



Mass transfer processes and equipment for the production of polymer and building materials and products

Work program of the educational component (Syllabus)

Details of the educational component

Higher education level	<i>Second (Master's)</i>
Field of Knowledge	<i>13 Mechanical Engineering</i>
Specialty	<i>G11 Mechanical Engineering</i>
Educational program	<i>OPP Engineering of Innovative Industry Equipment PEP Engineering of innovative industry equipment</i>
Status of the educational component	<i>Selective</i>
Form of study	<i>full-time</i>
Year of preparation, semester	<i>1st year, spring semester</i>
Scope of the educational component	<i>5 credits, 150 hours; lectures – 16 hours; practical classes – 30 hours; independent work – 104 hours.</i>
Semester control / control measures	<i>Exam</i>
Class schedule	
Language of instruction	<i>Ukrainian</i>
Information about the course leader / teachers	<i>Lecturer: Doctor of Technical Sciences, Senior Researcher, Prof. Mikulionok Ihor Olehovich, i.mikulionok@kpi.ua, 066-748-65-65 Practical: Doctor of Technical Sciences, Senior Researcher, Prof. Mikulionok Ihor Olehovich</i>
Course placement	<i>http://login.kpi.ua/</i>

Program of the educational component

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

The educational component "Mass transfer processes and equipment for the production of polymer and building materials and products" is one of the basic educational components of the cycle of educational components of professional training, which lays the foundations for the training of specialists in industrial engineering (chemical, polymer and silicate engineering) and has a theoretical and practical direction.

The subject of the educational component "Mass transfer processes and equipment for the production of polymer and building materials and products" is the theory of basic mass transfer processes, the principles of construction and methods of calculations of machines and devices used to carry out these processes.

The purpose of the educational component "Mass transfer processes and equipment for the production of polymer and building materials and products"

The purpose of the educational component is the process of forming a set of knowledge by students about the main exchange processes, to make a reasonable choice of equipment for the implementation of exchange processes and to perform their parametric calculations.

In accordance with the goal, the training of masters in this specialty requires strengthening the formation of the following competencies:

Integral competence:

Ability to solve complex problems and problems in the field of mechanical engineering, which involves conducting research on processes, equipment and/or innovations in this field and is characterized by uncertainty of conditions and requirements.

Professional competencies:

- Ability to create, improve and apply quantitative mathematical, scientific and technical methods and computer software, apply a systematic approach to solving engineering problems of industrial engineering, in particular, in conditions of technical uncertainty (SC01);
- Critical understanding of advanced scientific facts, concepts, theories, principles for the field of mechanical engineering and the ability to apply them to solve complex problems of industrial engineering and sustainable development (SC02);
- Awareness of promising tasks of modern production aimed at satisfying the needs of consumers, possession of trends in innovative development of industry technologies (SK04).

According to the requirements of the program of the educational component "Mass transfer processes and equipment for the production of polymer and building materials and products", students after mastering it must demonstrate the following **program learning outcomes**:

- Knowledge and understanding of the principles of technological, fundamental and engineering sciences that underlie the branch engineering of the relevant industry (PRN01);
- Knowledge and understanding of mechanics and mechanical engineering and prospects for their development (PRN02);
- Carry out engineering calculations to solve complex problems and practical problems in industrial engineering (PRN04);
- Analyze engineering objects, processes and methods (PRN05).

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

Prerequisites: The educational component "Mechanical Transfer Processes and Equipment for the Production of Polymer and Building Materials and Products" is based on the study of the following educational components: "Mathematics", "Physics", "Chemistry", "Mechanics of Materials and Structures", "Technology of Polymer Processing", "Machine Parts", "Hydromechanics and Hydraulics", "Heat Transfer", "Mechanical Processes and Equipment for the Production of Polymer and Building Materials and Products", "Hydromechanical Processes and Equipment for the Production of Polymer and Building Materials and Products".

Post details: The educational component "Mass transfer processes and equipment for the production of polymer and building materials and products" ensures the implementation of the course project on Engineering in innovative technologies and equipment, as well as the diploma project.

3. Content of the educational component

Topic 1. Basics of mass transfer

Topic 2. Absorption

Topic 3. Distillation

Topic 4. Liquid Extraction

Topic 5. Adsorption

Topic 6. Crystallization

Topic 7. Dissolution and extraction in a solid-liquid system

Topic 8. Mass transfer through separating membranes

Topic 9. Intensification and increase of the efficiency of mass transfer processes

4. Training materials and resources

Basic literature

1. Mikulionok I. O. *Mechanical, hydromechanical and mass transfer processes and equipment of chemical technology.* – 3rd ed. Kyiv: NTUU "KPI", 2014. 340 p. URL: <https://ela.kpi.ua/handle/123456789/38169>

2. Radchenko L. B., Mikulionok I.O. *Modeling of Chemical Technology Processes. Part 1. Theoretical Foundations: Teaching Aid.* Kyiv: VPI VPI VPK "Polytechnic", 2005. 126 p.

3. *Processes and equipment of chemical technology. Part 2: textbook.* / Y. M. Kornienko, Y. Y. Lukach, I. O. Mikulionok et al. Kyiv: NTUU "KPI", 2012. 416 p. (in Russian).

4. Mikulionok I. O., Ryabtsev G. L. *Mechanical, hydromechanical and mass transfer processes and apparatuses of chemical technology.* – 2nd edition. Kyiv: NTUU "KPI", 2000. 88 p. (in Russian).

5. Rakitskyi V. L., Mikulionok I. O., Ryabtsev G. L. *Fundamentals of design of nozzles rectification columns.* Kyiv: NMCVO, 2000. 200 p.

6. Mikulionok I.O. *Contact and auxiliary devices of heat and mass transfer columns: monograph.* Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2022. 194 p. URL: <https://ela.kpi.ua/handle/123456789/50142>.

Further reading

7. Vragov A. P. *Mass Transfer Processes and Equipment of Chemical and Gas and Oil Processing Industries. Manual.* Sumy: VTD "Universitetska kniga", 2007. 284 p. (in Russian).

8. *Column Apparatus* / compiled by I. A. Andreev. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2025. 74 p. URL: <https://ela.kpi.ua/handle/123456789/72186>.

9. *Processes and Apparatuses of Chemical Technology: Textbook.* / L. L. Tovazhnyanskyi, G. P. Gotlynska, V. A. Leshchenko et al. Kharkiv: NTU "KhPI", 2024. 1016 p. URL: <https://web.kpi.kharkov.ua/itpa1/nmkd-obov'yazkovi/>.

10. Mikulionok I. O. *Classification of Built-In Separators of Mass-Exchange Columns (Survey of Patents)* // *Chemical and Petroleum Engineering.* 2021. Vol. 57, № 5–6. P. 522–528. DOI: <https://doi.org/10.1007/s10556-021-00969-y>.

11. Mikulionok I. O. *Classification of Devices for Distribution and Redistribution of Liquid in Mass-Exchange Towers with Motionless Packing (Survey of Patents)* // *Chemical and Petroleum Engineering.* 2021. Vol. 57, № 7–8. P. 611–617. DOI: <https://doi.org/10.1007/s10556-021-00983-0>.

12. Mikulionok I. O. *Classification of Devices for Introduction and Distribution of Light Phase in Mass-Exchange Columns (Survey of Patents)* // *Chemical and Petroleum Engineering.* 2022. Vol. 58. № 5–6. P. 427–432. DOI: <https://doi.org/10.1007/s10556-022-01110-3>.

13. Mikulionok I. O. *Classification of Overflow Devices of Mass-Transfer Columns (Review of Designs)* // *Chemical and Petroleum Engineering*. 2022. Vol. 57, № 9–10. P. 878–884. DOI: <https://doi.org/10.1007/s10556-022-01020-4>.
14. Mikulionok I. O. *Classification of Support Devices of Contact Plates of Mass Transfer Columns (Survey of Designs)* // *Chemical and Petroleum Engineering*. 2022. Vol. 58, № 7–8. P. 606–612. DOI: <https://doi.org/10.1007/s10556-023-01136-1>.
15. Mikulionok I. O. *Ceramic nozzles of heat and mass transfer devices* // *Ceramics: science and life*. 2011. № 2. Pp. 24–34.
16. Mikulionok I. O. *Ring packing contact elements of mass transfer devices (review of patents)* // *Chemical and Petroleum Engineering*. 2018. Vol. 54, № 1–2. P. 125–129. DOI: <https://doi.org/10.1007/s10556-018-0450-y>.
17. Mikulionok I. O. *Classification of the Structures of Volume-Exchange Towers with Loose Packing (Survey of Patents)* // *Chemical and Petroleum Engineering*. 2021. Vol. 57, № 3–4. P. 168–175. DOI: <https://doi.org/10.1007/s10556-021-00941-w>.
18. Mikulionok I. O. *Classification of stamped packing elements of mass-exchange apparatuses (survey of patents)* // *Chemical and Petroleum Engineering*. 2021. Vol. 56, № 9–10. P. 861–869. DOI: <https://doi.org/10.1007/s10556-021-00853-9>.
19. Mikulionok I. O. *Classification of the Packing Contact Elements of Mass-Exchange Towers with Second-Order form of the Surfaces (Survey of Patents)* // *Chemical and Petroleum Engineering*. 2022. Vol. 57, № 11–12. P. 976–981. DOI: <https://doi.org/10.1007/s10556-022-01034-y>.
20. Mikulionok I. O., Lukinyuk M. V. *Placement of the oriented ring nozzle in column heat and mass apparatus (Review)* // *Bulletin of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"* : ser. "Chemical Engineering, Ecology and Resource Conservation". 2025. № 1(24). Pp. 26–36 (in Russian). DOI: 10.20535/2617-9741.1.2025.325834.
21. Mikulyonok I. O. *Combined contact devices for mass-exchange towers* // *Chemical and Petroleum Engineering*. 2012. Vol. 48, № 1–2. P. 71–76. DOI: 10.1007/s10556-012-9576-5.
22. Mikulionok I. O. *Designs of bubble caps of the contact plates of mass-exchange columns (review of patents)* // *Chemical and Petroleum Engineering*. 2018. Vol. 54, № 5–6. P. 410–417. DOI: <https://doi.org/10.1007/s10556-018-0495-y>.
23. Mikulionok I. O. *Design of the valves of the contact plates of mass-transfer columns (survey of patents)* // *Chemical and Petroleum Engineering*. 2020. Vol. 55, № 9–10. P. 762–771. DOI: <https://doi.org/10.1007/s10556-021-00881-5>.
24. Mikulionok I. O. *Classification of the designs of the stamped contact plates of mass-exchange columns (survey of patents)* // *Chemical and Petroleum Engineering*. 2020. Vol. 55, № 9–10. P. 847–855. DOI: <https://doi.org/10.1007/s10556-020-00703-0>.
25. Mikulionok I. O. *Classification of the Inclined Plates of Mass-Exchange Columns (Review of Designs)* // *Chemical and Petroleum Engineering*. 2022. Vol. 58, № 7–8. P. 613–620. DOI: <https://doi.org/10.1007/s10556-023-01137-0>.
26. Mikulionok I. O. *Proektirovaniya liquid column extractors: nauch. posob.* Kyiv: IZMN, 1996. 100 p.
27. Lukach Yu. E., Mikulionok I. O., Ryabtsev G. L. *The pervaporation technique in chemical technological processes* // *Journal of Water Chemistry and Technology*. 1999. Vol. 21, № 3. P. 38–43.
28. *Removal of Organic Impurities from Sewage by Evaporation Through Polymer Membranes* / Yu. E. Lukach, N. V. Shafarenko, I. O. Mikulionok, G. L. Ryabtsev // *Journal of Engineering Physics and Thermophysics*. 1996. Vol. 69, № 6. P. 757–759. DOI: 10.1007/BF02606111.
29. Ryabtsev G. L., Lukach Yu. E., Mikulionok I. O. *Pervaporation separation of homogeneous liquid systems* // *Chemical and Petroleum Engineering*. 1997. Vol. 33, № 3. P. 245–249. DOI: 10.1007/BF02418465.
30. Mikulyonok I. O., Ryabtsev G. L. *Combined mass-transfer chemical engineering processes using pervaporation* // *Chemical and Petroleum Engineering*. 2012. Vol. 48, № 1–2. P. 9–14. DOI: 10.1007/s10556-012-9565-8.

31. Mikulionok I. O. Stabilization of the temperature of the working medium in the equipment of chemical plants (a survey of patents) // *Chemical and Petroleum Engineering*. 2015. Vol. 51, № 5–6. P. 324–327. DOI: 10.1007/s10556-015-0046-8.
32. Mikulionok I. O. Application of ferromagnetic materials to ensure the necessary thermal regime of technological equipment (Review) // *Energy technologies and resource saving*. 2019. № 1. Pp. 60–72 (in Russian). DOI: <https://doi.org/10.33070/etars.1.2019.06>.
33. Mikulionok I. O., Ivanenko O. I. Application of ferromagnetic materials for stabilization of the thermal regime of technological processes (Review) // *Bulletin of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute": ser. "Chemical Engineering, Ecology and Resource Conservation"*. 2024. № 3(23). Pp. 19–38. DOI: 10.20535/2617-9741.3.2024.312417.
34. Mikulionok I. O., Ivanenko O. I. Practical use of the effects of Seebeck and Peltier (Review) // *Bulletin of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute": ser. "Chemical Engineering, Ecology and Resource Conservation"*. 2024. № 4(23). Pp. 9–34. DOI: 10.20535/2617-9741.4.2024.319010.
35. Mikulionok I. O. Use of Möbius Strip in Chemical Machine Design (Survey of Patents) // *Chemical and Petroleum Engineering*. 2021. Vol. 56, № 11–12. P. 1037–1042. DOI: <https://doi.org/10.1007/s10556-021-00880-6>.
36. Mikulionok I. O., Lukinyuk M. V. Applied application of the Mobius tape (Review) // *Bulletin of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute": ser. "Chemical Engineering, Ecology and Resource Conservation"*. 2025. № 2(24). Pp. 32–52. DOI: 10.20535/2617-9741.2.2025.333973.
37. Mikulionok I. O. Mechanical processes and equipment for the production of polymer and building materials and products . 5th ed., revised. and supplemented. Kyiv : Igor Sikorsky Kyiv Polytechnic Institute, 2025. 102 p. URL: <https://ela.kpi.ua/handle/123456789/74513>.
38. Mikulionok I. O. Hydromechanical processes and equipment for the production of polymer and building materials and products . 5th ed., revised. and supplemented. Kyiv : Igor Sikorsky Kyiv Polytechnic Institute, 2025. 102 p. URL: <https://ela.kpi.ua/handle/123456789/74533>.

Information resources on the Internet

37. DSpace NTB KPI. Igor Sikorsky, <https://ela.kpi.ua/handle/123456789/38169>, <https://ela.kpi.ua/handle/123456789/41037>, <http://ela.kpi.ua/handle/123456789/26157>
38. Сайт кафедри ХПЧМ, <https://cpsm.kpi.ua/metodichni-rozrobki.html>.
39. Campus of Igor Sikorsky Kyiv Polytechnic Institute. Igor Sikorsky, <http://login.kpi.ua/>.
40. Official websites of patent offices, <https://sis.nipo.gov.ua/uk/search/simple/>, http://worldwide.espacenet.com/advancedSearch?locale=en_EP, <http://www1.fips.ru/iiss/>.

Educational content

5. Methods of mastering the educational component

Lectures

Lectures are aimed at:

- provision of modern, holistic, interdependent knowledge on the educational component "Mass transfer processes and equipment for the production of polymer and building materials and products", the level of which is determined by the target setting 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 independent creative thinking;
- formation of students' necessary interest and provision of direction for independent work;
- determination at the current level of development of science in the field of the current state of polymer processing technology;
- reflection of methodological processing of the material (highlighting the main provisions, conclusions, recommendations, clear and adequate to their formulation);
- use for demonstration of visual materials;
- teaching the materials of the educational component in a clear and high-quality language in compliance with structural and logical connections, explaining all newly introduced terms and concepts;
- accessibility for perception by this audience.

No. s/p	Title of the lecture topic and a list of main questions (links to literature and tasks on the SRC)	Number of hours
1	Topic 1. Basics of mass transfer <i>Lecture 1. General provisions on mass transfer processes. Equilibrium in mass transfer processes. Basic equation of mass transfer. Methods of expressing the composition of phases. Material balance of mass transfer processes. Driving force of mass transfer processes. Modifications of the basic equation of mass transfer. Law of molecular diffusion (Fick's first law). Differential equation of molecular diffusion (Fick's second law).</i> <i>References: [1, 3].</i> <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Analysis of dependencies for ways of expressing the composition of phases.	2
2	<i>Lecture 2. Convective diffusion. Models of the mass transfer process. Mass transfer. Mass transfer equation (Shchukarev's law). Kinetics of the mass transfer process. Expression of the mass transfer coefficient in terms of mass transfer coefficients. Differential equation of convective diffusion. Similarity of mass transfer processes. Fundamentals of calculation of mass transfer apparatuses. Mass transfer between liquid (gas, steam) and solid phases.</i> <i>References: [1, 3].</i> <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Analysis of the physical content of the criteria for the similarity of mass transfer processes.	2
3	Topic 2. Absorption <i>Lecture 3. General provisions on absorption. Equilibrium in liquid-gas systems. Material balance of absorption. Thermal balance of absorption. Absorption of multicomponent mixtures. Kinetics of absorption. Technological schemes of absorption. Calculation of absorbers. Desorption.</i> <i>References: [1, 3].</i>	2

No. s/p	Title of the lecture topic and a list of main questions (links to literature and tasks on the SRC)	Number of hours
	<u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Designs and principle of operation of absorbers. Requirements for the design of absorbers. Designs of devices for introducing phases into column devices, deriving phases from column devices, as well as separators of column devices.	
4	Topic 3. Distillation Lectures 4. General provisions on distillation. Equilibrium in liquid-vapor systems. Simple distillation. Rectification (Continuous rectification of binary mixtures. Periodic rectification of binary mixtures. Molecular rectification. Extractive and azeotropic rectification. Rectification scheme with a heat pump. Rectification apparatuses. Calculation of rectification columns. Rectification of multicomponent mixtures). References: [1, 3]. <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Designs and principle of operation of rectification columns. The main types of contact devices of rectification columns.	2
5	Topic 4. Liquid Extraction Lecture 5. General provisions on liquid extraction. Equilibrium in liquid-liquid systems. Extractant selection. Material balance of liquid extraction. Kinetics of liquid extraction. Technological schemes of liquid extraction. Design and principle of operation of liquid extractors. Calculation of liquid extractors. References: [1, 3]. <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on CPS:</u> Designs and principle of operation of liquid extractors.	2
6	Topic 5. Adsorption Lecture 6. General provisions on adsorption. Adsorbents and their properties. Equilibrium during adsorption. Material balance of adsorption. Adsorption kinetics. Technological schemes of adsorption. Calculation of adsorbers. Desorption. Ion exchange. Topic 6. Crystallization General provisions on crystallization. Equilibrium during crystallization. Material and thermal balances of crystallization. Crystallization kinetics. Designs and principle of operation of crystallizers. Crystallization from melt. References: [1, 3]. <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Designs and principle of operation of adsorbers, desorbers and crystallizers.	2
7	Topic 7. Dissolution and extraction in a solid-liquid system Lecture 7. General provisions on dissolution and extraction in the "solid – liquid" system. Technological schemes, designs and principle of operation of extractors in the "solid – liquid" system. Calculation of extractors in the "solid – liquid" system. References: [1, 3]. <u>List of didactic tools:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture. <u>Tasks on the SRS.</u> Designs and principle of operation of extractors in the solid-liquid system.	2

No. s/p	Title of the lecture topic and a list of main questions (links to literature and tasks on the SRC)	Number of hours
8.	Topic 8. Mass transfer through separating membranes <i>Lecture 8. General information about membrane processes. Basic methods of membrane separation (reverse osmosis (hyperfiltration); ultrafiltration; membrane gas separation; evaporation through the membrane (pervaporation); dialysis; electrodialysis). Separation membranes. Kinetics of membrane processes. Calculation of membrane devices.</i> Topic 9. Intensification and increase of the efficiency of mass transfer processes <i>References: [1, 3].</i> <i>List of didactic tools: The lecture uses a laptop with an electronic version of the lecture and a projector. Visual samples, diagrams and drawings for the lecture.</i> <i>Tasks on the SRS. Designs and principle of operation of membrane devices with flat, tubular and half-fiber membrane elements. Directions of intensification of mass transfer processes. Application of ferromagnetic materials to stabilize the thermal regime of mass transfer processes. Use of Seebeck and Peltier effects in mass transfer equipment.</i>	2
Just		16

Practical (seminar) classes

In the system of professional training of students in this credit module, practical classes occupy 65% of the classroom load. Being an addition to the lecture course, they lay and form the foundations of the master's qualification in industrial engineering, namely the industry of production of polymer and building materials and products. The content of these classes and the methods of their conduct should ensure the development of creative activity of the individual. They develop practical thinking and the ability to use special terminology, allow you to test knowledge, so this type of work is an important means of prompt feedback. Practical (seminar) classes should perform not only cognitive and educational functions, but also contribute to the growth of students as creative workers in the field of industrial engineering.

The main tasks of the cycle of practical (seminar) classes:

- to help students systematize, consolidate and deepen theoretical knowledge in the field of modern mass transfer processes, devices and machines of chemical technology;
- to teach them to work with scientific, technical and reference literature and other sources of scientific and technical information;
- to form the ability to learn independently, that is, to master the methods, ways and techniques of self-study, self-development and self-control.

No. s/p	Title of the topic of practical (seminar) classes and a list of main issues (links to literature and tasks on the SRC)	Number of hours
1	Topic 1. Basics of mass transfer <i>Equilibrium in the processes of mass transfer.</i> <i>Practical lesson 1. Ways to express the composition of phases.</i> <i>References: [1, 3, 4].</i>	2
2	Topic 2. Absorption <i>Calculation of absorbers.</i> <i>Practical classes 2–5. Calculation of the nozzle or plate absorber.</i> <i>References: [1, 3].</i>	8
3	Topic 3. Distillation <i>Simple distillation</i>	2

No. s/p	Title of the topic of practical (seminar) classes and a list of main issues (links to literature and tasks on the SRC)	Number of hours
	<i>Practical classes 6. Calculation of the simple distillation process (simple distillation). References: [1, 3, 4].</i>	
4	Topic 3. Distillation <i>Rectification of multicomponent mixtures Practical classes 7–10. Calculation of the nozzle rectification column. References: [1, 3, 5].</i>	8
5	Topic 5. Liquid Extraction <i>Calculation of liquid extractors Practical classes 11–14. Calculation of a nozzle or plate liquid extractor. References: [1, 3, 26].</i>	8
6	<i>Practical lesson 15. Modular control work. References: [1, 3].</i>	2
Just		30

6. Independent work of a student

Independent work takes 69.3% of the time spent studying the educational component, including preparation for the exam. The main task of students' independent work 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 educational component, the student must learn to deeply analyze modern approaches to the development and implementation of the latest technologies for processing polymer materials.

No. s/p	Name of the topic submitted for independent study	Number of CPC hours
1	Topic 1. Basics of mass transfer <i>General provisions on mass transfer processes Tasks on CPS: Analysis of dependencies for ways of expressing the composition of phases. Analysis of the physical content of criteria for similarity of mass transfer processes. References [1, 3].</i>	4
2	Topic 2. Absorption <i>Designs and principle of operation of absorbers. Requirements for the design of absorbers. Designs of devices for introducing phases into column devices, deriving phases from column devices, as well as separators of column devices. References [1, 3].</i>	12
3	Topic 3. Distillation <i>Tasks on the SRS: Designs and principle of operation of rectification columns. The main types of contact devices of rectification columns. References [1, 3].</i>	12
4	Topic 4. Liquid Extraction <i>Tasks on CPS: Designs and principle of operation of liquid extractors. References [1, 3].</i>	12
5	Topic 5. Adsorption Topic 6. Crystallization <i>Tasks on CPS: Designs and principle of operation of adsorbers, desorbers and crystallizers. References [1, 3].</i>	10
6	Topic 7. Dissolution and extraction in a solid-liquid system	10

No. s/p	Name of the topic submitted for independent study	Number of CPC hours
	<i>Tasks on the CPS: Designs and principle of operation of extractors in the "solid-liquid" system. References [1, 3].</i>	
7	Topic 8. Mass transfer through separating membranes Topic 9. Intensification and increase of the efficiency of mass transfer processes <i>Tasks on the SRS: Designs and principle of operation of membrane devices with flat, tubular and semi-fibrous membrane elements. Directions of intensification of mass transfer processes. Application of ferromagnetic materials to stabilize the thermal regime of mass transfer processes. Use of Seebeck and Peltier effects in mass transfer equipment. Literature [1, 3, 30–36].</i>	10
8	<i>Preparation for the modular test work</i>	4
9	<i>Exam preparation</i>	30
Just		104

Individual tasks

According to the working curriculum, individual tasks are not provided.

Tests

The working curriculum provides for modular control work, which is carried out in the form of a test.

Policy and control

7. Educational Component Policy

Rules for attending classes and behavior in the classroom

Attendance at classes is a mandatory component of 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's conduct, not to be distracted by actions that are not related to the educational process.

Rules for the implementation and defense of practical work (seminar classes):

- performance of practical work (tasks for seminar classes) takes place during the hours of practical classes and SRS and is sent to the teacher's e-mail or telegram;
- in accordance with the "Code of Honor", practical work (tasks for seminar classes) and preparation of answers to theoretical and practical questions are performed by students independently;
- The rules for the defense of practical works (tasks for seminar classes) are based on the rating system for evaluating learning outcomes.

Rules for assigning incentive and penalty points:

- Incentive points are not provided.
- There are no penalty points.

Deadline and retake policy

In case of debts from the educational component 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

Violation of the Code of Academic Integrity of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" is a serious violation, even if it is unintentional. The Code is available at the link: <https://kpi.ua/code.3>.

In particular, compliance with the Code of Academic Integrity means that all work on exams and tests must be done individually. When doing independent work, students can consult with teachers and with other students, but must solve problems on their own, guided by their own knowledge, skills and abilities. References to all resources and sources (e.g. in computer workshop reports, independent papers or presentations) should be clearly defined and properly designed. That is, the absence of references when using printed and electronic materials, quotes, opinions of other authors is unacceptable.

Academic Conduct and Ethics Policy

Students should be tolerant, respect the opinions of others, formulate objections in the correct form, and 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.2>.

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

Distribution of study time by types of classes and tasks from the educational component according to the working curriculum:

Semester	Study time		Distribution of training hours					Control measures		
	Loans	Acad. H.	Lecture	Practice.	Labor.	Ind. work	CPC	FDM	WGR	Semester certification
2	5,0	150	16	30	–	–	104	1	–	Exam

Current control: Reports on practical classes, modular control work.

Calendar control: carried out twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus.

Semester control: exam.

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

- 1) performance and defense of practical work (5 works in total);
- 2) performance of modular control work;
- 3) answer at the exam (in writing with oral defense).

System of rating (weight) points and evaluation criteria

1. Practical classes:

Weight score – 8. Maximum number of points in all practical classes

equals: $8 \text{ points} \times 5 = 40 \text{ points}$.

Evaluation criteria (the solution of the problem should be received by the teacher by the end of the corresponding pair):

Score 8 is given provided that the problem is solved without errors;

points 7–6 are given if the problem is solved with a minor error after correcting the corresponding error;

a score of 5–3 is given if the problem is solved with several minor errors after correcting the corresponding errors;

a score of 2–1 is given if the problem is solved with several significant errors after correcting the corresponding errors;

A score of 0 is given if the problem is solved with at least one significant error without correcting it.

If the student is absent from the practical lesson, in order to receive positive points, the student must defend the completed relevant task to the teacher during the interview.

2. Modular control work:

Weight score – 10. The maximum number of points for the test is 10 points $\times$ 1 = 10 points.

a score of 10 is given if at least 95% of the questions are answered;

A score of 9–7 is given if at least 85% of the questions are answered;

a score of 6–4 is given if 75% of questions are answered;

a score of 3–1 is given if 60% of questions are answered;

A score of 0 is given if less than 60% of the questions are answered.

Incentive points are not provided.

There are no penalty points.

The maximum amount of points of the starting component is 50. A prerequisite for admission to the exam is the starting component of the rating of at least 25 points (50% of the maximum sum of points of the starting component).

According to the results of educational work for the first 7 weeks, the "ideal student" should score 20 points. At the attestation (8th week), the student receives "enrolled" if his current rating is at least 10 points.

According to the results of 15 weeks, the "ideal student" should score 40 points. At the second attestation (14th week), the student receives "enrolled" if his current rating is at least 20 points.

The maximum amount of points for the RC semester is 50:

$$RC = R_{pz} + R_{mcr} = 40 + 10 = 50 \text{ points.}$$

At the exam, students perform a written test. Each task contains three questions. The list of questions is given in this syllabus. Questions are evaluated at 17, 17 and 16 points, respectively.

Question evaluation system (r_{T1} , r_{T1}):

- "excellent", complete answer (at least 95% of the required information) – 17-16 points;*
- "good", a sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 15-13 points;*
- "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 12-10 points;*
- "unsatisfactory", unsatisfactory answer – 0 points.*

The maximum rating of the exam test is

$$RE = R1 + R2 + R3 = 17 + 17 + 16 = 50 \text{ points.}$$

Conditions for admission to semester control: *the presence of the starting component of the semester rating of at least 25 points.*

The sum of starting points and points for the exam test work is converted to the exam grade according to the table:

Table of correspondence of rating scores to grades on the university scale:

Score	Score
100-95	Perfectly
94-85	Very good

84-75	Well
74-65	Satisfactory
64-60	Dostagno
Less than 60	Disappointing
Not met the conditions of admission	Not allowed

9. Additional information on the educational component

List of questions submitted for semester control

1. Explain what the mass transfer process is. Show the importance of mass transfer processes in chemical technology.
2. Present the classification of mass transfer processes of chemical technology.
3. Describe the ways in which the composition of the phases is expressed.
4. Explain what the equilibrium state of a system is.
5. Justify the need to take into account the difference between equilibrium and operating concentrations in engineering calculations.
6. Formulate a phase rule and talk about its use in solving engineering problems.
7. Determine the number of degrees of freedom for the process of absorption of ammonia from the air-ammonia mixture with water (the solubility of air in water can be neglected).
8. Explain what equations and equilibrium lines are, as well as what the working line of the mass transfer process is.
9. Reveal how the direction of the mass transfer process can be determined using equilibrium and operating concentrations.
10. Justify whether the working and equilibrium lines can have a common point.
11. Give a scheme for calculating the material balances of mass transfer processes with a free phase separation limit.
12. Formulate Fick's first law. Analyze in which units the dimension of the diffusion coefficient is determined. Explain what factors and how the value of the diffusion coefficient depends. Give its approximate values for liquid and gaseous media.
13. Explain the mechanisms of mass transfer by diffusion and convection.
14. Explain the physical content of the mass return coefficient.
15. Explain exactly what the concentration of the distributed substance at the phase separation boundary is equal to.
16. Describe the main models of mass transfer.
17. Derive the differential equations of molecular and convective transfer of matter.
18. Give the main criteria for the similarity of mass transfer processes. Explain their physical content. Write down the general form of the criterion equation for constant convective mass transfer.
19. Explain what is the driving force of mass transfer processes.
20. Tell us about the reasons for determining the cross-sectional area (as well as the diameter) of the contact part of mass transfer devices. Tell us what the choking rate is.
21. Write the basic equation of mass transfer. Analyze its modified variants.
22. Derive the dependence of mass transfer coefficients in terms of mass transfer coefficients.
23. Explain the concept of a limited stage of the mass transfer process.
24. Tell us how you can determine the height of the contact part of the mass transfer machine.
25. Explain the number of transfer units and the height of the transfer unit. Tell us exactly how they are defined.
26. Explain what column efficiency is. Tell us how the height of the contact part of the mass transfer apparatus is determined using the efficiency of the column.
27. Give the order for determining the number of valid column plates using a kinetic curve.
28. Give a classification of pores of solids by types and sizes. Explain what the coefficient of tortuosity of pores is.
29. Tell us what types of diffusion are distinguished in solids. Write down the mass conductivity equation.

30. Explain the physical content of the mass conductivity coefficient (effective diffusion coefficient).
31. Explain the physical content of the diffusion criteria of Biot and Fourier.
32. Explain what dimensionless concentration is. Tell us how it is used to calculate the value of the concentration of the distributed substance in the solid or the time to reach this concentration.
33. Explain what absorption and desorption are. Give examples of the application of these processes in technology.
34. Formulate Henry's Law. Tell us how pressure and temperature affect the solubility of gases in liquids.
35. Explain how and why the material balance of absorption is composed. Explain the concepts of absorption and desorption working lines.
36. Explain how the minimum and working specific consumption of the absorbent are determined.
37. Tell us the sequence of compiling the thermal balance of absorption. Explain how and why the position of the equilibrium line changes in this case.
38. Explain the kinetic patterns of physical and chemical absorption.
39. Give the main technological schemes of absorption. Compare the upstream and countercurrent schemes.
40. Tell us in which cases absorption schemes with recirculation are used. Explain what the multiplicity of absorbent circulation is.
41. Give the main groups of absorbers. Explain what a nozzle is. Analyze the requirements that are placed on the nozzle. Explain why nozzles usually work in the countercurrent mode of phase movement.
42. Tell us what a plate of a mass transfer apparatus is. Explain what the overflow of the plate is. Justify the predominant hydrodynamic mode, in which plate absorbers mainly operate.
43. Explain what spray removal is. Explain how and why it affects the effectiveness of plate columns.
44. Explain what exactly explains the hydrodynamic unevenness along the length of the plates with overflows.
45. Give the procedure for calculating absorbers.
46. Give methods for absorbent regeneration.
47. Tell us the sequence of compiling the material balance of desorption with an inert gas. GIVE THE ORDER OF BUILDING A WORKING LINE IN THIS CASE.
48. Explain the operation of the scheme of the absorption and desorption unit for gas separation. Justify the presence of an intermediate absorbent refrigerator in it.
49. Explain what the methods of distillation of liquid mixtures are based on. Explain how and why distillation and evaporation are completely different processes.
50. Explain what the relative volatility of the components of the mixture is. Tell us how it depends on temperature and pressure.
51. Formulate Konovalov's laws and Vrevsky's rules.
52. Explain the concept of an azeotropic mixture. Give examples of how an azeotropic mixture can be divided into individual components.
53. Justify the advantages that distillation with dephlegmation has compared to simple distillation.
54. Explain what water vapor distillation is. Explain the essence of molecular distillation.
55. Explain the principle of rectification. Give a diagram of the distillation column, indicate the flows of liquid and vapor on it. List the types of devices that are used to carry out rectification processes.
56. Write down the equation of the material balance of the rectification column to separate the binary mixture.
57. Explain what the phlegm number and the number of nutrition of the column are, as well as the feeding plate of the column, the strengthening and exhausting parts of the column.
58. Derive the equations of the working lines for the reinforcing and exhausting parts of the column.
59. Justify why the working lines of rectification on the phase diagram $y-x$ are located between the equilibrium line and the diagonal of the diagram.
60. Tell us how the minimum, working and optimal phlegm numbers are determined.
61. Plot the equilibrium curve and work lines on the $y-x$ diagram if the value of the phlegm number R

is known. Tell us exactly how you can use this diagram to determine the height of the reinforcing and exhausting parts of the column.

62. Explain the purpose of compiling the thermal balance of the distillation column.
63. Tell us in which cases periodic rectification is used. Explain the main methods of periodic rectification.
64. Explain what molecular rectification is. Justify the cases when it is advisable to apply this process.
65. Explain what extractive and azeotropic rectification are. Justify the cases in which it is advisable to apply these processes.
66. Explain the operation of the scheme of a distillation unit with a heat pump.
67. Explain the layouts of the reflux unit's dephlegmators, as well as the layouts of the built-in and remote boilers.
68. Estimate the number of columns to completely separate the N-component mixture into individual components. Give a diagram of the possible implementation of the process.
69. Uncover the essence of liquid extraction. Give diagrams of the process and scope of liquid extraction.
70. Formulate the law of distribution, explain the limitations of its use in liquid extraction calculations.
71. Explain triangular diagrams and the construction of equilibrium (binoidal) curves.
72. Explain what the choice of extractant is based on. Explain what extraction selectivity is.
73. Tell us what are the features of compiling material balances of liquid extraction under the condition of practical mutual insolubility and partial mutual solubility of components.
74. Explain the basic provisions of the kinetics of liquid extraction.
75. Explain how the working line is built on the diagram $y-x$ and on the triangular diagram: single extraction, multiple extraction with counterflow of the extractant, continuous counterflow extraction.
76. List the characteristics by which liquid extractors are classified.
77. Provide structure diagrams and explain the principle of operation of hollow extractors. Analyze the advantages and disadvantages of hollow extractors compared to plate and nozzle extractors.
78. Give a diagram of the structure and explain the principle of operation of the rotary disc extractor. Justify its advantages and disadvantages.
79. Give examples of the use of adsorption. Describe the main industrial adsorbents.
80. Reveal the essence of static and dynamic activity of adsorbents.
81. Describe the adsorption equilibrium.
82. Tell us how the material balance of adsorption is composed.
83. Explain the structure and principle of operation of adsorbers with a fixed layer of adsorbent. Tell us for what purpose the vertical shell-and-tube adsorber is used.
84. Give the technological schemes of adsorption.
85. Explain what the adsorption front is., as well as its movement along the height of the adsorbent layer.
86. Write down the Shilov equation. Tell us how to use it.
87. Explain the physical content of the protective effect of the adsorbent layer, as well as the procedure for determining the time of slippage of a certain adsorbent layer.
88. Describe the main methods of adsorbent regeneration.
89. Formulate the basics of ion exchange. Tell us what cationite, anionite, amphotite are, the procedure for regenerating and washing ions. Reveal the stages of the ion exchange process.
90. Tell us what crystallization is. Give examples of its application.
91. Describe the main methods of crystallization. Explain when they are used.
92. Perform an analysis of the state diagrams of the system "gas (steam) - liquid - solid" and "liquid - solid".
93. Write down the material and thermal balances of crystallization.
94. Explain the features of crystallization kinetics. Analyze the advantages and disadvantages of obtaining a fine-crystalline product.
95. Give a classification of crystallizers.

96. Justify in which cases crystallization from the melt is performed. Explain what is zone melting that occurs during crystallization from a melt.
97. Explain the mechanism of dissolution and extraction processes in the solid-liquid system.
98. Show the distribution of concentrations in the solid during the extraction of the distributed substance from it.
99. Explain the kinetic patterns of extraction in the solid-liquid system.
100. Justify why pre-grinding of a solid can lead to a significant increase in the cost of extracting a distributed component by extraction from a solid?
101. Describe the main methods of extraction and dissolution.
102. Evaluate devices for extraction from solid and dissolution of solids.
103. Explain the principle of separation of mixtures using membranes. What is the driving force of membrane processes?
104. Explain what membrane selectivity and permeability are. Explain how they depend on external factors of the process. Tell us what concentration polarization is and how you can reduce its effect on membrane separation.
105. Submit a classification of membrane processes. What is the difference between reverse osmosis, ultra and microfiltration? What is osmotic pressure?
106. Explain the features of evaporation through the membrane. Justify for which mixtures it is most expedient to use this method.
107. Explain the principle of separation of solutions by electrodialysis.
108. Provide a classification of separating membranes. Tell us the methods for obtaining pores in membranes. Explain what rigid, non-rigid, folded, dynamic and liquid membranes are.
109. Analyze the components of the total resistance of the membrane process.
110. Provide a classification of membrane devices. In what cases is it advisable to use devices with membranes in the form of hollow fibers? Why do thin hollow fibers withstand significant pressures without collapsing?
111. Compare the methods of separation of liquid, gas and vapor mixtures (absorption, rectification, liquid extraction, etc.) with membrane methods.
112. In what cases can the intensification of agitation lead to a decrease in the rate of mass transfer?
113. Justify the factors that limit the size of the dispersed phase particles in mass transfer processes.
114. How does the effect of cavitation affect mass transfer processes, in particular the crystallization process?
115. Justify possible ways to increase the efficiency and intensity of various mass transfer processes by combining them.
116. Give examples of practical use of various physical, chemical and/or geometric effects to intensify and increase the efficiency of mass transfer processes.

List of questions submitted for modular control work

1. Which of the following processes do not belong to mass transfer?
2. What dimension corresponds to the concentration of the distributed substance in phase?
3. From which phase will the distributed substance pass under such conditions?
4. Can the working line of the mass transfer process cross the equilibrium line?
5. Can the working and equilibrium lines be tangent to each other?
6. What exactly is the concentration of the distributed substance at the interface of phase separation?
7. In what phase should the mass transfer process be intensified to accelerate the mass transfer process?
8. Can the number of valid column plates be a fractional number?

9. *What is the dimension of dimensionless concentration?*
10. *How does an increase in temperature in the mass transfer apparatus affect the absorption process?*
11. *How does an increase in temperature in the mass transfer apparatus affect the desorption process?*
12. *How does an increase in pressure in the mass transfer apparatus affect the absorption process?*
13. *How does an increase in pressure in the mass transfer apparatus affect the desorption process?*
14. *In which stream (which streams) of the distillation column is the lowest content of the low-boiling component?*
14. *In which flow (which streams) of the distillation column is the highest content of the low-boiling component?*
16. *What liquid systems can participate in liquid extraction?*
17. *What is the porosity of the adsorbent layer?*
18. *What is the porosity of adsorbent?*
19. *A dynamic membrane for membrane separation is... (continue the phrase)*
20. *Flows involved in the mass transfer processes listed below should not be subjected to the effect of cavitation.*

Work program of the educational component (syllabus):

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Approved by the Department of Chemical, Polymer and Silicate Engineering (Minutes No. 17 of 04.06.2025).)

Approved by the Methodological Commission of the Faculty of Engineering and Chemistry (Minutes No. 11 dated 27.06.2025).)