Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Ecology and technology of plant polymers

Extraction of organic and inorganic pollutants from water
Work program of the discipline (Syllabus)

Requisites of the discipline	
Level of higher education	***First (bachelor's)***
Field of expertise	*10 Natural sciences*
Speciality	*101 Ecology*
Educational program	*Environmental safety*
Discipline status	*Custom*
Form of education	*full-time / remote / mixed*
Year of preparation, semester	*3kurs/6 semester*
Scope of discipline	*4 ECTS credits (120 hours)*
Semester Control/ Control Measures	*Passed*
Schedule of classes	*4 hours per week (1 hour of lecture and 3 hour lab classes)*
Language of instruction	*Ukrainian*
Information about the course /teachers	Lector: *https://eco-paper.kpi.ua/pro-kafedru/vykladachi/trus-inna-mikolajivna.html* *Laboratory classes: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/trus-inna-mikolajivna.html*
Course placement	*https://do.ipo.kpi.ua*

The program of the discipline

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

Human life and economic activity are inextricably linked with the use of natural resources and changes in the state of the environment. Negative phenomena that have arisen as a result of anthropogenic impact on nature have recently directly threatened the health and existence of people. Today in Ukraine there are almost no reservoirs, the waters of which belong to the first category of quality, a significant part of the population is not provided with high-quality drinking water. Therefore, there is an urgent need for a radical change in the strategy of water consumption and water use, in the introduction of resource-saving closed systems in industry and energy.

The subject of the discipline "Extraction of organic and inorganic pollutants from water" *is the implementation of approaches that will provide high-quality preparation of natural waters, reliable wastewater treatment, sludge dewatering for the complete transition of industrial enterprises to the use of drainless (closed) water consumption systems.*
To a large extent, the solution of this problem will be determined by the level of training of specialists working in the field of environmental protection, including individual enterprises, institutions, organizations.
To successfully solve the problems of protecting and preserving natural water bodies, such specialists must be well aware of modern methods and technologies of water purification.

The purpose of the discipline "Extraction of organic and inorganic pollutants from water"

The purpose of studying the discipline "Extraction of organic and inorganic pollutants from water" is to form students' complex of knowledge in the field of modern physicochemical methods of water

purification, a set of skills and abilities necessary for conducting scientific research in this direction, to create reliable, environmentally friendly and cost-effective methods of deep water purification from organic and inorganic pollutants, for qualified management of existing technological processes. to the goal of preparing bachelors requires strengthening the competencies formed by students:

In accordance with the goal of preparing bachelors in this specialty requires the formation of students' competencies:

- *the ability to improve, design, implement and operate technologies and equipment for treatment and processing of raw gases, wastewater and solid waste;*
- *the ability to critically understand basic theories, methods and principles of natural sciences.*

*According to the requirements of the program of the discipline "**Extraction of organic and inorganic pollutants from water**", students after its assimilation must demonstrate the following programmatic learning outcomes:*

- *to be able to choose the best methods and tools for research, data collection and processing;*
- *to develop technologies, to use processes and devices that ensure efficient separation, concentration, removal, destruction of harmful impurities in water systems and gas medium, processing and disposal of 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. Prerequisites and post-requisitions of disciplines (place in the structural and logical scheme of education according to the relevant educational program)

*The study of the discipline "**Extraction of organic and inorganic pollutants from water**" is based on the principles of integration of various knowledge gained by students during the undergraduate period in the study of natural and engineering-technical disciplines: "Hydrology", "Chemistry with the basics of biogeochemistry", "Special sections of biogeochemistry", "Biogeochemistry", "Organic chemistry", "Analytical chemistry". Fundamental basis for the study of the following disciplines: "Technologies of water purification", "Water treatment in industry and public utilities", "Mechanical and biological processes of liquid waste disposal", "Design of water supply systems", "Circulating and closed water consumption systems", "Centralized water supply systems", "Design of treatment facilities and water use systems", "Processes and equipment of water purification", "Water treatment stations", and ensures the implementation of bachelor's Project.*

3. Contents

Section 1. Extraction of toxic organic and inorganic pollutants from water

Topic 1. Toxic organic matter that is present in wastewater

Topic 2. Toxic inorganic substances that are present in wastewater

Topic 3. Application of physicochemical methods for the extraction of organic impurities from water

Topic 4. Application of ion exchange and adsorption for the extraction of organic impurities from water

Topic 5. Application of biochemical purification for the extraction of organic impurities from water

Topic 6. Application of destructive methods for the extraction of organic impurities from water

Section 2. Extraction of heavy metal ions and radionuclides from water

Topic 7. Extraction of heavy metal ions from water

Topic 8. Extraction of radionuclides from water

Topic 9. Extraction of heavy metal ions and radionuclides from water by magnetosorption method

4. Training materials and resources

Basic literature

1. *Gomel M.D., Shabliy T.O., Radovenchyk Ya.V. Physico-chemical bases of water purification processes: textbook. – Kyiv: Condor Publishing House, 2019. – 256 p.*
2. *Radovenchyk Ya.V., Gomelya M.D. Physico-chemical methods of water purification. Textbook. – Kyiv: Condor Publishing House, 2016. – 264 p.*
3. *Gomelya M.D., Krysenko T.V., Omelchuk Yu.A. Methods and technologies of wastewater treatment: Textbook. persons. / – Sevastopol: Institute of Nuclear Energy and Industry, 2012. – 244 p.*
4. *Shabliy T.O., Radovenchyk V.M. Gomel M. D. The use of new reagents and technologies in industrial water consumption.- K.: Infodruk, 2014. – 302p.*
5. *Gomel M.D., Radovenchyk V.M. Shabliy T. O. Modern methods of air conditioning and water purification in industry. -K.: Graphics, 2007. – 168 p.*
6. *Extraction of organic and inorganic pollutants from water. Laboratory workshop [Electronic resource]: a textbook for applicants for a bachelor's degree in the educational program "Environmental Safety" specialty 101 "Ecology" educational program "Industrial ecology and resource-efficient clean technologies" specialty 161 Chemical technologies and engineering / KPI them. Igor Sikorsky; compiled by: M. D. Gomel, T. O. Shabliy, O. I. Ivanenko, I. M. Trus. – Electronic text data (1 file: 1.79 MB). – Kyiv: KPI them. Igor Sikorsky, 2022. – 63 p. – Title from the screen. https://ela.kpi.ua/handle/123456789/50467*
7. *Trus I.M., Halysh V.V., Skyba M.I., Radovenchyk Ya.V., Gomelya M.D. New highly effective methods of purification from soluble and insoluble pollutants: monograph. / – K.: Condor-Publishing House, 2020. – 272 p.*

Further reading

8. *Halysh V.V., Trus I.M., Radovenchyk Ya.V., Fleischer G.Yu., Gomelya M.D. Complex technologies of water purification from heavy metal ions: monograph. – Kyiv: Condor Publishing House, 2020. – 152 p.*
9. *Zapolsky A.K. Water supply, drainage and water quality: Textbook. – K.: Vyshcha shk. 2005 – 671 p.*
10. *Trus I.M. Low-waste technologies of water demineralization: monograph. – Kyiv: Condor-Publishing House, 2016. – 250 p.*
11. *Petruk V.G., Severyn L.I., Vasilkovskyi I.V., Bezvozyuk I.I. Environmental technologies. Tutorial. Part 2: Methods of wastewater treatment – Vinnytsia: VNTU, 2014. – 258 p.*
12. *Petruk V.G., Vasilkivskyi I.V., Bezvozyuk I.I., Petruk R.V., Turchyk P.M. Environmental technologies. Tutorial. Part 3: Methods of sewage sludge processing – Vinnytsia: VNTU, 2013. – 324 p.*
13. *WHO, Guidelines for drinking water quality, 4th edition, incorporating the 1st addendum, 2017.*
14. *Trus I.M., Halysh V.V., Gomelya M.D. Development of methods for processing sludge and spent biosorbents for the creation of low-waste water treatment technologies: monograph. – Kyiv: Condor-Publishing House, 2023. – 115. p.*

Information resources on the Internet

15. *Ministry of Environmental Protection and Natural Resources of Ukraine – https://mepr.gov.ua/*
16. *Professional Association of Ecologists of Ukraine (PAEU) - https://ecolog-ua.com/paeu*
17. *Library. V.I. Vernadsky – www.nbuv.gov.ua*
18. *Ecological portal of Ukraine – www.ecologya.com.ua*

Educational content

5. Methods of mastering the discipline (educational component)

Lecture classes

Lectures are aimed at:

- *providing modern, holistic, interrelated knowledge in the discipline "Extraction of organic and inorganic pollutants from water", the level of which is determined by the target installation for each specific topic;*
- *ensuring the creative work of students together with the teacher during the lecture;*
- *education of students' professional and business qualities and the development of their independent creative thinking;*
- *formation of students' necessary interest and determination of direction for independent work;*
- *determination at the present level of science development in the field of modern methods and processes of water conditioning, forecasting development for the coming years;*
- *reflection of the methodical processing of the material (highlighting the main provisions, conclusions, recommendations, their clear and adequate formulation)*
- *use for demonstration of visual materials, combination, if possible with the demonstration of results and samples;*
- *teaching research materials in a clear and high-quality language in compliance with structural and logical connections, clarification of all newly introduced terms and concepts;*
- *accessibility for perception by this audience.*

No salary	***The title of the lecture topic and the list of main issues (list of didactic means, references to literature and tasks on the CPC)***	***Hours***
Section 1. Extraction of toxic organic and inorganic pollutants from water		
1	***Topic 1. Toxic organic substances that are present in wastewater*** *The main classes of organic substances of a toxic nature, which are present in wastewater in odes. Toxic and harmful aliphatic and aromatic hydrocarbons, heterocyclic compounds. Organic acids, bases (amines, pyridine and its derivatives, cations and anions). Neitheronne nor cationic surfactants. Oil and petroleum products. Complex organic toxins. Dyes. Oligomers and polymers. The main sources of income.* *References: [11] p. 9-12; [13] p. 307-380* *Objectives for CPC: Physical, chemical and organoleptic indicators of water quality*	***2***
2	***Topic 2. Toxic non-organicsubstances that are present in wastewater*** *Toxic inorganic substances. Heavy and non-ferrous metals, radionuclides. Fluorides, cyanides, nitrites, ammonium. Nitrates and phosphates. Anthropogenic and natural sources of entry into the aquatic environment.* *References: [9] pp. 462-488; [1, 2], p. 9-12; [13] p. 307-380* *Tasks on the CPC: Requirements for the quality of process water and drinking water*	***2***
3	***Topic 3. Application of physicochemical methods for the extraction of organic impurities from water*** *Physicochemical methods of peelingorganic impurities from water. Coagulation, flocculation during extraction of humates and surfactants. Settling and flotation in the extraction of oil and petroleum products.* *References: [1] p. 39-134; [1 1] p. 86-88* *Tasks on CCF: Heterocoagulation, mutual coagulation*	***2***
4	***Topic 4. Application of ion exchange and adsorption to extract organic impurities from water*** *The use of ion exchange and adsorption in the extraction of organic impurities from water. The use of ion exchange in the extraction of amines (organic bases), organic*	***2***

	salts, organic acids from water. The use of adsorption and filtration in the extraction of non-ionogenicorganic impurities from water. *References: [1] p. 165-194; [1, 4] p. 73-98* *Tasks on the CPC: Ion exchange desalting and softening of highly mineralized waters*	
5	***Topic 5. The use of biochemical purification to extract organic impurities from water*** *The use of biochemical purification from organic impurities. The use of biofilters, aeration tanks, oxytanks in the treatment of large volumes of wastewater. Additional treatment of wastewater from organic impurities in oxidation channels, biostavki and biofilters. Dehydration of sediments and activated sludge during biochemical water purification.* *References: [9] p. 565-594; [1 1] p. 91-133* *Tasks on CPC: Filtering fields. Irrigation fields.*	***2***
6	***Topic 6. Application of destructive methods to extract organic impurities from water*** *The use of destructive methods of water purification from organic impurities. The use of thermal catalytic methods of oxidation of impurities with oxygen and other oxidizing agents. Electrochemical destruction of organic impurities. Thermooxide without evaporation of water.* *References: [1] p. 222-237; [3] pp. 210-224; [9] p. 372-393* *Tasks on the CPC: Liquid-phase oxidation. Deep oxidation mechanism*	***2***
Section 2. Removal of heavy metal ions and radionuclides from water		
7	***Topic 7. Extraction of heavy metal ions from water*** *Application of ion exchange and membrane methods to extract heavy metal ions from water. Electroextraction of heavy metals from regeneration solutions. Extraction of chromaticmats, nitrates and phosphates on anoonites. Recycling of regeneration solutions.* *References: [1] p. 241-244; [4] p. 196-209; [8] p. 9-39; [1, 4] p. 7-37* *Tasks on CPC: Sorption methods for removing heavy metal ions from aqueous solutions*	***2***
8	***Topic 8. Removal of radionuclides from water*** *Extraction of radionuclides from aqueous solutions. Purification of water from compounds of uranium, cesium, strontium, cobalt, ion exchange and other physicochemical methods. Extraction of cesium and strontium compounds from laddersand from washx waters AEC.* *References: [1] p. 247-252; [5] p. 105-120* *Tasks on CPC: Radiation sources*	***2***
9	***Topic 9. Extraction of heavy metal ions and radionuclides from water by magnetosorption method*** *Application of magnet ossorption method for extraction of heavy metal ions and radionuclides from water. The use of magnetite for water purification from radionuclides and heavy metal ions.* *References: [3] p. 238-241; [8] p. 9-39, 100-108* *Tasks on the CPC: Absorbed dose, radiation-chemical yield*	***2***
	Just	***18***

Laboratory classes

In the system of professional training of students, laboratory classes occupy 75% of the classroom load. Being a supplement to the lecture course, they lay and form the basis for the qualifications of the organizer of environmental management. The purpose of laboratory and practical classes is to develop students'

experimental skills, a research approach to the study of the subject, and the consolidation of theoretical material.

No salary	**Title of laboratory work**	**Hours**
1	*Entry. Safety instruction, familiarization with the program of laboratory work, issuance of methodological literature.*	***2***
2	*Ion exchange water purification from organic acids*	***6***
3	*Restoration of sorption capacity of anionite AB-17-8 with alkali*	***6***
4	*Adsorption water purification with activated carbon in dynamic conditions.*	***6***
5	*The dependence of ion exchange water purification on dyes depending on the initial form of ionite*	***6***
6	*Determination of the degree of ionite regeneration depending on the composition of the regeneration solution*	***6***
7	*Removal of manganese ions from natural waters*	***6***
8	*The use of catalysts based on cationite modified magnetite for iron removal of water.*	***12***
9	*Modular test paper*	***2***
10	*Passed*	***2***
	Just	***54***

Providing program results by the components of the educational component

Program result	*Lecture classes*	*Practical and laboratory classes, individual tasks*
Be able to choose the best methods and tools for research, data collection and processing.		*Laboratory lesson 7. Removal of manganese ions from natural waters* *Laboratory lesson 8. The use of catalysts based on cationite-modified magnetite for iron removal of water*
Develop technologies, use processes and devices that ensure effective separation, concentration, extraction, destruction of harmful impurities in water systems and gas environments, waste processing and disposal.	*Lecture 1. Toxic organic substances that are present in wastewater* *Lecture 2. Toxic inorganic substances present in wastewater* *Lecture 3. Application of physicochemical methods for the extraction of organic impurities from water* *Lecture 4 Application of ion exchange and adsorption to extract organic impurities from water* *Lecture 5. The use of biochemical purification to extract organic impurities from water* *Lecture 6. Application of destructive methods to extract organic impurities from water*	

	Lecture 7. Extraction of heavy metal ions from water *Lecture 8. Removal of radionuclides from water* *Lecture 9. Extraction of heavy metal ions and radionuclides from water by magnetosorption method*	
Conduct laboratory tests using modern devices, ensure sufficient measurement accuracy and reliability of results, process the results.		*Laboratory lesson 2. Ion exchange water purification from organic acids Laboratory lesson 3. Restoration of sorption capacity of anionite AB-17-8 with alkali* *Laboratory lesson 4. Adsorption water purification with activated carbon under dynamic conditions* *Laboratory lesson 5. The dependence of ion exchange water purification on dyes depending on the initial form of ionite* *Laboratory lesson 6. Determination of the degree of ionite regeneration depending on the composition of the regeneration solution*

6. Independent work of a student / graduate student

Independent work takes 40% of the time studying the credit module, including preparation for credit. The main task of students' independent work is to master scientific knowledge in areas that are not included in the list of lecture issues through personal search for information, the formation of an active interest in a creative approach in educational work. In the process of independent work within the educational component, the student must learn to deeply analyze modern approaches to the development and implementation the latest technologies of air conditioning and water purification, based on the characteristics of water and quality requirements for purified water. He should be able to create the most effective methods of water purification.

No salary	***The name of the topic submitted for independent study***	***Number of hours CPC***
Section 1. Removal of toxic organic and inorganic pollutants from water		
1	*Physical, chemical and organoleptic indicators of water quality* *References: [1] pp. 8-19; [2] p. 9-18; [7] p. 1-41.* *Requirements for the quality of process water and drinking water. Requirements for water quality in agriculture* *References: [1] pp. 20-27; [2] p. 18-24; [7] p. 1-41.* *Getting coagulants. Heterocoagulation, mutual coagulation.* *References: [1] pp. 38-84; [2] p. 42-48; [7] p. 132-156.* *Ion exchange desalting and softening of highlymineralized waters* *References: [10] p. 60-69* *Filter fields. Irrigation fields.* *References: [11] p. 91-103.* *Liquid-phase oxidation. Deep oxidation mechanism*	***24***

	References: [1] pp. 223-237; [2] pp. 210-216.	
Section 2. Removal of heavy metal ions and radionuclides from water		
2	*Sorption methods for removing heavy metal ions from aqueous solutions.* *References: [8] pp. 5-99.* *Ionizing radiation. The main stages of radiolysis* *References: [1] pp. 223-237; [2] pp. 220-224.* *Absorbed dose, radiation-chemical yield.* *References: [1] pp. 223-237; [2] pp. 220-224.*	***16***
3	***Preparing for ICR***	***4***
4	***Preparation for the test***	***4***
	Just	***48***

Policy and control

7. Policy of the discipline (educational component)

Rules for attending classes and behavior in classes

Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to interfere with the teacher to conduct classes, not to be distracted by actions that are not related to the educational process.

Rules for assigning incentive and penalty points

- *Encouraging points can be awarded by the teacher only for performing creative works on the discipline or additional passing of online specialized courses with obtaining the appropriate certificate:*
- *https://www.coursera.org/learn/water-treatment*
- *https://cropaia.com/water-treatment-pro/*
- *https://www.shortcoursesportal.com/studies/113424/drinking-water-treatment.html?ref=search_card*

But their amount cannot exceed 10 % of the rating scale.

- *Penalty points within the discipline are not provided.*

Deadlines and rebuilds policy

In case of arrears in the discipline or any force majeure circumstances, students should contact the teacher through the available (provided by the teacher) communication channels to solve problem issues and agree on an algorithm of actions for working out.

Academic Integrity Policy

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism refers to the lack of references when using printed and electronic materials, quotes, opinions of other authors. Inadmissible hints and cheating when writing tests, conducting classes; passing an 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 section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: 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 section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code

8. Types of control and rating system for assessing learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working curriculum:

Semester	Study time		Distribution of training hours				Control measures		
	Loans	Acad. H.	Lecture	Practical	Lab. Rob.	CPC	FDM	OCD	Semester control
6	4	120	18	-	54	48	1	-	Passed

The student's rating in the discipline consists of points that he receives for:

The student's credit module rating consists of the points that he receives for his work in laboratory work, for writing a modular test. Semester control is credit.

System of rating (weight) points and evaluation criteria

Performance of laboratory work.

The weight score for 1 laboratory work is 10 points. Criteria for evaluating the performance of laboratory works

Completeness and signs of the task	Points
The task is fully completed	10
Minor deficiencies under paragraph 1	8-9
Late completion of the task	7
Late completion of the task, shortcomings in paragraph 1	2-6
Poor performance of the task	1
Task failure	0

Modular tests

Weight score – 1.5points. The maximum number of points for all tests is equal to: 15 points x2 papers = 30 points

Test evaluation criteria

Completeness and signs of response	Points
Full answer	15
The answer does not provide secondary or dependent on the main parameters (materials)	12-14
The answer does not provide half of the major and several minor parameters or materials	8-11
The answer is superficial without analyzing parameters, conditions, materials, facts, incomplete conclusions	1-7
Test paper not credited	0

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

$$R_c = 7 \cdot 10 + 15 \cdot 2 = 100 \text{ points}$$

According to the results of educational work for the first 7 weeks, the "ideal student" should score 40 points. At the first certification (8th week), the student receives "credited" if his current rating is at least 20 points.

According to the results of academic work for 18 weeks of study, the "ideal student" should score 90 points. At the second certification (16th week), the student receives "credited" if his current rating is at least 40 points.

The maximum amount of points is 100. To obtain a credit from the credit module "automatically" you need to have a rating of at least 60 points. A prerequisite for admission to the test is a rating of at least 40% of the rating scale (R), i.e. 40 points.

Students who score less than 0.6 R during the semester, as well as those who want to increase the overall rating, perform credit tests. In this case, all points received by them during the semester are canceled. The test tasks contain 2 questions that relate to different sections of the credit module. For the correct answer

to each question, students receive 50 points. Consequently, the maximum number of points for the test test is 50 points 2 = 100 points. System of evaluation of individual questions of credit test.

Completeness and signs of response	*Points*
Full answer	*47-50*
The answer does not provide a sufficient number of facts, examples, conclusions are not drawn, or some inaccuracies are made;	*26-46*
A partial answer is given, the specific wording of laws and terms is absent or gross mistakes have been made;	*1-25*
The question is not counted or missing	*0*

The list of credit questions is given in Chapter 9. To obtain a credit grade, the sum of all rating points R received during the semester is translated according to the table:

Score	***Score***
95... 100	*Perfectly*
85... 94	*very good*
75...84	*well*
65... 74	*Satisfactory*
60...64	*enough*
RD 60<	*Disappointing*
Not met the conditions of admission	*not admitted*

9. Additional information on the discipline (educational component)

NFishing list of questions submitted for semester control

1. *Describe the main classes of organic substances of a toxic nature that are present in wastewater.*
2. *Describe the anthropogenic and natural sources of entry into the aquatic environment of pollutants.*
3. *Describe the physical indicators of water quality.*
4. *Describe the chemical and organoleptic indicators of water quality.*
5. *Give the requirements for the quality of industrial water.*
6. *Give requirements for drinking water quality*
7. *Describe the physicochemical methods of peeling organic impurities from water*
8. *The use of ion exchange in the extraction of organic impurities from water.*
9. *Give the conditions andonoexchange of desalting and softening of highly mineralized waters*
10. *The use of adsorption in the extraction of organic impurities from water.*
11. *What are the advantages and disadvantages in the use of biochemical purification from organic impurities*
12. *Compare the effectiveness of destructive methods of water purification from organic impurities.*
13. *The use of ion exchange to extract heavy metal ions from water.*
14. *Describe by applying membrane methods to extract heavy metal ions from water.*
15. *Describe the use of sorbents to remove heavy metal ions from aqueous solutions*
16. *Give methods for the removal of radionuclides from aqueous solutions.*
17. *Application of magnet adsorption method for extraction of heavy metal ions and radionuclides from water.*
18. *Give methods for obtaining coagulants based on iron and aluminum compounds.*
19. *Give methods for the production of magnetite and its application to purify water from heavy metal ions.*
20. *Extraction of cesium and strontium compounds from ladders and from washx waters AEC.*

Work program of the discipline (syllabus):

Compiled by *Assoc., Ph.D., Trus I.M.*

Approved *by the Department of E and PPT (protocol № 14 from 05.18.2023)*

Approved *by the methodological commission of the*

Faculty of Engineering and Chemistry (protocol № 10 from 05.26.2023)