MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION
Federal state autonomous educational institution
of higher education
«Far Eastern Federal University»
(FEFU)

INSTITUTE OF LIFE SCIENCES AND BIOMEDICINE (SCHOOL)

AGREED

Head of OP

_______________ Kalenik T.K.
(signature) (full name)
«28» September 2021 г.

APPROVE

Head of VSP

_______________ Kalenik T.K.
(signature) (full name)
«28» September 2021 г.

WORKING PROGRAM OF THE DISCIPLINE

«Research methods in biotechnology»
Direction of training 19.04.01 «Biotechnology»
(«Agri-Food Biotechnology»)
Form of training full-time

course 1 semester 4
lectures 18 hours.
practical classes 36 h.
laboratory work 0 hours.
including using
total classroom hours 54 hours.
independent work 9 h.
including preparation for the exam 45 hours (if the exam is provided).
control works (quantity) are not provided
term paper / term project are provided
credit not included
exam 1 semester

The program of the state final certification was compiled in accordance with the requirements of the Federal State Educational Standard in the field of study 19.04.01 Biotechnology, approved by order of the Ministry of Science and Higher Education of the Russian Federation dated August 10, 2021 No. 737.

The program at the meeting of the Academic Council of the Institute of Life Sciences and Biomedicine (School) December 21, 2021
Director of the Department of Food Science and Technology Kalenik T.K.
Compiled by: Kalenik T.K., Senotrusova T.A.

Reverse side of the title page of the RPMU

I. The work program was revised at the meeting of the department:
Protocol dated «_____» _________________ 20___ № _______
Director _________________________ ______________
(signature) (full name)

II. The work program was revised at the meeting of the department:
Protocol dated «_____» _________________ 20___ № _______
Director _________________________ ______________
(signature) (full name)

III. The work program was revised at the meeting of the department:
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IV. The work program was revised at the meeting of the department:
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Director _________________________ ______________
(signature) (full name)

ANNOTATION
of the educational complex of discipline
«Research methods in biotechnology»
Direction of preparation: 19.04.01 Biotechnology
Educational program: «Agri-Food Biotechnology»

The educational-methodical complex of the discipline «Research methods in biotechnology» was developed for 1st year students in the direction 19.04.01 «Biotechnology» master's program «Agri-Food Biotechnology» in accordance with the requirements of OS HE in this area.

The discipline «Research methods in biotechnology» is included in block B1.B.02 and refers to the compulsory disciplines of its variable part of the direction of preparation of the master's program 19.04.01 Biotechnology.

The total complexity of mastering the discipline is 3 credits, 108 hours. The curriculum includes lecture classes (18 hours), practical classes (36 hours), independent work of the student (54 hours). The discipline is implemented in the 1st year in 1 semester.

The content of the discipline covers the following range of issues:

- research methods for raw materials, semi-finished products and food biotechnology products;

- planning, organizing and conducting research in the field of biotechnology, using modern research methods and data processing;

- the development of unique research methods for the quality and safety of raw materials and food biotechnology products.

The discipline «Research methods in biotechnology» is logically and meaningfully connected with such courses as “Methodology of scientific research in biotechnology”, «Agri-Food Biotechnology», «Safety and quality of food raw materials and food products».

The discipline is aimed at the formation of general cultural, general professional and professional competencies

Educational complex includes:

– the work program of the discipline;
– educational and methodological support of students' independent work (Appendix 1);
– appraisal fund (appendix 2).

Директор Департамента
пищевых наук и технологий ____________________ Каленик Т.К.

ABSTRACT

Master's degree in 19.04.01 Biotechnology

Master's Program "Title" Agri-food Biotechnology

Course title: «Research methods in biotechnology»

Basic part of Block 1, 3 credits

At the beginning of the course a student should be able to:

– the ability to perceive and creatively use the achievements of science and technology in the professional sphere, in accordance with the needs of regional and global labor market;

– the ability to use modern methods and technologies (including information) in professional activity;

– the ability and willingness to use the basic laws of natural sciences in professional activities;

– the ability to use knowledge of modern physical picture of the world, the laws of space-time, the structure of matter to understand the world and natural phenomena;

– the ability to work with scientific and technical information, to use the Russian and international experience in professional work;

– possession of the main methods and techniques of experimental research in the professional field; ability to carry out standard and certification tests of raw materials, finished products and production processes;

– knowledge of methods of experimental design, processing and presentation of the results.

Learning outcomes:

GC-11 ability to grow professionally, to learn independently new research methods, to change the scientific and production profile of their professional activities;

GC-12 the ability to practice to use the skills and abilities in the organization of research and design work and in team management;

GPC-1 ability to professional exploitation of modern biotechnology equipment and scientific instruments;

GPC -4 is ready to use methods of mathematical modeling of materials and technological processes, readiness for theoretical analysis and experimental testing of theoretical hypotheses;

SPC-3 the ability to present the results of the work done in the form of scientific and technical reports, reviews, research reports and publications using modern capabilities of information technologies and taking into account the requirements for the protection of intellectual property.

Course description: This discipline is the link between humanitarian disciplines and application areas, provides a competent perception of practical problems related to nutrition of different population groups, drawing evidence-based daily food rations, the design food; It has a certain importance in the training of specialists in the field of food biotechnology is a key element in the complex organizational and technological sciences that study human nutrition and health of the patient

Main course literature:

1. Visual biotechnology and genetic engineering / R. Schmid; per. with him. A. A. Vinogradova, A. A. Sinyushina. Moscow: BINOM. Laboratory of Knowledge, 2014. - 324 p. (10 copies) http://lib.dvfu.ru:8080/lib/item?id=chamo:797469&theme=FEFU

2. Biotechnology: a textbook for agricultural universities / V. A. Chkhenkeli. - St. Petersburg: Science Avenue, 2014. - 335 p. (3 copies.) Http://lib.dvfu.ru:8080/lib/item?id=chamo:785504&theme=FEFU

3. Biotechnology of combined food products based on dairy and microbiological raw materials: method. directions to the lab. works for students special. 240902 "Food Biotechnology" of all forms of training / comp. N.V. Situn, E.S. Fishchenko. Biotechnology of dairy production. Vladivostok: Publishing House of the Pacific University of Economics, 2009. - 96c. (8 copies.) Http://lib.dvfu.ru:8080/lib/item?id=chamo:357087&theme=FEFU

Form of final control: exam.

Annotation to the work program of the discipline «Research methods in biotechnology»

The course «Research methods in biotechnology» is included in block B1.B.02.02 and refers to the compulsory disciplines of the basic part of the preparation for the master's program 19.04.01 Biotechnology. The discipline is one of the integral in the fundamental training of students of this profile and is closely related to such disciplines as: «Methodology of scientific research in biotechnology», «Agri-Food Biotechnology», «Safety and quality of food raw materials and food products».

The total complexity of mastering the discipline is 3 credits, 108 hours. The curriculum includes lecture classes (18 hours), practical classes (36 hours), independent work of the student (54 hours). The discipline is implemented in the 1st year in 1 semester.

The purpose of mastering the discipline is the formation of systematic knowledge among students in the field of modern methods of researching food biotechnology products, as well as the education of sustainable independent research work among students.

Tasks of studying the discipline:

- the development of research methods for raw materials, semi-finished products and food biotechnology products;

- the acquisition of skills in planning, organizing and conducting research in the field of biotechnology, using modern methods of research and data processing;

- the formation of basic knowledge, skills and abilities for the successful (including independent) development of various methods of researching the quality and safety of raw materials and food biotechnology products.

To successfully study the discipline «Design and organization of production of agri-food biotechnology» the following preliminary competencies should be formed in students:

- the ability to use modern methods and technologies (including information) in professional activities;

- the ability to search, store, process and analyze information from various sources and databases, present it in the required format using information, computer and network technologies.

As a result of studying this discipline, the following general cultural, general professional, professional competencies (elements of competencies) are formed in students.

Code and wording of competency	**Competency Stages**	
GC-11 with the ability to professional growth, to self-study new research methods, to change the scientific and scientific-industrial profile of their professional activities	Knows	methodological theories and principles of modern science; research methodology
	Is able	develop research and development plans; use scientific, reference and methodical literature
	Owns	ability to professional growth, to self-study new research methods, to change the scientific and scientific-production profile of their professional activities
GC-12 ability to use skills in practice in the organization of research and design work and in team management	Knows	methods of organizing research and design work
	Is able	use skills in team management
	Owns	ability in practice to use skills in organizing research and design work and in team management
GPC-1 with the ability to professionally use modern biotechnological equipment and scientific instruments	Knows	types of modern biotechnological equipment and scientific instruments
	Is able	professionally operate advanced equipment and scientific instruments
	Owns	skills of professional operation of modern biotechnological equipment and scientific instruments
GPC-4 readiness to use methods of mathematical modeling of materials and technological processes, readiness for theoretical analysis and experimental verification of theoretical hypotheses	Knows	basic methods of mathematical modeling of materials and technological processes
	Is able	use methods of mathematical modeling of materials and technological processes; carry out theoretical analysis and experimental verification of theoretical hypotheses
	Owns	skills of using methods of mathematical modeling of materials and technological processes; ability to theoretical analysis and experimental verification of theoretical hypotheses
SPC-3 with the ability to present the results of the work performed in the form of scientific and	Knows	intellectual property requirements
	Is able	to present the results of work in the form of scientific and technical reports, reviews, scientific reports and publications

technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for the protection of intellectual property	Owns	skills to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for the protection of intellectual property

To form the above competencies within the framework of the discipline «Research methods in biotechnology» the following methods of active / interactive training are used: lectures, press conferences, seminar and press conferences.

I. STRUCTURE AND CONTENT OF THE THEORETICAL PART OF THE COURSE

Section I. Theoretical Foundations of Instrumental Analysis Methods

Topic 1. Instrumental methods of research and analysis of the properties of food products

The quality of food products and methods of its control. Properties, quality indicators of food products. General and physico-chemical properties of food products. Classification of instrumental methods of research and analysis of the properties of food products. Current trends in the development of instrumental methods of analysis.

Section II. Electrochemical analysis methods

Topic 1. Potentiometry

The essence of the potentiometric analysis method. Classification, characterization and selection of electrodes used in potentiometry. Ionometry Potentiometric titration. Instruments in potentiometry. Advantages of the method and its use in the food industry.

Topic 2. Conductometry

The essence of the conductometric analysis method. Direct and indirect conductometry. Types of conductometric titration curves. High frequency conductometry. Instruments in conductometry. Advantages of the method and its application in the food industry.

Theme 3. Voltammetry

The essence of voltammetry. Classification of voltammetric methods of analysis. Polarogram: characteristics, registration conditions, qualitative and quantitative characteristics. Direct voltammetry. Amperometric titration. Inversion voltammetry. Equipment for voltammetric analysis. Advantages of the method and its application in the food industry.

Topic 4. Coulometry

The essence of the coulometric analysis method. Direct coulometry. Coulometric titration. The equipment in coulometry. Advantages of the method and its application for food analysis.

Section III. Optical analysis methods

Topic 1. Refractometric analysis method

Classification of optical analysis methods. Methods based on polarization phenomena. The essence of the method of refractometry. The influence of factors on the value of the refractive index. Qualitative and quantitative refractometric analysis method. Equipment for refractometric measurements. Application of the method for food analysis.

Topic 2. Molecular spectral analysis (2 hours.)

Spectral methods based on the absorption, scattering or emission of electromagnetic radiation. Molecular spectral analysis. Origin, types, registration and decoding of optical spectra. Spectroscopy in the visible and UV regions. Selection of optimal analysis conditions. Quantitative analysis in the UV and visible spectral range. Instruments in the UV and visible spectral range. The use of spectral methods for food analysis.

Topic 3. Luminescent analysis method (2 hours)

Physical basis of the method. The main characteristics of luminescence. Factors affecting the intensity of the method. Qualitative and quantitative fluorescence analysis. Equipment for luminescent analysis. The use of fluorimetry for food analysis.

Section IV Chromatographic analysis methods (2 hours)

Topic 1. Gas and plane chromatography (2 hours.)

Methods of masking, separation and concentration. Theoretical foundations of chromatographic processes. Classification of chromatographic separation methods. Mobile and motionless phases. Qualitative and quantitative analysis. Equipment for gas chromatography. Application of the method for food analysis. Paper and thin layer chromatography. Recent advances in the application of chromatographic analysis methods. Application of TLC in the examination of food products.

II. STRUCTURE AND CONTENT OF THE PRACTICAL PART OF THE COURSE

Practical lessons
(36 hours., Including in the form of active training 18 hours.)

Lesson 1. Electrochemical methods of analysis (8 hours.)

Make calculations according to the received option.

Variant № 1

1. The potentials of the cadmium selective electrode, measured relative to the silver chloride electrode, in standard CdSO4 solutions with different concentrations of Cd2 + were:

$C(Cd^{2+})$, mol/dm^3	$1{,}0\cdot10^{-1}$	$1{,}0\cdot10^{-2}$	$1{,}0\cdot10^{-3}$	$1{,}0\cdot10^{-4}$	$1{,}0\cdot10^{-5}$
-E, mV	75,0	100	122	146	170

Based on these data, a calibration graph was constructed in the coordinates E = f (pCCd2 +).

The test solution of cadmium with a volume of 10.00 cm3 was diluted with water to 50.00 cm3 in a volumetric flask. The potential of the cadmium selective electrode in the resulting solution is 116 mV. Determine the concentration of the test solution of cadmium salt (in mol / dm3).

2. The analyzed solution was diluted in a 100.0 cm3 volumetric flask and an aliquot of 20.00 cm3 was titrated potentiometrically with 0.1000 mol / dm3 NaOH. Determine the mass of HCl (in mg) from the integral and differential titration curves, if the following results are obtained:

$V(NaOH)$, cm^3	1,50	1,80	1,90	1,95	1,98	2,00	2,02	2,05	2,10
pH	2,64	3,05	3,36	3,64	4,05	6,98	9,95	10,53	10,65

3. A mixture of HCl and CH3COOH was titrated with a solution of 0.2000 mol / dm3 NaOH. plot the conductometric titration curve and calculate the amount of acid in the analyzed solution.

$V(NaOH)$, $см^3$	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00
L, См	24,0	21,0	17,8	15,0	14,0	14,2	14,3	14,5	18,7	22,6	26,5

4. Calculate the content of Cu2 + (in mg / dm3) in canned apple juice if, in the analysis of 20.00 cm3, its height of the polarographic wave of copper was 15.5 mm, and after adding 1.00 cm3 of a standard solution of copper with a concentration of 0.0010 mol / dm3 increased to 29.0 mm.

5. Determine the concentration of zinc (in µg / cm3) in the test solution if, by amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6]) = 0,000325 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, $см^3$	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, µA	75,0	75,0	75,0	75,0	120	165	210	255	300

Variant № 2

1. Determine the potassium content in mineral water (in mol / dm3) if the electrode potential in the test solution is 10 mV, and for a standard potassium solution with a concentration of 0.0100 mol / dm3 is 46.0 mV.

2. To determine the titratable acidity, 15.00 cm3 of tomato juice was titrated with NaOH at a concentration of 0.09400 mol / dm3. Using the integral and differential titration curves, calculate the acidity of the juice in degrees Turner

(degrees Turner shows the volume of 0.1000 M NaOH spent on titration of 100 cm3 of food product).

V(NaOH), см^3	0	2,00	4,00	6,00	8,00	10,00	10,50	11,00	12,00	13,00
pH	5,05	5,56	5,88	6,19	6,92	8,82	10,56	11,29	11,58	11,90

3. Calculate the concentration of nitric acid and phenol in (g / cm3) if conductometric titration of 50.00 cm3 of their mixture with a KOH solution with a concentration of 0.5000 mol / dm3 yields the following results:

V(KOH), см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,0	11,0	12,0
L, См	19,0	17,0	15,0	13,2	12,5	12,6	12,7	12,8	13,0	14,0	15,0	16,5

4. To construct a calibration graph, polarograms of standard Cu2 + solutions were recorded and the wave height was measured:

C_{Cu}, мг/см^3	0,50	1,00	1,50	2,00
h_x, мм	9,0	17,5	26,2	35

A sample of brass 0.1000 g was dissolved and diluted to 50.00 cm3. Calculate the mass fraction of copper in the sample if the wave height at the polarogram is 18 mm.

5. Determine the mass of cadmium (in mg) in the test solution, if upon amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6]) = 0.002440 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, μA	30,0	29,0	31,0	32,0	32,0	60,0	137	210	300

Variant № 3

1. When determining Fe (III) by potentiometric method, it was found that the potential of the indicator electrode of standard solutions of Fe (NO3) 3 is equal to:

CFe(III), mol/dm^3	$1,0\cdot10^{-4}$	$5,0\cdot10^{-4}$	$1,0\cdot10^{-3}$	$5,0\cdot10^{-3}$
E, mV	290	278	272	260

Based on these data, a calibration graph was constructed in the coordinates E = f (pCFe3 +).

Determine the iron content in beer (in mg / dm3) if the electrode potential of 25.00 cm3 of the test product diluted to 50.00 cm3 with a background electrolyte solution was 275 mV.

2. A weighed portion of a silver alloy weighing 2.1570 g was dissolved and after appropriate treatment the volume of the solution was adjusted to 100.0 cm3 and 25.00 cm3 of the solution was titrated with 0.1250 mol / dm3 NaCl. Determine the mass fraction of Ag (in%) from the integral and differential titration curves, if the following results are obtained:

V(NaCl), см^3	16,00	18,00	19,00	19,50	19,90	20,00	20,10	20,50	21,00
E, mV	689	670	652	634	594	518	440	401	383

3. When conductometric titration of 50.00 cm3 of a mixture of NaOH and NH4OH with a HCl solution with a concentration of 0.1000 mol / dm3 the following data were obtained:

V(HCl), см^3	0	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
L, См	6,30	5,41	4,52	3,62	3,71	4,79	5,85	6,93	9,00	12,08	15,13

Calculate the amount of NaOH and NH4OH in the test solution.

4. When polarographing a saturated solution of Pb (SCN) 2, the height of the polarographic wave was 15.0 mm The standard solution of lead acetate with SEC = 0.0500 mol / dm3 had a height of 21.9 mm. Calculate the solubility product of lead thiocyanate.

5. Determine the mass of zinc contained in 1 dm3 of the test solution, if during amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6] / Zn) = 0.001820 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	60,0	60,0	60,0	61,0	61,0	120	176	230	285

Variant № 4

1. The potential of the nitrate selective electrode measured relative to the silver chloride electrode in standard KNO3 solutions is:

$C(NO_3^-)$, mol/dm^3	$5{,}0\cdot10^{-5}$	$1{,}0\cdot10^{-4}$	$5{,}0\cdot10^{-4}$
E, mV	325	289	207

Based on these data, a calibration graph was constructed in the coordinates E = f (p SK +).

Determine the NO3-content in water (in mmol / dm3) if the electrode potential of the test water is 260 mV.

2. To determine the content of Ca2 + 50.00 cm3 of milk, it was titrated with a solution of complexone III with SEC = 0.0930 mol / dm3. Determine the calcium content (in mg / dm3) from the integral and differential titration curves, if the following results are obtained:

V(ЭДТА), см^3	0	5,00	10,00	15,00	17,00	18,00	19,00	20,00	21,00	24,00
E, mV	260	276	288	312	320	440	450	455	460	463

3. Calculate the mass of nitric acid and ammonium nitrate (in mg) if, using conductometric titration of 10.00 cm3 of their mixture with a KOH solution with a concentration of 0.2500 mol / dm3, the following results were obtained:

V(KOH),см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00
L, См	21,0	18,0	15,0	12,3	11,5	11,3	11,4	11,5	11,6	12,6	14,8	18,2

4. When analyzing the alloy for cadmium content, a 3.5080 g sample was dissolved in an acid mixture and the solution was diluted to 250.0 cm3. When analyzing 20.00 cm3 of the resulting solution, the height of the cadmium polarographic wave was 16.5 mm, and after adding 5.00 cm3 of a standard solution of CdSO4 with a concentration of 0.0300 mol / dm3 it increased to 21.5 mm (other components in the alloy in these conditions do not interfere with the definition). Calculate the mass fraction of Cd2 + (in%) in the alloy.

5. Determine the lead content (in mol / dm3) in the test solution if, by amperometric titration of 10.00 cm3 of this solution with K2Cr2O7 solution with a lead titer of 0.006401 g / cm3, the following results were obtained:

$V(K_2Cr_2O_7)$, см^3	0	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	215	160	113	60	20	19	19

Variant № 5

1. The potential of the cadmium selective electrode, measured relative to the silver chloride electrode, in a standard CdSO4 solution with a concentration of Cd2 + 1.0 · 10-4 mol / dm3 was -146 mV. The test solution of cadmium with a volume of 10.00 cm3 was diluted with water to 50.00 cm3 in a volumetric flask. The potential of the cadmium selective electrode in the resulting solution is - 94.0 mV. Determine the concentration of the test solution of cadmium salt (in mol / dm3).

2. A weight of 0.1200 g of steel was dissolved, the iron was transferred to Fe (II) and titrated potentiometrically with 0.1000 mol / dm3 Ce (SO4) 2. Determine the mass fraction of Fe (in%) from the integral and differential titration curves, if the following results are obtained:

$V(Ce(SO_4)_2)$, $см^3$	2,00	10,00	18,00	19,80	20,00	20,20	22,00
E, mV	712	771	830	889	1110	1330	1390

3. When conductometric titration of 50.00 cm3 of a mixture of NaOH and NH4OH with a HCl solution with a concentration of 0.1000 mol / dm3 the following data were obtained:

V(HCl), $см^3$	0	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
L, См	5,68	4,46	3,20	2,40	3,00	3,84	4,68	5,50	7,00	10,80	14,55

Calculate the concentration of NaOH and NH4OH in the test solution (in g / dm3).

4. When polarographic standard solutions of lead (II) were obtained, the following results were obtained:

C_{Pb}, мкг/$см^3$	0,50	1,00	1,50	2,00
h_x, мм	4,0	8,0	12,0	16,0

A portion of an aluminum alloy weighing 0.0250 g was dissolved and diluted to 100.00 cm3. Calculate the mass fraction of lead in the sample if the wave height for the resulting solution in the polarogram is 6.0 mm.

5. Determine the amount of copper (II) in 200.0 cm3 of the test solution, if during amperometric titration of 50.00 cm3 of this solution with EDTA solution with Seq = 0.0100 mol / dm3 the following results were obtained:

V(ЭДТА), $см^3$	0	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	22,5	16,0	10,0	3,75	0,50	0,50	0,50

Variant № 6

1. Potentials of the potassium selective electrode, measured relative to the silver chloride electrode in standard solutions of potassium salt with various concentrations of K +, were:

$C(K^+)$, mol/dm^3	$1{,}0\cdot10^{-1}$	$1{,}0\cdot10^{-2}$	$1{,}0\cdot10^{-3}$	$1{,}0\cdot10^{-4}$	$1{,}0\cdot10^{-5}$
E, mV	100	46,0	-7,00	-60,0	-113,5

Based on these data, a calibration graph was constructed in the coordinates E = f (pC (K +)).

A sample of a sample weighing 0.2000 g containing potassium was dissolved in water, the volume of the solution was brought to 250.0 cm3. Determine the mass fraction of potassium if the electrode potential of the test solution was 34.0 mV.

2. A portion of the copper alloy was dissolved, the volume was adjusted to 250.0 cm3, and 20.00 cm3 of the prepared solution was titrated potentiometrically with sodium thiosulfate solution with a copper titer of 0.01664 g / cm3. Determine the mass of Cu from the integral and differential titration curves if the following results are obtained:

$V(Na_2S_2O_4)$, см^3	1,50	1,90	2,00	2,05	2,08	2,10	2,12	2,15	2,20
E, mV	475	445	424	405	382	305	232	186	162

3. Calculate the amount of NaOH and CH3COONa, if during conductometric titration of their mixture with HCl solution with a concentration of 0.1000 mol / dm3 the following results were obtained:

V(HCl), см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,0	11,0	12,0	13,0
L, См	13,5	10,1	6,2	3,1	2,1	2,2	2,2	2,3	3,0	4,2	5,4	6,6	8,0

4. When polarizing 15.00 cm3 of a zinc salt solution, the wave height was 29.5 mm. After adding a standard zinc solution with a concentration of 0.0150 mol / dm3 to the same volume of 1.00 cm3, the wave height increased to 41.5 mm. Calculate the concentration of zinc (in mg / cm3) in the test solution.

5. Determine the mass fraction of iron impurity in nickel (in%) if, after dissolving a sample weighing 1.5000 g and transferring all the iron to Fe (II), by amperometric titration of this solution with a solution of potassium permanganate with a titer of iron equal to 0.005585 g / cm3 the following results were obtained:

$V(KMnO_4)$, см^3	0	0,50	1,00	1,50	2,00	2,50	3,00	3,50	4,00
I_d, мкА	5	5	5	5,5	7	9,8	11,9	15,2	18,3

Variant №7

1. To determine the iron (III) ions in the analyzed solution of direct potentiometry, standard solutions of Fe (NO3) 3 were prepared and the potential of the indicator electrode in each of them was measured:

$C(Fe^{3+})$, mol/dm^3	$1{,}0 \cdot 10^{-4}$	$5{,}0 \cdot 10^{-4}$	$1{,}0 \cdot 10^{-3}$	$5{,}0 \cdot 10^{-3}$
E, mV	290	278	272	260

Based on these data, a calibration graph was constructed in the coordinates E = f (pC (Fe3 +)). The test beverage with a volume of 10.00 cm3 was diluted with water to 50.00 cm3 in a volumetric flask. The potential of the indicator electrode in the resulting solution is 275 mV. Determine the amount of iron ions in the drink.

2. Construct the integral and differential potentiometric titration curves to determine the concentration of the CH3COOH solution (g / cm3) if, when titrating 10.00 ml of this acid KOH with a concentration of 0.1000 mol / dm3, the following results were obtained:

V(KOH), мл	15,00	18,00	19,00	19,50	19,90	20,00	20,10	20,50	21,00
pH	5,22	5,71	6,04	6,35	7,05	8,79	10,52	11,22	11,51

3. 50 cm3 of a solution containing chloride ions were titrated with an AgNO3 solution with a molar concentration of 0.2824 mol / dm3. Calculate the mass of chloride ions in solution according to conductometric titration:

$V(AgNO_3)$,см^3	1	2	3	4	5	6	7	8	9	10
L, мСм	6,1	5,9	6,0	5,9	5,8	6,2	7,6	9,1	10,5	12,1

4. To determine the copper content by voltammetry, a sample of food product 20.0087 g was taken, which, after ashing and dissolving the ash, was transferred to a volumetric flask with a capacity of 50.00 cm3. For polarography, 20.00 cm3 of this solution were taken; the wave height was 24 mm. When polarizing the same volume of a standard copper solution containing 0.16 mg in 1 cm3, a polarographic wave with a height of 20 mm was obtained. Calculate the mass fraction of copper in the analyzed sample.

5. Determine the molar concentration of cadmium in the test solution, if amperometric titration of 20.00 cm3 with K4 [Fe (CN) 6] solution with a titer of 0.001010 g / cm3 yields the following results:

$V(K_4[Fe(CN)_6])$, см^3	0	0,50	1,00	1,50	2,00	2,50
I_d, мкА	30	30	31	32	120	240

Variant №8

1. The potential of the cadmium selective electrode, measured relative to the silver chloride electrode, in a standard CdSO4 solution with a concentration of Cd2 + 1.0 · 10-2 mol / dm3 was -100 mV. The test solution of cadmium with a volume of 5.00 cm3 was diluted with water to 100.00 cm3 in a volumetric flask. The potential of the cadmium selective electrode in the resulting solution is - 88.0 mV. Determine the concentration of the test solution of cadmium salt (in mol / dm3).

2. Construct the integral and differential potentiometric titration curves and determine the concentration of the HCl solution (mg / cm3) if, when titrating 10.00 cm3 of this acid with a NaOH solution with C = 0.1000 mol / dm3, the following results were obtained:

V(NaOH), см^3	0,50	1,50	2,50	3,50	4,50	5,55	6,50	7,65	8,65
pH	5,22	5,71	6,04	6,35	7,05	8,79	10,52	11,22	11,51

3. With conductometric titration of 15.00 cm3 of acetic acid with a KOH solution, the following results were obtained:

V(KOH),см^3	1	2	3	4	5	6	7	8	9	10
L,См	33	38	41	46	50	54	50	44	38	34

Calculate the mass of acetic acid in 200 cm3 of solution if the molar concentration of potassium hydroxide is 0.1020 mol / dm3.

4. To construct a calibration graph, polarograms of standard Cd2 + solutions were recorded and the wave height was measured:

C_{Cd}, мкг/см^3	0,50	1,00	1,50	2,00
h_x, мм	11	20	32	41

A sample of steel 0.1000 g was dissolved and diluted to 250.0 cm3. Calculate the mass fraction of cadmium in the sample if the wave height at the polarogram is 18 mm.

5. Determine the amount of zinc in 1 dm3 of the test solution, if during amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6] / Zn) = 0.002440 g / cm3 The following results were obtained:

V($K_4[Fe(CN)_6]$), см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	60,0	60,0	60,0	61,0	61,0	120	176	230	285

Variant №9

1. The potential of a nitrite selective electrode measured relative to a silver chloride electrode in standard KNO2 solutions is:

$C(NO_2^-)$, mol/dm^3	$5{,}0\cdot10^{-4}$	$1{,}0\cdot10^{-3}$	$5{,}0\cdot10^{-2}$
E, mV	410	370	227

Based on these data, a calibration graph was constructed in the coordinates E = f (p SK +).

Determine the content of NO2-in water (in mmol / dm3) if the electrode potential of the test water is 260 mV.

2. To determine the content of Ca2 + 50.00 cm3 of milk, it was titrated with a solution of complexone III with SEC = 0.0930 mol / dm3. Determine the calcium content (in mg / dm3) from the integral and differential titration curves, if the following results are obtained:

V(ЭДТА), см^3	0	5,00	10,00	15,00	17,00	18,00	19,00	20,00	21,00	24,00
E, mV	260	276	288	312	320	440	450	455	460	463

3. Calculate the amount of nitric acid and ammonium nitrate in 150.0 cm3 of solution, if the conductometric titration of 10.00 cm3 of a mixture with a solution of KOH with a titer of hydrochloric acid equal to 0.000500 g / cm3 yields the following results:

V(KOH), см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00
L, См	21,0	18,0	15,0	12,3	11,5	11,3	11,4	11,5	11,8	12,6	14,8	18,2

4. When analyzing the alloy for cadmium content, a 2.5000 g sample was dissolved in an acid mixture and the solution was diluted to 250.0 cm3. When analyzing 10.00 cm3 of the resulting solution, the height of the cadmium polarographic wave was 16.5 mm, and after adding 5.00 cm3 of a standard CdSO4 solution with a concentration of 0.0300 mol / dm3 it increased to 21.5 mm (other alloy components under these conditions do not interfere with the definition). Calculate the mass fraction of Cd2 + (in%) in the alloy.

5. Determine the cobalt content (in mg / dm3) in the test solution if, by amperometric titration of 10.00 cm3 of this solution with K4 [Fe (CN) 6] solution with a concentration of 0.0641 mol / dm3, the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	215	160	113	60	20	19	19

Variant 10

1. The potential of a nitrite selective electrode measured relative to a silver chloride electrode in a standard solution containing 1.0 · 10-3 mol / dm3 KNO2 is equal to 375 mV. Determine the amount of NO2- in the water if the electrode potential of the test water is 385 mV.

2. Build the integral and differential titration curves and determine the titer of the HCl solution if, when titrating 10.00 ml of this acid with KOH with a titer of 0.000178 g / cm3, the following results were obtained:

V(KOH), $см^3$	15,00	18,00	19,00	19,50	19,90	20,00	20,10	20,50	21,00
pH	5,22	5,71	6,04	6,35	7,05	8,79	10,52	11,22	11,51

3. When titrating barium chloride with sulfuric acid with a molar concentration of 0.0100 mol / dm3 with high-frequency titration, the following results were obtained:

V(H_2SO_4), $см^3$	2	4	6	8	10	12	14	16
I, мкА	62	55	43	30	19,2	28	37	45

Determine the mass of barium chloride in solution.

4. Calculate the content of Cu2 + (in mmol / dm3) in canned apple juice if, in the analysis of 20.00 cm3, its height of the polarographic wave of copper was 19.2 mm, and after adding 1.00 cm3 of a standard solution of copper with a concentration of 0.0010 mol / dm3 increased to 31.0 mm.

5. Determine the amount of copper (II) in the test solution, if during amperometric titration of this solution with an EDTA solution with SEC = 0.0100 mol / dm3 the following results were obtained:

V(ЭДТА), $см^3$	0	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	22,5	16,0	10,0	3,75	0,50	0,50	0,50

Variant № 11

1. The potential of the indicator electrode, measured relative to the silver chloride electrode, in a standard solution of Fe (NO3) 3 with a concentration of 1.0 · 10-3 was 272 mV. Determine the concentration of the test solution of iron (III) (in mol / dm3) if the potential of the indicator electrode for this solution is 278 mV.

2. The analyzed H2SO4 solution was diluted in a volumetric flask to 100.00 cm3 and an aliquot of 20.00 cm3 was titrated potentiometrically with a NaOH solution with C = 0.1000 mol / dm3.

Build the integral and differential titration curves and determine the mass of H2SO4 in solution (mg) from the following data:

V(NaOH),см^3	1,50	1,80	1,90	1,95	1,98	2,00	2,02	2,05	2,10
pH	2,64	3,05	3,36	3,64	4,05	6,98	9,95	10,53	10,65

3. The analyzed mixture of HCl and CH3COOH was placed in a volumetric flask with a capacity of 50.00 cm3 and brought to the mark with water. When titrating 10.00 cm3 of a NaOH solution with a titer of 0.000400 g / cm3, the following results were obtained:

V(NaOH),см^3	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00	15,00	16,00
χ,См	2,66	2,39	2,12	2,02	2,03	2,04	2,06	2,38	2,74	3,10

Build a titration curve and determine the amount of HCl and CH3COOH in the initial solution.

4. When polarographic standard solutions of lead (II) were obtained, the following results were obtained:

C_{Pb}, мкг/см^3	0,50	1,00	1,50	2,00
h_x, мм	4,0	8,0	12,0	16,0

A sample of an alloy weighing 1.5000 g was dissolved and diluted to 250.00 cm3. Calculate the mass fraction of lead in the sample if the wave height for the resulting solution in the polarogram is 6.0 mm.

5. Determine the concentration of zinc (in mg / dm3) in the test solution if, by amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6] / Zn) = 0 , 002440 g / cm3 the following results were obtained:

V($K_4[Fe(CN)_6]$), см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	30,0	29,0	31,0	32,0	32,0	60,0	137	220	300

Variant № 12

1. When determining Fe (III) by potentiometric method, it was found that the potential of the indicator electrode of standard solutions of Fe (NO3) 3 is equal to:

$C(Fe(III))$, mol/dm^3	$1{,}0\cdot10^{-4}$	$5{,}0\cdot10^{-4}$	$1{,}0\cdot10^{-3}$	$5{,}0\cdot10^{-3}$
E, mV	290	278	272	260

Based on these data, a calibration graph was constructed in the coordinates E = f (pCFe3 +).

Determine the iron content in beer (in mg / dm3) if the electrode potential of 25.00 cm3 of the test product diluted to 50.00 cm3 with a background electrolyte solution was 268 mV.

2. To determine the titratable acidity, 50.00 cm3 of apple juice was titrated with NaOH at a concentration of 0.0980 mol / dm3. Using the integral and differential titration curves, calculate the acidity of the juice in degrees Turner (degrees Turner shows the volume of 0.1000 M NaOH spent on titration of 100 cm3 of food product).

V(NaOH), см^3	0	2,00	4,00	6,00	8,00	10,00	10,50	11,00	12,00	13,00
pH	2,69	3,60	4,00	4,50	5,00	5,90	7,00	11,50	11,80	12,00

3. When conductometric titration of 50.00 cm3 of a mixture of NaOH and NH4OH with a HCl solution with a concentration of 0.1000 mol / dm3 the following data were obtained:

V(HCl), см^3	0	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
L, См	6,60	5,98	5,30	4,68	4,05	-	4,45	5,70	7,80	12,02	16,20

Calculate the concentration of NaOH and NH4OH in the test solution (in g / dm3).

4. When analyzing the alloy for cadmium content, a 3.5080 g sample was dissolved in an acid mixture and the solution was diluted to 250.0 cm3. When analyzing 20.00 cm3 of the resulting solution, the height of the cadmium polarographic wave was 12.3 mm, and after adding 5.00 cm3 of a standard CdSO4 solution with a concentration of 0.0300 mol / dm3 it increased to 18.6 mm (other

components in the alloy in these conditions do not interfere with the definition). Calculate the mass fraction of Cd2 + (in%) in the alloy.

5. Determine the concentration of zinc (in mg / dm3) in the test solution if, by amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6] / Zn) = 0 , 002440 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,20	0,40	0,50	1,00	1,50	2,00
I_d, мкА	20,0	20,0	31,0	40,0	94,0	146	200

Variant № 13

1. The potentials of the cadmium selective electrode, measured relative to the silver chloride electrode, in standard CdSO4 solutions with different concentrations of Cd2 + were:

$C(Cd^{2+})$, mol/dm^3	$1,0 \cdot 10^{-1}$	$1,0 \cdot 10^{-2}$	$1,0 \cdot 10^{-3}$	$1,0 \cdot 10^{-4}$	$1,0 \cdot 10^{-5}$
-E, mV	75,0	100	122	146	170

Based on these data, a calibration graph was constructed in the coordinates E = f (pCCd2 +).

The test solution of cadmium with a volume of 10.00 cm3 was diluted with water to 100.00 cm3 in a volumetric flask. The potential of the cadmium selective electrode in the resulting solution is 161 mV. Determine the concentration of the test solution of cadmium salt (in mg / dm3).

2. The analyzed solution was diluted in a volumetric flask with 250.0 cm3 and an aliquot of 15.00 cm3 was titrated potentiometrically with 0.1200 mol / dm3 NaOH. Determine the mass of HCl (in mg) from the integral and differential titration curves, if the following results are obtained:

V(NaOH), см^3	1,50	1,80	1,90	1,95	1,98	2,00	2,02	2,05	2,10
pH	2,64	3,05	3,36	3,64	4,05	6,98	9,95	10,53	10,65

3. A mixture of HCl and CH3COOH was titrated with a solution of 0.2500 mol / dm3 NaOH. plot the conductometric titration curve and calculate the amount of acids (in mmol) in the analyzed solution.

V(NaOH), см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00

L, См	24,0	21,0	17,8	15,0	14,0	14,2	14,3	14,5	18,7	22,6	26,5

4. Calculate the content of Cu2 + (in mg / dm3) in canned apple juice if, in the analysis of 20.00 cm3, its height of the polarographic wave of copper was 16.5 mm, and after adding 2.00 cm3 of a standard solution of copper with a concentration of 0.0010 mol / dm3 increased to 29.0 mm.

5. Determine the concentration of zinc (in mg / cm3) in the test solution, if during amperometric titration of 50.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6 / Zn]) = 0 , 000325 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	75,0	75,0	75,0	75,0	120	165	210	255	300

Variant № 14

1. Determine the potassium content in mineral water (in mol / dm3) if the electrode potential in the test solution is 40 mV, and for a standard potassium solution with a concentration of 0.0120 mol / dm3 is 46.0 mV.

2. To determine the titratable acidity, 15.00 cm3 of apricot juice was titrated with NaOH at a concentration of 0.09400 mol / dm3. Using the integral and differential titration curves, calculate the acidity of the juice (in g / dm3 in terms of malic acid).

V(NaOH), см^3	0	2,00	4,00	6,00	8,00	10,00	10,50	11,00	12,00	13,00
pH	5,05	5,56	5,88	6,19	6,92	8,82	10,56	11,29	11,58	11,90

3. Calculate the concentration of nitric acid and phenol in (mg / cm3), if conductometric titration of 20.00 cm3 of their mixture with a KOH solution with a concentration of 0.4700 mol / dm3 yields the following results:

V(KOH), см^3	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,0	11,0	12,0
L, См	19,0	17,0	15,0	13,2	12,5	12,6	12,7	12,8	13,0	14,0	15,0	16,5

4. To construct a calibration graph, polarograms of standard Cu2 + solutions were recorded and the wave height was measured:

C_{Cu}, мг/см^3	0,50	1,00	1,50	2,00
h_x, мм	9,0	17,5	26,2	35

A sample of brass 0.1000 g was dissolved and diluted to 50.00 cm3. Calculate the mass fraction of copper in the sample if the wave height at the polarogram is 27 mm.

5. Determine the mass of cadmium (in mg) in the test solution, if during amperometric titration of 10.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6 / Cd]) = 0.002440 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, см^3	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	30,0	29,0	31,0	32,0	32,0	60,0	137	210	300

Variant № 15

1. When determining Fe (III) by potentiometric method, it was found that the potential of the indicator electrode of standard solutions of Fe (NO3) 3 is equal to:

C(Fe(III)), mol/dm^3	$1{,}0\cdot10^{-4}$	$5{,}0\cdot10^{-4}$	$1{,}0\cdot10^{-3}$	$5{,}0\cdot10^{-3}$
E, mV	290	278	272	260

Based on these data, a calibration graph was constructed in the coordinates E = f (pCFe3 +).

Determine the iron content in beer (in mg / dm3) if the electrode potential of 15.00 cm3 of the test product diluted to 50.00 cm3 with a background electrolyte solution was 265 mV.

2. A weighed portion of a silver alloy weighing 2.1570 g was dissolved and after appropriate treatment the volume of the solution was adjusted to 100.0 cm3 and 25.00 cm3 of the solution was titrated with 0.1500 mol / dm3 NaCl. Determine the mass fraction of Ag (in%) from the integral and differential titration curves, if the following results are obtained:

V(NaCl), см^3	16,00	18,00	19,00	19,50	19,90	20,00	20,10	20,50	21,00
E, mV	689	670	652	634	594	518	440	401	383

3. When conductometric titration of 50.00 cm3 of a mixture of NaOH and NH4OH with a HCl solution with a concentration of 0.1000 mol / dm3 the following data were obtained:

V(HCl), $см^3$	0	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
L, См	6,30	5,41	4,52	3,62	3,71	4,79	5,85	6,93	9,00	12,08	15,13

Calculate the content of NaOH and NH4OH (in mg / cm3) in the test solution.

4. To determine the lead impurity, a weighed portion of the alloy weighing 0.2510 g was dissolved in 250.0 cm3 of nitric acid. When polarizing 10.00 cm3 of the resulting solution, the height of the polarographic wave was 15.0 mm. The standard solution of lead nitrate with SEC = 0.0500 mol / dm3 had a height of 21.9 mm. Calculate the mass fraction of lead in the alloy.

5. Determine the mass of zinc contained in 500.0 cm3 of the test solution, if during amperometric titration of 25.00 cm3 of this solution with a solution of K4 [Fe (CN) 6] with T (K4 [Fe (CN) 6] / Zn) = 0 , 001820 g / cm3 the following results were obtained:

$V(K_4[Fe(CN)_6])$, $см^3$	0	0,20	0,40	0,50	1,00	1,50	2,00	2,50	3,00
I_d, мкА	60,0	60,0	60,0	61,0	61,0	120	176	230	285

Lesson 2. Optical methods of analysis (8 hours.)

Complete the task according to the variant.

Variant №1

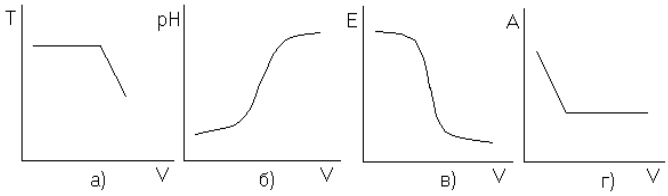
1. The refractive index of which solution cuts off the calibration graph in refractometry along the ordinate?

2. Write the equation of the Bouguer-Lambert-Beer law. What do the quantities included in it mean?

3. Determine the alcohol content in industrial alcohol if the refractive index of industrial alcohol is 1.4005 and the refractive indices of standard alcohol solutions are given in the table.

ω alcohol, %	10,0	20,0	30,0	40,0	50,0
n	1,3502	1,3745	1,3932	1,4122	1,4310

4. Select titration curves corresponding to the photocolorimetric analysis method. Explain how to determine the value of the equivalent volume, name the device.



5. The concentration of potassium sulfate solution, C (K2SO4) ~ 1 • 10–7 mol / dm3, is determined by the method of photocolorimetry, the detection limit of which is 1 • 10–6 mol / dm3. Is the analysis method correct?

Variant №2

1. Give examples of the use of refractometry in the food industry.

2. Draw a graph of the optical density versus wavelength. What is it used for?

3. In the photometric determination of the cadmium content in water with crystalline violet extraction, the concentration of cadmium in the sample was increased by a factor of 105. What is the molar concentration of cadmium in the source water equal if the optical density measured in a cuvette with a layer thickness of 2 cm3 is 0.45?

4. Draw the photocolorimetric titration curve of the FeSO4 solution with KMnO4 solution. Write a chemical equation. Show how the equivalent volume is found from the titration curve, write down the calculation formula for determining the mass of FeSO4 in the analyzed solution.

5. The molar concentration of the copper solution is 1 • 10–8 mol / dm3. Which analysis method, luminescence or photocolorimetry, should be selected if the detection limits of these analysis methods are 1 • 10–9 mol / dm3 and 1 • 10–6 mol / dm3, respectively.

Variant № 3

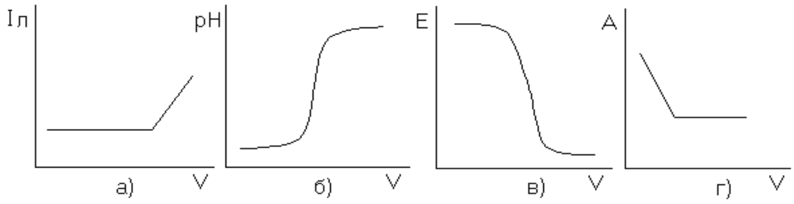
1. Describe the sequence for determining the concentration of sugar in refractometry using the calibration graph.

2. List the factors that affect the optical density of the solution. How do you choose the time after which you can meter the solution?

3. Calculate the molar concentration of the equivalent of potassium permanganate if, when titrating 10.00 cm3 of sodium oxalate, C (Na2C2O4) = 0.0050 mol / dm3, the following data are obtained:

$V(KMnO_4)$	0,0	1,0	2,0	2,5	3,0	3,5	4,0	5,0
T, %	100	100	100	99	98	74	60	30

4. Indicate the graph of the photocolorimetric titration curve. Which of the substances entering into the reaction has a color. What is the measured value and determine the equivalent volume



5. The detection limit of the photocolorimetry method is 1 • 10–6 mol / dm3. Is this method suitable for determining the concentration of lead ions, C (Pb2 +) = 1 • 10–9 mol / dm3?

Variant №4

1. What is the physical meaning of the absolute and relative refractive index? How are they connected? What refractive index is measured in practice?

2. Draw graphs of the dependence of optical density on the pH of the solution. Is this addiction used for practical purposes?

3. Calculate the mass of copper in 1 dm3 of the solution if the optical density of the standard and the analyzed solutions are 0.54 and 0.13, respectively, and the molar concentration of the standard solution is C (Cu2 +) = 1 • 10–4 mol / dm3.

4. Draw a photocolorimetric titration curve of the stained OM if it is known that the PB and PR are not colored. Show how the equivalent volume is found from the titration curve, write down the calculation formula for determining the mass fraction of OM in the analyzed solution.

5. Which method, photocolorimetry or amperometry, is suitable for determining the concentration of cobalt ions, C (Co2 +) = 1 • 10–7 mol / dm3, if

the detection limits of these methods are 1 • 10–6 mol / dm3 and 1 • 10– 8 mol / dm3, respectively?

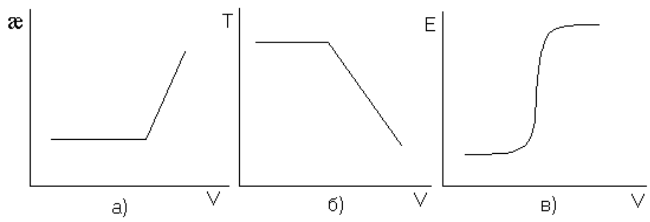
Variant №5

1. What factors and how does the refractive index depend?

2. What values are measured in photocolorimetry? How do they depend on the concentration of the solution?

3. To determine the mercury content in wastewater after adding dithizone, the optical density Ax = 41 was measured at λmax = 492 nm. Calculate the mercury content in mg / dm3 if the optical density of the standard mercury solution is 0.18 and Cst (Hg) = 1 • 10 –5 mol / dm3.

4. Indicate the graph of the photocolorimetric titration curve. What is the measured value and determine the equivalent volume?



5. What substances cannot be determined by luminescence:

Cu^{2+} - $5{\cdot}10^{-12}$; Mg^{2+} - $5{\cdot}10^{-2}$;

Zn^{2+} - $2{,}5{\cdot}10^{-15}$; Mo^{2+} - $3{\cdot}10^{-1}$;

Bi^{2+} - $\cdot10^{-9}$; Ag^{+} - $2{\cdot}10^{-4}$;

Variant № 6

1. What does the superscript and subscript show at the refractive index? Where is the refractometric analysis method used in the food industry?

2. Draw a plot of absorbance versus concentration. Is it used for practical purposes?

3. Determine the content of vitamin B12 in baby food in mg / kg, if the luminescence intensity of the sample is 0.18, and the luminescence intensity data for standard solutions containing vitamin B12 are shown in the table:

$C \cdot 10^{-2}$, мкг/кг	0,1	0,2	0,3	0,4	0,5
$I_л$	0,09	0,23	0,35	0,45	0,56

4. What kind of absorption curves do they have? What coordinates do they represent?

5. The detection limit of the photocolorimetry method is 1 • 10–6 mol / dm3, and the conductometry method is -1 • 10–4 mol / dm3. Which method should be used to determine the concentration of magnesium solution, C (Mg2 +) = 1 • 10–5 mol / dm3?

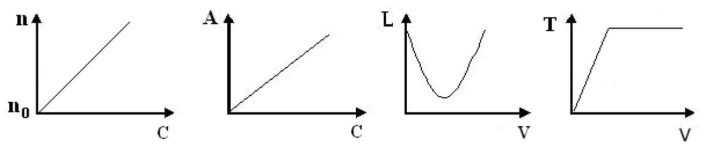
Variant №7

1. What factors and how affect the value of the refractive index?

2. What is the difference between the methods of ultraviolet spectroscopy (UFS), photocolorimetry and infrared spectroscopy (IR)? What do they have in common?

3. The lead content in the sample is 0.42 mg / dm3. With what layer thickness was the cuvette used if the optical density was 0.10 and the molar coefficient of light absorption was 104?

4. Which of the following dependencies corresponds to the refractometric analysis method? In the selected Variant, name the device, the quantity measured on it, its unit of measurement, the sensitivity of the methods. Show on the titration curves how the equivalent volume of the working solution is determined.



5. The concentration of potassium chromate solution, C (K2CrO4) = 1 • 10–8 mol / dm3, is determined using the photocolorimetry method, the detection limit of which is 1 • 10–7 mol / dm3. Is the analysis method correct?

Variant №8

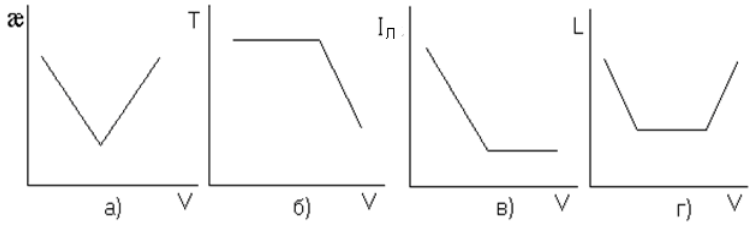
1. Draw a graph of the dependence of the refractive index on the wavelength of light. What is it called?

2. What is the essence of the luminescence method? What value is measured in this method?

3. Determine the mass fraction of sugar in the solution, if the refractive index of the sample is equal to 1.3751, and the refractive indices of standard sugar solutions are given in the table:

ω, %	5,00	10,00	15,00	20,00	25,00
n	1,3502	1,3744	1,3937	1,4122	1,4310

4. Select the graphs corresponding to the optical methods of analysis, name the measured value and the instrument.



5. The detection limit of the refractometry method is 1.00%. The mass fraction of which of the glycerol solutions can be determined precisely: a) ω = 0.01%; b) ω = 1.5%?

Variant №9

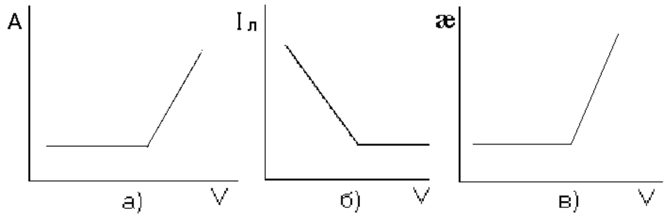
1. Draw a graph of the transition of a ray of light from air to solution. How is the refractive index calculated in this case?

2. What happens to the light intensity when it passes through a colored solution?

3. Calculate the concentration in mol / dm3 for chromium in the K2CrO4 solution if the optical density of the sample is 0.42, and the optical densities of standard chromium solutions are given in the table.

$C \cdot 10^3$, моль/дм^3	0,05	0,10	0,15	0,20	0,25	0,30
A	0,09	0,23	0,35	0,45	0,54	0,64

4. Indicate the graph of the photocolorimetric titration curve. What is he serving for?



5. The detection limit for luminescence and photocolorimetry methods is 1 • 10–9 mol / dm3 and 1 • 10–6 mol / dm3, respectively. What method should be used to determine the iron (II) content if C (Fe2 +) = 1 • 10–7 mol / dm3?

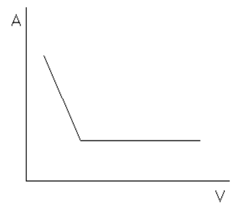
Variant № 10

1. Draw a graph of the dependence of the refractive index on the concentration. What is it called and what is it used for?

2. Give a mathematical expression for calculating the optical density and transmittance. What is their physical meaning?

3. Determine the iron (III) content in mg / cm3 if the optical density of the analyzed and standard solutions is 0.11 and 0.28, respectively, and the concentration of the standard solution is 1 • 10-4 g / dm3.

4. In what physicochemical method of analysis does the titration curve have the form shown in the figure? How the equivalent volume is determined from this graph



5. The concentration of ions in solution is presented in the table. Which of the listed ions can be determined by photocolorimetry, the sensitivity (detection limit) of which is 10-6 mol / dm3:

Ion	molar concentration of ion, mol / dm3
Cd^{2+}	$1 \cdot 10^{-9}$
Ba^{2+}	$1{,}5 \cdot 10^{-4}$
Ca^{2+}	$5 \cdot 10^{-2}$
Cl^{-}	$5 \cdot 10^{-5}$
SO_4^{2-}	$7 \cdot 10^{-6}$

Variant № 11

1. Using an example, explain how temperature affects the value of the refractive index.

2. Draw a block diagram of the photocolorimeter. Explain the purpose of the nodes.

3. Determination of calcium in solution was performed with murexide at a wavelength of 514 nm. Calculate the calcium content in mg / dm3 if the absorbance of 0.24 is measured in a cuvette with a layer thickness of 2 cm (ε = 14 • 103).

4. Draw a photocolorimetric titration curve for stained OL. Show how the equivalent volume is found from the titration curve, write down the calculation formula for determining the molar concentration of OM equivalents.

5. Is it possible to determine the concentration of sugar solution by refractometry, C (sah) = 0.01 mol / dm3, if the detection limit of the refractometry method is 0.05 mol / dm3?

Variant № 12

1. What is the phenomenon of refraction of a ray of light called during the transition from one transparent medium to another? Why is it happening?

2. Is the substance to be always colored during photocolorimetric titration? What will the titration curve look like if the reaction product is colored?

3. Calculate the magnesium content in the sample in mg / dm3 if the photometry was carried out with oxyquinoline in a cuvette with a layer thickness of 10 mm and an optical density of 0.54 (ε = 5.5 • 103).

4. Select a fluorescent titration curve. Determine the equivalent volume from it.

5. Mass fractions of ethanol solutions are respectively equal to: a) 5.0%; b) 0.1%; c) 10.0%. The ethanol content in which solution cannot be determined by refractometry, if the detection limit of this method is 1.00%?

Variant №13

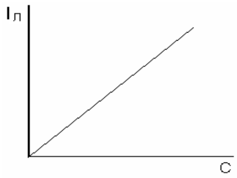
1. Draw a beam of light in a refractometer? What two mediums does a ray of light pass through?

2. Is it possible to use colorless solutions of analytes in direct photocolorimetry? Motivate the answer.

3. Determine the cobalt mass if, when titrating the sample with Trilon B (RV), SECV (EDTA) = 0.0050 mol / dm3, the following data were obtained in the presence of arsenazo:

V(PB),см^3	0,50	1,00	1,50	2,00	3,00	4,00	5,00	6,00	8,00
A	0,1	0,15	0,25	0,30	0,4	0,48	0,49	0,50	0,50

4. What physicochemical analysis method does the given graph correspond to? What is the measured value and what is it used for.



5. The detection limit of the photocologimetry method is 1 • 10–6 mol / dm3. Can this method be used to determine the concentration of calcium salt solution if C (Ca2 +) = 1 • 10–7 mol / dm3?

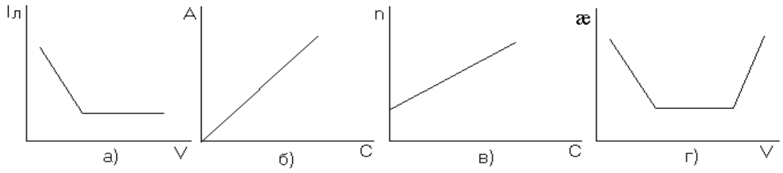
Variant № 14

1. What are the components of an optical refractometer circuit?

2. Is it possible in the process of photocolorimetric analysis to replace a cuvette with one solution layer thickness with a cuvette with another layer thickness? Why?

3. The analyzed zinc solution was successively diluted 1000 times. Then, the optical density (A = 0.15) was measured with dithizone in a cuvette with a layer thickness of 10 mm. Calculate the molar concentration of the initial zinc solution.

4. Indicate graphs corresponding to indirect methods of analysis. What method of analysis and measured value.



5. The detection limit of the photocolorimetry method is 1 • 10–6 mol / dm3. The concentration of which of the calcium solutions (a or b) can be determined by this method; if a) C (Ca2 +) = 1 • 10–5 mol / dm3; b) C (Ca2 +) = 1 • 10–8 mol / dm3?

*Variant №*15

1. List the factors that lead to an increase in the refractive index.

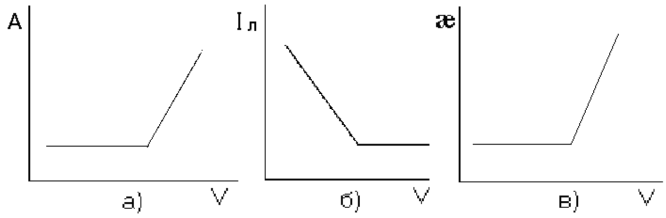
2. Formulate the Bouguer-Lambert-Beer law. Which of the quantities included in it depends on the wavelength of light and the nature of the substance?

3. For the photocolorimetric determination of aluminum in water with aluminone, a series of standard solutions was prepared, then the optical density of these solutions was measured, the data are presented below:

С, мг/дм^3	0,05	0,10	0,15	0,20	0,25	0,30
A	0,04	0,09	0,13	0,18	0,26	0,28

Determine the molar concentration of the aluminum solution if Ax = 0.15.

4. Indicate the graph of the photoelectric titration curve, determine the equivalent volume from it.



5. Which of the methods, photocolorimetry or refractometry, can determine the concentration of a sugar solution, C (sugar) = 1 • 10–5 mol / dm3, if the detection limits of the methods are 1 • 10-6 mol / dm3 and 0.05 mol / dm3, respectively ?

Lesson 3. Organoleptic methods of analysis (6 hours), using the method of active learning - seminar-press conference.

For each question of the plan of the seminar, a group of trainees (3-4 people) as experts is appointed by the teacher. They comprehensively study the problem and provide a rapporteur for the presentation of abstracts on it. After the first report, the seminar participants ask questions that are answered by the speaker and other members of the expert group. Questions and answers form the central part of the workshop. Based on questions and answers, a creative discussion unfolds, the results of which are first summed up by the speaker and then the teacher. Other issues of the seminar plan are discussed in a similar manner. In the final word, the teacher summarizes the discussion of the topic, evaluates the work of expert groups, defines the tasks of independent work.

Issues for discussion:

1. Characterization of organoleptic methods of analysis;
2. Advantages and disadvantages of the research method;
3. Preparation of tasters for analysis;
4. Ballroom assessment of the quality of finished products..

Lesson 4. "Chromatographic methods of analysis" (8 hours.)

Complete the task according to variant.

Variant № 1

1. What are the requirements for the mobile phase in gas and gas-liquid chromatography? What is her role?

2. Equate the ion exchange reaction between cation exchange resin and FeSO4. Convert anion exchange resin to NO3 - form.

3. The chromatograms of standard substances (isobutane, tR = 52 mm; benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 52 mm, h (A) = 40 mm; tR (B) = 15 mm, h (B) = 18

mm). Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. When identifying amino acids in a concentrate from a protein hydrolyzate, the solvent front moved 55 mm from the center of chromatographic paper. After spraying the chromatogram with a ninhydrin solution, three blue concentric rings were obtained with centers 20, 25 and 45 mm away from the starting line. The area of the spots obtained was S1 = 0.75 cm2, S2 = 0.50 cm2, S3 = 0.31 cm2.

Determine the qualitative and quantitative composition of amino acids in a concentrate from a protein hydrolyzate.

The relative velocities of the component (Rf) movement of standard substances (amino acids) are given in the table.

Amino acids	R_f	***Amino acids***	R_f
Aspartic acid	0,24	Glutamic acid	0,36
Lysine	0,46	Valine	0,64
Alanine	0,82	Tyrosine	0,90

Variant №2

1. Draw a differential chromatogram of a mixture of three hydrocarbons and determine the measured value from it for quantitative analysis. Write a calculation formula.

2. Equate the ion exchange reaction between anion exchange resin and MnSO4. Transfer the cation exchange resin to the Zn2 + form.

3. The chromatograms of standard substances (isobutylene, tR = 64 mm; benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 10 mm, h (A) = 35 mm; tR (B) = 30 mm, h (B) = 10 mm). Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. When determining sterols in margarine by thin layer chromatography, the solvent front passed 12.0 cm, and the only spot appeared at a distance of 8.3 cm from the start line. Under these conditions, stigmasterol and ergosterol are

characterized by the parameters Rf 0.50 and 0.70, respectively. Which of the following sterols is found in margarine? Schematically depict the chromatogram.

Variant №3

1. What is the difference between gas chromatography and gas-liquid chromatography and what is their similarity?

2. Write the equation for the ion exchange reaction between cation exchange resin and $Ni(NO_3)_2$. Convert anion exchange resin to SO_4^{2-} form.

3. The chromatograms of standard substances (propylene, t_R = 47 mm; benzene, t_R = 15 mm; acetone, t_R = 10 mm; diethyl ether, t_R = 7 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (t_R (A) = 47 mm, h (A) = 23 mm; t_R (B) = 7 mm, h (B) = 80 mm). Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. The total dynamic capacity of cation exchanger for Mg^{2+} 2.50 mmol-equiv / g. What volume of 0.1 mol / dm^3 of a magnesium sulfate solution can be passed through a column containing 14 g of this cation exchanger.

Variant №4

1. What requirements should the stationary phase in gas chromatography satisfy?

2. Compose the equation for the ion exchange reaction between anion exchange resin and $Zn(NO_3)_2$. Transfer the cation exchange resin to the Mn^{2+} form.

3. The chromatograms of standard substances (propylene, t_R = 47 mm; methane, t_R = 20 mm; isopentene, t_R = 70 mm; diethyl ether, t_R = 7 mm) were measured by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (t_R (A) = 20 mm, h (A) = 50 mm; t_R (B) = 70 mm, h (B) = 15 mm). Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. To determine the dioxidiphenylmethane (DODPM) in food products, thin layer chromatography was used. For standard samples, the following results were obtained:

DODPM concentration, мкг/0,02 см^3	5,0	10,0	15,0	20,0
Spot area, мм^2	7,94	12,59	17,28	21,83

A portion of vegetables weighing 100 g was treated with alcohol, the ecstate was evaporated to 5 cm3. Chromatography of 0.02 cm3 of this solution gave a spot with an area of 16.43 mm2. Determine the concentration of DODPM in vegetables in μg / kg.

Variant № 5

1. What physical processes occur between the detected hydrocarbons and the stationary phase in gas and gas-liquid chromatography?

2. Write the equation for the ion exchange reaction between cation exchange resin and ZnBr2. Convert anion exchange resin to CH3COO - form.

3. The chromatograms of standard substances (propylene, tR = 47 mm; ethane, tR = 24 mm; isopentene, tR = 70 mm; propane, tR = 40 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 40 mm, h (A) = 30 mm; tR (B) = 24 mm, h (B) = 62 mm). Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. From 2.1271 g of a sample containing sodium nitrate and nonionic impurities, 100 cm3 of solution were prepared. 10 cm3 of this solution was passed through a column filled with cation exchange resin in the H + form. The entire eluate was titrated with 15.70 cm3 of sodium hydroxide solution with a molar concentration of 0.1110 mol / dm3. Calculate the mass fraction of sodium nitrate in the sample.

Variant № 6

1. Give a block diagram of the chromatograph.

2. Equate the ion exchange reaction between the cation exchange resin and NaCH3COO. Convert anion exchange resin to NO2 - form.

3. The chromatograms of standard substances (H-butane, tR = 59 mm; benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 10 mm, h (A) = 25 mm; tR (B) = 59 mm, h (B) = 90 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. When identifying amino acids in a concentrate from a protein hydrolyzate, the solvent front moved 55 mm from the center of chromatographic paper. After spraying the chromatogram with a ninhydrin solution, three blue concentric rings with centers 13, 25 and 45 mm away from the starting line were obtained. The area of the spots obtained was S1 = 0.21 cm2, S2 = 0.90 cm2, S3 = 0.07 cm2.

Determine the qualitative and quantitative composition of amino acids in a concentrate from a protein hydrolyzate.

The relative velocities of the component (Rf) movement of standard substances (amino acids) are given in the table.

Amino acids	R_f	***Amino acids***	R_f
Aspartic acid	0,24	Glutamic acid	0,36
Lysine	0,46	Valine	0,64
Alanine	0,82	Tyrosine	0,90

Variant № 7

1. What is the mobile phase in gas-liquid chromatography? What is her role?

2. Compose the equation for the ion exchange reaction between cation exchange resin and NaNO2. Convert anion exchange resin to Br- form.

3. The chromatograms of standard substances (isobutylene, tR = 64 mm; benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm) were recorded

by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 64 mm, h (A) = 62 mm; tR (B) = 15 mm, h (B) = 30 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. What volume of a 0.050 mol / dm3 solution of zinc sulfate can be passed through a column containing 5 g of cation exchange resin, the total dynamic capacity of which for zinc is 1.50 mmol-equiv / g.

Variant №8

1. What happens to a mixture of hydrocarbons in chromatographic columns? What materials are the columns made of?

2. Equate the ion exchange reaction between anion exchange resin and CaBr2. Transfer the cation exchange resin to the K + form.

3. The chromatograms of standard substances (benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm; propylene, tR = 47 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 15 mm, h (A) = 18 mm; tR (B) = 47 mm, h (B) = 61 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. When three amino acids were separated on chromatographic paper, the solvent front passed 16.2 cm from the start line, aspartic acid passed 2.3 cm from the start line, glutamic acid 3.9 cm, alanine 9.6 cm, unknown substance 7, 4 cm. Calculate the parameter Rf for each component.

Variant № 9

1. What is the detector in the chromatograph used for? Explain how the katharometer works.

2. Compose the equation for the ion exchange reaction between anion exchange resin and Na2SO4. Transfer the cation exchanger to the Ca2 + form.

3. The chromatograms of standard substances (propane, tR = 40 mm; methane, tR = 20 mm; isopentene, tR = 70 mm; diethyl ether, tR = 7 mm) were measured by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 7 mm, h (A) = 15 mm; tR (B) = 40 mm, h (B) = 50 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. A portion of anion exchange resin weighing 0.9810 g was poured into a 100 cm3 NaOH solution and C = 0.1070 mol / dm3. After establishing equilibrium for titration of 20.00 cm3 of this solution, 12.50 cm3 of a HCl solution with SEC = 0.0904 mol / dm3 was consumed. Calculate the statistical exchange capacity of anion exchange resin.

Variant №10

1. What factors influence the retention time of hydrocarbons in gas chromatography?

2. Compose the equation for the ion exchange reaction between anion exchange resin and NaNO3. Transfer the cation exchanger to the Mg2 + form.

3. The chromatograms of standard substances (H-butane, tR = 59 mm; benzene, tR = 15 mm; acetone, tR = 10 mm; ethylene, tR = 30 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 59 mm, h (A) = 35 mm; tR (B) = 30 mm, h (B) = 44 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. To determine the total dynamic capacity (PDOE) of cation exchange resin, 350.0 cm3 of a CaCl2 solution with a molar concentration of equivalent of 0.0500 mol / dm3 was passed through a column with 5 g of cation exchange resin in the H + form. When determining Ca2 + in the eluate in portions of 50.00 cm3, the

following concentrations were obtained: 0.0030; 0.0080; 0.0150; 0.0250; 0,0400 and 0,0500 mol-equiv / l. Determine PDOE of cation exchanger by calcium.

Variant № 11

1. What is the basis for qualitative analysis in gas chromatography?

2. Equate the ion exchange reaction between cation exchange resin and CaCl2. Convert anion exchange resin to CO32- form.

3. The chromatograms of standard substances (isobutane, tR = 52; benzene, tR = 15 mm; methane, tR = 20 mm; ethylene, tR = 30 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 52 mm, h (A) = 80 mm; tR (B) = 20 mm, h (B) = 23 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. When determining the residual content of pesticides in oyster mushrooms by thin-layer chromatography, the solvent front passed 23 cm from the start line, the only spot was 7.2 cm from the start line. Under these conditions, β - HCH, chlordimeform and heptachlor are characterized by the parameters Rf 0.31, 0.52, 0.43, respectively. Which of these pesticides is present in mushrooms?

Variant № 12

1. What does a differential chromatogram of a mixture of two hydrocarbons look like? Show how the measured value is determined to perform a qualitative analysis.

2. Compose the equation for the ion exchange reaction between anion exchange resin and KBr. Transfer the cation exchange resin to the Cu2 + form.

3. The chromatograms of standard substances (isobutylene, tR = 64 mm; propane, tR = 40 mm; diethyl ether, tR = 7 mm; methane, tR = 20 mm) were measured by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 64 mm, h (A) = 37 mm; tR (B) = 7 mm, h (B) = 73 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. The method of paper chromatography determined the content of rutin in the product. For standard samples containing rutin, the following results were obtained:

S, см^2	0,72	0,90	1,08	1,28
ω(* rutin*), %	0,5	1,0	1,5	2,0

Calculate the mass fraction of rutin in the test sample if Sx was 1.04 cm2.

Variant № 13

1. Due to what processes in the chromatographic column is the separation of hydrocarbons in gas chromatography?

2. Write the equation for the ion exchange reaction between cation exchange resin and Mg (NO3) 2. Transfer anion exchange resin to the Cl - form.

3. The chromatograms of standard substances (propylene, tR = 47 mm; methane, tR = 20 mm; isopentene, tR = 70 mm; ethane, tR = 24 mm) were measured by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 24 mm, h (A) = 10 mm; tR (B) = 70 mm, h (B) = 35 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. What mass of Co2 + will remain in solution if 200.00 cm3 of a CoCl2 solution with a molar concentration of the equivalent of 0.1000 mol / dm3 is passed through a column filled with 5 g of cation exchange resin in the H + form. The total dynamic capacity of cation exchanger is 1.60 mol-equiv / g.

Variant №14

1. What is the basis for quantitative analysis in gas-liquid chromatography? Explain the chromatogram of a mixture of two hydrocarbons as an example.

2. Make the equation of the ion exchange reaction between cation exchange resin and NiCl2. Convert anion exchange resin to SO32- form.

3. The chromatograms of standard substances (propylene, tR = 47 mm; ethylene, tR = 30 mm; isopentene, tR = 70 mm; ethane, tR = 24 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 70 mm, h (A) = 38 mm; tR (B) = 30 mm, h (B) = 56 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. What volume of sodium chloride solution with a molar concentration of 0.2 mol / dm3 can be passed through 400 cm3 of swollen cation exchange resin, the dynamic exchange capacity of which is 1.5 mmol-equiv / cm3?

Variant №15

1. Why is it necessary to keep the column temperature constant? How does increasing column temperature affect the retention time of hydrocarbons in gas chromatography?

2. Compose the equation for the ion exchange reaction between anion exchange resin and Na2CO3. Transfer the cation exchange resin to the Al3 + form.

3. The chromatograms of standard substances (propylene, tR = 47 mm; ethylene, tR = 30 mm; acetone, tR = 10 mm; ethane, tR = 24 mm) were recorded by gas-liquid chromatography. Draw a chromatogram of the mixture according to the obtained data (tR (A) = 24 mm, h (A) = 18 mm; tR (B) = 10 mm, h (B) = 40 mm).

Determine the qualitative and quantitative composition of the hydrocarbon mixture.

4. For the determination of nitrates in vegetables, thin layer chromatography was used. For standard samples, the following results were obtained:

$C(NO_3^-)$, мкг/0,02 $см^3$	10	20	30	40
Spot area, $мм^2$	12,5	20,7	29	37,3

A portion of vegetables weighing 100 g was processed and 5 cm3 of solution were obtained. Chromatography of 0.02 cm3 of this solution gave a spot with an area of 24.8 mm2. Determine the concentration of nitrates in vegetables in mg / kg.

Lesson 5. Optical methods of analysis (6 hours), using the method of active learning - seminar-press conference.

For each question of the plan of the seminar, a group of trainees (3-4 people) as experts is appointed by the teacher. They comprehensively study the problem and provide a rapporteur for the presentation of abstracts on it. After the first report, the seminar participants ask questions that are answered by the speaker and other members of the expert group. Questions and answers form the central part of the workshop. Based on questions and answers, a creative discussion unfolds, the results of which are first summed up by the speaker and then the teacher. Other issues of the seminar plan are discussed in a similar manner. In the final word, the teacher summarizes the discussion of the topic, evaluates the work of expert groups, defines the tasks of independent work.

Issues for discussion:

1. Advantages and disadvantages of optical methods;
2. Refractometric and spectral analysis;
3. Photometric analysis;
4. Nephelometric analysis;
5. Luminescent analysis.

III. TRAINING AND METHODOLOGICAL SUPPORT OF STUDENTS'S INDEPENDENT WORK

Educational and methodological support for the independent work of students in the discipline «Research methods in biotechnology» is presented in Appendix 1 and includes:

1) a schedule of independent work on the discipline, including approximate norms of time to complete each task;
2) characteristics of tasks for independent work of students and guidelines for their implementation;

3) requirements for the presentation and presentation of the results of independent work;

4) criteria for evaluating the performance of independent work.

IV. CONTROL OF ACHIEVING COURSE OBJECTIVES

№	Supervised sections opics of discipline	Codes and stages of formation of competencies		Evaluation Tools	
				current control	intermediate certification
1.	Section I. Theoretical Foundations of Instrumental Analysis Methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows basic instrumental analysis methods	UO-2 - colloquium, PR-4 – abstract	Exam Questions 1-3 Pr-1 - Final Test
			Able to choose methods of instrumental analysis		
			has knowledge for the selection of instrumental analysis methods		
2.	Section II. Electrochemical analysis methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows basic electrochemical analysis methods	UO-1 - interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 4-24 Pr-1 - Final Test
			Able to choose the method of electrochemical analysis		
			has knowledge for theselection of electrochemical analysis methods		
3.	Section III. Optical Analysis Methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows the classification of optical analysis methods	УО-1 – interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 25-39 Pr-1 - Final Test
			Able to apply optical methods for food analysis		
			Possesses knowledge for selecting optical methods		
4.	Section IV Chromatographic analysis methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows methods of masking, separation and concentration	УО-1 – interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 40-55 Pr-1 - Final Test
			Able to apply chromatographic methods for food analysis		
			has knowledge for the		

			selection of chromatographic methods, taking into account the latest advances in the application of chromatographic methods of analysis		

Typical control tasks, methodological materials that determine the procedures for assessing knowledge, skills and (or) experience, as well as criteria and indicators necessary for assessing knowledge, skills, and characterizing the stages of formation of competencies in the process of mastering an educational program are presented in the Appendix 2.

V. LIST OF EDUCATIONAL LITERATURE AND INFORMATION AND METHODOLOGICAL SUPPORT OF DISCIPLINE

Main literature

(electronic and print editions)

1. Visual biotechnology and genetic engineering / R. Schmid; trans. with him. A. A. Vinogradova, A. A. Sinyushina. Moscow: BINOM. Laboratory of Knowledge, 2014 .-- 324 p. (10 copies) http://lib.dvfu.ru:8080/lib/item?id=chamo:797469&theme=FEFU

2. Biotechnology: a textbook for agricultural universities / V. A. Chkhenkeli. - St. Petersburg: Prospect of Science, 2014 .-- 335 p. (3 copies) http://lib.dvfu.ru:8080/lib/item?id=chamo:785504&theme=FEFU

3. Biotechnology of combined foods based on dairy and microbiological raw materials: method. directions to the lab. works for students special. 240902 "Food biotechnology" of all forms of education / comp. N.V. Xitun, E.S. Fishchenko. Biotechnology of dairy production. Vladivostok: Publishing House of the Pacific Economic University, 2009. - 96c. (8 copies) http://lib.dvfu.ru:8080/lib/item?id=chamo:357087&theme=FEFU

Additional literature

(print and electronic publications)

1. Melnikova, E.I. Modern methods for studying the properties of raw materials and animal products. Laboratory workshop [Electronic resource]: study guide / E.I. Melnikova, E.S. Rudnichenko, E.V. Bogdanova. - The electron. Dan. - Voronezh: VGUIT, 2014. - 96 p. - Access mode: https://e.lanbook.com/book/71660

2. Matveeva, N.A. Methods of studying the properties of raw materials, fermentation products and soft drinks. Control tasks [Electronic resource]: teaching aid / N.A. Matveeva, M.M. Danina. - The electron. Dan. - St. Petersburg: NRU ITMO, 2013. - 21 p. - Access mode: https://e.lanbook.com/book/70911

3. Research methods of raw materials and products of sugar production: theory and practice [Electronic resource]: textbook / V.A. Golybin [et al.]. - The electron. Dan. - Voronezh: VGUIT, 2014. - 260 p. - Access mode: https://e.lanbook.com/book/71650

4. Danina, M.M. Methods of studying the properties of raw materials, fermentation products and soft drinks. Laboratory work [Electronic resource]: teaching aid / M.M. Danina. - The electron. Dan. - St. Petersburg: NRU ITMO, 2013. - 27 p. - Access mode: https://e.lanbook.com/book/70912

5. Danina, M.M. Methods of researching the properties of raw materials, semi-finished products, finished bakery and confectionery products. Laboratory work [Electronic resource]: teaching aid / M.M. Danina, E.S. Sergacheva, E.V. Sobolev. - The electron. Dan. - St. Petersburg: NRU ITMO, 2013. - 57 p. - Access mode: https://e.lanbook.com/book/70910

VI. METHODOLOGICAL INSTRUCTIONS FOR THE DEVELOPMENT OF THE DISCIPLINE

During the lectures, the teacher sets out and explains the basic, most complex concepts of the topic, as well as the theoretical and practical problems associated with it, gives recommendations for independent work.

During the lectures, students are recommended:

- keep notes of educational material;

- pay attention to categories, formulations that reveal the content of certain phenomena and processes, scientific conclusions and practical recommendations for their use;

- ask the teacher clarifying questions in order to clarify the theoretical provisions, resolve disputes.

It is advisable to leave fields in the working notes on which extracurricular time can be used to make notes from educational and methodological support for students to work independently, supplementing the material of the lecture, as well as notes emphasizing the particular importance of certain theoretical principles.

For successful mastery of the course, it is necessary to attend all lectures, since the thematic material is interconnected. In cases of skipping classes, the student needs to independently study the material and answer control questions on a missed topic during individual consultations.

Independent work (study of a theoretical course, preparation for current control and laboratory studies)

An important part of independent work is the reading of educational and scientific literature. The main function of textbooks is to orient the student in a system of knowledge, skills that should be learned by future specialists in this discipline.

In preparation for practical and laboratory studies, the student must study the basic and methodological literature, get acquainted with additional literature, and take into account the recommendations of the teacher.

VII. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

The material and technical support for the implementation of the discipline includes lecture halls and practical classes, provided with multimedia equipment and corresponding to sanitary and fire-fighting rules and norms.

Laboratory of Problems of Quality and Food Safety Vladivostok, about. Russian p. Ajax 10, Building 25.1, aud. M425. The classroom for lectures, practical and laboratory classes, group and individual consultations, ongoing monitoring and interim certification.

Training furniture for 26 workplaces, teacher's place (table, chair). Analytical and technological equipment (M425): water thermostat T-250; The microscope is monocular. Microscope chamber, GP-80 SPU Sterilizer, Ocean-4 refrigerator, Scales, Bactericidal irradiator OBN 150 2x30 wall AZOV (set) 101-230472, Microscope Biomed 10 pcs., Microorganism colony counter SKM-1, electric dream plate 111CH 101-226589; PE-6110 magnetic stirrer with heating.

Laboratory of Ecobiotechnology Vladivostok, about. Russian p. Ajax 10, Building 25.1, aud. M120, M122. The classroom for practical and laboratory studies of group and individual consultations, current monitoring and intermediate certification.

Ecobiotechnology Laboratory M120: Training furniture for 10 workplaces, Teacher's place (table, chair), total organic carbon analyzer, model TOC-L Manufacturer 'Shimadzu'; Gas Chromatoss Spectrometer GCMS-QP2010 Ultra; LC-20 Prominece High Performance Liquid Chromatography Module; Monoblock Lenovo C360G-i34164G500UDK; HP Pro 6200 SFF i3 2120 / 2Gb / 500Gb PC, Viewsonic 20 Monitor.

Laboratory of Ecobiotechnology M122: educational furniture for 10 workplaces, teacher's place (table, chair), voltammetric analyzer TA-Labk - set; Monoblock MSI AE1920-093 Atorm D525 / 2G / 250GB; Fume hood LK-1200 ШВП; Centrifuge 5810 R, with accessories (rotor-buckets) for the deposition of fine substances; Drying cabinet ШС-80-01; Rotary evaporator, model EV311-V; Vertical electrophoresis chamber CriterionCell, 13.3x8.7 cm 1-2 gels, Bio-R; Thermostat 20L, up to 60 C, TS-1/20.

For independent work of students, the following rooms can be used: Reading rooms of the FEFU Scientific Library with open access to the fund (building A - level 10).

Reading room equipment for the FEFU Scientific Library: HP All-in-One 400 All-in-One Monoblock 400 All-in-One 19.5 (1600x900), Core i3-4150T, 4GB DDR3-1600 (1x4GB), 1TB HDD 7200 SATA, DVD +/- RW, GigEth, Wi- Fi, BT, usb kbd / mse, Win7Pro (64-bit) + Win8.1Pro (64-bit), 1-1-1 Wty Internet access speed of 500 Mbps. Workplaces for people with disabilities are equipped with braille displays and printers; equipped with: portable devices for reading flat-printed texts, scanning and reading machines with a video enlarger with the ability to control color spectra; magnifying electronic magnifiers and ultrasonic markers.

Computer class: Vladivostok, about. Russian p. Ajax 10, Building 25.1, aud. M621. The classroom for lectures, practical classes, group and individual consultations, ongoing monitoring and interim certification.

Training furniture for 17 workplaces, teacher's place (table, chair).

Monoblock Lenovo C360G-i34164G500UDK 19.5 "Intel Core i3-4160T 4GB DDR3-1600 SODIMM (1x4GB) 500GB Windows Seven Enterprise - 17 pcs; Wired LAN - Cisco 800 series; Wireless LAN for students with a system based on 802.11a / b access points / g / n 2x2 MIMO (2SS).

Приложение 1

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

Федеральное государственное автономное образовательное учреждение высшего образования

«Дальневосточный федеральный университет»

(ДВФУ)

ИНСТИТУТ НАУК О ЖИЗНИ И БИОМЕДИЦИНЫ (ШКОЛА)

УЧЕБНО-МЕТОДИЧЕСКОЕ ОБЕСПЕЧЕНИЕ САМОСТОЯТЕЛЬНОЙ РАБОТЫ ОБУЧАЮЩИХСЯ

по дисциплине «Research methods in biotechnology»

Направление подготовки 19.04.01 Биотехнология

магистерская программа «Agri-Food Biotechnology»

Форма подготовки очная

Владивосток

2021

Schedule of independent work on the discipline

№	Date / Deadline	Type of independent work	Estimated time to complete	Form of control
1	1-5 week	Preparation of essays	18	Exam
2	5-6 week	Seminar press conference	18	Exam
3	During the semester	Preparing for the colloquium	18	Exam

Students' independent work consists of preparing for practical classes, working on recommended literature, writing reports on the topic of a seminar, and preparing presentations.

The teacher offers each student individual and differentiated tasks. Some of them may be carried out in a group.

Задания для самостоятельного выполнения

Independent work of students should have the following characteristics:

- to be personally performed by a student or to be independently performed part of a team work according to the assignment of the teacher;
- represent a completed development (completed development stage), which reveals and analyzes relevant problems on a particular topic and its individual aspects (actual problems of the discipline being studied and the corresponding sphere of practical activity);
- demonstrate sufficient competence of the author in the issues addressed;
- have educational, scientific and / or practical orientation and significance (if it comes to educational research);
- contain certain elements of novelty (if the CDS is carried out as part of research work).

Methodological instructions for the implementation of the essay

The goals and objectives of the essay

The essay(from lat. Referto - report, report) is a summary of the problems of a practical or theoretical nature with the formulation of certain conclusions on the subject. A student-selected problem is studied and analyzed based on one or more sources. In contrast to the term paper, which is a comprehensive study of the problem, the essay is aimed at analyzing one or more scientific papers.

The objectives of writing an essay are:

development of students' skills in finding relevant problems of modern legislation;

• development of skills to summarize the material with highlighting only the most significant points necessary to reveal the essence of the problem;

• development of skills to analyze the material studied and formulate their own conclusions on the selected issue in writing, in a scientific, competent language.

The tasks of writing an essay are*:*

- teach the student to convey the opinions of the authors as faithfully as possible, on the basis of which the student writes his essay;

- teach the student to correctly state their position on the problem analyzed in the abstract;

- prepare the student for further participation in scientific - practical conferences, seminars and competitions;

- help the student to determine the topic of interest to him, the further disclosure of which is possible when writing a term paper or diploma;

- to clarify for themselves and state the reasons for their consent (disagreement) with the opinion of one or another author on this issue.

The basic requirements for the content of the essay, course project

The student should use only those materials (scientific articles, monographs, manuals) that are directly related to their chosen topic. Remote reasoning not related to the problem being analyzed is not allowed. The content of the essay should be specific, only one problem should be investigated (several are allowed, only if they are interconnected). The student must strictly adhere to the logic of presentation (start with the definition and analysis of concepts, go to the problem statement, analyze the ways to solve it and draw the appropriate conclusions). The essay should end with a conclusion on the topic.

The structure of the abstract consists of:

1. The title page;

2. Introduction, where the student formulates the problem to be analyzed and investigated;

3. The main text, which consistently reveals the selected topic. Unlike term paper, the main text of the essay involves a division into 2-3 paragraphs without highlighting the chapters. If necessary, the text of the abstract can be supplemented by illustrations, tables, graphs, but they should not "overload" the text;

4. Conclusions, where the student formulates conclusions made on the basis of the main text.

5. The list of used literature. This list refers to those sources that the student refers to in preparing the essay, as well as others that were studied by him during the preparation of the essay.

The essay is 10-15 pages of typewritten text, but in any case should not exceed 15 pages. Interval - 1.5, font size - 14, margins: left - 3 cm, right - 1.5 cm, upper and lower - 1.5 cm. Pages must be numbered. The indent from the beginning of the line is 1.25 cm.

The order of delivery of the essay and its assessment

Essays are written by students during the semester in the terms set by the teacher in a particular discipline, reported by the student and submitted for discussion. The printed version is given to the teacher, leading the discipline.

Based on the results of the check, the student is given a certain number of points, which is included in the total number of student points scored by him during the semester. When evaluating the essay, the correspondence of the content to the chosen topic, the clarity of the work structure, the ability to work with scientific literature, the ability to pose a problem and analyze it, the ability to think logically, knowledge of professional terminology, and literacy are taken into account.

Recommended topics and list of essays

1) Essay on the topic «Organoleptic methods of analysis»

In addition to general information on the use of organoleptic methods of analysis in the food industry, the Essay should reflect the following issues: the advantages and disadvantages of the research method, the preparation of tasters for analysis, and a score on the quality of the finished product.

2) Essay on the topic «Microbiological methods for the analysis of raw materials and finished products»

In addition to general information on the use of microbiological methods of analysis in the food industry, the Essay should include the following questions:

bacterial analysis of raw materials and finished products, quantitative and alternative methods for determining microbiological parameters.

3) Essay on the topic «Gravimetric methods of analysis»

In addition to general information on the use of gravimetric methods of analysis in the food industry, the Essay should reflect the following questions: determination of the constant mass of a sample using an oven, vacuum desiccator, freeze drying.

4) Essay on the topic «Optical research methods»

In addition to general information about optical methods for studying food products and raw materials, the Essay should reflect the following issues: advantages and disadvantages of optical research methods, refractometric method, and spectral analysis.

5) Essay on the topic «Optical methods of analysis»

In addition to general information about optical methods for studying food products and raw materials, the Essay should reflect the following issues: advantages and disadvantages of optical methods of research, photometric analysis, nephelometric analysis, luminescent analysis, polarimetric analysis.

6) Essay on the topic «Electrochemical methods of analysis»

In addition to general information on the use of electrochemical research methods in the food industry, the Essay should reflect the following issues: advantages and disadvantages of electrochemical research methods, electric weight method, potentiometric method, amperometric titration.

7) Essay on the topic «Electrochemical methods of analysis»

In addition to general information on the use of electrochemical research methods in the food industry, the Essay should reflect the following issues: advantages and disadvantages of electrochemical research methods, conductometric analysis method, polarographic analysis, coulometric titration.

8) Essay on the topic «Combined and hybrid research methods»

In addition to general information on combined and hybrid methods for the study of food products and raw materials, the Essay should reflect the following issues: advantages and disadvantages of combined and hybrid methods of research, methods of concentration and separation, extraction.

9) Essay on the topic «Chromatographic methods of analysis»

In addition to general information on chromatographic methods for studying food products and raw materials, the Essay should reflect the following issues: advantages and disadvantages of chromatographic methods of research, classification of chromatographic methods, liquid ion exchange chromatography, planar chromatography, gas chromatography.

10) Essay on the topic «Rheological methods of analysis»

In addition to general information on the use of rheological methods of analysis in the food industry, the Essay should reflect the following issues: basic concepts of engineering rheology, rheological models, devices used to determine rheological characteristics.

11) Essay on the topic «Aquametry».

In addition to general information on the use of aquametry in the food industry, an Essay should include the following issues: the distribution of water in nature, water as a component is correct, the relationship between water and grain.

12) Essay on the topic «Aquametry».

In addition to general information on the use of aquametry in the food industry as a method for studying water quality, the Essay should include the following questions: water activity, methods for studying water quality (cryoscopy, psychrometers, hygroscopy), instruments used to study water quality.

13) Essay on the topic «Acoustic research methods»

In addition to general information about acoustic methods for studying food products and raw materials, the Essay should include the following questions: cavitation, types of cavitation, and the scope of ultrasound.

14) Essay on the topic of «Ultrasound»

In addition to general information about the use of ultrasound in the food industry, the Essay should reflect the following issues: ion electrophoresis, advantages and disadvantages of electrophoresis

Приложение 2

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
Федеральное государственное автономное образовательное учреждение высшего образования
«Дальневосточный федеральный университет»
(ДВФУ)

ИНСТИТУТ НАУК О ЖИЗНИ И БИОМЕДИЦИНЫ (ШКОЛА)

УЧЕБНО-МЕТОДИЧЕСКОЕ ОБЕСПЕЧЕНИЕ САМОСТОЯТЕЛЬНОЙ РАБОТЫ ОБУЧАЮЩИХСЯ

по дисциплине «Research methods in biotechnology»
Направление подготовки 19.04.01 Биотехнология
магистерская программа «Agri-Food Biotechnology»
Форма подготовки очная

Владивосток
2021

Паспорт ФОС

Code and wording of competency	Competency Stages	
GC-11 with the ability to professional growth, to self-study new research methods, to change the scientific and scientific-industrial profile of their professional activities	Knows	methodological theories and principles of modern science; research methodology
	Is able	develop research and development plans; use scientific, reference and methodical literature
	Owns	ability to professional growth, to self-study new research methods, to change the scientific and scientific-production profile of their professional activities
GC-12 ability to use skills in practice in the organization of research and design work and in team management	Knows	methods of organizing research and design work
	Is able	use skills in team management
	Owns	ability in practice to use skills in organizing research and design work and in team management
GPC-1 with the ability to professionally use modern biotechnological equipment and scientific instruments	Knows	types of modern biotechnological equipment and scientific instruments
	Is able	professionally operate advanced equipment and scientific instruments
	Owns	skills of professional operation of modern biotechnological equipment and scientific instruments
GPC-4 readiness to use methods of mathematical modeling of materials and technological processes, readiness for theoretical analysis and experimental verification of theoretical hypotheses	Knows	basic methods of mathematical modeling of materials and technological processes
	Is able	use methods of mathematical modeling of materials and technological processes; carry out theoretical analysis and experimental verification of theoretical hypotheses
	Owns	skills of using methods of mathematical modeling of materials and technological processes; ability to theoretical analysis and experimental verification of theoretical hypotheses
SPC-3 with the ability to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for the protection of intellectual property	Knows	intellectual property requirements
	Is able	to present the results of work in the form of scientific and technical reports, reviews, scientific reports and publications
	Owns	skills to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for the protection of intellectual property

№	Supervised sections opics of discipline	Codes and stages of formation of competencies		Evaluation Tools	
				current control	intermediate certification
1.	Section I. Theoretical Foundations of Instrumental Analysis Methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows basic instrumental analysis methods	UO-2 - colloquium, PR-4 – abstract	Exam Questions 1-3 Pr-1 - Final Test
			Able to choose methods of instrumental analysis		
			has knowledge for the selection of instrumental analysis methods		
2.	Section II. Electrochemical analysis methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows basic electrochemical analysis methods	UO-1 - interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 4-24 Pr-1 - Final Test
			Able to choose the method of electrochemical analysis		
			has knowledge for theselection of electrochemical analysis methods		
3.	Section III. Optical Analysis Methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows the classification of optical analysis methods	УО-1 – interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 25-39 Pr-1 - Final Test
			Able to apply optical methods for food analysis		
			Possesses knowledge for selecting optical methods		
4.	Section IV Chromatographic analysis methods	GC-11 GC-12 GPC-1 GPC-4 SPC-3	Knows methods of masking, separation and concentration	УО-1 – interview, UO-2 - colloquium, PR-4 – abstract	Exam Questions 40-55 Pr-1 - Final Test
			Able to apply chromatographic methods for food analysis		
			has knowledge for the selection of chromatographic methods, taking into account the latest advances in the application of chromatographic methods of analysis		

Competency Level Assessment Scale

Code and wording of competency	Competency Stages		Criteria	Indicators
GC-11 with the ability to professional growth, to self-study new research methods, to change the scientific and scientific-industrial profile of their professional activities	knows (threshold level)	methodological theories and principles of modern science; research methodology	knows the basic principles of modern science; research methodology	the ability to give definitions of the basic concepts of the subject area of research; ability to list and reveal the essence of the study that the master studied and mastered
	able (advanced)	develop research and development plans; use scientific, reference and methodical literature	able to develop research and development plans; use scientific, reference and methodical literature	ability to work with reference data for use in biotechnological production
	owns (high)	ability to professional growth, to self-study new research methods, to change the scientific and scientific-production profile of their professional activities	owns the ability to grow professionally, to independently learn new research methods, to change the scientific and scientific-production profile of his professional activity	the ability to fluently and accurately apply the terminological apparatus of the research subject area in oral answers to questions and in written works, the ability to conduct independent research and present their results for discussion at round tables, seminars, scientific conferences.
GC-12 ability to use skills in practice in the organization of research and design work and in team management	knows (threshold level)	methods of organizing research and design work	knows the basic methods of organizing research and design work	ability to justify and apply the results
	able (advanced)	use skills in team management	able to use basic skills in team management	ability to reveal the essence of research methods; the

				ability to justify the relevance of an assignment or study
	owns (high)	ability in practice to use skills in organizing research and design work and in team management	owns the ability in practice to use the basic skills in organizing research and design work and in team management	the ability to fluently and accurately apply the terminological apparatus of the research subject area in oral answers to questions and in written works, the ability to conduct independent research and present their results for discussion at round tables, seminars, scientific conferences.
GPC-1 with the ability to professionally use modern biotechnological equipment and scientific instruments	knows (threshold level)	types of modern biotechnological equipment and scientific instruments	knows the main types of modern biotechnological equipment and scientific instruments	ability to formulate a task for scientific research; the ability to conduct independent research and research as part of the team of authors and present their results for discussion
	able (advanced)	professionally operate advanced equipment and scientific instruments	knows how to professionally operate the main modern equipment and scientific instruments	ability to operate modern equipment and scientific instruments
	owns (high)	skills of professional operation of modern biotechnological equipment and scientific instruments	owns the basic skills of professional operation of modern biotechnological equipment and scientific instruments	ability to reveal the essence of scientific research methods; the ability to justify the relevance of an assignment or study; ability to prepare a publication or report on ongoing

				research
GPC-4 readiness to use methods of mathematical modeling of materials and technological processes, readiness for theoretical analysis and experimental verification of theoretical hypotheses	knows (threshold level)	basic methods of mathematical modeling of materials and technological processes	knows the basic methods of mathematical modeling of materials and technological processes	ability to produce mathematical modeling of technological processes
	able (advanced)	use methods of mathematical modeling of materials and technological processes; carry out theoretical analysis and experimental verification of theoretical hypotheses	able to use methods of mathematical modeling of materials and technological processes; carry out theoretical analysis and experimental verification of theoretical hypotheses	ability to use mathematical modeling methods
	owns (high)	skills of using methods of mathematical modeling of materials and technological processes; ability to theoretical analysis and experimental verification of theoretical hypotheses	owns the basic skills of using methods of mathematical modeling of materials and technological processes; ability to theoretical analysis and experimental verification of theoretical hypotheses	ability to conduct theoretical analysis and experimental verification of theoretical hypotheses
SPC-3 with the ability to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for	knows (threshold level)	intellectual property requirements	knows basic requirements for intellectual property protection	ability to formulate a task for scientific research; the ability to conduct independent research and present their results for discussion at round tables, seminars, scientific conferences
	able (advanced)	to present the results of work in the form of scientific and	able to present the main results of work in the form of scientific and	the ability to justify and apply the results of scientific research;

the protection of intellectual property		technical reports, reviews, scientific reports and publications	technical reports, reviews, scientific reports and publications	ability to apply research methods for non-standard solution of tasks
	owns (high)	skills to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using the modern capabilities of information technology and taking into account the requirements for the protection of intellectual property	owns the basic skills to present the results of the work performed in the form of scientific and technical reports, reviews, scientific reports and publications using modern capabilities of information technology and taking into account the requirements for the protection of intellectual property	ability to reveal the essence of scientific research methods; the ability to justify the relevance of an assignment or study; ability to prepare a publication or report on ongoing research

Interim certification includes the student's answer to the questions for the exam and passing the final test.

Student Examination Criteria

Points required to evaluate the final test	Credit mark	Requirements for completed competencies in the student's oral response
100-86	"Excellent"	the mark "Excellent" is given to a student who has knowledge of the basic technological equipment, its classification, processes occurring on the equipment being studied. Able to successfully conduct the selection of technological equipment to ensure the organization processes and the technological process.
85-76	"Good"	"Good" rating is given to the student who has the knowledge of the educational program material, successfully fulfilling the tasks stipulated in the program, having learned the basic literature recommended in the program. As a rule, the rating is "good" for students who have shown a systematic nature of knowledge in the discipline and are capable of independently replenishing

		and updating them in the course of further academic work and professional activity
75-61	“Satisfactory”	A student deserves “Satisfactory” if he has discovered the knowledge of the main educational program material in the amount necessary for further studies and upcoming work in the specialty, coping with the tasks stipulated by the program, familiar with the main literature recommended by the program, but having errors in the answer to the exam and when performing examination tasks, but possessing the necessary knowledge to eliminate them under the guidance of a teacher.
60-0	“unsatisfactory”	The mark “unsatisfactory” given to a student who does not know a significant part of the program material, makes significant mistakes, hesitates with practical difficulties with practical difficulties and cannot continue training without additional classes in the relevant discipline.

Questions for the exam

1. What methods of analysis are instrumental?
2. Innovations in instrumental analysis methods?
3. Instrumental methods of analysis in biotechnology.
4. The essence of the method of amperometric titration. Devices, electrodes. Give an example of a titration curve if the reaction product is electroactive.
5. The device and principle of operation of the electrodes: silver chloride, calomel, glass.
6. Conductometry: devices and electrodes. Give an example of a conductometric titration curve of a solution of ammonium hydroxide with sulfuric acid. Sources of radiation and monochromators used in spectroscopy in the visible and UV regions.
7. The essence of qualitative polarographic analysis. Devices, electrodes. Give an example. The use of polarography methods for food quality control.
8. The essence of amperometric titration. Devices and electrodes. The use of amperometric titration for food quality control.
9. The current-voltage curve. Indicate its main characteristics. Which of them are used in qualitative and quantitative polarographic analysis? The use of voltammetry for food quality control.

10. Devices and electrodes in conductometry. Give an example of conductometric titration of barium nitrate with a solution of sodium sulfate. Quantitative molecular spectral analysis.

11. Potentiometry. The essence of the method. Indicator electrodes used in potentiometric titration of a mixture of hydrochloric and acetic acids with an alkali solution?

12. Ionites: cation exchangers, anion exchangers, ampholytes.

13. Indicator electrodes in ionometry: the principle of their work. Give examples.

14. The exchange capacity of ion exchangers.

15. Indicator electrodes used in potentiometric titration in oxidation-reduction reactions. Give an example of a luminescent method. Classification.

16. The equations of ion exchange. Regeneration of ion exchangers.

17. Indicator electrodes in the potentiometric analysis method. The use of indicator electrodes in determining the pH of the solution. Give examples

18. Define specific and equivalent conductivity. Indicate on what factors and how their value depends

19. Potentiometry method. Give an example of a complexation reaction during potentiometric titration. Justify the choice of electrodes.

20. The essence of the method of polarography. Devices, electrodes. Give examples of quantitative polarographic analysis: additive method and calculation method

21. Conductometry. Devices, electrodes. Give an example of a conductometric titration curve of a mixture of acetic and hydrochloric acids with a solution of sodium hydroxide.

22. Potentiometric titration curves using deposition reactions.

23. Factors affecting the magnitude of the jump in the titration curve. Give an example.

24. The use of the potentiometric method in the food industry.

25. Optical methods. Classification of optical methods.

26. Factors affecting the amount of optical density.

27. Conditions for molecular spectral analysis. The choice of filters.

28. Molecular spectral analysis. The origin of the spectra.

29. Qualitative molecular spectral analysis.

30. Direct and indirect spectrophotometry. Types of spectrophotometric titration curves.

31. The use of molecular spectroscopy in the food industry.

32. Factors affecting the intensity of luminescence.

33. Qualitative luminescent analysis.

34. Quantitative luminescent analysis.

35. The use of luminescent analysis in the food industry.

36. List the factors affecting the value of the refractive index.

37. How can a substance be identified using a refractometric analysis?

38. What methods of quantitative analysis are used in refractometry?

39. The essence of the method of high-frequency titration. Specify the types of cells used in this method. Give an example of a titration curve.

40. Classification of chromatographic methods depending on the state of aggregation of the mobile and stationary phases.

41. Classification of chromatographic methods depending on the nature of the process.

42. Classification of chromatographic methods depending on the method of moving the sorbents along the sorbent layer.

43. Classification of chromatographic methods depending on the method of designing the separation process.

44. The main concepts of chromatography (sorption, sorbent, sorbate, sorption, adsorption, absorption, chemisorption).

45. Mobile and stationary phases in chromatography, requirements for them.

46. Gas and gas-liquid chromatography. Equipment: dispensers, evaporators, speakers, detectors.

47. Qualitative and quantitative chromatographic analysis in gas-liquid chromatography.

48. Paper and thin layer chromatography.

49. Liquid chromatography.

50. Ion exchange chromatography.

51. Qualitative and quantitative chromatographic analysis in thin-layer chromatography.

52. The use of chromatographic methods in the analysis of food products.

53. The main characteristics of the elution curve (chromatogram).

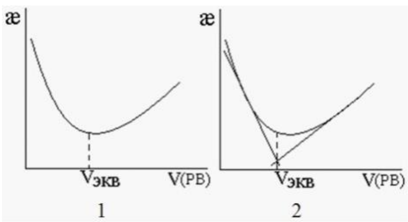
54. Methods for calculating chromatograms or the results of quantitative analysis in GC: absolute calibration method

55. The main processes underlying the separation of substances by chromatography.

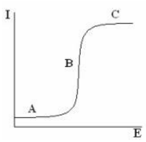
TEST TASKS

Test No. 1 "Electrochemical methods of analysis"

1. Indicate the graph on which the equivalent volume of titrant spent on conductometric titration was incorrectly found

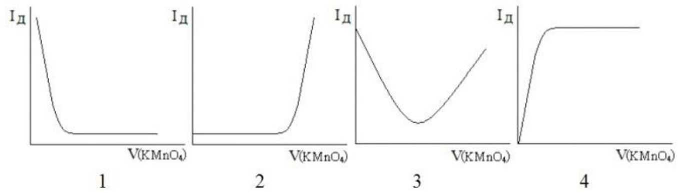


2. The classical polarogram has the form shown in the figure. The current flowing in the initial section of the polarogram (marked A) is called ...

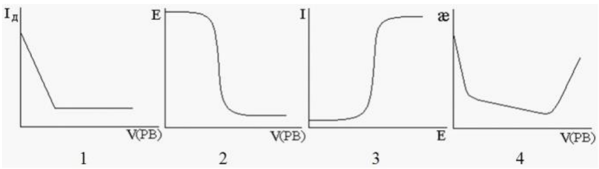


3. The curve of the amperometric titration of a FeSO4 solution in an acidic medium with a KMnO4 solution (during the titration, the anode current of

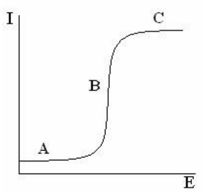
the electrode reaction Fe 2+ - e □ Fe 3+ is fixed) has the form shown in the figure ...



4. In conductometry, the most commonly used electrode ...
5. The graph corresponds to the potentiometric method ...

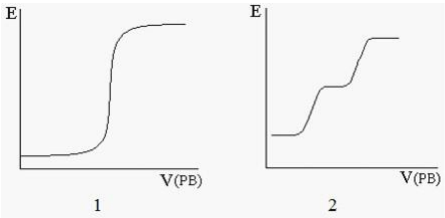


6. The specific and molar conductivity of the electrolyte solution are related by the ratio ...
7. Molar electrical conductivity with increasing concentration of the electrolyte solution ...
8. Indicate what value, measured by voltammogram, depends on the content of the analyte (its mass or concentration)
9. In the potentiometry method, the quantity measured experimentally is ...
10. The equation of Ilkovich corresponds to the formula ...
11. The method of voltammetry is based on a directly proportional relationship between the concentration of the substance and ...
12. When conductometric titration of a mixture of solutions of nitric and acetic acids with a solution of NaOH (PB) ...
13. The classical polarogram has the form shown in the figure. The current flowing in section C is called ...

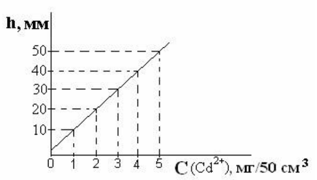


14. Indicate what value, measured by voltammogram, characterizes the qualitative composition of the analyte

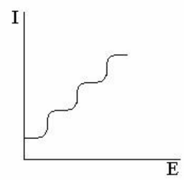
15. With potentiometric titration of a solution of a mixture of KCl and KI with an AgNO3 solution (PR AgCl = 2 · 10-10, PR AgI = 2 · 10-16), the integral titration curve will have the form shown in the figure ...



16. If h = 25 mm, then the concentration of cadmium (II) ions, found from the calibration curve (see figure), is ...



17. The volt-ampere curve of the analyzed ion mixture recorded on a polarograph has the form shown in the figure. The number of ions in the analyzed solution (provided that each of them corresponds to only one wave) is equal to ...

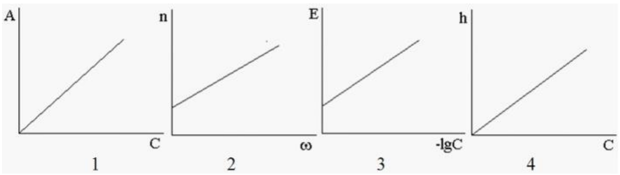


18. The main disadvantage of solid electrodes (platinum and graphite) is ...
19. The values of the detection limit of some voltammetric methods are known. The most sensitive of them is ...

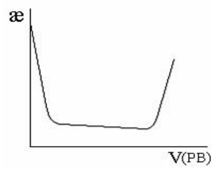
Analysis Method Name	Method detection limit, mol / dm3
1. Classical polarography	10^{-6}-10^{-5}
2. Amperometric titration	10^{-6}
3. Inversion voltammetry	10^{-10}-10^{-8}

20. In accordance with the GOSTs applicable to food products in the Russian Federation, polarography is an analysis method that should be used to determine ...

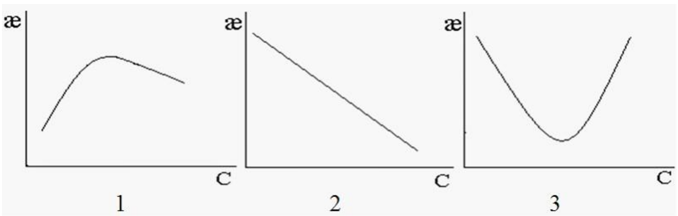
21. The membrane ion-selective electrodes include ... electrode
22. The pH meter is a device used in an analysis method called ...
23. In the polarographic determination of ions A and B with half-wave potentials (-0.21 V) and (-0.64 V, respectively), the ion will be the first to recover from the general background on the mercury dripping electrode ...
24. The values of the standard potentials of the redox pairs Fe3 + / Fe2 + and Sn4 + / Sn2 + are respectively + 0.77V and + 0.15V. Their separate definition in the general solution ...
25. Trilon B can be used as a titrant in conductometric determination of ions ...
26. The calibration graph in the ionometry has the form ...



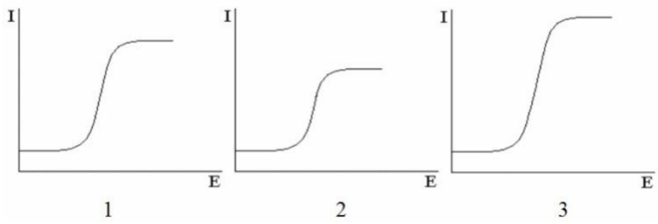
27. The titration curve shown in the figure corresponds to the method ...



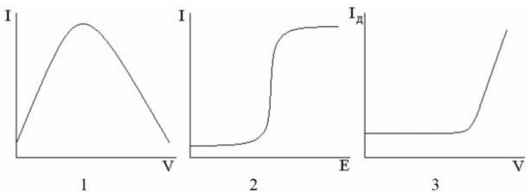
28. The dependence of the electrical conductivity (æ) of electrolyte solutions on the concentration is correctly shown in the figure ...



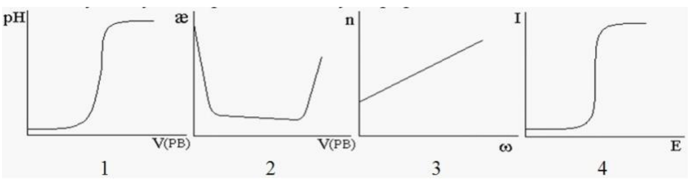
29. The basis of the coulometric analysis method is the equation ...
30. The method of voltammetry established the concentration of copper (II) ions in three samples: 10-4, 10-5 and 10-6 mol / dm3. The solution with the highest concentration of copper (II) corresponds to the current – voltage curve shown in the figure ...



31. By potentiometric titration (detection limit of 10-6 mol / dm3), ions cannot be determined ...
32. The main disadvantage of a mercury dripping electrode is ...
33. In potentiometric titration, when preparing the device for analysis, the electrodes and the electrochemical cell (cup) are rinsed ...
34. The method of conductometric titration (detection limit is 10-4 mol / dm3) can determine the content in the solution of ions ...
35. Silver nitrate (AgNO3) can be used as a titrant in the potentiometric determination of anions ...
36. The volt - ampere curve recorded on the polarograph has the form shown in the figure ...



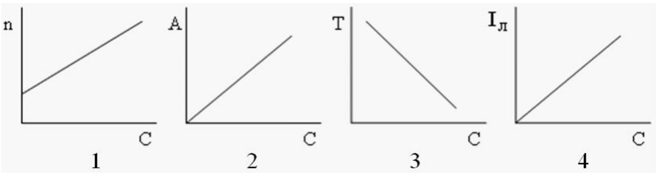
37. For analysis by amperometric titration, the background electrolyte ...
38. The method of conductometric titration by the neutralization reaction can determine the ions (if their concentration exceeds 10-4 mol / dm3) ...
39. The method of conductometry corresponds to the schedule ...



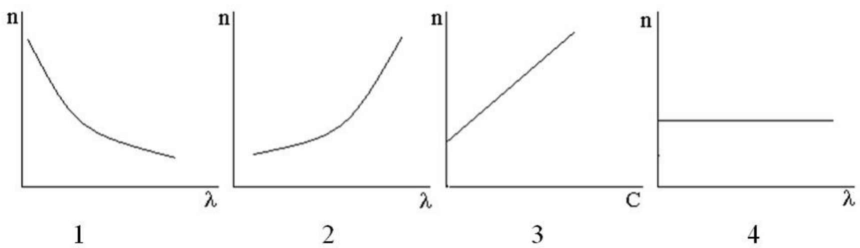
40. Zinc wire, dipped in a solution of zinc sulfate, refers to the electrodes ...

Test No. 2 "Optical methods of analysis"

1. The molar absorption coefficient does not depend on ...
2. The refractive index is the ratio of the sine of the angle of incidence to the sine of the angle ...
3. As measuring instruments in photocolorimetry use ...
4. Photocells are designed for ...
5. The analysis method, which is based on the ability of electromagnetic radiation to cause the glow of the investigated object, is called ...
6. The optical density of the solution depends on the concentration ...
7. The instruments used in molecular absorption analysis include ...
8. The refractive index is measured using a device ...
9. The dependence of the refractive index on the concentration of the dissolved substance is expressed by the equation ...
10. The molar absorption coefficient does not depend on ...
11. Refractometric analysis refers to the calibration graph shown in Figure ...



12. The phenomenon presented in the figure corresponds to the phenomenon of anomalous dispersion…



13. The strength of the photocurrent, in accordance with the law of Stoletov, ... the intensity of the light flux incident on the photocell
14. Quantitative luminescent analysis is based on measurement ...
15. The superscript in the designation of the refractive index shows ... at which it is measured
16. Indirect optical analysis methods include graphs ...

17. The refractometric analysis method is based on measurement ...
18. The dependence of the refractive index on the concentration of the dissolved substance is expressed by the equation ...
19. The concentration of the analyzed component in photocolorimetry, using the comparison method, is calculated by the formula ...
20. Direct optical analysis methods are based on using the dependence of the intensity of the analytical signal on ...
21. The glow of a substance that occurs when it is excited by various energy sources is called ...
22. The phenomenon of normal dispersion corresponds to the graph shown in the figure ...
23. The strength of the photocurrent, in accordance with the law of Stoletov, ... the intensity of the light flux incident on the photocell
24. The luminescent analysis includes the graph shown in figure ...
25. The optical density of the solution (absorption) is expressed as the equation ...
26. Direct optical methods include graphs ...
27. Qualitative luminescent analysis is based on the study of ...
28. As measuring instruments in refractometry using ...
29. The calibration graph shown in Fig. 1 relates to refractometric analysis.
30. The method for the quantitative determination of substances, based on the absorption of electromagnetic radiation by molecules, is called ...
31. If Ax = 0.18, then the concentration of copper ions (Cu2 +) in the solution, determined by the calibration curve, is ...
32. Refractometry is used to determine ... in food
33. Using the calculation method, the concentration of the analyzed component in spectrophotometry is calculated by the formula ...
34. Indirect optical analysis methods are based on using the dependence of the intensity of the analytical signal on ...

35. The phenomenon presented in the figure corresponds to the phenomenon of anomalous dispersion ...
36. Atomic emission analysis is used to determine ...

Test No. 3 "Chromatographic methods of analysis"

1. The separation of substances in gel chromatography is based on the difference ...
2. Calculate the mass fraction of each component in the mixture if the area of the chromatographic peak (mm2) is: for hexane - 25, heptane - 15, octane - 20.
3. The calibration graph in gas chromatography corresponds to the drawings ...
4. The separation of substances in gel chromatography is based on the difference ...
5. The area of the chromatographic peak ... the concentration of the analyte in the sample.
6. The method of separation of substances based on their ability to transfer from a solid to a gaseous state at low temperatures, bypassing the melting stage, is called ...
7. Coefficient Rf in thin-layer chromatography characterizes ...
8. The unit of exchange capacity is ...
9. The response of the integrated detector signal is proportional to ...
10. Depending on the method of placement of the stationary phase (layer geometry) ... chromatography is distinguished.
11. To obtain synthetic ion exchangers, reactions are used ...
12. Cation exchanger regenerate ...
13. For the implementation of ion exchange in the composition of cation exchangers there is a functional group ...
14. The height of the chromatographic peak ... the concentration of the analyte.
15. A qualitative characteristic of a substance in liquid chromatography is ...
16. The mobile phase containing the separated components is called ...

17. The separation of substances in gas-liquid chromatography is based on ...
18. Thin layer chromatography refers to ... chromatography.
19. Using gas chromatography to determine ...
20. A device in a chromatograph for continuously recording components leaving a column is called ...
21. For the appearance of the spot formed by Cu2 +, a reagent is used in paper chromatography ...
22. Calculate the mass fraction of each component in the mixture if the chromatographic peak area (mm2) is: for acetone - 10, methyl ethyl ketone - 20, diethyl ketone - 20.
23. The method of separation of substances based on their ability to transfer from a solid to a gaseous state at low temperatures, bypassing the melting stage, is called ...
24. Liquid adsorption chromatography uses ... a stationary phase.
25. The stationary phase when chromatography in a thin layer is ...
26. Paper chromatography refers to ... chromatography.
27. Anion exchange resin is a substance that is exchanged ... with the analyzed solution.
28. Physical adsorption is called ...
29. The operation of a flame ionization detector is based on measuring ...
30. For the implementation of ion exchange in the composition of anion exchangers there is a functional group ...
31. Hydrophobic substances ...
32. Hydrophilic substances ...
33. The area of the chromatographic peak can be calculated by the formula ...
34. Weakly basic anion exchangers are more capable of ion exchange in ... a medium.
35. The method of separation and concentration of substances, based on the different distribution of the components of the mixture between two liquid immiscible phases, is called ...

II. Evaluation tools for ongoing certification

Evaluation Criteria

- 100-86 points are awarded to the student if the student expressed his opinion on the formulated problem, argued for it, accurately determining its content and components. The data of domestic and foreign literature, statistical information, and regulatory information are presented. The student knows and possesses the skill of independent research work on the topic of research; methods and techniques of analysis of theoretical and / or practical aspects of the study area. There are no factual errors related to understanding the problem; graphically, the work is framed correctly
- 85-76 - points - the work is characterized by semantic integrity, coherence and sequence of presentation; no more than 1 mistake was made in explaining the meaning or content of the problem. For argumentation, data from domestic and foreign authors are given. Demonstrated research skills. There are no actual errors related to understanding the problem. One or two errors in the design of the work
- 75-61 points - the student conducts a fairly independent analysis of the main stages and semantic components of the problem; understands the basic foundations and theoretical justification of the chosen topic. The main sources on this topic were brought. No more than 2 errors were made in the meaning or content of the problem, the design of the work
- 60-50 points - if the work is a retransmitted or completely rewritten source text without any comments, analysis. The structure and theoretical component of the topic is not disclosed. Three or more than three errors were made in the semantic content of the problem being revealed and in the design of the work.