OF HEALTH OF UKRAINE
BUKOVINIAN STATE MEDICAL UNIVERSITY

APPROVE
Vice-Rector of the higher education establishment
on Scientific and Pedagogical Work
_____ Volodymyr KHODOROVSKY
«29» 08 2025

STUDENT'S GUIDE
(SYLLABUS)
of studying the discipline

"GENERAL AND INORGANIC CHEMISTRY"

Education degree– master

Field of knowledge – I Health and Social Security

Specialty – I8 Pharmacy

Departament – Medical and Pharmaceutical Chemistry

Educational year – I

Department of Medical and Pharmaceutical Chemistry

Approved at the meeting of the Department of Medical and Pharmaceutical Chemistry
"18" August 2025 (Protocol N 1).

Head of the Department _____ Vitaliy CHORNOUS

Approved by the subject methodological commission on the pharmaceutical profile disciplines
"27" August 2025 (Protocol N 1).

Ghairnal of the subject methodical commission _____ Oleg GERUSH

Chernivtsi - 2025

1. 1. GENERAL INFORMATION ABOUT SCIENTIFIC AND EDUCATIONAL STAFF WHO TEACH THE DISCIPLINE

Department	of Medical and Pharmaceutical Chemistry
Surname, first name, patronymic of scientific and pedagogical workers, position, academic degree, academic title, e-mail	Olena Vasylivna Krupko, Associate Professor of the Department of Medical and Pharmaceutical Chemistry, Candidate of Chemical Sciences, krupkoo@ukr.net
Department webpage on the official university website	https://www.bsmu.edu.ua/medichnoyi-ta-farmatsevtichnoyi-himiyi/
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2. 2. GENERAL INFORMATION ABOUT THE ACADEMIC DISCIPLINE

Status of the Discipline	compulsory
Number of credits	6
Total number of hours	180
Lectures	30
Practical classes	80
Independent work	70
Type of final control	final module control

3. DESCRIPTION OF THE DISCIPLINE (ABSTRACT)

General and inorganic chemistry is one of the fundamental natural disciplines in the system of higher pharmaceutical education, knowledge of which is necessary for the professional activity of specialists in the field of pharmacy. Knowledge of general and inorganic chemistry provides an opportunity to master and deepen scientific knowledge about matter, the dependence of the properties of substances on their composition and structure, the influence of conditions on the course and speed of chemical interactions, the synthesis and research of new medicinal substances, control of their quality and biotransformation in the human body.

4. POLICY OF THE DISCIPLINE

4.1. List of normative documents:

- Regulations on the organization of the educational process – https://cutt.ly/ArUqCMFh;
- Instructions on the assessment of the educational activities of BSMU students in the context of the implementation of the European Credit Transfer System for the organization of the educational process – https://cutt.ly/yrUqVPvn;
- Regulations on the procedure for making up missed and uncredited classes – https://cutt.ly/jrUqBS36;
- Regulations on the appeal of the results of the final knowledge control of higher education applicants – https://cutt.ly/3rUqMAbV;
- Code of Academic Integrity – https://cutt.ly/FrUq1ljK;
- Regulations on the prevention of academic plagiarism – https://cutt.ly/MrUq6QAt;
- Regulations on the procedure and conditions for students to choose elective subjects – https://cutt.ly/srUwo6Ci;
- Regulations on the procedure for recognizing learning outcomes obtained through non-formal and/or informal education – https://cutt.ly/SrUwp1ie;
- Rules of conduct for students – https://cutt.ly/ErUq72rZ;
- Rules of internal labor regulations – https://cutt.ly/UrUwiACe.

4.2. Policy on adherence to the principles of academic integrity of students:

- independent performance of educational tasks of current and final controls without using external sources of information;

- copying during knowledge control is prohibited;

- independent performance of individual tasks and correct registration of references to sources of information in case of borrowing ideas, statements, information.

4.3. Policy on adherence to the principles and norms of ethics and deontology by students:

- actions in professional and educational situations from the standpoint of academic integrity and professional ethics and deontology;

- compliance with the internal rules of the university and the rules of conduct of education seekers, to be tolerant, friendly and balanced in communicating with students and employees of departments, healthcare institutions, etc.;

- awareness of the significance of examples of human behavior in accordance with the norms of academic integrity and medical ethics.

4.4. Attendance policy for students:

- attendance at all classes (lectures, practical (seminar) classes, final module control) is mandatory for the purpose of current and final assessment of knowledge (except for cases of good reasons).

4.5. Deadlines policy and complection of missed or uncredited classes by students:

- making up missed classes takes place according to the schedule for making up missed or uncredited classes and consultations.

5. PREREQUISITES AND POST-REQUIREMENTS OF THE DISCIPLINE (INTERDISCIPLINARY CONNECTIONS)

List of academic disciplines on which the study of the academic discipline	List of academic disciplines for which the basis is laid as a result of studying the academic discipline
Chemistry	Analytical chemistry
Physics	Physical chemistry
	Organic chemistry
	Pharmaceutical chemistry

6. PURPOSE AND OBJECTIVES OF THE DISCIPLINE:

6.1. The **purpose** of studying the course is to acquire factual material on inorganic and general chemistry, laboratory techniques for obtaining and studying the properties of various substances.

6.2. The **main tasks** of studying the course are:

- to classify and name inorganic compounds;
- to interpret the general laws underlying the structure of substances;
- to classify the properties of solutions of non-electrolytes and electrolytes;
- to interpret and classify the main types of ionic, acid-base and redox equilibrium and chemical processes to form a holistic approach to the study of chemical and biological processes;
- to classify the chemical properties and transformations of inorganic substances;
- to interpret the general laws underlying the use of inorganic substances in pharmacy and medicine.

7. COMPETENCES, THE WHICH FORMATION IS CONTRIBUTES BY THE DISCIPLINE:

7.1. Integral competence: The ability to solve typical and complex specialized tasks and critically reflect on and solve practical problems in professional pharmaceutical and/or research and innovation activities using the principles, theories and methods of fundamental, chemical, technological, biomedical and socio-economic sciences; integrate knowledge and solve complex issues, formulate judgments with insufficient or limited information; clearly and unambiguously communicate one's own knowledge, conclusions and their justification to a professional and non-professional audience.

7.2. General competences:

GC 01. Ability to abstract thinking, analysis and synthesis.

GC 02. Knowledge and understanding of the subject area; understanding of professional activity.

GC 05. Ability to evaluate and ensure the quality of work performed.

7.3. Professional (special) competencies:

PC01. Ability to integrate knowledge and solve complex pharmacy problems in broad or multidisciplinary contexts.

PC02. Ability to collect, interpret and apply data necessary for professional activities, research and implementation of innovative projects in the field of pharmacy.

8.RESULTS OF STUDYING THE DISCIPLINE.

The academic discipline ensures the formation of the following program learning outcomes (PRU):
PLO 01. Have and apply specialized conceptual knowledge in the field of pharmacy and related fields, taking into account modern scientific achievements.
PLO 02. Critically reflect on scientific and applied problems in the field of pharmacy.
PLO 03. Have specialized knowledge and skills to solve professional problems and tasks, including for the purpose of further developing knowledge and procedures in the field of pharmacy.
As a result of studying the academic discipline, the student must:

8.1. Know:

- basic concepts and laws of chemistry and methods of their use for solving applied problems;
- modern theories of the structure of atoms and molecules and the dependence of the properties of matter on its composition and structure;
- classification and nomenclature of inorganic compounds;
- basic laws of the course of chemical reactions of various types;
- properties and methods of expressing the composition of solutions;
- basic types of ionic, acid-base and redox equilibrium and chemical processes for the formation of a holistic approach to the study of chemical and biological processes;
- properties of chemical elements, their most important compounds and possible ways of transformation.

8.2. Be able to:

- classify and name inorganic compounds;
- interpret the general laws underlying the structure of substances;
- classify the properties of solutions of nonelectrolytes and electrolytes, calculate the composition of solutions;
- interpret and classify the main types of ionic, acid-base and redox equilibrium 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;
- prepare solutions with a given quantitative composition;
- conduct a simple chemical experiment;
- classify the chemical properties and transformations of inorganic substances;
- conduct a 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.
- carry out chemical reactions that underlie methods of standardization and quality control of pharmaceuticals.

8.3. Demonstrate:

- skills in preparing solutions of a given concentration, buffer solutions with a given pH value;
- the ability to perform simple laboratory manipulations necessary to determine the physicochemical parameters of substances, measure the mass, volume and density of substances;
- the ability to assess the quantitative effect of temperature, concentration and catalysts on the rate of chemical processes.

9. INFORMATIONAL SCOPE OF THE DISCIPLINE

Module 1. "General Chemistry"

Content module 1. Atomic and molecular theory and the basic laws of chemistry.

Specific objectives:

To master the basic concepts and laws of chemistry and apply them to solve relevant problems. To classify simple and complex substances depending on their composition and chemical structure. To

explain the chemical properties of substances of a certain class using chemical reactions. To demonstrate knowledge of the nomenclature of inorganic compounds using specific examples.

Topic 1. Chemistry in the system of natural sciences. History of the development of chemistry. Atomic and molecular theory.

Subject, tasks and methods of chemistry. Substance. Purity of chemical substances. Atomic and molecular theory. The concept of an atom and its main characteristics: relative atomic mass, charge and ordinal number of an element in the periodic table, chemical symbol. Isotopes. Chemical equations. Calculations using chemical formulas and equations.

Topic 2. Basic laws of chemistry.

Basic laws of chemistry: the law of conservation of mass, the law of constancy of composition and its modern interpretation, Avogadro's law. Molar volume of a gas. The relationship between the density of a gas and its molecular mass. Bringing gases to normal conditions, the Clapeyron-Mendeleev equation.

Topic 3. The concept of equivalent substances.

Chemical equivalent, its modern definition. Molar mass of equivalent. Calculations of molar masses of equivalent simple and complex compounds. Law of equivalents.

Content module 2. The structure of matter and the periodic law of D.I. Mendeleev.

Specific objectives:

Apply the values of quantum numbers and the rules and principles that determine the sequence of filling atomic orbitals with electrons to depict electronic and electron-graphic formulas of atoms and ions of elements. Master the modern definition of the periodic law. Interpret the periodicity of changes in atomic radii, ionization energy, electron affinity, electronegativity and chemical properties of simple substances and compounds of elements based on the electronic structure of their atoms. Master the basic concepts of the modern theory of chemical bonding. Classify types of chemical bonding, explain the properties of substances depending on the type of bond in the molecule. Depending on the type of intermolecular interaction, explain the properties of substances in different states of aggregation.

Topic 4. The structure of the atom.

Electronic energy levels of the atom. The form of s-, p- and d-orbitals of the atom. Principles and rules that determine the sequence of filling atomic orbitals with electrons. Electronic and electron-graphic formulas of atoms of elements and their ions.

Natural and artificial radioactivity. Toxic effect of radionuclides. Radiopharmaceuticals used for treatment (Cobalt, Phosphorus, Iodine preparations) and diagnostics (Potassium, Phosphorus preparations) of various diseases.

Topic 5. Periodic law of D.I. Mendeleev.

Periodic law of D.I. Mendeleev. Structure of the periodic system of elements: periods, groups, families. Periodic nature of changes in the properties of elements: radius, activation energy, electron affinity energy, relative electronegativity.

Topic 6. Nature of chemical bonding and structure of chemical compounds.

Mechanism of formation of chemical bond (CB) between atoms. Types of chemical bond. Physicochemical properties of compounds with covalent, ionic and metallic bonds. Experimental characteristics of bonds: energy, length, directionality. Donor-acceptor mechanism of covalent bond formation.

Content module 3. Elements of chemical thermodynamics and kinetics.

Specific objectives:

Calculate the values of enthalpies of chemical reactions, dissolution processes, dissociation of acids and bases using Hess's law. Interpret the possibility of spontaneous chemical reactions and explain the thermodynamic stability of chemical compounds using the values of entropy and Gibbs energy. Explain the possibility of chemical reactions depending on the nature of the reactants and the presence of a catalyst. Apply the law of mass action, the Arrhenius equation and Van't Hoff's empirical rule to calculate the rate of homogeneous and heterogeneous reactions. Apply the law of mass action to equilibrium processes. Interpret the direction of the shift of the equilibrium of a chemical reaction according to Le Chatelier's principle

Topic 7. Basic concepts of chemical thermodynamics. The first law of thermodynamics. Thermochemistry.

Absorption and release of various types of energy during chemical transformations. Internal energy and enthalpy of substances. The first law of thermodynamics. Hess's law. Calculations of standard enthalpies of chemical reactions and physicochemical transformations based on Hess's law.

Topic 8. The second law of thermodynamics. Directionality of chemical processes.

The second law of thermodynamics. The concept of entropy as a measure of the disorder of the system (Boltzmann equation). Gibbs energy as a criterion for the spontaneous course of chemical reactions.

Topic 9. Rate and mechanisms of chemical reactions. Catalysis.

Average and instantaneous reaction rates. The concept of the reaction mechanism. Factors affecting the rate of chemical reactions in homogeneous and heterogeneous systems. The law of mass action. The rate constant of a chemical reaction, its physical content. The dependence of the reaction rate on temperature (Arrhenius equation and Van't Hoff's rule). Activation energy. Catalysis.

Topic 10. Chemical equilibrium.

Reversible and irreversible chemical reactions and the state of chemical equilibrium. Quantitative characteristics of the state of chemical equilibrium. Chemical equilibrium constant and its relationship to the standard change in Gibbs energy. Le Chatelier-Brown principle.

Content module 4. Solutions. Properties of solutions.

Specific objectives:

Determine the type of solution and distinguish its components. Interpret the mechanism of dissolution, electrolytic dissociation and hydrolysis of substances. Apply Dalton's and Sechenov's laws to calculate the solubility of gases in liquids. Calculate the mass fraction, molar, molal concentration, molar fraction, molar equivalent concentration and titer based on the specified values of the mass of the solute, the volume of the solution or solvent. Be able to prepare a solution with a certain mass fraction, molar, molal concentration, molar equivalent concentration or titer. Interpret the rule for mixing solutions with different mass fractions and apply it in practice. Calculate the molar mass of a substance according to Raoult's and Van't Hoff's laws.

Topic 11. The theory of solutions.

The essence of the main provisions: solutions, solvent, solute. Solubility of substances in liquids, factors affecting solubility.

Topic 12. Ways to express the composition of solutions.

Ways to express the composition of solutions. Mass, volume and mass-volume fraction of the solute. Molar concentration. Molar concentration of the equivalent. Molality of the solution. Molar fraction of the solute. Titer of the solution. Preparation of solutions with a given composition.

Topic 13. Colligative properties of solutions.

The concept of colligative properties of solutions. Raoult and Van't Hoff's laws. Osmosis and osmotic pressure. Hypo-, hyper- and isotonic solutions. The role of osmosis and osmotic pressure in biological systems. Plasmolysis, hemolysis, turgor. Cryometry, ebulliometry, osmometry and their applications**.**

Content module 5. Equilibrium in electrolyte solutions.

Specific objectives:

Classify electrolytes by the magnitude of the degree of dissociation. Apply the law of mass action to equilibrium processes of dissociation of weak electrolytes, water, and sparingly soluble electrolytes, use tabular data of the values of Kdis, DR to determine the concentration of the corresponding ions. Calculate the degree of dissociation, dissociation constant, concentration of a weak electrolyte, and acidity of the medium using the Oswald dilution law. Calculate the solubility of a sparingly soluble electrolyte by the magnitude of the solubility product, determine the conditions for the precipitation and dissolution of this compound. Interpret the basic provisions of the theory of strong electrolytes. Apply the law of mass action to the equilibrium process of hydrolysis of medium, acidic salts, and salts formed by a multiply charged cation or anion and propose an expression for the hydrolysis constant and a formula for its calculation for them. Calculate the degree and constant of hydrolysis, salt concentration, and acidity of the medium.

Analyze the factors that affect the shift in the equilibrium of hydrolysis reactions. Classify buffer solutions by composition. Calculate the pH of buffer solutions and buffer capacity

Topic 14. Theory of strong and weak electrolytes.

The concept of strong and weak electrolytes. Theory of strong electrolyte solutions. Solutions of weak electrolytes. Degree of dissociation. Dependence of the degree of dissociation on concentration (Ostwald's dilution law).

Topic 15. Theories of acids and bases. Dissociation of water.

Theories of acids and bases. Amphoteric electrolytes (ampholytes). Quantitative characteristics of the strength of acids and bases. Dissociation of water. Ion product of water. Characteristics of the acidity of the medium. Hydrogen and hydroxyl indicators (pH and pOH) of solutions of weak and strong acids and bases.

Topic 16. Protolytic processes.

Protolytic processes and their direction. Hydrolysis of cations, anions and compatible hydrolysis. Degree and constant of hydrolysis. Shift of equilibrium of protolytic reactions. The role of protolytic reactions in drug metabolism and in the analysis of medicinal products. Chemical incompatibility of medicinal substances.

Topic 17. Buffer solutions.

Types and composition of buffer solutions. Calculation of pH and buffer capacity. Buffer systems of blood.

Topic 18. Equilibrium in solutions of sparingly soluble electrolytes.

Equilibrium between solution and precipitate of sparingly soluble electrolytes. Solubility product (DP). Conditions for the formation and dissolution of precipitates.

Content module 6. Main types of chemical reactions.

Specific objectives:

Learn the basic concepts of redox processes. Analyze the redox properties of simple substances and compounds of elements depending on their position in the periodic table and the degree of oxidation. Apply the electron balance method and the electron-ion method to find coefficients in the equations of redox reactions. Determine the type of redox reaction. Calculate the equivalent and equivalent mass of the oxidant and reductant. Calculate the EMF of the redox system and determine the direction of the OCR. Apply Werner's coordination theory to study the structure and composition of complex compounds. Analyze the electronic structure of element atoms in order to establish their ability to form complexes. Classify complex compounds by the charge of the complex ion, the nature of the ligand, the acidity of the aqueous solution and the number and nature of the atoms of the complexing agent. Name complex compounds. Determine the type of isomerism of complex compounds. Apply the valence bond method to explain the mechanism of chemical bond formation in complex compounds. Propose an expression for the Knesh of a complex compound. Interpret its behavior in solution based on the value of this quantity. Give examples of the use of complex compounds in pharmaceutical analysis and medicine.

Topic 19. Electron transfer reactions.

Electronic theory of redox reactions (ROR). Oxidation degree of element atoms in compounds and rules for its calculation. Change in oxidation degree in ROR. Use of redox reactions in chemical analysis and analysis of drugs. Role of redox processes in metabolism.

Topic 20. Complexation reactions. Coordination compounds.

Modern meaning of the concept of "complex compound" (CS). Structure of CS according to Werner. Formation and dissociation of CS in solutions. Stability constants and instability constants of complex ions (step and general). Classification, nomenclature and isomerism of complex ions. Biological role of complex ions.

MODULE 2 "Inorganic Chemistry".

Content module 7. Organogenic and biogenic elements. Man and the biosphere.

Specific objectives:

Classify chemical elements according to various criteria. Interpret the relationship between the biological role of biogenic elements and the form of their presence in the body. Interpret the concepts of biosphere, noosphere based on the teachings of V. Vernadsky. Explain the patterns of

migration of chemical elements in the biosphere. Classify compounds into classes of inorganic compounds.

Topic 21. Chemical elements, their classification.

The concept of chemical elements, their classification by origin, chemical properties, structure of the external energy level, distribution in nature, significance for the body.

Topic 22. Man and the biosphere.

The concept of migration of chemical elements. The relationship of endemic diseases with the features of biogeochemical provinces.

Topic 23. Classification and nomenclature of inorganic compounds.

Main classes of inorganic compounds. Oxides, their classification and nomenclature. Hydroxides, their classification and nomenclature. Acids, their classification and nomenclature. Salts, their classification (medium, basic, acidic, oxosalts, double, mixed). Nomenclature of salts. Chemical properties of SNS.

Content module 8. Hydrogen and s-elements (typical metals).

Specific objectives:

To interpret the change in the values of atomic radii, ionization energy, electronegativity of s-elements and reducing properties of simple substances with increasing atomic number. To compare the conditions of preparation, stability and chemical properties of oxides, peroxides, per-peroxides, hydrides and hydroxides of s-elements depending on their position in the periodic table of elements. To explain the chemical properties of simple substances and compounds of s-elements using chemical reaction equations. To interpret the phenomenon of amphotericity using the example of the interaction of beryllium and its oxide and hydroxide with acids and alkalis. To explain the hardness of water and methods for its elimination. To interpret the redox duality of hydrogen peroxide. To propose reactions for the qualitative detection of cations of alkali and alkaline earth metals. To suggest examples of the use of s-element compounds in pharmacy and medicine.

Topic 24. Hydrogen and its compounds.

General characteristics of the element. Features of the position in the PSE. Hydrogen as a simple substance. Hydrogen and hydroxonium ions. Water as an important compound of Hydrogen, its physical and chemical properties. Aqua complexes and crystal hydrates. Hydrogen peroxide. Molecular structure, preparation, acid-base and redox characteristics, use in medicine and pharmacy.

Topic 25. s-elements of group IA. Alkali metals.

General characteristics of s-elements of group IA. Distribution in nature. Biological role of elements in the mineral balance of the body. Macroelements, their content in the body. Metallic state of alkali metals. Interaction with simple and complex substances. Hydroxides of alkali metals, salts and their properties, applications. Chemical foundations of the use of Lithium, Sodium and Potassium compounds in medicine.

Topic 26. s-elements of group IIA. Beryllium, Magnesium and alkaline earth elements.

General characteristics. Reducing properties of simple substances of elements. Comparative characteristics of the properties of beryllium, magnesium and calcium. The nature of the interaction of simple substances with water, solutions of acids and bases. Alkaline earth metals. General characteristics. Physico-chemical properties and characteristics of the most important compounds. The main nature of oxides and hydroxides. Solubility of hydroxides and salts in water. Reactions of detection of cations Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}. Reactions of cations of group IIA with complexones (on the example of EDTA). Water hardness, units of its measurement. Methods of its elimination. Chemical foundations of the application of compounds of Magnesium, Calcium and Barium in medicine and pharmacy

Content module 9. p-Elements of groups III – VIII of the periodic table of elements.

Specific objectives:

Explain the pattern of changes in atomic radii, ionization energy, electron affinity, and electronegativity of p-elements with increasing atomic number in the subgroup and period. Suggest possible oxidation states and explain the chemical activity of simple substances of p-elements depending on the configuration of valence electrons. Interpret the excited state of atoms and the hybridization of their atomic orbitals and the shape of molecules using the example of the formation

of corresponding compounds. Interpret the change in properties in the subgroup. Explain the chemical properties of simple substances and compounds of p-elements using chemical reaction equations. Compare the conditions of preparation, stability, and chemical activity of oxides, hydrogen derivatives, halides, hydroxides, and salts depending on the oxidation state and position of p-elements in the periodic system. Analyze the ability of p-element compounds to participate in complexation reactions. Explain the redox and acid-base properties of compounds of p-elements depending on the degree of oxidation of the element. Suggest reactions for the qualitative detection of cations and anions of p-elements. Suggest simple substances and compounds of p-elements that are used in pharmaceutical analysis and medicine.

Topic 27. p-Elements of Group IIIA. Boron and Aluminum.

General characteristics of elements of Group IIIA. Electron deficiency, its effect on the properties of elements and their compounds. General characteristics of Boron. Aluminum. General characteristics. Simple substance and its chemical activity. Amphotericity of aluminum, its oxide and hydroxide.

Topic 28. p-elements of Group IVA. Carbon and its inorganic compounds.

General characteristics of elements of Group IVA. Allotropy of Carbon. Types of hybridization of the Carbon atom and the structure of molecules containing Carbon. Carbon as the basis of all organic molecules. Biological role of Carbon and chemical basis of application of its inorganic compounds. Physical and chemical properties of simple substances. Activated carbon as an adsorbent. Compounds of Carbon (II). Cyanic acid, simple and complex cyanides. Compounds of Carbon (IV).

Topic 29. Silicon and its compounds.

Silicon. General characteristics. The main difference between Silicon and Carbon. Biological role.

Topic 30. Group IVA p-elements. Germanium subgroup (Germanium, Stannum, Plumbum).

Elements of the Germanium subgroup. General characteristics.

Topic 31. Group VA p-elements. Nitrogen and its compounds.

General characteristics of the VA group elements. Nitrogen, Phosphorus, Arsenic in the body, their biological role, occurrence in nature and the body. Nitrogen as a simple substance. Reasons for low chemical activity. Ammonia, acid-base and redox characteristics, substitution reactions. Nitrogen compounds with a positive oxidation state. Nitrogen oxides. Nitric acid and nitrites, their properties. Nitric acid and nitrates, acid-base and redox characteristics. Thermal stability, application. Aqua regia. Mechanism of toxic action of nitrogen oxides and nitrates.

Topic 32. Phosphorus and its compounds.

Phosphorus. General characteristics. Allotropic modifications of Phosphorus, their chemical activity. Phosphorus compounds with positive oxidation states. Qualitative reaction to phosphate ion. Biological role of Phosphorus and its compounds.

Topic 33. p-elements of group VA. Arsenic subgroup (Arsenic, Antimony, Bismuth).

Elements of the Arsenic subgroup. General characteristics. Compounds of Arsenic, Antimony and Bismuth with Hydrogen in comparison with ammonia and phosphine. Determination of Arsenic and Antimony by the Marsh method. Compounds with positive oxidation states. Chemical foundations of the application in medicine and pharmacy of oxides and salts of Arsenic, Antimony and Bismuth, and compounds of p-elements of group VA in pharmaceutical analysis.

Topic 34. Group VIA p-elements. Oxygen and its compounds.

General characteristics of the elements of group VIA. Oxygen. General characteristics, distribution in nature, biological role. Features of the electronic structure of the oxygen molecule, chemical activity. Classification of oxygen-containing compounds and their general properties. Biological role of Oxygen, chemical foundations of the use of oxygen and ozone in medicine and pharmacy.

Topic 35. Group VIA p-elements. Sulfur, Selenium, Tellurium.

Sulfur. General characteristics. Biological role of Sulfur. Sulfur as a simple substance, application in medicine. Hydrogen sulfide, acid-base and redox properties. Qualitative reaction to sulfide ion. Sulfur (IV) compounds, their acid-base and redox properties. Qualitative reaction to sulfite ion. Sulfur (VI) compounds. Oleum. Chemical foundations of the use of Sulfur compounds in medicine, pharmacy, pharmaceutical analysis. Selenium and Tellurium. The concept of antioxidants.

Topic 36. Group VIIA p-elements. Halogens.

General characteristics of halogens. Special properties of Fluorine as the most electronegative element. Simple substances, their chemical activity. Compounds of halogens with Hydrogen. Solubility in water. Acidic and redox properties. Reactions for detecting halide ions. The concept of the chemistry of the bactericidal action of chlorine and iodine. The use of bleach, chlorine water, active Chlorine, Iodine preparations, as well as fluorides, chlorides, bromides, iodides in medicine, sanitation and pharmacy.

Topic 37. Group VIIIA p-elements. Noble gases.

General characteristics of Group VIIIA p-elements. Features of the structure of molecules. Physical and chemical properties. The relativity of the concept of "inert gases". The use of noble gases in medicine.

Content module 10. d-elements of groups I–VIII of the periodic table of elements.

Specific objectives:

To interpret, based on the electronic structure of d-element atoms, their variable oxidation state, ability to form complexes, and decrease in chemical activity compared to s- and p-elements. To explain the chemical properties of simple substances and compounds of d-elements using the equations of the corresponding chemical reactions. To explain the dependence of the acid-base and redox properties of oxides, hydroxides, and salts of d-elements on the oxidation state of the element. To explain, using the equations of chemical reactions, the formation of cationic, anionic, and neutral complexes by d-elements. To analyze the ability to hydrolyze salts of d-elements. To propose reactions for the qualitative detection of cations and anions containing d-elements. Interpret the biological role of d-elements in the body and propose simple substances and compounds of d-elements that are used in medical and pharmaceutical practice. Analyze the chemical activity of a certain metal depending on its position in the periodic table, as well as in the electrochemical series of metal voltages.

Topic 38. General characteristics of d-elements. Types of chemical reactions with their participation.

General characteristics of d-elements, comparative characteristics of elements of the main and secondary subgroups. Characteristic features of d-elements: oxidation states, formation of complexes, color of cationic and anionic complexes, participation in OVR. Change in acid-base and redox properties of compounds with a change in oxidation state.

Topic 39. d-Elements of group IV. Copper, Argentum, Aurum.

General characteristics of group IV elements. Physical and chemical properties of simple and complex substances. Acid-base and redox properties, ability to form complexes. The complex nature of copper-containing enzymes, their biological role. Chemical foundations of the application of Copper compounds in medicine and pharmacy.

Argentum compounds, their acid-base and redox properties. Complexing ability. Bactericidal properties of Ag^+ ions. Chemical foundations of the application of Argentum compounds as medicines and in pharmaceutical analysis.

Aurum. Application of gold and Aurum compounds in medicine and pharmacy.

Topic 40. d-Elements of group IIB. Zinc, Cadmium, Hydrargyrum.

General characteristics of elements of group IIB. Physical and chemical properties of simple and complex substances. Acid-base and redox characteristics of compounds.

Topic 41. d-elements of IIIB – VB groups of the Periodic Table of the Elements. Titanium, Vanadium. Lanthanides

d-elements of IIIB group (Scandium subgroup). General characteristics, similarities and differences from the elements of IIA group. Biological role of Scandium, its chemical properties. f-elements as analogues of d-elements of IIIB group, similarities and differences using the example of Cerium. d-elements of IVB and VB groups. General characteristics. Chemical foundations of the use of simple substances and compounds of Titanium, Niobium, Tantalum and Vanadium in medicine and pharmacy.

Topic 42. d-elements of VIB group. Chromium subgroup.

General characteristics of the subgroup. Chromium, natural compounds. Simple substance and its chemical activity. Chromium compounds. Molybdenum and Tungsten, general characteristics, redox properties of compounds. Biological role of Chromium and Molybdenum.

Topic 43. d-Elements of Group VIIB. Manganese Subgroup.
General characteristics of the elements of the Manganese subgroup. Manganese compounds Chemical bases of the use of potassium permanganate and its solutions as an antiseptic and in pharmaceutical analysis.
Topic 44. d-Elements of Group VIIIB. Iron and its compounds.
General characteristics of the elements of the Iron family. Characteristics of the element, its ionic states, coordination numbers. Natural compounds. Iron compounds. Hemoglobin and iron-containing enzymes, their biological role. Qualitative reactions to iron cations Fe^{2+} and Fe^{3+}. Chemical bases of the use of reduced iron and iron-containing drugs in medicine.
Topic 45. d-Elements of Group VIIIB. Cobalt and Nickel.
Cobalt and Nickel. Valence states. Chemical activity. Coenzyme B12. Qualitative reactions to cations Co^{2+} and Ni^{2+}. Biological significance and chemical bases of application of compounds of Cobalt and Nickel in medicine and pharmacy.
Topic 46. d-Elements of group VIIIB. Platinum metals
Platinum metals, general characteristics of simple substances, their interaction with acids. Physical properties and applications of platinum metals. Complex compounds of Platinum. Chemical bases of application of compounds of platinum metals in medicine.

10. STRUCTURE OF THE DISCIPLINE

Names of content modules and topics	Amountof hours				
	Total	including			
		Classroom		Independent students work	Individul work
		Lectures	Practicals		
1	2	3	4	5	6
Module 1. "General Chemistry"					
Content module 1. Atomic and molecular theory and the basic laws of chemistry					
Topic 1. Chemistry in the system of natural sciences. History of the development of chemistry. Atomic and molecular theory.	2,5	0,5	1	1	
Topic 2. Basic laws of chemistry.	4	1	2	1	
Topic 3. The concept of equivalent substances.	3,5	0,5	1	2	
Total on the content module 1	**10**	**2**	**4**	**4**	
Content module 2. The structure of matter and the periodic law of D.I. Mendeleev					
Topic 4. The structure of the atom.	3	1	1	1	
Topic 5. The periodic law of D.I. Mendeleev.	3	1	1	1	
Topic 6. The nature of the chemical bond and the structure of chemical compounds.	5	2	2	1	
Total on the content module 2	**11**	**4**	**4**	**3**	
Content module 3. Elements of chemical thermodynamics and kinetics					
Topic 7. Basic concepts of chemical thermodynamics. The first law of thermodynamics. Thermochemistry.	2,5	0,5	1	1	
Topic 8. The second law of thermodynamics. Directionality of chemical processes.	2,5	0,5	1	1	
Topic 9. Rate and mechanisms of	2,5	0,5	1	1	

chemical reactions. Catalysis.					
Topic 10. Chemical equilibrium.	2,5	0,5	1	1	
Total on the content module 3	**10**	**2**	**4**	**4**	
Content module 4. Solutions. Properties of solutions.					
Topic 11. The study of solutions.	3,5	0,5	1	2	
Topic 12. Ways of expressing the composition of solutions.	5	1	2	2	
Topic 13. Colligative properties of solutions.	3,5	0,5	1	2	
Total on the content module 4	**12**	**2**	**4**	**6**	
Content module 5. Equilibrium in electrolyte solutions					
Topic 14. Theory of strong and weak electrolytes.	3,5	1	2	0,5	
Topic 15. Theories of acids and bases. Dissociation of water. pH.	4	1	2	1	
Topic 16. Protolytic processes.	3,5	0,5	2	1	
Topic 17. Buffer solutions	3,5	0,5	2	1	
Topic 18. Equilibrium in solutions of sparingly soluble electrolytes.	5,5	1	4	0,5	
Total on the content module 5	**20**	**4**	**12**	**4**	
Content module 6. Main types of chemical reactions					
Topic 19. Electron transfer reactions.	7	1	4	2	
Topic 20. Complexation reactions. Coordination compounds.	7	1	4	2	
Total on the content module 6	***14***	***2***	***8***	***4***	
Individual work	**5**				**5**
(if available)	**9**		**4**	5	
Total module control of module 1 "General chemistry".	**91**	**16**	**40**	30	5
Module 2. "Inorganic Chemistry"					
Content Module 7. Organogenic and biogenic elements. Man and the biosphere					
Topic 21. Chemical elements, their classification.	1	0,3	0,2	0,5	
Topic 22. Man and the biosphere.	1	0,2	0,3	0,5	
Topic 4. Classification and nomenclature of inorganic compounds.	1,5		0,5	1	
Total on the content module 7	**3,5**	**0,5**	**1**	**2,0**	
Content module 8. Hydrogen and s-elements (typical metals)					
Topic 23. General characteristics of s-elements. Hydrogen and its compounds.	2,5	0,5	1	1	
Topic 24. s-elements of group IA. Alkali metals.	2,5	0,5	1	1	
Topic 25. s-elements of group IIA. Beryllium, Magnesium and alkaline earth elements.	2,5	0,5	1	1	
Total on the content module 8	**7,5**	**1,5**	**3**	**3**	
Content module 9. p-Elements of groups III-VIII of the periodic table of elements					
Topic 26. General characteristics of p-elements. Group IIIA p-elements. Boron and Aluminum.	5,5	0,5	4	1	

Topic 27. Group IVA p-elements. Carbon and its inorganic compounds.	4	1	2	1	
Topic 28. Silicon and its compounds.	2,25	0,25	1	1	
Topic 29. Group IVA p-elements. Germanium subgroup.	2,25	0,25	1	1	
Topic 30. Group VA p-elements. Nitrogen and its compounds.	4	1	2	1	
Topic 31. Phosphorus and its compounds.	2,5	0,5	1	1	
Topic 32. Group VA p-elements. Arsenic subgroup (Arsenic, Antimony, Bismuth).	2,5	0,5	1	1	
Topic 33. Group VI p-elements. Oxygen and its compounds.	3		2	1	
Topic 34. Group VI p-elements. Sulfur, Selenium, Tellurium.	4	1	2	1	
Topic 35. Group VII p-elements. Halogens.	6	1	4	1	
Topic 36. p-elements of group VIIIA. Noble gases.	1			1	
Total on the content module 9	**37**	**6**	**20**	**11**	
Content module 10. d-elements of groups I - VIII					
Topic 37. General characteristics of d-elements. Types of chemical reactions involving them.	2	0,5	1	1	
Topic 38. d-elements of group IV. Copper, Argentum, Aurum.	4	0,5	2	1	
Topic 39. d-elements of group IIB. Zinc, Cadmium, Mercury.	3	1	1	1	
Topic 40. d-elements of group IIIB –VB. Titanium, Vanadium. Lanthanides.	1			1	
Topic 41. d-elements of group VIB. Chromium subgroup.	4	1	2	1	
Topic 42. d-elements of group VIIB. Manganese subgroup.	4	1	2	1	
Topic 43. d-elements of group VIIIB. Iron and its compounds.	4	1	2	1	
Topic 44. d-elements of group VIIIB. Cobalt and Nickel.	2,5	0,5	1	1	
Topic 45. d-elements of group VIIIB. Platinum metals.	2,5	0,5	1	1	
Total on the content module 10	***27***	***6***	***12***	***9***	
Individual work	**5**				**5**
(if available)	**9**		**4**	5	
Summary module control 2 "Inorganic Chemistry".	**89**	**14**	**40**	**30**	**5**
Total for Module II	**180**	**30**	**80**	**70**	

11 Thematic plan of lectures (full-time study)

№	Name of topic	Amount of hours
	Modul I	
1	Atomic and molecular theory. Basic laws of chemistry. The concept of the equivalent of a substance 2	2
2	The structure of the atom. D.I. Mendeleev's periodic law 2	2
3	The nature of the chemical bond and the structure of chemical compounds 2	2
4	Chemical thermodynamics. Thermochemistry. Directionality of chemical processes. Chemical kinetics and equilibrium. 2	2
5	The theory of solutions. Ways of expressing the composition of solutions. Colligative properties of solutions 2	2
6	The theory of strong and weak electrolytes. Equilibrium in solutions of sparingly soluble electrolytes. 2	2
7	Dissociation of water. pH. Protolytic processes. Electron transfer reactions 2	2
8	Complexation reactions. Coordination compounds 2	2
	Total MODULE I: 16	16
	Modul II	
9	Chemical elements and their classification. Man and the biosphere. Hydrogen and alkali metals. s-Elements of group IIA. 2	2
10	p-Elements of group IIIA. Boron, Aluminum.	2
11	p-Elements of group IVA. Carbon, Silicon. Subgroup Germanium. 2 p-Elements of group VA. Nitrogen, Phosphorus and their compounds. Subgroup Arsenic. 2	2
12	p-Elements of group VIA. Sulfur, Selenium, Tellurium. p-Elements of group VIIA. Halogens. 2	2
13	d-Elements of group IV and IIV. 2	2
14	d-Elements of group VIB and VIIB. Subgroups of Chromium and Manganese 2	2
15	d-Elements of group VIIIB. Iron family. Platinum metals 2	2

12 Thematic plan of practical classes (full-time study)

№	Name of topic	Amount of hours
	Modul I	
1	Atomic and molecular theory. Basic concepts of chemistry.	2
2	Basic laws of chemistry. The concept of equivalent substances.	2
3	Structure of the atom. Periodic law of D.I. Mendeleev.	2
4	Nature of chemical bonding and structure of chemical compounds.	2
5	Basic concepts of chemical thermodynamics. Thermochemistry. Direction of chemical processes.	2
6	Speed and mechanisms of chemical reactions. Chemical equilibrium.	2
7	Theory of solutions. Ways of expressing the composition of solutions.	2
8	Colligative properties of solutions.	2
9	Theory of strong and weak electrolytes.	2
10	Dissociation of water. pH.	2
11	Protolytic processes.	2
12	Buffer solutions.	2
13	Equilibrium in solutions of sparingly soluble electrolytes.	2

14	Sparingly soluble compounds. Solubility product constant.	2
15	Electron transfer reactions.	2
16	1Experimental study of redox reactions.	2
17	Coordination compounds. Complexation reactions.	2
18	Experimental study of complex compounds.	2
19-20	Final control of the mastery of module 1 "General Chemistry".	4
	Total MODULE I	**40**
	Modul II	
21	Chemical elements and their classification. KNS.	2
22	Hydrogen and s-Elements.	2
23	General characteristics of p-elements.	2
24	p-Elements of Group IIIA. Boron and Aluminum.	2
25	p-Elements of Group IVA. Carbon. Silicon.	2
26	p-Elements of Group IVA. Subgroup of Germanium (Germanium, Stannum, Lead).	2
27	p-Elements of Group VA. Nitrogen. Phosphorus.	2
28	p-Elements of Group VA. Subgroup of Arsenic (Arsenic, Antimony, Bismuth).	2
29	p-Elements of Group VIA. Oxygen, Sulfur.	2
30	Oxygen-containing sulfur compounds. Selenium, Tellurium.	2
31	p-Elements of Group VIIA. Hydrogen. Halogens.	2
32	p-elements of group VIIA. Halogen compounds. 2	2
33	General characteristics of d-elements. d-elements of group IV. Copper, Argentum, Aurum.	2
34	d-elements of group IIB. Zinc, Cadmium, Mercury.	2
35	d-elements of group VIB. Chromium subgroup.	2
36	d-elements of group VIIB. Manganese subgroup.	2
37	d-elements of group VIIIB. Iron and its compounds. Cobalt and Nickel compounds.	2
38	d-elements of group VIIIB. Platinum metals.	2
39-40	Final control of the assimilation of module 2 "Inorganic Chemistry".	4
	Total MODULE II	40
	TOTAL	80

13 Thematic plan for independent work (full-time study)

№ з/п	**Topic name**	**Number of hours**
	Modul I	
1	Topic 1. Chemistry in the system of natural sciences. History of the development of chemistry. Atomic and molecular theory.	1
	Topic 2. Basic laws of chemistry.	1
	Topic 3. The concept of the equivalent of substances.	1
	Topic 4. Classification and nomenclature of inorganic compounds.	1
	Topic 5. Structure of the atom.	1
	Topic 6. Periodic law of D.I. Mendeleev.	1
	Topic 7. The nature of the chemical bond and the structure of chemical compounds.	1
	Topic 8. Basic concepts of chemical thermodynamics. The first law of thermodynamics. Thermochemistry.	1
	Topic 9. The second law of thermodynamics. Directionality of chemical processes.	1

	Topic 10. Speed and mechanisms of chemical reactions. Catalysis. Topic 11. Chemical equilibrium. Topic 12. The theory of solutions. Topic 13. Ways of expressing the composition of solutions. Topic 14. Colligative properties of solutions. Topic 15. Theory of strong and weak electrolytes. Topic 16. Equilibrium in solutions of sparingly soluble electrolytes. Topic 17. Theories of acids and bases. Dissociation of water. Topic 18. Protolytic processes. Topic 19. Electron transfer reactions. Topic 20. Complexation reactions. Coordination compounds.	1 1 2 2 2 1 1 1 1 2 2
3	Individual work – preparation of a review of scientific literature or conducting research on one of the topics (optional)	5
4	Preparation for the final control of the modules	5
	Total MODULE I:	**35**
	Modul II	
1	Topic 21. Chemical elements, their classification. Topic 22. Man and the biosphere. Topic 23. Hydrogen and its compounds. Topic 24. s-elements of group IA. Alkali metals. Topic 25. s-elements of group IIA. Beryllium, Magnesium and alkaline earth elements. Topic 26. p-elements of group IIIA. Boron and Aluminum. Topic 27. p-elements of group IVA. Carbon and its inorganic compounds. Topic 28. Silicon and its compounds. Topic 29. p-elements of group IVA. Subgroup of Germanium (Germanium, Stannum, Lead). Topic 30. p-elements of group VA. Nitrogen and its compounds. Topic 31. Phosphorus and its compounds. Topic 32. p-elements of group VA. Subgroup Arsenic (Arsenic, Antimony, Bismuth). Topic 33. p-elements of group VIA. Oxygen and its compounds. Topic 34. p-elements of group VIA. Sulfur, Selenium, Tellurium. Topic 35. p-elements of group VIIA. Halogens. Topic 36. p-elements of group VIIIA. Noble gases. Topic 37. General characteristics of d-elements. Types of chemical reactions with their participation. Topic 38. d-elements of group IV. Copper, Argentum, Aurum. Topic 39. d-elements of group IIB. Zinc, Cadmium, Mercury Topic 40. d-elements of groups IIIB – VB of the PSE. Titanium, Vanadium. Lanthanides Topic 41. d-Elements of Group VIB. Chromium Subgroup. Topic 42. d-Elements of Group VIIB. Manganese Subgroup. Topic 43. d-Elements of Group VIIIB. Iron and its compounds. Topic 44. d-Elements of Group VIIIB. Cobalt and Nickel. Topic 45. d-Elements of Group VIIIB. Platinum Metals	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1.
3	Individual work – preparation of a review of scientific literature or conducting research on one of the topics (optional)	5
4	Preparation for the final control of the modules	5
	Total MODULE I:	**35**
	TOTAL	**70**

14. LIST OF INDIVIDUAL TASKS (if provided)

- Speeches at the scientific student group.
- Participation in scientific conferences.

- Publication of reports in the form of abstracts and articles in the periodical scientific press (journals, collections of scientific works).
- Production of visual aids according to the educational programs (tables, visual aids, graphological schemes of practical classes, presentations).

15. ASSIGNMENTS FOR INDEPENDENT WORK (if provided)

1. Prepare a short scientific report on new pharmaceutical products containing an active substance of inorganic origin.
2. Prepare handouts on the chemical properties of inorganic compounds of the main classes of inorganic compounds.
3. Prepare a presentation on the use of inorganic compounds in pharmacy.
4. Prepare a presentation on new pharmaceutical products containing an active substance of inorganic origin.
5. Prepare handouts on the content of chemical elements in food products.
6. Prepare handouts on the content of chemical elements in cosmetics.
7. Prepare handouts on the action of chemical elements in cosmetics.
8. Prepare handouts on qualitative chemical reactions on metal cations.

16. METHODS AND FORMS OF CONTROL (including assessment criteria

16.1. Form, procedure, methodology and criteria for assessing current educational activities.

Current control is the control of students' independent work in studying educational materials. It is carried out at each practical lesson in accordance with the specific goals of the topic in order to check the degree and quality of mastering the material being studied. In all practical lessons, objective control of theoretical preparation and mastering practical skills is used in order to check the student's preparedness for the lesson. In the process of current control, the student's independent work is assessed in terms of the completeness of the tasks, the level of mastering educational materials, mastering practical skills of analytical, research work, etc.

Criteria for assessing current educational activities:

A student who actively participated in the discussion of the most complex questions on the topic of the lesson, gave at least 90% of correct answers to standardized test tasks, answered the questions without errors written assignments, completed practical work and drew up a report.

A student who participated in the discussion of the most difficult questions on the topic, gave at least 75% correct answers to standardized test tasks, made some minor errors in the answers to written assignments, completed practical work and drew up a report receives a "good" grade.

A student who participated in the discussion of the most difficult questions on the topic, gave at least 60% correct answers to standardized test tasks, made significant errors in the answers to written assignments, completed practical work and drew up a report receives a "satisfactory" grade.

A student who did not participate in the discussion of the most complex questions on the topic, gave less than 60% of correct answers to standardized test tasks, made gross errors in the answers to written tasks or did not give answers to them at all, did not complete practical work and did not draw up a protocol receives an “unsatisfactory” grade.

16.2. Form, procedure, methodology and criteria for assessing individual independent work.

The number of points for the student’s individual independent work (ISW) is calculated as the difference between the maximum number of points for the current educational activity (120 points) and the maximum number of points for the student’s current success in mastering the topics of the module. Points for ISW are awarded upon successful defense.

Assessment of individual independent work of students (individual tasks) is carried out by awarding points for the successful completion and defense of the received individual task:

- Speeches at a scientific student circle – 8 points.
- Participation in scientific conferences - 12 points
- Publication of reports in the form of abstracts and articles in the scientific press (journals, collections of scientific works) - 12 points

- Production of visual aids according to the educational programs (tables, visual aids, graphological schemes of practical classes, presentations) - 8 points.

16.3. Conditions for admission to the final control.

Students who have attended all classroom training sessions provided for by the curriculum in the discipline and received positive grades for them ("5", "4", "3"), as well as scored at least the minimum number of points during the module study are allowed to take the final module control.

A student who has missed training sessions for good or bad reasons is allowed to work off academic debt by a certain specified deadline.

16.4. Form, procedure, methodology and assessment criteria during the final control.

The final control performs a controlling function, is carried out in order to assess the results of training at a certain educational and qualification level or at its individual completed stages.

The form of final control of the success of training is the module final control.

The module final control is carried out upon completion of the module study. Students who have completed all types of work provided for by the curriculum and have scored at least the minimum number of points in the module are allowed to take the final test.

The form of the final test should be standardized and include control of theoretical and practical training. Specific forms of control in inorganic chemistry are determined in the working curriculum.

The maximum sum of points for the final test is 80.

The final module test is considered passed if the student has scored at least 50 points.

17. LIST OF QUESTIONS FOR THE FINAL TEST

17.1. List of theoretical questions for the final module test.

1. Qualitative and quantitative information contained in a chemical formula and chemical equation.
2. Chemical formulas: empirical, structural, molecular.
3. Basic provisions of atomic-molecular theory.
4. Valence and oxidation state, how do these concepts differ? Give examples.
5. Law of conservation of mass and energy.
6. Law of constancy of composition. Law of multiple ratios.
   Gas laws: volume ratios; partial pressures of Dalton; Gay-Lussac. Clapeyron-Mendeleev equation.
7. Avogadro's law, conclusions from it. Relative density of gases.
8. Basic gas laws. Reducing the volume of a gas to normal conditions, the Mendeleev-Claiperon equation.
9. Avogadro's law. Molar volume of a gas. Avogadro's number.
10. Basic laws of chemistry: the law of conservation of mass, the law of constancy of composition and its modern interpretation, Avogadro's law.
11. Avogadro's law and its consequences. Relative density of gases.
12. The law of equivalents. Methods for determining equivalent masses.
13. Equivalent of a substance. The law of equivalents, its formulation and mathematical expression.
14. The concept of an equivalent. Calculation of the equivalent of simple substances, bases and oxides.
15. Formulation of the law of equivalents. Its calculation for acids, salts and substances participating in redox reactions.
16. What set of quantum numbers is needed to describe the state of an electron in an atom?
17. Formulate the basic rules for filling energy levels with electrons.
18. Explain the reasons for the formation of chemical bonds in compounds. What is the nature of chemical bonds?
19. The periodic law of D. I. Mendeleev and its interpretation from the point of view of the modern theory of the structure of atoms. The periodic table of elements.
20. The periodic nature of changes in the properties of atoms of elements of the periodic table.
21. What is the essence of the classification of chemical elements proposed by D. I. Mendeleev?
22. What is the similarity of elements placed vertically, horizontally and diagonally in the periodic table? What explains this similarity?
23. Define the concepts: activation energy, electron affinity energy, electronegativity.

24. Define the concepts: dispersed system, dispersed phase, dispersion medium. Classification of dispersed systems depending on the size of the particles of the dispersed phase.
25. Solutions as molecular-ionic dispersed systems. The essence of the basic concepts: solution, solute, solvent.
26. Water as one of the most common solvents in living nature and chemical technology.
27. What solutions are called: 1) dilute; 2) concentrated; 3) unsaturated; 4) saturated; 5) supersaturated?
28. Theories of solutions. The essence of Van't Hoff's physical theory.
29. Dissolution as a physicochemical process. What are solvates (hydrates)?
30. General properties of solutions.
31. How does the Gibbs energy change during dissolution? The role of enthalpy and entropy factors in the dissolution process.
32. What is the heat (enthalpy) of dissolution? What process causes a significant thermal effect when dissolving sulfuric acid, alkalis, ethanol in water?
33. Thermal effects during dissolution. The destruction of the crystal lattice requires energy, but when dissolving crystalline alkalis (NaOH, KOH), heat is released.
34. What is solubility? What quantities are used to quantitatively express the solubility of solids, liquids, gases? What is the solubility coefficient, the absorption coefficient?
35. Dependence of solubility on the nature of the solute and solvent. Give examples of readily soluble, sparingly soluble and practically insoluble solids, liquids and gases.
36. What factors affect the solubility in a liquid: a) solids; b) gases?
37. What factors affect the solubility of gases?
38. How does the solubility of oxygen in the blood change with a change in atmospheric pressure? What is the essence of mountain sickness, caisson disease?
39. Solubility of gases in the blood. I.M. Sechenov's law. Explain the different solubility of gases (O_2, N_2, CO_2) in water, plasma, whole blood.
40. What does the concentration of a solution express? What are the two groups of methods for expressing concentration?
41. What is the mass fraction of a substance in a solution? In what units is it expressed?
42. Mass fraction of a dissolved substance in percent.
43. Molar concentration of the equivalent (normality of the solution).
44. What is osmosis? Can osmosis be considered a special case of diffusion?
45. What is osmotic pressure? What laws govern osmotic pressure?
46. What is a thermodynamic process? What are thermodynamic processes and what are their characteristics?
47. What are the thermodynamic parameters of a system? How are they divided?
50. What characterizes the internal energy of the system? Can it be measured experimentally?
51. What is the rate of a chemical reaction?
52. The influence of the nature of the solvent, the concentration of reactants on the rate of a chemical reaction.
53. The dependence of the rate of a chemical reaction on temperature. Van't Hoff's rule, the Arrhenius equation.
54. What reactions are called reversible? Give examples. Explain the terms: dynamic chemical equilibrium and shift of chemical equilibrium.
55. What factors affect the state of chemical equilibrium. Explain with examples.
56. How does chemical equilibrium shift with increasing temperature for exothermic and endothermic reactions? Illustrate with examples.
57. What is the essence and insufficiency of the Arrhenius theory of electrolytic dissociation?
58. Give the main provisions of the Brønsted-Lowry protolytic theory and give examples of protolytic reactions.
59. How are electrolytes classified by the degree of dissociation? Give examples.
60. What is the dissociation constant of weak electrolytes, the dissociation constant of the first degree, the second degree, etc.? What is the relationship between them?

61. The relationship between the dissociation constant and the concentration of the solution and the degree of dissociation. Ostwald's dilution law.
62. The mechanism of electrolytic dissociation of molecules with ionic and covalent bonds.
63. The degree of dissociation of weak electrolytes.
64. Strong, weak and medium-strength electrolytes. Give examples.
65. Definition of the solubility product.
66. Derive the formula for the ionic product of water. What factors affect its value?
67. What do the hydrogen and hydroxyl indices and their mathematical formulas mean?
68. What are solvolysis and hydrolysis?
69. Hydrolysis. Mechanism of hydrolysis of cations and anions. Degree and constant of hydrolysis.
70. How do various factors (dilution, temperature, addition of acid or alkali) affect the shift of the hydrolysis equilibrium?
71. Give quantitative characteristics of hydrolysis using the example of ammonium chloride and sodium acetate.
72. Describe redox reactions (ROR) from the point of view of electronic theory.
73. Explain the essence of the following concepts using specific examples: oxidation state, oxidant, reductant, oxidation process, reduction process.
74. Explain the oxidizing and reducing properties of elements and their compounds depending on their position in the periodic system.
75. How is the equivalent and molar concentration of the equivalent of solutions of oxidizing agents and reducing agents determined? Give examples.
76. Redox reactions. Indicate which substances are called oxidizing agents and which are reducing agents. Indicate the most important oxidizing agents and reducing agents in pharmaceutical practice.
77. The modern meaning of the concept of "complex compound" (CS). The structure of CS according to Werner.
78. What classifications of complex compounds do you know? Give examples.
79. Indicate the types of complex compounds by the nature of the ligands.
80. Using the example of a complex compound, determine: the central atom (complexing agent), coordination number, number of ligands, complex ion, ions of the outer and inner spheres and their charges (according to Werner).

17.2. List of practical tasks and works for the final modular control.

1. Determine the volumetric composition in percent of a gas mixture of carbon monoxide (II) and air, if 3.58 g of it at 47 °C and a pressure of $4.96 \cdot 10^5$ Pa occupy a volume of 656 cm^3.
2. Determine at what temperature (at an atmospheric pressure of $1.047 \cdot 10^5$ Pa) 5 dm^3 of methane will have a mass of 2.937 g.
3. Determine the density in terms of helium of a gas mixture consisting of 60% nitrogen, 30% oxygen and 10% carbon dioxide.
4. The mass of 1640 cm^3 of a mixture of carbon monoxide (II) and methane at 27 °C and a pressure of $3.803 \cdot 10^5$ Pa is 5.2 g. Determine the volume of air required for its combustion.
5. When 9 g of a substance was burned, 1.8 g of water and 4.48 dm^3 of carbon dioxide (n. u.) were formed. The molecular weight of the substance is 90. Determine its molecular formula.
6. The substance contains 34.59% sodium, 23.31% phosphorus and 42.10% oxygen. Determine the molecular formula of this compound.
7. When 2.46 g of a substance was burned, 1.59 g of sodium carbonate, 0.81 g of water and 1008 cm3 of carbon dioxide (n. u.) were formed. Determine the molecular formula of this compound.
8. When 20 g of a metal carbonate was burned, 11.2 g of the oxide of this metal was formed. Determine what metal this is and its equivalent mass.
9. When 2.16 g of a metal is treated with chlorine, 10.68 g of its chloride are formed. Determine the equivalent mass and name of the metal.
10. Write the electronic formulas of the C, O, Co, N, Ca atoms. Determine the number of valence and unpaired electrons.
11. Name the elements in which the 3d-, 4d-, 5d-orbitals end up being filled. Write the electronic formulas of these elements.

12. Make up the electronic formulas of the Ti^{3+}, Mn^{2+}, Cu^{2+}, Co^{3+}, Pt^{2+} ions. Determine the number of valence and unpaired electrons.
13. List the main types of chemical bonds. What does the type of bond in compounds depend on? What type of bond is in the compounds: CO_2, NCl_3, RbCl, MgO, H_2S?
14. The main characteristics of chemical bonds, the definition of these quantities and their units of measurement. What is the nature of the bond in the molecules: LiOH, CS_2, ClF, NH_4CI, O_2?
15. What is the relative electronegativity of atoms? How does it affect the degree of ionicity of the bond? Calculate the □BEH of atoms for the bond H–O and Al–O.
16. How is the polarity of molecules determined? Arrange the formulas of the compounds given below in order of increasing polarity: N_2–NH_3–NO–NF_3–HF; b) CH_4–H_2O–HCl–H_2S–LiCl.
17. What are γ-, δ- and p-bonds? Schematically depict the overlap of the AO (atomic orbital) during the formation of these bonds.
18. What chemical bond is called ionic? Between the atoms of which elements does this bond arise?
19. What is a donor-acceptor bond? Explain the mechanism of formation of NH^+_4 and H_3O^+. ions.
20. What is AO hybridization? What types of hybridization do you know? What type of hybridization of the central atom and the geometric shape of the molecules: H_2O, BeF_2, SO_3?
21. What is the meaning of the concept of "d-compression". The atom of which element - potassium or copper - has a larger radius?
22. Write the electronic formulas of the elements with serial numbers 19, 30, 37, 53. What valence possibilities can they exhibit?
23. How to prepare 200 cm^3 of a 10% nitric acid solution (density 1.054 g/cm^3) from a 21% acid solution (density 1.125 g/cm^3)?
24. Molar concentration of a solution. In what units is it measured?
25. What is the titer of a solution? Derive the formula that connects the titer and the normality of a solution.
26. At 25°C, the solubility of NaCl is 36.0 g in 100 g of water. Calculate the mass fraction of the substance in a saturated solution.
27. Calculate the mass of water that must be added to 3 kg of a 30% hydrogen peroxide solution to obtain a 3% solution.
28. Calculate the molar concentration of a 25% solution of hydrochloric acid if its density is 1.2 g/ml.
29. How to prepare 250 cm^3 of a 0.12M solution of sodium hydroxide from crystalline alkali?
30. How to prepare 500 cm^3 of a 0.2M solution of sodium hydroxide from a 20% solution of NaOH?
31. How to prepare 200 cm3 of aluminum sulfate solution with a molar concentration of 0.2 mol/dm3?
32. How will the rate of the reaction of nitrogen monoxide oxidation by oxygen change if the volume of the gas mixture is reduced by 3 times?
33. How will the rate of the reaction of iron with chlorine change if the pressure in the system is increased by 4 times?
34. How many times will the reaction rate increase when the temperature increases by 60^0C, if γ =3?
35. 6 dm^3 of saturated lead sulfate solution contains 0.186 g of lead in the form of ions. Calculate the pH($PbSO_4$).
36. Will calcium sulfate precipitate when mixing equal volumes of 0.02 M solutions of calcium chloride and sodium sulfate? pH($CaSO_4$)= $9.1\cdot10^{-8}$.
37. The solubility product of barium carbonate is $5.1\cdot10^{-9}$. Calculate the solubility of this compound in mol/dm^3.
38. Calculate the pH and pOH of a solution containing 4 g of sodium hydroxide in 1 dm^3. The degree of dissociation is 100%.
39. Calculate the pH and degree of dissociation in a 0.02 M solution of ammonium hydroxide. Kdis= $1.76\cdot10^{-5}$.
40. Calculate the pH value of a 0.1 M solution of acetic acid. Kdis= $1.8\cdot10^{-5}$.
41. Write the molecular equation for the hydrolysis of sodium sulfide and the expression for the hydrolysis constant.

42. Write the hydrolysis equations for $Al_2(SO_4)_3$ and Al_2S_3.
43. Write the molecular and ionic equations for the hydrolysis of $SbCl_3$.
44. Hydrolysis of acidic salts. Indicate the acidity of the medium in $NaHSO_3$ and $NaHCO_3$ solutions.
45. Write molecular and ionic-molecular equations for the hydrolysis reactions of 0.1 M solutions of sodium phosphate and ammonium carbonate.
46. Write molecular and ionic-molecular equations for the hydrolysis reactions of 0.1 M solutions of ammonium nitrate and aluminum chloride.
47. Write molecular and ionic-molecular equations for the hydrolysis reactions of 0.1 M solutions of copper sulfate and ammonium sulfide.
48. Write the reaction equation and select the coefficients using the electron-ion method:
$NH_3 + KMnO_4 \rightarrow$
49. Complete the reaction equation and select the coefficients using the electron-ion method:
$KI + KIO_3 + H_2SO_4 \rightarrow$. Calculate the equivalent masses of the oxidizing agent and the reducing agent.
50. Complete the reaction equation and select the coefficients using the electron-ion method:
$KBr + MnO_2 + H_2SO_4 \rightarrow$. Determine the equivalent mass of the reducing agent.
51. Complete the reaction equation and select the coefficients using the electron-ion method:
$H_2S + KMnO_4 + H_2SO_4 \rightarrow S + \ldots$; $NaNO_2 + KMnO_4 + H_2O \rightarrow$
52. Specify the type of redox reactions. Calculate the equivalent of KMnO4.
53. Complete the OVR equation, write electronic diagrams, ionic equations and find the coefficients: $K_2Cr_2O_7 + H_2S + H_2SO_4 \rightarrow S\square + Cr_2(SO_4)_3 + K_2SO_4 + ...$
54. Using the values of standard redox potentials, determine whether the following reactions can occur: $FeCl_3 + KCl \rightarrow$, $FeCl_3 + KI \rightarrow$, $FeCl_3 + KBr \rightarrow\square$
55. Write the equation for the reaction of the formation of a complex compound when aluminum hydroxide interacts with an excess of sodium hydroxide solution.
56. Determine the charge of the complex ion and the coordination number of the iron ions in the compounds: $Na_3[FeF_6]$ and $K_4[Fe(CN)_6]$.
57. For the complex compounds $[Cu(NH_3)_4](OH)_2$ and $Na_3[Cr(OH)_6]$, name the components and write the expression for the general instability constants.
58. Determine the charge of the complex ion, the degree of oxidation of the complexing agent and its coordination number in the compounds: $[Cr(OH_2)_5Cl]Cl_2$; $[Pt(NH_3)4Cl_2]Br_2$; $K_3[Co(NO_2)_6]$.
59. Determine the coordination number of the complexing agent and write the expression for the general instability constant of the complex ion: $[Al(OH)_6]^{3-}$.
60. Write the reaction equations and name the products of the interaction: $AgCl + NH_3 \rightarrow$.
61. Form complex compounds and name them: $KI + HgI_2 \rightarrow$, $Co(OH)_2 + NH_3 \rightarrow$.
62. Determine the degree of oxidation, the coordination number of the complexing agent in the compounds: $K_2[Co(CN)_4]$; $[Pt(NH_3)_2Cl_2]$; $K[AuBr_4]$.
63. Write the chemical formulas of the following substances: caustic, crystalline, calcined and baking soda. Indicate their application.
64. Carry out the transformations: $B \rightarrow B_2O_3 \rightarrow H_3BO_3 \rightarrow Na_2B_4O_7 \rightarrow H_3BO_3$.
65. Complete the reaction equations, determine the coefficients by the half-reaction method:
$As + HNO_3(k) \rightarrow$, $Al + HNO_3(p) \rightarrow$.
66. Complete the reaction equations and determine the coefficients by the electron-ion method:
$I_2 + HNO_3(k) \rightarrow$, $As + HNO_3(k) \rightarrow$. Give the resulting compounds traditional names.
67. Write the formulas of possible oxides and hydroxides of Phosphorus.
68. Obtain phosphine from phosphide, as well as by the disproportionation reaction of phosphorus in an alkaline medium.
69. Obtain potassium bismuthate by the reaction: $BiCl_3 + Cl_2 + KOH \rightarrow$. Determine the coefficients by the method of half-reactions.
70. Indicate by what oxidizing agents it is possible to oxidize the compound Sulfur with an oxidation state of –2 to compounds with an oxidation state of + 6, + 4, 0.

71. Write the formulas of the complex compounds: chlorotriaminoplatinum (II) chloride, bromopentaaminecobalt (III) sulfate, potassium dicyanoargentate, potassium hexanitritocobaltate, hexamminenickel (II) chloride, magnesium trifluorohydroxyberyllate.
72. Empirical formula of the complex salt $CrCl_3 \cdot 5H_2O$. Assuming that the coordination number of chromium is 6, calculate the volume of 0.1 N solution of $AgNO_3$ required to precipitate chlorine in the outer coordination sphere for 200 ml of a 0.01 M solution of this complex salt.

18 SCORE CALCULATION AND DISTRIBUTION SCHEME

Information is provided on the distribution of points that are assigned to higher education applicants during the study of the academic discipline with notes:

- on the maximum and minimum number of points for studying the module;

- on the conversion of points into traditional grades "5", "4", "3", "2" when mastering the module topic;

- on the minimum number of points for admission to the final module control (PMK);

- on the minimum number of points for passing the module control.

Module number, number of teaching hours/number of ECTS credits	Number of content modules, their numbers	Number of practical classes	Conversion to traditional grades					Minimum number of points
			Traditional assessments				Points for completing an individual task	
			«5»	«4»	«3»	«2»		
Module 1 91/3,0	6 №1-6	18	6	5	4	0	12	72
Module 2	4 №7-10	18	6	5	4	0	12	71

When students master module 1, the following conversion of traditional grades into points takes place:
Grade “5” – 6 points (6 points x 18 lessons = 108 points)
Grade “4” – 5 points (5 points x 18 lessons = 90 points)
Grade “3” – 4 points (4 points x 18 lessons = 72 points)
Grade “2” – 0 points

The maximum number of points that a student can score for current educational activities when studying modules is 120 points, calculated by multiplying the number of points corresponding to the grade “5” by the number of assessed topics with the addition of points for the student’s individual independent work:
Module No. 1: 6 points * (18 PZ + 1 ISRS) = 6*18 + 12=120 points;
Module No. 2: 6 points * (18 PC + 1 ISRS) = 6*18 + 12=120 points.

The minimum number of points with which a student is admitted to the final module lesson is calculated by multiplying the number of points corresponding to the grade "3" by the number of assessed topics and is 72 points:
Module No. 1: 4 points * 18 PC = 72 points;
Module No. 2: 4 points * 18 PC = 72 points.

19 RECOMMENDED LITERATURE

19.1. Basic (basic)

General and inorganic chemistry: a textbook for students of higher education. / E.Ya. Levitin, A.M. Bryzytska, R.G. Klyueva; ed. by E.Ya. Levitin.- 3rd ed. -Kharkiv: National University of Physics and Technology: Golden Pages, 2017. - 512 p.

19.2. Auxiliary:

1. General and inorganic chemistry: a textbook / V.O. Kalibabchuk, V.V. Ogurtsov, V.I. Galunska [and others]; ed. by V.O. Kalibabchuk. - Kyiv: Medicine, 2019. - 456 p. - Text in English. - Bibliography: p. 455.
2. V.I. Homonay, S.S. Milevich. General and inorganic chemistry: a textbook for students of pharmaceutical faculties of higher educational institutions. - Uzhgorod, 2016. - 448 p.
3. General and inorganic chemistry: teaching-methodical manual. Part 1 / O.V. Krupko; Ministry of Health of Ukraine, Bukovyn. State Medical University. - 2nd ed., trans. and add. - Chernivtsi: BDMU, 2022. - 111 p.
4. Okrepka G.M. General and inorganic chemistry. Workshop (Module 1) [Text]: teaching-methodical manual. / G. M. Okrepka; Ministry of Health of Ukraine, VDNH of Ukraine "Bukovyn. State Medical University". - Chernivtsi: BDMU, 2020. - 62 p.
5. Okrepka G.M. General and inorganic chemistry. Practical course (module 2) [Text]: teaching-methodical manual. / G.M. Okrepka; Ministry of Health of Ukraine, VDNH of Ukraine "Bukovyn. State Medical University". - Chernivtsi: BSMU, 2020. - 65 p.

19.3. Information resources:

1. https://eosvita.bsmu.edu.ua/course/index.php?categoryid=308
2. https://phet.colorado.edu
3. https://www.compoundchem.com
4. https://ed.ted.com/search?qs=Chemistry+

20. COMPILERS OF THE STUDENT'S GUIDE (SYLLABUS)

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