MINISTRY OF HEALTH OF UKRAINE

ODESA NATIONAL MEDICAL UNIVERSITY

Department of Medical Biology and Chemistry

CONFIRMED by

Vice-rector for scientific and pedagogical work

Eduard BURIACHKIVSKYI

September 1st, 2024

WORKING PROGRAM IN THE DISCIPLINE

"MEDICAL CHEMISTRY"

Level of higher education: second (master's degree)

Field of knowledge: 22 "Health care"

Specialty: 222 "Medicine"

Educational and professional program: Medicine

2024

The program is based on the educational-professional program " Medicine", training of the second (master's) level of higher education in the specialty 222 " Medicine " in the field of knowledge 22 "Health", approved by the Academic Council of ONMedUM (minutes No. 10 dated 27/06/2024).

Authors:
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The program was discussed at a meeting of the Department of Clinical Chemistry and Laboratory Diagnostics
Protocol № 1 dated 26.08.2024

Head of the Department _____ Gennady STEPANOV

Approved by the guarantor of
the educational and professional program _____ Valeriia MARICHEREDA

Approved by the Subject and Cyclical Methodological Commission on Medical and Biological Disciplines of ONMedU.

Protocol № 1 dated 27.08.2024

Head of the Subject Cycle Methodological Commission for Medical and Biological Disciplines at ONMedU

_____ Leonid GODLEVSKYI

Revised and approved at the meeting of _____

Protocol No.__ dated _____

Head of the department _____ _____

Revised and approved at the meeting of _____

Protocol No.__ dated _____

Head of the department _____ _____

1. Description of the discipline:

Name of indicators	Field of knowledge, specialty, specialization, level of higher education	Characteristics of the discipline
The total number of: Credits - 3.0 Hours - 90 Content sections - 2	Branch of knowledge 22 "Health care" Specialty 222 "Medicine" Level of higher education second (master's)	*Full-time education* *Mandatory discipline*
		Year of preparation: 1
		Semester I
		Lectures (14 hours)
		Seminars (0 hours)
		Practical classes (32 hours)
		Laboratory work (0 hours)
		Individual work (44 hours)
		Including individual tasks (0
		Form of final control – Differential credit test

2. The purpose and tasks of the educational discipline, competencies, program learning outcomes

Goal: Formation of higher education applicants' knowledge of the main types of chemical equilibrium for the formation of a holistic physico-chemical approach to the study of life processes, as well as be able to apply chemical methods of quantitative and qualitative analysis, be able to classify chemical properties and transformation of bioinorganic substances.

Task:

1. To teach higher education applicant basic chemical concepts, concepts, principles to understand and evaluate the physical and chemical processes of a living organism;
2. To reveal practical aspects of chemical experiments, ways and methods of using chemical research in medical practice;
3. To create a fundamental scientific basis for future doctors in understanding the general physical and chemical laws underlying the processes of human life.

The process of studying the discipline is aimed at forming elements of the following competencies:

- **Integral (IC):**
  The ability to solve typical and complex problems, including research and innovation in the field of medicine. Ability to continue learning with a high degree of autonomy.

• General competence (GC):

GC1. Ability to abstract thinking, analysis and synthesis
GC2. Ability to learn and master modern knowledge
GC3. Ability to apply knowledge in practical situations

GC4. Knowledge and understanding of the subject area and understanding of professional activities.

GC7 - Ability the ability to evaluate and ensure the quality of the work performed.

GC8 - The abilities are based on the basis of ethical considerations, social, responsible and conscientious.

GC11 - Ability to search, process and analyze information from various sources.

GC16 - The ability to evaluate and ensure the quality of the work performed.

GC17 - The desire to preserve the environment.

• Special competence (SC) are:

SC2. Ability to determine the necessary list of laboratory and instrumental studies and evaluate their results

SC23. Ability to develop and implement scientific and applied projects in the field of health care

SC24. Adherence to ethical principles when working with patients and laboratory animals

SC25. Adherence to professional and academic integrity, to be responsible for the reliability of the obtained scientific results

SC28. Ability to apply fundamental biomedical knowledge at a level sufficient to perform professional tasks in the field of health care.

• Program learning outcomes (PLO) are:

PLO 1. Have thorough knowledge of the structure of professional activity. To be able to carry out professional activities that require updating and integration of knowledge. To be responsible for professional development, the ability for further professional training with a high level of autonomy.

PLO 2. Understanding and knowledge of basic and clinical biomedical sciences, at a level sufficient for solving professional tasks in the field of health care.

PLO 21. Search for the necessary information in the professional literature and databases of other sources, analyze, evaluate and apply this information.

PLO 24. To organize the necessary level of individual safety (own and the persons he cares for) in case of typical dangerous situations in the individual field of activity.

As a result of studying the discipline the higher education applicant must:

Know:

• The relationship between the biological role of biogenic s–, p–, d– elements and the form of their presence in the body.

• Principles of structure of complex compounds.

• Features of the structure of complex compounds as a basis for their use in chelation therapy.

• Characteristics of the quantitative composition of solutions.

• Quantitative content in the solution of acids and bases using acid-base titration methods.

• The mechanism of action of buffer systems and their role in maintaining acid-base balance in biosystems.

• Relationship between colligative properties and solution concentration.

• Thermal effects of chemical and biochemical processes.

• Thermodynamic functions to assess the direction of processes, to explain the energy conjugation in living systems.

• Dependence of reaction rate on concentration and temperature.

• Conditions of formation and dissolution of sediments, to explain the role of heterogeneous equilibria with the participation of salts in the general homeostasis of the organism.
• The mechanism of formation of electrode potentials.
• Features of the structure of the surface layer of adsorbed molecules of surfactants, principles of structure of biological membranes.
• Adsorption equations and limits of their use.
• Regularities of adsorption of substances from solutions on a solid surface.
• Physico-chemical bases of methods of adsorption therapy.
• Principles of methods for obtaining and purifying colloidal dispersed solutions.
• Physico-chemical properties of proteins that are structural components of all body tissues.

Be able:

• Characterize the quantitative composition of solutions.
• Be able to prepare solutions with a given quantitative composition.
• Analyze the principles of titrimetric research methods.
• Analyze the quantitative content in the solution of acids and bases using acid-base titration methods.
• To draw conclusions about the acidity of biological fluids on the basis of hydrogen.
• Explain the mechanism of action of buffer systems and their role in maintaining acid-base balance in biosystems.
• Analyze the relationship between the colligative properties and the concentration of solutions.
• Interpret chemical and biochemical processes from the standpoint of their thermal effects.
• Be able to use thermodynamic functions to assess the direction of processes, to explain the energy conjugation in living systems
• Analyze the dependence of the reaction rate on concentration and temperature.
• Interpret the dependence of the reaction rate on the activation energy.
• Analyze the features of catalysts and explain the mechanism of homogeneous and heterogeneous catalysis.
• Explain the mechanism of action of enzymes and analyze the dependence of the rate of enzymatic processes on the concentration of enzyme and substrate.
• Analyze chemical equilibrium and explain its condition from the standpoint of thermodynamics and kinetics.
• Explain the influence of external factors on chemical equilibrium.
• Analyze the conditions of precipitation and dissolution of sediments, explain the role of heterogeneous equilibria with the participation of salts in the general homeostasis of the organism.
• Explain the mechanism of formation of electrode potentials.
• Analyze the principles of the method of potentiometry and draw conclusions about its use in medical and biological research.
• Be able to measure redox potentials and predict the direction of redox reactions.
• To draw conclusions about the surface activity of substances on the basis of their structure.
• Analyze the structure of the surface layer of adsorbed molecules of surfactants, explain the principles of structure of biological membranes.
• Analyze the adsorption equations and the limits of their use, distinguish between monomolecular and polymolecular adsorption.
• Interpret the laws of adsorption of substances from solutions on a solid surface.

• Explain the physicochemical basis of methods of adsorption therapy
• Distinguish selective and ion exchange adsorption of electrolytes.
• Interpret methods of chromatographic analysis and their role in medical and biological research.
• Analyze the principles of methods for obtaining and purifying colloidal dispersed solutions.
• Explain the physicochemical basis of hemodialysis.

3. The content of the educational discipline

Content module 1.

"Medical Significance of Biogenic Elements, Complex Compounds, Thermodynamics, and Kinetics"

Topic 1: Chemistry of Biogenic Elements. Chemical Elements in Living Organisms.

General information about nutrients Qualitative and quantitative content of nutrients in the human body. Macronutrients, micronutrients and impurities. Organogens. The concept of the teachings of V.I. Vernadsky on the biosphere and the role of living matter (living organisms). The relationship between the content of nutrients in the human body and their content in the environment. Endemic diseases, their connection with the features of biogeochemical provinces (areas with natural deficiency or excess of certain chemical elements in the lithosphere). Problems of pollution and purification of the biosphere from toxic compounds of man-made origin.

The contribution of the works of domestic scientists Vernadsky V.I., Vinogradov A.P., Kovalsky V.V., Venchikov A.I.. Babenko G.A., as well as foreign scientists E. Underwood, Schütte and others. in addressing the relationship between the nutritional role and physiological properties of chemical elements with the structure of atoms and their location in the periodic table.

Topic 2. Biological Role and Medical Applications of Biogenic s-, p-, and d-Elements. Qualitative Reactions for the Detection of s-, p-, and d-Elements.

The structure of atoms **s-, p-, d-** elements based on the position in the periodic table (PSE). Topography of s-elements in the human body and biological role. The use of derivatives of **s-, p-, d-** elements in medicine. Analytical reactions for the determination of ions of s-elements: (K^+, Mg^{2+}, Ba^{2+}, Ca^{2+}). Qualitative reactions to CO_3^{2-}, SO_4^{2-}, NO_2^-, $S_2O_3^{2-}$ ions.

Topic 3: Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds in Medicine.

Complexation reactions. A. Werner's coordination theory and modern ideas about the structure of complex compounds. The concept of complexing agent (central ion). Nature, coordination number, hybridization of complexing orbitals. The concept of ligands. Coordination capacity (dentance) of ligands. Internal and external spheres of complexes. Geometry of a complex ion. The nature of chemical bonds in complex compounds. Classification of complex compounds by the charge of the internal sphere and by the nature of ligands. Internally complex compounds. Polynuclear complexes. Chelation effect and strength of complexes of biometal cations with polydentate ligands. Metalloligand homeostasis and

metabolism. Causes of violations of metalloligand homeostasis. Toxicity of d-element cations and stability of complex compounds. Ferrum - , cobalt - , copper - and zinc-containing biocomplex compounds. Complexones and their use in medicine as antidotes for heavy metal poisoning (chelation therapy) and as antioxidants for the storage of medicinal products.

Topic 4. Basic concepts of chemical thermodynamics.

The subject of chemical thermodynamics. Basic concepts of chemical thermodynamics: thermodynamic system (isolated, closed, open, homogeneous, heterogeneous), state parameters (extensive, intensive), thermodynamic process (reversible, irreversible). Living organisms are open thermodynamic systems. Irreversibility of life processes.

The first law of thermodynamics. Enthalpy. Thermochemical equations. Standard heat of formation and combustion. Hess's law. Calorimetry method. Energy characteristics of biochemical processes. Thermochemical calculations to assess the caloric content of food and the preparation of rational and therapeutic diets.

Spontaneous and non-spontaneous processes. The second law of thermodynamics. Entropy. Thermodynamic potentials: Gibbs energy, Helmholtz energy. Thermodynamic equilibrium conditions. Criteria for the direction of spontaneous processes.

Application of the basic provisions of thermodynamics to living organisms. ATP as an energy source for biochemical reactions. Macroergic compounds. Energy conjugations in living systems: exergonic and endergonic processes in the body.

Topic 5. Physicochemical Foundations of Kinetics and Catalysis. Kinetics of Enzymatic Reactions. Application of Enzyme Preparations in Medicine.

Chemical kinetics as a basis for studying the rates and mechanism of biochemical reactions. Reaction rate. Dependence of reaction rate on concentration. The law of active masses for the reaction rate. Speed constant. The order of the reaction. Kinetic equations of first, second and zero order reactions. The half-life is a quantitative characteristic of changes in the concentration of radionuclides, pesticides, etc. in the environment. The concept of the reaction mechanism. Molecularity of the reaction.

Dependence of reaction rate on temperature. Vant-Goff's rule. Features of the temperature coefficient of the reaction rate for biochemical processes.

Activation energy. Theory of active collisions. Arrhenius equation. The concept of the theory of transition state (activated complex).

Representation of the kinetics of complex reactions: parallel, sequential, conjugate, reversible, competing, chain. The concept of antioxidants.

Free radical reactions in a living organism. Photochemical reactions, photosynthesis.

Catalysis and catalysts. Features of catalysts. Homogeneous, heterogeneous and microheterogeneous catalysis. Acid-base catalysis. Autocatalysis. The mechanism of action of catalysts. Promoters and catalytic poisons.

Representation of the kinetics of enzymatic reactions. Enzymes as biological catalysts. Features of enzyme action: selectivity, efficiency, dependence of enzymatic action on temperature and reaction of environment. The concept of the mechanism of action of enzymes. Dependence of the rate of enzymatic processes on the concentration of enzyme and substrate. Activation and inhibition of enzymes. Influence of ecological factors on the kinetics of enzymatic reactions.

Topic 6. Chemical Equilibrium. Influence of External Factors on the Shift of Chemical Equilibrium. Equilibrium in Heterogeneous Systems.

Chemical equilibrium. Chemical equilibrium constant and methods of its expression. Displacement of chemical equilibrium with changes in temperature, pressure, concentration of substances. Le Chatelier principle.

Precipitation and dissolution reactions. The product of solubility. Conditions for precipitation and dissolution of sediments. The role of heterogeneous equilibrium with the participation of salts in the general homeostasis of the organism.

Study of the effect of concentration and temperature on the shift of chemical equilibrium.

Topic 7. Electrochemistry and Electrochemical Methods of Investigation in Medicine.

The role of electrochemical phenomena in biological processes. Electrode potentials and the mechanism of their occurrence. Nernst's equation. Normal (standard) electrode potential. Normal hydrogen electrode. Measurement of electrode potentials. Determination electrodes and comparison electrodes. Silver chloride electrode. Ion-selective electrodes. Glass electrode. Galvanic cells.

Diffusion potential. Membrane potential. Biological role of diffusion and membrane potentials. Damage potential. The potential for peace. Action potential.

The role of redox reactions in life processes. Redox potential as a measure of oxidative and reductive capacity of systems. Peters equation. Normal redox potential. Prediction of the direction of redox reactions by the values of redox potentials. The equivalent of oxidant and reducing agent. The value of redox potentials in the mechanism of biological oxidation processes. Potentiometry. Potentiometric determination of pH, ion activity. Potentiometric titration.

Content Module 2

"Physicochemical Properties of Homogeneous and Heterogeneous Solutions"

Topic 8: Modern Concepts of Solutions. Quantities Characterizing the Qualitative Composition of Solutions.

Methods of quantitative analysis. Classification of methods of quantitative analysis. Indicators. The law of equivalents. Basic calculation formulas. The role of solutions in the life of organisms. Classification of solutions. The mechanism of dissolution processes. Thermodynamic approach to the dissolution process. Solubility of substances.

Solubility of gases in liquids. Dependence of gas solubility on pressure (Henry-Dalton's law), nature of gas and solvent, temperature. Influence of electrolytes on gas solubility (Sechenov's law). Solubility of gases in the blood. Bends.

Solubility of liquids and solids in liquids. The solubility depends on the temperature, the nature of the solute and the solvent. Distribution of substances between two non-displacing liquids. Nernst distribution law and its significance in the phenomenon of permeability of biological membranes.

Topic 9: Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids.

Electrolyte solutions. Electrolytes in the human body. Degree and constant of dissociation of weak electrolytes. Ostwald's law of breeding.

Properties of solutions of strong electrolytes. Activity and activity rate. Ionic strength of the solution. Water-electrolyte balance is a necessary condition for homeostasis. pH intervals for body fluids are normal and in pathology. Acidosis. Alkalosis. The role of electrolytes in life processes. Acid-base balance in electrolyte solutions. Determination of the constant and degree of dissociation of a weak electrolyte.

Dissociation of water. Ionic product of water. Hydrogen pH indicator. The theory of acids and bases of Arrhenius, the proteolytic theory of Brønsted and Lowry, the electronic theory of Lewis. Types of proteolytic reactions: reactions of neutralization, hydrolysis, ionization.

Topic 10: Colligative Properties of Dilute Solutions. Osmometry, Cryometry, Ebulliometry. The Role of Osmosis in Biological Systems.

Colligative properties of dilute solutions of non-electrolytes. The relative decrease in the saturated vapor pressure of the solvent over the solution. Raoul's law. Ideal solutions. Decrease in freezing point and increase in boiling point of solutions in comparison with solvents. Osmosis and osmotic pressure. Vant-Goff's law. Colligative properties of dilute electrolyte solutions. Isotonic coefficient. Hypo-, hyper- and isotonic solutions. Cryometry, ebuliometry, osmometry, their application in medical and biological research. The role of osmosis in biological systems. Osmotic pressure of blood plasma. Haller's equation. Oncotic pressure. Plasmolysis and hemolysis.

Topic 11: Buffer Solutions. Types of Buffer Systems and pH Calculation. Buffer Systems of the Body. Acid-Base Balance of the Body.

Buffer systems-conjugate acid-base pairs. Classification of buffer solutions. The mechanism of buffer action. Henderson - Hasselbach equation for calculating the pH of buffer systems of different types. Buffer capacity and its dependence on various factors.

Buffer capacity as a quantitative characteristic of the effectiveness of the buffer action. Blood buffer systems. Bicarbonate buffer, phosphate buffer. Protein buffer systems. The concept of acid-base state of blood. Acidosis. Alkalosis. Determination of buffer capacity.

Topic 12: Physicochemical Chemistry of Surface Phenomena. Adsorption at Phase Boundaries. Chromatography.

Surface phenomena and their significance in biology and medicine. Surface tension of liquids and solutions. Surface tension isotherm. Surfactants and surfactants. Surface activity. Duclos-Traube rule.

Adsorption at the liquid-gas and liquid-liquid interface. Gibbs equation.

Orientation of surfactant molecules in the surface layer. Representation of the structure of biological membranes. Adsorption at the solid-gas interface. Langmuir's equation. Adsorption from the solution on the surface of the solid. Physical and chemical adsorption. Regularities of adsorption of solutes, vapors and gases.Freundlich equation.

Physico-chemical bases of adsorption theory (hemosorption, plasma sorption, lymphosorption, enterosorption, application therapy). Immunosorbents.

Adsorption of electrolytes:specific (optional) and ion exchange. Panetta-Faience rule. Natural and synthetic ion exchangers. The role of adsorption and ion exchange in the vital processes of plants and organisms.

Chromatography. Classification of chromatographic methods of analysis on the basis of the physical state of the phases, technique and distribution mechanism. Adsorption, ion exchange and distribution chromatography. Application of chromatography in biology and medicine.

Topic 13: Physical Chemistry of Dispersed Systems. Classification and General Properties of Dispersed Systems.

The body as a complex set of dispersed systems. Classification of dispersed systems by degree of dispersion. Colloidal state. Lyophilic and lyophobic colloidal systems. The structure of colloidal particles. Double electric layer. Electrokinetic potential of colloidal particles.

Methods of obtaining and purifying colloidal solutions. Dialysis, electrodialysis, ultrafiltration, compensatory dialysis, vividialysis. Hemodialysis and the device "artificial kidney".

Molecular kinetic properties of colloidal systems. Brownian motion, diffusion, osmotic pressure. Optical properties of colloidal systems.

Electrokinetic phenomena. Electrophoresis. Helmholtz-Smoluchowski equation. Application of electrophoresis in research and clinical-laboratory practice. Electrophoregrams.

Kinetic (sedimentation) and aggregative stability of dispersed systems. Stability factors. Coagulation. The mechanism of coagulating action of electrolytes. Coagulation threshold. Schultze-Hardy rule. Mutual coagulation. Coagulation processes in the treatment of drinking water and wastewater. Colloidal protection.

Disperse systems with gaseous dispersion medium. Classification of aerosols, production methods and properties. Application of aerosols in clinical and sanitary practice. Toxic effects of some aerosols. Powders.

Coarsely dispersed systems with liquid dispersion medium. Suspensions,production methods and properties. Pastes, their medical use.

Emulsions, production methods and properties. Types of emulsions. Emulsifiers. The use of emulsions in clinical practice. Biological role of emulsification.

Semi-colloidal soaps, detergents. Micelle formation in solutions of semi-colloids. Obtaining sols by condensation method.

Topic 14: Macromolecules and Their Solutions.

High molecular weight compounds are the basis of living organisms. Globular and fibrillar structure of proteins. Comparative characteristics of solutions of high molecular weight compounds, true and colloidal solutions.

Swelling and dissolution of polymers. The mechanism of swelling. Effect of pH, temperature and electrolytes on swelling. The role of swelling in physiology. Dragging of IV solutions. The mechanism of drag. The effect of pH, temperature and electrolytes on the rate of drag. Thixotropy. Syneresis. Diffusion in the draglines. Drying of biopolymers from solutions. Coacervation and its role in biological systems.

Abnormal viscosity of IV solutions. Viscosity of blood. Donnan's membrane equilibrium.

Isoelectric state of protein. Isoelectric point and methods of its determination. Ionic state of biopolymers in aqueous solutions**.**

Topic 15: Nanochemistry in the Modern World.

Definition of Nanochemistry and Its Core Concepts. Types of Nanomaterials (Nanoparticles, Nanotubes, Nanoplastics, Graphene). Synthesis and Characterization of Nanomaterials.

Nanomaterials for Molecular Imaging and Early Disease Diagnosis.

Advantages and Limitations of Nanomaterials in Diagnostics. Targeted Drug Delivery Using Nanomaterials. Nanoparticles in Gene Therapy and Immunotherapy. Development and Use of Nanomaterials for Cancer Treatment and Cardiovascular Diseases.

Biocompatibility of Nanomaterials and Their Effects on Cells and Tissues.

Toxicity of Nanomaterials and Mechanisms of Their Metabolism in the Body.

Topic 16: Differential credit test.

4. The structure of the discipline

Topics	Number of hours					
	total	Including				
		lectures	**seminars**	**practical**	**laboratory**	**ISW**
Content module 1. Acid-base equilibria and complexation in biological fluids						
Topic 1: Chemistry of Biogenic Elements. Chemical Elements in Living Organisms.	5	1	0	2	0	2
Topic 2: Biological Role and Medical Applications of Biogenic s-, p-, and d-Elements. Qualitative Reactions for the Detection of s-, p-, and d-Elements.	5	1	0	2	0	2
Topic 3: Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds in Medicine.	6	2	0	2	0	2
Topic 4: Fundamentals of Chemical Thermodynamics and Bioenergetics.	6	2	0	2	0	2
Topic 5: Physicochemical Foundations of Kinetics and Catalysis. Kinetics of Enzymatic Reactions. Application of Enzyme	6	1	0	2	0	3

Preparations in Medicine.						
Topic 6: Chemical Equilibrium. Influence of External Factors on the Shift of Chemical Equilibrium. Equilibrium in Heterogeneous Systems.	6	1	0	2	0	3
Topic 7: Electrochemistry and Electrochemical Methods of Investigation in Medicine.	5	0	0	2	0	3
Total for content module 1	39	8	0	14	0	17
Content Module 2. Physicochemical Properties of Homogeneous and Heterogeneous Solutions						
Topic 8: Modern Concepts of Solutions. Quantities Characterizing the Qualitative Composition of Solutions.	5			2		3
Topic 9: Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids.	6	1	0	2	0	3
Topic 10: Colligative Properties of Dilute Solutions. Osmometry, Cryometry, Ebulliometry. The Role of Osmosis in Biological Systems.	5	0	0	2	0	3
Topic 11: Buffer Solutions. Types of Buffer Systems and pH Calculation. Buffer Systems of the Body. Acid-Base Balance of the Body.	6	1	0	2	0	3
Topic 12: Physicochemical Chemistry of Surface Phenomena. Adsorption at Phase Boundaries. Chromatography.	7	2	0	2	0	3
Topic 13: Physical Chemistry of Dispersed Systems. Classification and General Properties of Dispersed Systems.	6	2	0	2	0	2
Topic 14:	4	0	0	2	0	2

Macromolecules and Their Solutions.						
Topic 15: Nanochemistry in the Modern World.	4			2		2
Total for content module 2	43	6	0	16	0	21
Differential credit test.	8	0	0	2	0	6
Individual tasks	0	0	0	0	0	0
Hours in general	90	14	0	32	0	44

5.1. Topics of lectures

№ n \ n	**Topic**	Number of hours
Content module 1. Acid-base balances and complexation in biological fluids.		
1.	Chemistry and Medicine. Biogenic Elements and Their Role in Vital Processes.	2
2.	Complex Formation in Biological Fluids. Basics of Chelation Therapy.	2
3.	Chemical Thermodynamics and Theoretical Foundations of Bioenergetics	2
4.	Kinetic Patterns of Biochemical Processes	
Content Module 2: Physicochemical Properties of Homogeneous and Heterogeneous Solutions		
5.	Solutions. Acid-Base Equilibria in Biosystems	2
6.	Physicochemical Chemistry of Surface Phenomena. Basics of Adsorption Therapy. Chromatography	
7.	Dispersed Systems. Colloidal Solutions and Their Physicochemical Properties	2
	Hours in general	14

5.2. Themes of seminars

Seminars are not provided.

5.3. Topics of practical classes

№	**Topic**	Several. hours
1	Chemistry of Biogenic Elements. Chemical Elements in Living Organisms.	2
2	Biological Role and Medical Applications of Biogenic s-, p-, and d-Elements. Qualitative Reactions for the Detection of s-, p-, and d-Elements	2
3	Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds in Medicine	2
4	Fundamentals of Chemical Thermodynamics and Bioenergetics	2
5	Physicochemical Foundations of Kinetics and Catalysis. Kinetics of Enzymatic Reactions. Application of Enzyme Preparations in Medicine	2
6	Chemical Equilibrium. Influence of External Factors on the Shift of Chemical Equilibrium. Equilibrium in Heterogeneous Systems	2
7	Electrochemistry and Electrochemical Methods of Investigation in Medicine.	2
8	Modern Concepts of Solutions. Quantities Characterizing the Qualitative Composition of Solutions	2
9	Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids	2
10	Colligative Properties of Dilute Solutions. Osmometry, Cryometry, Ebulliometry.	2

	The Role of Osmosis in Biological Systems.	
11	Buffer Solutions. Types of Buffer Systems and pH Calculation. Buffer Systems of the Body. Acid-Base Balance of the Body	2
12	Physicochemical Chemistry of Surface Phenomena. Adsorption at Phase Boundaries. Chromatography	2
13	Physical Chemistry of Dispersed Systems. Classification and General Properties of Dispersed Systems	2
14	Macromolecules and Their Solutions	2
15	Nanochemistry in the Modern World	2
16	Differential credit test.	
	Hours in general	32

5.4. Topics of laboratory classes

Laboratory classes are not provided.

6. Independent work of a higher education applicant of higher education

№	Types of IWS	Hours
1.	Topic 1. Preparation for practical lesson 1	2
2.	Topic 2. Preparation for practical lesson 2	2
3.	Topic 3. Preparation for practical lesson 3	2
4.	Topic 4. Preparation for practical lesson 4	2
5.	Topic 5. Preparation for practical lesson 5	3
6.	Topic 6. Preparation for practical lesson 6	3
7.	Topic 7. Preparation for practical lesson 7	3
8.	Topic 8. Preparation for practical lesson 8	3
9.	Topic 9. Preparation for practical lesson 9	3
10.	Topic 10. Preparation for practical lesson 10	3
11.	Topic 11. Preparation for practical lesson 11	3
12.	Topic 12. Preparation for practical lesson 12	3
13.	Topic 13. Preparation for practical lesson 13	2
14.	Topic 14. Preparation for practical lesson 14	2
15.	Topic 15. Preparation for practical lesson 15	2
16.	Topic 16. Preparation for practical lesson 16	2
	Hours in general	**44**

7. Teaching methods

Lectures: lectures with the use of multimedia presentations.

Practical classes:
- verbal methods: conversation, explanation, discussion, discussion of problem situations;
- visual methods: illustration (including multimedia presentations).

Independent work: independent work with the recommended basic and additional literature, with electronic information resources, preparation for practical classes; independent solution of situational problems.

8. Forms of control and evaluation methods

(including criteria for evaluating learning outcomes)

Ongoing / current control: oral examination, assessment of practical skills, solving situational problems, assessment of activity in the classroom.

Final control: differentiated credit.

Assessment of current learning activities in practical classes:

1. Assessment of theoretical knowledge on the topic of the lesson:
- methods: questioning, solving a situational problem;
- maximum score - 5, minimum score - 3, unsatisfactory score - 2.
2. Assessment of practical skills on the topic of the lesson:
- methods: assessment of the correctness of practical skills
- maximum grade - 5, minimum grade - 3, unsatisfactory grade - 2;

The grade for one practical lesson is the arithmetic mean of all components and can only have an integer value (5, 4, 3, 2), which is rounded by the statistical method.

Criteria for ongoing assessment in the practical lesson:

Score	Assessment criterion
Excellent «5»	The higher education applicant is fluent in the material, takes an active part in the discussion and solution of the situational problem, confidently demonstrates practical skills in the interpretation of laboratory tests, expresses his opinion on the topic of the lesson.
Good «4»	The higher education applicant is well versed in the material, participates in the discussion and solution of the situational problem, demonstrates practical skills during and interpretation of laboratory tests with some errors, expresses his opinion on the topic of the lesson.
Satisfactory «3»	The higher education applicant does not have enough material, uncertainly participates in the discussion and solution of a situational problem with significant errors.
Unsatisfactory «2»	The higher education applicant does not have the material, does not participate in the discussion and solution of the situational problem, does not demonstrate practical skills.

The higher education applicant is admitted to the differential test provided that the requirements of the curriculum are met and if for the current academic activity he received at least 3.00 points.

The structure of the differential test

The content of the evaluated activity	Number
Answer to theoretical questions	2
Practical task	3
	5

Criteria for assessing the learning outcomes of higher education applicants in the exam:

Excellent «5»	Exhibited to a higher education applicant who worked systematically during the semester, showed during the differential test comprehensive and deep knowledge of the program material, is able to successfully perform the tasks provided by the program, mastered the content of basic and additional

	literature, realized the relationship of individual sections of the discipline, their importance for future profession , showed creative abilities in understanding and using educational material, showed the ability to independently update and replenish knowledge; level of competence - high (creative);
Good «4»	It is presented to a higher education applicant who has shown full knowledge of the curriculum, successfully performs the tasks provided by the program, mastered the basic literature recommended by the program, showed a sufficient level of knowledge of the discipline and is able to independently update and update during further study and professional activities; level of competence - sufficient (constructive-variable)
Satisfactory «3»	Exhibited to a higher education applicant who has shown knowledge of the basic curriculum in the amount necessary for further study and further work in the profession, copes with the tasks provided by the program, made some mistakes in answering the differential test and tasks, but has the necessary knowledge to overcoming mistakes; level of competence - average (reproductive)
Unsatisfactory «2»	Exposed to a higher education applicant who did not show sufficient knowledge of the basic curriculum, made fundamental mistakes in performing the tasks provided by the program, can not without the help of the teacher to use the knowledge in further study, failed to master the skills of independent work; level of competence - low (receptive-productive)

9. Distribution of points received by applicants for higher education

The obtained grade point average for the discipline for higher education applicants who have successfully completed the work programme of the discipline is converted from the traditional four-point scale to points on a 200-point scale, as shown in the table:

Conversion table of traditional to multi-point:

National score for the discipline	The sum of scores for the discipline
Excellent («5»)	185 – 200
Good («4»)	151 – 184
Satisfactory («3»)	120 – 150
Unsatisfactory («2»)	Less than 120

A multi-point scale (200-point scale) characterises the actual performance of each higher education applicant in mastering the educational component. The conversion of the traditional grade (grade point average) into a 200-point scale is carried out by the University's Information Technology Department.

According to the points obtained on a 200-point scale, the achievements of applicants are assessed according to the ECTS rating scale. Further ranking according to the ECTS rating scale allows to evaluate the achievements of applicants in the educational component, who study in the same course of one speciality, according to the points they received.

The ECTS scale is a relative and comparative rating scale that establishes the applicant's belonging to the group of the best or worst among the reference group of fellow higher education applicants (faculty, speciality). Grade A on the ECTS scale cannot be equal to grade A, and grade B cannot be equal to grade B, etc. When converting from a multi-point

scale, the limits of grades "A", "B", "C", "D", "E" on the ECTS scale do not coincide with the limits of grades "5", "4", "3" on the traditional scale. Applicants who have received grades "FX" and "F" ("2") are not included in the list of ranked applicants. The grade "FX" is assigned to higher education applicants who have scored the minimum number of points for the current learning activities, but who are not credited with the final control. The grade "F" is assigned to applicants who have attended all classes in the discipline, but have not gained an average score (3.00) for the current academic activity and are not allowed to take the final control.

Applicants studying in the same course (one speciality), based on the number of points gained in the discipline, are ranked on the ECTS scale as follows:

Assessment on the ECTS scale	Statistical indicator
A	The best 10% of higher education applicants
B	The next 25% of higher education applicants
C	The next 30% of higher education applicants
D	The next 25% of higher education applicants
E	The next 10% of higher education applicants

10. Methodical support:

- Working program of the discipline
- The syllabus of the discipline
- Multimedia presentations
- Situational tasks (including calculation)
- Methodical development of practical classes.

Educational and methodical literature:

1. Chemical thermodynamics. Theoretical principles of bioenergetics : Educational and methodical manual / A. O. Shyrykalova, T. A. Sidelnykova, K. V. Bevziuk. – Odessa : Astroprint, 2018. — 48 p.

2. Theoretical principles of chemical kinetics. Catalysis : educational and methodical manual / A. O. Shyrykalova, A. V. Grekova, T. A. Sidelnykova. — Odessa : Astroprint, 2019. — 44 p

3. Mironovich L. M. Medical chemistry: textbook. manual / L. M. Mironovich, O. O. Mardashko. - K.: Каравела, 2007. – 168 p.

11. List of questions to the differential test

1. Concept of Biogenic Elements. Classification of Biogenic Elements. Organogens.
2. Classification of Biogenic Elements Based on the Electron Configuration of s-, p-, and d-Block Elements. Electron Configuration, Topography of Elements in the Human Body. Qualitative Reactions for Identifying cations and anions of s-, p-, and d-Elements.
3. Solubility Product. Hydrolysis of Salts.
4. Werner's Coordination Theory and Modern Concepts of Complex Compound Structures. Biological Role of Complex Compounds.
5. Classification, Nomenclature, and Isomerism of Complex Compounds. Structure of Complex Compounds. Intracomplex Compounds and Chelates. Their Medical Significance and Applications.
6. Chemical Thermodynamics and Bioenergetics. Thermodynamic Systems and the Surrounding Environment. Types and Properties of Systems.

7. Thermodynamic Process. State Functions of Systems. First Law of Thermodynamics. Thermochemistry. Hess's Law. Application of Thermochemical Calculations for the Energy Characterization of Biochemical Processes.

8. Second and Third Laws of Thermodynamics.

9. Characteristic State Functions and Thermodynamic Potentials. Gibbs-Helmholtz Equation and Its Applications in Bioenergetics. Criteria for the Direction and Limit of Spontaneous Processes in an Isolated System.

10. Reaction Rate, Methods of Expression. Rate Constant. Factors Affecting the Rate of Chemical Reactions. Molecularity and Order of Reaction. Half-Life Period.

11. Homogeneous and Heterogeneous Catalysis. Enzymatic Biochemical Processes. Factors Affecting Their Rate. Chemical Catalysts and Enzymes: Similarities and Differences.

12. Kinetics of Complex Reactions (Parallel, Sequential, Combined, Chain, Photochemical). Examples of Complex Reactions Occurring in the Body.

13. Thermodynamic Criteria for Chemical Equilibrium. Le Chatelier's Principle. Factors Affecting the Shift in Chemical Equilibrium.

14. Mechanism of Electrode Potential Formation. Electrode Potentials. Nernst Equation for Calculating Electrode Potentials.

15. Classification of Electrodes. Types of Galvanic Cells. Electrochemical Processes in Biological Systems. Potentiometry in Medicine.

16. Oxidation-Reduction Processes in Biological Systems. Oxidation-Reduction Electrodes. Electron Transport in the Mitochondrial Respiratory Chain.

17. Diffusion and Membrane Potentials. Bioelectric Potentials.

18. Solubility of Substances. Factors Affecting Solubility.

19. Methods of Expressing Solution Composition and Concentration. Types of Concentration.

20. Role of Solutions in Nature and Living Organisms. Biological Role of Solutions. Hydrates, Crystallohydrates, Crystal Water. Medical Solutions.

21. Electrolytic Dissociation Theories. Ostwald's Dilution Law. Water. Dissociation of Water. Ionic Product of Water.

22. Hydrogen Ion Concentration. pH Scale. pH Values for Different Biological Fluids in Normal Conditions. Methods for Measuring pH. Acid-Base Disorders in the Body. Alkalosis and Acidosis.

23. Colligative Properties of Solutions: Vapor Pressure, Raoult's Law, Diffusion, Fick's Law, Osmosis, and Osmotic Pressure. Van 't Hoff's Law.

24. Colligative Properties of Electrolytes and Nonelectrolytes. Differences and Specificities. Formulas for Calculations.

25. Role of Osmosis in Biological Systems and Classification of Solutions by Osmotic Pressure. Isotonic, Hypertonic, and Hypotonic Solutions. Oncotic Pressure. Plasmolysis, Hemolysis. Cryometry, Ebulliometry, Osmometry and Their Applications in Medicine.

26. Main Types of Buffer Systems, Their Chemical Composition and Classification. Buffer Systems of Blood.

27. Buffer Action. Mechanism of Buffer Systems. Factors Affecting the pH of Buffer Systems. Formulas for Buffer System pH Calculation.

28. Quantitative Characteristics of Buffer Systems. Buffer Capacity and Factors Affecting It. Calculation of Buffer Capacity. Disruption of Acid-Base Balance in Blood.

29. Surface Phenomena. Surface Energy. Surface Tension of Liquids. Surface Activity. Factors Affecting Surface Tension.

30. Surfactants, SIC, SNC. Orientation of Surfactant Molecules in the Surface Layer. Structure and Classification of Surfactants.

31. Types of Adsorption. Adsorption at the Gas-Liquid and Liquid-Liquid Interfaces. Gibbs Adsorption.

32. Adsorption at the Gas-Solid, Solid-Liquid Interfaces: Mechanism and Patterns. Langmuir Adsorption Isotherm. Freundlich Isotherm. Structure of Biological Membranes.

33. Biological Role of Adsorption in Medical Practice. Fundamentals of Adsorptive Therapy. Role of Adsorption and Ion Exchange in Biological Processes. Adsorption Methods in Efferent Therapy.

34. Adsorption of Electrolytes. Selective Adsorption. Ion Exchange Adsorption. Specifics of Ion Adsorption.

35. Chromatography. Classification of Chromatographic Methods. Application of Chromatography in Biology and Medicine. Examples.

36. General Characteristics and Classification of Dispersed Systems.

37. Physical and Chemical Methods for Obtaining Colloidal Systems. Structure of Micelles.

38. Methods for Purifying Colloidal Solutions: Dialysis, Electrodialysis, Ultrafiltration, etc.

39. Optical, Molecular-Kinetic, and Electrical Properties of Dispersed Systems.

40. Kinetic and Aggregative Stability of Colloidal Systems. Mechanism of Electrolyte Coagulation Action. Schulze-Hardy Rule. "Colloidal Protection" Phenomenon.

41. Types of Dispersed Systems. Ultramicroscopic Heterogeneous and Coarse Dispersed Systems.

42. Polymer Solutions. Similarities and Differences between Polymer Solutions and Sols. Swelling and Dissolution of Polymers. Mechanism of Swelling. Stages of Swelling.

43. Proteins as Natural Polymers. Effect of pH on Swelling and Dissolution of Proteins. Isoelectric State of Proteins.

44. Classification of Nano-Objects. Methods of Synthesis and Properties of Nanoparticles.

45. Chemical Properties of Nanoparticles. Carbon Nanomaterials.

46. Nanoparticles and Medicine. Fullerenes. Toxicity of Nanoparticles.

12. Recommended literature

Basic literature:

1. Medical Chemistry: textbook / V.Y. Tsuber, A.A. Kotvytska, K.V. Tykhonovych et al. - – Kyiv, AUS Medicine Publishing, 2022. – 392 p.

2. Medical chemistry: a textbook for universities / V. O. Kalibabchuk, I. S. Chekman, V. I. Galynska and others; for ed. Prof. V. O. Kalibabchuk – 4th ed. – K. VSV "Medicine", 2019 – 336 p.

3. Medical chemistry / V.O. Kalibabchuk, V.I. Halynska, L.I. Hryshchenko et al. – Kyiv, AUS Medicine Publishing, 2020. – 224 p.

4. General and Inorganic Chemistry: textbook / V.O. Kalibabchuk, V.V. Ohurtsov, V.I. Halynska et al. – Kyiv, AUS Medicine Publishing, 2019. – 456 p.

Additional literature:

1. Medical chemistry: a textbook / V. P. Muzychenko, D. D. Lutsevich, L. P. Yavorska; for order. B. S. Zimenkovsky. – 3rd ed., Ed. – K.: BCB «Medicine», 2018. – 496 p.

2. Mironovich L. M. Medical Chemistry: A Textbook. – Kyiv: Karavella, 2008. – 159 p.

3. Moroz A. S. Medical chemistry: a textbook / D. D. Lutsevich, L. P. Yavorska. – Vinnytsia: New book, 2006. – 776 p.

4. Gotsulyak L. O., Mardashko O. O., Yerigova S. G., Kuzmenko G. I., Kuzmina A. V., Zhilinskaya K. I. Bioinorganic, physicoloid and bioorganic chemistry. Teaching. manual. Odessa. Odessa State Medical University 1999. – 248 p.

5. Textbook of Medicinal Chemistry / V. Alagarsamy // CBS Publishers & Distributors Pvt Ltd, India; 3rd edition, 2018 – 584 p.

6. Richard Post. Chemistry: Concepts and Problems / Richard Post, Chad Snyder, Clifford C. Houk // A Self-Teaching Guide, Jossey-Bass, 2020. – 432 p.
7. Darrell D. Ebbing. General Chemistry / Darrell D. Ebbing, Steven D. Gammon. – Boston: Cengage Learnin, 2017. – 1190 c. – (Eleventh Edition).

13. Electronic information resources

1. http://moz.gov.ua - Ministry of Health of Ukraine
2. www.who.int - World Health Organization
3. www.dec.gov.ua/mtd/home/ - State Expert Center of the Ministry of Health of Ukraine
4. http://bma.org.uk - British Medical Association
5. www.gmc-uk.org - General Medical Council (GMC)
6. www.bundesaerztekammer.de - German Medical Association