopy.
10. Show the nature and explain the spectra of luminescence.
11. Explain the scheme of the device for luminescent analysis.
12. Give the main xemiluminescent reagents and explain the analysis.
13. Characterize catalytic chemiluminescent reactions.
14. Explain what nephelometry and turbidimetry are.
15. Describe the methods of atomic spectroscopy and emission spectral analysis.

16. Give the main characteristics of electromagnetic radiation.
17. Explain the theoretical foundations of emission spectroscopy.
18. Explain the principle of operation of spectral devices.
19. Describe the basic principles of the flame photometry method. Show the practical application of the method.
20. Describe the main principles of the atomic absorption spectroscopy method.
21. Explain the theoretical foundations of the method.
22. Bring the scheme of the device for AAS.
23. Explain how quantitative measurements are carried out. Explain the application of the method.
24. Explain the essence of X-ray spectral methods of analysis.
25. Explain the origin of X-ray spectra and absorption of X-ray radiation.
26. Explain the design of X-ray devices.
27. Explain how qualitative and quantitative X-ray spectral analysis is performed.
28. Show the practical application of the method.
29. Describe the electrochemical methods of analysis.
30. Explain the principle of the potentiometric method of analysis.
31. Give a classification of electrochemical methods of analysis. Explain the basics of electrochemical processes.
32. Explain the construction of electrodes in the potentiometric method of analysis.
33. Explain the main principles of classical polarography.
34. Explain the current-potential curve.
35. Give a diagram of a polarographic installation.
36. Describe the amperometric titration method. Give a general description of the method. Show the practical application of the method.
37. Give the theoretical foundations of chromatographic methods of analysis.
38. Give the classification of chromatographic methods of analysis.
39. Explain the methods of obtaining chromatograms.
40. Explain the theory of chromatographic separation: kinetic plate theory, kinetic theory.
41. Give a block diagram of a chromatograph and explain how chromatograms are processed.
42. Describe the method of liquid column chromatography.
43. Describe the methods of adsorption chromatography, partition chromatography, ion exchange chromatography.
44. Planar chromatography.
45. Chromatography on paper.
46. Formulate the basic laws and give quantitative characteristics of the extraction method.
47. Define the term "extraction rate".
48. Classify extraction processes. Explain the practical application of the method.

Work program of the discipline (syllabus):

Compiled by Assoc. Prof., Ph.D., Tereshchenko O.M.

Approved by the Department of E and TRP (protocol № 14 of 08.06.2022)

Approved by the Methodical Commission of the faculty [1] (protocol № 10 from 24. 06. 2022)