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

Department of Ecology and Plant Polymers Technology

Physicochemical methods of environmental analysis

Working program of the discipline (Syllabus)

Details of the discipline

Level of higher education	***First (Bachelor)***
Branch of knowledge	*16 Chemical and bioengineering*
Speciality	*161 Chemical technology and engineering*
Educational program	*Industrial ecology and resource-efficient clean technologies*
Status of discipline	*Custom*
Form of training	*full-time/remote/mixed*
Year of preparation, semester	*4th year, autumn semester*
Volume of discipline	*4(120)*
Semester control/ control measures	*Passed*
Schedule of classes	*4 hours a week (2 hours of 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

Monitoring of the chemical composition of air, surface waters of land, soils is a necessary prerequisite for solving many economic problems related to the protection and rational use of natural resources. The main source of information about the state of environmental objects is analysis, so the correctness of determining a large number of chemical ingredients available in these objects is of particular importance. Many of them are of natural origin and are necessary for the normal functioning of the water bodies. At the same time, a large number of compounds of different origins enter the environment due to the action of the anthropogenic factor. In most cases, these compounds are toxic, they need to be determined at the level of maximum permissible concentrations. In addition, the multicomponent chemical composition of natural ecosystems requires careful selection of effective methods of analysis and mastery of their implementation, because their results are a database for the creation of a data bank, without which it is impossible to scientifically substantiated implementation of technical measures aimed at preserving or restoring normal ecological status.

The subject of the discipline "Physicochemical methods of environmental analysis" is the formation of students' knowledge on the theoretical foundations of chemical analysis and

practical skills and skills of its implementation, taking into account the peculiarities of the composition of the environment.

The purpose of the discipline "Physicochemical methods of environmental analysis"

The purpose of this discipline is to study the theoretical foundations of methods of chemical and physico-chemical analysis of natural components in order to have an idea of the impact of chemicals on the environment and the possibility of solving the problems that arise with the means and methods of chemical analysis; acquaintance with the main modern methods of elemental composition research and mastering the possibilities of applying these methods in solving professional tasks.

According to the requirements of the program of the study discipline "Physico-chemical methods of environmental analysis", students must demonstrate the following learning outcomes after mastering it:

- the ability to use modern information resources for environmental research;

- the ability to use methods of fundamental and applied disciplines in research activities;

- to conduct experiments on given methods with the processing and analysis of their results, to make a description of the performed studies;

- the ability to apply knowledge of general chemistry and biogeochemistry, inorganic, organic, analytical, physical and colloidal chemistry to the extent necessary for the development of professional disciplines.

In accordance with the requirements of the program of the discipline " Physico-chemical methods of environmental analysis ", 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)

The study of the discipline "Physicochemical methods of environmental analysis" requires knowledge that is formed on the basis of the study of the following disciplines: " Chemistry and Fundamentals of Biogeochemistry", " Specific Topics of Biogeochemistry ", "Soil science", "Biology", "General ecology". » provides the disciplines "Modeling and forecasting of the environment", "Ecological and natural-technogenic safety", diploma design.

3. Contents of the discipline

Section** 1. **The importance of analytical chemistry in solving environmental problems.

Topic 1. Organization of chemical observations and control over the state of environmental objects.

Section 2. Characteristics of the chemical composition of surface waters of Ukraine

Topic 1. Characteristics of the chemical composition of water in the river basins of Ukraine.

Section 3. Sampling and their preparation for analysis

Topic 1. Types of water samples and methods of their selection, canning, transportation and storage.

Topic 2. Separation of suspended, colloidal, dispersed and truth-dissolved substances.

Section 4. Classification, possibilities and limitations of analysis methods

Topic 1. Taming and automation of methods for analyzing environmental objects.

Topic 2. Methods of separation, masking and concentration of components of natural waters.

Section 5. Assessment of the quality of analysis

Topic 1. Methods for determining dissolved gases.

Topic 2. Methods for determining salt components (macrocomponents).

Topic 3. Methods for determining biogenic substances.

Topic 4. Microelements.

Topic 5. Organic compounds.

Topic 6. Methods of analysis of metals in natural and wastewater.

Investigation of forms of finding metals in natural and wastewater.

Section 6. Express test methods

Topic 1. Operational quality control of natural waters

Section 7. Donnie sediments

Topic 1. Methods of analysis of bottom sediments

4. Training materials and resources

Basic literature

1. *Textbook for the study of the discipline "Environmental Monitoring"/Roma V.V., Stepova O.V., Mokin V.B. – Poltava: PoltNTU, 2016. – 117 p.*
2. *Shakirzanova Zh.R., Kichuk N.S. Hydrochemistry of rivers and reservoirs of Ukraine: textbook. – Odessa, ODEKU, 2019. – 124 p.*
3. *Tsyganok L.P. Analytical chemistry. Chemical methods of analysis: textbook/ L.P. Tsyganok, T.O. Bubel, A.B. Vyshnikin, O.Y. Vashkevich; edited by Prof. L.P. Tsyganok. – Dnipropetrovsk: DNU named after O. Gonchar, 2014. – 252 p.*
4. *Minaeva V.O., Ninova T.S. Analysis of environmental objects: educational and methodological manual for students of higher educational institutions. – Cherkasy: View. from Chabanenko Y.A., 2020. – 266 p.*
5. *Chebotaryov O.M., Guzenko O.M., Snigur D.V. Modern methods of sample preparation of substances and materials for analysis. – Odessa: Odessa, National University named after I.I. Mechnikov, 2020. – 40 p.*
6. *Minaeva V.O. Methods of concentrating inorganic substances: educational and methodological manual for students of higher educational institutions. – Cherkasy: View. from Bohdan Khmelnytsky National University, 2014. – 313 p.*
7. *Fundamentals of Metrology: Textbook/ I.V. Soltis, O.V. Derevyanchuk. – Chernivtsi: Chernivtsi National University, 2021. – 152 p.*
8. *Nabyvanets B.Y., Osadchiy V.I., Osadcha N.M., Nabyvanets Y.B. Analytical chemistry of surface waters: Monograph.- K.: Naukova Dumka, 2007. – 455 p.*
9. *Manual for studying the course "Express methods of analysis"/ F.O. Chmilenko, S.M. Khudiakova. – D.:RVVDNU, 20215. – 24 p.*
10. *Methodical instructions for laboratory work on the course "Physicochemical methods of environmental analysis"/Tereshchenko O.M., Glushko O.V. – K.: "Polytechnic", 2022. – 60 p.*

Secondary

11. *I. M. Netrobchuk. Assessment of surface water quality of right-bank tributaries of the Pripyat basin in Volyn region/ Scientific Bulletin of Volyn State University named after Lesya Ukrainka SECTION VI. Ecology and environmental protection. 2, 2007. – 260-265.*

12. *Drushov Y.S. Ecological analistic chimiya.- St. Petersburg: "Anatoly", 2002. – 464 p.*
13. *ALEMASOVA A.S., Lugovoi K.S. Ekological anatomical chimiya. Uchebnoe posobie (for bachelors of specialties "chimiya" and "bohymiya" day and correspondence forms of study) / Sost.: A.S. Alemasova, K.S. Lugovoi. – Donetsk: DonNU, 2010. – 271 p.*
14. *Amelin V.G. Chemical test methods of opredeleniya components of the zhidky sred. Obzor. Zhurn. analit. Khymy, 2000, v.55 No 9, p.902-932.*
15. *Lurye Yu.Yu., Rybnikova A.I. Khymechesky analiz proizvodstvennyh stationary waters.- M.: Khymya, 1974.- 335 p.*
16. *Nabyvanets B.I., Linnyk P.N., Kalabyna L.V. Kinetic methods of analization of static waters.- K.: Naukova Dumka, 1981.-138 p.*
17. *Linnik P.N., Nabyvanets B.I. Forms of metallic mygratsiya in presnyh surface waters.- L: Gidrometeoizdat, 1986.- 270 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).

5. Methods of mastering the discipline (educational component)

Lectures are aimed at: providing modern, holistic, interdependent knowledge in the discipline "Physicochemical methods of environmental 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. The importance of analytical chemistry in solving environmental problems. Analytical service. The relationship between the analysis and management of the environmental situation of water bodies***

	Organization of chemical observations and control over the state of environmental objects. Prospects for ecoanalytic control. Assessment of the degree of pollution of environmental objects. *Literature: [1], 14 – 28.* *Tasks at the IWS: Features of the organization of monitoring and control of soil pollution with pesticides and heavy metals.*
2-3	***Section 2. Characteristics of the chemical composition of surface waters of Ukraine*** *Topic 2.1. Characteristics of the chemical composition of water in the river basins of Ukraine. Quality of surface. Classification of natural waters by chemical composition of dissolved substances.* *Literature: [2], p. – 33 – 50.* *Tasks at the IWS: Hydrochemical index of water pollution.*
4	***Section 3. Sampling and their preparation for analysis*** *Topic 3.1. Types of samples and ways to select them.* *Topic 3.2. Preservation, transportation and storage of water samples.* *Topic 3.3. Separation of suspended, colloidal, dispersed and truth-dissolved substances.* *Literature: [3], p. 29 – 33; [4], c. 20 – 28; 48 - 50; [5], c. 8 – 37.* *Tasks at the IWS: Microwave sample preparation.*
5	***Section 4. Classification, possibilities and limitations of analysis methods*** *Topic 4.1. Metrological characteristics of analysis methods.* *The principle of choosing the best methods of analysis. Taming and automation of methods for analyzing environmental objects.* *Literature: [7], p. 8 – 70.* *Tasks at the IWS: Calibration of measuring instruments. Standards. Exemplary measuring instruments. Verification schemes.*
6	*Topic 4.2. Methods of separation, masking and concentration of components of natural waters.* *Freezing methods: general characteristics of the method, methods of freezing. Co-planting: the basics of the method, the reasons for co-planting, the use of this method for concentration.* *Literature: [3], p. 37 – 39; [6], 26- 178.* *Tasks at the IWS: Cryogenic concentration.*
7-9	*Topic 4.3. Extraction. Chromatographic methods of analysis.* *General characteristics of methods, basic quantitative characteristics.* *Literature: [3], 41–53.* *Tasks at the IWS: Methods for extracting pollutants from water: solid phase extraction, gas extraction, extraction, membrane methods.*
10-11	***Section 5. Assessment of the quality of analysis*** *Topic 5.1. Methods for determining dissolved gases.* *The concentration of dissolved oxygen and its relationship with production and destruction processes in natural waters. Carbonate equilibrium and determination of free carbon dioxide. Determination of hydrogen sulfide, chlorine, ammonium.* *Literature: [8], p. 85 -101.* *Tasks at the IWS: Determination of nitrogen, ozone, L.A. compounds in the air.*
12-13	*Topic 5.2. Methods for determining salt components (macrocomponents).* *Determination of acidity and alkalinity, hardness of water, salt components. Method of flame photometry.*

	Literature: [8], 102 - 130. *Topic 5.3. Methods for determining biogenic substances and trace elements. Determination of compounds of nitrogen, phosphorus, silicium, iron in natural and wastewater. Methods of molecular and atomic spectroscopy in determining trace elements in natural and wastewater. The use of kinetic methods of analysis in the determination of trace elements.* *Literature: [8], 132 - 173.* *Tasks at the IWS: Determination of PAHs; inorganic ions with ion chromatography.*
14-15	*Topic 5.4. Organic compounds.* *Determination of carbon of organic-, nitrogen of organic substances. Determination of individual organic compounds: non-ionogenic determinants, petroleum products, phenols in natural and wastewater.* *Literature: [8], 292 - 408,* *Topic 5.5. Methods of analysis of metals in natural and wastewater. Investigation of forms of finding metals in natural and wastewater.* *Literature: [8], 179 – 258.* *Tasks at the IWS: Methods for determining metal-organic compounds and volatile organic compounds.*
16	***Section 6. Express test methods*** *Topic 6.1. Portable analytical devices and mobile laboratories* *Topic 6.2. Chemical sensors* *Topic 6.3. Chemical test systems of simplified express control* *Literature: [9], p. 6 – 18; [8], 416 – 434.* *Tasks at the IWS: Determination of the test strip.*
17	***Section 7. Donnie sediments*** *Topic 7.1. Selection and preparation of samples for analysis.* *Topic 7.2. Determination of losses during roasting.* *Topic 7.3. Definition of heavy metals.* *Literature: [8], p. 438 – 441* *Tasks at the IWS: Determination of petroleum products in the soil and bottom sediments.*
18	*Final lesson. Passed*

Laboratory classes (computer workshop)

In the system of professional training of students, laboratory classes occupy 30% of the classroom load. Being an addition to the lecture course, they consider chemical, physicochemical and physical methods of analysis, which are most often used in the study of the chemical composition of natural environment objects.

The purpose of laboratory and practical classes is to develop students' experimental skills, a research approach to the study of the subject, fixing theoretical material.

No lab. Work	*Content of laboratory work*	*Quantity Hours*
1.	*Determination of the total content of carbonates.*	*4*
2.	*Determination of the total oxygen content by winkler method.*	*2*
3.	*Determination of the total content of hydrogen sulfide and sulfides.*	*2*
4.	*Determination of smallpox (III) and plumbum (II) in solution by complexonometric titration.*	*2*

5.	*Photometric determination of ammonium with Nesler reagent.*	*2*
6.	*Determination of nitrides with sulfonic acid and -naftilamin.*	*4*
7.	*Determination of acid nitrates by photometric method with salicylic acid.*	*4*
8.	*Determination of nickel by photometric method with dimethyl glyoxime.*	*4*
9.	*Determination of the total content of chromium by the photometric method with diphenylcarbazide.*	*2*
10.	*Photometric determination of phenols with paranitroaniline.*	*2*
11.	*Determination of arsenase, blue dextrin and nitrophenol by gel chromatography.*	*4*
12.	*Separate determination of dyes by thin-layer chromatography.*	*2*
FDM		*2*
Total hours		*36*

6. Independent work

Independent work of students takes about 40% of the time to study 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 self-study*	*Number of hours of SRS*
Section 1. Section 1. The importance of analytical chemistry in solving environmental problems. Analytical service. The relationship between the analysis and management of the environmental situation of water bodies		
1	*Features of the organization of observation and control of soil pollution with pesticides and heavy metals.* *Literature: [1]. 59 – 63.*	*2*
Section 2. Characteristics of the chemical composition of surface waters of Ukraine .		
2	*Hydrochemical index of water pollution.* *Literature: [11], 260-265.*	*2*
Section 3. Sampling and their preparation for analysis		
3	*Microwave sample preparation* *Literature: [13], p. 83 - 85.*	*2*
Section 4. Classification, possibilities and limitations of analysis methods		
4	*Calibration of measuring instruments. Standards. Exemplary measuring instruments. Verification schemes.* *Literature: [7], P. 72-86; 90-93.* *Cryogenic concentration.* *Literature: [13], C. 61-62.* *Methods of extraction of pollutants from water: solid phase extraction, gas extraction, extraction, membrane methods.* *Literature: [13], p. 77 – 82.* *Capillary electrophoresis, use in analysis.*	*7*

	Literature: [2], 219 – 225. *Determination of organochlorine compounds.* *Literature: [3], p. 117 – 119; 122 - 124.* *Prospects for improving ion exchange chromatography.* *Literature: [3], p. 185 – 190; [13], 351 - 355.*	
Section 5. Assessment of the quality of analysis		
	Determination in the air of compounds of nitrogen, ozone, L.A. *Literature: [13], 162 - 175.* *Definition of PAHs; inorganic ions with ion chromatography* *Literature: [13], p. 137 – 142.* *Methods for determining metal-organic compounds and volatile organic compounds.* *Literature: [13], 248 – 256.*	*8*
Sections 6-7. Express test methods. Donnie sediments		
	Definition of test bands. *Determination of petroleum products in the soil and bottom sediments.* *Literature: [5], p. 22 – 23; [8], p. 21 – 22; [13], 223– 230.*	*4*
4	*HCW* *Literature: 1 - 17.*	*15*
5	*MCT*	*4*
6	Final test	*4*
	Total hours	*48*

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 a standings. 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://www. edx. org/course/basic-analytical-chemistry;*
- *https://www. coursera. org/learn/chemistry.*
- *https://studyabroadnations.com/uk/free-online-chemistry-courses-with-certificates/*

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
7	4	120	36	-	36	48	1	1	final test

** - 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 11 minutes);

2) performing 12 laboratory works;

3) execution of stretching and graphic work.

System of rating (weight) points and evaluation criteria:

1. Modular control.

Weight point – 10. The maximum number of points for all control works is equal to:

10 points x 4 robots = 40 points.

Criteria for evaluation of control works

Mark	Completeness of the answer
10-9	"excellent" – fluency in the material (at least 90% of the necessary information)
8-6	"good" – incomplete disclosure of one of the questions (at least 75% of the required information), or a complete answer with minor inaccuracies; inaccuracy in the calculations
5-2	"satisfactory" – incomplete disclosure of the issue (at least 60% of the necessary information) and minor errors in calculations, units of measurement;
1	"unsatisfactory" – the task is not completed, gross errors in calculations, units of measurement.
0	Lack of work

2. Laboratory work.

Weight point – 3 points.

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
24 – 23	impeccable, creative performance of work
22 – 16	a sufficiently complete answer (at least 75% of the required information), with minor shortcomings
15 – 14	work done with certain errors
13 - 0	work is not counted (task not completed or there are gross errors)

The condition of the first attestation is obtaining at least 12 points and performing all laboratory and control work during the attestation. The condition of the second attestation is to obtain at least 45 points, to perform all control and laboratory work during the attestation and to enroll in calculation and graphic work.

The maximum number of points is 100. To receive credit "automatically" you need to have a rating of at least 60 points.

Thus, the rating scale for the discipline is:

$$12 \cdot 3 + 4 \cdot 10 + 24 = 100 \text{ points.}$$

Students who at the end of the semester have a rating of less than 60 points, as well as those who want to improve their rating, complete a credit test. At the same time, the points received by the student during the semester are not saved.

The task of the control work consists of eight questions from different sections of the program from the list of given questions.

Each theoretical question is evaluated at 10 points according to the evaluation system:

- 10-9 points – complete answer (at least 90% of information);

- 8-7 points – sufficiently complete answer (at least 75% of information);

- 6-5 points – incomplete answer (at least 60% of information);

- 4-0 is an unsatisfactory answer.

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

$$RC=4*5+12*2+16=60 \text{ points}$$

The exam component is equal to 40% of R:

$$Rex = 40 \text{ points}$$

Thus, the credit module rating scale is:

$$R=R_C+R_{EKZ}=60+40=100 \text{ points.}$$

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 submitted for semester control

1. Explain the importance of analytical chemistry in solving environmental problems, the relationship between the analysis and management of the ecological situation of water bodies, air and soil.

2. To characterize the chemical composition of natural and wastewater, air and soil.

3. Explain the organization of chemical observations and control over the condition of environmental objects.

4. Classify methods of analysis, substantiate their capabilities and limitations.

5. Define the concepts of "sensitivity", "accuracy", "reproducibility" of analysis methods.

6. To justify the principle of choosing optimal methods of analysis. Explain what instrumentation and automation of environmental object analysis methods are.

7. Describe the types of samples and sampling, their preservation and storage.

8. Give methods of separation of suspended, colloidally dispersed and truly dissolved substances.

9. Describe the methods of separation, masking and concentration of natural water components (general characteristics). Show the disadvantages and advantages of these methods.

10. Describe freezing methods: give a general description of the method, methods of freezing.

11. Explain what co-precipitation is: the basics of the method, reasons for co-precipitation, application of this method for concentration.

12. Formulate the principles of extraction: give a general description of the method, describe the main quantitative characteristics.

13. Describe chromatographic methods: general characteristics of the method, classification of chromatographic methods.

14. Explain the principle, areas of application of adsorption chromatography.

15. Thin-layer chromatography, basics of the method, areas of application: qualitative and quantitative analysis.

16. Explain the essence of the gas chromatography method.

17. Detectors in gas chromatography.

18. Explain the essence of quantitative and qualitative determinations in gas chromatography.

19. Describe the method of gas-liquid chromatography, formulate the main advantages of the method.

20. Explain the essence of ion-exchange chromatography: the principle of the method, the theoretical basis of the method.

21. Give a general description of kinetic methods of analysis.

22. Explain the methods of determining dissolved gases. Determination of dissolved oxygen concentration and its relationship with production and destruction processes in natural waters.

23. Explain what carbonate balance is and give methods for determining free carbon dioxide.

24. Define hydrogen sulfide.

25. Determine "active chlorine" in water.

26. Describe the methods of determining the main components (macrocomponents) in natural and wastewater. Determination of acidity and alkalinity, hardness of water.
27. Determine Cl- and SO42- in natural and wastewater.
28. To determine potassium and sodium in wastewater and natural waters, the principle of the method.
29. Describe the methods of determining biogenic substances, give a general description of the methods.
30. Determination of ammonium and ammonia ions.
31. Determination of nitrate and nitrite ions.
32. Definition of phosphates, polyphosphates, "total phosphorus".
33. Determination of dissolved forms of silicates in water.
34. Determination of Fe^{2+}, Fe^{3+}, total content of all forms of iron in water.
36. Formulate the basic principles of kinetic methods of analysis, give a description of the method, name the fields of application.
37. Formulate the basic principles of luminescent and chemiluminescent methods of microelement analysis of natural and wastewater.
38. Determination of carbon and nitrogen of organic compounds.
39. Determination of individual organic compounds (petroleum products, organic acids).
40. Formulate the basic principles of research methods for all forms of metals in natural and wastewater.
41. Formulate the basic principles of chromatography-mass spectrometry methods, the application of this method in the analysis of natural and wastewater.

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)