MINISTRY OF EDUCATION AND SCIENCE OF THE KYRGYZ REPUBLIC

Government-run Educational Institution of Higher professional Education

Kyrgyz- Russian Slavic University named after B.N. Yeltsin

School of Medicine

ENDORSED BY
Dean faculty
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11 ____ 11 2024

# Chemistry

Course outline (Module)

Assigned to

Academic Curriculum 560001 - KR General medicine

Qualification Specialist

Mode of study Intramural

## Course hours scheduling (per semester)

| Semester Academic year | 1 (1.1) | | 2 (1.2.) | | Total | |
|---|---|---|---|---|---|---|
| weeks | 12 | | | | | |
| Type of training | AC | CO | AC | CO | AC | CO |
| Lectures | 8 | 8 | | | 8 | 8 |
| Lab practical | 24 | 24 | | | 24 | 24 |
| Contact work during the period of theoretical training | 0,3 | 0,3 | | | 0,3 | 0,3 |
| Including interactive | 4 | 4 | | | 4 | 4 |
| Total in-class session | 32 | 32 | | | 32 | 32 |
| Face-to face leaning | 32,3 | 32,3 | | | 32,3 | 32,3 |
| Individual work | 31,7 | 31,7 | | | 31,7 | 31,7 |
| Total | 64 | 64 | | | 64 | 64 |

The Course outline developed by:

Abdurashitova J.A., associate professor, CCS and Ibraeva I.G., associate professor, CMS

Reviewers:

*Internal:* Karaeva R.R., CBS, associate professor, the Head of Physics, Health informatics and Biology Department of KRSU named after B.N. Yeltsin

*External:* Dusheyeva B.M., CCS, associate professor of Biochemistry with the course of general and bioorganic chemistry Department of KSMA named after I.K. Akhunbaev

The Course Outline Chemistry
Developed in full compliance with:

Federal State Education Standards of Higher Professional Education for students trained for specialty 560001 General Medicine (The Ministry of Education and Science of the Kyrgyz Republic Order of 30.07.2021. № 1357/1)

in accordance with Academic Curriculum:
560001-KR General Medicine
Confirmed by KRSU Board of Academics in 29.10.2024 record №4

The Course Outline endorsed by Chemistry and Biochemistry Department Meeting

Record of 25.10.2024 record № 2

Valid for: 2023-2028 academic years

The Head of Chemistry and Biochemistry Department

Matyushchenko N.S., associate professor, CBS

**The Course outline endorsed for the following academic year**

Chairman of the Educational and Methodological Board

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The course outline has been revised, considered and endorsed for implementation in 2023-2024 Academic Year at the Staff Meeting of **Chemistry and Biochemistry** Department

Record of _____ _____20____ №__
The Head of Department Matushenko N.S., associate professor, CBC

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**The Course outline endorsed for the following academic year**

Chairman of the Educational and Methodological Board
_____20_____

The course outline has been revised, considered and endorsed for implementation in 2024-2025 Academic Year at the Staff Meeting of **Chemistry and Biochemistry** Department

Record of _____ _____20_____ №
The Head of Department Matushenko N.S., associate professor, CBC

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**The Course outline endorsed for the following academic year**

Chairman of the Educational and Methodological Board
_____20_____

The course outline has been revised, considered and endorsed for implementation in 2025-2026 Academic Year at the Staff Meeting of **Chemistry and Biochemistry** Department

Record of _____ _____20___ №____
The Head of Department Matushenko N.S., associate professor, CBC

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**The Course outline endorsed for the following academic year**

Chairman of the Educational and Methodological Board
_____20_____

The course outline has been revised, considered and endorsed for implementation in 2026-2027 Academic Year at the Staff Meeting of **Chemistry and Biochemistry** Department

Record of _____ _____20_____№_
The Head of Department Matushenko N.S., associate professor, CBC

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## 1. COURSE OUTLINE OBJECTIVES

- to acquire knowledge related to the structure, properties and mechanism of functioning of biologically active substances;
- to establish a solid foundation for studying such disciplines as biological chemistry, microbiology, physiology, pathological physiology;
- to form scientific vision of basic physical and chemical regularities in the behavior of biochemical processes;
- to develop integral perception of chemistry which allows to understand functioning of the organism as a whole and its interaction with the environment.

## 2. PLACE OF THE COURSE IN THE EDUCATIONAL PROGRAM

Educational Program Units: B1.B

### 2.1. Students' Preliminary Training Requirements:

2.1.1. Mathematics

2.1.2. Biology

2.1.3. Chemistry

### 2.2. Course Units and Practical Sessions imposing the prior Proficiency

2.2.1. Biochemistry

2.2.2. Normal physiology

2.2.3. Pharmacology

2.2.4. Clinical biochemistry

## 3. STUDENTS' COMPETENCIES RESULTING FROM THE COURSE UNIT (MODULE)

**GS (1).** Able to analyze socially significant problems and processes and use in practice methods of natural-scientific, mathematical and humanitarian sciences in various types of professional and social activities.

**Knowledge:**

*Level 1.*

- methodology of processing scientific and technical information to solve standard tasks of professional activity;
- basic laws of physical, chemical and biochemical concepts, information and communication technologies, including physical, mathematical concepts and research methods for solving professional tasks.

**Skills:**

*Level 1.*

- to use medical and biological terminology, information and communication technologies, and research methods to solve standard tasks of professional activity;
- to apply basic physical and chemical concepts and research methods to solve professional tasks;
- to search for scientific and technical information using general and specialized databases and apply specialized software when carrying out theoretical calculations and processing experimental data to solve standard tasks of professional activity;

**Expertise:**

*Level 1.*

- skills of working with scientific and educational portals;
- basic skills of using standard as well as specialized software and databases for statistical processing of research results and their presentation to the scientific community;
- biomedical and other terminology;
- elementary techniques of work in the biochemical laboratory;
- general safety regulations for handling computers, laboratory equipment and chemical reagents;
- skills of mathematical, chemical and biochemical thinking;
- skills of independent work with reference books, educational and scientific literature.

3. **Final Students' Competences**

**3.1. Knowledge:**

- general patterns of natural sciences;
- general physical chemical concepts, laws and methods of analysis.

**3.2. Skills:**

3.2.1.

- to apply basic concepts of natural scientific disciplines;
- to predict the progress of biochemical processes occurring in living organisms;
- to interpret the obtained results at the modern level.

**3.3. Expertise:**

-the knowledge of the basic principles of the natural sciences, experimental skills for studying and analysis of biochemical processes.

## 4. COURSE (MODULE) STRUCTURE AND CONTENT

| Class code | Subject Name /Type of Class/ | Semes-ter / Acade-mic year | Hours | Competencies | *Literature* | Notes |
|---|---|---|---|---|---|---|
| | **Section 1. General chemistry** | 1 | 2 | **GS (1)** | | |
| 1.1. | *Introduction to fundamental concepts of chemistry. Solutions* **/lec/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 2.1 | |
| 1.2. | *Colligative properties of solutions* **/lec/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 2.1 | |
| 1.3. | *Equilibrium in aqueous solutions Buffer solutions* **/lec/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 2.1 | |
| 1.4. | *Complex compounds* **/lec/** | 1 | 2 | **GS (1)** | L 1.10<br>L 1.11<br>L 2.2 | |
| 1.5. | **Introduction to the subject of general chemistry. Safety regulations in a chemical laboratory. Solutions.** Types of solutions: intermolecular forces and solubility. Liquid, solid and gaseous solutions. Water balance of the body. Water and electrolyte management: electrolyte composition. Effect of temperature and pressure on solubility. Application of solutions in medicine **/pr/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.1 | |
| 1.6. | **Colligative properties of solutions.** Nonvolatile nonelectrolyte solutions. Osmosis, iso-, hypo-, hypertonic solutions **/pr/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.7 | **Equilibrium in aqueous solutions.** Strong and week electrolytes. Acids and bases. Concept of pH. Importance of pH homeostasis in body fluids. Methods for pH measurement and biological significance. pH of various selected body fluids (blood plasma, saliva, gastric juice, urine, bile, cerebrospinal fluid). Hydrolysis of salts. Biological meaning of hydrolysis **/pr/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.1 | |
| 1.8. | **Acid-base balance of the organism and buffer systems.** Mechanism of buffer systems function. Acid-base balance in a human organism. Bicarbonate buffer, acidosis and alkalosis. Hemoglobin buffer – the role in gas exchange in the lungs. Globular proteins as buffers. Phosphate buffer – the role in kidneys' reabsorption. Henderson-Hasselbalch equation. Buffer capacity. Biological meaning of buffers **/pr/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.1 | |
| 1.9 | **Qualitative chemical analysis. Methods and techniques.** Test reactions for ions of s, p, d, elements **/pr/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12 | 4 |
| 1.10 | Biogenic elements classification. Micro-, macro- and trace elements of the body. Intake and demands. Toxic elements **/individual work/** | 1 | 4 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.8 | |
| 1.11. | Methods of quantitative analysis. Overviewing quantitative drug analysis in terms of the technics, reagents, apparatus, and handling of analytical data. Volumetric analysis. Acid-base titration **/individual work /** | 1 | 4 | **GS (1)** | L 2.3<br>L 2.8<br>L 1.12 | |
| 1.12 | Biological role, application of alkali metal and alkali earth compounds in medicine **/individual work /** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.13<br>L 2.8 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.13 | P-block elements and their compounds. Biological role, application of their compounds in medicine **/individual work /** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.8 | |
| 1.14 | D-block elements and their compounds. Biological significant **/individual work/** | 1 | 3 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.8 | |
| 1.15 | Chemical redox processes. Biological oxidation **/individual work/** | 1 | 2 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12 | |
| 1.16 | Complex compounds. Chelate compounds. Biological significant. Complex nature of hemoglobin, cyanocobalamin and their analogs. Participation in metabolic processes. Application of complex compounds in medicine **/individual work/** | 1 | 3 | **GS (1)** | L 1.3<br>L 1.4<br>L 1.6<br>L 1.8<br>L 1.9<br>L 1.12<br>L 2.1<br>L 2.3 | |
| | **Section 2. Bioorganic chemistry** | | | **GS (1)** | | |
| 2.1 | **Introduction to bioorganic chemistry.** Carboxylic acids and their derivatives **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.2 | **Lipids. Phospholipids.** Properties of the storage and biological membranes lipids. The role of unsaturated fatty acids and cholesterol for biological membrane fluidity and formation of lipid rafts **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.3 | **Carbohydrates.** Properties and classification of sugars. Monosaccharides: structure, properties. Biological significant **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4 | |
| 2.4 | **Carbohydrates.** Oligosaccharides of human milk and their immunomodulating significance. Disaccharides. Reducing and nonreducing sugars.<br>Polysaccharides as dietary fiber – the significance of their structure for a healthy microbiome. Structure of a disaccharide fragment. Heparin and hyaluronic acid – examples of functional glycosaminoglycans **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.5 | **α-Amino acids.** α-Amino acids: substrates for protein synthesis. Overview of amino acids present in proteins, ionic properties, significance of side chains for protein properties. Biogenic amines as biologically active compounds. Stereochemistry of amino acids. Amphoteric properties and amino acids chemical reactivity **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.6 | **Peptides and proteins.** Biologically active peptides: glutathione and peptide hormones-oxytocin, vasopressin, insulin, glucagon - their biological function. Protein general structure. Organization levels: primary, secondary, tertiary and quaternary structure. Chemical bonds and forces involved in maintaining protein spatial arrangement. Structural classes of proteins: contribution of α and β-structures. Globular proteins: properties and solubility. Fibrous proteins: collagen, keratin, elastin, silk fibroin – association of structure and function. Membrane proteins: ways of association with the membrane **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.7 | **Nucleic acids.** Structural components of nucleic acids. Nucleic bases. Purine (adenine and guanine) and pyrimidine derivatives (cytosine, thymine, uracil). Nucleosides and nucleotides. Nucleic acids. RNA and DNA: structure, biological significance **/pr/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.8 | Structure of a carbon atom. Orbital hybridization ($sp^3$, $sp^2$, sp). σ-, π-bonds, bond lengths, bond strengths, and bond angles. Functional groups. The ways of covalent bond cleavage. Radicals, electrophiles, nucleophiles. Inductive and mesomeric effects. π,π- and p,π-conjugation. **/individual work/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.16 | Reactivity of saturated and unsaturated hydrocarbons. General mechanism of $S_R$ and $A_E$. Cyclic conjugated systems. Benzene and its derivatives. General mechanism of $S_E$ **/individual work/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.17 | Carbonyl compounds. Aldehydes and ketones. Nucleophilic addition reactions $A_E$ **/individual work /** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4 | |
| 2.18 | Space structure of organic molecules **/individual work /** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4 | |
| 2.19 | **Reactivity and biological significance of heterofunctional compounds.** Some representatives of oxy acids: glycolic, lactic, oxybutyric, malonic, tartaric, citric, succinic acids. Aldehydes and ketoacids **/individual work/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4<br>L 2.7 | |
| 2.20 | **Biologically important heterocycles with one and two heteroatoms.** Five- and six - membered ring heterocycles and their derivatives **/individual work/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.21 | Natural biologically active substances **/individual work/** | 1 | 2 | **GS (1)** | L 1.1<br>L 1.3<br>L 1.4<br>L 1.7<br>L 1.12<br>L 2.4 | |
| 2.19 | Credit | 1 | 0 | | | |

## 5. **ASSESSMENT FUND**

### 5.1. Advancement Questions and Assignments.

***Questions to check students' competence*** **knowledge:**

- Classification of solutions. The role of water and solutions in the body. Physical and chemical properties of water.
- Dependence of substance solubility in water on the ratio of hydrophilic and hydrophobic properties. Effect of external conditions on solubility. Thermodynamics of solubility.
- Solubility of gases in liquids. Henry's law, its medical and biological importance.
- Solubility of liquids and solids in liquids.
- Ways of expressing the concentration of solutions (mass fraction, molarity, molality, molar concentration of the equivalent, titer, normality).
- Biological significance of solutions.
- Diffusion in solutions. Osmosis. Osmotic pressure. Van't Hoff law.
- Measuring osmotic pressure. Osmometry. The role of osmosis and osmotic pressure in biological systems.
- Osmotic homeostasis. Isotonic, hypotonic and hypertonic solutions. Raoult's law. Consequences of Raoult's law.
- Deviation of properties of dilute electrolyte solutions according to Raoult's and Van't Hoff laws. Isotonic coefficient.
- Concepts of quantitative analysis.
- Classification of quantitative methods of analysis.
- Classification of volumetric analysis methods (neutralization, oxidation-reduction, precipitation, complex formation).
- Basics of the volumetric analysis. Measuring vessels. Volumetric analysis technique. The law of equivalent.
- Acid-base method of measure analysis. (Neutralization method).
- Theoretical grounds of neutralization method.
- Ways of calculating normality and titer of solutions.
- Volumetric analysis using potassium permanganate as a standard solution.

- Methods of oxidation-reduction titration.
- Volumetric analysis using potassium permanganate as a standard solution.
- Oxidation-reduction reactions in the body.
- Acid-base concepts. Arrhenius theory of acids and bases. Brønsted-Lowry theory of acids and bases. Conjugate acids and bases.
- Acid-base properties of water. The ion product of water (self-ionization).
- pH: a measurement scale for acids and bases. Definition of pH. Measuring, calculating pH. The importance of pH and pH control.
- Acid and base strength. Strong and weak acids. Strong and weak bases.
- Weak acids and acid ionization constants. Weak bases and base ionization constants.
- Reactions between acids and bases. Neutralization.
- Salt hydrolysis. Types of salt hydrolysis. ATP hydrolysis. Role of hydrolysis in chemical and biochemical processes.
- Acidic-basic buffer solutions. The value of buffer solutions in chemistry, biology, medicine.
- Chemical composition of buffer systems. Acidic, basic, amphoteric buffer systems.
- Preparation of buffer solutions. Buffer curves. Henderson-Hasselbalch equations.
- Buffer system action after the addition of acid or base.
- Blood buffer systems. Buffer action as the main mechanism of protolytic homeostasis of an organism.
- Buffer capacity: dependence on various factors, methods of determination.
- Structure of a carbon atom. Orbital hybridization ($sp^3$, $sp^2$, sp). σ-, π- bonds: bond lengths, bond strengths, and bond angles.
- The ways of demolishing covalent bonds. Radicals, electrophiles, nucleophiles.
- Mutual influence of atoms in the molecules of organic substances. Inductive electron donation, inductive electron withdrawal (+I, -I). Mesomeric effect (+M, -M).
- Conjugation. π,π- and p,π-conjugation.
- Reactivity of hydrocarbons: saturated, unsaturated and aromatic. Radical substitution reactions ($S_R$). Electrophilic addition reactions ($A_E$). Electrophilic substitution reactions ($S_E$).
- Acidic-basic properties of organic compounds. Brønsted acids and bases.
- Comparative characteristic of acidic-basic properties of organic compounds. Acidic-basic properties of alcohols, phenols, thiols, amines, carboxylic acid. Properties of mono- and polyatomic alcohols.
- General characteristic of carboxylic acids. Classification, nomenclature, isomerism.
- Structure and physical properties of carboxylic acids. The structure of a carboxylic group.

- Representatives of carboxylic acids:

  a) formic, acetic, propionic, butyric, valeric, caproic acids;

  b) oxalic, malonic, succinic acids;

  c) acrylic acid and its derivatives, crotonic, fumaric, maleic acids;

  e) benzoic, phtalic acids.
- Reactions involving carboxylic acids. Acid-base reactions. Salt formation.
- General mechanism of nucleophilic acyl substitution reactions ($S_N$). Formation of acyl halides, acid anhydrides, esters, and amides. Ester hydrolysis.
- Aromatic carboxylic acid derivatives.
- Chemical properties of dicarboxylic and aromatic carboxylic acids. Application of carboxylic acids in medicine.
- Lipids. Classification. Biological functions of lipids.
- Simple lipids: fats, oils, waxes. Structure and composition.
- Fatty acids. Common saturated and unsaturated fatty acids. Structure and properties.
- Chemical reactions of fatty acids. Reactions at the double bond (unsaturated fatty acids).
- Chemical properties of triglycerides. Hydrolysis and addition reactions. Oxidation of lipids.
- Complex lipids. Phospholipids and glycolipids. General characteristic, classification, chemical properties and biological functions.
- Heterofunctional derivatives of benzene series.
- Analgetics on the basis of p-aminophenol: phenetidine, phenacetinum, paracetamol.
- Salicylic acid and its derivatives: sodium salicylate, phenylsalicylate, acetylcalicylate (aspirine), p-aminocalycylic acid (PAS-acid).
- Para-aminobenzoic acid and its derivatives with local anesthetic action: anaesthesin (benzocaine), novocaine.
- Sulfanilic acid, streptocide. Sulfonylamide drugs - etazolum, sulfapyridazinum, sulfadimethoxine.
- Heterocyclic compounds. Classification. Major classes of heterocyclic compounds. Biological role.
- Five- and six-membered ring heterocycles.
- Five-membered ring compounds with one heteroatom: pyrrolidine, pyrrole, tetrahydrofuran, furan, tetrahydrothiophene, thiohene.
- Five-membered ring compounds containing two heteroatoms: imidazolidine, pyrazolidine, imidazole, pyrazole, oxazolidine, isoxazolidine, oxazole, isoxazole.
- Six-membered ring compounds with a single heteroatom: piperidine, pyridine, tetrahydropyran, pyran.

- Six-membered ring compounds with two heteroatoms: piperazine, oxazine, morpholine, oxazine.
- Some representatives of heterocyclic compounds: indole, benzofuran, benzothiophene, tryptophan, proline, porphyrin ring system, heme.
- Benzopirrol (indole) and its derivatives - tryptophane, tryptamine, serotonin, skatole.
- Azoles - pyrazole, imidazole, thiazol. Compounds containing an imidazole ring: histidine, histamine.
- Pyrazolone (pyrazyl ketone) and its derivatives: antipyrine, amidopyrinum, analgin, butadion.
- Six-membered heterocycles with one or two nitrogen atoms. Pyridine, quinoline. Nicotinic acid and its amide (vitamin PP).
- Pyrimidine, its oxy-and amine derivatives. Barbituric acid. Tautomeric forms of barbituric acid. Barbiturates, application in medicine.
- Condensed heterocycles. Purine and its oxy- and amino derivatives: adenine, guanine, xanthine, uric acid. Examples of common methylated purines: caffeine, theobromine, theophylline.
- Types of carbohydrates. Biological role.
- Monosaccharides. Classification: aldoses, ketoses, pentoses, hexoses. Some representatives: ribose, deoxyribose, xylose, glucose, mannose, galactose, fructose.
- Stereoisomerism. Stereoisomers. Stereoisomerism of monosaccharides. Fischer projections. Anomers. The D- and L-system of nomenclature.
- Cyclic structure of monosaccharides: hemiacetal formation. Cyclo-oxo tautomerism. Haworth projections. Anomers.
- Reactions of monosaccharides:
  a) ester and ether formation; b) glycoside formation;
  c) reduction of monosaccharides; d) oxidation of monosaccharides.
- Derivatives of monosaccharides. Deoxy sugars, amino sugars, neuraminic and sialic acid.
- Biologically important monosaccharides and their biological functions.
- Biologically important disaccharides. Classification, composition, structure. Type of glycosidic linkage: α-1,4 and β-1,4.
- Reducing disaccharides: maltose, cellobiose, lactose. Chemical properties.
- Nonreducing sugars: sucrose. Chemical properties. Hydrolysis of sucrose. Inversion of sugar cane.
- Polysacharides. Classification. Biological role.
- Gomopolysaccharides: starch, glycogen, cellulose, dextranes. Composition, structure, chemical properties, hydrolysis reactions.

- Heteropolysaccharides: hyaluronic acid, heparin, chondroitin sulfate, their composition, biological significance.
- The concept of mixed carbohydrate containing biopolymers. Glycoproteins.
- Structure of α-amino acids. Nomenclature, isomerism. Biological role, application in medicine.
- Classification of biogenic amino acids according to the acid-base properties and nature of the radical.
- Configuration of natural amino acids.
- Amino acids as dipolar ions. Isoelectric point (pI) of aminoacids.
- Reactions of amino acids.
- Reactions of carboxylic group: esterification, reactions with phosphorus halogenides ($PCl_5$, $PCl_3$).
- Reactions of amino group: reactions with formaldehyde, nitrous acid, acetic anhydride.
- Amphoteric properties of amino acids. Acid-base properties of amino acids. Types of salts.
- Biologically important reactions of amino acids: deamination, decarboxylation, transamination.
- Qualitative analysis of α-amino acids and their role in the diagnosis.
- Peptides and proteins. Composition and amino acid sequence. Electronic and spatial structure of peptide bond.
- Classification, properties and biological functions of proteins. Fibrous proteins. Collagen, α-keratins, myosin. β-pleated sheet. Silk fibroin. Globular proteins.
- Dipeptides, tripeptides. Some representatives. Biological role.
- Insulin, vasopressin, oxytocin: their composition, structure, biological role.
- Levels of protein structural organization: primary, secondary (α-helix), tertiary, quaternary. Bond types.
- Denaturation of proteins (temperature, pH, organic solvents, detergents, heavy metals, mechanical stress).
- Structure and biological functions of myoglobin and hemoglobin.
- Dietary protein and protein digestion.
- Structural components of nucleic acids. Nucleic bases. Purine derivatives (adenine and guanine) and pyrimidine derivatives (cytosine, thymine, uracil). Lactime-lactame tautomeric forms.
- Nucleosides: definition, structure, types of linkages, nomenclature, properties. Ribonucleosides and deoxyribonucleosides. Hydrolysis.
- Nucleotides: definition, structure, types of linkages, nomenclature, properties. Ribonucleotides and deoxyribonucleotides. Hydrolysis.

- RNA and DNA: structure, types of linkages, nomenclature, properties. Complementary pairs. Biological significance of nucleic acids.
- DNA structure: The Double Helix.

*Questions to check students' competences:* **skills and expertise:**

**Skills:**

-knowledge of fundamental basis of natural sciences;

-knowledge of chemical laws and theoretical basis of chemistry;

-methods of scientific thinking and ability to percept information;

-general principles of solving standard and complex problems;

-regularities of the occurrence of chemical reactions;

-theoretical basis for different methods of quantitative and qualitative analysis;

- technology of performing laboratory works;

-skills for weighing and measuring;

-skills to prepare solution of a given concentration;

-skills for research work;

-methods of mathematical, physical chemical analysis and model operation.

**Expertise:**

-to use fundamental laws of chemistry and analyze different chemical processes occurring in living organisms;

-to conduct a search for scientific and technical information;

-to systematize and generalize the obtained information;

-to work out equations of chemical reactions and predict possibility and direction of chemical processes;

-to use the laws of chemistry and natural sciences to acquire professional skills;

-to use scientific information, experimental results and professional knowledge taking part in different conferences, debates and competitions.

### 5.2. Course Papers Themes

Discipline doesn't involve writing a term paper (course work).

### 5.3. List of Assessment Tools

**LABORATORY WORK**. List of laboratory works.

**TOPIC: «Introduction to general chemistry. Safety regulations in a chemical laboratory. Solutions»**

-Preparation of solutions with sodium chloride of a given mass percentage concentration.

-Preparation of solutions of a given concentration from a fixed weight (from a fixanal).

-Preparation of a standard solution from an initial substance with a given weight.

**TOPIC: «Colligative properties of electrolyte and nonelectrolyte solutions»**

- The growth of Traube "Artificial cell"
- Changing the state of red blood cells in sodium chloride solutions of different mass percentage concentrations.

**TOPIC: «Methods of quantitative analysis»**

- Determination of normality and titer of acid solution ($H_2SO_4$) by the titrant of alkali ($Na_2B_4O_7$).
- Determination of normality and titer of potassium permanganate solution by a standard solution of oxalic acid.
- Determination of general hardness of water by complexometry.

**TOPIC: «Methods of qualitative chemical analysis»**

*Test-reactions for s-elements.*

-Test - reactions for $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Ba^{2+}$- ions.

*Test-reactions for p-elements.*

-Test - reactions for $Al^{3+}$, ($HPO_4^{2-}$), $NO_3^-$, $Cl^-$, $Br^-$, $I^-$, $B_4O_7^{2-}$-ions.

*Test-reactions for d-elements.*

- Test - reactions for $Cu^{2+}$, $Ag^+$, $Zn^{2+}$, $Cr^{3+}$, $Fe^{2+}$, $Co^{2+}$, $Ni^{2+}$ -ions.

**TOPIC: «Properties of acids and bases»**

- Salt hydrolysis. Determining the pH of the salt solutions.
- Effect of temperature on hydrolysis.
- Complete hydrolysis.

**TOPIC: «Buffer solutions and their properties. Buffer systems of the body»**

- Determination of the buffer solution action.
- Preparing buffer solutions and studying their action.
- Determination of buffer capacity of blood serum.

**TOPIC: «Carboxylic acids and their derivatives»**

-Formation and hydrolysis of iron (III) acetate.

-Formation of insoluble calcium salts of fatty acids.

-Calcium oxalate formation.

-Ethyl acetate preparation.

**TOPIC: «Lipids and their functions in biochemical systems»**

-Chemical properties of saponifiable lipids:

-Oxidation reaction.

-Formation of insoluble fatty acids of calcium salts.

-The solubility of fats.

-Test with bromine water.

-Test with potassium permanganate.

-Hydrolysis of fats and oils.

**TOPIC: «Carbohydrates. Monosaccharides»**

-Evidence for the presence of hydroxyl groups in monosaccharides.

- Reduction of copper (II) hydroxide with glucose in alkaline medium. (Trommer's test).

-The Tollens' silver mirror test.

-Test-reaction on hexoses (Selivanov's reaction for fructose).

**TOPIC: «Carbohydrates. Disaccharides and polysaccharides»**

-Demonstration of sucrose non-reducing ability

-Hydrolysis of sucrose.

-Reducing ability of lactose.

-Test-reactions on starch with iodine.

-Hydrolysis of starch.

**TOPIC: «Structure and reactivity of α-amino acids»**

-Interaction of glycine with ninhydrin (ninhydrin test).

-Interaction of glycine with formaldehyde.

-Interaction of glycine with nitrous acid.

-Reaction of glycine with copper (II) carbonate.

-Amphoteric properties of α-amino acids.

**TOPIC: «Peptides and proteins»**

-The Biuret test for peptide bonds.

-Xanthoproteic reaction.

-Foll's reaction.

-Protein settling.

**TOPIC: «Nucleic acids»**

-Benedict's reaction of carbohydrate skeleton detection.

-Hydrolysis of nucleoproteins.

-Molybdenic probe for detection of phosphoric acid residue.

-Detection of purine bases.

**PROJECT. Themes of projects.**

-Circulation of biogenic elements in nature.

-Classification of biogenic elements.

-The most important compounds, containing potassium and sodium. Biological action of $K^+$ and $Na^+$-ions.

-Lithium and beryllium. Their structures, properties and biological role.

-Major compounds, containing Ca, Mg and Ba. Their biological role.

-Application of alkali metal compounds and alkali earth compounds in medicine.

- Major compounds, containing boron and aluminum (boric acid and borax). Their properties and biological action.

-Major compounds containing carbon, silica, tin and lead. Their biological action. Toxicity of lead.

-The biological role of oxygen and sulfur. Application of oxygen and ozone in medicine

-Major compounds containing Cu, Ag, Au, Zn, Hg. Their biological action. Toxicity of these metals. Application of copper, silver, gold, zinc and mercury containing compounds in medicine.

***Heterofunctional derivatives of benzene series.***

-Analgetics on the basis of p-aminophenol: phenetidine, phenacetinum, paracetamol.

-Salicylic acid and its derivatives: sodium salicylate, phenylsalicylate, acetylcalicylate (aspirine), p-aminocalycylic acid (PAS-acid).

-Para-aminobenzoic acid and its derivatives with local anesthetic action: anaesthesin (benzocaine), novocaine.

-Sulfanilic acid, streptocide. Sulfonylamide drugs - etazolum, sulfapyridazinum, sulfadimethoxine.

-Five-membered ring compounds containing two heteroatoms: imidazolidine, pyrazolidine, imidazole, pyrazole, oxazolidine, isoxazolidine, oxazole, isoxazole.

-Six-membered ring compounds with a single heteroatom: piperidine, pyridine, tetrahydropyran, pyran.

-Six-membered ring compounds with two heteroatoms: piperazine, oxazine, morpholine, oxazine.

-Some representatives of heterocyclic compounds: indole, benzofuran, benzothiophene, tryptophan, proline, porphyrin ring system, heme.

-Benzopirrol (indole) and its derivatives - tryptophane, tryptamine, serotonin, skatole.

-Azoles - pyrazole, imidazole, thiazol. Compounds containing an imidazole ring: histidine, histamine.

-Pyrazolone (pyrazyl ketone) and its derivatives: antipyrine, amidopyrinum, analgin, butadion.

-Six-membered heterocycles with one or two nitrogen atoms. Pyridine, quinoline. Nicotinic acid and its amide (vitamin PP).

-Pyrimidine, its oxy- and amine derivatives. Barbituric acid. Tautomeric forms of barbituric acid. Barbiturates, application in medicine.

-Condensed heterocycles. Purine and its oxy- and amino derivatives: adenine, guanine,

xanthine, uric acid. Examples of common methylated purines: caffein, theobromine, theophylline.

**CONTROL WORK. List of questions.**

-Solutions. Classification of solutions. The role of water and solutions in the body. Physical and chemical properties of water.

-Ways of expressing the concentration of solutions (mass fraction, molarity, molality, molar concentration of the equivalent, titer, normality).

-Solubility of liquids and solids in liquids.

-Solutions of weak acids or bases. Acid-ionization equilibrium. Acid ionization constant, base-ionization constant.

-Diffusion in solutions. Osmosis. Osmotic pressure. Van't-Hoff law.

-Osmosis. Osmotic homeostasis. Isotonic, hypotonic and hypertonic solutions.

-An aqueous solution is made from 0,798g of potassium permanganate. If the volume of the solution is 50,0 ml, what is the molarity of $KMnO_4$ in the solution?

-Insulin is a hormone that controls the use of glucose in the body. How many moles of insulin are required to make up 28 ml of 0,0048 M insulin solution?

-Calculate the molarity of a sucrose (table sugar, $C_{12}H_{22}O_{11}$) solution that contains 50 g of sucrose per liter.

-Define solutions. Write their classification, general properties of solutions and their application. *Calculate how many grams of $Na_2CO_3$ is contained in 200 ml of solution with concentration 0,1mol/L.*

-The osmotic pressure of blood at $37^0$ C is 7,7 atm. What should the molarity of glucose solution which is isotonic with blood be?

-Solubility of gases in liquids. Henry's law, its medical and biological importance.

-Deviation of properties of dilute electrolyte solutions according to Raoult's and Van't-Hoff laws. Isotonic coefficient.

-Give examples of neutralization reaction.

-Barium chloride (6g) is dissolved in 250 ml of water (density of water is 1g/ml). What is the mass fraction of salt in the obtained solution?

-Give an example of salt, which water solution is alkaline. Write the equation of chemical reactions.

-2 mol potassium sulfate was dissolved in 1000g of water. Calculate the mass fraction of solute.

-What is the boiling point of a solution of 0,150 g of glycerol, $C_3H_8O_3$, in 20,0 g of water? What is the freezing point?

-Arrhenius and Brønsted-Lowry concept of acids and bases. Give examples.

-Write the hydrolysis of $NH_4NO_3$. Is this salt acidic, basic or neutral in aqueous solution?

-Types of buffer solutions. Give the mechanism of action on the example of phosphate buffer.

-Buffer solutions and their properties. Acetate buffer action by adding acid or base.

-Buffer systems of the body. Hydrocarbonate and hemoglobin buffers action by adding acid or base.

-Chemical composition of buffer systems. Acidic, basic, amphoteric buffer systems. Ammonia buffer action.

-Buffer capacity: dependence on various factors, methods of determination.

-Raoult's law. Consequences of Raoult's law. *Urea, $(NH_2)_2CO$, is dissolved in 100,0 g of water. The solution freezes at -0.085C. How many grams of urea were dissolved to make this solution?*

-Write the reactions of hydrolysis of the following salts in the molecular and net ionic forms: $NaNO_2$, $KHCO_3$, $NH_4Cl$ , $CH_3COONa$. Indicate reaction of the environment.

-Self-ionization of water. The pH of a solution. Solutions of strong acids or bases. Degree of electrolytic dissociation.

-Calculate the pH of a $1{,}0\times10^{-3}$ M solution of HCl.

-Name the functional group in each of the following molecules:

a) $CH_3$-$CH_2$-$CH_2$-OH;
b) $CH_3$-$CH_2$-$CH_2$-COH;
c) $CH_3$-$CH_2$-$CH_2$-$COOCH_2CH_3$;
d) $CH_3$-$CH_2$-$CH_2$-$NH_2$;
e) $CH_3$-$CH_2$-$CH_2$-COOH;
f) $CH_3$-$CH_2$-O-$CH_2CH_3$.

Name each of the following using the IUPAC nomenclature system.

-Write the acid-catalyzed ester hydrolysis of ethyl acetate.

-Write the scheme of decarboxylation of acetoacetic acid and give the name of the product.

-Which of the following compounds would be expected to give a positive Tollen's test?

a) 3-pentanone;
b) cyclohexanone;
a) 3-methylbutanal;
d) cyclopentanol;
e) 2,2-dimethyl-1-pentanol;
f) acetaldehyde.

-Aminoalcohols. Structure, properties, biological role. Ethanolamine-colamin. Choline, acetylcholine. Biogenic amines. Noradrenaline, adrenaline.

-Classification of lipids. Describe the differences between fat, oil and waxes. Write the configuration of linoleic acid.

-What is the major structural feature that distinguishes between saturated and unsaturated hydrocarbons?

-Write the scheme of hydrolysis for 1,2-dipalmito-3-oleoglycerol in acidic and basic solutions.

-Oxy- and aminoacids. Structure, nomenclature, isomers. α-, β-, γ-oxy and aminoacids. Chemical properties. Dehydration reactions.

-Composition, structure, properties and biological role of phospholipids. Give the structural formula for lecithin, containing parts of stearic and linolenic acids. What are the products of hydrolysis of this lipid?

-Some representatives of oxy acids: glycolic, lactic, oxybutyric, malonic, tartaric, citric, succinic acids.

-Ethanal is produced by oxidation of ethanol. Where does this reaction occur in the body? Write the equation.

-Saturated and unsaturated fatty acids. Configurational isomers of fatty acids. Write the structural and configurational formulas of fatty acids: palmitic, stearic, oleic, linoleic, linolenic acids.

-Give the scheme of oxidation of D-glucose and D-galactose by the action of mild ($Br_2$) and strong ($HNO_3$) oxidizing agents.

-Classification of disaccharides. The structure of disaccharides, monosaccharide composition. α-1,4 and β-1,4-glycosidic linkage.

-Structure of α-amino acids. Nomenclature, isomerism. Biological role, application in medicine.

-How do ribonucleotides and deoxyribonucleotides differ in structure? Do they form polymers in the same way?

-Write the structural formula for the nucleotide adenosine-5′-monophosphate.

-Draw the following sugars using Haworth projections:

a) β-D-galactopyranose; b) α-D-glucofuranose;

c) α-D-fructofuranose; d) β-D-ribofuranose.

-Reducing and nonreducing sugars. Representatives: maltose, cellobiose, lactose and sucrose.

-Predict the products of the treatment of glycine with:

a) aqueous NaOH; b) aqueous HCl;

c) acetic anhydride; d) $NaNO_2$+HCl; e) $C_2H_5OH + H_2SO_4$.

-Write the structural formulas of two tripeptides formed in the reaction of L-tryptophan, L-glutamic acid, and L-tyrosine. How many tripeptides are possible?

-Write a structural formula for nucleotide deoxyadenosine-5′-monophosphate.

-Write the structures of:

a) penta-O-acetyl-β-D-glucopyranose; b) D-glucuronic acid;

c) ethyl β-D-glucopyranoside; d) ethyl α-D-fructofuranoside.

-What products would be obtained if maltose itself were subjected to methylation and

hydrolysis? What would this tell us about the structure of maltose?

-Give the scheme of dehydration of:

a) glycine; b) γ-amino butyric acid; c) β-amino isobutyric acid.

-Write the structural formulas of all possible tripeptides with the composition of two glycine and one serine.

-RNA and DNA: structure, types of linkages, nomenclature, properties. Complementary pairs. Biological significance of nucleic acids.

-Give structures and names of the principal products of the reaction of D(+)-galactose with: a)bromine water; b)$HNO_3$; c)acetic anhydride; d)$CH_3OH$, HCl; e)$NaBH_4$.

-Sucrose is a disaccharide formed by linking α-D-glucose and β-D-fructose by an α (1→2) bond. Draw the structure of this disaccharide.

-Give the schemes of decarboxylation of histidine, aspartic acid, glycine, lysine.

-Predict the product of the reaction of valine with the following reagents:

a) $CH_3CH_2OH$, $H^+$; b) HCl; c) KOH, $H_2O$; d) $CH_3COCl$, pyridine; then $H_2O$.

-Give the structure of deoxythymidilic acid, uridilic acid, deoxyguanilicacid. Give their names as phosphates of nucleosides.

-Write equations to show how D (+)-glucose could be converted into:

a) methyl-β-D-glucoside; b) methyl-β-2,3,4,6-tetra-O-methyl-D-glucoside;

c) D-glucuronic acid; d) sorbitol.

-Maltose is a disaccharide isolated from amylase that consists of two glucose units linked by α(1→4). Draw the structure of this molecule.

-Classification of biogenic amino acids according to acid-base properties and nature of the R-groups. Draw the structure for each of the following compounds:

a) N-ethylethanamine; b) 3-ethyl-1-(methylamino)pentane;

c) 4-amino-2-methylhexane; d) 5-methyl-1-hexanamine;

e) methyldipropylamine; f) N,N-dimethyl-3-pentanamine;

-Draw a dipeptide composed of glycine and alanine. Begin by drawing glycine with its amino group on the left. Circle the amide bond.

-Nucleotides. Definition, structure, types of linkages, nomenclature, properties. Ribonucleotides and deoxyribonucleotides.

-Draw the structure of the open-chain form of D-fructose, and show how it cyclizes to form α- and β-D-fructose.

-Show the product you would obtain from the reaction of cellobiose with the following reagents:

a) $NaBH_4$; b) $Br_2$, $H_2O$; c) $CH_3COCl$, pyridine.

-Draw the zwitter-ion structure for the amino acid serine, leucine. Using the behavior of

hydroxy acids as a pattern, predict structures for the products obtained when the following amino acids are heated:

a) α-amino acid, glycine $\rightarrow C_4H_6O_2N_2$ (diketopiperazine);

b) β-amino acid, $CH_3CH(NH_2)CH_2COOH \rightarrow C_4H_6O_2$;

c) γ-amino acid, $CH_3CH(NH_2)CH_2CH_2COOH \rightarrow C_5H_9ON$ (a lactam);

d) δ-amino acid, $NH_2CH_2CH_2CH_2CH_2COOH \rightarrow C_5H_9ON$ (a lactam).

-Describe the primary structure of a protein. What makes one protein different from another one of the same size? What is the basis of the unique conformation of a protein?

-Nucleosides: definition, structure, types of linkages, nomenclature, properties. Ribonucleosides and deoxyribonucleosides. Hydrolysis.

-Carbohydrates. Classification. Biological role. Distinguish between simple and complex sugars. What are some sources of complex carbohydrates?

-What are homopolysaccharides? Give examples.

-Amino acids as dipolar ions. Isoelectric point (pI) of amino acids. Show the structures of the following amino acids in their zwitter ionic forms: a) Trp; b) Ile; c) Cys; d) His.

-Predict the products of the treatment of glycine with:

a) aqueous NaOH; b) aqueous HCl; c) acetic anhydride;

d) $NaNO_2$+HCl; e) $C_2H_5OH + H_2SO_4$.

-Proteins. Classification. Structure. Distinguish between secondary and tertiary structures of proteins.

-Nucleic acids. Name the complementary base pairs. Describe the DNA double helix, structure.

-Carbohydrates. Classification. Structure. Monosaccharides. Refer to the linear structure of D-galactose. Draw the Haworth projections of α- and β-D-galactose.

-Polysaccharides. Write the structure of cellulose disaccharide fragment and show the bond type between two monosaccharide units.

-Structural components of nucleic acids. Nucleic bases. Purine derivatives (adenine and guanine) and pyrimidine derivatives (cytosine, thymine, uracil). Lactime-lactame tautomeric forms.

-Carbohydrates. Classification. Monosaccharides. Refer to the linear structure of D-ribose. Draw Haworth projections of α- and β-D-ribose. Note that D-ribose is a pentose.

-Hyaluronic acid is a component of connective tissue and is the fluid that lubricates the joints. It is an alternating polymer of N-acetyl-D-glucosamine and D-glucuronic acid joined by β-1,3-glycosidic linkages. Draw a short segment of hyaluronic acid.

-Amino acids reactions on carboxylic group: esterification reaction, reactions with

phosphorus halogenides ($PCl_5$, $PCl_3$).

-Structure and biological functions of myoglobin and hemoglobin.

-Pectin is a polysaccharide obtained from fruits that is used as a jelling agent in making jams and jellies. It can be synthesized by reacting amylose with nitric acid. Draw a short segment of pectin.

-Amino acids. Reactions of amino group with formaldehyde, nitrous acid, acetic anhydride.

-Levels of protein structural organization: primary, secondary (α-helix), tertiary, quaternary. Bond types.

-Draw the complete structure of the RNA dinucleotide UA.

-Monosaccharides. Properties. Draw the products you would obtain by reaction of β-D-ribofuranose with:

a) $CH_3I$, $Ag_2O$; b) $(CH_3CO)_2O$, pyridine; c) $HNO_3$; d) $Br_2$, $H_2O$.

-What are polysaccharides? Types of polysaccharides. Give examples. Write the formula of disaccharide fragment of amylose. Point the linkage type.

-Classification, properties and biological functions of proteins. Fibrous proteins. Collagen, α-keratins, myosin. β-pleated sheet. Silk fibroin. Globular proteins.

-Draw the complete structure of the DNA dinucleotide AG.

-Monosaccharides. Properties. Draw all of the different possible aldotetroses of molecular formula $C_4H_8O_4$ .

-Write the formula of disaccharide fragment of amylopectin. Point the linkage type. Write the equation of starch hydrolysis in the presence of acid.

-Amphoteric properties of amino acids. Acid-base properties of amino acids. Types of salts. Write the equations of the formation of all types of salts for alanine.

-Nucleic acids. The structure of nucleotides. Base pairing in DNA. The Watson-Crick model.

## TEST

### Module 1. General chemistry

Solutions are:

a) isolated systems, separated from the surroundings by an interface surface;

b) homogeneous systems which do not exchange by mass with the surroundings;

c) homogeneous systems which contain at least two components;

d) heterogeneous systems which contain at least two components.

A solution of a salt and 100 grams of water that can still dissolve more solute at a given temperature is classified as:

a) unsaturated; b) supersaturated; c) diluted; d) saturated.

110 grams of KF are dissolved in water to make 850 ml of solution. What is the molarity of

the solution?

a) 0,129 M; b) 0,620 M; c) 0,002 M; d) 2,23 M.

The effect of the nature of a solvent and a solute on solubility is described by the following rule:

a) «like dissolves like»;

b) the solubility of a gas in a liquid is proportional to the partial pressure of a gas above the solution;

c) the larger the concentration of reactant molecules, the faster the reaction;

d) the mass of the substances entering into a reaction equals the mass of the substances formed as a result of the reaction.

The statement that solubility of a gas in a liquid is proportional to its partial pressure above the solution is defined as:

a) the Henry's law; b)the Sechenov equation;

c) the Ostvald's dilution law; d) the Paul's principle.

Solutions which are applied in medicine for intravenous injections are characterized by their osmolarity or osmolality. These concentration units express:

a) concentration of water;

b) concentration of substances unable to diffuse through cell membranes;

c) concentration of substances able to diffuse through cell membranes;

d) concentration of electrolytes.

In order to increase solubility of gases in water it is necessary:

a) to increase gas pressure above water solution; to decrease temperature;

b) to add some electrolytes into a solution;

c) to add some nonelectrolytes into a solution;

d) to increase temperature.

Osmolarity is:

a) the molarity of particles in a solution;

b) the amount of solute dissolved in a specified amount of solution;

c) mass percentage concentration;

d) the concentration in parts per thousand.

Solubility of solids depends upon:

The nature of solutes and solvents and temperature;

a) pressure;

b) heat of solution;

c) all answers are right.

The density of an aqueous solution containing 10 percent of ethanol by mass is 0,984 g/ml. The molarity of this solution will be:

a) 2,41mol/kg; b) 2,13M; c) 0,059ℓ; d) 36%.

Generally, solubility is defined as:

a) ability of substances to be dissolved in a particular solvent;

b) diffusion of solute particles throughout a solution;

c) heat amount absorbed or released when one mole of a solute is dissolved in the endless amount of a solvent under the standard conditions.

d) destruction of solute's crystal lattice.

An erythrocyte placed into 10% NaCl solution undergoes:

a) hemolysis; b) plasmolysis; c) swelling; d) precipitation.

Point out solutions which are isotonic with blood plasma:

a) 3 % sodium chloride; 4,5 % glucose;

b) 0,9 % glucose; 0,9 % sodium chloride;

c) 0,9 % sodium chloride; 4,5 % glucose;

d) 20 % glucose; 10% $CaCl_2$.

Osmosis is a spontaneous process defined as:

a) a reversible thermodynamic process of water diffusion through semipermeable membrane from a solution of a weak electrolyte into a solution of a strong electrolyte;

b) a reversible thermodynamic process of water diffusion through semipermeable membrane from a true solution to a colloidal solution;

c) a reversible thermodynamic process of solute diffusion through semipermeable membrane from pure water to a solution;

d) a reversible thermodynamic process of water diffusion through semipermeable membrane from a dilute solution into a more concentrated one.

Normal osmotic pressure of blood plasma is:

a) 740-780 kPa; b) 140-240 kPa; c) 840-980 kPa; d) 60-70 kPa.

The osmolarity of $5 \cdot 10^{-3}$ M $Na_3PO_4$ is:

a) $5 \cdot 10^{-3}$osmol; b) $2 \cdot 10^{-2}$ osmol; c) $4 \cdot 10^{-3}$ osmol; d) $2 \cdot 10^{-3}$osmol.

In accordance with the state of aggregation solutions are:

a) liquid, transparent, colored;

b) solid, liquid, turbid;

c) gaseous, liquid, solid;

d) liquid, turbid, colored.

The molality of the solution containing 7,2 mole of ethylene glycol ($C_2H_6O_2$) in 3546 g of

water is:

a) 0,03mol/kg; b) 0,03mol/l; c) 0,03mol; d) 30%.

Point out a solution with the highest boiling point:

a) 0,01M sucrose; b) 0,01 M sodium phosphate;

c) 0,01M potassium chloride; d) 0,01 M sodium carbonate.

Define the Raoult's cryoscopic law:

a) freezing points of solutions containing nonvolatile solutes are always lower than those of pure solvents;

b) freezing points of solutions containing nonvolatile solutes are always higher than those of pure solvents;

c) freezing points of pure solvents are always lower than those of solutions**;**

d) freezing points of pure solvents are always higher than those of solutions.

Cryoscopy and ebullioscopy are experimental methods to determine:

a) density; b) molar mass; c) viscosity; d) osmotic pressure.

Osmotic pressure can be calculated according to the following equation:

a) $\pi = MRT$; b) $\Delta T_f = K_f C_m$; c) $\Delta T_b = K_b C_m$; d) $\Delta T_f = iK_f C_m$.

Colligative properties of solutions depend upon:

a) the number of the solute particles; b) the chemical structure of solute;

c) catalysts; d) pH scale.

The mathematical expression of cryoscopic Raoult's law is defined as:

a) $\Delta T_f = K_f \cdot C_m$; b) $\pi = MRT$; c) $\Delta T_b = K_b \cdot C_m$; d) $pH = -\log[H^+]$.

The molality of the solution containing 14,3 g of sucrose ($C_{12}H_{22}O_{11}$) in 676 g of water is:

a) 0,08mol/kg; b) 0,08mol/l; c) 0,008 mol; d) 80%.

A 10 % solution of NaCl means that in 100 grams of the solution there is:

a) 5,85 g of NaCl; b) 10 g of NaCl; c) 10 g of NaCl d) 58,5 g of NaCl.

The Raoult's ebullioscopic law can be defined as:

a) boiling points of solutions containing nonvolatile solutes are always lower than those of pure solvents;

b) boiling points of solutions containing nonvolatile solutes are always higher than those of pure solvents;

c) boiling points of pure solvents are always higher than those of solutions containing nonvolatile solutes;

d) boiling points of pure solvents are always lower than those of solutions containing nonvolatile solutes.

The osmolarity of $5{,}0\times10^{-2}$ M NaCl is equal to:

a) $2{,}0\times10^{-2}$osmol; b) $1{,}0\times10^{-1}$osmol;

c) $3,0\times10^{-2}$osmol; d) $5,0\times10^{-3}$osmol.

The osmotic pressure of a $5\times10^{-2}$ M solution of NaCl at $25^0$ is:

a) 7,7atm; b) 2,7 atm; c) 2,4 atm; d) 6,9 atm.

Gastric juice pH is approximately 1. The hydrogen ions molarity in it is:

a) 0,01M; b) 0,001M; c) 0,1M; d) 1,0M.

Which pair of solutes could be used to prepare an aqueous buffer solution with a pH□7?

a) HCl-NH4Cl; b) HF-NaF; c) NH3-NH4Cl; d) NaOH-NaCl.

The Henderson-Hasselbalch equation allows the calculation of:

a) a buffer pH; b) pH of acids; c) pH of bases; d) pH of salts.

Condition of high blood $CO_2$ level and low pH is termed as:

a) alkalosis; b) hemolysis; c) acidosis; d) homeostasis.

What substance is applied in medicine to treat acidosis?

a) $NaNO_2$; b) $NaHCO_3$; c) $Na_2CO_3$; d) $KMnO_4$.

Buffer capacity of a solution depends upon:

a) nature of components; the ratio of concentrations of buffer components.

b) atmospheric pressure;

c) boiling point;

d) vapor pressure.

According to the Brønsted-Lowry theory, an acid is:

a) a proton donor; b) a proton acceptor;

c) an electron donor; d) an electron acceptor.

The acid-base state of blood is determined by:

a) pH value, $HCO_3^-$ concentration and pressure of $CO_2$;

b) pOH value, $H^+$ and $OH^-$ concentration;

c) pH value, $CH_3COO^-$ and $H^+$ concentration;

d) concentration of $H^+$ and $OH^-$.

The point at which a titration is complete is called the:

a) end point; b) equilibrium point;

c) calibrated point; d) chemical point.

The pH of a $1,0\times10^{-3}$ M solution of HCl is:

a) 1; b) 6; c) 3; d) 8.

Specify which of the following systems can be classified as a buffer system:

a) KCl/HCl; b) $NaH_2PO_4/Na_2HPO_4$;

c) $KHSO_4/H_2SO_4$; d) $NH_3/NH_4Cl$.

Mixtures in which particles settle out upon standing are defined as:

a) suspensions; b) electrolytes; c) molecular solutions; d) alloys.

## Module 2. Bioorganic chemistry

What is the difference between the covalent bonding structure of alkenes and alkynes?

a) alkenes have no covalent bonds and alkynes have one;

b) alkenes have one covalent bond and alkynes have two;

c) alkenes have two covalent bonds and alkynes have three;

d) alkenes have three covalent bonds and alkynes have four.

Carboxylic acids are generally:

a) weak acids; b) weak bases; c) strong acids; d) amphoteric.

The two principal contractile proteins found in skeletal muscles are:

a) actin and troponin; b) actin and myosin;

c) troponin and tropomyosin; d) myosin and tropomyosin.

Sodium or potassium salts of fatty acids are called:

a) proteins; b) terpenes; c) carbohydrates; d) soaps.

An ester can be prepared by the reaction of :

a) two alcohols; b) an alcohol and an aldehyde;

c) an alcohol and an organic acid; d) an acid and a ketone

Carboxylic acids produce salts and water by reacting with:

a) acids; b) bases; c) alkalis; d) alcohols.

Clicaric acids are produced from aldoses by:

a) oxidation; b) reduction; c) esterification; d) transamination.

A _____is a triglyceride that has a fatty acid which has been replaced by a polar phosphate group:

a) phospolipid; b) steroid; c) tridlyceride; d) fatty acid.

Which of the following is an unsaturated carboxylic acid?

a) succimic acid; b) acetic acid; c) stearic acid; d) oleic acid.

Base catalyzed hydrolysis of oils and fats is called:

a) saponification; b) fermentation; c) rancidification; d) glycolisis.

The characteristic group of an organic ester is:

a) –CO-; b) –COOH; c) –COH; d) –COO-.

A lipid with a four-ring structure is known as a:

a) steroid; b) fatty acid; c) wax; d) triglyceride.

A long chain carboxylic acid is known as a:

a) steroid; b) fatty acid; c) wax; d) triglyceride.

When three fatty acids are bonded to a glycerol backbone through ester bonds, a _____is formed:

a) steroid; b) fatty acid; c) wax; d) triglyceride.

Unsaturated fatty acids have _____covalent bonds:

a) triple; b) double; c) single; d) none of the above.

Fats and oils are:

a) monoesters of glycerol; b) diesters of glycerol;

c) triesters of glycerol; d) diesters of glycol.

A _____is a large nonpolar biological molecule:

a) nucleotide; b) carbohydrate; c) lipid; d) protein.

Combining a fatty acid with a long chain alcohol produces_____:

a) steroids; b) fatty acids; c) waxes; d) triglycerides.

Plant fats are _____at room temperature:

a) solid; b) liquid; c) none of the above; d) gaseous.

Invert sugar is:

a) starch; b) glucose; c) fructose; d) hydrolytic product of sucrose.

Maltose is composed of:

a) glucose and glucose; b) glucose and galactose;

c) glucose and fructose; d) fructose and galactose.

Glycogen, a polysaccharide, in your liver may be broken down to glucose by the process of ___:

a) hydrolysis; b) dehydration synthesis;

c) condensation; d) isomerization.

Large molecules formed when many monosaccharides are bonded together are ____:

a) calcium; b) sugars; c) monosaccharides; d) polysaccharides.

Which of the following is an amino acid found in proteins:

a) adenosine; b) adenine; c) alanine; d) linoleic acid.

Which of the following releases most energy when completely oxidized in the body?

a) one gram of glucose; b) one gram of palmitic acid;

c) one gram of leucine; d) one gram of alcohol.

The carbohydrate that provides structural support in plants is called___:

a) chitin; b) cellulose; c) dextrose; d) lipids.

Choose the keto triose:

a) glyceraldehydes; b) erythrose; c) dihydroxyacetone; d) arabinose.

Galactose and glucose are:

a) epimers; b) isomers; c) anomers; d) none of the above.

Single sugars, called monosaccharides supply_____to cells:

a) energy; b) health; c) calcium; d) hydrolysis.

Which of the following are anomers?

a) D-glucose and L-glucose; b) D-glucose and D- fructose;

c) α,D-glucose and β,D-glucose; d) α,D-glucose and β,L-glucose;

The process of breaking down triacylglycerol into free fatty acids and glycerol is called:

a) beta oxidation; b) lipogenesis; c) lipolysis; d) none of the above.

A disaccharide produced by hydrolysis of starch is called:

a) sucrose; b) lactose; c) maltose; d) trehalose.

Which of the following is NOT classified as a biopolymer?

a) collagen; b) glucose; c) cellulose; d) chitin.

Which of the following molecules is not an aldose?

a) ribose; b) fructose; c) glucose; d) glyceraldehyde.

Which of the following is not true about the disaccharide lactose:

a) lactose is a reducing sugar; b) lactose undergoes mutarotation;

c) lactose is optically active; d) lactose has a $1,1^{/}$-α-glycosidic linkage.

Carbohydrates and lipids have many carbon-hydrogen bonds, therefore they both___:

a) store energy in these bonds; b) dissolve in water;

c) dissolve in salts; d) are similar to water.

The three types of carbohydrates are:

a) monosaccharide; polysaccharide; disaccharide;

b) glycerol, polysaccharide; monosaccharide;

c) disaccharide; monosaccharide; glycerol;

d) glycerol; monosaccharide; polysaccharide.

Reduction of D-xylose with $NaBH_4$ yields a product that is:

a) D-sorbitol; b) D-xylitol; c) D-gluconic acid; d) D-frucrose.

Which of the following molecules is a monosaccharide?

a) $C_6H_6$; b) $C_6H_{12}O_6$; c) $C_{12}H_{22}O_{11}$; d) $C_2H_6O$.

What elements make up a carbohydrate?

a) hydrogen, calcium, oxygen; b) hydrogen, oxygen, carbon;

c) carbon, potassium, oxygen; d) calcium, potassium, oxygen.

Which of the following is a polymer of fructose?

a) inulin; b) dextrin; c) cellulose; d) glycogen.

Common table sugar is:

a) glucose; b) sucrose; c) fructose; d) maltose.

One function of a carbohydrate is _____:

a) to provide the body with immediate energy;

b) keep heart functioning smoothly;

c) store and transport genetic material; d) control the rate of reactions.

Determine a type of α-amino acid –phenylalanine:

a) aliphatic; b) aromatic; c) heterocyclic; d) complex.

Biogenic amines are produced under reaction of:

a) transamination; b) oxidation; c) reduction; d) decarboxylation.

Glycine is a unique amino acid because it:

a) has no chiral carbon; b) cannot form a peptide bond;

c) has a sulfur containing group; d) is an essential amino acid.

A chain of at least 10 amino acids is:

a) polysaccharide; b) polypeptide; c) protein; d) peptide.

Many proteins function as:

a) polymers; b) hormones; c) substrates; d) enzymes.

Which protein carries oxygen throughout the blood:

a) gonadotropin; b) hemoglobin; c) insulin; d) chitin.

Which amino acid is represented by the abbreviation «Glu»?

a) glycine; b) glutamine; c) glutamic acid; d) cysteine.

Bonds stabilizing the secondary structure of peptides are:

a) coordination; b) ionic; c) hydrogen; d) hydrophobic.

An α-amino acid exists in the form of a cation in:

a) acidic medium; b) basic medium;

c) neutral medium; d) none of the above.

The amide bond that joins two amino acids is called_____:

a) polypeptide bond; b) peptide bond; c) ether bond; d) ester bond.

What is the abbreviation for the amino acid asparagine?

a) asp; b) arg; c) ala; d) asn.

Determine the type of α-amino acid – tyrosine:

a) aliphatic; b) aromatic; c) heterocyclic; d) complex.

The sequence of amino acids in a protein is known as its:

a) primary structure; b) secondary structure;

c) tertiary structure; d) quaternary structure.

Which of the following is not an amino acid?

a) glutamic acid; b) aspartic acid; c) glutamine; d) palmitic acid.

An α-amino acid exists in the form of a zwitter-ion in:

a) acidic medium; b) basic medium;

c) neutral medium; d) any medium.

Collagen is a _____protein:

a) structural; b) hormonal;

c) transport; d) enzymatic.

_____are messenger molecules:

a) proteins; b) enzymes;

c) hormones; d) vitamins.

Which protein do diabetics lack?

a) collagen; b) gonadotropin; c) insulin; d) chitin.

Which of the following molecules does not form part of DNA?

a) purine; b) deoxyribose; c) amino acid; d) phosphate.

Proteins are:

a) polyamides; b) polymers of ethylene;

c) polymers of propylene; d) polyalcohols.

What is the number of different kinds of nucleotides present in any RNA or DNA molecule?

a) four; b) five; c) six; d) seven.

What is the abbreviation for the amino acid methionine?

a) pro; b) met; c) val; d) phe.

What type of covalent bonds link amino acids in a protein?

a) peptide bonds; b) hydrogen bonds;

c) ionic bonds; d) ester bonds.

A chain of two or more amino acids is called a _____:

a) peptide; b) polypeptide; c) protein; d) polysaccharide.

What is the abbreviation for the amino acid tryptophan?

a) thr; b) ser; c) tyr; d) trp.

Which of the following are the three "single ring" bases that are present in nucleic acids?

a) adenine, guanine and uracil; b) adenine, cytosine and uracil;

c) cytosine, thymine and uracil; d) cytosine, guanine and thymine.

How many parts does a nucleotide have?

a) 1; b) 2; c) 3; d) 4.

Which of the following statements concerning the double helix structure present in DNA molecules is *correct*?

a) the two nucleotide strands are identical;

b) hydrogen bonds between sugar units hold the two nucleotide strands together;

c) base pairing between strands always involves one purine base and one pyrimidine base;

d) base pairing combinations are always A–C and G–T.

Which of the following statements concerning tRNA molecules is *incorrect*?

a) they are carriers of the amino acids needed for protein synthesis;

b) they have a "cloverleaf" shape with four hairpin loops;

c) they interact with mRNA at the site of protein synthesis;

d) an anticodon is present within their structure.

In which of the following pairs of nucleic acid bases are both members of the pair "single ring" bases?

a) A and C; b) G and T;

c) T and U; d) more than one correct response.

Which of the following types of RNA is paired with a correct piece of information about that type of RNA?

a) tRNA; contains exons; b) mRNA; contains codons;

c) rRNA; contains anticodons; d) more than one correct response.

A nucleoside is composed of:

a) a base+ a sugar; b) a base+ a sugar+ a phosphate;

c) a base+ a phosphate; d) none of these.

Adjacent nucleotides are joined by:

a) a covalent bond; b) a phosphor diester bond;

c) an ionic bond; d)a peptide bond.

The transcription of DNA into a molecule of messenger RNA occurs:

a) on the ribosomes; b) in the nucleus;

c)only during cell division; d) when amino acids are made by transfer RNA.

The instructions in a DNA molecule are carried in the form of a specific sequence of:

a) nucleotides; b) nitrogen bases; c) triglycerides; d) oxygen bases.

RNA is usually:

a) single-stranded; b) double-stranded; c) single helix; d) double helix.

Which of the following nucleotide bases is not found in RNA?

a) thymine; b) adenine; c) uracil; d) guanine;

Any given nucleotide in a nucleic acid contains:

a) two bases and a sugar;

b) one sugar, two bases and one phosphate;

c) two sugars and one phosphate;

d) one sugar, one base and one phosphate.

The "backbone" of a nucleic acid molecule consists of an alternating sequence of:

a) sugar and phosphate groups; b) sugar and base groups;

c) phosphate and base groups; d) sugar, phosphate and base groups.

The backbone of a DNA molecule always has a free –OH group on a:

a) ribose molecule at the 3' end; b) deoxyribose molecule at the 3' end;

c) ribose molecule at the 5' end; d) deoxyribose molecule at the 5' end.

In a dinucleotide the linkage between nucleotide units involves:

a) carbon 3' of a sugar; b) carbon 5' of a sugar;

c) both carbons 2' and 3' of a sugar; d) more than one correct response.

Which of the following elements is *not* present in the "backbone" of a nucleic acid molecule?

a) phosphorus; b) nitrogen; c) oxygen; d) none of the above.

DNA is the genetic material in:

a) viruses, prokaryote and eukaryote; b) prokaryote and eukaryote;

c) only in eukaryotes; d) in some viruses, prokaryotes and eukaryotes.

In a DNA double-helix, guanine and cytosine bases are paired together by:

a) covalent bonds; b) hydrogen bonds;

c) peptide bonds; d) hyper conjugation.

The double helical structure of DNA is held together by:

a) peptide bonding; b) hydrogen bonding;

c) glycosidic bonds; d) sulfur-sulfur linkages.

In addition to the standard organic elements carbon, hydrogen and oxygen, nucleic acids also contain_____:

a) phosphorus; b) calcium; c) nitrogen; d) sulfur.

The order of nitrogen bases in RNA determine the sequence of:

a) amino acids in a nucleotide; b) amino acids in a protein;

c) phosphate groups in a nucleotide; d) phosphate groups in a protein.

35% of the bases in a certain DNA molecule are found to be T. What percent of the bases in this molecule is G?

a) 15%; b) 25%; c) 35%; d) 65%.

Which of the following is a correct structural characteristic of a nucleotide?

a) the base unit is bonded to the phosphate unit;

b) the phosphate unit is bonded to the sugar unit;

c) the sugar unit is bonded to the base unit;

d) more than one correct response.

Genetic mutation occurs in:

a) protein; b) RNA; c) DNA; d) nucleus.

The length of one turn of DNA is:

a) 3,4A$^{o}$; b) 34 A$^{o}$; c) 20 A$^{o}$; d) 3,04A$^{o}$.

Sugar bonds to _____to form the backbone:

a) phosphate; b) carbonate; c) oxalate; d) sulfate.

The main function of DNA is:

a) instigating mitosis; b) sitting in the nucleus;

c) storing genetic information; d) none of the above.

Which of the following is not part of a nucleotide?

a) nitrogen base; b) monosaccharide sugar;

c) phosphate group; d) oxygen base.

Replication of DNA produces two daughter DNA molecules in which:

a) one daughter molecule contains both parent strands and one daughter molecule contains both newly synthesized strands;

b) each daughter molecule contains one parent strand and one newly synthesized strand;

c) each daughter molecule contains two newly synthesized strands;

d) each daughter molecule contains a segment of both parent strands.

The genetic code is a listing that gives relationships between codons and:

a) anticodons; b) amino acids; c) exons; d) genes.

In which of the following sets of nucleic acid "building blocks" are all members of the set possible components of a DNA molecule?

a) phosphate, ribose, and thymine;

b) adenine, ribose, and 2-deoxyribose;

c) cytosine, guanine, and uracil;

d) no correct response.

Which of the following events occurs during the ***translation*** phase of protein synthesis?

a) mRNA interacts with a chromosome; b) codon-anticodon base pairing occurs;

c) rRNAs carry amino acids to the site for protein synthesis;

d) no correct response.

The two strands in a DNA double is joined by:

a) covalent bond; b) hydrogen bond; c) ionic bond; d) phosphor diester bond.

The basic repeating unit of a DNA molecule is:

a) nucleoside; b) nucleotide; c) histones; d) amino acids

Thymine is never found in :

a) DNA; b) RNA; c) none of the above.

**5.4. Assessment fund.**

Laboratory work (in-process monitoring).

Project (in-process monitoring).

Control work (midterm examination).

Test (midpoint monitoring).

Assessment scale (appendix 2).

## 6. COURSE (MODULE) METHODOLOGICAL AND INFORMATIONAL SUPPORT

### 6.1. Recommended Reading.


1. John McMurry. Organic chemistry. 9th-Edition. Canada. 2019.
2. Handbook of chemistry: for students Faculty of Medicine and Faculty of Dentistry; ed. Iwona Kątnik-Prastowska; Wroclaw: Wroclaw Medical University, 2017.
3. Katherine J. Denniston. General, Organic and BioChemistry. Ninth edition. New York. 2017. https://rapidgator.net/file/fa69c4feef0763ffa960ebee7af145f7/geneorgbi9.rar.html
4. Laura Frost. General, Organic and Biological Chemistry. 3rd. Edition. USA. 2017. https://vk.com/doc187961010_461601880?hash=261207166fbb89d57f&dl=0bb9c54954e7b33f71
5. Raymond Chang, Kenneth A. Goldsby. Chemistry. 2016.
6. Ebbing D.D. General Chemistry/ D.D. Ebbing, M.S. Wrighton.- Boston. Third edition. Houghton Mifflin Company.11th Edition. 2015.
7. Chemistry. An Introduction to General, Organic and Biological Chemistry. Timberlake KC, Benjamin Cummings, Pearson Education, Inc., 2015
8. Raymond Chang, Janson Overby. General chemistry. The essential concepts. Sixth edition. New York. 2011. https://www.twirpx.com
9. Ralph H. Petrucci. General Chemistry. Principles and modern application. Tenth edition. Canada. 2011. https://www.twirpx.com
10. Krister Holmberg. Handbook of applied surface and colloid chemistry. Volume 1. 2002. http://www.wiley.co.uk
11. Krister Holmberg. Handbook of applied surface and colloid chemistry. Volume 2. 2002. http://61.188.205.38:8081/hxgcx/hcjs/UploadFiles/pdf/%E6%96%87%E7%8C%AE%E5%BA%93/%E6%A8%A1%E5%9D%972%E8%A1%A8%E9%9D%A2%E6%B4%BB%E6%80%A7%E5%89%82/Handbook%20of%20applied%20surface%20and%20colloid%20chemistry%20-%20Volume%202.pdf
12. J.A. Abdurashitova, J.A. Djamanbaev. General and bioorganic chemistry. Study guide. 2018. http://lib.krsu.edu.kg/


### 6.2. Required Reading List.


1. Lister T. Chemistry for Advanced Level / T. Lister, J. Renshaw; - Third edition. Stanley Thornes (Publishers) Ltd. 2000. – 680 p.
2. DrWalfgangSchärtl / Basic physical chemistry.-Bookboon.com.-2014.
3. Roman Elsair. Fundamentals of chemistry. 2012. Bookboon.com.
4. William H. Brown. Introduction to Organic Chemistry. 6th. Edition. USA. 2016. https://vk.com/doc348852382_456866825?hash=1f43b3c8faa7804a82&dl=1e6abadf8dcee1535a
5. Daniel Bloch. Organic chemistry. McGraw Hill, USA. 2006.

7. Zurabyan S. E. Fundamentals of bioorganic chemistry/ S.E. Zurabyan,-M.: Geotar-med.-2003.
8. Bioanalytical chemistry. Manz A, Pamme N, Ossifidis D, Imperial Colleg Press, 2004 USA.

**6.3. List of information and education technologies.**

**6.3.1 Competence-based educational technologies.**

**6.3.1.1.** For the organization of course discipline studying traditional educational technologies are used.

Traditional educational technologies include lectures, practical sessions, lab practical.

**6.3.1.2.** Innovative educational technologies are interactive sessions, which form systemic thinking and ability to generate ideas to solve different situational problems.

Innovative educational technologies include debates, discussions, solution of situational tasks.

Monitoring is made in the form of individual work assessment.

**6.3.1.3.** Informational educational technologies mean individual work of students with different resources including computer equipment and internet to solve practical problems and do individual work.

**7. COURSE (MODULE) LOGISTICS.**

7.1. Teaching facilities should be study halls for lectures, seminar classes, group and individual consultations, in-process monitoring, mid-term examination, individual work and storage facilities for preventive maintenance of educational equipment.

7.2. Study halls should be equipped with specialized furniture and technical training tools serving to present educational information to a large audience.

7.3. For conducting lectures sets of demonstration materials and educational visual aids are offered. They provide thematic illustrations corresponding to the course outline (Module): interactive board, projector, microphone, tables and schemes.

7.4. List of material support which is necessary for realization of course outline (module) includes: chemical laboratories and their equipment: balances: techno-chemical, torsion and analytical; exhaust hoods; distillers; calorimeters; thermometers; cryometers; photoelectrocalorimeters; pH-meters; potentiometer; microscopes; stalagmometers; viscosimeters; thermostats; drying chambers; rangettes; chemical supports; areometers; chemical utensils: test tubes, beakers, burettes, pipettes, cylinders, flasks, porcelain mortars, water bathes, exsiccators, spirit-lamps, weighing bottle; manipulative material; stands: Periodic table of chemical elements, pH of biological liquids, name and structure of functional groups of organic compounds,

electronic effects of different substituents, chemistry reference books.

## 9. COURSE (MODULE) PROFICIENCY METHODICAL GLUIDELINES (FOR STUDENT).

The planning sheet of discipline «Chemistry». Appendix 1.

**Appendix 1**

**The planning sheet of discipline «Chemistry»**

Discipline: **Chemistry**

Field of study/specialization: 560001-KR General Medicine
Course/semester: **1/1**

Credit units (CU): **2**

| Title of module according to WPD | Type of control | Forms of control | Minimal credit points | Maximal credit points | Week of control |
|---|---|---|---|---|---|
| **Module 1** | | | | | |
| **General chemistry** | Formative assessment | Activity, attendance, lecture notes, performance and presentation of lab works, individual work, discussion of situational tasks, writing of reports | 15 | 25 | 6 |
| | Midterm examination | Evaluation test | 5 | 10 | |
| **Module 2** | | | | | |
| **Bioorganic chemistry** | Formative assessment | Activity, attendance, lecture notes, performance and presentation of lab works, individual work , discussion of situational tasks, reports | 15 | 25 | 11 |
| | Midterm examination | Tests | 5 | 10 | 12 |
| **Total** | | | 40 | 70 | |
| **Midpoint assessment** | | | 20 | 30 | |
| **Summative assessment** | | | 60 | 100 | |

***Appendix: For each missed and unfinished class 0,5 points are removed***

**Appendix 2**

**Assessment scale**

**Types of control and attestation, forms of estimation tools**

| № | Semester | Types of control | Section name COURSE (MODULE) | Estimating tools | | |
|---|---|---|---|---|---|---|
| | | | | Form | Number of questions in a task | Number of independent options |
| 1. | 1 | Midterm examination | **Section 1. General chemistry** (Midterm examination) | Evaluation test | 5 | 12 |
| 2. | 1 | Midterm examination | **Section 2. Bioorganic chemistry** (Midterm examination) | Evaluation test | 5 | 12 |
| 3. | 1 | Midpoint assessment | **Midpoint assessment** | Test | 20 | 12 |

**Laboratory assessment scale**

- *Preparation for laboratory work:* goals and leaning objectives are formulated; the expected results are explained; equations of chemical reactions are correctly worked out (40%);
- *Performance of laboratory work:* the laboratory work is fully done by the student; the necessary sequence of experiments is observed; safety regulations are observed; all necessary measurements and calculations are carried out; relevant conclusions are drawn (40%);
- *Protocol design:* correct and accurate keeping of records, tables, graphs, calculations, chemical equations and design of conclusions (20%).

**Examination (evaluation test) assessment scale (midterm examination)**

- All necessary definitions, laws and their mathematical expressions are formulated (20%);
- The purpose and requirements of laboratory works are established, the conclusions are correctly made (20%);
- Analysis and explanations for solving problems using theoretical knowledge, calculated formulas and equations of chemical reactions are made, explanations of the choice of the method for solving the problem are given, alternative methods are offered (40%);
- The exact accounting is carried out, the corresponding conclusions are made and answers are accurately issued (20%).

**Project assessment scale**

- *Problem solving:* relevance to the topic of the essay, the content of the subject and the plan; completeness and depth of disclosure of basic concepts (30%);
- Ability to work with literature, systematize and structure the material (20%);
- *Project design:* title page, plan, introduction, the main part, conclusion, list of literature (15%);
- Literacy and manner of presentation, compliance with the volume requirements of the abstract (15%);
- Answers on questions: comprehensive and in-depth knowledge of the material (20 %);

**Structure of the project**

6. Title page;
7. Content (a work plan indicating the pages of each question, sub question paragraph, subparagraph);
8. Introduction;
9. Textual presentation of the material using references to literary sources;
10. Conclusion;
11. List of literature;
12. Appendices including tables, schemes, drawings, graphs.

**Requirements for the implementation of the report**

The report is carried out on one of the proposed topics in accordance with the chemistry course program.

The content of the report should include a detailed written answer.

The structure of the report should include definitions of the main categories and concepts, their meaning, different approaches to the definition of the phenomenon. When writing a report it is necessary to use 3-4 various literature sources.

**Report assessment scale**

- The subject is disclosed, analysis of the problem with references to specialized literature is made (10%);
- Presented information is systematized, consistently and logically stated using scientific concepts and terms (30%);
- Information technologies such as presentations, visual aids in the form of tables, figures and schemes (20%);
- Basic concepts, conclusions, generalizations are competently, convincingly and demonstratively formulated using specific examples and references to literature sources (30%);
- Complete and informative answers to additional questions (10%);

**Criteria for assessing the performance of tests (Midpoint monitoring)**

- One test task contains 20 questions;
- Each question includes 4 variants of answer, one of which is correct;
- For each correct answer 1,5 % is awarded.