INTERNATIONAL HIGHER SCHOOL OF MEDICINE

Department of Natural Sciences Disciplines

SYLLABUS

Chemistry (general and bioorganic)
2026-2027 academic year
for students of medical faculty
1 course 1 semester, groups 1-40
3 credits (90 h, including auditorial 54 h, independent work – 36 h)

Lecturer: **Ph.D. of chemical science,**
Assoc. Prof. Aitkeeva Cholpon Alymkulovna
+996700040801 (Whatsapp)
Email: cholpon.chf@mail.ru

Venue: Zoom

Practical classes: **Senior teacher Aidyralieva Chynara Baktybekovna**
+996558870929 (Whatsapp)
Email: chynara_153@mail.ru

Venue: room 408 of Administrative building of IHSM, 4th floor.

Senior teacher Torokulova Sofia Suyundukovna
+996703767142 (Whatsapp)
Email: sophtorok@gmail.com

Venue: room 406 of Administrative building of IHSM, 4th floor.

Senior teacher Makeshova Aizada Duishonkulovna
+996709098977 (Whatsapp)
Email: aizada.makeshova1974@gmail.com

Venue: room 406 of Administrative building of IHSM, 4th floor.

The Syllabus is considered
at the meeting of the department of Natural Sciences Disciplines
Protocol №1 dated 28.08.2026
Head of the department Ch.S. Ismailova

Course Objective: the purpose of studying the discipline is to develop competencies based on the formation of a systematic natural science understanding of the structure and transformation of organic and inorganic substances underlying the processes of vital activity and influencing these processes in direct connection with the biological functions of these compounds, the formation of natural science thinking of medical professionals.

After study of the discipline the student must:

Knowledge: Physico-chemical aspects of the most important biochemical processes and various types of homeostasis in the body; the role of biogenic elements and their compounds in living systems; features of the physico-chemistry of dispersed systems and solutions of biopolymers; fundamental foundations of theoretical organic chemistry.

Skill: Predict the result of chemical transformations of inorganic and organic compounds. To isolate functional groups, acidic and basic centers in molecules to determine the chemical behavior of organic compounds. Perform laboratory work, fill out the research protocol, evaluate its results.

Attitude: Possess chemical terminology; skills in using laboratory instruments, laboratory chemical utensils and other equipment. Possess the skills of performing chemical laboratory research; the skills of independent work with chemical literature: to search for data, turn what you read into a tool for solving chemical, and in the future professional tasks.

Pre-requisites. To study the discipline, the student must have knowledge of the cycle of chemical-biological and physical-mathematical disciplines of the school educational program: Chemistry, Biology, Mathematics, Physics, Computer Science.

Post-requisites. Biochemistry, Histology, Basic pharmacology, Medical Biology, Molecular Biology, Epidemiology, Normal physiology.

THEMATIC PLAN OF LECTURES

№	Theme of lecture	Hours	Date
1	The bases of chemical thermodynamics and bioenergetics. Chemical kinetics. Chemical equilibrium. Factors affecting rate of reaction.	2	05.10.26
2	Solutions. The properties of solutions and the role of solutions in biological processes. Colligative properties of weak and strong electrolytes solutions. Electrolytic homeostasis. Buffer systems. Blood buffer systems.Acidosis. Alkalosis.	2	12.10.26
3	Red-ox reactions and their role in biochemical processes. Electrode potentials and mechanism of their originating. Nernst equation for electrode potentials calculating.	2	19.10.26
4	Biogenic elements. Macro- and microelements in the environment and human organism. Radioactivity of elements. Complex compounds. Structure and properties of complex compounds. Complex compounds in medicine.	2	26.10.26
5	Colloid state of the substance. Principles of classification, producing and purification of dispersed systems. Optical and molecular-kinetical properties of colloid systems.	2	02.11.26
6	Theory of chemical structure of organic compounds. Classification of organic reactions. Radical and electrophilic reactions of hydrocarbons and their derivatives.	2	09.11.26
7	Basic chemical properties of oxygen-containing organic compounds.	2	16.11.26
8	Biologically important classes of poly and heterofunctional compounds. Biologically important heterocyclic compounds.	2	23.11.26
9	Proteins. Lipids. Nucleotides and nucleic acids. Carbohydrates. Biorole and functions of biomolecules in living organisms. Vitamins.	2	30.11.26

THEMATIC PLAN OF PRACTICAL CLASSES

№	Theme of practical class	Hours	Date
1	The main classes of inorganic compounds. Chemical properties of inorganic compounds	2	05.10-10.10.26
2	Chemical thermodynamics. Thermodynamical equilibrium conditions. Thermodynamical accounts.	2	12.10-17.10.26
3	The rate of chemical reactions. Chemical equilibrium. **Laboratory work: Factors affecting rate of reaction.**	2	19.10-24.10.26
4	The ways of expression of solutions concentration. The determination of concentration of produced solutions. Colligative properties of non-electrolytes solutions.	2	26.10-31.10.26
5	Electrolytic dissociation of water, acids, bases, salts. Salts hydrolysis. Buffer systems. pH calculation and measuring.	2	02.11-07.11.26

6	Red-ox reactions types. Electrode potentials. **Laboratory work: Red-ox reactions and their role in medicine.**	2	09.11-14.11.26
7	Complex compounds. Biorole of complex compounds. **Laboratory work: The impact of drinking water quality on human health. The determinations of water hardness.**	2	16.11-21.11.26
8	Colloid state of substance. Principles of classification of disperse systems. The producing of disperse systems. Stability and coagulation of colloid systems.	2	23.11-28.11.26
9	**1st unit passing (module 1)**	2	30.11-05.12.26
10	Classification, nomenclature and isometry of organic compounds. Organic reactions types. Radical and electrophilic reactions of hydrocarbons and their derivatives.	2	07.12-12.12.26
11	Basic chemical properties of oxygen-containing organic compounds. **Laboratory work: Chemical properties of Oxygen containing organic compounds.**	2	14.12-19.12.26
12	Biologically important classes of poly and heterofunctional compounds.	2	21.12-26.12.26
13	Biologically important heterocyclic compounds.	2	28.12.26 02.01.27
14	a-amino acids. Peptides and proteins. **Laboratory work: Colour tests of proteins.**	2	04.01-09.01.27
15	Saponified and unsaponified lipids. Biorole and functions in living organism.	2	11.01-16.01.27
16	Nucleotides and nucleic acids. Structure, biorole and functions in living organism.	2	18.01-23.01.27
17	Carbohydrates. Classification, biorole and functions in living organism. **Laboratory work: Chemical properties of Carbohydrates.**	2	25.01-30.01.27
18	**2nd unit passing (module 2)**	2	01.02-06.02.27

THEMATIC PLAN OF INDEPENDENT WORK OF STUDENTS

Unit №	Theme of independent work	Hours	Date
I. General and Bio-inorganic chemistry	• Taking notes and studying lecture material. • Preparation for laboratory and practical classes. • To make up project (brief report) on biological role of chemical elements group (on teacher's indication) according to points: Element 1. General properties 2. Chemical properties 3. Important compounds 4. Biological role 5. Using in medicine • Preparation for border control.	18	05.10-28.11.26
II. Bioorganic chemistry	• Taking notes and studying lecture material. • Preparation for laboratory and practical classes. • To make up project (brief report) according to topic "Vitamins. Biorole and functions in living organism" (on teacher's indication). • Preparation for border control. • Preparation for the exam.	18	30.11.26-06.02.27

Recommended reading for the discipline:

Basic:

1. Russell J.B. General Chemistry. 2nd ed. 1992.
2. Mahan B.M. University Chemistry. 4th ed. 1998.
3. Prescott. Chemistry. 2004

Additional:

1. Bhatnagar R. Chemistry. 2002.
2. Rao S.B. Chemistry. 2010.
3. Cotton F.A. Basic Inorganic Chemistry. 3rd ed. 1994.
4. Sharpe A.G. Inorganic Chemistry. 3rd ed. 1999.
5. Anwar J. Chemistry. 2003.

6. Prescott C.N. Chemistry. 2001.

Electronic:

1. Handbook of Medicinal Chemistry 2023 EBSCO-eBooks-Medical-Collection
2. Sergey Bylikin, Gary Horner, Elisa Jimenez Grant, David Tarcy. Oxford Resources for IB DP Chemistry: Course Book. 2023 IHSM Digital Resource http://dspace.ism.edu.kg/
3. Zuzana Országhová, Ingrid Žitňanová. Textbook of Medical Chemistry 2018 IHSM Digital Resource http://dspace.ism.edu.kg/
4. Paola Antonello. Mechanisms and Catalysis in Organic Chemistry. 2024. IHSM Digital Resource http://dspace.ism.edu.kg/
5. Basic Concepts in Medicinal Chemistry 2023 EBSCO-eBooks-Medical-Collection
6. Forensic Chemistry of Substance Misuse 2022 EBSCO-eBooks-Medical-Collection

Grading policy and procedures for all types of work

For the period of studying the discipline, the student gains points for the relevant parameters (per unit):
current score - 40 points
independent work - 20 points
control score (final assessment of knowledge per unit) - 40 points
Maximum score - 100 (40+20+40)

Grading system for student's achievements

Grading criteria per discipline				
Maximum score	Intervals			
	«unsatisfactory»	«satisfactory»	«good»	«excellent»
Current control - 40	0-23	24-30	31-35	36-40
Interval description	The student is poorly oriented in the material of the lesson topic, answers questions incompletely and inconsistently. There were difficulties or mistakes in the definition of concepts, the use of terminology. I tried to complete tasks on my own (exercises, situational tasks, tests), but about 25% of the tasks were completed correctly. The answers to the questions of the programmed control are not complete, the formulas are not written, there is an attempt to write reactions.	The student has a shallow knowledge of the topic of the lesson, answers questions incompletely and inconsistently, but showed a general understanding of the question and demonstrated skills sufficient to assimilate further program material. There were difficulties or mistakes in the definition of concepts, the use of terminology, corrected after several additional questions from the teacher. Independently completed all the tasks (exercises, situational tasks, tests), but about 80% of the tasks were completed correctly. The answers to the questions of programmed control are not completely complete, but the basic concepts are reflected, most formulas and reactions are written with errors.	The student showed knowledge of the topic material, but allowed 2-3 minor inaccuracies in the answer, which he corrected after the teacher's remark, showed the ability to think logically and gave correctly selected examples to confirm knowledge, was able to draw reasonable conclusions. Independently and correctly completed all tasks (exercises, situational tasks, tests). Answers to questions of programmed control with minor errors, formulas and reactions are written correctly. 2-3 minor errors are allowed when writing formulas.	The student showed a deep understanding of the topic of the lesson, the ability to think logically. The presentation of the material fully corresponds to the questions posed, contains all the necessary theoretical facts, illustrated by correctly selected concrete examples. The student was able to draw reasonable conclusions. Independently and correctly completed all tasks (exercises, situational tasks, tests). The answers to the questions of the programmed control are complete, without errors, all formulas and reactions are written correctly
Independent work - 20	0-11	12-15	16-17	18-20
Interval description	if the SIW is not delivered or the SIW is delivered in printed form	significant inaccuracies were made when performing the	there are some inaccuracies in the implementation of the SIW, 15-20	with 90-100% fulfillment of all requirements, answers all

	without protection or with large comments, i.e. the SIW does not meet the requirements.	SIW, the number of questions is up to 15, there are grammatical errors, the student does not answer all the questions, the list of references is decorated with comments – few sources, up to 5, or they are old (up to 90 years)	questions, there are incorrect ones, for example, adjectives, verbs; answers all questions during the defense, the list of references with inaccuracies – and the number 6-7, there are old sources	questions without errors
Control work (module) - 40	0-23	24-30	31-35	36-40
Interval description	The student receives in the case when he did not fully complete the task, showed an insufficient level of knowledge, could not explain the results obtained. Such a test paper does not meet the requirements, contains contradictory information, and the tasks in it are solved incorrectly.	The student receives a control task for a fully completed task if there are significant inaccuracies and shortcomings in it, the student is not able to correctly apply the knowledge gained, there are violations in the design of the work, not reasoned answers, irrelevant or unreliable sources of information.	It is set when the student has completed all the tasks, showed good knowledge of the material covered, but failed to justify the proposed solutions to the problems, when there are shortcomings in the design of the control work and general small remarks that do not affect its quality.	It is exhibited on the condition that the student has fully completed the task of the control work and has shown excellent knowledge of the educational material. At the same time, the work is designed in accordance with the requirements, a minimum of comments can be submitted to it.

Conduct Policy: (lateness, absence, behavior in the auditorium, late submission of work).
- Punctuality and completion of tasks.
- Mandatory attendance of classes.
- Attending class in a clean medical uniform.
- Eliminating conversations on a cell phone in the classroom.
- Active participation in the learning process.
- Doing homework on time.
- Academic detention at the time specified by the teacher.

For violations of the Conduct Policy, the total points for discipline might be reduced to 1-10 points.

Academic Ethics Policy.
- Be tolerant, respect the opinions of others.
- Formulate objections in the correct form.
- Constructively support feedback in all classes.
- Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the following: the absence of references when using printed and electronic materials, quotes, thoughts and works of other authors or students.
- Prompting and cheating during tests, exams, classes is unacceptable as well as passing an exam for another student, unauthorized copying of materials.

For violations of the Academic Ethics Policy, the total points for the discipline may be reduced to 1-10 points.

Guidelines for the lessons of the discipline

Key questions covered in lesson 1.
1. Classification of inorganic compounds: oxides, acids, bases, and salts.
2. General chemical properties of inorganic compounds.

Recommended reading for the lesson: [BL1] PP. 145-182; [AL1-AL-2];

Key questions covered in lesson 2.
1. The calculation of reactions heat effects on standard enthalpies of formation and combustion.
2. Thermodynamical equilibrium conditions.

Recommended reading for the lesson: [BL1] PP. 145-182; [AL5-AL-6];

Key questions covered in lesson .3
1. The order and molecularity of chemical reaction.
2. The methods of determination of reaction's rate and activation energy.
3. Chemical equilibrium. Le-Schatelye principle.
4. Factors, affecting rate of reactions.

Recommended reading for the lesson: [BL1] PP. 491-538; [AL5-AL-6];

Key questions covered in lesson 4.
1. Modern representations on solutions nature. Classification of solutions.
2. Solubility of gases, solids and liquids. Influence of different factors on solubility.
3. The ways of expression of solutions concentrations.
4. Colligative properties of dilute solutions of non-electrolytes.

Recommended reading for the lesson: [BL1] PP. 453-490; [AL1-AL-2];

Key questions covered in lesson 5.
1. Electrolytic dissociation of water, acids, bases and salts.
2. Hydrolysis of salts. pH calculation.
3. Buffer systems. Classification.
4. Blood buffer systems and their role in organism.

Recommended reading for the lesson: [BL1] PP. 621-630; [AL5-AL-6];

Key questions covered in lesson 6.
1. Balancing of oxidation-reduction reactions.
2. Equivalent of oxidant and reductant.
3. The calculation of electrode potentials.

Recommended reading for the lesson: [BL1] PP. 723-770; [AL5-AL-6];

Key questions covered in lesson 7.
1. Coordination compounds playing important biological role.
2. Structure and stability of coordination compounds.
3. The determination of water's hardness.

Recommended reading for the lesson: [BL1-3]; [AL2]; [AL1-AL-2];

Key questions covered in lesson 8.
1. Classification of disperse systems.
2. Structure of micelle of hydrophobic sol.
3. Dispersion and condensation methods of colloid solutions obtaining.
4. Stability of colloid systems. Coagulation. Peptization.
5. Emulsions, suspensions, airsols, powders. General characteristics and using in medicine.

Recommended reading for the lesson: [BL1] PP. 479-490; [AL1-AL-2];

Key questions covered in lesson 9.

Control questions for module 1.
1. Basic concepts of the theory of solutions. Methods of expressing the composition of solutions: mass fraction, molar concentration, molar concentration of the equivalent, molar fraction, molal concentration, titer of the solution.
2. Colligative properties of dilute solutions of nonelectrolytes and electrolytes. Raoul's law. Consequences of Raoul's law. Osmosis. Osmotic and oncotic pressure. Van't-Hoff's law. Osmolarity and osmolality of biological fluids. The role of osmosis in biology and medicine.

3. Electrolytic dissociation. Arrhenius theory of electrolytic dissociation. The protolytic theory of Brensted-Lowry. The hydrogen pH index as a characteristic of the acidity of the medium. Ostwald's law of breeding.
4. Electrolytes in a living organism. The pH of various fluids of the human body is normal and pathological. The need to maintain acid-base homeostasis in the body.
5. Buffer systems. Definition, classification, composition. Calculation of the pH of buffer solutions (Henderson-Hasselbach equation). The mechanism of buffering action of bicarbonate, hemoglobin, protein and phosphate buffering systems. Buffer capacity.
6. Blood buffer systems, their biological role in ensuring the normal functioning of the body. Comparative characteristics of the power of blood buffer systems. Acidosis. Alkalosis.
7. Thermodynamic system. Classification of thermodynamic systems. States of the thermodynamic system. The first law of thermodynamics.
8. Thermochemistry. Thermal effect of a chemical reaction. Thermochemical equations. Hess's law and its consequences. Principles of calculating the caloric content of food products.
9. The second law of thermodynamics. Entropy. Gibbs free energy as a criterion of spontaneous processes. Enthalpy and entropy factor.
10. The rate of chemical reaction. Factors affecting the reaction rate. The law of the acting masses. The Van't-Hoff rule.
11. The molecular nature of the reaction and the order of the reaction. Kinetic equations of reactions of various orders. Determination of the reaction order.
12. Enzymatic catalysis. The Michaelis-Menten equation.
13. The state of chemical equilibrium. Chemical equilibrium constant. The Le Chatelier principle.
14. Biogenic elements. Classification of biogenic elements. Structural features the structure of the atoms of biogenic elements.
15. Biogenic s-, p-, d-elements, their properties, biological role and application of compounds in medicine. The impact of environmental factors on human health.
16. The nature of chemical bonding in complex compounds. Structure, isomerism and nomenclature of complex compounds. Stability of complex compounds. The instability constant of a complex ion. Complex compounds of a living organism. The medico-biological role of complex compounds.
17. The electrode. Electrode potential. The Nernst equation.
18. Galvanic cell. Electromotive force of the galvanic cell.
19. Fundamentals of the chromatographic method of analysis. Application in biology and medicine.
20. Dispersed systems. Classification of dispersed systems. Methods for obtaining colloidal solutions. The structure of the micelle.
21. Properties of dispersed systems: molecular kinetic, electrokinetic, optical. Electrophoresis. Electroosmosis. Application in medicine.
22. Methods of purification of colloidal solutions: dialysis, electrodialysis, ultrafiltration. The use of dialysis in medicine.
23. Stability and coagulation of colloidal systems. Colloidal protection. Role in the body.
24. Coarse-dispersed systems: aerosols, suspensions, emulsions. Application in medicine.

Examples of test questions of module 1.

1. Determine the type of thermodynamic system "0.9% NaCl solution in a sealed ampoule".
   1) homogeneous system
   2) heterogeneous system
   3) isolated system
   4) closed system
   5) open system
2. What is the amount of heat released or absorbed during the formation of 1 mole of a complex substance from simple substances under standard conditions?
   1) the enthalpy of combustion
   2) the enthalpy of neutralization
   3) standard heat of formation
   4) standard decomposition heat
   5) standard enthalpy of formation
3. Select the conditions under which the spontaneous flow of the thermodynamic process is impossible
   1) $\Delta G > 0$
   2) $\Delta G < 0$
   3) $\Delta H > 0$; $\Delta S < 0$
   4) $\Delta H = T\Delta S$
   5) $\Delta H < 0$; $\Delta S > 0$
4. What kind of reaction does the kinetic equation w = k correspond to?
   1) zero order
   2) first order
   3) second order

4) third order
5) fractional order

5. How will the rate of direct reaction $N_2(g) + O_2(g) = 2NO(g)$ change if the pressure in the system is increased by 5 times?
   1) increase by 5 times
   2) decrease by 5 times
   3) not change
   4) increase by 25 times
   5) decrease by 25 times
6. On what factors do the colligative properties of the solution depend?
   1) the nature of the solvent
   2) the nature of the solute
   3) the temperature
   4) the number of solute particles
   5) do not depend on the nature of the dissolved substance
7. Choose solutions that are hypertonic in relation to blood.
   1) 10% NaCl
   2) 0,9 % $CaCl_2$
   3) 0,1 % NaCl
   4) 0,01 % NaCl
   5) 0,9 % NaCl
8. What substance is included in the phosphate buffer solution?
   1) Na_3PO_4
   2) $MgHPO_4$
   3) NaH_2PO_4
   4) K_3PO_4
   5) $Ca_3(PO_4)_2$
9. According to what rule are potential-determining ions chosen when writing a micelle?
   1) Schulze-Hardy
   2) Van't-Goff
   3) Paneta Faience
   4) Mendeleev-Clapeyron
   5) Duclos-Traube
10. Which substance has the greatest coagulating effect on sol with positively charged particles?
    1) K_2SO_4
    2) $NaNO_3$
    3) $CaCl_2$
    4) $FeCl_3$
    5) K_3PO_4

Key questions covered in lesson 10.

1. Classification, nomenclature, isomery of organic compounds.
2. Carbon atom configuration. Space structure of organic compounds.
3. Classification of organic reactions.
4. Electrophylic addition reactions. Markovnikoff's rule.

Recommended reading for the lesson: [BL2]; [AL3-AL-4];

Key questions covered in lesson 11.

1. General characteristics of alcohols, phenols and ethers, aldehydes and ketones.
2. The main reactions of alcohols, phenols and ethers, aldehydes and ketones.
3. Methods for producing alcohols, phenols and esters, aldehydes and ketones.
4. Carboxylic Acids and their Derivatives. Chemical properties of carboxylic acids and their Derivatives.

Recommended reading for the lesson: [BL2]; [AL3-AL-4];

Key questions covered in lesson 12.

1. General characteristic of poly and heterofunctional compounds.
2. The chemical properties of heterofunctional compounds.
3. Heterofunctional compounds of benzene series.

Recommended reading for the lesson: [BL2]; [AL3-AL-4];

Key questions covered in lesson 13.

1. Heterocyclic compounds classification.

2. Biological significance of heterocyclic compounds.
Recommended reading for the lesson [BL2]; [AL3-AL-4];

Key questions covered in lesson 14.
1. The structure and classification of α-amine acids, entering into proteins. Their medical-biological importance. Acidic-basic properties of α-amine acids.
2. Biologically important reactions of α-amine acids: reactions of transamination, decarboxylation, hydroxylation.
3. Proteins. Primary, secondary, tertiary and quaternary structures of proteins. Types of interaction, Colour tests of proteins.

Recommended reading for the lesson: [BL2]; [BL3]; [AL3-AL-4];

Key questions covered in lesson 15.
1. General characteristics and functions of lipids.
2. The main classes of lipids (fatty acids, waxes, triglycerides, Phospholipids).
3. Prostaglandins, Steroids, Lipoproteins.

Recommended reading for the lesson [BL2]; [AL3-AL-4];

Key questions covered in lesson 16.
4. Nucleic acids components. Nucleic bases.
5. Nucleosides. The character of N-base connection with carbohydrate rest.
6. Nucleotides. The structure of ATP, cAMP. DNA and RNA.

Recommended reading for the lesson [BL2]; [AL3-AL-4];

Key questions covered in lesson 17.
1. Classification, structure and stereoisomery of carbohydrates.
7. Mono-, di- and polysaccharides: chemical properties, biorole and functions in living organisms.

Recommended reading for the lesson [BL2]; [AL3-AL-4];

Key questions covered in lesson 18.
Control questions for module 2.
1) Classification features of organic compounds: the structure of the carbon skeleton and the nature of the functional group.
2) Basic rules for the compilation of names according to the nomenclature for organic compounds
3) Functional group. Classification and nomenclature of functional derivatives of hydrocarbons: alcohols, phenols, thiols, amines.
4) Types of organic reactions: 1) substitution; 2) addition; 3) cleavage; 4) rearrangement; 5) oxidation and reduction.
5) Reaction mechanisms: 1) radical; 2) ionic: electrophilic, nucleophilic. The concept is a substrate, reagent, reaction center. Types of reagents: radical, electrophilic, nucleophilic.
6) Radical substitution reactions characteristic of marginal hydrocarbons (halogenation reaction).
7) Electrophilic addition reactions characteristic of unsaturated hydrocarbons (halogenation, hydrohalogenation, hydration reactions). Markovnikov's rule.
8) Electrophilic substitution reactions characteristic of aromatic hydrocarbons (nitration, sulfonation, acylation reactions).
9) Acid-base properties of alcohols, phenols, thiols, amines and acids.
10) Oxidation reactions
• primary and secondary alcohols;
• diatomic phenols;
• mild oxidation of thiols;
• oxidation of aldehydes with silver and copper (II) hydroxides.
11) Reduction reactions of aldehydes and ketones.
12) Qualitative reactions to polyatomic alcohols, phenols.
13) Reactions of alkylation, acylation and deamination of amines.
14) Reactions characteristic of aldehydes and ketones (with water, alcohols, thiols).
15) Formation of esters, esters with organic and inorganic acids, amides.
16) Aldol addition reactions. The biological significance of this reaction.
17) Properties of dicarboxylic acids: decarboxylation reactions and formation of cyclic anhydrides.
18) Amino alcohols: ethanolamine, choline, acetylcholine. The concept of biogenic amines. Dopamine, norepinephrine, adrenaline, their biological significance as hormones and neurotransmitters.
19) Hydroxy acids: glycolic, lactic, malic, tartaric and citric acids.
20) Aldehydes and ketoacids: glyoxylic, pyruvic, acetoacetic, oxaloacetic, α-ketoglutaric acids are the most important metabolites.
21) Reactions of α-, β-, γ – hydroxyacids due to the carboxyl group: 1) formation of salts; 2) formation of esters; 3) formation of amides; 4) decarboxylation.

22) Reactions of α-, β-, γ - hydroxyacids due to the hydroxyl group: 1) formation of salts, oxidation; 2) formation of esters and esters; 3) formation of O-acyl derivatives.
23) Chemical properties of oxoacids due to the carbonyl group: reduction reaction.
24) Heterofunctional organic compounds of the benzene series. Salicylic acid and its derivatives. P-aminobenzoic acid.
25) Biopolymers of a living organism. The role of proteins in the human body. The structure of protein molecules.
26) Denaturation of proteins. Processes accompanying denaturation; physical and chemical factors causing denaturation; the significance of the denaturation process for physiology and medical practice.
27) Qualitative reactions of proteins: xanthoprotein, ninhydrin, biuretic.
28) Classification of α-amino acids by the chemical nature of the radical. Classification of α-amino acids taking into account the total number of carboxyl and amino groups in the α-amino acid molecule.
29) Interchangeable and irreplaceable (valine, leucine, isoleucine, methionine, threonine, phenylalanine, tryptophan, lysine) amino acids. Conditionally interchangeable amino acids (histidine and arginine).
30) Chemical properties of amino acids as bifunctional compounds.
Reactions -COOH groups:
a) formation of amides on the example of aspartic, glutamic acids.
b) decarboxylation of tryptophan and histidine.
31) Reactions -SH groups:
a) mild oxidation of cysteine. The biological role of this reaction.
b) severe oxidation of cysteine followed by decarboxylation.
32) Reactions -NH2 groups:
a) deamination (non-oxidative, oxidative, hydroxylation).
b) the formation of salt with HCL on the example of methylamine, alanine.
33) Reactions -OH groups:
a) oxidation;
b) the formation of esters.
34) Specific reactions of α-amino acids:
a) formation of a bipolar ion;
b) formation of peptides. Nomenclature. Electronic and spatial structure of the peptide group.
35) Carbohydrates, classification.
36) Monosaccharides. Classification by the nature of functional groups (aldoses, ketoses) and the number of carbon atoms (pentoses, hexoses).
37) Stereoisomerism of carbohydrates. Enantiomers. Diastereomers. Epimers. α, β- anomers. Racemate.
38) Glucose, galactose, mannose, fructose, ribose, deoxyribose, xylose. Formation and properties of α- and β-glycosides.
39) Qualitative reactions based on oxidation reactions: silver mirror reaction (Tollens), with copper (II) hydroxide (Trommer) and Fehling reagent.
40) Recovery of monosaccharides: mannitol, sorbitol, xylitol.
41) Reactions due to hydroxyl groups: formation of copper saccharate, monosaccharide esters with organic and mineral (H2SO4, H3PO4) acids.
42) Amino sugar: glucosamine, galactosamine. Formation of O- and N-acyl derivatives.
43) Complex carbohydrates are oligosaccharides. Classification.
44) Reducing disaccharides (maltose, lactose), their composition, type of bond.
45) Non-reducing disaccharide (sucrose), its composition, type of bond. Why does sucrose not react with Trommer, silver mirror?
46) Polysaccharides. Homopolysaccharides and heteropolysaccharides, representatives.
47) Starch. Composition, structural unit of starch. Starch dextrinization.
48) The structure of amylose, amylopectin.
49) Glycogen. The structural unit of glycogen.
50) Polysaccharides of connective tissue. Scheme of formation of disaccharide fragment of hyaluronic acid. What functions does hyaluronic acid perform in the body?
51) Heterocycles. Classification. Five-, six-membered heterocycles: pyrrol, furan, thiophene, imididozole, pyrazole, pyridine, pyrimidine. Criteria of aromaticity.
52) Acid-base character of pyrrole, pyridine.
53) Reduction reaction of pyrrole and pyridine.
54) Reactions of electrophilic substitution of pyrrole, pyridine.
55) Pyrimidine bases: uracil, thymine, cytosine. Alkaloids. Nicotine. Caffeine. Chemical nature and significance
56) Nicotinic acid and its amide (vitamin B3) as a structural unit of coenzymes NAD+ and NADP.
57) Condensed heterocycles: purine.
58) Amino derivatives of purine: adenine, guanine. Turning them into uric acid.
59) The concept of the structure of porphine, heme.
60) Nucleosides. The nature of the bond of the nucleic base with the carbohydrate residue. Hydrolysis of nucleosides.
61) Nucleotides. The structure of nucleoside monophosphates, -diphosphates, -triphosphates. Nomenclature. Macroergic connections.

62) Nucleic acids. The general scheme of the structure. Types of nucleic acids. Ribonucleic (RNA) and deoxyribonucleic (DNA) acids. Features of the composition. The nature of the bond between the nucleotide residues in the polynucleotide chain. The concept of the primary structure of nucleic acids: RNA, DNA.
63) Lipids, classification.
64) The main higher fatty acids that are part of natural lipids.
65) Triacylglycerols. Simple and mixed fats. Solid and liquid fats. The iodine number is a measure of fat unsaturation.
66) Phospholipids. Amino alcohols included in the structure of phosphoglycerides and the genetic relationship between them.
67) Chemical properties of saponified lipids: hydrolysis (saponification), oxidation, hydrogenation, iodine and bromine addition reactions.
68) Sterols: cholesterol, ergosterol. Distribution in nature. Biological role.
69) Formation of vitamins D2 and D3. Meaning.
70) Bile acids. Cholic acid. Deoxycholic acid.

Examples of test questions of 2 modules 4.

1. Which compounds are called heterofunctional?
   1) Compounds containing 2 identical functional groups in molecules.
   2) Compounds containing 3 identical functional groups in molecules.
   3) Compounds containing 4 identical functional groups in molecules.
   4) Compounds containing various functional groups in molecules.
   5) Compounds containing 1 functional group in molecules.
2. Which of these compounds is heterofunctional?
   1) Ethanol.
   2) Glycerin.
   3) Phenol.
   4) Ethanolamine.
   5) Ethylene glycol.
3. What is the name of malic acid according to the systematic nomenclature?
   1) 2 – hydroxybutanedioic acid.
   2) Butanoic acid.
   3) 2 – oxobutanoic acid.
   4) Butanedioic acid.
   5) Butenedioic acid.
4. What functional groups are there in citric acid?
   1) – OH, – COOH and – NH2
   2) – OH and – NH2
   3) – OH and – COOH
   4) – NH2 and – COOH
   5) – CONH2
5. What products are formed during the hydrolysis of acetylsalicylic acid?
   1) phenol, sodium salicylate
   2) phenol, salicylic acid
   3) acetic acid, salicylic acid
   4) acetic aldehyde, salicylic acid
   5) acetic acid, salicylic aldehyde
6. Which α-amino acid forms a disulfide bond during oxidation?
   1) methionine (α-amino-γ-methylthiobutyric acid)
   2) cysteine (α-amino-β-thiopropionic acid)
   3) alanine (α-aminopropionic acid)
   4) aspartic (aminoyantaric acid)
   5) valine (α-aminoisovaleric acid)
7. What is the formula of glycine (aminoacetic acid)?
   1) CH3 – CH(NH2) – COOH.
   2) NH2 – CH2 – CH2 – OH.
   3) NH2 – CH2 – CH2 – COOH.
   4) CH3 – CHOH – CH2 – NH2.
   5) NH2 – CH2 – COOH.
8. What substance belongs to monosaccharides?
   1) ribose
   2) sucrose
   3) fructose
   4) galactose

5) starch

9. What substances are formed during the hydrolysis of maltose?
   1) glucose and galactose
   2) glucose and mannose
   3) galactose and fructose
   4) 2 glucose molecules
   5) glucose and fructose
10. What substance is the coenzyme HAD+ derived from?
   1) piperidine
   2) pyridazine
   3) nicotinamide
   4) adenine
   5) thymidine

Methodological instructions for the implementation of independent work on the discipline
Methodical recommendations for drawing up lecture notes and materials in preparation for practical classes.

The abstract is a coherent, concise exposition of the most important, the main one in the material under study. Abstract - the result of logical analysis of the text; attention is focused on the most significant, in brief generalized formulations the key semantic provisions of the normative document are given. These important semantic provisions are the basic system-forming thoughts, ideas, explanations, justifications, requirements, etc., which form the semantic nucleus of the normative document, expressed in the form of brief provisions, - theses. Theses formulate in abstract expressions (in the form of affirmation, inference, denial), and in each situation contains one thought. Each statement should be short, capacious and justified. Correctly compiled theses follow one another. Do not seek consider in the thesis solution to the problem: abstracts - this is an analytical work on the selected topic.
Outlining, as a kind of cognitive activity: - promotes a deep understanding and a solid mastering of the studied material;
- helps to develop skills and competencies in correct, literate presentation of written theoretical and practical questions;
- Forms the ability to clearly articulate other people's thoughts in their own words;
- Teaches you how to process any information, giving it a different appearance, type, shape;
- Forms the ability to create a model (conceptual or structural) of the object of study (problem, research, documentary source).
The main requirements for writing a summary: the systematic and logical nature of the presentation of the material, brevity, persuasiveness and evidence. When drawing up a summary it is necessary to avoid verbosity, excessive citations, the desire to preserve the systematic feature of the text to the detriment of its logic.
General algorithm for note-taking.
1. Read the text, mark in it new words, incomprehensible places, names, dates; make a list of the main thoughts contained in the text, and a simple plan that will help group the material in accordance with the logic of the presentation.
2. Look in the dictionary of the meaning of new incomprehensible words, write them into a notebook or dictionary at the end of the notebook.
3. Secondarily read the text, simultaneously write down the main thoughts of the author. Recording is in your own words. It is important to strive for brevity, to use the rules for writing text.
4. Read the abstract again, finalize it.

Criteria for the evaluation of the abstract.

Assessment	Criteria
"Excellent"	- the logic of presentation of the subject matter is observed; - the material is presented in full; - Key points of the issue are highlighted; - the material is presented in a clear language; - formulas are written clearly and with explanations; - schemes, tables, graphs, figures are provided with explanations, executed in accordance with the requirements; - all necessary explanations are given to them; - examples are given that illustrate the key points of the topic.
"Good" - "Satisfactory"	- non-compliance with the literary style of presentation, - the vagueness and vagueness of the presentation, - illustrative examples are not presented in full.
"Unsatisfactory"	- the abstract is made carelessly and illiterately, - there are violations of the logic of the presentation of the topic material, - no illustrative examples are given, - Key points of the topic are not highlighted.

Methodical recommendations for the performance of laboratory works.

The student must come to the laboratory prepared. Each lesson is preceded by the student's self-study, which includes:
a) acquaintance with the content of laboratory work on a methodical manual;
b) the development of the theoretical part of the textbooks recommended in the guidelines;
Methodical instructions for laboratory work are just the basis for the experiment. Theoretical preparation for laboratory work should be done with the help of educational literature.
In the course of laboratory studies, there are three parts:
The first is the preparation of practical work and its beginning.
The second is the work.
The third is summarizing the work, its analysis and evaluation.
Registration of work is the last, final stage of it. The design allows you to recall once again the whole course of the work done, to repeat the necessary material, to evaluate what has been done, to analyze the quality of mastering knowledge, skills and skills and to outline a program for their further improvement. The order of performance of laboratory works.
1. The student must come to a laboratory class prepared for this topic.
2. The student must know the safety rules when working in a chemical laboratory and when working with reagents in this work.
3. After the work, the student submits a written report.
4. Report on the work done should be carried out in a general notebook for laboratory work in the cage. The content of the report is indicated in the description of the laboratory work.
5. The student must familiarize himself with the description of devices, the list of dishes and reagents and the order of performance of work before performing the work.
6. Run the experiment.
7. Put the workplace in order.
8. Write a report on the work.

Requirements for registration of reports

1. The number and title of the work should be indicated.
2. The purpose of the work is indicated.
3. The number and name of the experiment are recorded.
4. A short description of the progress of work is indicated, indicating the conditions for conducting the experiment.
5. Observations and reaction equations are recorded.
6. Conclusions are drawn.
Based on the results of the protection of laboratory work, a test is set.

General requirements for the successful conduct of laboratory classes are as follows:

- basic theoretical positions must be learned clearly and deeply, otherwise laboratory and practical exercises will be of little use;
-During the laboratory-practical work, you should act in accordance with the task;
-You should learn the culture of recording experience, experiment, remembering that this will have to teach others;
-it is necessary to develop a habit of exemplary organization of the workplace - this affects the success of the work;
- it is necessary to develop a habit of careful attitude to laboratory equipment.
-You should train yourself according to the results of the laboratory-practical
work, while fresh in the memory of its content, read theoretical material. This will be a good condition for preparing for exams and developing the necessary professional skills.

Criteria for assessing the performance of laboratory work.

Assessment	Criteria
"Excellent"	1. The work was done in full with the observance of necessary sequence of experiments. 2. All experiments were carried out under conditions and regimes providing obtaining results and conclusions with the greatest accuracy. 3. Scientifically correct, logically described observations and formed conclusions from experience. In the presented report correctly and accurately all records, tables, figures, graphs, reaction equations, calculations and conclusions. 4. Organizational and labor skills are shown. Experiment is carried out according to the plan taking into account safety precautions and rules work with materials and equipment.
"Good"	1. The experiment was carried out under conditions that did not provide sufficient accuracy of measurements. 2. There were two or three sub-accounts or more than one gross error and one shortcoming. 3. The experiment was not carried out completely or in the description of observations from experience or the formulation of reaction equations, there are inaccuracies, conclusions are made incomplete.
"Satisfied	1. The work is done correctly by at least half, but The volume of the executed part is such that it allows to receive correct Results and conclusions on the main, fundamentally important tasks work. 2. Work on the beginning of the experiment was conducted with the help of a teacher; or in the course of the experiment and measurements, the formulation of reaction equations mistakes were made in the description of observations, in the formulation of conclusions. 3. Allows a gross error in the course of the experiment (in explanation, in registration of work, in observance of safety rules at work with materials and equipment), which is corrected by requirement of the teacher.
"Unsatisfactory''	1. I did not complete the work and the amount of work done was not allows you to make the right conclusions. 2. Experiments, measurements, calculations, observations, formulation of equations reactions were not performed correctly. 3. During the work and in the report, all The shortcomings noted in the requirements for the assessment of "3" 4. Allows two or more gross errors during the experiment, in explanation, in the design, work, in compliance with the rules of technology safety when working with substances and equipment that are not can correct even at the request of the teacher.