

DANYLO HALYTSKYI LVIV NATIONAL MEDICAL UNIVERSITY

Department of General, Bioinorganic, Physical and Colloidal Chemistry



**APPROVED:**

First Vice-Rector

on research and educational work

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

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**for training of specialists of the 2<sup>nd</sup> Master's degree of higher education**  
**Branch of knowledge: 22 "Health care"**  
**Speciality: 221 "Dentistry"**

**Discussed and approved**

at the meeting of  
Department of General, Bioinorganic,  
Physical and Colloidal Chemistry  
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Head of the Department  
Prof. I. Drapak

**Approved**

at the methodical commission  
on Pharmaceutical and Chemical  
Disciplines  
Protocol № 3  
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## INTRODUCTION

**Syllabus of the Discipline “Medical Chemistry”** is developed under the requirements to *the Academic Standard of 2<sup>nd</sup> Master's degree of higher education*

Branch of knowledge: 22 “*Health care*”

Speciality: 221 “*Dentistry*”

Educational program *Master of Medicine*

### Description of the academic discipline (abstract)

Medical chemistry is one of the fundamental natural sciences disciplines in higher medical education, the knowledge of its bases is essential for productive and creative work of experts in the field of health care. It develops the dialectical way of thinking, expands and deepens the scientific knowledge about matter, structure and properties of chemical compounds and the regularities of their interaction and transformation in living organism, and identifies the ways of applied problems solving in the health care sector.

The knowledges on medical chemistry will enable the future specialist to acquire skills most essential for qualitative and quantitative prediction of biochemical processes occurrence probability and physicochemical principles of various types of equilibria in biological systems interpretation.

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)			
<b>Discipline “Medical Chemistry”</b> <i>The number of Thematic modules – 2</i>	<b>3 credits / 90 hours</b>	<b>12</b>	<b>32</b>	<b>46</b>	<b>1<sup>st</sup> year (1<sup>st</sup> semester)</b>	<b>Pass-fail test, exam</b>
<b>by semesters</b>						
<i>Thematic module 1</i> <i>Acid-Base Equilibria and Coordination Compounds Formation in Biological Liquids</i>	<b>1.5 credit / 45 hours</b>	<b>6</b>	<b>16</b>	<b>23</b>	<b>1<sup>st</sup> semester</b>	
<i>Thematic module 2</i> <i>Heterogeneous equilibria in Biological Liquids</i>	<b>1.5 credit / 45 hours</b>	<b>6</b>	<b>16</b>	<b>23</b>	<b>1<sup>st</sup> semester</b>	<b>Pass-fail test, exam</b>

**The subject of course “Medical chemistry”** is the knowledge of the chemical foundations of the vital functioning processes of the organism, which obey the basic chemical laws. Medical chemistry examines the structure and reactivity of the most important biologically active molecules, the theory of chemical bonding in coordination compounds of biometals with bioligand and the role of biogenic elements in the life of the organism. The studying of Medical chemistry generates basic understanding of physical and chemical processes that take place at the molecular and sub-molecular levels as the possible reasons for various forms of diseases and the specificity of hereditary symptoms.

### Interdisciplinary connections:

The studying of the discipline "Medical Chemistry" is based directly on the knowledge of chemistry in the secondary education extent, as well as the fundamentals of elementary mathematics and physics. Knowledge of the theoretical foundations of medical chemistry is required for a deeper study of physiology, pathophysiology, biological chemistry, general and molecular pharmacology and toxicology, hygiene disciplines and ecology.

### 1. The aims and objectives of the academic discipline

**1.1. The goal of the academic discipline “Medical chemistry” studying** is the scientific outlook of students formation, the contemporary forms of their theoretical thinking development and the ability to analyze

phenomena, the skills and abilities formation for the chemical and physico-chemical laws and processes application during the other disciplines studying and in future practical activities.

**1.2. The ultimate objectives of the academic discipline “Medical chemistry” teaching** is to teach students to use the basic concepts of chemistry, the basic laws of chemistry, the general regularities of the chemical reactions proceeding, the theory of solutions, the general knowledge about chemical elements and their compounds, knowledge of the physico-chemical foundations of various types of equilibria in biological systems in solving specific problems in medicine in accordance to modern requirements.

**1.3 Competencies and learning outcomes**, the formation of which is facilitated by the discipline (the relationship with the normative content of the higher education graduates teaching, formulated in terms of study results in the Standard of Higher Education).

The course provides the students’ *competences* according to the requirements of the High education standard:

-*general*:

- the ability to abstract thinking, analysis and synthesis;
- the ability to learn and to acquire modern knowledge;
- the ability to apply knowledge in practical situations;
- knowledge and understanding of the subject area and understanding of professional activity;
- the ability to assess and ensure the quality of work;
- the skills of information and communication technologies application;
- certainty and perseverance on tasks set and responsibilities assumed.

- *special (professional, substantive)*:

- the ability to determine the required list of laboratory and instrumental studies and evaluate their results;
- the ability to determine the nature of nutrition in the treatment of diseases;
- to define tactics of emergency medical care provision on the basis of the urgent state diagnosis;
- the ability to determine the principles and nature of the treatment of diseases;
- the ability to assess the impact of the environment, socio-economic and biological determinants on the health of the individual, family, population.

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

### Competencies Matrix

No	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
<b>Integral competencies</b>					
The ability to solve common and complex specialized tasks and practical problems in professional activities of the health care field or during the studying process providing research and / or supplying innovations implementation and is characterized by complexity and uncertainty of conditions and requirements.					
<b>General competencies</b>					
1.	The ability to apply knowledge in practical situations.	Have specialized conceptual knowledge gained in the learning process.	Be able to solve difficult tasks and problems that arise in professional activities.	A clear and unequivocal report of their own findings, knowledge and substantiating explanations to experts and non-professional audience.	Be responsible for the timeliness of decisions in difficult conditions.
2.	Knowledge and understanding of the subject area and understanding of the profession.	Have a profound knowledge of the structure of professional activity.	Be able to carry out professional activities that require updating and integration of	The ability to effectively form a communication strategy in professional	To be responsible for professional development, the ability to further professional

No	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
			knowledge.	activity.	training with a high degree of autonomy.
3.	Skills in the information and communication technologies application.	To have deep knowledge in the field of information and communication technologies used in professional activities.	Be able to use information and communication technologies in a professional field that require updating and integration of knowledge.	To use information and communication technologies in professional activities	To be responsible for the development of professional knowledge and skills.
4.	The ability to abstract thinking, analysis and synthesis, the ability to learn and to be contemporary trained.	To know methods of analysis, synthesis and further contemporary training.	Be able to analyze information, make informed decisions, be able to acquire modern knowledge.	To establish appropriate relationships to achieve goals.	To be responsible for the timely acquisition of modern knowledge.
5.	The ability to apply knowledge in practical situations.	To know the methods of knowledge implementation in solving practical issues.	Be able to use knowledge in a variety of practical situations.	To establish relationships vertically and horizontally, depending on the practical situation.	To be responsible for the timeliness of the decisions made in these situations.
6.	The ability to assess and ensure the quality of work performed.	To know the methods of evaluating performance indicators.	Be able to provide high-quality performance of work.	To build and maintain working relationships to ensure work quality.	To be responsible for the quality of work.
7.	The desire to save the environment.	Know the problems of preserving the environment and how to save it.	Be able to formulate requirements for themselves and others regarding the environment protection.	To make proposals to the relevant authorities and institutions regarding measures for the environment protection.	To be responsible for the implementation of environmental protection measures within the scope of its competence.
<b>Special (professional, substantive) competencies</b>					
1.	The ability to evaluate the results of laboratory and instrumental studies.	To have specialized knowledge about human, his organs and systems, to know the standard methodology of laboratory and instrumental researches.	To be able to analyze the results of laboratory and instrumental studies and to evaluate the information on the diagnosis of the patient on their basis.	To assign and evaluate substantially the results of laboratory and instrumental studies.	To be responsible for making decisions on evaluating the results of laboratory and instrumental studies.
2.	The ability to determine the principles and nature of the diseases treatment.	To have specialized knowledge about algorithms and standard	To be able to determine the principles and nature of the diseases treatment.	To formulate and communicate to the patient and specialists their own findings	To be responsible for making decisions about the principles and nature of the

No	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
		treatment regimens.		concerning the principles and nature of treatment.	disease treatment.
3.	The ability to diagnose urgent states.	To have specialized knowledge about a human, his organs and systems, standard survey techniques of a human (at home, on the street, in a health care institution) in the absence of information.	To be able, in the absence of information, to assess the state of a human and to diagnose, using standard methods, by making a reasonable decision.	At any circumstances, following the relevant ethical and legal standards, to make a reasonable decision on the assessment of a human's state, diagnosis and the necessary medical measures organization, depending on the state of the human; to fill in the relevant medical documents.	To be responsible for the timeliness and effectiveness of medical measures for the diagnosis of urgent states.
4.	The ability to determine medical nutrition in the treatment of diseases.	To have specialized knowledge about a human, his organs and systems, knowledge of algorithms and standard schemes for the medical nutrition assignment in the treatment of diseases.	To be able to determine, on the basis of the previous clinical diagnosis, the nature of medical nutrition in the treatment of diseases.	To formulate and to report to the patient and experts the conclusions concerning medical nutrition in the treatment of the disease.	To be responsible for the validity of the medical nutrition definition in the treatment of the disease.
5.	The ability to assess the environmental impact on the health of the population (individual, family, population).	To know the health assessing methods for the population (individual, family, population); the environmental factors that affect negatively the health of the population; Statistic analysis and laboratory research techniques, assessment of	To be able to assess the health status of the population, assess the state of the environment and the negative factors affecting the health of the population. To be trained with statistic analysis and laboratory research techniques for the health assessment of different groups of the population. Be able to form	To formulate conclusions concerning the health status of the population based on the relationship data with environmental factors and make proposals to the relevant authorities and institutions on the implementation of preventive measures. To communicate with	To be responsible for timely conclusions made about the health state of the population based on the negative impact of environmental factors data; for timely making suggestions on appropriate preventive measures.

No	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
		the health of certain contingents, assessment of environmental factors and methods for determining the relationship between them; the preventative measures towards the negative impact of environmental stresses on the health of the population. To know the principles of forming risk groups, risk areas, time and risk factors.	preventive measures on the basis of data on the relationship between the state of the environment and the health status of certain contingents of the population.	specialists in the sanitary and hygienic sector and managers of enterprises, institutions and relevant departments on environmental protection.	

#### Learning outcomes:

The integrative final syllabus learning outcomes, the formation of which is promoted by the discipline "Medical Chemistry":

- to assess the information concerning the diagnosis using a standard procedure based on the results of laboratory and instrumental studies.
- to determine the necessary medical nutrition in the treatment of the disease.
- to define tactics of emergency medical care on the basis of emergency diagnosis.
- to identify the negative environmental factors; to analyze the health of a certain contingent; to determine the relationship between the state of the environment and the health status of a contingent; to develop preventive measures based on data concerning the relationship between the state of the environment and the health status of a contingent.

The results of studying of "Medical chemistry" are:

#### *to know:*

- properties of solutions and the ways of their concentrations expressing;
- classification and nomenclature of inorganic compounds;
- basic concepts and laws of chemistry and the methods of their application for applied problems solving;
- the main regularities of chemical reactions of different types proceeding;
- the biosphere theory of V.I. Vernadsky;
- the classification and principles of titrimetric and physico-chemical methods of analysis;
- the regularities of adsorption of substances from solutions on a solid surface;

#### *to be able to:*

- to interpret the main types of chemical equilibrium for the formation of a holistic physical and chemical approach to the study of the processes of vital activity of the organism in norm and pathology;
- to interpret the main types of chemical equilibrium for the holistic physico-chemical approach formation towards the studying of the organism vital activity processes normally and in pathology;
- to apply chemical and physico-chemical methods of quantitative and qualitative analysis and to make conclusions about the possibility of their application in medical-biological research;
- to classify chemical properties and transformations of bioinorganic substances in the process of vital activity of an organism;

- to interpret general physical and chemical regularities, which are fundamental for human life processes;
- to prepare solutions with the given concentration.

## 2. Information scope of the academic discipline

3 ECTS credits (90 hours) are allocated for academic discipline.

### Thematic module1.

#### «Acid-Base Equilibrium and Coordination Compounds Formation in Biological Liquids»

##### **Topic 1. The 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. Colligative properties of solutions. Experimental determination of the molecular mass of a solute, osmotic concentration of solutions with the cryometry method**

Colligative properties of diluted nonelectrolytes solutions. Lowering of the vapor pressure of the solvent above the solution. Raoult's law. Ideal solutions. Depression of the freezing point of a solution and boiling point elevation of a solution. Osmosis and osmotic pressure. Vant' Hoff's law.

Colligative properties of diluted electrolytes solutions. Isotonic coefficient. Hypo-, hyper- and isotonic solutions.

Cryometry, ebulliometry, osmometry, and their use in biomedical researches. The role of osmosis in biological systems. Osmotic pressure of blood plasma. Haller equation. Oncotic pressure. Plasmolysis and hemolysis.

##### **Topic 3. The equilibrium and processes with coordination compounds. Preparation and properties of complex and inner complex compounds. Complexometry**

Complex formation reactions. Werner coordination theory and modern understanding of the structure of complex compounds. The concept about complexing agent (central ion). Nature, coordination number, hybridization of central atom orbitals. The concept about ligands. Denticity of ligands. The inner and external spheres of the coordination compounds. Geometry of the complex ion. The nature of the chemical bond in complex compounds. Classification of complex compounds according to the charge on the inner sphere and the nature of ligands. Chelate compounds. Polynuclear complexes.

Ferro-, cobalto-, copper- and zinc- containing biocomplex compounds. Concept about metal-ligand homeostasis. Violation homeostasis. Complexons and their application in medicine as antidotes to remove toxic metal ions from the organism and as antioxidants at storage of drugs.

Trilon B and eugenol in dentistry.

The chemical composition of mineralized tooth and saliva tissues. Physical and chemical characteristics of saliva. Heterogeneous equilibria in the oral cavity. Chemical bases of mineralization of bone and dental tissue and method of remineralization. Application of fluoride drugs and toothpastes in dentistry.

##### **Topic 4. Bio-elements in medicine and dentistry. 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. Uses in medicine. Toxic effects of compounds.

Reactions of identification of  $\text{CO}_3^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}_2\text{O}_3^{2-}$  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 oxidation numbers changing, complex formation reactions). Their biological significance. Uses in medicine. Toxic effects of *d*-elements and their compounds.

Metals and alloys in dentistry and requirements they should meet. Alloys and amalgams of gold, silver and copper in dental practice. Chromium-nickel and chromium-cobalt stainless steel. Auxiliary materials in orthopedic dentistry. Blemish materials: dental gypsum, tar acids, gentian paste. Forming materials.

Dental fill materials: phosphate cements (zinc phosphate, bactericidal, silicophosphate); price-sensitive genol, zinc-polycarboxylate, ionomer cements. The chemistry of stubble cements.

#### ***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. Properties of buffer solutions and their role in biological systems. Preparation of buffer solutions. Determination of the buffer capacity***

Buffer solutions and their classification. Henderson-Hasselbach equation. Mechanism of buffer action. Buffer capacity. Buffer systems of the blood. Bicarbonate (hydrogencarbonate) buffer, phosphate buffer. Protein buffer systems. The concept of acid-base condition 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 module 2.**

#### ***«Heterogeneous Equilibrium in Biological Liquids»***

#### ***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. Thermodynamical 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. Kinetical regularities of biochemical processes proceeding. Precipitation and dissolving***

## **reactions**

Chemical kinetics as the basis for the rates and mechanism of biochemical reactions studying. The reaction rate. Concentration affection the reaction rate. The law of mass action for the reaction rate. Rate constant. The reaction order. Kinetical equations for zero-, first- and second-order reactions. Half-life. Half-time of decomposition as quantitative characteristic of changes in the concentration in the environment of radionuclides, pesticides, etc. The reaction mechanism concept and the reaction molecularity.

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

Activation energy. Collision theory. Arrhenius equation. The concept of the transition state theory.

The kinetics of complex reactions: parallel, successive, conjugated, reversible, chain. The concept of antioxidants. Free radical reactions in living organisms. Photochemical reactions, photosynthesis.

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

The kinetics of enzymatic reactions. Enzymes as biological catalysts. Enzymes features: selectivity, efficiency, temperature and reaction medium affections. The concept of the enzymes action mechanism. Dependence of enzymatic processes rate on the concentration of enzyme and substrate. Activation and inhibition of enzymes. The impact of environmental factors on the kinetics of enzymatic reactions.

Chemical equilibrium. Equilibrium constant and its expression. Chemical equilibrium shifting at change of temperature, pressure, concentration of substances. Le Chatelier principle.

Precipitation and dissolving reactions. Solubility product constant. Precipitates formation conditions. The heterogeneous equilibrium role in general homeostasis of the organism.

## ***Topic 11. Measuring the electrical driving force of electrochemical elements and electrodes potentials***

The electrochemical phenomena significance for biochemical processes.

Electrodes potentials and their origin mechanisms. Nernst equation. The standard electrode potential. The standard hydrogen electrode. Half-cells potentials measurement. Indicator electrodes and reference electrodes. Silver-silver chloride electrode. Ion-selective electrodes. Glass electrode.

Galvanic (electrochemical or voltaic) cells.

## ***Topic 12. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration***

Redox reactions significance for biochemical processes. Redox potential as a measure of the half-cell tendency to act as oxidizing or reducing agent. Peters' equation. A standard redox potential.

The spontaneity and the direction of redox reaction proceeding prediction by their redox potentials values. Equivalent factors of reduction and oxidizing agents. Redox potentials role for the biological oxidation mechanism.

The fundamentals of potentiometry method.

Electrochemical processes in the oral cavity.

Protective films.

## ***Topic 13. 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. Duclou'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 14. 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 (hemisorbtion, plazmosorbtion, limfosorbtion, enterosorbtion, 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.

**Topic15. 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. Electrokinetical 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.

Electrokinetical 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.

**Topic16. 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**

Topic	Lectures	Practical and laboratory classes	Self-study	Individual work
<b>Thematic module 1. “Acid-Base Equilibrium and the Processes of Coordination Compounds Formation in Biological Liquids”</b>				
1. Topic 1. Variables which characterizes quantitative composition of solutions. Preparation the solution The ways of expression concentrations of solutions. Preparation the solution with known concentration. <b>Solutions used as disinfectants and antiseptics to prevent infection and spread of COVID-19</b>	1	2	3	-

2. Topic 2. Colligate properties of solutions. Experimental determination of the molecular mass of a solute, osmotic concentration of solutions with the cryometry method	1	2	2	
3. Topic 3. The equilibrium and processes with coordination compounds. Preparation and properties of complex and inner complex compounds. Complexonometry	1	2	3	
4. Topic 4. Bio-elements in medicine and dentistry. Chemical properties and biological role of macroelements.	0.5	2	3	
5. Topic 5. Chemical properties and biological role of microelements	0.5	2	3	
6. Topic 6. Acid-base equilibrium. Calculation and experimental determination of the pH of biological liquids. Protolytical processes in living organisms	1	2	3	
7. Topic 7. Properties of buffer solutions and their role in biological systems. Preparation of buffer solutions. Determination of the buffer capacity	0.5	2	3	
8. Topic 8. The basic principles of the volumetric analysis. Acid-base titration	0.5	2	3	
<b><i>In total for thematic module1</i></b>	<b>6</b>	<b>16</b>	<b>23</b>	
<b><i>Thematic module 2. "Heterogeneous Equilibrium in Biological Liquids"</i></b>				
9. Topic 9. Chemical thermodynamics. The direction of chemical and biochemical processes proceeding	2	2	3	
10. Topic 10. Kinetical regularities of biochemical processes passage. Precipitation and dissolving reactions	2	2	2	
11. Topic 11. Measuring the electrical driving force of electrochemical elements and electrodes potentials	-	2	3	
12. Topic 12. Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration	-	2	3	
13. Topic 13. Adsorption on the mobile interface. The determining of the surface tension of solutions and biological liquids. Surface tension and adsorption isotherms	1	2	2	
14. Topic 14. Molecular adsorption of the surface of a solid. Adsorptive processes and ions exchange in bio-systems. Chromatography	1	2	2	
15. Topic 15. Preparation, purification and properties of colloidal solutions	1	2	3	
16. Topic 16. Electrolytic coagulation of colloids. Physical chemistry of bio-polymers solutions	1	2	3	
<b><i>In total for thematic module2</i></b>	<b>6</b>	<b>16</b>	<b>23</b>	
<b><i>In total 90 hours/3 ECTS credits</i></b>	<b>12</b>	<b>32</b>	<b>46</b>	
<b>Final control</b>				Exam

#### 4. Thematic schedule of lectures

No	TOPIC	Duration, hours
<b><i>Thematic module 1. Acid-Base Equilibrium and Coordination Compounds Formation in Biological Liquids</i></b>		
1.	Solutions. The ways of expression concentrations of solutions. Colligate properties of solutions. Osmosis, osmotic pressure. Protolytical equilibrium in biological systems	2
2.	Coordination compounds formation in biological liquids. Complexonometry. The chemistry of bio-elements. The general knowledge of bio-elements, their biochemical role and their compounds using in medicine	2
<b><i>Thematic module 2. Heterogeneous Equilibrium in Biological Liquids</i></b>		
3.	The theoretical basis of bioenergetics. The use of thermodynamic functions for energetic characteristic of biochemical processes. The criteria of spontaneous passage	2

	of chemical processes	
4.	Kinetical regularities of biochemical processes passage. Precipitation and dissolution reactions on biological liquids	2
5.	Physics and chemistry of the surfaces phenomena	2
6.	The methods of colloidal solutions preparation. Purification and properties of colloids. Physical chemistry of bio-polymers solutions	2
<b>Totally:</b>		<b>12</b>

### 5. Thematic schedule of laboratory and practical studies

No	TOPIC	Duration, hours
<b><i>Thematic module 1. Acid-Base Equilibrium and Coordination Compounds Formation in Biological Liquids</i></b>		
1.	The ways of expression concentrations of solutions. Preparation the solution with known concentration	2
2.	Colligate properties of solutions. Experimental determination of the molecular mass of a solute, osmotic concentration of solutions with the cryometry method	2
3.	The equilibrium and processes with coordination compounds. Preparation and properties of complex and inner complex compounds. Complexometry	2
4.	Bio-elements in medicine and dentistry. Chemical properties and biological role of macroelements	2
5.	Chemical properties and biological role of microelements	2
6.	Acid-base equilibrium. Calculation and experimental determination of the pH of biological liquids. Protolytical processes in living organisms	2
7.	Properties of buffer solutions and their role in biological systems. Preparation of buffer solutions. Determination of the buffer capacity	2
8.	The basic principles of the volumetric analysis. Acid-base titration.	2
<b><i>Thematic module 2. Heterogeneous Equilibrium in Biological Liquids</i></b>		
9.	Chemical thermodynamics. The direction of chemical and biochemical processes proceeding	2
10.	Kinetical regularities of biochemical processes passage. Precipitation and dissolving reactions	2
11.	Measuring the electrical driving force of electrochemical elements and electrodes potentials	2
12.	Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration	2
13.	Adsorption on the mobile interphases. The determining of the surface tension of solutions and biological liquids. Surface tension and adsorption isotherms	2
14.	Molecular adsorption of the surface of a solid. Adsorptive processes and ions exchange in bio-systems. Chromatography	2
15.	Preparation, purification and properties of colloidal solutions	2
16.	Electrolytic coagulation of colloids. Physical chemistry of bio-polymers solutions	2
<b>Totally:</b>		<b>32</b>

### 6. Thematic schedule of students' individual work

No	TOPIC	Duration, hours	Forms of assessment
<b><i>Thematic module 1. Acid-Base Equilibrium and Coordination Compounds Formation in Biological Liquids</i></b>			
1.	The ways of expression concentrations of solutions. Preparation the solution with known concentration. <b><i>Solutions used as disinfectants and antiseptics to prevent infection and spread of COVID-19</i></b>	3	The current control during practice classes activities
2.	Colligate properties of solutions. Experimental determination of the molecular mass of a solute, osmotic concentration of solutions with the cryometry method	3	
3.	The equilibrium and processes with coordination compounds.	3	

	Preparation and properties of complex and inner complex compounds. Complexonometry		
4.	Bio-elements in medicine and dentistry. Chemical properties and biological role of macroelements	3	
5.	Chemical properties and biological role of microelements	3	
6.	Acid-base equilibrium. Calculation and experimental determination of the pH of biological liquids. Protolytical processes in living organisms	3	
7.	Properties of buffer solutions and their role in biological systems. Preparation of buffer solutions. Determination of the buffer capacity	3	
8.	The basic principles of the volumetric analysis. Acid-base titration.	3	
<b><i>Thematic module 2. Thermodynamical and kinetical regularities of the processes passing and electrochemical phenomena in biological systems</i></b>			
9.	Chemical thermodynamics. The direction of chemical and biochemical processes proceeding	3	The current control during practice classes activities
10.	Kinetical regularities of biochemical processes passage. Precipitation and dissolving reactions	3	
11.	Measuring the electrical driving force of electrochemical elements and electrodes potentials	3	
12.	Measuring the red-ox potentials. Potentiometry determination of pH. Potentiometry titration	3	
13.	Adsorption on the mobile interphases. The determining of the surface tension of solutions and biological liquids. Surface tension and adsorption isotherms	3	
14.	Molecular adsorption of the surface of a solid. Adsorptive processes and ions exchange in bio-systems. Chromatography	1	
15.	Preparation, purification and properties of colloidal solutions	3	
16.	Electrolytic coagulation of colloids. Physical chemistry of bio-polymers solutions	3	
<b><i>Totally:</i></b>		<b>46</b>	

## 7. Individual tasks are not supposed

## 8. Teaching methods

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

- by the cognitive activity type:
  - explanatory-illustrative;
  - reproductive;
  - problematic presentation;
  - the logic of cognition;
  - analytical;
  - inductive;
  - deductive;
- according to the main stages of the process:
  - knowledge formation;
  - skills and abilities formation;
  - knowledge application;
  - generalization;
  - fixing;
  - assessment;
- by the system approach:
  - stimulation and motivation;
  - assessment and self-assessment;
- 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.

## 9. Methods of control

**The current control** is a regular check of educational trained achievements, fulfilled 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 classes and were scored with the points 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 80 multiple 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 activity taking into account the approved evaluation criteria

**10.1. The current educational activity assessment.** When evaluating the educational activities achievements of each topic for the current educational activity, the student is assessed with grades in the 4-grading scale (national). It takes into account all types of activities provided for by the discipline syllabus. 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 9 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 % of standardized questions of the topic correctly. He/she uses the 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 answers 50-69% of standardized 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 11 to 16	3
< 9 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 in 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 skills on 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 score points** 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:

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

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

4-	200-	grading	grading	scale	scale	5.00	120
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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 exams** 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 next 25 % 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
From 170 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. METHODOLOGICAL 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 1<sup>st</sup> year students of Faculty of Dentistry (Part 1).  
[http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl\\_Metodychne\\_zabezpechennaj/Engl\\_Metod\\_Medical\\_chem\\_1\\_Med\\_M-1.pdf](http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Metodychne_zabezpechennaj/Engl_Metod_Medical_chem_1_Med_M-1.pdf)
2. Medical chemistry study guide for the 1<sup>st</sup> year students of Faculty of Dentistry (Part 2).  
[http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl\\_Metodychne\\_zabezpechennaj/Engl\\_Metod\\_Medical\\_chem\\_1\\_Med\\_M-2.pdf](http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Metodychne_zabezpechennaj/Engl_Metod_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](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](http://www.meduniv.lviv.ua/files/kafedry/bioneorgan/Engl_Tests/Engl_Medical_chem_1_Med_M-2_Tests.pdf)

