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

Ecology and Plant Polymers Technology

Analytical Chemistry. Part 2. Quantitative Analysis

Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	***first (bachelor's)***
Field of knowledge	*16 Chemical and Bioengineering*
Speciality	*161 Chemical Technologies and Engineering*
Educational program	*Industrial Ecology and Resource Efficient Clean Technologies*
Discipline status	*Mandatory*
Form of study	*full-time (day)/remote/mixed*
Year of preparation, semester	*2nd year, spring semester*
Scope of discipline	*4 credits (120 hours)*
Semester control/ control measures	*Exam*
Schedule of classes	*3 hours a week (1 hour of lectures and 2 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 discipline

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

"Analytical Chemistry. Part 2. Quantitative Analysis" is a fundamental chemical discipline about methods for determining the quantitative composition of compounds and their mixtures. This discipline provides theoretical and practical knowledge about chemical methods of analysis. The knowledge that students receive in the process of studying the discipline "Analytical Chemistry. Part 2. Quantitative Analysis", is a theoretical and practical basis for studying specialized disciplines at senior courses. Work in the laboratory, practical mastering of the basics of various methods of analysis is an important component of the training of highly qualified specialists. Students study the discipline "Analytical Chemistry. Part 2. Quantitative Analysis" requires them to be able to focus on a detailed study of the properties of chemical elements and their compounds, the state of matter in solutions, the assimilation of the theoretical foundations of the most important types of chemical transformations, which are the basis of various methods of analysis. When performing laboratory work on this academic

discipline, students acquire the skills to perform the most important chemical operations. Their knowledge, intelligence, abilities will manifest themselves when performing individual control tasks for analysis.

Subject of the discipline "Analytical Chemistry 2. Part 2. Quantitative Analysis" *- the study of the theoretical foundations of analytical methods, the improvement of existing and the development of new methods of analysis, their practical use.*

The purpose of the discipline "Analytical Chemistry. Part 2. Quantitative Analysis".

The purpose of studying this discipline is to form in students a complex of knowledge of the theoretical foundations of important types of chemical transformations, methods for identifying the substances under study, a set of skills and abilities necessary to perform basic chemical operations.

In accordance with the purpose of studying the discipline requires the formation of students' ***competencies:***

- the ability to abstract thinking, analysis and synthesis;

- the ability to apply knowledge in practical situations;

-the ability to use the provisions and methods of fundamental sciences to solve professional tasks;

- the ability to apply up-to-date experimental methods of working with technological objects in industrial and laboratory conditions.

According to the requirements of the program of the discipline ***«Analytical Chemistry. Part 2. Quantitative analysis"****, after mastering it, students must demonstrate the following programmatic learning outcomes:*

- to know mathematics, physics and chemistry at the level necessary to achieve the results of the educational program;

- to correctly use the terminology and basic concepts of chemistry, chemical technologies, processes and equipment for the production of chemicals and materials based on them in professional activities;

- to carry out qualitative and quantitative analysis of substances of inorganic and organic origin, using appropriate methods of general and inorganic, organic, analytical, physical and colloidal chemistry.

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

Study of the discipline ***"Analytical Chemistry. Part 2. Quantitative Analysis"*** *is based on the principles of integration of knowledge gained by students during the first year in the study of the disciplines "General and Inorganic Chemistry". Discipline* ***"Analytical Chemistry. Part 2. Quantitative Analysis"*** *is a fundamental chemical discipline that should provide such disciplines as "Physical Chemistry", "Toxicology", "General Chemical Technology".*

3. The content of the discipline

Topic 1. Tasks and methods of quantitative chemical analysis.

Topic 2. Gravimetric analysis.

Topic 3. Titrimetric methods of analysis.

Topic 3.1. General provisions of the titrimetric method of analysis.

Topic 3.2. Acid-base titration method (neutralization method).

Topic 3.3. Complexonometric titration.

Topic 3.4. Methods of oxidation-reduction (redoxmetry).

Topic 3.4.1. General characteristics of reduction oxidation methods.

Topic 3.4.2. The method of permanganateometry.

Topic 3.4.3. The method of dichromatometry.

Topic 3.4.4. Iodometry.

4. Learning materials and resources

Basic literature

1. *Slobodnyuk R.E. Course of analytical chemistry. – Kherson: Oldie plus, 2020. – 256 p.*
2. *Butchenko L.I., Khokhotva O.P., Tereshchenko O.M., Glushko O.V. Analytical chemistry. Quantitative chemical analysis: method. instructions for performing lab. works. for students of all areas of training. – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, Publishing House "Polytechnic", 2015. – 120 p.*
3. *Butchenko L.I., Khokhotva O.P., Tereshchenko O.M., Glushko O.V. Analytical chemistry. Methods of quantitative chemical analysis (problem solving): textbook posibn. – K: NTUU "KPI", 2017. – 176 p.*

Further reading

4. *Fedushchak N.K., Bidnychenko Yu.I., Kramarenko S.Yu., Kalibabchuk V.O. Analytical Chemistry. – Vinnytsia: Nova Kniga, 2012. – 640 p.*
5. *Shevryakov M.V., Povstyanyi M.V., Yakovenko B.V., Popovych T.A. Analytical chemistry. Theoretical foundations of qualitative and quantitative analysis. – Kherson: Ailant, 2011. – 404 p.*
6. *Bolotov V.V., Svechnikova O.M., Golik M.Yu. and others. Analytical chemistry. – Vinnytsia: New Book, 2011. – 424 p.*
7. *Segeda A.S. Analytical Chemistry. Quantitative Analysis. – K.: Phytosociocenter, 2006. – 544 p.*
8. *Dorokhova E.M., Prokhorova G.V. Tasks and questions on analytical chemistry.— K.: Kyiv. univer., 2001.—282 p.*
9. *Analytical chemistry. Methods of analytical chemistry in environmental research. Methodical instructions for studying the discipline for students of the direction of training 6.040106 "Ecology, environmental protection and balanced environmental management"/ Butchenko L.I., Khokhotva O.P., Tereshchenko O.M. – K: NTUU "KPI", 2011. – Ch.I. Chemical methods of analysis. –68 p.*

Information resources on the Internet

10. *Union of Chemists of Ukraine http://www.chemunion.org.ua/uk/*
11. *Scientific and practical magazine "Methods and objects of chemical analysis" https://anchem.knu.ua/*

Educational content

5. Methods of mastering the discipline (educational component)

Lectures

Lectures are aimed at:

- providing modern, holistic, interdependent knowledge in the discipline ***"Analytical Chemistry. Part 2. Quantitative Analysis", the*** level of which is determined by the target setting for each specific topic;
- ensuring in the process of the lecture the creative work of students together with the teacher;
- education of students' professional and business qualities and the development of their independent creative thinking;
- formation of students' necessary interest and providing direction for independent work;
- determination at the modern level of development of science and technology in the field of chemical technology, forecasting their development for the coming years;
- reflection of the methodological processing of the material (selection of the main thoughts and provisions, underlining the conclusions, repeating them in different formulations);
- acquisition of clarity, combination, if possible, with the demonstration of audiovisual materials, layouts, models and samples;
- teaching in a clear and clear language, explaining all newly introduced terms and concepts;
- accessibility for perception by this audience.

N⁰	***Title of the lecture topic and list of main questions (list of didactic means, references to literature and tasks for IWS)***	***Hours***
1	***Topic 1. Tasks and methods of quantitative chemical analysis.*** *Subject and tasks of quantitative chemical analysis. Classification of chemical methods of quantity analysis. Basics of processing the results of quantitative analysis. Sampling and preparation of the sample for analysis.* ***Literature: [****2] pp. 17-24; [5] pp. 118-120; [7] pp. 9-28.* ***Tasks on the IWS.*** *Classification of errors. Significant numbers and rounding rules.*	***2***
2	***Topic 2. Gravimetric analysis.*** *The essence of the method and the requirements for it. The division of gravimetric analysis into groups. The main stages of gravimetric analysis and their characteristics. Calculations in gravimetric analysis. Use of gravimetric methods.* ***Literature: [****1] pp. 120-133; [4] pp.250-271; [5] pp.120-134.* ***Tasks on the IWS.*** *Quantitative separation by deposition method.*	*4*

3	***Topic 3. Titrimetric methods of analysis.*** ***Topic 3.1. General provisions of the titrimetric method of analysis.*** *Requirements that relate to reactions in titrimetric analysis. Classification of methods of titrimetric analysis. Forms of expression of concentrations of solutions Calculations in titrimetric analysis.* ***Literature: [****1] pp. 134-161; [4] pp.272-288 ; [5] pp.146-152 .* ***Tasks on the IWS.*** *The relationship between measurement accuracy and accuracy of calculations. Calculations in the preparation and dilution of solutions*	*2*
4	***Topic 3.2. Acid-base titration method (neutralization method).*** *Indicators of the neutralization method. Titration with acids and bases. Working solutions of the acid-base titration method. Titration curves and their calculations. Differential titration with two indicators. Indicator selection and calculation of indicator errors.* ***Literature: [****1] pp. 165-175; [4] pp.289-317 ; [5] pp.153-172 .* ***Tasks on the IWS.*** *Titration errors. Titration curves of polybasic acids. Titration of salt solutions. Titration in non-aqueous solutions. examples of application of the method of acid-base titration.*	***4***
5	***Topic 3.3. Complexonometric titration.*** *The essence of the method. Working solutions. Classification of complexonometry methods. Complexes of metal ions with complexions. Indicators of the method of complexonometry and requirements for them. Examples of using the method.* ***Literature: [****1] pp. 190-195; [4] pp.385-393; [5] pp.181-201 .* ***Tasks on the IWS.*** *Argentometry. Mercurymetry. Application of mercurometry in analysis. Construction of titration curves in the method of complexonometric titration.*	***2***
6	***Topic 3.4. Methods of oxidation-reduction (redoxmetry).*** ***Topic 3.4.1. General characteristics of oxidation-reduction methods****.* *Curvesand titration. Methods for determining the end of titration.* ***Topic 3.4.2. The method of permanganateometry.*** *Characteristics of the method. Preparation and storage of the working solution. Advantages and disadvantages of permanganateometry. Application of the method.* ***Literature: [****1] pp. 175-185; [4] pp. 327-342 ; [5] pp.206-212 .* ***Tasks on the IWS.*** *Titration curves of the oxidation-reduction method. Bromatometry.*	***2***
7	***Topic 3.4.3. Dichromatometry method.*** *Characteristics of the method. Cpostdetermining the end of titration. Advantages and disadvantages of dichromatometry. .* ***Topic 3.4.4. Iodometry.*** *Characteristics of the method. Advantages and disadvantages of iodometry.* *Literature:* ***[****1] pp. 104-108; [4] pp.343-363; [5] pp.214-220.* ***Task on the IWS*** *. Cerimetric. Vanadometry.*	***2***
	Just	***18***

Laboratory classes

The main objectives of the laboratory cycle are:

♦ *help students systematize, consolidate and deepen theoretical knowledge of quantitative chemical analysis;*

♦ *teach students the basic skills of working in a chemical laboratory and promote the mastery of skills and abilities to perform chemical analysis;*

♦ *teach students techniques for solving practical problems, promote mastery of skills and abilities to perform calculations and other types of tasks.*

N⁰	***The name of the topic of the laboratory lesson and the list of main questions (list of didactic support, references to literature)***	***Hours***
1	*Gravimetric analysis. Weighing on technical and analytical scales. Determination of iron (III) content in solution.* *Literature: [2] pp. 24-28.*	***6***
2	*Titrimetric analysis. Neutralization method. Preparation of working solutions and establishment of their concentration* *Writing a test paper 1.* *Literature: [2] pp. 45-50.*	***5***
3	*Determination of the content of temporary hardness of water, ammonium hydroxide, sodium phosphate.* *Writing a test paper 2.* *Literature: [2] pp. 50-57.*	***5***
4	*Complexonometry. Preparation of working solutions and establishment of their concentration. Determination of the total and constant hardness of water, magnesium (zinc) content in the technical sample.* *Writing a test paper 3.* *Literature: [2] pp. 89-93.*	*6*
5	*Redox methods. Preparation of working solutions and determination of their concentration. Permanentatometric and dichromatometric determination of iron (II).* *Literature: [2] pp. 100-108.*	*8*
6	*The method of iodometry. Preparation of working solutions and determination of their concentration. Determination of copper in a technical sample.* *Writing a test paper 4.* *Literature: [2] pp. 110-114.*	*6*
	Just	***36***

6. Independent work of the student

Independent work takes 55% of the time to study the credit module, including preparation for the exam. The main task of independent work of students is to master knowledge in areas that are not included in the list of lecture questions 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 framework of the educational component, the student must learn to analyze the information received and use it to solve the tasks.

N⁰	*The name of the topic submitted for independent study*	*Number of hours of **IWS***
Topic 1. Tasks and methods of quantitative chemical analysis.		
1	Classification of errors. Significant numbers and rounding rules. *Literature: [2] pp. 13-16; [4] pp. 234-249.*	*3*
Topic 2. Gravimetric analysis.		
2	*Quantitative separation by deposition. Distillation methods.* *Literature: [3] pp. 23-28.*	*4*
Topic 3. Titrimetric analysis methods ***Topic 3.1. General provisions of the titrimetric method of analysis.***		
3	*The relationship between measurement accuracy and accuracy of calculations. Calculations in the preparation and dilution of solutions.* *Literature: [3] pp. 10-15.*	*4*
Topic 3.2. Acid-base titration method (neutralization method).		
4	*Curves of titration of polybasic acids. Titration of salt solutions. Titration in non-aqueous solutions. Examples of the use of the method of acid-base titration.* *Literature: [1] pp. 165-175; [4] pp. 318-326.*	*6*
Topic 3.3. Complexonometric titration.		
5	*Argentometry. Mercurymetry. The use of mercurometry in the analysis. Construction of titration curves in the method of complexonometric titration.* *Literature: [1] pp. 232-235, 256-261; [4] pp.376-400 ; [5] pp.176-180 .*	*5*
Topic 3.4. Methods of oxidation-reduction (redoxmetry). ***3.4.1. General characteristics of oxidation-reduction methods.*** ***3.4.2. The method of permanganate***		
6	*Titration curves of the oxidation-reduction method. Bromatometeri.* *Literature: [3] pp. 109-110; [4] pp. 354-357.*	*4*
Topic 3.4.3. Bi chromatometry method. ***Topic 3.4.4. Iodometry.***		
7	*Cerimetric. Vanadatometry.* *Literature: [1] pp. 175-185; [4] pp. 367-371.*	*2*
8	*Writing a settlement work*	*8*
9	*Exam preparation*	*30*
	Total hours	*66*

Policy and control

7. Policy of the discipline (educational component)

Rules for attending classes and behavior in the classroom

Attendance is a mandatory component of the assessment. 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

- *Incentive points can be awarded by the teacher solely for performing creative work in the discipline or additional completion of online specialized courses with the receipt of the appropriate certificate:*

https://www. edx. org/course/basic-analytical-chemistry.

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

- *penalty points are not provided.*

Deadlines and Rescheduling Policy

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

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 discipline in accordance with the working curriculum:

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

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

- performance of laboratory works (7 works);
- writing a modular test (1 modular test is divided into 2 tests);
- performance of settlement work.

Semester control is the exam.

The system of rating (weight) points and evaluation criteria

1. Performance of laboratory works:

The necessary conditions **for admitting a** student to laboratory work are:

• availability of a protocol for appropriate laboratory work;

• a positive answer to the question of incoming express quality control of the theoretical preparation of the student for laboratory work (express control is carried out in the form of an oral survey conducted at the beginning of the lesson). In case of non-compliance with these conditions, the student is not allowed to perform laboratory work.

Weight score – 3. The maximum number of points for the performance of all laboratory work is equal to:

3 points • 7 = 21 points.

Criteria for evaluating the performance of laboratory work

Completeness and signs of completing the task	***Points***
The work is completed and fully protected *(*relative error in determining the δ ≤ 3 %*,, appropriate design (protocol and calculations are presented on time)).*	*3*
Minor shortcomings in execution and protection *(*relative error of determination 3 < δ ≤ 5 %*), there are certain shortcomings in the design (the protocol is presented on time and calculations are somewhat late).*	*2*
Gross shortcomings in execution and protection *(work performed with gross errors,* relative error of determination 5 < δ ≤ 8 %*), inappropriate design (protocol and calculations are not presented on time)*	*1*
Failure to complete the task *(Work not done* (relative error of the experiment δ > 8%) *or not protected)*	*0*

2. Writing a modular test*:*

1 modular test is divided into 2 tests, 10 points each.

Evaluation criteria	***Points***
"excellent", complete answer (at least 95% of the necessary information)	*10*
"good", incomplete disclosure of one of the issues (at least 75% of the required information)	*9-8*
"satisfactory", ncomplete answer (at least 65% of the necessary information)	*7-6*
unsatisfactory work (does not meet the requirements for "satisfactory").	*5-0*

3. Writing a calculation work:

The maximum number of points for writing a settlement work is 9 points.

Points	***Evaluation criteria***
9	*"excellent" - the work is done carefully, in full, the answers are justified, examples and equations of chemical reactions are given, which are discussed in the question*
8-7	*"good" - theoretical questions and calculations contain minor flaws (or the work is completed with some delay from the deadline)*
6-5	*"satisfactory" - there are no answers to 1-2 questions or theoretical questions and calculations are presented with certain errors (or the work is completed with a significant delay from the deadline)*

4-0	*"unsatisfactory" - the task is not completed, or there are gross errors, the work is not credited*

According to the results of educational work for the first 7 weeks, the "ideal studentnt" must perform all laboratory work (at the time of certification) and score 17 points.

According to the results of educational work for 13 weeks of study, the "ideal student" must complete all the laboratory work (at the time of certification) and score 33 points.

***4. Exam (oral)**.*

The examination ticket contains two theoretical questions (tasks) and two practical tasks (tasks from the laboratory course and the task). An approximate list of theoretical questions is provided in Chapter 9. Each theoretical question/task and task from the laboratory course is estimated at 10 points, and the task is 20 points according to the following criteria:

Evaluation criteria	***Points***	
"excellent" - a complete answer, at least 90% of the necessary information (complete, error-free solution of the problem)	*10*	*20-19*
"good" - a sufficiently complete answer, at least 75% of the necessary information or minor inaccuracies (complete solution of the problem with minor inaccuracies)	*9-8*	*18-16*
"satisfactory" is an incomplete answer. at least 60% of the required information and some errors (the problem is solved with certain shortcomings)	*7-6*	*15-12*
"unsatisfactory" - the answer does not meet the conditions to "satisfactory"	*5-0*	*11-0*

***The condition for admission to the exam is the** enrollment of all laboratory works, settlement work, all tests and a starting rating of at least 30 points.*

Thus, the sum of rating points is:

$$R_c = 21 + 20 + 9 + 50 = 100.$$

The sum of the starting points and points for the examination test is transferred to the examination mark according to the table:

Points	***Score***
100...95	*Perfectly*
94...85	*very good*
84...75	*well*
74...65	*Satisfactory*
64...60	*enough*
R<60 points	*Disappointing*
Conditions of admission have not been met	*not allowed*

1. Additional information on the discipline (educational component)

An approximate list of questions for the discipline *exam "Analytical Chemistry. Part 2. Quantitative Analysis"*

1. *Formulate the content, tasks and methods of quantitative analysis,*
2. *To give a classification of chemical methods of quantity analysis.*
3. *Formulate requirements for reactions that are used in quantitative chemical analysis.*
4. *Characterize the selection and preparation for the analysis of samples of gases, liquids and solids.*
5. *To characterize the "dry" and "wet" way of decomposition.*
6. *Reveal the content of the gravimetric analysis and its requirements. Present the classification of the method.*
7. *Characterize the main stages of gravimetric analysis.*
8. *Explain what the deposition form and gravimetric form are. Submit requirements for them.*
9. *Present the calculation of the number of depositors and requirements for it.*
10. *Explain how to get crystalline and amorphous sediments.*
11. *Reveal the meaning of the concept of aging ("ripening") of sediment.*
12. *Characterize the content of the concept of co-planting. Present the types of co-planting and their characteristics.*
13. *Explain how crystalline and amorphous sediments are washed. What solutions are used as flushing? Submit requirements for washing solutions.*
14. *To characterize the content of the titrimetric method and the requirements for the reactions used in titrimetric analysis.*
15. *To give a classification of titrimetric methods of analysis according to the technique of titration and the type of reactions on which the method is based.*
16. *Give ways to express the concentration of solutions.*
17. *Give calculations in titrimetric analysis.*
18. *Present the mathematical processing of titration results.*
19. *Cite the ion-chromophore theory of indicators.*
20. *To characterize the working solutions of the acid-base titration method and methods of their preparation.*
21. *To define the concepts: the equivalence point and how to establish it.*
22. *Give indicators of the neutralization method and requirements for them.*
23. *To characterize the titration curves of the neutralization method and provide calculations for their construction.*
24. *Reveal the content of differential titration, give an example.*
25. *Justify the choice of indicator and calculate the indicator errors.*
26. *Give examples of the use of the method of acid-base titration.*
27. *Characterize the method of complexonometry and indicate its advantages.*
28. *Present working solutions of the complexonometry method and their preparation.*
29. *Classification of the method of complexonometry.*
30. *Give indicators of the method of complexonometry and their classification.*
31. *Present the scheme of determination for complexonometric titration and requirements for metal indicators.*
32. *To characterize the content of the definition of cations and anions. Give examples.*
33. *Give a classification of methods of redox titration and characterize the methods for determining the end of titration.*
34. *Present indicators of the method of redox titration and the conditions of their use.*

35. *Characterize the content of the method of permanganateometry. Bring the method of preparation and storage of the working solution.*
36. *Present the advantages and disadvantages of the permanganatometry method.*
37. *To reveal the content of the definition of reducing agents and substances that do not have redox properties by the method of permanganateometry.*
38. *Formulate the content of the method of bichromatometry. Give advantages and disadvantages.*
39. *Present the characteristics of the method of iodometry, the advantages and disadvantages of the method.*
40. *Provide working solutions of the method of iodometry, their preparation and storage.*
41. *Present the definition of oxidizing agents and reducing agents by iodometry. Give examples.*

The work program of the discipline (syllabus):

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

Approved *by the department ___E and PPT___ (protocol N^0 _14_ of _18.05.2023)*

Approved by the Methodical Commission

Faculty of Chemical Engineering (protocol N^0 10 from __26.05.2023)