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

Department of Chemical Engineering and Oil Refining Industry

EQUIPMENT OF CHEMICAL INDUSTRIES

Working program of the academic discipline (Syllabus)

Level of higher education	***First (undergraduate)***
Branch of knowledge	*15 Automation and instrumentation*
Specialty	*151 Automation and computer-integrated technologies*
Educational program	*Technical and software automation tools*
Discipline status	*Selective*
Form of education	*Full-time (day)/distance/mixed*
Year of training, semester	*3rd year, spring semester, ЛА-11, ЛА-12, ЛА-13*
Scope of the discipline	*4 credits (120 hours)*
Semester control/ control measures	*Test*
Lessons schedule	*Lectures - 2 hours (1 pair once every two weeks), practical - 2 hours (1 pair per week)* *https://rozklad.kpi.ua/,https://ecampus.kpi.ua/*
Language of teaching	*Ukrainian*
Information about the lector/ teachers	Lector: *Ph.D., Husarova Olena Vitaliivna, sunflowers@i.ua* Practical: *assistant Hryhoriy Serhiyovych Podyman, podiman_g_s@ukr.net*
Placement of the course	https://classroom.google.com/c/NTg3NzEyMTk4Mjkw

Program of educational discipline

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

An effective automation system cannot be developed without knowing the design and parameters of the automation object. Such problems are solved by this educational discipline, which plays a significant role in the training of bachelors at real industrial facilities.

The study of the discipline contributes to the development of professional thinking and the use of methods and knowledge from this discipline when mastering the professional disciplines of the program "Technical and software tools of automation".

***The purpose** discipline is the formation of the acquirers of the ability to understand the technical and functional characteristics of chemical production facilities and to use the acquired knowledge and skills in solving engineering problems related to the development, design and modernization of equipment chemical industries.*

***Subject** discipline is the study of structures and basic parameters of regulated equipment processes chemical production, methods of determining the kinetic and dynamic characteristics of equipment, methods of applying the theoretical apparatus of heat and mass exchange when solving practical problems.*

Program learning outcomes are:

1) Knowledge and ability to apply the principles of hydrodynamics and heat and mass transfer in the development of automation systems.

2) Knowledge of constructions and principles of operation of chemical production equipment as objects of automation.

3) The ability to calculate and select control valves and devices.

4) The ability to explain the influence of measurement accuracy on product quality and consumption of raw materials and energy.

Required skills:

1) Knowledge of the professional foundations of chemical technology processes and devices.

2) Knowledge of software products: Microsoft Office, AutoCAD, Matlab.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

The discipline belongs to the elective cycle and is based on the knowledge of the following disciplines: "Higher mathematics", "Physics", "Engineering and computer graphics", "Processes and devices of chemical technology".

Theoretical knowledge and practical skills acquired during the study of this discipline can be used when mastering the disciplines of the educational program "Technical and software tools of automation".

3. Content of the academic discipline

Chapter 1. Basics of transference theory.

Topic 1.1 Introduction to the chemical industry equipment course

Chapter 2. Technical hydraulics

Topic 2.1 Hydrostatics and hydrodynamics

Chapter 3. Thermal processes

Topic 3.1 Diffusion transfer of thermal energy

Topic 3.2 Convective heat exchange. Partial cases of convective heat transfer

Topic 3.3Radiant heat exchange

Chapter 4. Heat exchange equipment

Topic 4.1Heating, cooling and heat exchange devices

Topic 4.2Evaporation and evaporation installations

Topic 4.3Drying and drying installations

4. Educational materials and resources

Basic literature, which must be used to master the discipline, is worked out independently for preparation for practical classes and in the conditions of distance learning. It is suggested to use additional literature and Internet resources to perform modular tests, prepare reports, presentations, and write essays based on the results of independent work.

Basic literature:

1. Обладнання хімічних виробництв : Конспект лекцій [Електронний ресурс] : навч. посіб. для студ. спеціальності 151 Автоматизація та комп'ютерно-інтегровані технології, освітня програма "Технічні та програмні засоби автоматизації" / КПІ ім. Ігоря Сікорського; уклад.: Швед М.П., Степанюк А.Р., Гусарова О.В., Швед Д.М. – Електронні текстові дані (1 файл: 3,71 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2023. – 181 с. https://ela.kpi.ua/handle/123456789/54632

2. Обладнання хімічних виробництв: Практикум [Електронний ресурс] : навч. посіб. для студ. спеціальності 151 «Автоматизація та комп'ютерно-інтегровані технології», освітня програма "Технічні та програмні засоби автоматизації" / КПІ ім. Ігоря Сікорського; уклад.: Степанюк А.Р., Гусарова О.В. – Електронні текстові дані (1 файл: 2,71 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2023. – 152 с. https://ela.kpi.ua/handle/123456789/54106

Additional literature:

3. Корнієнко Я.М. Процеси та обладнання хімічної технології 1: підручник / Я.М. Корнієнко, Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев – К. :НТУУ „КПІ", 2011 – Ч.1 – 300 с.

4. Корнієнко Я.М. Процеси та обладнання хімічної технології 2: підручник / Я.М. Корнієнко, Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев – К. :НТУУ „КПІ", 2011 – Ч.2 – 416 с.

5. Теплові процеси та апарати хімічних і нафтопереробних виробництв // Ч.1. Ю.Ю. Лукач, І.О. Мікульонок, Г.Л. Рябцев, М.В. Сезонов. – К.: НМЦВО, 2000.-172 с.

6. Теплові процеси та апарати хімічних і нафтопереробних виробництв // Ч.2. Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев. – К.: НМЦВО, 2004.- 161 с.

Regulatory documentation:

7. DSTU EN 247-2003 Heat exchangers. Terminology.

8. DSTU EN 305-2001 Heat exchangers. Determination of operational characteristics of heat exchangers and general test methodology for establishing operational characteristics of all heat exchangers.

9. DSTU EN 1118:2008. Heat exchangers. Liquid coolers cooled by a refrigerant. Test methods for establishing performance characteristics (EN 1118:1998, IDT).

5. Educational content
Methods of mastering an educational discipline (educational component)

Information (by sections, topics) about all educational classes (lectures, practical, seminars, modular control work, tasks on independent processing).

5.1 Lecture classes

Lectures are aimed at:

- *provision of modern, comprehensive in-depth knowledge of the discipline;*
- *provision of critical creative work together with the teacher in the process of work;*
- *education of students' professional qualities and development of their independent creative thinking.*

No.	The name of the topic of the lecture and a list of the main questions (a list of didactic tools, references to the literature and tasks on independent processing	Number hours
	Chapter 1. Basics of transference theory	
	Topic 1.1. Introduction to the chemical industry equipment course	
1	***Lecture 1.*** *Introduction to the chemical industry equipment course.* *The classification of chemical-technological processes is given, and transfer phenomena in chemical technology are considered. The equations of conservation of mass, energy, balance and driving force are analyzed.* ***Tasks on independent processing:*** *Analysis of equations of conservation of mass, energy, equilibrium and driving force. The principles of their solution.* ***literature****: 1-6.*	1
	Chapter 2. Technical hydraulics	
	Topic 2.1. Hydrostatics and hydrodynamics	
1	***Lecture 1***. Properties and concepts of liquid viscosity are considered. Ideal and real fluids are characterized. The equations of Euler, Navier-Stokes, the basic equation of hydrostatics, continuity of the flow are presented. Hydraulic radius and equivalent diameter. Modes of fluid movement. ***Tasks on independent processing:*** *Cases of practical use of the basic equation of hydrostatics.* ***literature****: 1-6.*	1
2	***Lecture 2.*** *Derivation and analysis of the Bernoulli equation. Friction resistance and local resistance, their calculation. Fluid consumption at steady (stationary) fluid flow. Poiseuille's equation.* *The optimal diameter of the pipeline. Head losses along the length of the channel and local losses are considered. Dependencies are analyzed to determine the optimal pipeline diameter.*	2

	Tasks on independent processing: *The use ofBernoulli's evolution in technology for determining the speed and flow of matter.* ***Literature: 1 - 6.***	
3	***Lecture 3.*** *Hydraulic machines.* *Dynamic and volumetric pumps, their classification. Basic parameters. Structural change in pump characteristics. Vane pumps, their characteristics, classification, principle of operation and designation according to international standards ISO 2853. Piston pumps.* ***Tasks on independent processing:*** *Compile an album of constructions, provide a classification, give the advantages and disadvantages of hydraulic machines.* ***Literature:*** *1-2.*	2
	Chapter 3. Thermal processes	
4	***Topic 3.1. Diffusion transfer of thermal energy*** ***Lecture 4.*** *Types of heat transfer and concepts of temperature gradient, temperature field, heat flow and heat flow density are considered. The basic equation of heat conduction is derived and analyzed.* *Unambiguity conditions and cases of stationary thermal conductivity are considered. Kinetic coefficients of thermal conductivity, thermal conductivity and heat transfer are considered.* ***Tasks on independent processing:*** *Thermal conductivity of a cylindrical wall under boundary conditions of the third kind.* ***Literature:****1-6.*	1
	Topic 3.2. Convective heat exchange. Partial cases of convective heat exchange	
4	***Lecture 4.*** *The physical essence of convective heat exchange is considered. The Newton-Richmann heat transfer equation is considered. The concept of heat transfer coefficient is introduced. The system of convective heat transfer equations is derived and the ways of its solution are considered.* ***Tasks on independent processing:*** *Energy equation and its analysis.* ***Literature:****1-6.*	1
5	***Lecture 5.*** *The method of similarity theory, theorems and criteria of thermal similarity are considered. Criterion equations for determining the heat transfer coefficient and ways of its intensification are given. Heat transfer during forced transverse flow around the pipe. Thermal conductivity when washing bundles of pipes. Heat transfer during free convection in an unlimited space. Cases of convection in a limited space are possible.* ***Tasks on independent processing:*** *Heat transfer when the aggregate state changes (phase transition). Boiling. Condensation.* ***Literature:****1-6.*	1
	Topic 3.3. Radiant heat exchange	
5	***Lecture 5.*** *Radiant heat exchange (thermal radiation). Basic laws of thermal radiation.* ***Tasks on independent processing:*** *Features of thermal radiation of gases.* ***Literature: 1-6.***	1
	Chapter 4. Heat exchange equipment	
	Topic 4.1. Heating, cooling and heat exchange devices	
6	***Lecture 6.*** *Requirements for coolants and heating schemes with water, steam, mineral oils and other high-temperature coolants, electric current and furnace gases are given. Types of movement of heat carriers and methods of determining the driving force of heat transfer are considered.* ***Tasks on independent processing:*** *Mutual radiation of two solid bodies.* ***literature****: 1-6.*	2

7	***Lecture 7.*** *Designs of heat exchangers. Their advantages and disadvantages, the principle of operation. Comparison of heat exchangers. The material and heat balances of heat transfer, as well as the design and verification calculation algorithm of heat exchangers, are presented.* ***Tasks on SRS:*** *Classify and compile an album of designs of heat exchangers. Highlight the cases of use, their advantages and disadvantages.* ***literature****: 1-6.*	2
	Topic 4.2. Evaporation and evaporation installations	
8	***Lecture 8.*** *The mechanism and features of concentration of solutions by evaporation are considered. Material and heat balances of a single-body evaporation plant. Temperature losses and the algorithm for determining the heat transfer surface are analyzed. Multi-body evaporation plants. The principle of action.* ***Tasks on independent processing:*** *To classify and compile an album of the designs of evaporation plants. To highlight the cases of use, advantages and disadvantages* ***literature****: 1-6.*	2
	Topic 4.3. Drying and drying installations	
9	***Lecture 9:*** *The mechanism, stages and types of drying units are given. The characteristics of moist air as a drying agent and their display on the I-x diagram are given. The material and heat balances of a convective dryer are considered and the concept of an ideal dryer is defined. Variants of drying processes and an algorithm for determining heat and air costs for drying are given. Periods and kinetics of drying are considered. Dependencies are given for determining the duration of drying periods and overall dimensions of dryers.* ***Tasks on independent processing:*** *Classify and compile an album of designs of drying plants. Highlight use cases, advantages and disadvantages.* ***literature****: 1-6.*	2
	Hours in general	***18***

5.2. Practical training

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

No.	***The name of the topic presented at the practical lesson***	***Number hours***
	Chapter 1. Basics of transference theory	
	Chapter 2. Technical hydraulics	
1-4	*Study of the designs of machines for the movement of liquids and gases and calculations based on the equations of hydrostatics and Bernoulli. Hydraulic supports. Hydraulic calculation and selection of a centrifugal pump* *Literature 1, 2*	*8*
	Chapter 3. Thermal processes	
	Chapter 4. Heat exchange equipment	
	Topic 4.1. Heating, cooling and heat exchange devices	
5	*Study of designs of heat exchange devices.* *Literature 1-6*	*2*
6-8	*Calculation of the shell-and-tube heat exchanger.* *Literature 1,2*	*6*
9-10	*Calculation of the irrigation refrigerator.*	*4*

	Literature 1,2	
	Topic 4.2. Evaporation and evaporation installations	
11-14	*Study of structures of evaporation apparatuses and calculation of evaporation plant*	*8*
	Topic 4.3. Drying and drying installations	
15-16	*Study of designs of dryers and calculation of a convective drying unit. Literature 1,2*	*4*
17	*Modular control work Literature 1-6*	*2*
18	*Control Homework Literature 1-6*	*2*
	Hours in general	***36***

5.3 Laboratory classes

Laboratory classes are not included in the curriculum.

6. Independent work of the student

The discipline "Equipment of chemical industries" provides the following types of student work: lectures and practical classes, one modular control work, Control Homework, as well as independent work of the student, which is 55% of the time of the credit module, including preparation for the assessment. The study of the discipline ends with the preparation of a credit, to which students who have fully completed the program of the credit module are admitted. The main form of studying the discipline by students is independent work with recommended educational and educational and methodological literature.

The purpose of this work *is the acquisition of theoretical knowledge of the discipline, the formation of skills and experience in the design of industrial equipment.*

Lectures are aimed at summarizing and systematizing knowledge acquired by students during independent work.

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

The purpose of the Control Homework *is the development of the ability to apply the acquired knowledge to solve practical and theoretical tasks of modern production, gaining experience in the execution of reporting documentation.*

6.1 Individual tasks

When studying the course, students perform one Control Homework, the purpose of which is to study equipment structures.

The result of the work is drawn up in the form of a report, which includes the formulation of the purpose of the work, a description of the design features of the device. The volume of the report is 10-15 A4 pages.

6.2 Control works

One modular control work is planned.

The main purpose of the control work is to check the level of learning of the taught material, which will make it easier for students to learn the material and provide more complete control by the teacher over the students' implementation of the curriculum.

Approximate questions are listed in Addition A.

7. Policy and control

7.1 Policy of academic discipline (educational component)

The student must be present at all lectures, practical and laboratory classes, except for confirmed valid reasons.

Defense of practical and individual tasks is carried out personally according to established deadlines, taking into account incentive and penalty points

Students have the right to dispute the points for the assignment, but must be reasoned, explaining which criterion they disagree with according to the evaluation letter and/or comments.

The detailed criteria for evaluating students' learning outcomes are defined in the regulation on RSO of the discipline.

7.2 University policy

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism refers to the absence of references when using printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes, tests, exams.

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

Policy of academic behavior and ethics

Students must be tolerant, respect the opinion of others, formulate objections in the correct form, adequately support feedback during classes.

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details: https://kpi.ua/code.

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

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

Semester	Training time		Distribution of study hours				Control measures		
	Loans	Acad. hours	audio hour	Lectures	Practical	IW	MCW	CGW Album of constructions	Semester control
2	4	120	54	18	36	66	1	1	test

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

1) *performance of 5 tasks;*
2) *defense (at the choice of the teacher) of 4 sections of the construction album;*
3) *writing MCW;*
4) *the answer to the test.*

System of rating (weighted) points and evaluation criteria

1. Work in practical classes

Weight score - 10.

Evaluation criteria:

- *a score of 9-10 is awarded under the condition of an excellent answer.*
- *a score of 6-8 is given if the answer is sufficient.*
- *a score of 0 is given if the answer is unsatisfactory.*

The maximum number of points for all practical classes is equal to: 10 points x 5 = 50 points.

2. Modular control

Weight score is 10.

- "excellent" - 10 points;

- "good" - 8-9 points;

- "satisfactory" - 6-7 points;

- "unsatisfactory" - 0 points.

3. Album of constructions (HCW).

The weight score is 20.

Evaluation criteria for the Construction Album **(HCW):**

- a score of 18-20 is awarded if all sections of the work are covered in full, or individual inaccuracies are admitted;

- a score of 13-15 is given if certain inaccuracies are admitted in the work;

- a score of 10 is awarded if the topic of the work is not clearly covered, mistakes are made in wording, terms and definitions;

- A score of 0 is assigned if the work is performed unsatisfactory: the presence of significant errors or the absence of separate sections, the RGR or the album are not included.

4. Penalty and incentive points for:

*- **penalty points:** untimely (later than in the practical session) submission of the task or section of the synopsis of structures - minus 2 points.*

- untimely (later than during the practical lesson) handing in the calculation of the device - minus 2 points;

- untimely (later than a week) submission of calculation work - minus 5 points;

*- **incentive points**: performance of tasks to improve didactic materials from the credit module - up to 10 points.*

The size of the rating scale

RD = Rпр+Рмкр+РРП+ Rалб=50+10+20+20 = 100 points

Conditions of positive intermediate attestation

In order to receive "passed" from the first intermediate certification (week 8), a student must have at least 10 points (provided that at the beginning of week 8, according to the calendar of control measures, the "ideal" student must receive 20 points).

In order to receive "credited" from the second intermediate certification (week 14), a student must have at least 22 points (provided that at the beginning of week 14, according to the calendar of control activities, the "ideal" student must receive 50 points).

For 18 weeks of training based on the results of practical work, execution of modular control and calculation and graphic work, protection of the design album, the maximum number of points a student can score is 100 points.

Conditions for admission to credit:

Enrollment of all practical classes, calculation work, design album, a positive result of the modular control work, as well as a starting rating Rs > 40 points.

***To receive credit from the credit module "automatically"** you need to have a rating of at least 60 points, and all types of work are also included.*

***Students who at the end of the semester have a rating of less than 60 points,** as well as those who want to increase their score in the system of rating points, perform a credit test.*

***Credit evaluation criteria:** the ticket contains 4 questions, the maximum number of points for each question is distributed equally.*

Table of criteria for evaluating answers to ticket questions

Response rate	Number of points for answering the question			
	Question 1	Question 2	Question 3	Question 4
Distinctive	9-10	9-10	9-10	9-10
Very good	7-8	9-10	9-10	9-10
Good	5-6	6-8	6-8	6-8
Satisfactory	3-4	3-5	3-5	3-5
Sufficient	1-2	1-2	1-2	1-2
Unsatisfactory	0	0	0	0

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

Scores	Rating
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactoy
Admission conditions not met	Not allowed

9. Additional information on the discipline (educational component)

During their studies, students acquire new knowledge, skills and abilities, mainly during specific lectures and practical classes under the leadership of the department's leading NPPs.

Quite often during their studies, students, in order to receive incentive points, are involved in providing assistance in the development of educational and methodological documentation (publication of manuals, licensing, development of methodological documentation, etc.). At the same time, the nature of such assistance must strictly correspond to the profile of the discipline and in terms of duration should not interfere with the implementation of the student's study plan.

Working program of the academic discipline (syllabus):

Compiled by Ph.D, Olena Husarova

Approved by the Department of Chemical Engineering and Oil Refining Industry (protocol No. 19 dated May 17, 2023)

Agreed by the Methodical commission of the faculty[1] (protocol No. 10 dated 05/26/2023)

[1] Methodical council of the university – for general university disciplines.

Questions to the MCW:

1. *Unambiguity conditions and their types.*
2. *Derive the equation for temperature distribution in a flat wall.*
3. *Derive the equation for the temperature field in the cylindrical wall.*
4. *Derive the equation for the temperature distribution in a multi-layered wall under boundary conditions of the 1st kind.*
5. *Derive and analyze the basic heat transfer equation.*
6. *On what factors does the radiative capacity of the body depend?*
7. *What are temperature gradient, isothermal surface and temperature field and what are their properties?*
8. *State the basic laws of thermal radiation.*
9. *How to determine the amount of heat transferred from a more heated body to a less heated one?*
10. *Give the mechanism of convective heat transfer.*
11. *Give a system of equations that describes convective heat transfer.*
12. *The essence and main theorems of the similarity theory method.*
13. *How do you convert differential equations that describe one or another process into criterion equations? Give the generalized criterion equation.*
14. *Name the main criteria of hydrodynamic and thermal similarity. Specify their main physical meaning.*
15. *What are the differences between the equations for determining the heat transfer coefficient during forced and free convection.*
16. *The intensity of heat transfer and ways of its intensification depend on what.*
17. *Give the algorithm for calculating the heat transfer coefficient.*
18. *Give the mechanism of condensation and the features of determining the heat transfer coefficient. Name the condensation factors. How does the gas content affect heat transfer?*
19. *Give the types of boiling and explain the concept of critical temperature difference during boiling.*
20. *Derive and analyze the equation for the average temperature difference between heat carriers in direct and counterflow.*
21. *What are the requirements for coolants?*
22. *What process is called heat transfer?*
23. *What equation determines the relationship between the amount of transferred heat and the dimensions of the heat exchange equipment?*
24. *What is the physical meaning of the heat transfer coefficient?*
25. *What process is called heat transfer?*
26. *What parameters characterize heat transfer during natural and forced convection?*
27. *What criteria of thermal and hydrodynamic similarity are included in the criterion equations of convective heat transfer? What is their physical significance?*
28. *What are the features of heat transfer in the event of a change in aggregate state? By what criteria are these features taken into account? What is the physical essence of this criterion?*
29. *What is the relationship between heat transfer coefficient and heat transfer coefficients?*
30. *What are the total thermal resistances of heat transfer?*
31. *What is the driving force of heat exchange processes?*
32. *Why is the average driving force used in the calculations of heat exchange processes? How is it*

defined?

33. *In what ways can the heat transfer process be intensified?*
34. *What is the purpose of the condensation process in chemical industries?*
35. *List the main requirements for coolants.*
36. *What methods of heating are used in chemical industries?*
37. *From which equation is the flow rate of the coolant for heating determined?*
38. *In what cases can "hot" steam be used for heating?*
39. *In what cases is heating with combustion gases used? What are the disadvantages of heating with combustion gases?*
40. *What methods of electric heating are used in chemical industries?*
41. *What positive qualities and disadvantages do water and air have when cooling hot coolants? How to determine the flow of cooling water in the heat exchanger?*
42. *How are heat exchangers classified?*
43. *What is the structure and principle of operation of a single-pass shell-and-tube heat exchanger?*
44. *Why is heat exchange intensified in multi-pass shell-and-tube heat exchangers?*
45. *In what cases are temperature compensators used in shell and tube heat exchangers?*
46. *When are heat exchangers of the "pipe-in-pipe" type used? What are their advantages and disadvantages compared to shell and tube heat exchangers?*
47. *How is a spiral heat exchanger built? What are its disadvantages?*
48. *In which chemical industries are plate heat exchangers used? What are their positive qualities and disadvantages?*
49. *When are heat exchangers with ribbed heat exchange surfaces used? Give a comparative description of heat exchangers of different types.*
50. *Give the diagram of the design calculation of heat exchangers. What values should be known during design calculations of heat exchangers?*
51. *Why perform a hydraulic calculation of heat exchangers?*
52. *What is the optimal calculation of heat exchangers?*
53. *What is the difference between the verification calculation of heat exchangers and the design one?*
54. *What is called condensation?*
55. *Explain the essence of the evaporation process.*
56. *What methods are used in the chemical industry to carry out the evaporation process?*
57. *What is the difference between the useful temperature difference and the total difference?*
58. *What are the temperature losses in the evaporation plant?*
59. *How is the consumption of heating steam determined during evaporation?*
60. *What is the procedure for calculating evaporation plants?*
61. *Why is the extra pair selected?*
62. *How to determine the optimal number of cases of a multi-case evaporation plant?*
63. *What process is called drying?*
64. *Explain the concepts: relative humidity, moisture content and enthalpy of moist air.*
65. *Clarity of the principles of constructing a diagram of the I-th state of moist air.*
66. *How is air consumption (total and specific) determined for drying?*
67. *From which balance are specific heat consumption and heating steam consumption for drying determined?*
68. *How is the process of theoretical and real drying constructed on the I-x diagram?*
69. *What are the options for the drying process?*
70. *Clarity of the principles of construction of drying curves and drying speed.*