


MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS
EDUCATIONAL INSTITUTION
BELARUSIAN STATE MEDICAL UNIVERSITY

Контрольный
экземпляр

APPROVED
by First Vice-Rector, Professor
I.N.Moroz
27.06.2023
Reg. # UD-L.687/2324/edu.



ANALYTICAL CHEMISTRY

Curriculum of educational institution
in the educational discipline for the specialty:

1-79 01 08 «Pharmacy»

Curriculum is based on the educational program «Analytical Chemistry», approved 01.07.2022, registration # УД-Л.687/2223/уч.; on the educational plan in the specialty 1-79 01 08 «Pharmacy», approved 17.05.2023, registration # 7-07-0912-01/2324/mf.

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Department Pharmaceutical Chemistry of the Educational Institution «Belarusian State Medical University»
(protocol # 10 of 19.05.2023);

by the Methodological Commission of Pharmaceutical Sciences of the Educational Institution «Belarusian State Medical University»
(protocol # 6 of 27.06.2023)

EXPLANATORY NOTE

«Analytical Chemistry» is an academic discipline of the «Chemical Module», containing systematized scientific knowledge about the principles and methods of determining the chemical composition and structure of substances.

The goal of the discipline «Analytical Chemistry» is the formation of basic professional competencies to obtain a high level of knowledge, skills, and abilities for the identification and quantification of medicines and other.

The objectives of the academic discipline «Analytical Chemistry» are to develop students' scientific knowledge about the theoretical foundations of chemical and instrumental methods of analysis to determine the qualitative and quantitative composition of objects, sampling and sample preparation, methods of concentration and separation; methodology for conducting qualitative and quantitative analysis; statistical processing of chemical analysis results; skills and abilities necessary for identification and quantification of various objects, including when monitoring the quality of medicines.

The knowledge, abilities and skills acquired in the study of the academic discipline «Analytical Chemistry» are necessary for the successful study of the following academic disciplines: «Pharmaceutical Chemistry», «Pharmacognosy», «Toxicological Chemistry», «Standardization of Drugs», «Biological chemistry», «Pharmaceutical Ecology».

A student who has mastered the content of the educational material of the academic discipline «Analytical Chemistry» should have the following basic professional competencies: apply knowledge of basic physical, chemical and biological laws to control the quality of medicines and medicinal plant materials.

As a result of studying the discipline «Analytical Chemistry» the student should

know:

basic concepts of analytical chemistry, the role and importance of analytical chemistry in pharmacy;

foundation of sampling, sample preparation and chemical analysis of samples;

basic methods of separation and concentration;

methods of preparation, standardization and storage of solutions, including titrated solutions;

theoretical foundations of methods for qualitative and quantitative analysis of the composition of substances;

construction of the main types of analytical equipment used in instrumental methods of analysis;

methods of statistical processing and presentation of chemical analysis results;

be able to:

choose the method, methodic and process of identification and quantification chemical substances, carry out all the necessary calculations

use the techniques and methods of working with chemical reagents and laboratory glassware necessary for qualitative and quantitative analysis;

work with the main types of analytical instruments used in the analysis;
 use the main types of analytical equipment used in chemical analysis;
 carry out identification and quantitative determination of substances by
 chemical and instrumental methods of analysis;

make statistical processing of chemical analysis results;

master:

methods of sampling and sample preparation, separation and concentration
 of substances;

skills in working with chemical glassware, chemical reagents, analytical
 equipment and other instruments used in the qualitative and quantitative analysis
 of various substances;

methods for performing qualitative and quantitative analysis of various
 objects;

skills in the preparation and standardization of chemical reagents, incl.
 titrated solutions;

technique for performing the analysis of substances using chemical and
 instrumental methods

Total number of hours for the study of the discipline is 408 academic
 hours. Classroom hours according to the types of studies: lectures - 40 hours
 (including 13 hours of supervised student independent work), laboratory studies -
 180 hours, student independent work (self-study) - 183 hours.

Intermediate assessment is carried out according to the syllabus of the
 specialty in the form of a credit (3 semester) and examination (4 semester).

Form of higher education – full-time.

ALLOCATION OF ACADEMIC TIME ACCORDING TO SEMESTERS OF STUDY

Code, name of the specialty	semester	Number of academic hours						Form of current assessment
		total	in-class	including		supervised independent work	out-of-class self-studies	
				lectures	laboratory studies			
1-79 01 08 «Pharmacy»	3	210	115	20	95	6,5	95	credit
	4	198	110	20	90	6,5	88	examination
		408	225	40	185	13	183	

THEMATIC PLAN

Section (topic) name	Number of class hours		
	lecture	laboratory	
1. Subject and task of analytical chemistry	1	5	
2. Chemical methods of inorganic substances detection	1		
3. Chemical methods of separation and concentration	1	5	
4. Sampling and sample preparation	1	10	
5. Analytical chemistry and chemical statistics	2	5	
6. Chemical equilibrium in analytical chemistry. Protolytic equilibrium	2	20	
6.1. Chemical equilibrium in analytical chemistry	1	5	
6.2. The main properties of solvent influencing on the acidic and basic properties of substance. The most important theories of acids and bases		5	
6.3. Calculation pH water solutions in which occur protolytic equilibrium. Acidic and basic buffer solutions		1	5
6.4. Analysis of unknown substances		-	5
7. Titrimetric methods of analysis. Main concepts and principles. Acid-base titration	2	15	
7.1. General characteristic of acid-base titration methods. Acid-base indicators. The main types of acid-base titration curves. Uncertainty of acid-base titration	-	5	
7.2. Titration of mixtures of acids or bases. Kjeldahl analysis	1	5	
7.3. Determination of ammonium salts. Titration in non-aqueous solutions	1	5	
8. Precipitation equilibria. Precipitation titration	2	5	
9. Argentometric determination of bromides and iodides	1	5	
10. Gravimetric method analysis	1	5	
11. Equilibria of a complex formation. Complex formation titration	2	5	
12. Complex formation titration	2	5	
13. Oxidation-reduction equilibria	2	10	
14. Oxidation-reduction titration methods	2	20	
14.1. General characteristic of oxidation-reduction titration methods. Iodometry titration. Chloriodometric titration	1	5	

Section (topic) name	Number of class hours	
	lecture	laboratory
14.2. Iodometry titration. Nitritometric titration	1	5
14.3. Permanganatometric titration. Chromatometric titration	-	5
14.4. Cerymetric titration. Bromatometric titration	-	5
15. Main characteristics of instrumental methods analysis	1	5
16. Spectroscopic methods of the analysis. Absorption spectroscopic methods of analysis	1	10
16.1. Atomic absorption methods of analysis. IR - spectrometry	1	5
16.2. Molecular absorption methods of analysis. UV – vis spectrometry	-	5
17. Emission spectroscopic analysis methods. Atomic emission spectroscopic analysis methods. Luminescent analysis	2	10
17.1. Atomic emission spectroscopic analysis methods	1	5
17.2. Molecular emission spectroscopy	1	5
18. Optical methods not related to the absorption or emission of energy	2	5
19. Chromatographic methods of analysis	6	20
19.1. General characteristic and theoretical bases of chromatographic methods of the analysis	2	5
19.2. Gas chromatography	1	5
19.3. Liquid chromatography	2	5
19.4. Chromatographic and mass-spectrometric hybrid analysis	1	5
20. Electrochemical methods of analysis	4	15
20.1. Main characteristic and classification of electrochemical methods of analysis. Conductometry Coulometric method of analysis. Potentiometric methods of analysis	2	10
20.2. Polarography. Voltamperometric methods of analysis	2	5
21. Radiometric methods of analysis	2	5
Total hours	40	185

CONTENT OF THE EDUCATIONAL MATERIAL

1. Subject and task of analytical chemistry

Analytical service. Main concepts of analytical chemistry: principle, method and analysis' technique. The kinds of analysis: the qualitative, quantitative, isotopic, molecular, functional phase. Analysis chemical, physical and instrumental.

A brief historical review of analytical chemistry development. Application of analytical chemistry methods in pharmacy.

2. Chemical methods of inorganic substances detection

The most important characteristics of analytical reaction (selectivity, detection limit). Systematic method of the analysis. Fractional method of the analysis. Elimination false positive test.

3. Chemical methods of separation and concentration

General characteristics and classification of methods of selection and concentration. Quantitative characteristics of measurement efficiency and concentration (measurement factor, concentration factor). Basic concepts used in the method of liquid extraction (extractant, extract, re-extraction, re-extract, re-extractant, extraction reagent, raffinate). Quantitative characteristics of the extraction content (extraction constant, distribution constant, distribution coefficient, single extraction degree, multiple extraction degree). Extraction systems, extractants and extractable compounds. Influence of various factors on the extraction process. Extraction methods. Application of extraction in analytical chemistry.

4. Sampling and sample preparation

Sample. Types of samples (general, average representative, laboratory, analyzed). Sampling of gases, liquids and solids, sample averaging. Causes of errors in sampling. Sample decomposition. «Dry» and «wet» methods of sample decomposition. Decomposition of the sample by dissolution (without a chemical reaction and with a chemical reaction), fusion and thermal decomposition. Undesirable processes occurring during the decomposition of the sample.

5. Analytical chemistry and chemical statistic

Approximate calculation and significant figures, the concept of the analytical signal. Methods for calculating the concentration of the substance in magnitude of the analytical signal. The uncertainty and measurement error

Definition of the analytical signal. Reference and non-reference methods of the quantitative analysis. Standard substances and standard samples. Calculating methods of substance concentration by magnitude of the analytical signal. «Measurement uncertainty» and «measurement error». Types of errors: systematic, random, outlier: rough, constant determinant error, indeterminate error. The sources determinant error.

Basic concepts of mathematical statistics used in analytical chemistry:

Main definitions of mathematical statistics methods used in analytical chemistry: random variable, distribution function of the random variable, the probability density of continuous random variable, normal distribution, sampling,

sample mean, sample variance, dispersion, the sample standard deviation, Student's t-test, the confidence interval. Statistical processing and presentation of the analysis results. Methods of rounding digits. The concept of significant figures. Detection of outlier. Basic characteristics of analytical methodic: limit of identification, limit of quantitation, reproducibility, accuracy. Comparison of reproducibility mean values of analysis results, correctness check. Calculation of substance concentration by means of magnitude of the analytical signal: the calibration curve method, standard method, additive method.

6. Chemical equilibrium in analytical chemistry. Protolytic equilibrium

6.1. Chemical equilibrium in analytical chemistry

Constant of chemical equilibrium. Types of the chemical equilibrium constants, used in analytical chemistry (thermodynamic, real and conditional, cumulative, stepwise). Deviations from ideality in solutions of strong electrolytes. Activity and activity coefficient. Ionic strength of solution. Dependence of the strong electrolyte activity on the ionic strength of solution. Debye- Hückel and Davies equations. General principles of calculation of equilibrium systems composition.

Overall and the equilibrium concentration, fraction of dissociating species in polyligand complexes. Equations of material balance and electroneutrality. The concept of equilibria graphic description.

6.2. The main properties of solvent influencing on the acidic and basic properties of substance. The most important theories of acids and bases

The main theories of acids and bases: Arrenius's theory, protolytic theory of Brensted-Lowri, Lewis theory. Quantitative description of acids and base strength (acid dissociation constant and base dissociation constant, dissociation constant of conjugate acid). P-function of acidity constant. Classification of solvents by their physical and chemical properties. Solvent autoprotolysis. Constant of autoprotolysis. The pH scale.

Influence of solvent on the acid-base properties of the solute. Protic and aprotic solvents. Classification of solvents on the acid-base properties and polarity. Autoprotolysis of solvent. Constant of autoprotolysis, self-ionization constant. Leveling and differential action of solvent. Strong and weak acids and bases. P-function of acidity.

6.3. Calculation pH water solutions in which occur protolytic equilibrium. Acidic and basic buffer solutions

Ph calculation of aqueous solutions of strong and weak acids and bases, several mixtures of strong and weak bases or its /and/ mixtures, ampholytes, several bases. Calculation of equilibrium mixture of protolytes composition at the given pH.

Acidic and basic buffer solutions. Main characteristic. The Henderson-Hasselbalch equation. Action principle. Buffer action, pH calculation of buffer solution. Buffer capacity.

6.4. Analysis of unknown substances

General characteristic and principles of systematic analysis by the acid-base method. Analytical reactions of cations detection. General characteristic and analytical classification on anions on solubility of barium and silver salts, on oxidation-reduction properties. Analytical reactions of anions detection. Preliminary tests in the analysis of anions.

7. Titrimetric methods of analysis. Main concepts and principles. Acid-base titration

7.1. General characteristic of acid-base titration methods. Acid-base indicators. The main types of acid-base titration curves. Uncertainty of acid-base titration

Main definitions of the titrimetric method of analysis: titration, titrant, titrand, equivalence point, final point of titration, indicator, titration curve, jump of titration, degree of titration. Requirements for reactions in titrimetry. Classification of the titrimetric analysis methods. Direct titration, reverse titration, back titration, displacement titration (indirect, titration, substitution titration).

Characteristics of volumetric glassware and prepare it for operation. Rules for working with volumetric glassware. Check a volume of glassware.

Titrimetric and standard substance in the titration methods of analysis. Quantitative composition of solutions. Calculations in titrimetric methods of analysis for preparation of solutions and titrimetric for titration.

Primary standard solution. Secondary standard solution.

7.2. Titration of mixtures of acids or bases. Kjeldahl analysis

Acid-base titration. Acidimetry and alcalimetry. Preparation and standardization of titrant solutions for acid-base titration. Main characteristics and classification of indicators. Acid-base indicators, pH transition range. Examples of acid-base indicators. The concept of titration curves. Degree of titration. Titration curves of a strong acid with a strong base and a strong base with a strong acid. Titration curves of a weak acid with a strong base and a weak base with strong acid. Systematic indicator error of acid-base titration. Random error of acid-base titration.

Titration of polyprotic acids and polyhydroxylic bases. Analysis of alkali metal hydroxide and carbonate mixture or alkali metal carbonate and bicarbonate mixtures. Methods for the titrimetric determination of ammonium salts. Determination of nitrogen in organic compounds by the method of Kjeldahl. Determination of boric acid.

7.3. Determination of ammonium salts. Titration in non-aqueous solutions

Titration in non-aqueous solutions. Criteria of solvent selection for the acid-base titration. Titration constant. Practical application of the non-aqueous acid-base titration analysis for determining of pharmaceutical weak acids and bases. Solvents, titrimetric, standard substance and indicators.

8. Precipitation equilibria. Precipitation titration

Constant of solubility (thermodynamic, real and conditional). Using the constant of solubility to determine the precipitation possibility. Solubility.

Relationship between ionic and molecular solubility of substance and the solubility constant.

9. Argentometric determination of bromides and iodides

The influence of various factors (the nature of the solute and solvent, temperature, ionic strength, presence of the same ion, side reactions) on the dissolution of weakly soluble electrolytes. Main principles of precipitates dissolution of weak slightly soluble electrolytes.

Characteristics of precipitated titration methods, their classification, requirements to the reactions.

Mercurimetry. The principle of method, titration conditions. Titrants. Detection of the titration end point. Practical application of mercurimetric titration in pharmacy.

Argentometry. Argentometric titration curves. Factors influencing the value of the titration jump. The methods of determination of the titration end point: the Mohr method, the Volhard method, the Fajans method. Titrants for the argentometric titration. Practical application of the argentometric titration in pharmacy.

10. Gravimetric method of analysis

Classification of gravimetric method of analysis. Precipitation and gravimetric forms. Main technique stages of gravimetric definition by sedimentation method.

The concept of the precipitation mechanism. The formation of primary nuclei. Relative supersaturation. Relative supersaturation and its influence on the type of primary precipitate. Colloidal state of substances, coagulation and peptization. The main processes leading to impurity of the precipitate, their causes and prevention.

Application of gravimetry in the pharmaceutical analysis.

11. Equilibria of a complex formation. Complex formation titration

Definition complexes. Classification of complex compound. Equilibrium in complexes compound solution.

Complex compounds. Main definitions. Classification of complex compounds. Equilibrium constants used for characterization of complex compounds: formation constant, dissociation constant, (overall or cumulative formation constant, stepwise formation constant. Kinetic stability of complex compounds.

Influence of various factors (type of central atom and ligands, temperature, ionic strength, side reactions) on the process of complex formation and stability of complex compounds. Effect of reactants concentrations on complexation. Calculation of every fraction of dissociating species in polyligand complexes. fraction of free - non complexes - metal ions and partial complexes in an equilibrium mixture. Average number of ligand per metal atom.

Application of organic reagents in analytical chemistry. Functional analytical group. Classification of organic reagent according to the type of donor atoms. Main organic reagents used in chemical analysis.

12. Complex formation titration

Main characterization and classification of complexometric titration methods. Mercurimetric titration (Mercurimetry)

Complex formation titration.

Mercurimetric titration. The principle of method, titration conditions. Titrant. End point of detection. Practical application of mercurimetric titration.

Complexometric titration. Method for detection of the titration end point. Способы обнаружения конечной точки титрования. Metallochromic indicators.

Intracomplex (chelate) compounds. Main characteristics of complexometric titration. Titrants for the complexometric titration. Disodium edetate (trilon B). Equilibrium in aqueous solutions of EDTA. Composition and stability of metal complexonates. Complexometric EDTA titration curves. Factors influencing the value of the titration jump. Methods for detection of the complexometric titration end point. Metallochromic indicators.. General characteristics, classification, interaction with metal ions, transition color interval of metallochromic indicators. Complexometric titration methods and its application in pharmaceutical analysis.

13. Oxidation-reduction equilibria

Oxidation-reduction reactions. Electrode potentials. Standard potential of half-reaction. Nernst equation. Formal potential of half-reaction. Equilibrium constant of oxidation-reduction reactions. The influence of various factors (temperature, type of ions in solution, pH, side reactions) on redox reactions.

14. Oxidation-reduction titration methods

14.1. General characteristic of oxidation-reduction titration methods.

Iodometry titration. Chloridometric titration

Method of oxidation-reduction titration. Requirements for reactions. Calculation of redox titration curves. Factors affecting the value of the jump of the titration. Detection of final-point redox titration. The oxidation-reduction indicators. Transition color interval of redox indicators. Examples of redox indicators. Systematic indicator error. Iodometric titration. Chloridometric titration Iodometry titration. Titration conditions. Titrants. Detection of the titration end point. Practical use of iodometric titration. Water detection by Carl Fisher's method. Detection of active chlorine. Determination of water contamination by the Karl Fischer method. Chloridometric titration. Titration condition. Titrants. Detection of the titration end point. Practical use of iodometric titration. Determination of the iodine index value.

14.2. Iodatometry titration. Nitritometric titration

Iodatometric titration. Titration conditions. Titrants. Detection of the titration end point. Practical use of iodatometric titration.

Nitritometric titration conditions. Titrants. Detection of the titration end point. Practical use of nitritometric titration.

Chromatometric titration. Titration conditions. Titrants. Detection of the titration end point. Practical use of chromatometric titration.

14.3. Permanganatometric titration. Chromatometric titration. Cerymetric titration

Permanganatometric titration. Titration condition. Titrants. Detection of the titration end point. Practical use of permanganatometric titration.

14.4. Cerymetric titration. Bromatometric titration

Bromatometric titration. Titration conditions. Titrants. Detection of the titration end point. Practical use of bromatometric titration.

Cerymetric titration. Titration conditions. Titrants. Detection of the titration end point. Practical use of cerymetric titration

15. Main characteristics of instrumental methods analysis. Spectroscopic methods of the analysis. The basic law of electromagnetic radiation absorption – the Beer-Lambert law

General characteristics of physical and physicochemical methods of analysis. Classification of physical and physicochemical methods of analysis. The basic law of electromagnetic radiation absorption – the Beer-Lambert law. The transmittance and absorbance. Molar and specific absorption coefficients and their use in analytical chemistry. The main properties of electromagnetic radiation. Classification of spectral methods of analysis. Limitation to Beer's law.

16. Spectroscopic methods of the analysis. Absorption spectroscopic methods of analysis

16.1. Atomic absorption methods of analysis. IR - spectrometry

Absorption spectroscopic methods of the analysis. Main concepts of atomic absorption spectroscopy. The processes leading to analytical signal. Detection of the analytical signal. Practical application of atomic absorption spectroscopy.

16.2. Molecular absorption methods of analysis. UV – vis spectrometry

Molecular adsorption spectroscopy in the ultraviolet and visible region. Analytical capabilities of the method. The processes leading to the appearance of the analytical signal. Detection of the analytical signal and its practical application. The main techniques used in spectroscopic analysis: direct, difference, and derivative spectrophotometry, multiwavelength photometric reaction, extraction photometry, photometric titration. IR-spectroscopy. The process leading to the analytical signal. Practical application of IR-spectroscopy.

17. Emission spectroscopic analysis methods. Atomic emission spectroscopic analysis methods. Luminescent analysis

17.1. Atomic emission spectroscopic analysis methods.

Atomic emission spectroscopy. Processes leading to the analytical signal. Detection of the analytical signal. Practical application of the atomic emission spectroscopic analysis.

17.2. Molecular emission spectroscopy.

Fluorescence and phosphorescence. Luminescent methods of the analysis, their classification and characteristics. Processes leading to appearance of the analytical signal. Influence of various factors on the intensity of the solutions luminescence. Working principle and construction of instruments used to measure the fluorescence. The main techniques used in fluorescent analysis methods.

18. Optical methods not related to the absorption or emission of energy

Unpolarized and light. Optical activity of chemical substances. Polarimetric method of concentration determination of optically active substances. Pharmaceutically application of Polarimetry.

Refraction and reflection electromagnetic radiation. Refraction indexes. Abbe refractometr .Application of refractometric measurements in analysis.

19. Chromatographic methods of analysis

19.1. General characteristic and theoretical bases of chromatographic methods of the analysis

The principle of the method. Classification of chromatographic methods. Chromatographic parameters of retention and separation. Methods of quantify chromatography (internal standard method, external standard, internal normalization.. Theory of column efficiency in chromatography: theoretical plates and kinetic theory (van Deemter equation).

19.2. Gas chromatography

Gas chromatography. General characteristics and classification of the gas chromatography methods. Main characteristic and principle of the gas chromatography operations. Gas-solid (adsorption) chromatography and gas-liquid chromatography. Characteristic of stationary and mobile phases and carrier gases. Practical application of chromatography.

19.3. Liquid chromatography

General characteristic and classification of liquid chromatography methods. Basic components and work principles of liquid chromatography. High performance liquid chromatography. Practical application of high performance liquid chromatography in pharmaceutical analysis.

19.4. Chromatographic and mass-spectrometric hybrid analysis

Size exclusion chromatography. The mechanism of separation, characteristics of used solvents and solid carriers.

Paper and thin-layer chromatography. Characteristic of stationary and mobile phases. Preparation procedure of thin-layer chromatogram. Analysis of thin-layer chromatographic plates. Practical application of thin-layer chromatography.

Ion exchange chromatography. Characteristic of stationary and mobile phases. Ion exchange equilibrium. Practical application of ion exchange chromatography.

Combined methods of analysis: mass-spectrometric hybrid analysis

20. Electrochemical methods of analysis

20.1. Main characteristic and classification of electrochemical methods of analysis. Conductometry

General characteristic and classification of electrochemical methods of analysis.. Electrode characteristics and working principle of electrochemical cell..

Conductometry.. Theoretical bases and classification. Measurement of an analytical signal. Practical application of direct conductometry. Conductometric titration. The principle of the method. Practical applications. The concept of high frequency conductometry. .

Main characteristic and classification of electrochemical methods of analysis .
Potentiometric and coulometric methods of analysis.

Potentiometric method of analysis. Potentiometric analysis. Principle of operation, classification and main characteristics of the ion-selective electrodes. Methods for determining of substance concentration by direct potentiometry. Potentiometric titration. The principle of the method. Detection of end point using the titration curve, there derivatives or by Gran's method. Practical application.

Coulometry. Main characteristics and classification. Direct coulometry. Measurement of the analytical signal. Practical use. Coulometric titration. The principle of the method. Measurement of the analytical signal. Practical application.

20.2. Polarography. Voltamperometric methods of analysis

General characteristic and classification. Voltammetric analysis. Polarography and actually amperometry. Conditions for voltammetric measurement. Polarographic curves. Polarographic wave. Half-wave potential. Residual current. Ilkovic's equation. Practical application of voltammetry. Modern voltammetric measurements. Amperometric titration. The principle of the method. Titration conditions. Practical use. Amperometric titration with two indicator electrodes.

21. Radiochemical methods of analysis

Main characteristic of radiometry. General characteristics of the method. The requirements in the radioactive tracer. Radiochemical titration. The use of radiochemical methods in pharmaceutical analysis.

ACADEMIC DISCIPLINE CURRICULAR CHART

No	Section (topic) name	Number of class hours				Self-studies	Form of control
		lectures (including supervised work)	supervised student work	independent work	laboratory classes		
3 semester							
1	Subject and tasks of analytical chemistry. Chemical methods of identification inorganic substances	1	0,5	5	5	discussion	
2	Chemical methods detection of the I-III cation and mixture of this cations	1	0,5	5	5	discussion	
3	Chemical methods of separation and concentration. Application of liquid-liquid extraction for the separation of substances reaction of cations of the IV analytical group	1	0,5	10	10	discussion, electronic tests, accounts of laboratory work	
4	Sampling and sample preparation	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work	
4.1	Analytical chemistry and chemical statistics Reaction of detection a mixture of the anions of the I- III analytical group	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work	
4.2	Control work #1. Identification of an unknown inorganic substance	2	0,5	5	5	discussion, electronic tests, accounts of laboratory work	
5	Sampling and sample preparation. Analytical chemistry and chemical statistics	2	1	20	20	discussion, electronic tests, accounts of laboratory work	
6	Chemical equilibrium in analytical chemistry	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work	
6.1	Reaction of cations of the V-VI analytical group	1	0,5	5	6	discussion, electronic tests, accounts of laboratory work	

6.2	Analysis of mixture of cations of the I-VI of analytical group				5	5	discussion, electronic tests, accounts of laboratory work
6.3	Reaction of anions of the I analytical group	1	0,5		5	5	discussion, electronic tests, accounts of laboratory work
6.4	Acidic and basic buffer solutions. Reaction of anions of the II- III analytical group	-	-		5	5	discussion, electronic tests, accounts of laboratory work
7.	Titrimetric methods of analysis. Main concepts and principles Acid-base titration	2	1		15	15	
7.1	Titrimetric methods of analysis. Main concepts and principles	-	-		5	5	discussion, electronic tests, accounts of laboratory work
7.2	General characteristic of acid-base titration methods. Acid-base indicators. The main types of acid-base titration curves. Uncertainty of acid-base titration. Titration of mixtures of acids or bases. Kjeldahl analysis	1	0,5		5	5	discussion, electronic tests, accounts of laboratory work
7.3.	Determination of ammonium salts. Titration in non-aqueous solutions	1	0,5		5	5	discussion, electronic tests, accounts of laboratory work
8.	Precipitation equilibria. Precipitation titration	2	0,5		5	5	discussion, electronic tests, accounts of laboratory work
9.	Argentometric determination of bromides and iodides	1	0,5		5	6	discussion, electronic tests, accounts of laboratory work
10.	Gravimetric method of the analysis. Detection of mass fraction of different crystallohydrates $MgSO_4 \cdot xH_2O$ in sample	1	-		5	5	discussion, electronic tests, accounts of laboratory work
11.	Equilibria of a complex formation. Complex formation titration	2	0,5		5	5	discussion, electronic tests, accounts of laboratory work
12.	Complex formation titration	2	0,5		5	5	discussion, electronic tests, accounts of laboratory work
13.	Oxidation-reduction equilibria	2	0,5		10	7	discussion, electronic tests, accounts of laboratory work electronic tests credit

4 semester						
Oxidation-reduction titration methods						
		2	1	20	22	
14.1.	General characteristic of oxidation-reduction titration methods	1	0,5	-	2	
	Iodometry titration	-	-	5	5	discussion, electronic tests, accounts of laboratory work
14.2.	Iodometry titration. Chlorimetric titration	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
14.3.	Nitritometric titration. Bromatometric titration.	-	-	5	5	discussion, electronic tests, accounts of laboratory work
14.4.	Chromatometric titration. Cerymetric titration. Bromatometric titration. Cerymetric titration.	-	-	5	5	discussion, electronic tests, accounts of laboratory work
15.	Control test N 4 «Titrimetric methods of analysis» Main characteristics of instrumental methods analysis. Spectroscopic methods of the analysis	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
16.	Optical methods of analysis. Molecular absorption methods of analysis. UV - vis spectrometry. IR - spectrometry	1	0,5	10	10	
16.1.	Atomic absorption methods of analysis. IR - spectrometry	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
16.2.	Molecular absorption methods of analysis. UV - vis spectrometry	-	-	5	5	discussion, electronic tests, accounts of laboratory work
17.	Emission spectroscopic analysis' methods. Atomic emission spectroscopic analysis methods. Luminescent analysis	2	1	10	10	
17.1.	Atomic emission spectroscopic analysis methods	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
17.2.	Molecular emission spectroscopy	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
18.	Optical methods not related to the absorption or emission of energy	2	0,5	5	5	discussion, electronic tests, accounts of laboratory work

19. Chromatographic methods of analysis		6	2	20	20	
19.1.	General characteristic and theoretical bases of chromatographic methods of the analysis	2	0,5	5	5	discussion, electronic tests, accounts of laboratory work
19.2.	Gas chromatography	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
19.3.	Liquid chromatography	2	0,5	5	5	discussion, electronic tests, accounts of laboratory work
19.4.	Chromatographic and mass-spectrometric hybrid analysis	1	0,5	5	5	discussion, electronic tests, accounts of laboratory work
20.	Electrochemical methods of analysis	4	0,5	15	10	
20.1.	Main characteristic and classification of electrochemical methods of analysis. Conductometry	2	0,5	10	5	discussion, electronic tests, accounts of laboratory work
20.2.	Polarography. Voltamperometric methods of analysis	2	0,5	5	5	discussion, electronic tests, accounts of laboratory work
21.	Radiometric methods of analysis	2	0,5	5	6	electronic tests, examination
		40	13	185		

INFORMATION AND INSTRUCTIONAL UNIT

LITERATURE

Basic:

1. Kharitonov, Y.Ya. Analytical chemistry. Analytics 1. General theoretical foundation. Quantitative analysis : textbook/Physical-chemical (instrumental) methods of analysis – Geotar-Media, 2021 - 602 p.
2. Kharitonov, Y.Ya. Analytical chemistry. Analytics 2. Quantative analysis/Physical-chemical (instrumental) methods of analysis – Geotar-Media, 2021 - 537 p.
3. Analytical chemistry : textbook [textbook for students of high school] / I.S.Grytsenko [и др.]; ed.by I.S.Grytsenko. – Kharkiv : National University of Pharmacy : Golden Pages, 2019. – 600 p.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

The time allotted for independent work can be used by students to:

- preparation for lectures, laboratory classes;
- preparation for tests and exams in the academic discipline;
- task solving;
- performing research and creative tasks;
- preparation of thematic reports, abstracts, presentations;
- compiling a review of scientific literature on a given topic;
- design of information and demonstration materials (stands, posters, graphs, tables, newspapers, etc.);
- compiling a thematic selection of literary sources and Internet sources;
- compiling tests for students to organize mutual control

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

Basic forms of organizing supervised independent work:

- writing and presentation of an abstract;
- giving a report;
- taking notes from primary sources (sections of anthologies, collections of documents, monographs, textbooks);
- computer testing.

Control of supervised independent work is carried out in the form of:

- final lesson in the form of an oral interview, written work, testing;
- discussions of abstracts;
- checking abstracts, written reports, reports, recipes;
- checking abstracts of primary sources, monographs and articles;
- individual consultation

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

Oral form:

discussion.

Written form:

accounts of laboratory work;
credits.

Technical form:

electronic tests;
electronic workshops (practicals).

Oral-written form:

exam.

LIST OF AVAILABLE TEACHING METHODS

Traditional method (lecture, laboratory practicals);

Active (interactive) methods:

training based on simulation technologies;

Problem-Based Learning (PBL);

Team-Based Learning (TBL);

Case-Based Learning (CBL);

Research-Based Learning (RBL).

LIST OF LECTURES

Semester 3

1. Subject and tasks of analytical chemistry. Chemical methods of identification inorganic substances.
2. Chemical methods detection of the I-III cation and mixture of this cations.
3. Chemical methods of separation and concentration. Application of liquid-liquid extraction for the separation of substances reaction of cations of the IV analytical group.
4. Analytical chemistry and chemical statistics. Reaction of detection a mixture of the anions of the I- III analytical group.
5. Sampling and sample preparation. Analytical chemistry and chemical statistics.
6. Reaction of cations of the V-VI analytical group.
7. Reaction of anions of the I analytical group.
8. General characteristic of acid-base titration methods. Acid-base indicators. The main types of acid-base titration curves. Uncertainty of acid-base titration. Titration of mixtures of acids or bases. Kjeldahl analysis.
9. Determination of ammonium salts. Titration in non-aqueous solutions.
10. Precipitation equilibria. Precipitation titration.
11. Argentometric determination of bromides and iodides.

12. Gravimetric method of the analysis. Detection of mass fraction of different crystallohydrates $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ in sample.
13. Equilibria of a complex formation. Complex formation titration.
14. Complex formation titration.
15. Oxidation-reduction equilibria.

Semester 4

1. General characteristic of oxidation-reduction titration methods.
2. Iodatometry titration. Cloriodometric titration Permanganatometric titration.
3. Main characteristics of instrumental methods analysis. Spectroscopic methods of the analysis.
4. Atomic absorption methods of analysis.
IR – spectrometry.
5. Atomic emission spectroscopic analysis methods.
6. Molecular emission spectroscopy.
7. Optical methods not related to the absorption or emission of energy.
8. General characteristic and theoretical bases of chromatographic methods of the analysis.
9. Gas chromatography.
10. Liquid chromatography.
11. Chromatographic and mass-spectrometric hybrid analysis.
12. Main characteristic and classification of electrochemical methods of analysis. Conductometry.
13. Polarography. Voltamperometric methods of analysis.
14. Radiometric methods of analysis.

LIST OF LABORATORY STUDIES

Semester 3

1. Subject and tasks of analytical chemistry. Chemical methods of identification inorganic substances.
2. Chemical methods of separation and concentration. Application of liquid-liquid extraction for the separation of substances reaction of cations of the IV analytical group.
3. Analytical chemistry and chemical statistics. Reaction of detection a mixture of the anions of the I- III analytical group.
4. Control work #1. Identification of an unknown inorganic substance.
5. Sampling and sample preparation. Analytical chemistry and chemical statistics.
6. Reaction of cations of the V-VI analytical group.
7. Acidic and basic buffer solutions. Reaction of anions of the II- III analytical group.
8. General characteristic of acid-base titration methods. Acid-base indicators. The main types of acid-base titration curves. Uncertainty of acid-base titration. Titration of mixtures of acids or bases. Kjeldahl analysis.
9. Determination of ammonium salts. Titration in non-aqueous solutions.

10. Precipitation equilibria. Precipitation titration.
11. Argentometric determination of bromides and iodides.
12. Gravimetric method of the analysis. Detection of mass fraction of different crystallohydrates $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ in sample.
13. Equilibria of a complex formation. Complex formation titration.
14. Complex formation titration.
15. Oxidation-reduction equilibria.

Semester 4

1. Iodometry titration.
2. Iodatometry titration. Cloriodometric titration Permanganatometric titration.
3. Nitritometric titration. Bromatometric titration. Chromatometric titration. Cerymetric titration.
4. Bromatometric titration. Cerymetric titration. Control test N 4 «Titrimetric methods of analysis».
5. **Main characteristics of instrumental methods analysis. Spectroscopic methods of the analysis.**
6. Atomic absorption methods of analysis.
IR – spectrometry.
7. Molecular absorption methods of analysis.
UV – vis spectrometry.
8. Atomic emission spectroscopic analysis methods.
9. Molecular emission spectroscopy.
10. Optical methods not related to the absorption or emission of energy.
11. General characteristic and theoretical bases of chromatographic methods of the analysis.
12. Gas chromatography.
13. Liquid chromatography.
14. Chromatographic and mass-spectrometric hybrid analysis.
15. Main characteristic and classification of electrochemical methods of analysis. Conductometry.
16. Polarography. Voltamperometric methods of analysis.
17. Radiometric methods of analysis.

**PROTOCOL OF THE CURRICULUM APPROVAL
BY OTHER DEPARTMENTS**

Title of the discipline requiring approval	Department	Amendments to the curriculum of the academic discipline	Decision of the department, which designed the curriculum (date, protocol)
Toxicological Chemistry	Pharmaceutical Chemistry	No amendments	protocol № 10 of 19.05.2023
Pharmaceutical Chemistry	Pharmaceutical Chemistry	No amendments	protocol № 10 of 19.05.2023
Pharmacognosy	Organization and economic of pharmacy	No amendments	protocol № 10 of 19.05.2023
Industrial technology of drugs	Pharmaceutical Technology	No amendments	protocol № 10 of 19.05.2023

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V.N. Belyatsky

Curriculum content, composition and the accompanying documents comply with the established requirements.

Dean of the Medical Faculty for
International Students of the
educational institution «Belarusian
State Medical University»

27.06.2023



O.S. Ishutin

Methodologist of the educational
institution «Belarusian State Medical
University»



S.V. Zaturanova