DANYLO HALYTSKYI LVIV NATIONAL MEDICAL UNIVERSITY

Department of General, Bioinorganic, Physical and Colloidal Chemistry

APPROVED:
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on research and educational work
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"24" 10 2023

S Y L L A B U S
OF DISCIPLINE
ОК 8 "MEDICAL CHEMISTRY"

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for training of specialists of the 2nd Master's degree of higher education
Branch of knowledge: 22 "Health care"
Speciality: 228 "Pediatrics"

Discussed and approved
at the meeting of
Department of General, Bioinorganic,
Physical and Colloidal Chemistry
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Head of the Department
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Approved
at the methodical commission
on Pharmaceutical and Chemical
Disciplines
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Head of the Methodical Commission
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INTRODUCTION

The program of study of the discipline "Medical Chemistry" is compiled in accordance with the Standard of Higher Education of Ukraine of the second (master's) level of the field of knowledge 22 "Health Care", specialty 222 "Medicine" and the educational and professional program in the specialty 228 "Pediatrics" of the second (master's) level.

Description of the subject (summary)

Medical chemistry is one of the fundamental natural sciences in the system of higher medical education, the knowledge of which is necessary for the fruitful, creative work of health care professionals. It develops a dialectical way of thinking, expands and deepens scientific knowledge about matter, structure and properties of chemical compounds and the laws of their interaction and transformation in the body, and identifies ways to solve applied problems in the field of healthcare.

Knowledge of medical chemistry will allow the future specialist to master the most essential skills of qualitative and quantitative prediction of the probability of biochemical processes and the physicochemical basis for interpreting various types of equilibria in biological systems.

The educational process is organized in accordance with the requirements of the European Credit Transfer and Accumulation System.

Structure of the discipline	**The amount of credits, hours including**				**Year of study, semester**	**Forms of the control**
	Totally	**Auditorial**		**Individual work**		
		Lectures (hours)	Practical classes (hours)			
Discipline "Medical Chemistry" ***The number of Thematic parts – 4***	**4credits / 120 hours**	**16**	**44**	**60**	**1st year (1st semester)**	**Pass-fail test, exam**
by semesters						
Thematic part 1. Acid-Base Equilibrium and the Processes of Coordination Compounds Formation in Biological Liquids	**1 credit / 30 hours**	**4**	**14**	**12**	**1st semester**	
Thematic part 2. Acid-base equilibria in biological liquids	**1 credit / 30 hours**	**2**	**9**	**19**	**1st semester**	
Thematic part 3. Thermodynamic and kinetic properties of processes and electrochemical phenomena in biological systems	**1 credit / 30 hours**	**6**	**9**	**15**	**1st semester**	
Thematic part 4. Physicochemistry of surface phenomena. Lyophobic and lyophilic dispersed systems	**1 credit / 30 hours**	**4**	**12**	**14**	**1st semester**	**Pass-fail test, exam**

The subject of study of the discipline is the chemical basis of the processes of vital activity of the body, which are subject to basic chemical laws. Medical chemistry studies the structure and reactivity of the most important biologically active molecules, the theory of chemical bonding in complex compounds of biometals with bioligands and the role of biogenic elements in the vital activity of the organism. It studies the physicochemical processes that occur at the molecular and submolecular levels, as this is where the causes of various forms of diseases and the specificity of hereditary traits are found.

Interdisciplinary connections: The study of the discipline "Medical Chemistry" directly relies on the basics of chemistry in the scope of secondary education, as well as the basics of elementary mathematics and physics. Knowledge of the theoretical foundations of medical chemistry is necessary for a deeper study of physiology, pathophysiology, biological chemistry, general and molecular pharmacology and toxicology, hygiene disciplines and ecology.

1. Purpose and objectives of the discipline

1.1.The purpose of teaching the discipline "Medical Chemistry" is to form the scientific outlook of students, develop their modern forms of theoretical thinking and the ability to analyze phenomena, develop skills and abilities to apply chemical and physicochemical laws and processes in the study of other disciplines and in future practical activities.

1.2. The main objectives of the discipline "Medical Chemistry" are to teach students to use the basic concepts of chemistry, the basic laws of chemistry, the general laws of chemical reactions, the doctrine of solutions, general information about chemical elements and their compounds, knowledge of the physicochemical basis of various types of equilibria in biological systems in solving specific problems in the field of medicine in accordance with modern needs.

1.3 Competencies and learning outcomes contributed to by the discipline (relationship with the normative content of higher education training formulated in terms of learning outcomes in the Higher Education Standard).

According to the requirements of the Higher Education Standard, the discipline ensures that students acquire ***competencies:***

- ***integrative:***

The ability to solve complex problems, including research and innovation in the field of medicine. Ability to continue learning with a high degree of autonomy.

- ***general:***

1. The ability to think abstractly, analyze and synthesize (GC1).
2. The ability to apply knowledge in practical situations (GC 3).
3. Knowledge and understanding of the subject area and understanding of professional activity (GC 4).
4. The ability to make informed decisions (GC 6).
5. The ability to search, process and analyze information from various sources (GC 11).
6. Determination and perseverance in tasks and responsibilities (GC 12).
7. The ability to exercise their rights and responsibilities as a member of society, to realize the values of civil (free democratic) society and the need for its sustainable development, the rule of law, human and civil rights and freedoms in Ukraine (GC 14).

- ***special (professional, subject):***

1. The ability to determine the required list of laboratory and instrumental studies and evaluate their results (PC2).
2. Ability to assess the impact of the environment, socio-economic and biological determinants on the health status of an individual (including children and adolescents), family, population (PC17).

The detailing of competencies is given in the form of "Competencies Matrix"

Competencies Matrix

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
Integral competence					
The ability to solve complex problems, including research and innovation in the field of medicine. Ability to continue learning with a high degree of autonomy.					
General competencies					

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
1.	The ability to think abstractly, analyze and synthesize (GC1).	Specialized conceptual knowledge that including modern scientific achievements in the field of professional activity or field of knowledge and are the basis for original thinking and conducting research.	Specialized skills to solve problems necessary for conducting research and/or implementation of innovative activities with to develop new knowledge and procedures.	Clear and unambiguous communication of your own knowledge, conclusions and arguments to specialists and non-specialists, in particular, to persons who are students.	Management of working or learning processes or learning processes that are complex, unpredictable and require new strategic approaches.
2.	The ability to apply knowledge in practical situations (GC 3). .	Specialized conceptual knowledge that including modern scientific achievements in the field of professional activity or field of knowledge and are the basis for original thinking and conducting research.	The ability to integrate knowledge and solve complex problems in broad or multidisciplinary or multidisciplinary contexts.	Clear and unambiguous communication of your own knowledge, conclusions and arguments to specialists and non-specialists, in particular, to persons who are students.	Management of working or learning processes or learning processes that are complex, unpredictable and require new strategic approaches.
3.	Knowledge and understanding of the subject area and understanding of professional activities (GC 4).	Critical reflection on of problems in the field and on the edge of fields of knowledge.	Ability to integrate knowledge and solve complex problems in broad or multidisciplinary contexts. .	The use of of foreign languages in professional activities.	Responsibility for contribution to professional knowledge and practice and/or evaluation of the results of activities of teams and groups.

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
4.	The ability to make informed decisions (GC 6). .	Specialized conceptual knowledge that including modern scientific achievements in the field of professional activity or field of knowledge and are the basis for original thinking and conducting research.	The ability to solve problems in new or unfamiliar environments in a unfamiliar environments with the presence of incomplete or limited information with taking into account aspects of social and ethical responsibility.	Clear and unambiguous communication of your own knowledge, conclusions and arguments to specialists and non-specialists, in particular to persons who students.	Management of working or learning processes or learning processes that are complex unpredictable and require new strategic approaches.
5.	The ability to search, process and analyze information from various sources (GC 11).	Critical reflection on of problems in the field and on the edge of fields of knowledge.	The ability to integrate knowledge and solve complex problems in broad or multidisciplinary contexts.	The use of of foreign languages in professional activities.	Responsibility for contribution to professional knowledge and practice and/or evaluation of the results of activities of teams and groups.
6.	Determination and perseverance in terms of tasks and responsibilities (GC 12).	Critical reflection on of problems in the field and on the edge of fields of knowledge.	The ability to solve problems in new or unfamiliar environments in a unfamiliar environments with the presence of incomplete or limited information with taking into account aspects of social and ethical responsibility.		The ability to to continue learning with a high degree of of autonomy.

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
7.	The ability to exercise one's rights and responsibilities as a member of society, to realize the values of civil (free democratic) society and the need for its sustainable development, the rule of law, human and civil rights and freedoms in Ukraine (GC 14).	Specialized conceptual knowledge that including modern scientific achievements in the field of professional activity or field of knowledge and are the basis for original thinking and conducting research.	The ability to integrate knowledge and solve complex problems in broad or multidisciplinary contexts.	Clear and unambiguous communication of your own knowledge, conclusions and arguments to specialists and non-specialists, in particular to persons who students.	The ability to to continue learning with a high degree of of autonomy.
Special (professional) competencies					
1.	The ability to determine the required list of laboratory and instrumental studies and evaluate their results (PC2).	Critical reflection on of problems in the field and on the edge of fields of knowledge.	The ability to solve problems in new or unfamiliar environments in a unfamiliar environments with the presence of incomplete or limited information with taking into account aspects of social and ethical responsibility		Management of working or learning processes processes that are complex, unpredictable and require new strategic approaches.
2.	Ability to assess the impact of the environment, socio-economic and biological determinants on the health status of an individual (including children and adolescents), family, population (PC17).	Critical reflection on of problems in the field and on the edge of fields of knowledge.	Specialized skills to solve problems necessary for conducting research and/or implementation of innovative activities with in order to develop new knowledge and procedures.	Clear and unambiguous communication of your own knowledge, conclusions and arguments to specialists and non-specialists, in particular to persons who students	Management of working or learning processes or learning processes that are complex, unpredictable and require new strategic approaches.

Learning outcomes:

Integrative final program learning outcomes, the formation of which is facilitated by the discipline "Medical Chemistry":

Compliance with the learning outcomes and competencies defined by the standard

Learning outcome	Program learning outcome code	Competence code
Have a thorough knowledge of the structure of professional activity. Be able to carry out professional activities that require updating and integrating knowledge. Be responsible for professional development, the ability to further professional training with a high level of autonomy.	PLO-1	GC1, GC3, GC4, GC6, GC11, GC12, GC14, PC2, PC17
Understanding and knowledge of basic and clinical biomedical sciences, at a level sufficient to solve professional problems in the field of health care.	PLO-2	GC 4, GC 6, GC 11, GC 12, PC2, PC17
Find the necessary information in professional literature and databases of other sources, analyze, evaluate and apply this information.	PLO-21	GC1, GC11
Evaluate the impact of the environment on human health to assess the state of morbidity of the population.	PLO-23	GC1, GC4, PC17
Clearly and unambiguously communicate your own knowledge, conclusions and arguments on health care and related issues to specialists and non-specialists.	PLO-25	GC1, GC4, PC17

Learning outcomes for the discipline "Medical Chemistry":
As a result of studying the discipline "Medical Chemistry" the student should:
to know:

- properties and methods of expressing the composition of solutions;
- classification and nomenclature of inorganic compounds;
- basic concepts and laws of chemistry and methods of their use for solving applied problems;
- basic laws of chemical reactions of various types;
- Vernadsky's doctrine of the biosphere;
- classification and principles of titrimetric and physicochemical research methods;
- regularities of adsorption of substances from solutions on a solid surface;

to be able to:

- interpret the main types of chemical equilibrium to form a holistic physicochemical approach to the study of the processes of vital activity of the body in normal and pathological conditions;
- apply chemical and physicochemical methods of quantitative and qualitative analysis and draw conclusions about the possibility of their use in biomedical research;
- classify the chemical properties and transformations of bioorganic substances in the process of vital activity of the organism;
- interpret the general physical and chemical laws underlying the processes of human life;
- prepare solutions with a given quantitative composition.

2. Information volume of the discipline "Medical chemistry"

The discipline is allocated 4 ECTS credits / 120 hours. The program of the discipline "Medical Chemistry" is structured into four content sections:

Thematic part 1. Acid-Base Equilibrium and the Processes of Coordination Compounds Formation in Biological Liquids

Topic 1. Variables which characterizes quantitative composition of solutions. Preparation the solutionThe ways of expression concentrations of solutions. Preparation the solution with known concentration. Solutions used as disinfectants and antiseptics to prevent infection and spread of COVID-19

Role of solutions in the organisms life. Classification of solutions. Mechanism of dissolution processes. Thermodynamic approach to the process of the dissolution. The solubility of the substances.

The solubility of gases in liquids. The dependence of the solubility of gases on the pressure (Henry-Dalton's law), nature of the gas and solvent, temperature. Effect of electrolytes on the solubility of gases (Sechenov's law). Solubility of gases in the blood. Decompression sickness.

The solubility of liquids and solids in liquids. The dependence of solubility on temperature and the

nature of the solute and solvent. Nernst law of distribution and its importance in the phenomenon of the permeability of biological membranes.

The values that characterize the quantitative composition of solutions.

Preparation of solutions of a given quantitative composition.

Solutions used as antiseptics for personal hygiene, as well as for disinfection in public and residential premises and buildings. Classification of disinfectants and antiseptics by the main active substances and their concentration in working solutions.

Topic 2. Colligate properties of solutions.

Colligate 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 compared to 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 3. Coordination compounds formation in biological liquids.

Complex formation 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. Intra-complex compounds. Polyunit complexes.

Iron-, cobalt-, copper- and zinc-containing biocomplex compounds. The concept of metal-ligand homeostasis. Homeostasis disorders. Complexes and their use in medicine as antidotes for heavy metal poisoning (chelation therapy) and as antioxidants for the storage of drugs.

Topic 4. Bioelements and their classification. Chemical properties and biological role of macroelements.

General information about nutrients. Qualitative and quantitative content of nutrients in the body. Macronutrients, micronutrients and impurity elements. Organogens. The concept of Vernadsky's doctrine about biosphere and the role of living matter (living organisms). Relationship between the content of biogenic elements in the human body and its contents in the environment. Endemic diseases and their connection with the peculiarities of biogeochemical provinces (regions with a natural deficiency or excess of certain chemical elements in the lithosphere). Problems of biosphere pollution and purification because of toxic chemicals.

Electronic structure and electronegativity of *s*- and*p*- elements. Typical chemical properties of *s*-, *p*-elements and their compounds (reactions without changing of oxidation state. The relationship between the location of *s*-and *p*-elements in the periodic table and their content in the body. Usesin medicine. Toxic effects of compounds.

Reactions of identification of CO_3^{2-}, SO_4^{2-}, NO_2^-, $S_2O_3^{2-}$ions.

Topic 5. Chemical properties and biological role of microelements.

The Metals of life. Electronic structure and electronegativity of d-elements. Typical chemical properties of *d*-elements and their compounds (reactions with changes in the degree of oxidation, complexation). Biological role. Application in medicine. Toxic effect of d-elements and their compounds.

Qualitative reactions to ions MnO_4^-, Fe^{3+}, Cu^{2+}, Ag^+.

Thematic part 2. Acid-base equilibria in biological liquids

Topic 6. Acid-base equilibrium.Calculation and experimental determination of the pH of biological liquids. Protolytical processes in living organisms

Electrolyte solutions. Electrolytes in the human body.The degree and the dissociation constant of weak electrolytes. Properties of solutions of strong electrolytes. Activity and activity coefficient. Ionic force of solution. Water and electrolyte balance - a necessary condition for homeostasis. Dissociation of water. Ionic product of water. pH. The pH values for different liquids of the human body in normal and

pathological conditions.

Theories of acids and bases. Types of protolytic reactions: neutralization, hydrolysis and ionization. Hydrolysis of salts. The degree of a hydrolysis, its dependence on concentration and temperature. Constant of a hydrolysis. The role of hydrolysis in biochemical processes.

Topic 7. Buffer solutions, their biological role.

Buffer solutions, their classification. Henderson-Hasselbach equation. The mechanism of buffering action.

Buffer capacity. Buffer systems of blood. Bicarbonate buffer, phosphate buffer. Protein buffer systems. The concept of acid-base state of blood.

Topic 8. The basic principles of the titrimetric analysis. Acid-base titration

Principles of titrimetric analysis.

The method of acid-base titration.Choice of indicators for various types of acid-base titration.

Thematic part 3. Thermodynamic and kinetic properties of processes and electrochemical phenomena in biological systems

Topic 9. Chemical thermodynamics. The direction of chemical and biochemical processes proceeding

The special fields of chemical thermodynamics. Basic terms of chemical thermodynamics: thermodynamical system (isolated, closed, open, homogeneous, heterogeneous), the state variables (extensive and intensive), thermodynamical processes (reversible, irreversible). Living organisms as open thermodynamical systems. Irreversibility of life processes.

The first law of thermodynamics. Enthalpy. Thermochemical equations. Standard enthalpies of formation and combustion. Hess's law. Calorimetry techniques. Biochemical processes energetic characteristics. Thermochemical calculations for the foods fuel capacity (caloricity) evaluation and making rational and therapeutic diets.

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

The basic principles of thermodynamics applying to living organisms. ATP as an energy source for biochemical reactions. Macroergic compounds. Energetical conjugations in living systems: exergonic and endergonic processes in the organism.

Topic 10. Kinetics of biochemical reactions. The chemical equilibrium. Solubility product constant.

Chemical kinetics as a basis for studying the rates and mechanisms of biochemical reactions. Reaction rate. 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 transition state (activated complex).

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. Features of enzyme action: selectivity, efficiency, dependence of enzymatic action on temperature and reaction of the medium. 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 environmental factors on the kinetics of enzymatic reactions.

Chemical equilibrium. Chemical equilibrium constant and methods of its expression. Shift of

chemical equilibrium with changes in temperature, pressure, concentration of substances. The principle of Le Chatelier's principle.
Precipitation and dissolution reactions. Solubility product constant. Conditions of precipitation and dissolution of precipitates. The role of heterogeneous equilibrium with the participation of salts in the overall homeostasis of the body.

Topic 11. Measuring the electrical driving force of electrochemical elements and electrodes potentials. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration.
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 and comparison electrodes. Chlorosilver electrode. Ion-selective electrodes. Glass electrode.
Galvanic elements.
Diffusion potential. Membrane potential. Biological role of diffusion and membrane potentials. Damage potential. Resting potential. Potential of action.

The role of redox reactions in vital processes. Redox potential as a measure of oxidation and reduction capacity of systems. The Peters equation. Normal redox potential.
Prediction of the direction of redox reactions by the values of redox potentials. The equivalent of an oxidizing agent and a reducing agent. The value of redox potentials in the mechanism of biological oxidation processes.
Potentiometry. Potentiometric determination of pH, ionic activity. Potentiometric titration.

Thematic part 4. Physicochemistry of surface phenomena. Lyophobic and lyophilic dispersed systems

Topic 12. Adsorption on the mobile interphases. The determining of the surface tension of solutions and biological liquids. Surface tension and adsorption isotherms
Surface phenomena and their importance in biology and medicine.Surface tension of liquids and solutions.Isotherm of surface tension.Surfactants and surface-inactive substance.Surface activity.Duclo's-Traube rule.

Adsorption at the liquid-gas and liquid-liquid interfaces. Gibb's equation. The orientation of the surfactants molecules in the surface layer. The concept of the structure of biological membranes.

Topic 13. Molecular adsorption of the surface of a solid. Adsorptive processes and ions exchange in bio-systems. Chromatography

Adsorption at the solid-gas interface. Langmuir equation.Adsorption from solution at the solid-liquid interface.Physical sorption (or physisorption) and chemical sorption (or chemisorption). General rules for the solutes, vapours and gases adsorption. Freundlich equation.

Physico-chemical basis of adsorption therapy (hemosorbtion, plazmosorbtion, limfosorbtion, enterosorption, application therapy). Immunosorbents.

Adsorption of electrolytes: specific (selective) and ion exchange. Fajans-Peneth precipitation and adsorption rule. Naturally occurring ion exchangers and synthetically produced organic resins.
Adsorption and ion exchange significance for the vital process in plants and living organisms.
Chromatography. Chromatographic methods of analysis classification based on the phases states of matter, the technique and the separation mechanism. Adsorption, ion exchange and distribution chromatography. Chromatography applications in biology and medicine.

Topic 14. Preparation, purification and properties of colloidal solutions

The living organism as a disperse systems combination. Classification of disperse systems according to the aggregative state, interphase interaction, dispersion. Lyophilic and lyophobic dispersions. A structure of micelle. Structure of a double electric layer (DEL). The overall performance and history of development the ideas about DEL structure. Electrokinetial potential of a colloidal particle.

Methods of preparation and purification of colloidal solutions. Dialysis, electro-dialysis, ultrafiltration, compensatory dialysis. Haemodialysis and "artificial kidney" device.

Molecular-kinetic properties of dispersions. Thermal molecular motion and Brownian motion, diffusion, and osmotic pressure. Optical properties of dispersions.

Electrocinetical phenomena. Electrophoresis. Helholtz-Smoluchovsky's equation. Application of electrophoresis in research, clinical and laboratory practice. Electrophoregrams.

Disperse systems with gaseous dispersion medium. Classification of aerosols, methods of preparation and properties. The use of aerosols in clinical and sanitary practices. Toxic effect of some aerosols. Powders.

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

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

Semi colloidal soaps, detergents. Micelle formation in semi colloids solutions.

Topic 15. Electrolytic coagulation of colloids. Properties of bio-polymers solutions

Kinetic (sedimentation) and aggregative stability of disperse systems. The reasons of colloidal stability. Coagulation. The mechanism of electrolytes coagulating action. Coagulation threshold or critical concentration of coagulation. Schulze-Hardy rule. Mutual coagulation of sols. Coagulation proceedings for the potable water and wastewater purification. Colloidal protection.

Macromolecular compounds as the basis of living organisms. Globular and fibrillar structure of proteins. Macromolecular solutions features and their similarities and differences with true and colloidal solutions.

Swelling and dissolution of polymers. The mechanism of swelling. Swelling affecting with pH, temperature and electrolytes nature. The role of swelling in the organism physiology. Gels creation in polymers solutions. The mechanism of gels formation. The influence of pH, temperature and electrolytes presence on the gels formation rate. Thixotropy. Syneresis. Diffusion in gels. Salting out effect of biopolymers. Coacervation and phase separation and its role in biological systems.

Anomalous viscosity of polymers solutions. The viscosity of the blood.

Donnan membrane equilibrium.

Isoelectric state of proteins. Isoelectric point and its determining methods. Ionic state of biopolymers in aqueous solutions.

3. Structure of the academic discipline «Medical chemistry»

Topic	**Lectures**	**Practical and laboratory classes**	**Self-study**	**Individual work**
Thematic part 1. Acid-Base Equilibrium and the Processes of Coordination Compounds Formation in Biological Liquids				
1. Topic 1. Variables which characterizes quantitative composition of solutions. Preparation the solutionThe ways of expression concentrations of solutions. Preparation the solution with known concentration. ***Solutions used as disinfectants and antiseptics to prevent infection and spread of COVID-19***	1	3	2	-
2. Topic 2. Colligate properties of solutions.	1	2	2	
3. Topic 3. Coordination compounds formation in biological liquids.	1	3	2	
4. Topic 4. Bioelements and their classification. Chemical properties and biological role of macroelements.	0,5	3	3	
5. Topic 5. Chemical properties and biological role of microelements	0,5	3	3	
Totally:	***4***	***14***	***12***	
Thematic part 2. Acid-base equilibria in biological liquids				
6. Topic 6. The acid-base equilibrium in biological liquids. The ionic product of water. The pH. Protolytical processes in organisms.	1	3	6	-
7. Topic 7. Buffer solutions, their biological role	0,5	3	7	
8. Topic 8. The basic principles of the volumetric analysis	0,5	3	6	

Totally:	***2***	***9***	***19***	
Thematic part 3. Thermodynamic and kinetic properties of processes and electrochemical phenomena in biological systems				
9. Topic 9. The heat effects of chemical reactions in solutions. The direction of processes.	2	3	4	-
10. Topic 10. Kinetics of biochemical reactions. The chemical equilibrium. Solubility product constant.	2	3	4	
11. Topic 11. Measuring the electrical driving force of electrochemical elements and electrodes potentials. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration.	2	3	7	
Totally:	***6***	***9***	***15***	
Thematic part 4. Physicochemistry of surface phenomena. Lyophobic and lyophilic dispersed systems				
12. Topic 12. The physical chemistry of surface phenomenon. Adsorption on the mobile phases division bounders.	1	3	4	-
13. Topic 13. Adsorption on the immobile surface of the phases division. Sorption of biologically active substances. The bases of the adsorption therapy. Ions-exchange adsorption. Chromatography.	1	3	4	
14. Topic 14. Preparation, purification and properties of colloidal solutions.	1	3	3	
15. Topic 15. Electrolytic coagulation of colloids. Properties of bio-polymers solutions.	1	3	3	
Totally:	***4***	***12***	***14***	
In total 120 hours/4 ECTS credits	**16**	**44**	**60**	
Final control				Exam

4. Thematic plan of lectures "Medical chemistry"

No	The topic	Number of hours
1.	Solutions. Ways of expressing concentrations of solutions. Colligative properties of solutions. Osmosis, osmotic pressure	2
2.	Coordination compounds formation in biological liquids. The basics of chelates therapy. The chemistry of bioelements. Classification of bioelements, their biochemical role and medical uses.	2
3.	The acid-base equilibrium in biological liquids. The ionic product of water. The pH. Protolytical processes in organisms. Hydrolysis of salts. Buffer solutions. The quantitative characteristics of buffer systems. Buffer systems of blood. The concept of acid-base equilibrium in biological liquids. The basic principles of the volumetric analysis. The method of acid-base titration	2
4.	The theoretical basis of bioenergetics. The use of thermodynamic functions for energetic characteristic of biochemical processes. The criteria of spontaneous passage of chemical processes	2
5.	The kinetical regularities of biochemical reactions passing. The chemical equilibrium. Solubility product constant	2
6.	The electrodes processes, their biological role and application in medicine	2
7.	Physics and chemistry of the surfaces phenomenon. The bases of the adsorption therapy. Chromatography.	2
8.	Colloid solutions. Preparation, purification and properties of colloidal solutions. Electrolytic coagulation of colloids. Colloidal protection. Physical and chemical properties of the biopolymers solutions	2
	Totally:	***16***

5. Thematic plan of practical (seminar) classes "Medical chemistry"

No	The topic	Number of hours
1.	Variables which characterizes quantitative composition of solutions. Preparation the solution	3
2.	Colligate properties of solutions	2
3.	Coordination compounds formation in biological liquids	3
4.	Bioelements and their classification. Chemical properties and biological role of macroelements	3
5.	Chemical properties and biological role of microelements	3
6.	Acid-base equilibrium in an organism. pH of biological liquids	3
7.	Protolytical processes. Buffer systems, their biological role	3
8.	The basic principles of the volumetric analysis	3
9.	The heat effects of chemical reactions in solutions. The direction of processes	3
10.	Kinetics of biochemical reactions. The chemical equilibrium. Solubility product constant	3
11.	Measuring the electrical driving force of electrochemical elements and electrodes potentials. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration	3
12.	The physical chemistry of surface phenomenon. Adsorption on the mobile phases division bounders	3
13.	Adsorption on the immobile surface of the phases division. Sorption of biologically active substances. The bases of the adsorption therapy. Ions-exchange adsorption. Chromatography	3
14.	Preparation, purification and properties of colloidal solutions	3
15.	Electrolytic coagulation of colloids. Properties of bio-polymers solutions	3
	Totally:	***44***

6. Thematic plan of individual work of students "Medical chemistry"

No	The topic	Number of hours	Forms of assessment
1.	Variables which characterizes quantitative composition of solutions. Preparation the solution. ***Solutions used as disinfectants and antiseptics to prevent infection and spread of COVID-19***	2	The current control during practice classes activities
2.	Colligate properties of solutions	2	
3.	Coordination compounds formation in biological liquids	2	
4.	Bioelements and their classification. Chemical properties and biological role of macroelements.	3	
5.	Chemical properties and biological role of microelements	3	
6.	Acid-base equilibrium in an organism. pH of biological liquids	6	
7.	Protolytical processes. Buffer systems, their biological role	7	
8.	The basic principles of the volumetric analysis	6	
9.	The heat effects of chemical reactions in solutions. The direction of processes	5	
10.	Kinetics of biochemical reactions. The chemical equilibrium. Solubility product constant	5	
11.	Measuring the electrical driving force of electrochemical elements and electrodes potentials. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration	5	
12.	The physical chemistry of surface phenomenon. Adsorption on the mobile phases division bounders	4	
13.	Adsorption on the immobile surface of the phases division. Sorption	4	

	of biologically active substances. The bases of the adsorption therapy. Ions-exchange adsorption. Chromatography		
14.	Preparation, purification and properties of colloidal solutions	3	
15.	Electrolytic coagulation of colloids. Properties of bio-polymers solutions	3	
	Totally:	***60***	

7. Individual tasks <u>are not supposed</u>

1. **Teaching methods**

In the process of"Medical Chemistry"disciplines studying the following teaching methods are usedfor students:

- by the cognitiveactivitytype:
  - explanatory-illustrative;
  - reproductive;
  - problematic presentation;
  - the logic of cognition;
  - analitical;
  - inductive;
  - deductive;
- according to the main stages of the process:
  - knowledgeformation;
  - skills and abilitiesformation;
  - knowledge application;
  - generalization;
  - fixing;
  - assesment;
- by thesystem approach:
  - stimulation and motivation;
  - assessment and self-assesment;
- by sources of knowledge:
  - verbal – lecture, explanation;
  - visual – demonstration, illustration;
- according to the individual mental activity level:
  - problematic;
  - partially discovering;
  - explorative;
  - the method of problematic teaching.

2. **Methods of control**

The current control is a regular check of educational trained achievements, fulfiled by the teacher according to syllabus of the discipline. It is carried out on each practical class according to the specific objectives, during the individual work of the teacher with the student for those topics which are not part of the structure of practical classes. The objective (standardized) control of theoretical and practical knowledge and skills of students is used.

The following means of the level of students' knowledge assessment are used: testing, situational problems solving, laboratory research activities and their results interpreting and evaluating, practical skills evaluation.

At each practical class the student gives answers on 20 questions (multiple choice questions on the topic of the practical classes, standardized questions, knowledge of which is necessary for understanding the current topic, the issue of a lecture course and individual work related to the current class, demonstrates knowledge and skills of practical abilities in accordance with the topic of the practical class).

The exam is the form of final control for the discipline "Medical Chemistry" studying. Students, who completed all types of activities provided by the syllabus, attended all practical classesand were scored with thepoints number not less than the minimum.

Methodology and means of standardized evaluation for the final

Regulations of the final semester exam realization

The final control is carried out in the standardized form and includes the theoretical and practical skills assessment.

It should be performed in writing as 80 multiple choice questions (1 point for each correct answer). The student meets the test package. Each package contains 80multiple choice format tests for each thematic module, and is rated at 1 score point for each correct answer.

10. The current control is realized during the practical classes and aims at checking the learning of educational material.

The form of the current control assessment during the classes is defined by syllabus of discipline.Forms of current educational activities assessment are standardized and include the control of theoretical and practical training. The 4-point (traditional) scale is used in evaluating the learning of each topic for current educational activitytaking into account the approved evaluation criteria.

10.1. The current educational activity assessment.When evaluating the educational activitees achievements of each topic for the current educational activity, the student is assessed with grades in the 4-graiding scale (national). It takes into account all types of activities provided for by the discipline sullabus. A student should gain an assessment from each topic for further conversion of 4-grading scale points into 200-grading scale points.

Test control is performed at each practice class according to specific objectives. Theoretical students' self-preparation control is performed in writing by answering 18 multiple choice questions in the form one-of-five, the correct answer to each is estimated at 1 point, and two numerical problems, the correct solving being estimated at 2 points. The maximum score for the entire test is 22 points.The minimum score points number a student must gain for the successful assessment of the theoretical part is 13 points (50 % of the correct answers).

At each practical class, the teacher assesses the knowledge of each student in a four-grading scale.

Grade "excellent" ("5") – student answers all standardized questions of the topic correctly (90 – 100 %), clearly, logically and completely (including questions of lectures and individual work). Student closely applies theory and practice and correctly solves the problems of higher complexity with the professional content.Completed the planned individual work.

Grade "very good" ("4") – student answers 70 – 89 % ofstandardized questions of the topic correctly. He/she usesthe theoretical knowledge to solve the practical problems correctly. Student is able to solve easy and medium level problems with the professional content.A student has the necessary practical skills and methods of their application in an amount that exceeds the required minimum.

Grade "satisfactory" ("3") – student answers50-69% ofstandardized questions of the topic. The answers are not complete, with additional questions (including questions of lectures and individual work). He/she is not able to give clear and logical answer. Student makes mistakes and solves only the easiest tasks in answers and practical demonstrations.

Grade "poor" ("2")–student does not know the topic and gives the correct answers to less than 50% of the tests. He/she is not able to give logical answer, gives no answer to additional questions and does not understand the topic. He/she makes significant and serious mistakes in answers and practical demonstrations.

At each practical class, student's knowledge is assessed on a four-grade scaling system ("5", "4", "3", "2") according to the criteria for evaluating the student's current activity.

The practical skills gained and the laboratory experiments carrying out assessment is performed after the laboratory work fulfilling by assessing the quality and fullness of its performance, the ability to interpret the obtained results. For the practical part of the lesson the student can get:

4 points if laboratory work is completely fulfilled and the student correctly explains the experiments interpret the results and make conclusions;

2 points if the laboratory work is done with some errors, the student can not fully explain and summarize the obtained results;

0 points if the laboratory work is not performed or the student can not explain and summarize the obtained results.

The final score for the class is determined by the sum of the points for the current theoretical control and the laboratory experiments carrying out points as follows:

Total score points	Grade in 4-point scale
from 22 to 26	5
from 17 to 21	4
from 13 to 16	3
< 13 points for the current theoretical control or 0 points for the laboratory experiments carrying out	2

The students' individual work issues and achievements which are provided by the syllabus in the content of practical training practical class activities, are evaluated during the current control of the topic at the appropriate practical class. The evaluation of the topics submitted for individual study and not included into the content of the practical class training is monitored during the final control.

11. The exam if the form of the final control and students' knowledge assessment during their "Medical chemistry" studying.

Final control at the end of semester is a form of final control, which is aimed to assess the students' theoretical and practical material knowledge and skillson the academic discipline.Semester exam is a form of final control of the student theoretical and practical material from discipline.Students who completed all types of works provided by the syllabus, attended all practical classes and were scored with the points number not less than the minimum.

The final control is carried out in the standardized form and includes the theoretical and practical skills assessment.

It should be performed in writing as 80 multiple choice questions (1 point for each correct answer).

12. The regularities for grades and score points number gaining by students:

The highest possible scorepoints which a student can gain for the current educational activity for the semester for admission to the exam is 120 points.

Minimal number of score points which a student must gain for current educational activity for the semester for admission to the exam is 72 points.

Calculation of the points number is based on grades gained by student under the traditional scale (by calculation of the arithmetic mean (*AM*) rounded to two decimal places). The resulting value is converted into points by multi-points scale as follows:

$$x = \frac{\mathrm{CA} \times 120}{5}$$

Conversion of the average grade for current educational activity to the point scale for discipline which is finished with exam

4-grading scale	200-grading scale
5.00	120
4.95	119
4.91	118
4.87	117
4.83	116
4.79	115
4.75	114
4.70	113
4.66	112
4.62	111
4.58	110
4.54	109
4.50	108

4-grading scale	200-grading scale
4.45	107
4.41	106
4.37	105
4.33	104
4.29	103
4.25	102
4.20	101
4.16	100
4.12	99
4.08	98
4.04	97
3.99	96
3.95	95

4-grading scale	200-grading scale
3.91	94
3.87	93
3.83	92
3.79	91
3.74	90
3.70	89
3.66	88
3.62	87
3.58	86
3.54	85
3.49	84
3.45	83
3.41	82

4-grading scale	200-grading scale
3.37	81
3.33	80
3.29	79
3.25	78
3.20	77
3.16	76
3.12	75
3.08	74
3.04	73
3.00	72
Less than 3	Insuffici-ently

Individual work of students is evaluated during the current control of topic on the appropriate class. Mastering of topics for individual work is controlled at the final control.

The highest possible score points which a student can get in exam is 80.

A minimum point required for passing is 50.

An assessment of the discipline which is finished with examis defined as the sum of score points number for the current educational activity (not less than 72) and the score points number for the exam (not less than 50).

Points on discipline are converted regardless both in ECTS scale and a 4-point scale. Scores of ECTS scale can not be converted into 4-point scale and vice versa. Scores of students taking into account the number of points on the discipline are ranked on a ECTS scale so that:

Grade in ECTS	Statistical index
A	Top 10 % of students
B	The next 25 % of students
C	The next 30 % of students
D	The next25 % of students
E	The last 10 % of students

A, B, C, D, E rankings are awarded to students of the whole course, of the same specialty and successfully completed the studying of discipline. Students who were scored as FX, F ("2") ratings are not included into the ranking list. Students with an FX score after reassembly automatically receive a "E" score.

Points on discipline for students who completed the program successfully are converted into a traditional 4-point scale by absolute criteria, which are listed in the table below:

Points on discipline	Grade in 4-point scale
From170 to 200 points	5
From 140 to 169 points	4
From 139 points to the minimum number of points that a student must score	3
Lower than minimum number of points that a student must score	2

The ECTS score points are not converted into traditional scale score because the ECTS scale and the four-point scale are independent.

The objectivity of students' educational activity assessment is verified by statistical methods (correlation coefficient between ECTS assessment and national scale assessment).

13. METHODICAL PROVIDING:

- syllabus of the discipline;
- thesis of lectures on discipline;
- thematic schedules of lectures, practical and laboratory classes and the students' individual work;
- guidelines for teacher;
- guidance for practical training for students;
- teaching materials, providing individual work;
- test and control tasks for practical classes;
- questions and tasks for final control (exam).

14. Recommended literature

Main sources:

1. V.O. Kalibabchuk, V.I. Halynska, L.I. Hryshchenko et al. Medical Chemistry. – AUS

MEDICINE Publishing. – 2010. – 224 p.
2. Raymond Chang. Chemistry (6th Edition). – WCB/McGraw-Hill. – 1998. – 995 p.
3. Steven S. Zumdahl. Chemistry (4th Edition). – Houghton Mifflin Company. – 1997. – 1031 p.
4. Gary L. Miessler, Donald A. Tarr. Inorganic Chemistry. – Prentice Hall. – 1991. – 625 p.

Additional sources:

5. Rodney J. Sime Physical Chemistry. Methods. Techniques. Experiments. – Saunders College Publishing. – 1990. – 806 p.
6. John McMurry, Robert C. Fay. Chemistry (3rd Edition). – Prentice Hall. – 2001. – 1067 p.
7. David E. Goldberg. Fundamentals of Chemistry (2nd Edition). – WCB/McGraw-Hill. – 1998. – 561 p.
8. Theodore L. Brown, H.Eugene LeMay, Bruce E. Bursten. Chemistry. The Central Science. – Prentice Hall. – 2000. – 1017 p.
9. John Olmsted III, Gregory M. Williams. Chemistry. The Molecular Science. – Mosby. – 1994. – 977 p.

15. Information resources

When studying the discipline students use the following information resources and knowledge bases through the use of local and global computer networks:

- Wikipedia(https://www.wikipedia.org/)
- http://chemistry.inf.ua
- Wolfram|Alpha (http://www.wolframalpha.com/)

Electronic versions of teaching and studying support:

1. Medical chemistry study guide for the 1st year students of Faculty of Dentistry (Part 1). http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Metodychne_zabezpechennaj/Engl_Method_Medical_chem_1_Med_M-1.pdf

2. Medical chemistrystudy guide for the 1st year students of Faculty of Dentistry (Part 2). http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Metodychne_zabezpechennaj/Engl_Method_Medical_chem_1_Med_M-2.pdf

3. Multiple choice questions on Medical chemistry. Part 1. http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Tests/Engl_Medical_chem_1_Med_M-1_Tests.pdf

4. Multiple choice questions on Medical chemistry. Part 2. http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Tests/Engl_Medical_chem_1_Med_M-2_Tests.pdf