

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**

**ББ – 1.6 “BIOLOGICAL ROLE OF LIFE ELEMENTS”**

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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: 226 “Pharmacy, industrial pharmacy”**

**Discussed and approved**

at the meeting of

Department of General, Bioinorganic,  
Physical and Colloidal Chemistry

Protocol № 20

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Head of the Department

Prof. I. Drapak

**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 discipline "Biological role of life elements"

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: 226 "Pharmacy, industrial pharmacy"

educational program *Master of pharmacy*

### Optional course description (abstract)

The Syllabus of discipline "The Biological Role of the Elements of Life" is an organic complement and deepening of the study of one of the fundamental natural disciplines in the system of higher pharmaceutical education, knowledge of which is necessary for fruitful, creative work of health professionals. The knowledge acquired during the study of the Syllabus of discipline is necessary for the fruitful, creative work of specialists in the field of pharmacy. The Syllabus of discipline 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 the field of health care.

Knowledge from the Syllabus of discipline "Biological role of life elements" will allow future specialists to master the most essential skills of qualitative and quantitative forecasting of the probability of biochemical processes and physico-chemical basis of interpretation of different types of balance of biological systems.

The 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)			
Syllabus of discipline "Biological role of life elements" The number of Thematic modules –1	3 credits / 90 hours	10	20	60	1 <sup>st</sup> year (1 <sup>st</sup> semester)	Pass-fail test
<b>for semesters</b>						
<i>The Thematic module 1</i> <i>Biological role of life elements</i>	1 credit / 30 hours	10	20	60	1 <sup>st</sup> semester	Pass-fail test

**The subject of Syllabus is:** the chemical basis of the vital processes of the organism, which are based on basic chemical laws. The Syllabus of discipline "Biological role of life elements" provides a study of 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 body. Physicochemical processes that occur at the molecular and submolecular levels are also considered, because this is where the causes of various forms of disease and the specificity of hereditary traits.

### Interdisciplinary links:

The study of the Syllabus of discipline "Biological role of the elements of life" is directly based on the basics of chemistry in secondary education, as well as the basics of elementary mathematics and physics. Knowledge of the theoretical foundations of inorganic chemistry is necessary for a deeper study of physiology, pathophysiology, biological chemistry, general and molecular pharmacology and toxicology, hygienic disciplines and ecology.

### 1. The aim and objectives of the Syllabus of discipline

**1.1. The goal of the Syllabus of discipline "Biological role of elements of life" studying** is the formation of students' scientific worldview, development of modern forms of theoretical thinking and ability to

analyze phenomena, skills and abilities to apply chemical and physicochemical laws and processes in other disciplines. and in future practical activities.

**1.2. The ultimate objectives of the Syllabus of discipline "Biological role of life elements"** are to teach students to use basic concepts of chemistry, basic laws of chemistry, general laws of chemical reactions, the doctrine of solutions, general information about chemical elements and their compounds, knowledge of physicochemical bases different types of balance of biological systems in solving specific problems in the field of medicine in accordance with modern needs.

**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).

In accordance with the requirements of the Standard of Higher Education, the discipline provides students with the acquisition of **competencies**:

*-general:*

- ability to abstract thinking, analysis and synthesis;
- ability to learn and be modernly trained;
- knowledge and understanding of the subject area and understanding of the profession;
- ability to apply knowledge in practical situations;
- skills of using information and communication technologies;
- ability to search, process and analyze information from various sources.
- ability to adapt and act in a new situation; ability to work autonomously;
- ability to identify, pose and solve problems;
- ability to evaluate and ensure the quality of work performed.

*-special (professional, substantive):*

- the ability to organize the production activities of pharmacies regarding the preparation of medicinal products in various dosage forms according to the prescriptions of doctors and the orders of medical institutions, including the justification of the technology and the selection of auxiliary materials in accordance with the rules of Good Pharmacy Practice (GPP).
- the ability to organize and participate in the production of medicinal products in the conditions of pharmaceutical enterprises, including the selection of a technological process with justification of the technological process and the selection of appropriate equipment in accordance with the requirements of Good Manufacturing Practice (GMP).
- the ability to develop methods of quality control of medicinal products, pharmaceutical substances, medicinal plant raw materials and auxiliary substances using physical, physico-chemical and chemical control methods.
- the ability to identify medicinal products and their metabolites in biological fluids and body tissues, to conduct chemical and toxicological studies for the purpose of diagnosing acute poisoning, drug and alcohol intoxication.
- the ability to ensure proper storage of medicines and medical products in accordance with their physical and chemical properties in health care institutions.

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

### Competencies Matrix

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
<b>Integral competencies</b>					
The ability to solve typical and complex specialized tasks and practical problems in professional activities in the field of health care, or in the learning process, which involves research and / or innovation and is characterized by complex and uncertain conditions and requirements.					
<b>General competencies</b>					

<b>№</b>	<b>Competence</b>	<b>Knowledge</b>	<b>Skills</b>	<b>Communication</b>	<b>Autonomy and responsibility</b>
1.	The ability to apply knowledge in practical situations	To have specialized conceptual knowledge acquired in the learning process.	To be able to solve complex problems and problems that arise in professional activities.	Clear and unambiguous communication of one's own conclusions, knowledge and explanations that substantiate them to specialists and non-specialists.	Responsible for making decisions in difficult circumstances
2.	The knowledge and understanding of the subject area and understanding of the profession.	To have deep knowledge of the structure of professional activity.	To be able to carry out professional activities that require updating and integration of knowledge.	The ability to effectively form a communication strategy in professional activities.	To be responsible for professional development, ability to further professional training with a high level of autonomy.
3.	Skills in the use of information and communication technologies.	To have fundamental knowledge in the field of information and communication technologies used in professional activities.	To be able to use information and communication technologies in a professional field that requires updating and integrating knowledge.	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 be modernly trained.	Know the methods of analysis, synthesis and further modern learning	To be able to analyze information, make informed decisions, be able to acquire modern knowledge	Establish appropriate links to achieve goals.	Be responsible for the timely acquisition of modern knowledge.
5.	The ability to apply knowledge in practical situations.	To know the methods of applying knowledge in solving practical problems.	Be able to use knowledge in a variety of practical situations.	Establish vertical and horizontal connections depending on the practical situation.	Be responsible for the timeliness of decisions in these situations.
6.	The ability to evaluate and ensure the quality of work performed.	To know the methods of evaluating performance indicators.	Be able to ensure quality work.	Establish connections to ensure quality work.	Be responsible for the quality of work.
7.	The desire to save the environment.	To know the problems of environmental protection and ways to preserve it	Be able to form requirements for yourself and others to protect the environment	Make proposals to relevant authorities and institutions on measures to preserve and protect the environment	Be responsible for the implementation of environmental measures within its competence.
<b>Special (professional, substantive) competencies</b>					
1.	The ability to organize the production activities	To know: - acid-base balances and	To determine in writing and eliminate	Pharmacy specialists employed in the	Independence, responsibility

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
	of pharmacies for the preparation of drugs in various dosage forms according to the prescriptions of doctors and orders of medical institutions, including the justification of technology and the selection of auxiliary materials in accordance with the rules of Good Pharmacy Practice (GPP).	oxidation-reduction reactions; - kinetics of chemical reactions and catalysis	incompatibilities of medicinal substances and medicinal plant raw materials: - physical, chemical and physico-chemical according to list 1a	field of pharmaceutical drug production	
2.	The ability to organize and participate in the production of medicinal products in the conditions of pharmaceutical enterprises, including the selection of a technological process with justification of the technological process and the selection of appropriate equipment in accordance with the requirements of Good Manufacturing Practice (GMP).	To know: - chemical resistance of glass, requirements for vials for injection solutions	To prepare and test ampoules and vials for injection solutions	Specialists employed in the field of industrial production of medicines	Independence, responsibility
3.	The ability to develop methods of quality control of medicines, pharmaceutical substances, medicinal plant raw materials and auxiliary substances using physical, physico-chemical and chemical control methods.	To know: - qualitative analysis of cations and anions. - classification and nomenclature of inorganic compounds - general methods of analysis of inorganic compounds.	To carry out calculations of various ways of expressing the composition of solutions related to the preparation of solutions from chemical reagents	Regulatory documentation and quality standards	Independence, responsibility
4.	The ability to determine medicinal products and their metabolites in	To know: - physico-chemical properties of	Taking into account the distribution of poison in the body, metabolism, other	Methods of expert research	Independence, responsibility

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
	biological fluids and body tissues, to conduct chemical and toxicological studies for the purpose of diagnosing acute poisoning, drug and alcohol intoxication.	drugs of inorganic nature; - classification of heavy metal compounds; - compounds of heavy metals (Ba <sup>2+</sup> , Pb <sup>2+</sup> , Mn <sup>2+</sup> , Cr <sup>2+</sup> , Ag <sup>+</sup> , Cu <sup>2+</sup> , Cd <sup>2+</sup> , Sb <sup>3+</sup> , As <sup>3+</sup> , Bi <sup>3+</sup> , Zn <sup>2+</sup> , Hg <sup>2+</sup> , Tl <sup>+</sup> )	factors, choose biological objects of analysis and evaluate the results obtained, using the physico-chemical features of poisonous substances		
5.	The ability to ensure proper storage of medicines and medical products in accordance with their physical and chemical properties in healthcare facilities.	To know: - classification and nomenclature of inorganic compounds - speed of chemical reactions and chemical equilibrium. - kinetics of chemical reactions and catalysis	To be able to assess the state of health of the population, assess the state of the environment and the negative factors influencing the state of health of the population. Have methods of statistical and laboratory analysis of the health of different groups Be able to form preventive measures on the basis of data on the relationship between the state of the environment and the state of health of certain contingents of the population	Provide conditions to prevent unwanted consequences, taking into account the possible impact of storage conditions on the quality of pharmacy products, medicinal plant raw materials and medical products	Independence, responsibility

### Learning outcomes:

Integrative final program learning outcomes, the formation of which is facilitated by Syllabus of discipline "Biological role of life elements":

- *general:*
- apply knowledge of general and professional disciplines in professional activity.
- comply with the norms of the sanitary and hygienic regime and the requirements of safety equipment when carrying out professional activities.
- use the results of independent search, analysis and synthesis of information from various sources to solve typical tasks of professional activity.
- argue information for decision-making, bear responsibility for them in standard and non-standard professional situations; adhere to the principles of deontology and ethics in professional activity.
- use methods of evaluating performance quality indicators; identify reserves for improving labor efficiency.
- analyze information obtained as a result of scientific research, generalize, systematize and use it in professional activities
- professionals:

- to choose a rational technology, to manufacture medicinal products in various medicinal forms according to the prescriptions of doctors and orders of medical institutions, to process them before discharge. Perform technological operations: weigh, measure, dose various medicinal products by weight, volume, etc.
- substantiate the technology and organize the production of medicinal products at pharmaceutical enterprises.
- determine the main organoleptic, physico-chemical, chemical and pharmaco-technological indicators of medicinal products, substantiate and choose methods for standardization, carry out statistical processing of the results in accordance with the requirements of the State Pharmacopoeia of Ukraine.
- choose biological objects of analysis, determine xenobiotics and their metabolites in biological environments and evaluate the results obtained taking into account the distribution of toxins in the body.
- determine the influence of environmental factors: moisture, temperature, light, etc. on the stability of medicines and medical products.

Learning outcomes for the elective course "Biological role of life elements":

***to know:***

- classification and nomenclature of inorganic compounds;
- basic concepts and laws of chemistry and methods of their use to solve applied problems;
- modern theories of the structure of atoms and molecules and the dependence of the properties of matter on its composition and structure;
- basic laws of chemical reactions of different types;
- properties of chemical elements, their most important compounds and possible ways of transformation
- V.I. Vernadsky's doctrine of the biosphere.

***to be able to:***

- classify and name inorganic compounds;
- interpret the general laws underlying the structure of substances;
- classify the properties of solutions of non-electrolytes and electrolytes, calculate the composition of solutions;
- interpret and classify the main types of ionic, acid-base and redox balance and chemical processes to form a holistic approach to the study of chemical and biological processes;
- use chemical utensils and weigh substances;
- calculate the relative error of the experiment;
- conduct a simple chemical experiment;
- classify chemical properties and transformations of inorganic substances;
- qualitative determination of some cations and anions;
- interpret the general laws underlying the use of inorganic substances in pharmacy and medicine;
- apply the theoretical foundations of general and inorganic chemistry and acquired experimental skills in the study of specialized disciplines.
- interpret the main types of chemical equilibrium for the formation of a holistic physico-chemical approach to the study of vital processes in normal and pathology;
- classify the chemical properties and transformation of bioinorganic substances in the process of life of the organism;
- to interpret the general physical and chemical laws underlying the processes of human life

## **2. Information scope of the elective course**

Elective ECTS 3 credits / 90 hours are allocated for studying the Syllabus of discipline.

### **Thematic module 1.**

#### ***"Biological role of elements of life"***

***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 infection and spread of COVID-19 caused by SARS-CoV-2 virus, and should 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 microelementosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status***

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.

Man and the biosphere. The noosphere. Technical progress and ecology.

The position of nutrients in the periodic system of D.I. Mendeleev. Relationship of physicochemical parameters of elements with their position in the periodic table and content in the body.

Human microelementosis as pathological processes caused by deficiency, excess or imbalance of macro- and microelements. Methods of assessing the elemental status of man. Indications for laboratory diagnostics. Biochemical indicators of human elemental status.

***Topic 3 Chemical composition of the cell. Minerals and organic substances in the cell***

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 vital activity of living organism cells.

The role of mineral salts in the cell.

Organic compounds in the cell and their biological significance.

***Topic 4. Chemical composition of blood and the function of individual elements in it***

Blood and its functions, components of blood. Blood volume (total, circulating, 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 importance 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. Organogenic bioelements (O, C, H, N)***

Oxygen. General characteristics, distribution in nature, biological role. Features of the electronic structure of the oxygen molecule, chemical activity. Oxygen molecule as a ligand in oxyhemoglobin. Trioxygen (ozone), stereochemistry and the nature of communication. Chemical activity in comparison with dioxygen, qualitative reaction. The value of the ozone layer for human life. Classification of oxygen-containing compounds and their general properties. Binary compounds: oxides, peroxides, superoxides (peroxides), ozonides. Oxygen compounds with fluorine. Biological role of Oxygen, chemical bases of oxygen and ozone application in medicine and pharmacy.

Carbon. Carbon allotropy. Types of hybridization of the carbon atom and the structure of molecules containing carbon. Carbon as the basis of all organic molecules. The biological role of carbon and the chemical basis of its inorganic compounds. Physical and chemical properties of simple substances. Activated carbon as an adsorbent. Carbon with a negative oxidation state. Carbides of active and transition metals, their properties and applications. Carbon (II) compounds. Carbon monoxide, its acid-base and redox characteristics. Carbon monoxide as a ligand, the chemical basis of its toxicity.

Hydrogen. General characteristics of the element. Features of the situation in the periodic table of elements. Reactions with oxygen, halogens, metals, oxides. Characteristics and reactivity of hydrogen compounds with other common elements

Nitrogen. General characteristics. Compounds with different values of oxidation states. Nitrogen as a simple substance. Causes of low chemical activity. Nitrogen molecule as a ligand. Negative oxidation compounds. Nitrides. Ammonia, acid-base and redox characteristics, substitution reactions. Ammonia derivatives. Amides, Ammonia. Ammonium ion and its salts, acid-base properties, thermal decomposition. Hydrazine and hydroxylamine. Acid-base and redox characteristics. Azide acid, azides, their stability.

### ***Topic 6. Macronutrients of non-metals (P, S, Cl)***

Phosphorus. General characteristics. Allotropic modifications of Phosphorus, their chemical activity. Phosphides, phosphine. Phosphorus compounds with a positive oxidation state. Halides, their hydrolysis. Oxides, stereochemistry and the nature of the bond, interaction with water and alcohols. Phosphate (I) and phosphate (III) acids, molecule structure, acid-base and redox properties. Orthophosphate acid and its ions; dihydrogen phosphates, hydrogen phosphates and phosphates, their acid-base properties. Diphosphate acid. Iso-, poly- and heteropolyposphate acids. Metaphosphate acid, its comparison with nitric acid. Qualitative reaction to phosphate ion. Biological role of Phosphorus and its compounds.

Sulfur. General characteristics. Biological role of sulfur (sulfhydryl groups and disulfide bridges in proteins). Ability to form homochains. Sulfur as a simple substance, used in medicine. Sulfur compounds with a negative oxidation state. Hydrogen sulfide, acid-base and redox properties. Sulphides of metals and nonmetals, their solubility in water and hydrolysis. Qualitative reaction on sulfide ion. Polysulfides, acid-base and redox properties, stability.

Sulfur (IV) compounds - oxide, chloride, oxochloride, sulfite 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 to 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. Chlorinated lime. Chlorates. Biological role of chlorine compounds.

Application of chlorinated lime, chlorinated water, active chlorine preparations in medicine, sanitation and pharmacy.

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

General characteristics of s-elements of IA and IIA groups. Distribution 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 and pharmacy.

### ***Topic 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)***

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, Mo with 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. Application of compounds Ferrum, Zinc, Copper, Manganese, Molybdenum, Chromium and Cobalt in pharmaceutical analysis and 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 selenium, extraction and properties. Selenides. Selenium oxide (IV), selenic acid: extraction, acid-base and redox properties. Selenites. Selenium oxide (IV), selenate 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. Iodide ion detection reactions.

Iodine compounds in positive oxidation states. Oxygen 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 and pharmacy.

#### ***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  $\pi$ -bonds in the compounds. Biological role. Silicides. Hydrogen compounds, their oxidation and hydrolysis. Silicon tetrafluoride and tetrachloride, their hydrolysis. Hexafluorosilicates.

Oxygen-containing compounds Silicon, silicon oxide (IV). Silica gel, its application. Glass, its properties and stability. Silicate acids. Silicates, their solubility and hydrolysis. Natural silicates and aluminosilicates. Organosilicon compounds. Silicones and siloxanes. Application 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. Application of compounds of these elements in medicine, sanitation and pharmacy.

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

General characteristics of the elements Lithium, Nichole, Vanadium and Arsenic. Valence states. Chemical activity. Distribution 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 March method. Arsenites and arsenates, acid-base and redox properties.

Distinguish Lithium from other alkali metals.

The most important compounds of Nichole (II). Hydrolysis of salts of Nichole (II). Complex compounds with cyanide, thiocyanate and fluoride ions. Aqua complexes. Ammonia. Coenzyme B<sub>12</sub>. Qualitative reaction on Ni<sup>2+</sup> cation. Chugaev's 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. Distribution 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. Distribution 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. Manifestations of 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, pharmacy and cosmetology.

***Topic 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***

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

**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). Application of metals as probes in biochemical research.

**3. The structure of the elective course**

Topic	Lectures	Practical and laboratory classes	Self-study	Individual work
<b>Thematic module 1. "Biological role of elements of life"</b>				
1. Topic 1. Biological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry. <b>The main measures to prevent infection and spread of COVID-19</b>	0,5	1	4	
2. 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 microelementosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status	0,5	1	4	
3. Topic 3. The chemical composition of the cell. Minerals and organic substances in the cell	0,5	1	4	
4. Topic 4. Chemical composition of blood and the function of individual elements in it	0,5	2	4	
5. Topic 5. Organogenic bioelements (O, C, H, N)	1	2	4	
6. Topic 6. Macronutrients of non-metals (P, S, Cl)	0,5	1	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	1	4	
9. Topic 9. Microelements 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	2	
13. Topic 13. Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)	0,5	1	2	

14. Topic 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	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	
<b>Разом за змістовим модулем 1</b>	<b>10</b>	<b>20</b>	<b>60</b>	
<b>Total hours 90/3 ECTS credits</b>	<b>10</b>	<b>20</b>	<b>60</b>	
<b>Final control</b>				Test

#### 4. Thematic schedule of lectures

No	TOPIC	Duration, hours
1.	Biogenic elements, their classification. Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of D.I. Mendeleev. The concept of human microelementosis. Chemical composition of cells and blood. Mineral and organic substances in their composition	2
2.	Macronutrients, their properties and biological role	2
3.	Properties and biological role of some <i>d</i> -elements. Trace elements in the composition of enzymes, hormones, vitamins and other biologically active substances	2
4.	Conditionally vital trace elements (non-metals, metalloids). Potentially toxic and toxic trace elements.	2
5.	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
<b>Totally:</b>		<b>10</b>

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

No	TOPIC	Duration, hours
1.	Biological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry. Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of D.I. Mendeleev. The concept of human microelementosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status	2
2.	The chemical composition of the cell. Minerals and organic substances in the cell. The chemical composition of blood and the function of individual elements in it	2
3.	Organogenic bioelements (O, C, H, N). Non-metallic macronutrients (P, S, Cl)	2
4.	Biological role of compounds of metallic elements. Properties and biological role of some <i>s</i> -elements. Macronutrients metals (Ca, K, Na, Mg)	2
5.	Properties and biological role of some <i>d</i> -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)	2
6.	Non-metallic trace elements (Se, I)	2
7.	Conditionally vital non-metallic trace elements (F, B, Si, Br). Conditionally vital trace elements metals and metalloids (Ni, V, As, Li)	2
8.	Chemical potentially toxic trace elements (Rb, Ag, Au, Zr, Sn, W, Ge, Ga, Sr, Ti). Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)	2
9.	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	2

10.	Medicines of non-metals and metalloids. Medicines based on metals and their coordination compounds	2
<b>Totally:</b>		<b>20</b>

## 6. Thematic schedule of students' individual work

No	TOPIC	Duration, hours	Forms of assessment
1.	iological significance of chemical elements. Biogenic elements, their classification. Bioinorganic chemistry. <b>The main measures to prevent infection and spread of COVID-19</b>	4	The current control during practice classes activities
2.	Chemical elements in the geosphere and biosphere. The position of nutrients in the periodic system of DI Mendeleev. The concept of human microelementosis. Determination of chemical elements in human biosubstrates. Biochemical indicators of human elemental status.	4	
3.	The chemical composition of the cell. Minerals and organic matter in cells.	4	
4.	The chemical composition of blood and the function of individual elements in it.	4	
5.	Organogenic bioelements (O, C, H, N)	4	
6.	Non-metallic macronutrients (P, S, Cl)	4	
7.	Biological role of compounds of metallic elements. 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)	2	
13.	Toxic trace elements (Al, Pb, Ba, Bi, Cd, Hg, Tl, Be, Sb)	2	
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.	Medicines of non-metals and metalloids	4	
16.	Medicines based on metals and their coordination compounds	4	
<b>Totally:</b>		<b>60</b>	

## 7. Individual tasks are not supposed

## 8. Teaching methods

In the process of "Biological role of life elements" Syllabus of discipline 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:
  - knowledgeformation;
  - skills and abilitiesformation;
  - 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.

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 form of *final control* in the study of the elective course "Biological role of the elements of life" is a test. Students who have completed all types of work provided for in the initial program, completed all training sessions and scored at least the minimum number of points while studying the module are admitted to the final control.

**10. The current control** is carried out during training sessions and aims to verify the assimilation of students' learning material.

Forms of assessment of current educational activities are standardized and include control of theoretical and practical training.

**10.1. The current educational activity assessment.** When evaluating the educational activitees achievements of each topic for the current educational activity, the student is assessed with grades in the 4-grading scale (national). It takes into account all types of activities provided for by the discipline sullabus. A student should gain an assessment from each topic for further conversion of 4- grading scale points into 200-grading scale points. Test control is performed at each practice class according to specific objectives. Theoretical students' self-preparation control is performed in writing by answering 18 multiple choice questions in the form one-of-five, the correct answer to each is estimated at 1 point, and two numerical problems, the correct solving being estimated at 2 points. The maximum score for the entire test is 22 points. The minimum score points number a student must gain for the successful assessment of the theoretical part is 13 points (50 % of the correct answers). At each practical class, the teacher assesses the knowledge of each student in a four-grading scale.

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

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

**Grade "satisfactory" ("3")** – student 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 17 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:

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

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

**11. The form of final control of the study of the elective course "Biological role of elements of life" is a test.**

**The test** is a form of final control, which consists in assessing the student's mastery of educational material solely 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.

**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:

$$x = \frac{CA \times 200}{5}$$

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



4- gradi ng 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- gradi ng 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- gradi ng 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- gradi ng 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	Insufficien tly

**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.

Scores in the discipline are independently converted into both the ECTS scale and the 4-point (national) scale. ECTS scores are not converted to a 4-point scale and vice versa.

The scores of students studying in one specialty, taking into account the number of scores earned in the discipline are ranked on the ECTS scale as follows:

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).

## 11. METHODOLOGICAL PROVIDING:

The list and content of the initial methodological support for the study of the elective course "Biological role of the elements of life" includes:

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

## 12. 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.

**13. 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/>)
- <http://chemistry.inf.ua>