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: 221 «Dentistry»

Educational and professional program: Dentistry

2024

The working program is compiled on the basis of the educational and professional program "Dentistry" for the training of specialists of the second (master's) level of higher education in the specialty 221 "Dentistry" of the field of knowledge 22 "Health care", approved by the Academic Council of ONMedU (minutes No. 10 dated 27/06/2024).

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The working program is approved at the meeting of the department of Medical Biology and Chemistry
Minutes No._1_ dated_____26.08.2024_____

Head of the department _____ Hennadii STEPANOV

Approved by the guarantor of

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Approved by the subject-cycle methodological commission for Biomedical Sciences of ONMedU
Minutes No._1_ dated ___27.08.2024__

Head of the subject-cycle methodological commission for
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Revised and approved at the meeting of _____
Minutes No.__ dated _____

Head of the department _____

Revised and approved at the meeting of _____
Minutes 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 221 "Dentistry" Level of higher education second (master's)	*Full-time education* *Mandatory discipline*
		Year of preparation: 1
		Semester I
		Lectures (8 hours)
		Seminars (0 hours)
		Practical classes (48 hours)
		Laboratory work (0 hours)
		Individual work (34 hours)
		Including individual tasks (0 hours)
		Form of final control – Differential credit test

2. The purpose and objectives of the discipline

Goal: on the basis of modern achievements, to systematize knowledge of the most important theoretical generalizations of chemistry, to learn to actively apply this knowledge to reveal the physico-chemical essence of phenomena that occur in a living organism in normal and pathological changes, as well as when the body is affected by environmental, chemo- and physiotherapeutic factors means.

Task: Creating a fundamental scientific base of future doctors in their understanding of the general physical and chemical laws that underlie the processes of human life.

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

• Integral competence (IC):

- IC – The ability to solve typical and complex specialized tasks and problems in the field of health care in the specialty "Dentistry", in professional activity or in the learning process, which involves conducting research and/or implementing innovations and is characterized by the complexity and uncertainty of conditions and requirements

• General competence (GC):

GC1. Ability to abstract thinking, analysis and synthesis.
GC3. Ability to apply knowledge in practical activities.
GC12. The desire to preserve the environment.1. Ability to abstract thinking, analysis and synthesis.

• Professional competences of the specialty (PC):

FC2. Ability to interpret the results of laboratory and instrumental research.

• Program learning outcomes (PLO)

PLO2. Collect information about the patient's general condition, evaluate the patient's psychomotor and physical development, the condition of the maxillofacial organs, evaluate information based on the results of laboratory and instrumental studies regarding the diagnosis (according to box 5).
PLO3. To prescribe and analyse additional (mandatory and optional) examination methods (laboratory, radiological, functional and/or instrumental) according to the list 5, patients with diseases of organs and tissues of the oral cavity and maxillofacial region for differential diagnosis of diseases (according to the list 2).
PLO20. To organise the necessary level of individual safety (own and persons under care) in case of typical dangerous situations in the individual field of activity

Expected learning outcomes. 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.
• Interpret the physicochemical properties of proteins that are structural components of all body tissues.
• Draw conclusions about the charge of dissolved biopolymers based on their isoelectric point.

3. The content of the 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 biogenic elements Qualitative and quantitative content of biogenic elements in the human body. Macronutrients, trace elements and impurity elements. Organogens. The concept of Vernadsky's doctrine of the biosphere and the role of living matter (living organisms). The relationship between the content of biogenic elements in the human body and their content in the environment. Endemic diseases, their connection with the peculiarities of biogeochemical provinces (areas with a natural deficit 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, Schutte and others in solving the issues of connection between the biogenic role and physiological properties of chemical elements with the structure of atoms and their location in the periodic table.

Topic 2. Typical chemical properties, biological role and application in medicine of biogenic s-elements. Qualitative reactions for the determination of s-elements.

The structure of atoms of s elements based on their position in the periodic table of elements (PTE). Forms of compounds of s elements. Topography of s - elements in the human body and biological role. Application of s-elements derivatives in medicine. Analytical reactions for the determination of s-elements ions: (K^+, Mg^{2+}, Ba^{2+}, Ca^{2+}). The relationship between the location of s - elements in the periodic table and their content in the body.

Topic 3: Chemical properties and biological role of biogenic p - elements. Qualitative reactions for the determination of p - elements.

Electronic configuration of p - elements atoms. Forms of compounds of p - elements. Acid-base properties of p - element compounds. Amphotericity. Redox reactions involving p - elements. Topography of p - elements in the human body, participation in vital processes. Chemical properties of p - elements. Application in medicine. Toxic effect of compounds. Qualitative reactions to ions CO_3^{2-}, SO_4^{2-}, NO_2^-, $S_2O_3^{2-}$.

Topic 4. General characteristics of biogenic d - elements. Redox properties of compounds of d - elements.

Metals of life. Electronic structure and electronegativity of d - elements. Typical chemical properties of d - elements and their compounds (reactions with a change in the degree of oxidation). Types of redox reactions (intermolecular, intramolecular, disproportionation reactions). Methods for determining the coefficients of redox reactions. Effect of pH on the properties of oxidizing agents and reducing agents.

Topic 5. Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds in Medicine.

Complexation reactions. Coordination theory of A. Werner and modern ideas about the structure of complex compounds. The concept of a complexing agent (central ion). Nature, coordination number, hybridization of complexing orbitals. The concept of ligands. Coordination capacity (dentativity) of ligands. Internal and external spheres of complexes. Geometry of the complex ion. The nature of chemical bonding in complex compounds. Classification of complex compounds according to the charge of the inner sphere and the

nature of the ligands. Intrinsically complex compounds. Polyunit complexes. Chelating effect and strength of complexes of biometal cations with polydentate ligands. Metal-ligand homeostasis and metabolism. Causes of disorders of metal-ligand homeostasis. Toxicity of d-element cations and stability of complex compounds. Ferro-, cobalt-, copper- and zinc-containing biocomplex compounds. Complexes and their use in medicine as antidotes for heavy metal poisoning (chelation therapy) and as antioxidants for the storage of drugs.

Topic 6. Biological role and application in medicine of d - elements. Qualitative reactions for the determination of d - elements.

Biological role of d - elements. Topography of d - elements in the human body. Application in medicine. Toxic effect of d - elements and their compounds. Qualitative reactions to ions MnO_4^-, Fe^{3+}, Fe^{2+}, Cu^+, Cu^{2+}, Ag^+, Cr^{3+}.

Topic 7: Basic concepts of chemical thermodynamics. Theoretical foundations of bioenergy. The first law of thermodynamics. Thermochemistry. Hess's law.

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 vital processes.

The first law of thermodynamics. Enthalpy. Thermochemical equations. Standard heats of formation and combustion. Hess's law. The method of calorimetry. Energy characterization of biochemical processes. Thermochemical calculations for assessing the caloric content of food and the preparation of rational and therapeutic diets.

Topic 8. The second law of thermodynamics. Thermodynamic potentials.

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

Application of the basic principles of thermodynamics to living organisms. ATP as a source of energy for biochemical reactions. Macroergic compounds. Energy conjugation in living systems: exergonic and endergonic processes in the body.Topic 10. Physico-chemical foundations of kinetics of biochemical reactions. Kinetics of complex reactions. Catalysis. Features of enzymes.

Chemical kinetics as a basis for studying the rates and mechanism of biochemical reactions. Insights into the kinetics of enzymatic reactions. Enzymes as biological catalysts.

Topic 9: Physical and chemical bases of biochemical reaction kinetics. Kinetics of Enzyme Reactions

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

Dependence of the reaction rate on temperature. The Van't Hoff rule. Features of the temperature coefficient of reaction rate for biochemical processes.

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

Topic 10: Kinetics of complex reactions. Catalysis. Features of the action of enzymes.

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

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

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

Concept of the kinetics of enzymatic reactions. Enzymes as biological catalysts.

Topic 11. Chemical Equilibrium. The Effect of External Factors on Shifts in Chemical Equilibrium. Equilibrium in Heterogeneous Systems.

Chemical equilibrium. The equilibrium constant and its expressions. Shifts in chemical equilibrium with changes in temperature, pressure, and concentration of substances. Le Chatelier's Principle.

Precipitation and dissolution reactions. Solubility product. Conditions for precipitation and dissolution of salts. The role of heterogeneous equilibrium involving salts in the overall homeostasis of the organism.

Studying the effects of concentration and temperature on shifts in chemical equilibrium.

Topic 12. Electrochemistry and Electrochemical Methods of Analysis.

The role of electrochemical phenomena in biological processes. Electrode potentials and their mechanisms of formation. The Nernst Equation. Standard electrode potential. The standard hydrogen electrode. Measurement of electrode potentials. Reference electrodes and comparison electrodes. Silver-chloride electrode. Ion-selective electrodes. Glass electrode. Galvanic cells.

Diffusion potential. Membrane potential. The biological role of diffusion and membrane potentials. Damage potential. Resting potential. Action potential.

The role of redox reactions in vital processes. Redox potential as a measure of the oxidizing and reducing power of systems. The Peters Equation. Standard redox potential. Predicting the direction of redox reactions based on redox potentials. Oxidant and reductant equivalents. The significance of redox potentials in the mechanism of biological oxidation processes. Potentiometry. Potentiometric determination of pH and ion activity.

Content Module 2.

Physicochemical Properties of Homogeneous and Heterogeneous Solutions

Topic 13. Modern Concepts of Solutions. Parameters Characterizing the Qualitative Composition of Solutions.

Methods of quantitative analysis. Classification of methods of quantitative analysis. Fixing the point of equivalence. Indicators. The law of equivalents. Basic calculation formulas. The role of solutions in the life of organisms. Classification of solutions. 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 law), nature of gas and solvent, temperature. Effect of electrolytes on the solubility of gases (Sechenov's law). Solubility of gases in blood. Caisson disease.

Solubility of liquids and solids in liquids. Solubility depends on temperature, nature of the solute and solvent..

Topic 14. Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids.

Solutions of electrolytes. Electrolytes in the human body. Degree and constant of dissociation of weak electrolytes. Ostwald's dilution law.

Properties of solutions of strong electrolytes. Activity and activity coefficient. Ionic strength of a solution. Water-electrolyte balance - a necessary condition for homeostasis. Intervals of pH for body fluids in normal and pathological conditions. Acidosis. Alkalosis. The role of electrolytes in vital processes. Acid-base equilibrium in electrolyte solutions. Determination of the constant and degree of dissociation of a weak electrolyte.

Dissociation of water. Ionic product of water. Hydrogen pH. Arenius' theory of acids and bases, Bransted and Lowry's proteolytic theory, Lewis' electronic theory. Types of proteolytic reactions: neutralization, hydrolysis, ionization..

Topic 15. Colligative properties of solutions. Osmometry, cryometry, ebuliometry. The role of osmosis in biological fluids.

Colligative properties of dilute solutions of nonelectrolytes. Relative decrease in the pressure of saturated vapor of the solvent above the solution. Raoul's law. Ideal solutions. Lowering of the freezing point and increasing of the boiling point of solutions in comparison with solvents. Osmosis and osmotic pressure. Van't Hoff's law. Colligative properties of dilute electrolyte solutions. Isotonic coefficient. Hypo-, hyper- and isotonic solutions. Cryometry, ebulliometry, osmometry, their application in biomedical research. The role of osmosis in biological systems. Osmotic pressure of blood plasma. The Haller equation. Oncotic pressure. Plasmolysis and hemolysis.

Topic 16. Buffer solutions, classification and mechanism of action.

Classification of buffer solutions. Buffer capacity and its dependence on various factors. Protein buffer systems. The concept of the acid-base state of blood.

Topic 17. Buffer capacity. The role of buffer systems in maintaining the body's acid-base balance. Determination of buffer capacity.

Buffer capacity and its dependence on various factors. Protein buffer systems. The concept of the acid-base state of blood. Acidosis. Alkalosis. Determination of buffer capacity by the titrimetric method.

Topic 18. Sorption of biologically active substances. Fundamentals of adsorption therapy.

Surface phenomena and their importance in biology and medicine. Surface tension of liquids and solutions. Surface tension isotherm. Surface active and surface inactive substances. Surface activity. The Duclo-Traube rule.

Adsorption at the liquid-gas and liquid-liquid interfaces. Gibbs' equation.

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

Physicochemical basis of adsorption theory (hemosorption, plasma adsorption, lymphatic adsorption, enterosorption, application therapy). Immunosorbents.

Topic 19: Electrolyte adsorption. Chromatographic methods for the analysis of mixtures of biologically active substances.

Electrolyte adsorption - specific (selective) and ion exchange. Paneth-Fayans rule. Natural and synthetic ion exchangers. The role of adsorption and ion exchange in the life processes of plants and organisms.

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

Topic 20: Colloidal solutions. Molecular kinetic, optical and electrokinetic properties.

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

Methods of preparation and purification of colloidal solutions. Dialysis, electrodialysis, ultrafiltration, compensatory dialysis, vividialysis. Hemodialysis and artificial kidney.

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

Electrokinetic phenomena. Electrophoresis. Application of electrophoresis in research and clinical laboratory practice. Electrophoregrams.

Topic 21. Kinetic and aggregate stability of dispersed systems. Production of ash by condensation method.

Kinetic (sedimentation) and aggregate stability of dispersed systems. Stability factors. Coagulation. Mechanism of coagulating action of electrolytes. Threshold of coagulation. The Schulze-Hardy rule. Mutual coagulation. Coagulation processes in drinking water and wastewater treatment. Colloidal protection.

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

Coarse dispersed systems with liquid dispersion medium. Suspensions, methods of preparation and properties. Pastes, their medical application.

Emulsions, methods of preparation and properties. Types of emulsions. Emulsifiers. Application of emulsions in clinical practice. Biological role of emulsification.

Preparation of ash by condensation method.

Topic 22. Properties of biopolymer solutions. Isoelectric point of protein.

High molecular weight compounds - 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.

Topic 23. Nanochemistry in the Modern World.

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

Nanomaterials for Molecular Imaging and Early Disease Diagnosis. Advantages and Limitations of Using Nanomaterials in Diagnostics. Targeted Drug Delivery Using Nanomaterials. Nanoparticles in Gene Therapy and Immunotherapy. Development and Use of Nanomaterials for the Treatment of Cancer and Cardiovascular Diseases.

Biocompatibility of Nanomaterials and Their Impact on Cells and Tissues. Toxicity of Nanomaterials and Mechanisms of Their Metabolism in the Body.

Class 24. Differentiated 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						
Тема 1. Chemistry of Biogenic Elements. Chemical Elements in Living Organisms.	4	1	0	2	0	1
Topic 2. Typical chemical properties, biological role and application in medicine of biogenic s-elements. Qualitative reactions for the determination of s-elements.	4	1	0	2	0	1
Topic 3: Chemical properties and biological role of biogenic p -	3	0	0	2	0	1

elements. Qualitative reactions for the determination of p - elements.						
Topic 4. General characteristics of biogenic d - elements. Redox properties of compounds of d - elements.	4	0	0	2	0	2
Topic 5. Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds.	3	0	0	2	0	1
Topic 6. Biological role and application in medicine of d - elements. Qualitative reactions for the determination of d - elements.	3	0	0	2	0	1
Topic 7: Basic concepts of chemical thermodynamics. Theoretical foundations of bioenergy. The first law of thermodynamics. Thermochemistry. Hess's law.	4	1	0	2	0	1
Topic 8. The second law of thermodynamics. Thermodynamic potentials.	4	0	0	2	0	2
Topic 9. Physico-chemical bases of kinetics of biochemical reactions. Kinetics of complex reactions. Catalysis. Features of enzymes action.	3	0	0	2	0	1
Topic 10: Kinetics of complex reactions. Catalysis. Features of the action of enzymes.	4	1	0	2	0	1
Topic 11. Chemical equilibrium. Equilibrium constant. The product of solubility.	4	0	0	2	0	2
Topic 12. Electrochemistry and Electrochemical Methods of Analysis.	3	0	0	2	0	1
	43	4		24		15
Content Module 2. Physicochemical Properties of Homogeneous and Heterogeneous Solutions.						

Topic 13. Modern Concepts of Solutions. Parameters Characterizing the Qualitative Composition of Solutions.	3	0	0	2	0	1
Topic 14. Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids.	4	1	0	2	0	1
Topic 15. Colligative properties of solutions. Osmometry, cryometry, ebuliometry. The role of osmosis in biological fluids.	4	0	0	2	0	2
Topic 16. Buffer solutions, classification and mechanism of action.	4	1	0	2	0	1
Topic 17. Buffer capacity. The role of buffer systems in maintaining the acid-base balance of the body. Determination of buffer capacity.	3	0	0	2	0	1
Topic 18. Sorption of biologically active substances. Fundamentals of occupational therapy.	4	1	0	2	0	1
Topic 19. Adsorption of electrolytes. Chromatographic methods of analysis of mixtures of biologically active substances.	5	1	0	2	0	2
Topic 20. Colloidal solutions. Molecular kinetic, optical and electrokinetic properties.	3	0	0	2	0	1
Topic 21. Kinetic and aggregative stability of dispersed systems. Obtaining sols by condensation method.	3	0	0	2	0	1
Topic 22. Properties of biopolymer solutions. Isoelectric point of protein.	3	0	0	2	0	1
Тема 23. Нанохімія в сучасному світі.	3	0	0	2	0	1
Total for content module 2	39	4	0	22	0	13
Differential credit test.	8	0	0	2	0	6

Individual tasks	0	0	0	0	0	0
Hours in general	90	8	0	48	0	34

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 dentistry. Biogenic elements, their role in life processes.	2
2.	Thermodynamic and kinetic laws of biochemical processes.	2
Content module 2. Equilibria in biological systems at the phase boundary.		
3.	Solutions. Acid-base equilibria in biosystems.	2
4.	Physicochemistry of surface phenomena. Fundamentals of adsorption therapy. Chromatography.	2
	Hours in general	8

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	Typical chemical properties, biological role and application in medicine of biogenic s-elements. Qualitative reactions for the determination of s-elements.	2
3	Chemical properties and biological role of biogenic p - elements. Qualitative reactions for the determination of p - elements.	2
4	General characteristics of biogenic d - elements. Redox properties of compounds of d - elements.	2
5	Werner's Coordination Theory and the Structure of Complex Compounds. Applications of Complex Compounds.	2
6	Biological role and application in medicine of d - elements. Qualitative reactions for the determination of d - elements.	2
7	Basic concepts of chemical thermodynamics. Theoretical foundations of bioenergy. The first law of thermodynamics. Thermochemistry. Hess's law.	2
8	The second law of thermodynamics. Thermodynamic potentials.	2
9	Physico-chemical bases of kinetics of biochemical reactions. Kinetics of complex reactions. Catalysis. Features of enzymes action.	2
10	Kinetics of complex reactions. Catalysis. Features of the action of enzymes.	2
11	Chemical equilibrium. Equilibrium constant. The product of solubility.	2
12	Electrochemistry and Electrochemical Methods of Analysis.	2
13	Modern Concepts of Solutions. Parameters Characterizing the Qualitative Composition of Solutions.	2
14	Equilibrium in Electrolyte Solutions. Electrolytic Dissociation in Solutions of Strong and Weak Electrolytes. pH of Biological Fluids.	2
15	Colligative properties of solutions. Osmometry, cryometry, ebuliometry.	2

	The role of osmosis in biological fluids.	
16	Buffer solutions, classification and mechanism of action.	2
17	Buffer capacity. The role of buffer systems in maintaining the acid-base balance of the body. Determination of buffer capacity.	2
18	Sorption of biologically active substances. Fundamentals of occupational therapy.	2
19	Adsorption of electrolytes. Chromatographic methods of analysis of mixtures of biologically active substances.	2
20	Colloidal solutions. Molecular kinetic, optical and electrokinetic properties.	2
21	Kinetic and aggregative stability of dispersed systems. Obtaining sols by condensation method.	2
22	Properties of biopolymer solutions. Isoelectric point of protein.	2
23	Нанохімія в сучасному світі.	2
24	Differential credit test.	2
	Hours in general	48

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	1
2.	Topic 2. Preparation for practical lesson 2	1
3.	Topic 3. Preparation for practical lesson 3	1
4.	Topic 4. Preparation for practical lesson 4	2
5.	Topic 5. Preparation for practical lesson 5	1
6.	Topic 6. Preparation for practical lesson 6	1
7.	Topic 7. Preparation for practical lesson 7	1
8.	Topic 8. Preparation for practical lesson 8	2
9.	Topic 9. Preparation for practical lesson 9	1
10.	Topic 10. Preparation for practical lesson 10	1
11.	Topic 11. Preparation for practical lesson 11	2
12.	Topic 12. Preparation for practical lesson 12	1
13.	Topic 13. Preparation for practical lesson 13	1
14.	Topic 14. Preparation for practical lesson 14	1
15.	Topic 15. Preparation for practical lesson 15	2
16.	Topic 16. Preparation for practical lesson 17	1
17.	Topic 17. Preparation for practical lesson 16	1
18.	Topic 18. Preparation for practical lesson 18	1
19.	Topic 19. Preparation for practical lesson 19	2
20.	Topic 20. Preparation for practical lesson 20	1
21.	Topic 21. Preparation for practical lesson 21	1
22.	Topic 22. Preparation for practical lesson 22	1
23.	Topic 23. Preparation for practical lesson 23	1
24.	Topic 24. Preparation for practical lesson 24	6
	Hours in general	**34**

7. Teaching methods

According to the sources of knowledge, the following teaching methods are used:

verbal - story, explanation, lecture, instruction;

visual - demonstration, illustration;

practical - practical work, tasks.

By the nature of the logic of cognition, the following methods are used:

analytical, synthetic, analytical-synthetic, inductive, deductive.

According to the level of independent mental activity, the following methods are used:

problematic, partially exploratory, research.

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.

The structure of the current assessment in the practical lesson:

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;

Criteria for current assessment in the practical lesson:

«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.
«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.
«3»	The higher education applicant does not have enough material, uncertainly participates in the discussion and solution of a situational problem with significant errors.
«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.

Only those applicants who have fulfilled the requirements of the curriculum in the discipline, have no academic debt and their average score for current academic activities in the discipline is at least 3.00 are allowed to take the final control in the form of a differentiated test.

The structure of the differential test

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

Criteria for assessing the learning outcomes of higher education applicant s 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 students 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 student 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 on 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 system that establishes the applicant's belonging to the group of the best or worst among the reference group of fellow students (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 applicants who have scored the minimum number of points for the current academic activity, but who have

not been 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:

Conversion of traditional discipline grade and grade point average to ECTS

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
- Textbooks:
- 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. Questions for Summative Assessment Preparation

1. Concept of biogenic elements. Classification of biogenic elements. Organogens.
2. Classification of biogenic elements based on the electronic structure of atoms in the s-, p-, and d-blocks. Electronic configuration, element topography in the human body. Qualitative reactions for determining cations and anions of s-, p-, and d-elements.
3. Solubility product. Hydrolysis of salts.
4. Werner's Coordination Theory and modern concepts of the structure of complex compounds. 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 environment. Types and properties of systems.
7. Thermodynamic processes. State functions of a system. The first law of thermodynamics. Thermochemistry. Hess's Law. Application of thermochemical calculations for energy characterization of biochemical processes.
8. The second and third laws of thermodynamics.

9. Characteristic state functions and thermodynamic potentials. Gibbs-Helmholtz equation and its application in bioenergetics. Criteria for the direction and limits of spontaneous processes in an isolated system.

10. Reaction rate, methods of expression. Rate constant. Factors affecting the rate of a chemical reaction. Molecularity and order of reaction. Half-life.

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. Bioelectrical potentials.

18. Solubility of substances. Factors affecting solubility.

19. Methods for expressing solution composition and concentrations. Types of concentration.

20. Role of solutions in nature and living organisms. Biological role of solutions. Hydrates, crystallohydrates, crystallization water. Medical solutions.

21. Theories of electrolytic dissociation. 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 the body. Methods of 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 non-electrolytes. Differences and characteristics. 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. Blood buffer systems.

27. Buffer action. Mechanism of buffer systems. Factors affecting pH of buffer systems. Formulas for calculating pH of buffer systems.

28. Quantitative characteristics of buffer systems. Buffer capacity and factors affecting it. Calculation of buffer capacity. Acid-base balance disorders in the blood.

29. Surface phenomena. Surface energy. Surface tension of liquids. Surface activity. Factors affecting surface tension.

30. Surfactants, surfactants, and detergents. Orientation of surfactant molecules at the surface. Structure and classification of surfactants.

31. Types of adsorption. Adsorption at the gas-liquid and liquid-liquid interfaces. Gibbs adsorption.

32. Adsorption at the solid-liquid, solid-gas interfaces, its mechanism and patterns. Langmuir adsorption isotherm equation. Freundlich equation. Structure of biological membranes.

33. Biological role of adsorption in medical practice. Basics of adsorption therapy. Role of adsorption and ion exchange in vital processes of organisms. Adsorption methods of apheresis therapy.

34. Adsorption of electrolytes. Selective adsorption. Ion-exchange adsorption. Features of ion adsorption.

35. Chromatography. Classification principles of chromatographic methods. Applications 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 coagulating action of electrolytes. Schulze-Hardy rule. "Colloidal protection" phenomenon.

41. Specific types of dispersed systems. Ultramicroscopic and coarse-dispersed systems.

42. Polymers solutions. Similarities and differences between polymer solutions and sols. Swelling and dissolution of polymers. Swelling mechanism. 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 obtaining 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