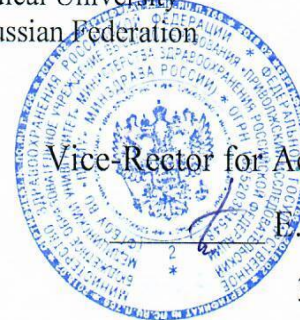


Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation



APPROVED

Vice-Rector for Academic Affairs

E.S. Bogomolova

31 August 2021

WORKING PROGRAM

Name of the academic discipline: **ANALYTICAL CHEMISTRY**

Specialty: **33.05.01 PHARMACY**

Qualification: **PHARMACIST**

Department: **GENERAL CHEMISTRY**

Mode of study: **FULL-TIME**

Labor intensity of the academic discipline: **396 academic hours**

The working program has been developed in accordance with the Federal State Educational Standard for the specialty 33.05.01 PHARMACY approved by Order of the Ministry of Science and Higher Education of the Russian Federation No. 219 dated of March 27, 2018.

Developers of the working program:


1. Piskunova M.S., Ph.D., Associate Professor,
2. Gordetsov A.S., Doctor of Chemistry, Professor, Head of the Department of General Chemistry.

The program was reviewed and approved at the department meeting (protocol No.1, 26.08.2021)

Head of the Department of General Chemistry,
Doctor of Chemistry, Professor Gordetsov A.S.


/Gordetsov A.S./

--- August 26, 2021

Deputy Head of EMA ph.d. of biology  Lovtsova L.V.

August 26, 2021

1. GOALS AND OBJECTIVES OF MASTERING THE DISCIPLINE

The purpose of the discipline is to prepare students for the assimilation of biomedical and special disciplines, for which, on the basis of modern scientific ideas and in accordance with the requirements of the Federal State Educational Standard of Higher Professional Education, to form knowledge about the patterns of chemical behavior of organic substances and about the relationship between the properties of compounds with their chemical structure, participation in the formation the following competencies:

UK-1: The ability to carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy

GPC-1: the ability to use basic biological, physico-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of medicines.

The tasks of the discipline are:

- study by students of the properties of organic substances;
- acquisition and consolidation of knowledge in the field of synthesis and analysis of organic compounds;
- formation of the ability to use modern methods for establishing the structure of organic compounds;
- acquiring the ability to work in a chemical laboratory using special equipment;
- formation of students' skills in studying scientific chemical literature;
- formation of students' skills for solving problematic and situational problems.

As a result of mastering the discipline, the student must:

Know:

- 1) principles of classification and nomenclature of the main classes of organic compounds;
- 2) types of isomerism of organic substances;
- 3) methods of obtaining and reactivity of the most important organic compounds;
- 4) chemical and physical methods for the identification of organic compounds;
- 5) rules for working with organic substances.

Be able to:

- 1) on the basis of the structure of substances, assign them to certain classes;
- 2) compile the names of organic compounds using the IUPAC nomenclature rules; build structural formulas of substances by their names;
- 3) depict the structural and spatial formulas of isomers, name the latter using D, L-, R, S- and E, Z-nomenclature systems;
- 4) predict methods of obtaining and chemical properties of compounds based on their structure;
- 5) establish the structure of substances based on their chemical properties and spectral characteristics;
- 6) describe in general terms and with specific examples the mechanisms of radical, electrophilic and nucleophilic substitution;
- 7) perform qualitative reactions to functional groups;
- 8) isolate and purify organic substances, determine their purity.

Possess:

- 1) the skills of safe work in a chemical laboratory, conducting experimental work using chemical glassware and equipment;
- 2) choose the optimal routes for the synthesis of given organic compounds;
- 3) skills of independent work with educational, scientific and reference literature;
- 4) find and use the necessary information to solve synthetic problems.

2. Position of the academic discipline in the structure of the General Educational Program of Higher Education (GEP HE) of the organization

- 1.1. The discipline Organic chemistry refers to the core part (*or the part formed by the participants of educational relations*) of Block 1 of GEP HE (Academic discipline index). The discipline is studied in III-IV semesters.
- 1.2. To study the discipline, knowledge, skills and abilities are required that are formed by previous disciplines: general and inorganic chemistry, physics, computer science, mathematics, physical and colloidal chemistry.
- 1.3. The study of the discipline is necessary for the knowledge, skills and abilities formed by the subsequent disciplines of the professional cycle: biochemistry, toxicological chemistry and such professional disciplines as biological chemistry, pharmaceutical chemistry, pharmacognosy, toxicological chemistry.

3. RESULTS OF MASTERING THE DISCIPLINE AND INDICATORS OF ACHIEVING COMPETENCES:

The process of studying the discipline is aimed at the formation of the following universal (UC), general professional (GPC):

№ п/п	Competence code	The content of the competence (or its part)	Code and name of the competence acquisition metric			
			know	be able to	possess	Evaluation tools

1.	UC-1	the ability to carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy	How to put into practice the methods of humanitarian, natural sciences, biomedical and clinical sciences in various types of professional and social activities	Analyze socially significant problems and processes	The methods of humanitarian natural sciences, biomedical and clinical sciences	Tests, multiply choice tests, colloquia, credits, exams
2.	GPC-1	the ability to use basic biological, physico-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of medicines	How to apply the basic methods, methods and means of obtaining storage, processing of scientific and professional information; receive information from various sources, including using modern computer tools, network technologies, databases and knowledge	Work with scientific literature analyze information, conduct searches, turn what is read into tool for solving professional problems Use the rules for constructing chemical formulas, graphs, tables using appropriate computer programs, including for creating computer presentations.	Ability and willingness to participate in the formulation of scientific problems and their experimental implementation Computer programs for constructing chemical and stereochemical formulas of organic compounds and other types of illustrative material.	Tests, multiply choice tests, colloquia, credits, exams

4. Sections of the academic discipline and competencies that are formed when mastering them

№ п/п	Competence code	Section name of the discipline	The content of the section in teaching units
1.	UC-1 GPC-1	General theoretical foundations of analytical chemistry (analytics)	Subject, tasks and methods of analytical chemistry. Analytical chemistry and chemical analysis. Basic concepts of analytical chemistry: method of substance analysis, analysis technique, qualitative chemical analysis, quantitative chemical analysis, elemental analysis, functional analysis, molecular analysis, phase analysis. A brief historical outline of the development of analytical chemistry: qualitative chemical analysis, quantitative analysis, organic elemental analysis, physical and physico-

		<p>chemical (instrumental) methods of analysis (optical, chromatographic, electrochemical).</p> <p>The main sections of modern analytical chemistry. Application of methods of analytical chemistry in pharmacy. Pharmaceutical analysis. pharmacopoeial methods.</p> <p>Analytical features of substances and analytical reactions. Types of analytical reactions and reagents. Sensitivity characteristic of analytical reactions (limiting dilution, limiting concentration, minimum volume of extremely diluted solution, limit of detection, sensitivity index). Sample preparation for analysis. Average test. Selection of an average sample of a liquid, solid (homogeneous and inhomogeneous substance). Sample weight. Dissolution of the sample (in water, in aqueous solutions of acids, in other solvents), processing of the sample or its fusion with salts.</p> <p>Some Provisions of the Theory of Electrolyte Solutions and the Law of Mass Action Used in Analytical Chemistry</p> <p>Strong and weak electrolytes. Total concentration and activity of ions in solution. Ionic strength of the solution. Influence of the ionic strength of the solution on the activity coefficients of the ions. Characteristics of the pH of aqueous solutions of electrolytes.</p> <p>Application of the law of mass action in analytical chemistry. Chemical balance. Chemical equilibrium constant (true thermodynamic, concentration). Conditional constant of chemical equilibrium.</p> <p>Heterogeneous equilibria in the system precipitate - saturated solution of a sparingly soluble electrolyte and their role in analytical chemistry</p> <p>Heterogeneous equilibria in analytical chemistry. Methods for expressing the solubility of sparingly soluble electrolytes. The solubility product of a poorly soluble strong electrolyte. Conditions for the formation of precipitates of poorly soluble strong electrolytes. Fractional precipitation and fractional dissolution of precipitates. Transfer of some sparingly soluble electrolytes to others. Influence of extraneous electrolytes on the solubility of poorly soluble strong electrolytes (influence of additions of an electrolyte with the same ion, influence of additions of an extraneous (indifferent) electrolyte). The influence of various factors on the completeness of precipitation and their dissolution. Acid-base equilibria and their role in analytical chemistry</p> <p>Protolytic equilibria. The concept of the protolytic theory of acids and bases. Protolytic equilibria in water. Characteristics of the strength of weak acids and bases. Acidity, basicity constants and their indicators; pH of solutions of weak acids and weak bases.</p> <p>Hydrolysis. Constant and degree of hydrolysis. Calculation of the pH values of salt solutions undergoing hydrolysis (hydrolysis of an anion of a weak acid, hydrolysis of a cation of a weak base, hydrolysis of a salt containing a</p>
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		<p>cation of a weak base and an anion of a weak acid). Buffer systems (solutions). pH value of buffer solutions: buffer systems containing a weak acid and its salt, a weak base and its salt. buffer capacity. The use of buffer systems in analysis. Redox systems and their role in analytical chemistry Redox potentials of redox couples (redox potentials, electrode redox potentials). Reaction potential (reaction electromotive force). The direction of the redox reaction. Influence of various factors on the values of redox potentials and the direction of redox reactions. The depth of the course of redox reactions. The use of redox reactions in chemical analysis. Complex formation equilibria and their role in analytical chemistry General characteristics of complex (coordination) compounds of metals. Equilibria in solutions of complex compounds. Stability constants and instability constants of complex compounds. Conditional stability constants of complexes. Influence of various factors on the processes of complex formation in solutions. Types of complex compounds used in analytical chemistry. Application of complex compounds in chemical analysis. Application of organic reagents in analytical chemistry Reactions based on the formation of complex compounds of metals. Reactions without the participation of complex metal compounds: the formation of colored compounds with detectable substances; the formation of organic compounds with specific properties; the use of organic compounds as indicators in titrimetric methods of quantitative analysis. Methods for the separation and concentration of substances in analytical chemistry Some basic concepts (separation, concentration, coefficient (factor) of concentration). Classification of separation and concentration methods (evaporation methods, ashing, precipitation, co-precipitation, crystallization, extraction, selective adsorption, electrochemical and chromatographic methods). Precipitation and co-precipitation. Application of extraction in analytical chemistry. The principle of the liquid extraction method. Some basic concepts of liquid extraction: extractant, extraction reagent, extract, re-extraction, re-extractant, re-extract. extraction equilibrium. Nernst-Shilov distribution law. Distribution constant. Distribution coefficient. Degree of extraction. The separation factor of two substances. Conditions for the separation of two substances. The influence of various factors on the extraction processes: the volume of the extractant, the number of extractions, the pH of the medium, etc. Classification of extraction systems used in chemical analysis: non-ionized compounds (molecular substances, chelate compounds, metal complexes with a mixed coordination sphere, including an inorganic ligand and a neutral extraction reagent) and ionic associates (metal-</p>
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			<p>containing acids and their salts, mineral acids, heteropolycompounds, extractable by oxygen-containing solvents, other ionic associates).</p> <p>Use of extraction processes in pharmaceutical analysis.</p> <p>Chromatographic methods of analysis</p> <p>Chromatography, the essence of the method. Classification of chromatographic methods of analysis: according to the mechanism of separation of substances, according to the state of aggregation of phases, according to the experimental technique, according to the method of relative movement of phases.</p> <p>Adsorption chromatography. Thin layer chromatography (TLC). The essence of the TLC method. Mobility coefficient, relative mobility coefficient, degree (criterion) of separation, separation coefficient. Materials and solvents used in the TLC method.</p> <p>Partition chromatography. Paper chromatography (chromatography on paper). Sedimentary chromatography. The concept of sieve (exclusion) chromatography. Gel chromatography.</p>
2.	UC-1 GPC-1	Qualitative Analysis	<p>Qualitative chemical analysis. Classification of qualitative analysis methods (fractional and systematic, macro-, semi-micro-, micro-, ultra-microanalysis).</p> <p>Analytical reactions and reagents used in qualitative analysis (specific, selective, group).</p> <p>The use of qualitative analysis in pharmacy.</p> <p>Analytical classification of cations by groups: hydrogen sulfide (sulfide), ammonia-phosphate, acid-base. Limitation of any classification of cations by groups.</p> <p>Acid-base classification of cations by groups. Systematic analysis of cations by the acid-base method. Analytical reactions of cations of various analytical groups.</p> <p>Qualitative analysis of anions. Analytical classification of anions by groups (according to the ability to form sparingly soluble compounds, according to redox properties).</p> <p>Limitation of any classification of anions by groups.</p> <p>Analytical reactions of anions of various analytical groups.</p> <p>Methods for the analysis of mixtures of anions of various analytical groups. Analysis of mixtures of cations and anions (qualitative chemical analysis of a substance).</p> <p>Application of physical and physico-chemical methods in qualitative analysis</p> <p>Optical methods of analysis: emission spectral analysis; flame photometry (flame photometry); molecular absorption spectral analysis (spectrophotometry) in the ultraviolet and visible regions of the spectrum; infrared spectroscopy; other optical methods (refractometry, polarimetry, luminescent method of analysis).</p> <p>Chromatographic methods of analysis. Electrochemical methods of analysis.</p>
3.	UC-1 GPC-1	Quantitative analysis.	<p>CLASSIFICATION OF QUANTITATIVE ANALYSIS METHODS (CHEMICAL, PHYSICO-CHEMICAL, PHYSICAL, BIOLOGICAL). REQUIREMENTS FOR REACTIONS IN QUANTITATIVE ANALYSIS. THE ROLE AND IMPORTANCE OF QUANTITATIVE ANALYSIS IN</p>

		<p>PHARMACY.</p> <p>STATISTICAL PROCESSING OF THE RESULTS OF QUANTITATIVE ANALYSIS</p> <p>SOURCES OF QUANTIFICATION ERRORS. ACCURACY AND REPRODUCIBILITY OF QUANTITATIVE ANALYSIS RESULTS. CLASSIFICATION OF QUANTIFICATION ERRORS (SYSTEMATIC ERROR, RANDOM ERRORS). SYSTEMATIC ERROR, THE RELATIVE MAGNITUDE OF THE SYSTEMATIC ERROR. SOURCES OF SYSTEMATIC ERRORS (METHODOLOGICAL, INSTRUMENTAL, INDIVIDUAL). EVALUATION OF THE CORRECTNESS OF THE RESULTS OF QUANTITATIVE ANALYSIS (USE OF STANDARD SAMPLES, ANALYSIS OF THE OBJECT UNDER STUDY BY OTHER METHODS, ADDITION METHOD OR DOUBLING METHOD). RANDOM BUGS.</p> <p>SOME CONCEPTS OF MATHEMATICAL STATISTICS AND THEIR USE IN QUANTITATIVE ANALYSIS. RANDOM VARIABLE, VARIANTS, GENERAL POPULATION, SAMPLE (SAMPLE POPULATION), STUDENT'S DISTRIBUTION.</p> <p>STATISTICAL PROCESSING AND PRESENTATION OF THE RESULTS OF QUANTITATIVE ANALYSIS. CALCULATION OF METROLOGICAL PARAMETERS. OPTIMUM SAMPLE SIZE, MEAN OF THE QUANTITY BEING DETERMINED, MEAN DEVIATION, VARIANCE, VARIANCE OF THE MEAN, STANDARD DEVIATION (RMS), STANDARD DEVIATION OF THE MEAN, RELATIVE STANDARD DEVIATION, CONFIDENCE INTERVAL (CONFIDENCE INTERVAL OF THE MEAN), HALF-WIDTH OF THE CONFIDENCE INTERVAL, CONFIDENCE PROBABILITY, COEFFICIENT OF NORMALIZED DEVIATIONS (STUDENT'S COEFFICIENT), RELATIVE (PERCENTAGE) ERROR OF THE AVERAGE RESULT. EXCLUSION OF BLUNDERS. PRESENTATION OF THE RESULTS OF QUANTITATIVE ANALYSIS. EXAMPLES OF STATISTICAL PROCESSING AND PRESENTATION OF THE RESULTS OF QUANTITATIVE ANALYSIS.</p> <p>EVALUATION OF ANALYSIS METHODS FOR CORRECTNESS AND REPRODUCIBILITY. COMPARISON OF TWO METHODS OF ANALYSIS FOR REPRODUCIBILITY (COMPARISON OF VARIANCES). METROLOGICAL CHARACTERISTICS OF ANALYSIS METHODS BY CORRECTNESS: ANALYSIS OF A STANDARD SAMPLE; COMPARISON OF THE RESULTS OF QUANTITATIVE ANALYSIS OF THE SAMPLE BY TWO METHODS (COMPARISON OF AVERAGES); EXAMPLES OF COMPARISON OF TWO METHODS OF QUANTITATIVE ANALYSIS IN TERMS OF CORRECTNESS AND REPRODUCIBILITY.</p> <p>EVALUATION OF THE ACCEPTABLE DISCREPANCY BETWEEN THE RESULTS OF PARALLEL DETERMINATIONS.</p> <p>RECOMMENDATIONS FOR PROCESSING THE RESULTS OF QUANTITATIVE ANALYSIS. COMPUTER DATA PROCESSING IN ANALYTICAL CHEMISTRY. EXAMPLES OF STATISTICAL PROCESSING OF RESULTS IN PHARMACEUTICAL ANALYSIS.</p> <p>GRAVIMETRIC ANALYSIS</p> <p>BASIC CONCEPTS OF GRAVIMETRIC ANALYSIS. CLASSIFICATION OF GRAVIMETRIC ANALYSIS METHODS (PRECIPITATION METHOD, DISTILLATION METHOD, ISOLATION METHOD, THERMOGRAVIMETRIC ANALYSIS).</p> <p>PRECIPITATION METHOD. MAIN STAGES OF GRAVIMETRIC DETERMINATION. PRECIPITATED AND GRAVIMETRIC (WEIGHT) FORMS; REQUIREMENTS FOR THESE FORMS. REQUIREMENTS FOR THE PRECIPITATOR, WASHING LIQUID. THE CONCEPT OF THE NATURE OF PRECIPITATION FORMATION. CONDITIONS FOR THE FORMATION OF CRYSTALLINE AND AMORPHOUS PRECIPITATES.</p> <p>EXAMPLES OF GRAVIMETRIC DEFINITIONS.</p>
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Chemical titrimetric methods of analysis

Titrimetric analysis (titrimetry). Basic concepts: aliquot, titrant, titration, equivalence point, end point of titration, indicator, titration curve, degree of titration, level of titration. Requirements for reactions in titrimetry. Reagents used in titrimetric analysis, standard substances, titrants.

Typical calculations in titrimetric analysis. Methods for expressing concentration in titrimetric analysis (molar concentration, molar concentration of the equivalent, titer, titrimetric conversion factor (titer for the analyte), correction factor). Calculation of the mass of the standard substance required for the preparation of the titrant.

Calculation of titrant concentration during its standardization. Calculation of the mass and mass fraction of the analyte based on the results of titration.

Classification of methods of titrimetric analysis: acid-base, redox, precipitation, compleximetric and complexometric titration.

Types (methods) of titration (direct, reverse, substitution). Methods of determination (individual samples, aliquot parts). Methods for establishing the end point of titration (visual, instrumental).

Acid-base titration

The essence of the method. Basic reactions and titrants of the method. Types of acid-base titration (acidimetry, alkalimetry).

Indicators of the acid-base titration method. requirements for indicators. Ionic, chromophore, ion-chromophoric theory of indicators of acid-base titration. Indicator titration index and color change interval. Classification of indicators (according to the method of application, by color, by the mechanism of processes of interaction with the titrant).

Examples of typical acid-base titration indicators.

Acid-base titration curves. Calculation, construction and analysis of typical titration curves of strong and weak acids with alkali, strong and weak bases with acid. Selection of indicators according to the acid-base titration curve.

Titration of polyprotic acids.

Errors in acid-base titration (errors due to physical measurements; indicator errors; causes, names).

Redox Titration

The essence of the method. Classification of redox methods. Conditions for redox titration. Reaction requirements. Types of redox titration (direct, reverse, substitution) and calculations of titration results.

Redox titration indicators. Classification of indicators.

Redox indicators (reversible and irreversible). Indicator titration index and color change interval. Examples of redox indicators often used in analysis (diphenylamine, phenanthrolic acid, ferroin, etc.)

Curves of redox titration: calculation, construction, analysis. The choice of indicator based on the analysis of the titration curve.

		<p>Indicator errors of redox titration, their origin, elimination. Permanganometric titration. The essence of the method. Titration conditions. Titrant, its preparation, standardization. Establishing the end point of the titration. The use of permanganometry. dichromatometric titration. The essence of the method. Titrant, its preparation. Determination of the end point of the titration. The use of dichromatometry. Iodimetric titration for the determination of reducing agents by direct titration. The essence of the method. Titrant (standard solution of iodine, its preparation, standardization, storage). Titration conditions, determination of the end point of the titration. Application of the method. Iodometric titration for the determination of oxidizing agents by substitution titration. The essence of the method. Titrant (standard solution of sodium thiosulfate), its preparation, standardization. Application of the method. Chloriodimetric titration. The essence of the method. Titrant. The use of chloriodimetry. Iodatometric titration. The essence of the method. Titrant. The use of iodatometry. Bromatometric titration. The essence of the method. Titrant. The use of bromatometry. bromometric titration. The essence of the method. Titrant. The use of bromometry. Bromide bromatometry. Nitritometric titration. The essence of the method. Titrant. Method indicators (external, internal). The use of nitritometry. Cerimetric titration. The essence of the method. Titrant. Application of cerimetry.</p> <p>Compleximetric titration The essence of the method. Requirements for reactions in compleximetry. Classification of methods and their application. complexometric titration. The concept of metal complexonates. Equilibrium in aqueous solutions of EDTA. Composition and stability of metal complexonates. The essence of the method of complexometric titration. Titration curves, their calculation and construction, analysis. Influence of various factors on the jump on the curve of compleximetric titration (stability of complexonates, concentration of metal and complexone ions, solution pH). Indicators of complexometry (metallochromic indicators), the principle of their action; requirements for metal-chromic indicators; interval of color change of indicators; examples of metallochromic indicators (eriochrome black T, xylenol orange, murexide, etc.). Choice of metal-chromic indicators. Method titrant, its preparation, standardization. Types (methods) of complexometric titration (direct, reverse, substitution). Method errors, their origin, elimination. Mercurimetric titration. The essence of the method. method titrant. The use of mercury.</p> <p>Precipitation titration</p>
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			<p>The essence of the method. Requirements for reactions in the precipitation titration method. Classification of methods according to the nature of the reagent interacting with the substances to be determined (argentometry, thiocyanatometry, mercurimetry, hexacyanoferrate titrimetry, sulfatometry, barymetry). Methods of precipitation titration (direct, reverse). Precipitation titration curves, their calculation, construction, analysis. Influence of various factors on the titration jump (concentration of reagent solutions, precipitate solubility, etc.).</p> <p>Indicators of the method of precipitation titration: precipitation, metallochromic, adsorption. Application conditions and selection of adsorption indicators.</p> <p>Argentometric titration. The essence of the method. Titrant, its preparation, standardization. Varieties of methods of argentometry (methods of Gay-Lussac, Mohr, Fayans-Fischer-Khodakov, Folgard). The use of argentometry. thiocyanatometric titration. The essence of the method. Titrant, its preparation, standardization. Method indicator. Application of thiocyanatometric titration.</p> <p>Mercurial titration. The essence of the method. Titrant, its preparation, standardization. Method indicators. Mercury application.</p> <p>Hexacyanoferrate titrimetry. The essence of the method. Titrant, its preparation, standardization. Application of hexacyanoferrate titrimetry.</p> <p>Sulfatometric and barymetric titration. Essence of methods. Titrants. Method indicators. Application of sulfatometry and barymetry.</p> <p>Precipitation titration errors. Their origin.</p> <p>Titration in non-aqueous media</p> <p>Limitation of titration methods in aqueous solutions. The essence of the method of acid-base titration in non-aqueous media.</p> <p>Classification of solvents used in non-aqueous titration (protic, aprotic). Influence of the nature of the solvent on the strength (acidity, basicity) of the dissolved protolith (leveling and differentiating effect of solvents, dielectric constant of the solvent). Completeness of reactions in non-aqueous solvents. Factors determining the choice of protolytic solvent. Application of acid-base titration in non-aqueous media (determination of weak acids, weak bases).</p>
4.	UC-1 GPC-1	Instrumental (physico-chemical) methods of analysis.	<p>General characteristics of instrumental (physico-chemical) methods of analysis, their classification, advantages and disadvantages.</p> <p>Optical methods of analysis</p> <p>General principle of the method. Classification of optical methods of analysis (according to the objects under study, by the nature of the interaction of electromagnetic radiation with matter, by the region of the electromagnetic spectrum used, by the nature of energy transitions).</p> <p>Molecular spectral analysis in the ultraviolet and visible region of the spectrum</p> <p>The essence of the method. Color and spectrum. Basic laws</p>

		<p>of Bouguer's light absorption. The combined Bouguer-Lambert-Beer light absorption law. Optical density (A) and light transmission (T), the relationship between them. Light absorption coefficient (k) and extinction coefficient - molar (ϵ) and specific (E1% 1cm); relationship between molar extinction coefficient and light absorption coefficient ($k = 2.3 \epsilon$), optical density additivity, reduced optical density. Schematic diagram of obtaining the absorption spectrum. The concept of the origin of electronic absorption spectra; features of electronic absorption spectra of organic and inorganic compounds.</p> <p>Absorption analysis methods; colorimetry, photoelectrocolorimetry, spectrophotometry.</p> <p>Colorimetry. Standard series method, color equalization method, dilution method. Their essence. Application in pharmacy.</p> <p>Photocolorimetry, photoelectrocolorimetry. Essence of methods, advantages and disadvantages, application.</p> <p>Quantitative photometric analysis. Conditions for photometric determination (selection of photometric reaction, analytical wavelength, solution concentration and absorbing layer thickness, use of reference solution).</p> <p>Determination of the concentration of the analyzed solution: calibration curve method, one standard method, determination of concentration by molar (or specific) extinction coefficient, standard addition method.</p> <p>Determination of the concentration of several substances in their joint presence.</p> <p>Differential photometric analysis. The essence of the method, methods for determining concentrations (calculation method, calibration curve method).</p> <p>Errors of spectrophotometric analysis, their nature, elimination.</p> <p>Extraction-photometric analysis. The essence of the method. conditions for the analysis. Photometric reactions in the extraction-photometric method. Application of the method.</p> <p>The concept of photometric titration.</p> <p>Luminescent analysis.</p> <p>The essence of the method. Classification of various types of luminescence. Fluorescence analysis. The nature of fluorescence. The main characteristics of luminescence: fluorescence spectrum, Stokes-Lommel law, Levshin's mirror symmetry rule, fluorescence quantum yield, law (rule) of S.I. Vavilov.</p> <p>Quantitative fluorescence analysis: principles of analysis, analysis conditions, luminescent reactions. Methods for determining the concentration of a substance (calibration curve method, single standard method). Application of fluorescent analysis.</p> <p>Extraction-fluorescence analysis.</p> <p>Titration with the use of fluorescent indicators.</p> <p>Chromatographic methods of analysis</p> <p>Ion exchange chromatography. The essence of the method.</p>
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			<p>electrodes. electrochemical sensors. The concept of electrogravimetric analysis. Coulometric analysis. Method principles. Direct coulometry. The essence of direct coulometry at a constant potential. Methods for determining the amount of electricity passed through a solution in direct coulometry. coulometric titration. The essence of the method. Conditions for coulometric titration. Equivalence point indication. Application of coulometric titration.</p>
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5. Volume of the academic discipline and types of academic work

Type of educational work	Labor intensity		Labor intensity (AH) in semesters	
	volume in credit units (CU)	volume in academic hours (AH)	3	4
Classroom work, including	6	216	108	108
Lectures (L)	1,33	48	24	24
Laboratory practicum (LP)*	4,67	168	84	84
Practicals (P)	-	-	-	-
Seminars (S)	-	-	-	-
Student's individual work (SIW)	4,0	144	72	72
exam	1	36	-	36
TOTAL LABOR INTENSITY	11	396	180	216

6. Content of the academic discipline

6.1. Sections of the discipline and types of academic work:

№	№ semester	Name of the section of the academic discipline	Types of academic work* (in AH)					Evaluation tools
			L	LP	P	S	SIW	
1	3	General theoretical foundations of analytical chemistry	10	18	-	-	25	Multiply choice tests, tests or colloquia, survey, exam
2	3	Qualitative Analysis	2	24	-	-	35	Multiply choice tests, tests or colloquia, laboratory works, survey, exam
3	3 - 4	Quantitative Analysis.	14	64	-	-	42	Multiply choice tests, tests or colloquia, laboratory works,

								survey, exam
4	4	Physical and chemical methods of analysis	22	62	-	-	42	Multiply choice tests, tests or colloquia, laboratory works, survey, exam
5	4	Exam					36	
		TOTAL	48	168	-	-	144	396

* - L – lectures; LP – laboratory practicum; P – practicals; S – seminars; SIW – student's individual work.

6.2. Thematic schedule of educational work types:

6.2.1 Thematic schedule of lectures

№	Name of lecture topics	Volume in AH	
		semester 3	semester 4
1.	The concept of analytical chemistry, its goals and objectives. Chemical analysis, its tasks. sensitivity and selectivity. Methods and methods of qualitative analysis. Fractional and systematic analysis. Acid-base classification of cations. Analytical classifications of anions. Application of physical and physico-chemical methods in qualitative analysis.	2	
2.	2. Main types of equilibria in analytical chemistry. Strong and weak electrolytes. Basic provisions of the theory of strong electrolytes. Ionic strength of solutions, activity of ions, activity coefficient.	2	
3.	The theory of ionic equilibria as applied to acid-base reactions. Theories of acids and bases. The concept of active and total acidity and alkalinity. Autoprotolysis. Absolute pH scale and pH scale for dilute solutions (including aqueous solutions). Calculation of pH in pure solutions of acids, bases, mixtures of acids or bases.	2	
4.	Hydrolysis. Constant and degree of hydrolysis. Calculation of the pH of hydrolyzable salts. buffer solutions. Calculation of pH, buffer capacity. Application.	2	
5.	Heterogeneous equilibrium in the "precipitate" - "saturated solution of a sparingly soluble electrolyte" system. Solubility. Solubility calculation. Ionic product and solubility product. Precipitation condition. Factors affecting the completeness of sedimentation.	2	
6.	Theory of ionic equilibria as applied to complex formation reactions. complex compounds. Constants of stability and	1	

	instability. Influence of various factors on complex formation in solutions. Theory of ionic equilibria as applied to oxidation-reduction reactions. Nernst equation. Direction of redox reactions. Influence of various factors. Application.	1	
7.	Quantitative analysis. The main stages of quantitative analysis. Sample preparation for analysis. Sampling. Sources of quantification errors. Statistical processing and presentation of results. Evaluation for correctness and reproducibility.	2	
8.	Gravimetric analysis. Basic concepts and stages of gravimetric determinations.	2	
9.	Acid-base titration. acidimetry and alkalimetry. Acid-base titration curves for individual substances and mixtures. Method indicators. Choice of indicators. Mistakes in acid-base titration.	2	
10.	Compleximetric titration. Classification of methods. Titration curves. Complexometry. Indicators. Application.	2	
11.	Precipitation titration. Classification of methods. Titration curves. Indicators. The essence of some methods of precipitation titration.	2	
12.	Redox titration. Method indicators. Curves of redox titration. Choice of indicators. indicator errors.	2	
13.	Types of oxidimetry. Permanganatometry. Dichromatometry. Iodometry. Bromatometry. Nitritometry. Chlorodimetry.		2
14.	General characteristics of instrumental methods of analysis. Classification of physical and chemical methods of analysis. Advantages and disadvantages. Choice for analysis.		2
15.	Electrochemical methods of analysis. Conductometry. The principle of the method, basic concepts. Direct and indirect conductometry. High-frequency conductometric analysis.		2
16.	Potentiometry. The principle of the method. Types of electrodes in potentiometry. Direct potentiometry. Potentiometric titration. Application.		2
17.	Voltammetric method of analysis. Polarographic analysis. The principle of the method, application. polarographic curves. Quantitative polarographic analysis. Amperometric titration. The essence of the method, application. Amperometric titration curves.		2
18.	Electrogravimetric method of analysis. Coulometric analysis. Method principles. Direct coulometry. The essence of direct coulometry at a constant potential. Application of direct coulometry. coulometric titration. The essence of the method, application.		2
19.	Optical methods of analysis. General principle of the method. Classification. Molecular spectral analysis in the ultraviolet and visible region of the spectrum. The essence of the method. Basic laws of light absorption. Electronic absorption spectra. Methods of absorption analysis. Quantitative photometric analysis.		2
20.	Differential photometric analysis. Errors of spectrophotometric analysis, their nature, elimination. Extraction-photometric analysis. Photometric titration. Luminescent analysis. Fluorescence analysis.		2
21.	Chromatographic methods of analysis. Classification. Ion exchange chromatography. The essence of the method. Ionites.		2

	ion exchange equilibrium. The method of ion exchange chromatography. Application of ion-exchange chromatography.		
22.	Absorption chromatography. Thin layer chromatography. The essence of the TLC method. Partition chromatography. Paper chromatography. Sieve and gel chromatography.		2
23.	Gas chromatography. The essence of the method. The concept of the theory of method. Retention options, separation options. Practice of the method, features of chromatography. Methods for quantitative processing of chromatograms.		2
24.	Liquid chromatography: high performance liquid chromatography. The essence of the method. Application of high performance liquid chromatography in pharmacy. The concept of combined methods: chromato-mass spectrometry, chromatosphotometry.		2
	TOTAL (48 AH)	24	24

6.2.2. The thematic plan of laboratory practicums

№	Name of laboratory practicums	Volume in AH	
		Semester 3	Semester 4
1.	Reactions and analysis of a mixture of cations of I-II analytical groups. Laboratory work.	4.42	
2.	Reactions and analysis of a mixture of cations of III-IV analytical groups. Laboratory work. Test No. 1. Reactions of cations of I-II analytical groups.	4.42	
3.	Reactions and analysis of a mixture of cations of V-VI analytical groups. Laboratory work. Test No. 2. Reactions of cations of III-IV analytical groups.	4.42	
4.	Analysis of a mixture of cations of I-VI analytical groups. Laboratory work. Test No. 3. Reactions of cations of V-VI analytical groups.	4.42	
5.	Reactions and analysis of a mixture of anions. Laboratory work.	4.42	
6.	Analysis of the substance (dry mixture or solution). Laboratory work. Test No. 4. Reactions of anions.	4.42	
7.	Hydrolysis and buffer systems in qualitative analysis. Substance analysis. Laboratory work.	4.42	
8.	Heterogeneous equilibrium. Substance analysis. Laboratory work.	4.42	
9.	Colloquium No. 1 on the topics: qualitative analysis, state of matter in solution, heterogeneous equilibrium.	4.42	
10.	Fundamentals of quantitative analysis. Statistical processing of results. Laboratory work. Evaluation of the error of measuring utensils.	4.42	
11.	Gravimetric analysis.	4.42	
12.	Test No. 5. Gravimetric method of analysis. Mathematical processing of results.	4.42	
13.	Titrimetric analysis. Laboratory work. Preparation of hydrochloric acid solution. Standardization of this solution by borax. Determination of the mass of alkali.	4.42	
14.	Alkalimetric titration. Laboratory work. Preparation of alkali solution. Standardization for oxalic acid. Determination of the mass of acid. Titration of a mixture of acids.	4.42	

15.	Acidimetric titration. Laboratory work. Determination of the mass of sodium hydroxide and sodium carbonate in the joint presence in the solution; total alkalinity of the solution.	4.42	
16.	Colloquium No. 2 (or test). Fundamentals of titrimetry. Acid-base titration.	4.42	
17.	Compleximetric titration. Laboratory work. Establishing the normality of EDTA. Determination of water hardness (or determination of the mass of lead).	4.42	
18.	Argentometric titration. Laboratory work. Titrant standardization; determination of chloride ions by the Folgard method.	4.42	
19.	Test lesson. Colloquium No. 3 (or test). Precipitation and compleximetric titration. The discussion of the results.	4.42	
20.	Redox titration. Laboratory work. Permanganometry. Standardization of the titrant, determination of the mass of iron in solution.		4.42
21.	Iodometry. Laboratory work. Preparation and standardization of iodine solution, determination of the mass of ascorbic acid. Dichromatometry.		4.42
22.	Bromatometry. Laboratory work. Preparation of a standard solution of potassium bromate, determination of the mass of streptocide or resorcinol.		4.42
23.	Nitritometry. Laboratory work. Preparation and standardization of the titrant, determination of the mass of novocaine in solution.		4.42
24.	Colloquium No. 4 (or test). Redox titration.		4.42
25.	Electrochemical methods of analysis. Laboratory work. Direct potentiometry using ion-selective electrodes.		4.42
26.	Conductometry. Coulometry. Laboratory work. Conductometric titration of a mixture of strong and weak electrolytes.		4.42
27.	Voltammetry. Laboratory work. Potentiometric acid-base titration of acetylsalicylic acid. Potentiometric redox titration of ascorbic acid.		4.42
28.	Test No. 6. Electrochemical methods of analysis.		4.42
29.	Photometric methods of analysis. Laboratory work. Determination of resorcinol content.		4.42
30.	Photometric methods of analysis. Laboratory work. Spectrophotometric determination of chromium and manganese in the joint presence.		4.42
31.	Photometric methods of analysis. Photometric titration. Laboratory work. Determination of copper content.		4.42
32.	Test No. 7. Photometric methods of analysis.		4.42
33.	Ion exchange chromatography. Laboratory work. Determination of the mass of copper salts.		4.42
34.	Chromatography on paper and in a thin layer. Laboratory work. Separation of halides by one-dimensional ascending TLC.		4.42
35.	Liquid and gas chromatography.		4.42
36.	Colloquium No. 5. Chromatographic methods of analysis.		4.42
37.	SSW.		4.42
38.	Starting lesson.		4.42
	TOTAL (total 168 AH)	84	84

6.2.3. Thematic plan of practicals: not provided for.

6.2.4. Thematic plan of seminars: not provided for.

6.2.5. Types and topics of student's individual work (SIW)

№	Types and topics of SIW	Volume in AH	
		Semester 3	Semester 4
1.	work with lecture material, providing for the development of lecture notes and educational literature, work with electronic literature;	25	25
2.	doing homework for class;	22	20
3.	preparation for control work;	25	22
4.	preparation for testing online.	-	5
	TOTAL (total 144AH)	72	72

6.2.6. Student's research work:

№	Student's research work:	Semester
1.	Methods for analyzing the quality of drugs.	3, 4
2.	Modern physical and chemical methods in qualitative analysis.	
3.	The use of complex compounds.	
4.	Application of redox reactions in the analysis of substances.	
5.	Analysis of substances by chromatography.	
6.	Application of thin layer chromatography in the analysis of drugs.	
7.	Identification of thiols. Modern optical methods.	
8.	Photometry: qualitative and quantitative analysis.	
9.	Modern electrochemical methods of analysis.	
10.	Combined physical and chemical methods of analysis.	
11.	Acid-base titration method. Quantitative determination of medicinal substances.	
12.	Precipitation titration method. Quantitative determination of medicinal substances.	
13.	Conductometry. Application of the method in pharmacy.	
14.	Iometry. Application of the method in pharmacy.	
15.	Voltammetry. Practical application of the method.	
16.	Luminescent analysis. Application of the method in pharmacy.	
17.	Methods for separating mixtures of substances.	
18.	Mass spectrometry.	
19.	Chromatographic methods for the identification and determination of substances in a mixture.	
20.	Methods of concentration of substances.	
21.	Extraction in analytics.	
22.	Application of organic reagents in analytical chemistry. Reactions based on the formation of complex compounds of metals.	
23.	Application of organic reagents in analytical chemistry. Reactions without the participation of complex metal compounds.	

7. Types of assessment formats for ongoing monitoring and mid-term assessment

№	Types	of	Name of section of
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	Semester No.	control	academic discipline	Competence codes		
					types	number of test questions
1.	3	Current monitoring	Reactions of cations of I-II analytical groups.	Current testing	3	16
				test or colloquium	3	16
				practical skills test	3	12
2.	3	Current monitoring	Reactions of cations of III-IV analytical groups.	Current testing	3	16
				test or colloquium	3	16
				practical skills test	3	12
3.	3	Current monitoring	Reactions of cations of V-VI analytical groups.	Current testing	3	16
				test or colloquium	3	16
				practical skills test	3	12
4.	3	Current monitoring	Anion reactions.	Current testing	3	16
				test or colloquium	3	16
				practical skills test	3	12
5.	3	Current monitoring	Qualitative analysis. The state of a substance in solution. Heterogeneous equilibrium.	Current testing.	5	15
6.	3	Current monitoring	Gravimetric method of analysis. Mathematical processing of results.	Current testing.	5	15
7.	3	Current monitoring	Fundamentals of titrimetry. Acid-base titration.	Current testing.	3	15
				practical skills test	2	5
8.	3	Current monitoring	Precipitation and compleximetric titration.	Current testing.	4	13
				practical skills test	2	5
9.	4	Current monitoring	Redox titration.	Current testing.	5	15
				practical skills test	2	5
10.	4	Current monitoring	Electrochemical methods of analysis.	Current testing.	4	15
				practical skills test	2	5
11.	4	Current monitoring	Photometric methods of analysis.	Current testing.	4	16
				practical skills test	2	5
12.	4	Current monitoring	Chromatographic methods of analysis.	Current testing.	4	8
				practical skills test	1	5
13.		Exam	All topics		12	60 (option is

	4					formed by random sampling)
				Exam cards	3	30

8. Educational, methodological and informational support for mastering the academic discipline (printed, electronic publications, the Internet and other network resources)

8.1. Key literature references

№	Name according to bibliographic requirements	Number of copies	
		at the department	at the department
1.	Watson, D. G. Pharmaceutical analysis : a textbook for pharmacy students and pharmaceutical chemists / D. G. Watson. – 5th ed. – Edinburgh : Elsevier, 2021. – VI, 462 p. : ill. – ISBN 978-0-7020-7808-8.	-	30
2.	Pedersen-Bjergaard S. Introduction to Pharmaceutical Analytical Chemistry / S. Pedersen-Bjergaard, B. Gammelgaard, T. G. Halvorsen. – 2nd ed. – [S. I.] : Wiley, 2019. – XXIII, 520 p. – ISBN 978-1-119-36272-2.	-	30
3.	Pharmaceutical Analysis for Small Molecules / ed. B. Davani. – [S. I.] : Wiley, 2017. – XXV, 229 p. – ISBN 978-1-119-12111-4.	-	2

8.2. Further reading:

8.3. Electronic educational resources for teaching academic subjects

8.3.1. Internal Electronic Library System of the University (IELSU)

№	Name of the electronic resource	Brief description (content)	Access conditions	Number of users

8.3.2. Electronic educational resources acquired by the University

№	Name of the electronic resource	Brief description (content)	Access conditions	Number of users
1.	International scientometric database "Web of Science Core Collection"	Web of Science covers materials on natural, technical, social, humanities; takes into account the mutual citation of publications developed and provided by Thomson Reuters; has built-in search, analysis and	Free access from PIMU computers [Electronic resource] - Access to the resource at: http://apps.webofknowledge.com	Free access from PIMU computers

		management of bibliographic information.		
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8.3.3 Open access resources

№	Name of the electronic resource	Brief description (content)	Access conditions
1.	Federal Electronic Medical Library (FEMB)	Includes electronic analogues of printed publications and original electronic publications that have no analogues recorded on other media (dissertations, abstracts, books, magazines, etc.). [Electronic resource] – Access mode: http://neb.pf/	from any computer on the Internet
2.	Scientific electronic library eLIBRARY.RU	The largest Russian information portal in the field of science, technology, medicine and education, containing abstracts and full texts of scientific articles and publications. [Electronic resource] - Access mode: https://elibrary.ru/	from any computer on the Internet
3.	Scientific electronic library of open access CyberLeninka	Full texts of scientific articles with annotations published in scientific journals in Russia and neighboring countries. [Electronic resource] - Access mode: https://cyberleninka.ru/	from any computer on the Internet

9. Material and technical support for mastering an academic discipline

9.1. List of premises for classroom activities for the discipline

1. Lecture hall equipped with multimedia equipment and a microphone.
2. Rooms for laboratory workshops.

9.2. List of equipment for classroom activities for the discipline

1. Multimedia complex (computer and projection equipment)
2. Information stands.

3. Tables and directories.
4. Slides and multimedia presentations of lectures.
5. Chemical glassware (burettes, pipettes, flasks, glass slides; chemical reagents).
6. Chemical reagents.
7. Hood.
8. Microscopes.
9. Spirit lamps.
10. Electric stoves.
11. Analytical balance.
12. Ionomers with a set of electrodes.
13. Photoelectrocolorimeters, spectrophotometers.
14. Centrifuge.
15. Water bath.
16. Test tube racks.
17. Reagent racks.
18. Magnetic stirrers.
19. Conductometer.
20. Chromatographic chamber.

9.3. A set of licensed and freely distributed software, including domestic production

Item no.	Software	number of licenses	Type of software	Manufacturer	Number in the unified register of Russian software	Contract No. and date
1	Wtware	100	Thin Client Operating System	Kovalev Andrey Alexandrovich	1960	2471/05-18 from 28.05.2018
2	MyOffice is Standard. A corporate user license for educational organizations, with no expiration date, with the right to receive updates for 1	220	Office Application	LLC "NEW CLOUD TECHNOLOGIES"	283	without limitation, with the right to receive updates for 1 year.

	year.					
3	LibreOffice		Office Application	The Document Foundation	Freely distributed software	
4	Windows 10 Education	700	Operating systems	Microsoft	Azure Dev Tools for Teaching Subscription	
5	Yandex. Browser		Browser	«Yandex»	3722	
6	Subscription to MS Office Pro for 170 PCs for FGBOU VO "PIMU" of the Ministry of Health of Russia	170	Office Application	Microsoft		23618/HN10030 LLC "Softline Trade" from 04.12.2020

10. List of changes to the working program (to be filled out by the template)

Position	Number and name of the program section	Contents of the changes made	Effective date of the changes	Contributor's signature
1				

Federal State Budgetary Educational Institution of Higher Education
 "Privolzhsky Research Medical University"
 Ministry of Health of the Russian Federation
 (FSBEI HE "PRMU" of the Ministry of Health of Russia)

Department of
General Chemistry

CHANGE REGISTRATION SHEET

working program for the academic discipline
Analytical Chemistry

Field of study / specialty / scientific specialty: 33.05.01 "PHARMACY"

Training profile: PHARMACIST

Mode of study: Full-time

Approved at the department meeting
Protocol No. 1, of August 26, 2021

Head of the Department
of General Chemistry,
Doctor of Chemistry, Professor Gordetsov A.S

/Gordetsov A.S./