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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"___" _____10_____ 2023

S Y L L A B U S
OF DISCIPLINE
ВБ 1.99 "BIOLOGICAL ROLE OF LIFE ELEMENTS"

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for training of specialists of the 2nd Master's degree of higher education
Branch of knowledge: 22 "Health care"
Speciality: 222 "Medicine"

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

Syllabus of the discipline "Biologocal role of life elements" is developed

under the requirements to *the Academic Standard of 2nd Master's degree of higher education*

Branch of knowledge: *22 "Health care"*

Speciality: *222 "Medicine"*

Educational program *Master of Medicine*

Description of the academic discipline (abstract)

The discipline " Biological role of life elements " is an organic complement to one of the fundamental natural sciences in the system of higher medical education. The knowledge acquired during the study of the elective course is necessary for the activities of specialists in the field of medicine. The study of the elective course develops a dialectical way of thinking, expands and deepens scientific knowledge about the matter, structure and properties of chemical elements and their transformations, as well as identifies ways to solve applied problems in medicine and pharmacy.

The knowledge gained from the discipline "Biological role of life elements" will allow future professionals to master the skills of establishing the mechanisms of interaction of inorganic substances used in medical and pharmaceutical practice, as well as their biological role and biotransformation in humans.

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: «Biological role of life elements» ***The number of Thematic modules –1***	**3 credits / 90 hours.**	**12**	**18**	**60**	**1_{st} cours (1^{st} semester)**	**test**
by semesters						
Thematic module 1 **Biological role of life elements**	**1 credit / 30 hours.**	**12**	**18**	**60**	**1^{st} semester**	**test**

The subject of discipline: "Biological role of life elements" are physicochemical processes that occur at the molecular and submolecular levels and which are subject to basic chemical laws. The discipline "Biological role of life elements" considers the structure and reactivity of the most important biologically active molecules, the theory of chemical bonds in complex compounds of biometals with bioligands and the role of nutrients in the life of the organism.

Interdisciplinary connections:

The studying of the discipline "Biological role of life elements" 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 "Biological role of life elements" 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 "Biological role of life elements" 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 discipline provides the students' ***competences*** according to the requirements of the High education standard:

-general:

- the ability to abstract thinking, analysis and synthesis (GC 1);
- the ability to apply knowledge in practical situations (GC 3);
- knowledge and understanding of the subject area and understanding of professional activity (GC 4);
- the ability to make informed decisions (GC 6);
- the ability to search, process and analyze information from various sources (GC 11);
- determination and persistence in tasks and responsibilities (GC 12);
- the ability to realize own 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 (GC14).

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

- the ability to determine the required list of laboratory and instrumental studies and evaluate their results (PC2);
- the 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 competencies					
Ability to solve typical and complex problems and practical problems in professional medical activities using the provisions, theories and methods of chemistry; integrate knowledge and solve complex issues, formulate judgments on insufficient or limited information; clearly communicate conclusions and knowledge reasonably substantiating them, to professional and non-professional audience.					
General competencies					
1.	The ability to abstract thinking, analysis and synthesis (GC 1)	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.

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
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 activity (GC 4)	Critical reflection on of problems in the field and on the border of of knowledge.	The ability to integrate knowledge and solve complex problems in broad or multidisciplinary 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 teams.
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 are students.	Management of working or learning processes or learning processes that are complex unpredictable and require new strategic approaches.

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
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 border of of knowledge.	The ability to integrate knowledge and solve complex problems in broad or multidisciplinary or multidisciplinary contexts.	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 teams.
	Determination and persistence in tasks and responsibilities (GC 12)	Critical reflection on of problems in the field and on the border of 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.
	The ability to realize own 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 (GC14)	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.	The ability to to continue learning with a high degree of of autonomy.
Special (professional, substantive) competencies					

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
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 border of 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	The 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 border of 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	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 processes that are complex, unpredictable and require new strategic approaches.

Learning outcomes:

The integrative final sillabus learning outcomes, the formation of which is promoted by the discipline "Biological role of life elements ":

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. To 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	GC4, GC6, GC11, GC12, 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	PLO-23	GC1, GC4, PC17

state of morbidity of the population.		
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

The results of studying of "Biological role of life elements" 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 module 1.

«Biological role of life elements»

Topic 1. Biological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry.

The main measures to prevent infection and spread of COVID-19

Classification of bioelements according to V.I. Vernadsky.

Biogenic elements.

Macro- and microelements.

Properties and biological role of some s-elements (Potassium, Sodium, Calcium, Magnesium).

Properties and biological role of some p-elements (Fluorine, Chlorine, Bromine, Iodine).

Properties and biological role of some d-elements (Iron, Manganese).

Know the basic measures to prevent the infection and spread of COVID-19 caused by the SARS-CoV-2 virus, and to implement them in higher education.

Topic 2. Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of D.I. Mendeleev. The concept of human microelentosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status.

Classifications of chemical elements. Biogenic elements. Macro- and microelements. The position of nutrients in the periodic system of DI Mendeleev. Relationship of physicochemical parameters of elements with their position in the periodic table and content in the body. Properties and biological role of some s-, p- and d-elements.

V. Vernadsky's doctrine of the biosphere and biogeochemistry. The concept of migration of chemical elements. Association of endemic diseases with features of biogeochemical provinces. Human and the biosphere. The noosphere. Technological progress and ecology.

Human microelementosis as a pathological process caused by deficiency, excess or imbalance of

macro- and microelements. Indications for laboratory diagnosis. Biochemical indicators of human elemental status.

Topic 3. The chemical composition of cells and blood, the function of individual elements in them

The chemical composition of the cell. General characteristics of macro- and microelements of the cell. Their biological significance.

Inorganic compounds in the cell. Influence of water in the activity of cells of a living organism. The role of mineral salts in the cell.

Organic compounds in the cell and their biological significance.

Topic 4. The chemical composition of blood and the function of its individual elements

Blood and its functions, components of blood. Blood volume (total, circulating (BCC), deposited). Blood viscosity. Relative density of blood (value, size).

Plasma, its composition, the role of plasma proteins. Osmotic and oncotic pressures. Functional system that maintains the stability of the osmotic pressure. The concept of physiological isotonic solutions; hypertonic and hypotonic solutions. Hemorrhagic fluids.

Acid-base homeostasis, its significance for the body. Physico-chemical mechanisms that maintain acid-base balance in the body. Physiological mechanisms of homeostatic regulatory functions of the kidneys, lungs, liver, gastrointestinal tract and bone tissue. Buffer systems of the internal environment of the organism. Functional system that maintains acid-base homeostasis..

Topic 5. Bioelements organogens (O, C, H, N).

Oxygen. General characteristics, distribution in nature, biological role. Chemical bases of oxygen and ozone application in medicine and pharmacy.

Carbon, biological significance. Carbon allotropy. Carbon (II) compounds. Carbon monoxide, its acid-base and redox characteristics. Carbon monoxide as a ligand, the chemical basis of its toxicity. Chemical bases of application of Carbon and its compounds in medicine and pharmacy.

Hydrogen. General characteristics of the element, biological significance. Features of the situation in the periodic system of elements. Chemical bases of Hydrogen and its compounds application in medicine and pharmacy.

Nitrogen. General characteristics, biological significance. Compounds with different values of oxidation states. Chemical bases of Nitrogen and its compounds application in medicine and pharmacy.

General characteristics of Chlorine as a representative of halogens. Chlorine compounds with metals and nonmetals. Biological role of chlorine compounds. The application of chlorinated lime, chlorinated water, active chlorine preparations in medicine, sanitation and pharmacy.

Topic 6. Non-metallic macronutrients (P, S, Cl)

Phosphorus. General characteristics, biological significance. Allotropic modifications of Phosphorus, their chemical activity. Qualitative reaction to phosphate ion. Chemical bases of application of Nitrogen and its compounds in medicine and pharmacy.

Sulfur. General characteristics. Biological role of sulfur (sulfhydryl groups and disulfide bridges in proteins). Sulphides of metals and nonmetals, their solubility in water and hydrolysis. Qualitative reactions on sulfur-containing ions. Chemical bases of Sulfur and its compounds application in medicine and pharmacy.

Sulfur (IV) compounds - oxide, chloride, oxochloride, sulfurous acid, sulfites and hydrogen sulfites, their acid-base and redox properties. Reduction of sulfites to dithionates, properties of dithionates. Interaction of sulfites with sulfur. Qualitative reaction on sulfite ion. Properties of thiosulfates: reactions with acids, oxidants (chlorine, iodine), metal cations, complexation reactions. Qualitative reaction on thiosulfate ion. Polityants, features of their structure. Thionyl chloride.

Sulfur (VI) compounds - oxide, hexafluoride, dioxochloride, sulfuric acid, sulfates, acid-base and redox properties. Oleum. Disulfuric acid, chlorosulfonic acid. Peroxosulfates and their oxidizing properties. The use of sulfur compounds in medicine, pharmacy, pharmaceutical analysis.

General characteristics of Chlorine as a representative of halogens. Chlorine compounds with metals and non-metals. Interaction of halogens with water and aqueous solutions of alkalis. Oxygen-containing halogen acids and their salts. The structure and nature of relationships. Stability in the free state and in solutions, change of acidic and redox properties depending on the degree of oxidation. Chlorates. Biological role of chlorine compounds. The use of chlorinated lime, chlorinated water, active chlorine preparations in medicine, and sanitation.

Topic 7. Biological role of metallic elements compounds. Properties and biological role of some s-elements. Macronutrients metals (Ca, K, Na, Mg)

General characteristics of s-elements of IA and IIA groups. Occurrence in nature. Chemical properties of s-elements. General information about nutrients. Qualitative and quantitative content of nutrients in the human body. Biological role of elements in the mineral balance of the organism. Macronutrients, their content in the body. Ionophores and their role in membrane transport of potassium and sodium ions. Characteristics of the ionic state of these elements. The use of sodium and potassium compounds in medicine. Biological role of Calcium and Magnesium. Chemical bases of application of compounds of Magnesium, Calcium in medicine.

Topic 8. Properties and biological role of some d-elements. Trace elements in enzymes, hormones, vitamins and other biologically active substances. Trace elements metals (Fe, Zn, Cu, Mn, Mo, Co, Cr)

General characteristics of iron, zinc, copper, manganese, molybdenum, chromium and cobalt, ionic states, coordination numbers, chemical activity of their simple substances, natural compounds. Acid-base and redox characteristics of iron, zinc, copper, manganese, molybdenum, chromium and cobalt. Salts of these biometals, their solubility and hydrolysis, thermal decomposition of nitrates. Complex compounds Zn, Fe, Cu, Co, Cr, Mn, ammonia, water, hydroxide ions, amino acids and polyhydric alcohols, cyanide and thiocyanate ions, dimethylglyoxime and porphyrins. Qualitative reactions to the detection of these metals. The composition and biological significance of enzymes containing Zn, Fe, Cu, Co, Cr, Mn, Mo. The use of Ferrum, Zinc, Copper, Manganese, Molybdenum, Chromium and Cobalt compounds in medicine. Diseases caused by deficiency and excess of these bioelements.

Topic 9. Non-metallic trace elements (Se, I)

Selenium: general characteristics, acid-base and redox properties of compounds. Hydrogen selenide, extraction and properties. Selenides. Selenium oxide (IV), selenic acid: extraction, acid-base and redox properties. Selenites. Selenium oxide (IV), selenic acid: extraction and properties. Biological role of selenium. The concept of antioxidants.

Iodine: general characteristics as an element of group VIII. Extraction and chemical activity of iodine. Compounds of Iodine with Hydrogen. Solubility in water, acid and redox properties. Ionic and covalent iodides, their relationship to the action of water, oxidants and reducing agents. Iodide ions as ligands in complex compounds. Identification reactions of Iodide ion. Iodine compounds in positive oxidation states. Oxygen compounds and interhaloid compounds. Interaction of iodine with water and aqueous solutions of alkalis. Oxygen-containing iodine acids and their salts. The structure and nature of relationships. Stability in the free state and in solutions, change of acidic and redox properties depending on the degree of oxidation of halogen. Biological role of iodine compounds. The concept of chemistry of bactericidal action of iodine. The use of active iodine, as well as iodides in medicine, sanitation.

Topic 10. Conditionally vital trace elements of non-metals (F, B, Si, Br)

General characteristics of halogens. Special properties of fluorine as the most electronegative element. Simple substances, their chemical activity. General characteristics of Boron. Simple substance and its chemical activity. Borides. Hydrogen compounds (borane), features of stereochemistry and the nature of the connection. Hydroborates. Boron halides, hydrolysis and complexation. Boron (III) oxide and boric acids, equilibrium in aqueous solution. Borates as derivatives of various simple and polymeric boron acids. Sodium tetraborate. Esterborate acid. Organo-boron compounds. Biological role of boron. Antiseptic properties of boric acid and its salts.

Silicon. General characteristics. The main difference between Silicon and Carbon is the lack of π-bonds in the compounds. Biological role. Silicides. Hydrogen compounds (silanes), their oxidation and hydrolysis. Silicon tetrafluoride and tetrachloride, their hydrolysis. Hexafluorosilicates. Oxygen-containing compounds Silicon, silicon oxide (IV). Silica gel, its use. Glass, its properties and stability. Silicate acids. Silicates, their solubility and hydrolysis. Natural silicates and aluminosilicates. Zeolites. Organosilicon compounds. Silicones and siloxanes. The use of silicon compounds in medicine. Physiological role of Fluorine, Boron, Silicon and Bromine. Indicators of elemental status in the human body. Correction of excess and deficiency of elements in the body. The use of compounds of these elements in medicine, and sanitation.

Topic 11. Conditionally vital trace elements metals and metalloids (Ni, V, As, Li)

General characteristics of the elements Lithium, Nicholas, Vanadium and Arsenic. Valence states. Chemical activity. Occurrence in nature. Their binary compounds (superoxides, ozonides). Hydroxides, salts of Li, Ni, V, As and their properties and applications in medicine and pharmacy. Determination of Arsenic by the Marsh method. Arsenites and arsenates, acid-base and redox properties.

The most important compounds of Nickel (II). Hydrolysis of salts of Nickel (II). Complex compounds with cyanide, thiocyanate and fluoride ions. Aqua complexes. Ammonia. Coenzyme B_{12}. Qualitative reaction on Ni^{2+} cation. Chugaev reaction.

Topic 12. Chemical potentially toxic trace elements (Rb, Ag, Au, Zr, Sn, W, Ge, Ga, Sr, Ti) General characteristics of potentially toxic trace elements. Occurrence in nature. Biological role of elements in the mineral balance of the organism. General characteristics of the elements. Features of the situation in the periodic table of elements. Physiological role of potentially toxic trace elements. Ways of entry into the human body. Causes of high content of potentially toxic trace elements in the human body. The main manifestations of excess potentially toxic trace elements in the human body. Correction of excess potentially toxic trace elements in the human body.

Topic 13. Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)

General characteristics of toxic trace elements. Occurrence in nature. Biological role of elements in the mineral balance of the organism. Characteristics of the ionic state of these trace elements. Toxic micronutrient poisoning, toxicity threshold, toxic and lethal doses. Toxicity and physiological role. Increased and decreased content of toxic trace elements. Environmental pollution. Sources of elements in the human body. The ability of toxic trace elements to form stable complexes. Chemical bases of application in medicine, and cosmetology.

Topic 14. Metal-ligand homeostasis.

Typical symptoms of deficiency of chemical elements in the human body. Adjustment of mineral metabolism in the human body The essence of the unity of the chemical composition of the organism and its significance. Metal-ligand homeostasis and the theory of metal-ligand pathologies. Pathologies in the life of the human body associated with abnormal content of certain chemical elements.

The most important bioligands, their isomerism. Basic elements and functional groups in bioligands. Ligand properties of complexes and drugs. Chelation therapy.

Topic 15. Medicines of non-metals and metalloids

Medicines based on metals and metalloids. Use in medicine of Oxygen, Sulfur, Chlorine, Bromine, Nitrogen inorganic compounds. Drugs based on coordination compounds of non-metals and metalloids (Boron, Phosphorus, Antimony, Arsenic, Selenium, Tellurium).

Topic 16. Medicines based on metals and their coordination compounds

Medicines based on metals and coordination compounds of metals (Mg, Ca, Al, Cu, Ag, Hg, Zn, Au). The use of metals as probes in biochemical research.

3. Structure of the academic discipline

Topic	**Lectures**	**Practical and laboratory classes**	**Self-study**	**Individual work**
Thematic module I. Biological role of life elements				
1. Topic 1. Biological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry. The main measures to prevent infection and spread of COVID-19	0,5	1	3	
2. Topic 2. Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of DI Mendeleev. The concept of human microelentosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status	0,5	1	3	
3. Topic 3. The chemical composition of the cell. Minerals and organic substances in the cell	0,5	1	4	
4. Topic 4. The chemical composition of blood and the function of its individual elements	1	0,5	4	
5. Topic 5. Organogenic bioelements (O, C, H, N)	2	1	4	
6. Topic 6. Macronutrients of nonmetals (P, S, Cl)	1	0,5	4	

7. Topic 7. Biological role of compounds of metallic elements. Properties and biological role of some s-elements. Macronutrients metals (Ca, K, Na, Mg)	0,5	2	4	
8. Topic 8. Properties and biological role of some d-elements. Trace elements in enzymes, hormones, vitamins and other biologically active substances. Trace elements metals (Fe, Zn, Cu, Mn, Mo, Co, Cr)	1	2	4	
9. Topic 9. Micronutrients of non-metals (Se, I)	1	2	4	
10. Topic 10. Conditionally vital trace elements of non-metals (F, B, Si, Br)	0,5	1	4	
11. Topic 11. Conditionally vital trace elements metals and metalloids (Ni, V, As, Li)	0,5	1	4	
12. Topic 12. Chemical potentially toxic trace elements (Rb, Ag, Au, Zr, Sn, W, Ge, Ga, Sr, Ti)	0,5	1	3	
13. Topic 13. Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)	0,5	1	3	
14. Topic 14. Metal-ligand homeostasis. Typical symptoms of deficiency of chemical elements in the human body. Adjustment of mineral metabolism in the human body	1	1	4	
15. Topic 15. Medicines of non-metals and metalloids	0,5	1	4	
16. Topic 16. Medicines based on metals and their coordination compounds	0,5	1	4	
In total for thematic module 1	***12***	***18***	***60***	
In total 90 hours / 3 ECTS credits	**12**	**18**	**60**	
Final control				Test

4. Thematic schedule of lectures

№	TOPIC	Duration, hours
1.	Biogenic elements, their classification. Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of DI Mendeleev. The concept of human microelentosis. Chemical composition of cells and blood. Mineral and organic substances in their composition	2
2.	Bioelements-organogens (O, C, H, N) and non-metal macroelements (P, S, Cl)	2
3.	Biological role of compounds of metallic elements. Macroelements (Ca, K, Na, Mg). Trace elements metals (Fe, Zn, Cu, Mn, Mo, Co, Cr). Non-metals trace elements (Se, I).	2
4.	Conditionally vital trace elements (non-metals, metals and metalloids).	2
5.	Potentially toxic and toxic trace elements.	2
6.	The unity of the chemical composition of the organism. Metal-ligand homeostasis. Adjustment of mineral metabolism in the human body. Medicines of non-metals and metalloids. Medicines based on metals and their coordination compounds	2
	TOTALLY	***12***

5. Thematic schedule of laboratory and practical studies

№	TOPIC	Duration, hours
1.	Chemical elements in the geosphere and biosphere. The position of biogenic elements in the Periodic Table. The concept of human microelentosis	3
2.	The chemical composition of cells and blood, the function of its individual elements. Organogenic bioelements (O, C, H, N).	3
3.	Macronutrients non-metals (P, S, Cl). Macronutrients metals (Ca, K, Na, Mg).	3
4.	Trace elements metals (Fe, Zn, Cu, Mn, Mo, Co, Cr). Non-metallic trace elements (Se, I)	3

5.	Conditionally vital trace elements non-metals, metals and metalloids (F, B, Si, Br, Ni, V, As, Li). Potentially toxic trace elements. Toxic trace elements	3
6.	The unity of the chemical composition of the organism. Metal-ligand homeostasis. Medicines based on metals and their coordination compounds	3
	Totally	***18***

6. Thematic schedule of students' individual work

№	Topic	Duration, hours	Forms of assessment
1.	Biological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry. The main measures to prevent infection and spread of COVID-19	3	The current control during practice classes activities
2.	Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of D.I. Mendeleev. The concept of human microelentosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status.	3	
3.	The chemical composition of the cell. Minerals and organic matter in cells.	4	
4.	The chemical composition of blood and the function of its individual elements.	4	
5.	Organogenic bioelements (O, C, H, N)	4	
6.	Non-metallic macronutrients (P, S, Cl)	4	
7.	Biological role of metallic element compounds. Properties and biological role of some s-elements. Macronutrients metals (Ca, K, Na, Mg)	4	
8.	Properties and biological role of some d-elements. Trace elements in the composition of enzymes, hormones, vitamins and other biologically active substances. Trace elements metals (Fe, Zn, Cu, Mn, Mo, Co, Cr)	4	
9.	Non-metallic trace elements (Se, I)	4	
10.	Conditionally vital trace elements of non-metals (F, B, Si, Br)	4	
11.	Conditionally vital trace elements metals and metalloids (Ni, V, As, Li)	4	
12.	Potentially toxic trace elements (Rb, Zr, Sn, Ag, Au, W, Ge, Ga, Sr, Ti)	3	
13.	Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)	3	
14.	The unity of the chemical composition of the organism. Metal-ligand homeostasis. Typical symptoms of deficiency of chemical elements in the human body. Adjustment of mineral metabolism in the human body	4	
15.	Non-metals and metalloids containing medicines	4	
16.	Medicines based on metals and their coordination compounds	4	
	Totally	***60***	

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

Teaching methods

In the process of "Biological role of life elements" disciplines studying the following teaching methods are used for students:

- by the cognitive activity type:
  - explanatory-illustrative;
  - reproductive;
  - problematic presentation;
  - the logic of cognition;
  - analitical;

- inductive;
- deductive;

- according to the main stages of the process:
  - knowledge formation;
  - skills and abilities formation;
  - knowledge application;
  - generalization;
  - fixing;
  - assesment;
- by the system 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.

8. **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 form of ***final control*** in the study of the elective course "Biological role of the elements of life" is a test. 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 are admitted to the final control.

9. 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.

9.1. 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-graiding 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 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 % 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 13 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.

10. The form of final control of academic performance in the study of the discipline **"Biological role of life elements"** is a test. Semester test is a form of final control, which consists in assessing the student's mastery of educational material on the basis of the results of his performance of certain types of work in practical, seminar or laboratory classes. Semester credit in disciplines is held after the end of its study, before the examination session.

11. 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:

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

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

4-grading scale	200-grading scale
5	200
4.97	199
4.95	198
4.92	197
4.9	196
4.87	195
4.85	194
4.82	193
4.8	192
4.77	191
4.75	190
4.72	189
4.7	188
4.67	187
4.65	186
4.62	185
4.6	184
4.57	183
4.52	181
4.5	180
4.47	179

4-grading scale	200-grading scale
4.45	178
4.42	177
4.4	176
4.37	175
4.35	174
4.32	173
4.3	172
4.27	171
4.24	170
4.22	169
4.19	168
4.17	167
4.14	166
4.12	165
4.09	164
4.07	163
4.04	162
4.02	161
3.99	160
3.97	159
3.94	158

4-grading scale	200-grading scale
3.92	157
3.89	156
3.87	155
3.84	154
3.82	153
3.79	152
3.77	151
3.74	150
3.72	149
3.7	148
3.67	147
3.65	146
3.62	145
3.57	143
3.55	142
3.52	141
3.5	140
3.47	139
3.45	138
3.42	137
3.4	136

4-grading scale	200-grading scale
3.37	135
3.35	134
3.32	133
3.3	132
3.27	131
3.25	130
3.22	129
3.2	128
3.17	127
3.15	126
3.12	125
3.1	124
3.07	123
3.02	121
3	120
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.

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**
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).

12. Methodical Providing

The list and content of the initial methodological support for studying the discipline "Biological role of life elements" includes:

- extended plan of lectures on the elective course "Biological role of life elements";
- thematic schedules of lectures, practical and laboratory classes and the students' individual work;
- tasks for laboratory work and independent work;
- questions, tasks, tasks or cases for current and final control of knowledge and skills of students;
- complex control work, post-certification monitoring of knowledge and skills from the elective course "Biological role of life elements".

13. Recommended literature

Required discipline textbooks:

1. V.O. Kalibabchuk, V.I. Halynska, L.I. Hryshchenko et al. Medical Chemistry. – AUS MEDICINE Publishing. – 2010. – 224 p.
2. General and Inorganic Chemistry: textbook / V.O. Kalibabchuk, V.V. Ohurtsov, V.I. Halynska et al.; edited by V.O. Kalibabchuk. – Kyiv: AUS Medicine Publishing, 2019. – 456 p.
3. Raymond Chang. Chemistry (6th Edition). – WCB/McGraw-Hill. – 1998. – 995 p.
4. Steven S. Zumdahl. Chemistry (4th Edition). – Houghton Mifflin Company. – 1997. – 1031 p.
5. Gary L. Miessler, Donald A. Tarr. Inorganic Chemistry. – Prentice Hall. – 1991. – 625 p.

Additional books:

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

14. Information resources

Students use the following information resources and knowledge bases when studying the discipline "Biological role of life elements", through the use of local and global computer networks:

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