/Translated from Russian into English/

MINISTRY OF SCIENCE, HIGHER EDUCATION AND INNOVATION OF THE KYRGYZ REPUBLIC

MINISTRY OF HEALTH OF THE KYRGYZ REPUBLIC

I.K. AKHUNBAEV KYRGYZ STATE MEDICAL ACADEMY

Endorsed by
Rector of
I.K. Akhunbaev KSMA
Professor Kudaibergenova I.O.

_____
"10" June, 2026

WORKING PROGRAM

FOR THE ELECTIVE COURSE IN CHEMISTRY

THE ROLE OF MAJOR AND TRACE ELEMENTS IN THE HUMAN BODY

Faculty / Degree programme	General Medicine, Dentistry, Pediatrics, Preventive Medicine, Higher Nursing Education.
Course	1
Total workload	2 credits
Total hours	60
Lectures	12
Practical classes	18
Individual work	30
Control	Pass/fail assessment

Bishkek–2026

Compiled

Based on	the State Educational Standard of Higher Professional Education for the following degree programmes: 560001 General Medicine 560002 Pediatrics 560003 Preventive Medicine 560004 Dentistry 560200 Nursing. Approved by Order No. 179 of the Ministry of Science, Higher Education and Innovation of the Kyrgyz Republic dated 3 April 2026.
Developed by	staff of the Department of Biochemistry with a Course of General and Bioorganic Chemistry, I. K. Akhunbaev KSMA: Head of Department Zh. A. Makhmudova, Doctor of Biological Sciences, Professor; Senior Lecturer N. E. Abdyldaeva; Zh. I. Berdalieva, Candidate of Chemical Sciences, Acting Associate Professor; and Lecturer F. A. Ismailov.
Reviewed by	O. A. Chonorova, Chief Physician of the National Center of Phthisiology under the Ministry of Health of the Kyrgyz Republic, physician of the highest qualification category, Candidate of Medical Sciences.
Discussed at the meeting	the Educational and Methodological Profile Committee for General Medicine (Minutes No. ___ dated _____ 2026)
Confirmed at the meeting	the Main Educational and Methodological Committee (Minutes No. ___ dated _____ 2026)

Annotation

Knowledge of the biological roles of major and trace elements is essential for studying biochemical processes in the human body, the actions of pharmacological agents, the medical use of compounds of various chemical elements, and chemical poisoning. Based on bioinorganic chemistry, future medical professionals should also learn to evaluate biochemical test results, environmental conditions and their effects on the human body. The syllabus provides sufficient contemporary theoretical material on the bioinorganic chemistry of s-, p- and d-block elements and on the chemistry and biological roles of coordination compounds. It also includes educational research laboratory work on the chemistry of elements and coordination compounds, review questions for independent study, standard problems with model solutions, examples of test questions, and a list of core and supplementary reading to deepen and broaden knowledge of bioinorganic chemistry.

The purpose of the training

To develop and deepen students' knowledge of the roles of major and trace elements and their compounds in bodily functions, the principal chemical transformations underlying metabolism, and the medical use of selected inorganic and organic substances.

Learning objectives

- Study the concepts and classification of major and trace elements.
- Examine the principal functions of major elements in the human body.
- Study the roles of trace elements in metabolism and the functioning of organs and systems.
- Identify the principal dietary sources of major and trace elements.
- Examine the health consequences of deficiency and excess of various elements. Consider the importance of a balanced diet in providing essential minerals.
- Develop an understanding of the prevention of diseases associated with mineral metabolism disorders.

The place of the discipline in the educational programme

Prerequisites

Subject	Knowledge, abilities and skills
Mathematics (school course)	Know: algebraic operations, logarithmic and power functions. Be able to: perform calculations using mathematical formulae and solve algebraic equations. Demonstrate skills in: mathematical calculations using a given formula and statistical processing of experimental results.
Biology (school course)	Know: the chemical nature of biological processes and the most important substances involved in the structure and functioning of living organisms. Be able to: identify relationships between biological and chemical processes occurring in nature and living organisms. Demonstrate skills in: finding relevant information on the chemical and biological roles of the elements studied.
Physics (school course)	Know: the fundamentals of atomic and molecular theory of matter and basic physical properties. Be able to: predict changes in the energy state of substances during chemical interactions and the properties of aqueous solutions. Demonstrate skills in: using mathematical methods and computers to calculate physical quantities describing the behaviour of substances.
Chemistry (school course)	Know: the fundamentals of theoretical inorganic and organic chemistry as a basis for studying the structure and reactivity of inorganic and organic compounds. Be able to: describe the properties of chemical compounds based on their structure. Demonstrate skills in: handling laboratory glassware and working safely in a chemical laboratory; performing basic chemical experiments; calculating quantitative chemical reaction results and the quantitative composition of solutions.

Postrequisites: Biological Chemistry; Normal Physiology; Pharmacology.

The student's competencies formed as a result of mastering the discipline

Competencies	General Medicine	Dentistry	Pediatrics	Preventive Medicine	Higher Nursing Education
General scientific (GSC)	GSC-2 GSC-3	GSC-3 GSC-4	GSC-3 GSC-4	GSC-3 GSC-4 GSC-8	GSC-3 GSC-4
Professional (PC)	PC-19 PC-20	PC-14 PC-15	PC-19 PC-20	PC-25 PC-26	PC-23

Planned learning outcomes correlated with the educational programme

№	Code	Competence content	Know	Be able to	Have the skills to
1	PC-19	Able and prepared to analyse and publicly present medical information based on evidence-based medicine.	• The classification of major and trace elements and their biological roles in the human body; • the physiological functions of the principal major elements (calcium, phosphorus, magnesium, sodium, potassium, chlorine, etc.); • the physiological functions of the principal trace elements (iron, iodine, zinc, copper, selenium, manganese, cobalt, etc.); • dietary sources of elements and daily requirements of different population groups; • mechanisms of absorption, transport, storage and excretion of major and trace elements; • clinical manifestations of deficiency and excess of individual elements; • laboratory methods for assessing the body's mineral status; • current evidence on the roles of major and trace elements in disease prevention and treatment; • principles of critical appraisal of scientific publications in nutrition science and trace element research.	• Analyse scientific and clinical information on the roles of major and trace elements from the perspective of evidence-based medicine; • find, select and critically appraise information from medical databases and clinical guidelines; • interpret laboratory test results reflecting mineral metabolism; • identify possible causes of deficiency and excess; • relate research findings to clinical practice; • justify recommendations on balanced nutrition and deficiency prevention; • prepare presentations, reports and communications on major and trace element metabolism; • present medical information to different audiences with evidence-based reasoning.	• Searching for medical information in evidence-based sources; • critically appraising scientific articles, systematic reviews and meta-analyses; • interpreting findings on the body's major and trace element status; • preparing and publicly presenting medical information; • visualising data using tables, diagrams, graphs and infographics; • citing and presenting scientific data appropriately; • conducting professional discussions and substantiating conclusions using evidence-based medicine; • using modern digital tools to prepare scientific communications and presentations.
2	PC-20	Able and prepared to plan and conduct scientific research.	• The classification of major and trace elements and their physiological roles in the human body; • mechanisms regulating mineral metabolism; • principal causes and consequences of deficiency and excess of major and trace elements;	• Formulate a research problem, hypothesis, aim and objectives concerning major and trace element metabolism; • search for and critically appraise scientific literature; • develop a study design appropriate to the stated aim;	• Planning scientific research; • searching for and systematising scientific information in medical databases; • preparing a research protocol; • collecting and recording research data; • statistically processing research results using modern software; • analysing and interpreting scientific data;

№	Code	Competence content	Know	Be able to	Have the skills to
			• current methods for measuring major and trace elements in biological samples; • principles of organisation and stages of medical research; • fundamentals of biostatistics and evidence-based medicine; • methods for searching, analysing and systematising scientific literature; • requirements for formulating research hypotheses, aims and objectives; • ethical principles of biomedical research; • current research directions in trace element research and nutrition science.	• select appropriate methods for assessing the body's mineral status; • plan the collection, processing and analysis of data; • use statistical methods to analyse research results; • interpret findings in the light of current scientific knowledge; • identify cause-and-effect relationships between element status and health; • present research results as an abstract, article, report or presentation; • present research findings at conferences and seminars.	• preparing scientific publications, reports and presentations; • observing research ethics and academic integrity; • publicly defending research findings and participating in scientific discussions; • preparing research project and grant applications concerning nutrition and major and trace element metabolism.

Scope of the discipline and forms of assessment

Elective course	Lectures	Practical classes	Individual work	Total	Control
The Role of Major and Trace Elements in the Human Body	12	18	30	60	Pass/fail assessment

Thematic lecture plan

№	Topic of the lecture	Hours
1	Chemical elements of the biosphere	2
2	Biomedical significance of s-block elements	2
3	Biomedical significance of p-block elements	4
4	Biomedical significance of d-block elements	2
5	Coordination compounds	2
	Total	12

Thematic plan of practical classes

№	Topic of practical classes	Hours
1	Chemistry of biogenic elements. V. I. Vernadsky's theory of the biosphere and biogeochemistry.	3
2	General characteristics of s-block elements. Hydrogen and its compounds. Biological roles of alkali and alkaline earth metals and their medical applications. Laboratory work: Qualitative reactions for s-block elements.	3
3	General characteristics of p-block elements. Biological roles and medical applications of p-block elements of Groups IIIA, IVA and VA. Laboratory work: Qualitative reactions for ions of p-block elements.	3
4	General characteristics of Groups VIA and VIIA. Biological roles and medical applications of p-block elements of Groups VIA and VIIA. Laboratory work: Qualitative reactions for ions of p-block elements.	3
5	General characteristics of d-block elements. Biological roles and medical applications of d-block elements of Groups IB, IIB, VIB, VIIB and VIIIB. Laboratory work: Qualitative reactions for ions of d-block elements.	3
6	Coordination compounds. Laboratory work: Determination of water hardness.	3
	Total	18

Thematic plan of individual work

№	Topic	Hours
1	Group IA elements. Biological roles and medical applications of rubidium, caesium and francium.	2
2	Group IIA elements. Biological role and medical applications of radium.	2
3	Chemistry of p-block elements. Group IIIA elements. Biological roles and medical applications of gallium, indium and thallium.	2
4	Chemistry of p-block elements. Group IVA elements. Biological role and medical applications of germanium.	2

№	Topic	Hours
5	Chemistry of p-block elements. Group VA elements. Biological roles and medical applications of antimony and bismuth.	2
6	Chemistry of p-block elements. Group VIA elements. Biological roles and medical applications of tellurium and polonium.	3
7	Chemistry of p-block elements. Group VIIA elements. Biological role and medical applications of astatine.	2
8	Chemistry of d-block elements. Group IIIB elements. Biological roles and medical applications of scandium and yttrium.	3
9	Chemistry of d-block elements. Group IVB elements. Biological roles and medical applications of zirconium, hafnium and rutherfordium.	3
10	Chemistry of d-block elements. Group VB elements. Biological roles and medical applications of vanadium, niobium and tantalum.	3
	Chemistry of d-block elements. Group VIIB elements. Biological roles and medical applications of technetium and rhenium.	
11	Biological roles and medical applications of lanthanides.	3
12	Biological roles and medical applications of actinides.	3
	Total	30

The content of the discipline

Topic 1. Chemistry of biogenic elements. V. I. Vernadsky's theory of the biosphere and biogeochemistry.

Abundance of chemical elements in nature. V. I. Vernadsky's theory of the biosphere and biogeochemistry. Major and trace elements in the environment and the human body. Distribution of the principal biogenic elements in the human body. Classification of elements. Relationships between electronic structure, biological roles and toxicity of elements. Roles of biogenic elements in the body. Toxicological roles of elements and their inorganic compounds. Applications of inorganic compounds in medicine and pharmacy. Biological roles of chemical elements in the body. Patterns of distribution of biogenic elements among the s-, p-, d- and f-blocks of Mendeleev's periodic table. Humans and the biosphere. Technological progress and the environment. Ecology. Relationships between endemic diseases in children and the characteristics of biochemical provinces.

Topic 2. General characteristics of s-block elements.

Hydrogen and its compounds. Biological roles of alkali metals and their medical applications.

General characteristics of s-block elements. Biological roles of Group I s-block elements: lithium (Li), sodium (Na) and potassium (K). Therapeutic effects of inorganic compounds of Group I s-block elements. Medical applications of inorganic compounds of Group I s-block elements. Toxic effects of s-block element compounds on living organisms.

Hydrides. Water and its physicochemical properties. Importance of water for the biosphere and the functioning of organisms. Hydrogen peroxide: acid–base and redox properties. Role of hydrogen peroxide as a metabolic by-product in bodily functions. Bactericidal properties of hydrogen peroxide. Principal compounds: oxides, peroxides, hydroxides and salts. Peroxides used for oxygen regeneration. Medical applications of Group IA element compounds.

Biological roles of Group II s-block elements: magnesium (Mg), calcium (Ca), strontium (Sr) and barium (Ba). Therapeutic effects of inorganic compounds of Group II s-block elements. Medical applications of inorganic compounds of Group II s-block elements. Toxic effects of s-block element compounds on living organisms.

Calcium compounds in bone tissue. Medical applications of Group IIA element compounds.

Laboratory work: Qualitative reactions for s-block elements.

Topic 3. General characteristics of p-block elements.

Biological roles and medical applications of p-block elements of Groups IIIA, IVA and VA.

General characteristics of p-block elements. Trends in nonmetallic properties. General characteristics of Groups IIIA, IVA and VA. Group III p-block elements: boron, aluminium and thallium. Biological roles of boron (B) and aluminium (Al). Therapeutic effects of inorganic boron and aluminium compounds. Applications of boron and aluminium compounds in medicine and pharmacy. Toxic effects of boron, aluminium and thallium compounds on living organisms.

Group IV p-block elements: carbon, silicon, tin and lead. Biological roles of carbon (C) and silicon (Si). Inorganic compounds of carbon, silicon and lead. Applications of carbon and inorganic compounds of carbon, silicon and lead in medicine and pharmacy. Toxic effects of carbon, silicon, tin and lead compounds on living organisms. Group V p-block elements: nitrogen, phosphorus, arsenic, antimony and bismuth. Biological roles of nitrogen (N), phosphorus (P) and arsenic (As). Therapeutic effects of inorganic nitrogen, phosphorus and arsenic compounds. Applications of inorganic nitrogen, phosphorus and arsenic compounds in medicine and pharmacy. Toxic effects of nitrogen, phosphorus and arsenic compounds on living organisms.

Laboratory work: Qualitative reactions for p-block elements.

Topic 4. General characteristics of Groups VIA and VIIA.

Biological roles and medical applications of p-block elements of Groups VIA and VIIA.

Group VI p-block elements: oxygen. Ozone and hydrogen peroxide. Biological roles of oxygen, ozone (O3) and hydrogen peroxide (H2O2). Medical applications of oxygen, ozone and hydrogen peroxide. Toxic effects of oxygen, ozone and hydrogen peroxide on living organisms. Group VI p-block elements: sulfur and selenium. Biological roles of sulfur (S) and selenium (Se). Therapeutic effects of inorganic sulfur compounds. Medical applications of inorganic sulfur and selenium compounds. Toxic effects of sulfur and selenium compounds on living organisms.

Group VII p-block elements: fluorine, chlorine, bromine and iodine. Biological roles of fluorine, chlorine, bromine and iodine. Therapeutic effects of inorganic fluorine, chlorine, bromine and iodine compounds. Applications of fluorine, chlorine, bromine and iodine compounds in medicine and pharmacy. Toxic effects of fluorine, chlorine, bromine and iodine compounds on living organisms.

Laboratory work: Qualitative reactions for ions of

p-block elements.

Topic 5. General characteristics of d-block elements. Biological roles and medical applications of d-block elements of Groups IB, IIB, VIB, VIIB and VIIIB.

General characteristics of d-block elements.

Group I and II d-block elements: copper, silver, zinc and mercury. Biological roles of copper (Cu), silver (Ag), zinc (Zn) and mercury (Hg). Therapeutic effects of inorganic copper, silver, zinc and mercury compounds. Medical applications of inorganic copper, silver, zinc and mercury compounds. Toxic effects of copper, silver and mercury compounds on living organisms.

Group VI d-block elements: chromium, molybdenum and tungsten. Biological roles of chromium (Cr), molybdenum (Mo) and tungsten (W). Therapeutic effects of inorganic molybdenum compounds. Applications of inorganic chromium and molybdenum compounds in medicine and pharmacy. Toxic effects of chromium compounds on living organisms.

Group VII d-block elements: manganese. Biological role of manganese. Therapeutic effects of inorganic manganese compounds. Applications of inorganic manganese compounds in medicine and pharmacy. Toxic effects of manganese compounds on living organisms.

Group VIII d-block elements: iron, cobalt and nickel. Biological roles of iron (Fe), cobalt (Co) and nickel (Ni). Therapeutic effects of iron and cobalt compounds. Applications of iron and cobalt compounds in medicine and pharmacy. Toxic effects of iron, cobalt and nickel compounds on living organisms.

Laboratory work: Qualitative reactions for ions of

d-block elements.

Topic 6. Complex compounds.

Werner's coordination theory and its development by Chugaev's school. Components and structure of coordination compounds: the central atom, its coordination number, and the inner and outer coordination spheres. Nomenclature of coordination compounds. Classification by charge and ligand type. Introduction to chelate complexes. Coordination compounds from the perspective of valence bond theory. Complex-forming ability of s-, p- and d-block elements. Complex formation reactions. Ionic equilibria and instability constants of complex ions. Metals and ligand exchange processes in the body.

Laboratory work: Determination of water hardness.

Questions for final assessment of students' knowledge

1. Chemical elements of the biosphere. Major, trace and ultratrace elements. Biogeochemical provinces. Chemical elements in the geosphere and biosphere. Essential elements. Impurity elements.

2. Classification of chemical elements. General characteristics of s-, p- and d-block elements and their compounds.

3. Abundance of chemical elements in nature. Relationship between the chemical composition of living organisms and the environment. Biological roles of elements according to their positions in Mendeleev's periodic table.

4. Patterns of distribution of biogenic elements among the s-, p-, d- and f-blocks of Mendeleev's periodic table. Distribution of the principal biogenic elements in the human body. Biological roles of chemical elements in the body.

5. Hydrogen. Water as the principal hydrogen compound: physical and chemical properties. Aqua complexes and crystalline hydrates. Distilled and pyrogen-free water: preparation and pharmaceutical applications. Natural and mineral waters.

6. Group IA s-block elements as metals. Ionophores and their roles in membrane transport of potassium and sodium.

7. Group IA s-block elements. Chemical properties, biological roles and medical applications of their compounds.

8. Biological roles of metallic s-block elements in the body's mineral balance. Major and trace s-block elements. Intake of elements through water.

9. Group IIA s-block elements. Chemical properties, biological roles and medical applications of their compounds. Alkali and alkaline earth metal ions as complex-forming species.

10. Water hardness: units, limits, effects on living organisms and reactions in aqueous solutions, and methods of water softening.

11. Biological roles of calcium and magnesium. Calcium compounds in bone tissue. Similarities between calcium and strontium ions. Isomorphous substitution and the strontium-90 problem.

12. Group IIIA p-block elements. Chemical properties, biological roles and medical applications of their compounds.

13. Boron. Boric anhydride and boric acid: equilibria in aqueous solution. Sodium tetraborate. Boric acid esters. Biological role of boron. Antiseptic properties of boric acid and its salts.

14. Aluminium. General characteristics. The element and its chemical reactivity. Forms of aluminium oxide. Medical applications. Amphoteric character of the hydroxide. Aluminates. Aluminium ions as complex-forming species. Anhydrous aluminium salts and crystalline hydrates: structural features. Alums. Physicochemical principles underlying the medical use of aluminium.

15. General characteristics of Group IVA. Physical and chemical properties of the elements. Carbon. Activated charcoal as an adsorbent. Carbon(II) compounds. Carbon(IV) compounds. Carbon(IV) oxide: stereochemistry, bonding and equilibria in aqueous solution. Carbonic acid, carbonates and hydrogen carbonates: hydrolysis and thermal decomposition. Biological role of carbon. Chemical principles underlying the use of inorganic carbon compounds in medicine and pharmacy.

16. Silicon. General characteristics. Principal difference from carbon: absence of pi bonding in its compounds. Silicides. Hydrogen compounds (silanes): oxidation and hydrolysis. Silicon(IV) oxide. Silica gel. Silicic acid. Silicates: solubility and hydrolysis. Medical applications of silicon compounds.

17. Elements of the germanium subgroup. General characteristics. Stability of hydrogen compounds. Lead. Oxides. Lead(IV) oxide as a strong oxidising agent. Soluble and insoluble salts of tin and lead. Redox reactions in solution. Chemical mechanisms of lead compound toxicity. Medical applications of lead-containing preparations: lead(II) acetate and lead(II) oxide.

18. Group V p-block elements. General characteristics of the group. Nitrogen, phosphorus and arsenic in the body and their biological roles.

19. Nitrogen. General characteristics. Diversity of compounds with different nitrogen oxidation states. Compounds with negative oxidation states. Nitrides. Ammonia: acid–base and redox properties and substitution reactions. Properties of amino acids as ammonia derivatives. Introduction to the chemical principles underlying ammonia use in medicine and pharmacy.

20. Nitrogen compounds with positive oxidation states. Nitrous acid and nitrites: acid–base and redox properties. Nitric acid and nitrates: acid–base and redox properties. Introduction to the chemical principles underlying the use of nitrous oxide, sodium nitrite and sodium nitrate in medicine and pharmacy.

21. Allotropic forms of phosphorus and their chemical reactivity. Phosphides. Phosphine. Comparison with the corresponding nitrogen compounds. Phosphorus compounds with positive oxidation states: chemical properties, biological roles and medical applications.

22. Hypophosphorous and phosphorous acids: molecular structure, acid–base and redox properties. Diphosphoric (pyrophosphoric) acid. Metaphosphoric acids and comparison with nitric acid. Phosphoric acid derivatives in living organisms.

23. Oxygen. General characteristics. Oxygen as one of the most abundant elements and a constituent of most inorganic compounds. Electronic structure of the oxygen molecule. Chemical reactivity of oxygen. The O2 molecule as a ligand in oxyhaemoglobin. Ozone: stereochemistry and bonding. Chemical reactivity compared with oxygen: reactions with iodide solutions.

24. Classification and general properties of oxygen compounds, including binary compounds: superoxides, peroxides, oxides and ozonides. Hydrogen peroxide (H2O2): acid–base and redox properties and medical applications. Biological role of oxygen. Chemical principles underlying the use of oxygen, ozone and oxygen compounds in medicine and pharmacy.

25. Sulfur. General characteristics. Sulfur compounds with negative oxidation states. Hydrogen sulfide: acid–base and redox properties. Metal and nonmetal sulfides: water solubility and hydrolysis. Sulfur(IV) compounds.

26. Sulfur(VI) compounds. Biological role of sulfur: sulfhydryl groups and disulfide bridges in proteins. Chemical principles underlying the use of sulfur and its compounds in medicine, pharmacy and pharmaceutical analysis.

27. Group VII p-block elements (halogens). Chemical properties, biological roles and medical applications of their compounds. Hydrogen halides: water solubility, acid–base and redox properties. Ionic and covalent

halides and their reactions with water, oxidising agents and reducing agents. Halide ions as ligands in coordination compounds.

28. Halogens with positive oxidation states. Chlorine oxyacids and their salts: stereochemistry, bonding, stability in the free state and in solution, and changes in acid–base and redox properties with halogen oxidation state. Bleaching powder, chlorates, bromates and iodates and their properties. Biological roles of fluorine, chlorine, bromine and iodine.

29. Introduction to the chemical mechanisms of the bactericidal action of chlorine and iodine. Applications of bleaching powder, chlorine water, active chlorine preparations, iodine, hydrochloric acid, fluorides, chlorides, bromides and iodides in medicine, sanitation and pharmacy.

30. Copper(I) and copper(II) compounds: acid–base and redox properties and complex-forming ability. Coordination nature of copper-containing enzymes and the chemical mechanisms of their action in metabolic reactions. Origin of colour in copper compounds. Chemical principles underlying the medical use of copper compounds.

31. Silver compounds: acid–base and redox properties and the bactericidal properties of silver ions. Complex-forming ability. Silver complexes with halides, ammonia and thiosulfates. Chemical principles underlying the therapeutic use of silver compounds.

32. Gold. Gold(I) and gold(III) compounds: acid–base and redox properties and complex-forming ability. Chemical principles underlying the use of gold and its compounds in medicine and pharmacy.

33. General characteristics of Group IIB elements. Zinc. General characteristics and reactivity of the element. Acid–base and redox properties of zinc compounds. Zinc complexes. Coordination nature of zinc-containing enzymes and the chemical mechanisms of their action. Chemical principles underlying the use of zinc compounds in medicine and pharmacy.

34. General characteristics of Group IIB elements. Mercury. Mercury(I) and mercury(II) compounds: acid–base and redox properties. Chemical mechanisms of cadmium and mercury compound toxicity. Chemical principles underlying the use of mercury compounds in medicine and pharmacy.

35. Group V d-block elements. General characteristics. Chemical principles underlying the use of niobium and tantalum in surgery and ammonium metavanadate in pharmacy.

36. Group VI d-block elements. General characteristics of the group. Chromium. General characteristics. General trends in the acid–base and redox properties of d-block element compounds from lower to higher oxidation states, illustrated by chromium compounds. Biological significance of Group VI d-block elements.

37. Molybdenum and tungsten. General characteristics. Comparative redox properties of molybdenum and tungsten compounds relative to chromium compounds. Biological significance of Group VI d-block elements.

38. Manganese. General characteristics. Manganese(VII) compounds: oxide, permanganic acid and permanganates. Acid–base and redox properties. Products of permanganate reduction at different pH values. Oxidation of organic compounds. Thermal decomposition. Chemical principles underlying the use of potassium permanganate and its solution as an antiseptic and in pharmaceutical analysis.

39. Iron. Reactivity of the element and complex-forming ability. Iron(II) and iron(III) compounds: acid–base and redox properties and complex-forming ability. Haemoglobin and iron-containing enzymes: chemical mechanisms of their action. Iron(VI). Chemical principles underlying the use of iron and iron-containing preparations in medicine and pharmacy.

40. Cobalt and nickel. Reactivity of the elements compared with iron. Nickel and cobalt as trace elements. Chemical principles underlying the use of cobalt and nickel compounds in medicine and pharmacy.

41. General characteristics of the platinum group elements. Medical applications of platinum group element compounds.

42. Environmental aspects of the effects of inorganic substances. Humans and the biosphere. Technological progress and the environment. Relationships between endemic diseases and the characteristics of biogeochemical provinces.

43. Werner's coordination theory and its development by Chugaev's school.

44. Components and structure of coordination compounds: the central atom, its coordination number, and the inner and outer coordination spheres.

45. Nomenclature of coordination compounds.

46. Classification of coordination compounds by charge and ligand type.

47. Introduction to chelate complexes.

Educational and methodological resources

Main sources of literature

1. Popkov, V. A., and Puzakov, S. A. General Chemistry: A Textbook for Medical Students. Moscow: GEOTAR-Media, 2007. [In Russian.]

2. Lensky, A. S., Belavin, I. Yu., and Bylikin, S. Yu. Biophysical and Bioinorganic Chemistry: A Textbook for Medical Students. Moscow: MIA, 2008. [In Russian.]

3. General and Bioorganic Chemistry. Edited by V. V. Popkov and A. S. Berlyand. 2nd edition. Moscow: Akademiya, 2011. [In Russian.]

4. Adenov, Zh. A. The Role of Chemical Elements and Their Compounds in Ecology, Biology and Medicine. Bishkek: Insanat, 2008. [In Russian.]

5. Adenov, Zh. A. Biogenic Elements. Bishkek: Insanat, 2008. [In Kyrgyz.]

6. Adenov, Zh. A. Programme Guide to Practical Classes in Bioinorganic and Biophysical Chemistry. Bishkek: Insanat, 2009. [In Russian.]

Additional sources of literature

1. Slesarev, V. I. Chemistry: Fundamentals of the Chemistry of Living Systems. A textbook for university students in natural science fields and degree programmes. 2nd revised and expanded edition. St Petersburg: KHIMIZDAT, 2001. 784 pp., illustrated. Endorsed by the Ministry of Education of the Russian Federation. [In Russian.]

2. Practical Manual in General and Bioorganic Chemistry. Edited by V. A. Popkov. 3rd edition, unchanged reprint. Moscow: Akademiya, 2008. 235 pp. Higher Professional Education series. [In Russian.]

Electronic resources

1. Website of KSMA named after I. K. Akhunbaev: https://www.kgma.kg/index.php/ru/
2. Electronic resources of the eIFL project: http://bik.org.kg/ru/eifl_resources/
3. KSMA Electronic Library: library.kgma.kg.

Head of the Library **G. Dzh. Ibraimova**