ASSESSMENT FUND

Course Outline *«Chemistry»*

Level of higher education Specialist

Academic Curriculum

560001 – General Medicine

(code and name of the training area)

Qualification

Specialist

2026

The fund of assessment tools is intended to monitor the knowledge of students in the field of training (specialty) «General Medicine» in the discipline of *«Chemistry»*.

The Assessment Fund endorsed and confirmed by Basic and Clinical pharmacology, Chemistry and Biochemistry Department Meeting

_____

Department name

Record of № 2 on 07.09.2026y.

The Head of Basic and Clinical pharmacology, Chemistry and Biochemistry Department

Zurdinova A.A. 

Implementer:
Associate professor  Abdurashitova Yu.A.

1. LIST OF COMPETENCIES, INDICATING STAGES OF THEIR FORMATION DURING THE PROCESS OF MASTERING THE DISCIPLINE

Competencies	Planned learning outcomes in the discipline, characterizing the stages of competencies formation	Types of assessment tools/ section code in this document
GCC (3): is capable of independently acquiring new knowledge and applying it in practice using modern information technologies in their professional activities.	**Know:** The key fundamental principles upon which the theoretical framework for the organization and planning of scientific research is based. **Skills:** Review the literature on the problem, clarify key concepts, provide a preliminary description of the research subject, and define the scope of the investigation. **Expertise:** Skills in taking a comprehensive approach to organizing and planning scientific research.	**Blok A, D** – reproductive level tasks; test; **Blok B, D** – reconstructive level tasks; problems solving; control work **Blok C, D –** practice-oriented and/or research level assignments; performance and presentation of lab works; individual work; reports.
ABC (1): able to use basic physicochemical, mathematical, and natural science concepts and methods in solving professional tasks.	**Know:** 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.	**Blok A, D** - reproductive level tasks test;
	Skills: -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	**Blok B, D** – reconstructive level tasks problems solving; control work

	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: - 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.	**Blok C, D** – practice-oriented and/or research level assignments performance and presentation of lab works; individual work; reports.

The planning sheet of discipline «Chemistry»

Discipline: **Chemistry**

Field of study/specialization: 560001-KR General Medicine

Course/semester: **1/1**

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	Test	5	10	
Total			40	70	
Midpoint assessment			20	30	
Summative assessment			60	100	

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

3. STANDARD CONTROL TASKS AND OTHER MATERIALS FOR EVALUATION OF DISCIPLINE TRAINING PLANNED RESULTS / PRACTICE (ASSESSMENT TOOLS)

Blok A

A.0 Discipline test tasks fund

A.1 Survey questions:

Topic 1. Solutions.

1.1 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.

1.2 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.

1.3 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.

1.4 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.

1.5 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.

1.6 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.

1.7 Solubility of solids depends upon:

a) the nature of solutes and solvents and temperature;
b) pressure;
c) heat of solution;
d) all answers are right.

1.8 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.

1.9 Molarity of a solution is expressed as:

a) the number of moles of a solute present in one litre of the solution;
b) the number of moles of a solute present in 1000 gm of the solvent;
c) the number of gram equivalent of solute present in one litre of solution;
d) the ratio of the number of moles of solute to the total number of moles of solute.

1.10 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.

Topic 2. Colligative properties of solutions.

2.1 Which one of the following is not a colligative property?

a) osmotic pressure;
b) elevation of boiling point;
c) freezing point;
d) depression in freezing point.

2.2 The phenomenon of lowering of vapour pressure is defined as:

a) decrease in vapour pressure of a solvent on addition of a volatile non electrolyte solute in it.
b) decrease in vapour pressure of a solvent on addition of a non-volatile non electrolyte solute init.
c) decrease in vapour pressure of a solvent on addition of a volatile electrolyte solute in it.
d) decrease in vapour pressure of a solvent on addition of a non-volatile solute in it.

2.3 When osmotic pressure and temperature are the same then:

a) equal volume of solutions would contain equal number of moles of the solute.
b) equal volume of solutions would contain non-equal number of moles of the solute.
c) non-equal volume of solutions would contain equal number of moles of the solute.
d) non-equal volume of solutions would contain non-equal number of moles of the solute.

2.4 An erythrocyte placed into 10% NaCl solution undergoes:

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

2.5 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% $CaCl_2$.

2.6 Normal osmotic pressure of blood plasma is:

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

2.7 The osmolarity of 5×10^{-3}M Na_3PO_4 is:

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

2.8 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.

2.9 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.

2.10 Vant Hoff's eqution for solution is:
a) pV = n / RT.
b) p = Vn / RT.
c) pV = nRT.
d) p = VnR / T.

Topic 3. Equilibrium in aqueous solutions.

3.1 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.

3.2 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.

3.3 The pH of a $1{,}0\times10^{-3}$ M solution of HCl is:
a) 1;
b) 6;
c) 3;
d) 8.

3.4 When an acid (H^+) is added to alkali (OH^-), the product is:
a) water;
b) salt;
c) hydroxide;
d) hydrogen gas.

3.5 Which one of the following is acidic?
a) lemon juice;
b) tomatoes;
c) milk;
d) blood.

3.6 Some fruits like mango, lemon, raw grapes, orange, etc., have a sour taste due to the presence of:
a) acetic acid;
b) citric acid;
c) lactic acid;
d) oxalic acid.

3.7 Which one of the given is a mineral acid?
a) lactic acid;
b) formic acid;
c) tartaric acid;
d) hydrochloric acid.

3.8 Which Acid is present in tomato?
a) Citric Acid;

b) oxalic Acid;
c) lactic Acid;
d) HCl.

3.9 Which salt is Neutral salt?
a) NH_4Cl;
b) CH_3COONH_4;
c) CH_3COONa;
d) Na_2CO_3.

3.10 Sodium acetate on hydrolysis forms sodium hydroxide and _____
a) benzene;
b) glycerol;
c) cytosine;
d) acetic acid.

Topic 4. Acid-base balance of the organism and buffer systems.

4.1 Which of the following could be added to a solution of acetic acid to prepare a buffer?
a) hydrofluoric acid or nitric acid;
b) sodium acetate only;
c) nitric acid;
d) sodium acetate or sodium hydroxide;
e) sodium hydroxide only

4.2 The primary buffer system that controls the pH of the blood is the _____buffer system:
a) carbonate, carbonic acid;
b) carbon dioxide, carbonate;
c) carbonic acid, bicarbonate;
d) carbonate, bicarbonate;
e) carbonic acid, carbon dioxide.

4.3 Which one of the following pairs cannot be mixed together to form a buffer solution?
a) NH_3, NH_4Cl;
b) KOH, HF;
c) H_3PO_4, KH_2PO_4;
d) RbOH, HBr;
e) $NaC_2H_3O_2$, HCl ($C_2H_3O_2$- = acetate).

4.4 Which pair of solutes could be used to prepare an aqueous buffer solution with a pH>7?
a) HCl-NH_4Cl;
b) HF-NaF;
c) NH_3-NH_4Cl;
d) NaOH-NaCl.

4.5 The Henderson-Hasselbalch equation allows the calculation of:
a) a buffer pH;
b) pH of acids;
c) pH of bases;
d) pH of salts.

4.6 Condition of high blood CO_2 level and low pH is termed as:
a) alkalosis;
b) hemolysis;
c) acidosis;
d) homeostasis.

4.7 What substance is applied in medicine to treat acidosis?
a) $NaNO_2$;
b) $NaHCO_3$;
c) Na_2CO_3;
d) $KMnO_4$.

4.8 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.

4.9 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^-.

4.10 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.

Topic 5. Complex compounds.

5.1 EDTA combines with cations to form:
a) chelates;
b) clathrates;
c) non-stoichiometric compounds;
d) polymers.

5.2 Primary and secondary valency of Pt in $[Pt(en)_2Cl_2]$ are:
a) 4,4;
b) 4,6;
c) 6,4;
d) 2,6.

5.3 Which of the following has magnesium?
a) chlorophll;
b) haemocyanin;
c) carbonic anhydrate;
d) vitamin B_{12}.

5.4 The ligand $N(CH_2CH_2NH_2)$ is:
a) bidentate;
b) tridentate;
c) tetradentate;
d) pentadentate.

5.5 The reagent commonly used to determine hardness of water titrimetrically is:
a) oxalic acid;
b) disodium salt of EDTA;
c) sodium citrate;
d) sodium thiosulphate.

5.6 Which of the following ligands will not show chelation?
a) EDTA;
b) DMG;
c) Ethene-1, 2-diamine;
d) SCN^-.

5.7 The coordination number of a central metal atom in a complex is determined by:
a) the number of ligands around a metal ion bonded by sigma and pi-bonds both;
b) the number of ligands around a metal ion bonded by pi-bonds;
c) the number of ligands around a metal ion bonded by sigma bonds;
d) the number of only anionic ligands bonded to the metal ion.

5.8 A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent?

a) thiosulphato;
b) oxalato;
c) glycinato;
d) ethane-1,2-diamine.

5.9 Which of the following elements do not form a complex with EDTA?

a) Ca;
b) Mg;
c) Be;
d) Sr.

5.10 A ligand can also be regarded as:

a) Lewis acid;
b) Bronsted base;
c) Lewis base;
d) Bronsted acid.

Topic 6. Carboxylic acids and their derivatives.

6.1 Carboxylic acids are generally:

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

6.2 Sodium or potassium salts of fatty acids are called:

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

6.3 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.

6.4 Carboxylic acids produce salts and water by reacting with:

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

6.5 The characteristic group of an organic ester is:

a) –CO-;
b) –COOH;
c) –COH;
d) –COO-.

6.6 Which of the following is an unsaturated carboxylic acid?

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

6.7 A long chain carboxylic acid is known as a:

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

6.8 Vinegar contains a carboxylic acid known as:
a) citric acid;
b) ethanoic acid;
c) lactic acid;
d) nitric acid.

6.9 Which functional groups contribute to the reactivity of carboxylic acids?
a) -OH;
b)-COOH;
c)-CO;
d)-NH_2.

6.10 What role do carboxylic acids play in the medical field?
a) structural components of DNA;
b) clinical therapy of pain and diseases;
c) stabilization of cell membranes;
d) energy storage in cells.

Topic 7. Lipids. Phospholipids.

7.1 A lipid with a four-ring structure is known as a:
a) steroid;
b) fatty acid;
c) wax;
d) triglyceride.

7.2 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.

7.3 Fats and oils are:
a) monoesters of glycerol;
b) diesters of glycerol;
c) triesters of glycerol;
d) diesters of glycol.

7.4 Combining a fatty acid with a long chain alcohol produces_____:
a) steroids;
b) fatty acids;
c) waxes;
d) triglycerides.

7.5 Plant fats are _____at room temperature:
a) solid;
b) liquid;
c) none of the above;
d) gaseous.

7.6 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.

7.7 A phospholipid consist of:
a) polar phosphate hydrophilic tail group and hydrophobic fatty acid head;
b) nonpolar phosphate containing head group and polar fatty acid tail;
c) polar phosphate containing hydrophilic head group and hydrophobic fatty acid tail;

d) nonpolar phosphate containing head group and nonpolar fatty acid tail.

7.8 All are functions of phospholipids except:

a) forms cell membranes;
b) major role in assembling and transporting lipoproteins in blood;
c) it works as emulsifiers in the body;
d) provides energy.

7.9 Neutral glycerides are:

a) non ionic;
b) non polar;
c) non amphipathic;
d) all of the above.

7.10 Which of the following is a glyceride lipid?

a) fats;
b) oils;
c) all of the above;
d) phospholipids.

Topic 8. Carbohydrates. Monosaccharides.

8.1 Choose the keto triose:

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

8.2 Galactose and glucose are:

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

8.3 Single sugars, called monosaccharides supply_____to cells:

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

8.4 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.

8.5 Which of the following is NOT classified as a biopolymer?

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

8.6 Which of the following molecules is not an aldose?

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

8.7 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.

8.8 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.

8.9 What elements make up a carbohydrate?

a) hydrogen, calcium, oxygen;
b) hydrogen, oxygen, carbon;
c) carbon, potassium, oxygen;
d) calcium, potassium, oxygen.

8.10 Which of the following is a polymer of fructose?

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

Topic 9. Carbohydrates. Disaccharides. Polysaccharides

9.1 Invert sugar is:

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

9.2 Maltose is composed of:

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

9.3 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.

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

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

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

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

9.6 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.

9.7 The carbohydrate that provides structural support in plants is called___:

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

9.8 A disaccharide produced by hydrolysis of starch is called:

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

9.9 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.

9.10 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.

Topic 10. α-Amino acids.

10.1 Determine a type of α-amino acid –phenylalanine:
a) aliphatic;
b) aromatic;
c) heterocyclic;
d) complex.

10.2 Biogenic amines are produced under reaction of:
a) transamination;
b) oxidation;
c) reduction;
d) decarboxylation.

10.3 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.

10.4 Which amino acid is represented by the abbreviation «Glu»?
a) glycine;
b) glutamine;
c) glutamic acid;
d) cysteine.

10.5 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.

10.6 The amide bond that joins two amino acids is called_____:
a) polypeptide bond;
b) peptide bond;
c) ether bond;
d) ester bond.

10.7 Determine the type of α-amino acid – tyrosine:
a) aliphatic;
b) aromatic;
c) heterocyclic;
d) complex.

10.8 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.

10.9 Which of the following is not an amino acid?
a) glutamic acid;
b) aspartic acid;
c) glutamine;
d) palmitic acid.

10.10 What is the abbreviation for the amino acid asparagine?
a) asp;
b) arg;
c) ala;
d) asn.

Topic 11. Peptides and proteins.

11.1 A chain of at least 10 amino acids is:
a) polysaccharide;
b) polypeptide;
c) protein;
d) peptide.

11.2 Many proteins function as:
a) polymers;
b) hormones;
c) substrates;
d) enzymes.

11.3 Which protein carries oxygen throughout the blood:
a) gonadotropin;
b) hemoglobin;
c) insulin;
d) chitin.

11.4 Bonds stabilizing the secondary structure of peptides are:
a) coordination;
b) ionic;
c) hydrogen;
d) hydrophobic.

11.5 The sequence of amino acids in a protein is known as its:
a) primary structure;
b) secondary structure;
c) tertiary structure;
d) quaternary structure.

11.6 Collagen is a _____protein:
a) structural;
b) hormonal;
c) transport;
d) enzymatic.

11.7 Which protein do diabetics lack?
a) collagen;
b) gonadotropin;
c) insulin;
d) chitin.

11.8 Proteins are:
a) polyamides;
b) polymers of ethylene;

c) polymers of propylene;
d) polyalcohols.

11.9 A chain of two or more amino acids is called a _____:
a) peptide;
b) polypeptide;
c) protein;
d) polysaccharide.

11.10 What is the abbreviation for the amino acid tryptophan?
a) thr;
b) ser;
c) tyr;
d) trp.

Topic 12. Nucleic acids.

12.1 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.

12.2 How many parts does a nucleotide have?
a) 1;
b) 2;
c) 4;
d) 5.

12.3 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.

12.4 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.

12.5 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.

*12.6*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.

12.7 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.

12.8 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.

12.9 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.

12.10 RNA is usually:
a) single-stranded;
b) double-stranded;
c) single helix;
d) double helix.

A.2 Questions for midterm examination

Модуль 1. General chemistry.

Topic 1. Solutions.

1.1 Solutions. Classification of solutions.

1.2 The role of water and solutions in the body. Physical and chemical properties of water.

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

1.4 Solubility of liquids and solids in liquids.

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

Topic 2. Colligative properties of solutions.

2.1 Diffusion in solutions.

2.2 Osmosis. Osmotic pressure. Van't-Hoff law.

2.3 Osmotic homeostasis. Isotonic, hypotonic and hypertonic solutions.

2.4 Raoult's law. Consequences of Raoult's law.

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

Topic 3. Equilibrium in aqueous solutions.

3.1 Acid-base concepts. Arrhenius theory of acids and bases. Brønsted-Lowry theory of acids and bases. Conjugate acids and bases.

3.2 Acid and base strength. Strong and weak acids. Strong and weak bases.

3.3 Weak acids and acid ionization constants. Weak bases and base ionization constants.

3.4 Reactions between acids and bases. Neutralization.

3.5 Salt hydrolysis. Types of salt hydrolysis. ATP hydrolysis. Role of hydrolysis in chemical and biochemical processes.

3.6 pH: a measurement scale for acids and bases. Definition of pH. Measuring, calculating pH. The importance of pH and pH control.

Topic 4. Acid-base balance of the organism and buffer systems.

4.1 Acidic-basic buffer solutions.

4.2 Chemical composition of buffer systems. Acidic, basic, amphoteric buffer systems.

4.3 Mechanism of buffer systems function. Acid-base balance in a human organism.

4.4 Bicarbonate buffer, acidosis and alkalosis.

4.5 Hemoglobin buffer – the role in gas exchange in the lungs.

4.6 Globular proteins as buffers.

4.7 Phosphate buffer – the role in kidneys' reabsorption.

4.8 Henderson-Hasselbalch equation.
4.9 Buffer capacity.
4.10 Biological meaning of buffers. The value of buffer solutions in chemistry, biology, medicine.

Topic 5. Complex compounds.
5.1 Coordination compounds. Oxidation number of metals in coordination compounds. Naming coordination compounds.
5.2 The structure of coordination compounds. Werner's coordination theory. The inner and outer spheres of coordination compounds. The central atom, coordination number of metals, ligands and their dentation.
5.3 Classification of coordination compounds.
5.4 Bonding in coordination compounds. The nature of the chemical bond in coordination compounds.
5.5 Reactions of coordination compounds. Participation in metabolic processes.
5.6 Chelating agents. Chelates. Application in medicine. Complexometry.
5.7 Coordination compounds in living systems. Hemoglobin and related compounds.

Module 2. Bioorganic chemistry.
Topic 1. Carboxylic acids and their derivatives.
1.1 General characteristic of carboxylic acids. Classification, nomenclature.
1.2 The structure of a carboxylic group.
1.3 General mechanism of nucleophilic acyl substitution reactions (S_N).
1.4 Reactions involving carboxylic acids. Acid-base reactions. Salt formation of carboxylic acids. Formation of acyl halides, acid anhydrides, esters, and amides. Ester hydrolysis.
1.5 Dicarboxylic acids. Properties.
1.6 Application of carboxylic acids in medicine.

Topic 2. Lipids. Phospholipids.
2.1 Types. Biological functions of lipids.
2.2 Simple lipids: fats, oils, waxes. Structure and composition.
2.3 Fatty acids. Common saturated and unsaturated fatty acids. Structure and properties. Configurational isomers of fatty acids.
2.4 Chemical reactions of fatty acids. Reaction at the double bond (unsaturated fatty acids).
2.5 Chemical properties of triglycerides. Hydrolysis and addition reactions.
2.6 Oxidation of lipids: rancidification and peroxide oxidation.
2.7 Complex lipids. Phospholipids and glycolipids. General characteristic, classification, chemical properties and biological functions.

Topic 3. Carbohydrates. Monosaccharides.
3.1 Types of carbohydrates. Biological role.
3.2 Monosaccharides. Classification: aldoses, ketoses, pentoses, hexoses. Some representatives: ribose, deoxyribose, xylose, glucose, mannose, galactose, fructose.
3.3 Stereoisomerism. Stereoisomers. Stereoisomerism of monosaccharides. Fischer projections. Anomers. The D- and L-system of nomenclature.
3.4 Rotation of plane-polarized light. The relationship between molecular structure and optical activity.
3.5 Cyclic structure of monosaccharides: hemiacetal formation. Cyclo-oxo tautomerism. Haworth projections. Anomers.
3.6 Reactions of monosaccharides: a) ester and ether formation; b) glycoside formation; c) reduction of monosaccharides; d) oxidation of monosaccharides.
3.7 Derivatives of monosaccharides. Deoxy sugars, amino sugars, neuraminic and sialic acids.
3.8 Biologically important monosaccharides and their biological functions.

Topic 4. Carbohydrates. Di-, polysaccharides.

4.1 Oligosaccharides of human milk and their immunomodulating significance.

4.2 Biologically important disaccharides. Reducing and nonreducing sugars.

4.3 Type of glycosidic bonds: α-1,4 and β-1,4.

4.4 Reducing disaccharides: maltose, cellobiose, lactose. Chemical properties.

4.5 Nonreducing sugars: sucrose. Chemical properties. Hydrolysis of sucrose. Inversion of sugar cane.

4.6 Polysacharides. Classification. Biological role.

4.7 Gomopolysaccharides: starch, glycogen, cellulose, dextranes. Composition, structure, chemical properties, hydrolysis reactions.

4.8 Heteropolysaccharides: hyaluronic acid, heparin, chondroitin sulfate. Composition, biological significance.

4.9 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

Topic 5. α-Amino acids.

5.1 α-Amino acids: substrates for protein synthesis.

5.2 Overview of amino acids present in proteins, ionic properties, significance of side chains for protein properties.

5.3 Biogenic amines as biologically active compounds.

5.4 Stereochemistry of amino acids.

5.5 Amino acids as dipolar ions. Isoelectric point (pI) of amino-acids.

5.6 Reactions of amino acids: 1) reactions of the carboxylic group: etherification, reactions with phosphorus halogenides (PCl_5, PCl_3); 2) reactions of the amino group: reactions with formaldehyde, nitrous acid, acetic anhydride.

5.7 Amphoteric properties of amino acids.

5.8 Biologically important reactions of amino acids: deamination, decarboxylation, transamination.

5.9 Qualitative analysis of α-amino acids and their role in the diagnosis of metabolic disorders.

Topic 6. Peptides and proteins.

6.1 Biologically active peptides: glutathione and peptide hormones-oxytocin, vasopressin, insulin, glucagon - their biological function.

6.2 Protein general structure. Organization levels: primary, secondary, tertiary and quaternary structure.

6.3 Chemical bonds and forces involved in maintaining protein spatial arrangement. Structural classes of proteins: contribution of α and β-structures.

6.4 Globular proteins: properties and solubility.

6.5 Fibrous proteins: collagen, keratin, elastin, silk fibroin – association of structure and function.

6.6 Membrane proteins: ways of association with the membrane ways of association with the membrane.

Topic 7. Nucleic acids.

7.1 Structural components of nucleic acids.

7.2 Nucleic bases. Purine (adenine and guanine) and pyrimidine derivatives (cytosine, thymine, uracil).

7.3 Nucleosides and nucleotides.

7.4 Nucleic acids. RNA and DNA: structure, biological significance.

B.1 Typical tasks:

Topic 1. Solutions.

1.1 Calculate how many grams of Na2CO3 is contained in 200 ml of solution with concentration 0,1mol/L.

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

1.3 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?

Topic 2. Colligative properties of solutions.

2.1 The osmotic pressure of blood at 370 C is 7,7 atm. What should the molarity of glucose solution, which is isotonic with blood, be?

2.2 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?

2.3 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?

Topic 3. Equilibrium in aqueous solutions.

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

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

3.3 Write the reactions of hydrolysis of the following salts in the molecular and net ionic forms: $NaNO_3$, K_2CO_3, $CaCl_2$, CH_3COONa. Indicate reaction of the environment.

Topic 4. Acid-base balance of the organism and buffer systems.

4.1 Explain acetate buffer action by adding acid or base.

4.2 Determine the concentration of [H+] ion in a solution with the pH value 4,25.

4.3 Calculate the pH of a buffer solution in which concentrations of acetic acid and sodium acetate are $1{,}0\times10^{-1}$ M, the equilibrium constant, Ka for acetic acid is $1{,}8\times10^{-5}$.

Topic 5. Complex compounds.

5.1 Complete these statements for the complex ion $[Co(en)_2(H_2O)CN]^{2+}$:

a) the term "en" is an abbreviation for _____;

b) the oxidation number of Co is _____;

c) the coordination number of Co is _____;

d) _____is a bidentate ligand.

5.2 Complete these statements for the complex ion $[Cr(C_2O_4)_2(H_2O)]^{2-}$:

a) the oxidation number of Cr is _____;

b) the coordination number of Cr is _____;

c) _____is a bidentate ligand.

5.3 Write formulas for each of these ions and compounds:

a) bis(ethylenediamine)dichlorochromium (III);

b) pentacarbonyliron (0);

c) potassiumtetracyanocuprate (II);

d) tetraammineaquachlorocobalt (III) chloride.

Topic 6. Carboxylic acids and their derivatives.

6.1 Write the formula of the organic product obtained through each of the following reactions:

a) $CH_3CH_2COOH + KOH \rightarrow ?$

b) $CH_3CH_2CH_2COOH + Ba(OH)_2 \rightarrow ?$

c) $CH_3CH_2CH_2CH_2CH_2COOH + KOH \rightarrow ?$

d) Benzoic acid + sodium hydroxide → ?

6.2 List the following compounds in order of increasing acidity:

a) oxalic acid, formic acid;

b) 2-bromopropanoic acid, 3-bromopropanoic acid;
c) acetic acid, acrilyc acid.

6.3 When salicylic acid reacts with acetic anhydride, one of the products is an ester, acetylsalicylic acid. Acetylsalicylic acid is the active ingredient in aspirin. Write the corresponding equation.

Topic 7. Lipids. Phospholipids.

7.1 Write balanced equations showing the hydrogenation of cis-9-hexadecenoic acid and arachidonic acid.

7.2 Write equations for the following esterification reactions:
a) glycerol with two molecules of stearic acid;
b) glycerol with one molecule of myristic acid.

7.3 Draw the structure of the phosphatidate formed between glycerol-3-phosphate that is esterified at C-1 and C-2 with capric and lauric acids, respectively.

Topic 8. Carbohydrates. Monosaccharides.

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

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

8.3 Read the labels on some of the foods in your kitchen. How many products containing one or more carbohydrates among the ingredients in the package can you find? Make a list of these compounds and classify them according to parent structure (e.g., monosaccharides, disaccharides, polysaccharides).

Topic 9. Carbohydrates. Disaccharides and polysaccharides.

9.1 Write the formula of lactose. Point the linkage type. Write the reaction proving the reducing properties of lactose.

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

9.3 Hyaluronic acid is a component of connective tissue; 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.

Topic 10. α-Amino acids.

10.1 Write the structures of aromatic amino acids. Indicate whether you would expect to find each of them on the surface or buried in a globular protein.

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

10.3 Predict the products of the interaction of glycine with:
a) aqueous NaOH; b) aqueous HCl; c) acetic anhydride; d) $NaNO_2$ + HCl; e) $C_2H_5OH + H_2SO_4$.

Topic 11. Peptides and proteins.

11.1 Describe the four levels of protein structure.

*11.2*Describe the forces that maintain the two types of secondary structure: α-helix and β-pleated sheet.

11.3 List five biological functions of proteins.

Topic 12. Nucleic acids.

*12.1*Draw the structures for nucleotides consisting of the following units: a) ribose, adenine, two phosphoryl groups; b) 2/-deoxyribose, guanine, three phosphoryl groups.

12.2 Draw the structures for nucleotides consisting of the following units:
a) 2/-deoxyribose, thymine, one phosphoryl group;

b) ribose, cytosine, three phosphoryl groups;
c) ribose, uracil, one phosphoryl group.

12.3 ATP is the universal energy currency of the cell. What components make up the ATP nucleotide?

Block C

C.2 Individual tasks.

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.

Block D

List of questions and tasks for midterm examination.

Questions to check the level of training: (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.
-Methods of oxidation-reduction titration. - 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. 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.
-Heterogeneous systems. Dispersed phase and dispersion medium. Suspensions, colloids and solutions.
- Methods of colloid purification: dialysis, electro dialysis, compensation dialysis, ultra-filtration.
- Electrical, optical and molecular-kinetic properties of colloids. Tyndall effect.
- The role of colloidal solutions in biology and medicine.
-Polymers. Classification, properties, application.
-Synthetic organic polymers. Addition and condensation reactions.
-Natural polymers. Polysaccharides. Proteins. Nucleic acids.
-Swelling and dissolution of polymers. Mechanism of swelling. Influence of different factors on the process of swelling.
-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.
-General characteristic of carboxylic acids. Classification, nomenclature, isomerism.
-Structure and physical properties of carboxylic acids. The structure of a carboxylic group.
-Reactions involving carboxylic acids. Acid-base reactions. Salt formation.

-General mechanism of nucleophilic acyl substitution reactions (SN). Formation of acyl halides, acid anhydrides, esters, and amides. Ester hydrolysis.
-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.
-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.
-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 (PCl5, PCl3).
-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.
-Synthesis and structure of peptides. 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 the level of training: (skills/expertise)

-Calculate the molarity of a sucrose (table sugar, $C_{12}H_{22}O_{11}$) solution that contains 50 g of sucrose per liter.
-*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 370 C is 7,7 atm. What should the molarity of glucose solution which is isotonic with blood be?
-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?
-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?
-Write the hydrolysis of NH4NO3. Is this salt acidic, basic or neutral in aqueous solution?
-*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?*
-Calculate the pH of a $1{,}0\times10^{-3}$ M solution of HC
-Write the scheme of hydrolysis for 1,2-dipalmito-3-oleoglycerol in acidic and basic solutions.
-Ethanal is produced by oxidation of ethanol. Where does this reaction occur in the body? Write the equation.
-Draw the following sugars using Haworth projections:
a) β-D-galactopyranose; b) α-D-glucofuranose;
c) α-D-fructofuranose; d) β-D-ribofuranose.
-Give the scheme of dehydration of:
a) glycine; b) γ-amino butyric acid; c) β-amino isobutyric acid.
b) Draw the structure for each of the following compounds:
c) a) N-ethylethanamine; b) 3-ethyl-1-(methylamino)pentane;
d) c) 4-amino-2-methylhexane; d) 5-methyl-1-hexanamine;
e) e) methyldipropylamine; f) N,N-dimethyl-3-pentanamine.
-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.
-Structural components of nucleic acids. Nucleic bases. Purine derivatives (adenine and guanine) and pyrimidine derivatives (cytosine, thymine, uracil). Lactime-lactame tautomeric forms.
-Write the formula of disaccharide fragment of amylopectin. Point the linkage type. Write the equation of starch hydrolysis in the presence of acid.

4. METHODOLOGICAL MATERIALS DETERMINING THE PROCEDURE FOR ASSESSING KNOWLEDGE, SKILLS AND (OR) EXPERIENCE THAT CHARACTERIZE THE STAGES OF COMPETENCE DEVELOPMENT

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

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

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.

5. METHODOLOGICAL INSTRUCTIONS FOR STUDENTS ON MASTERING THE DISCIPLINE/PRACTICE AND COMPLETING CONTROL TASKS.

Competence-based educational technologies.

For the organization, of course discipline studying traditional educational technologies are used.
Traditional educational technologies include lectures, practical sessions, and lab practical.
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.
Informational educational technologies mean individual work of students with different resources including computer equipment and internet to solve practical problems and do individual work.

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.

Requirements for performing laboratory work:

- A new worker in a laboratory must have an orientation before starting the work.
- The new worker should be given instructions as to how to operate major equipment including microscope, analytical balance and pH meter.
  The orientation should also include potentials for fire, broken glasses, spill of chemicals, cuts with sharp tools like scalpel, blades, etc. handling hazardous chemicals, UV, disposal of wastes like contaminated media and cleaning up of spills.
  A laboratory report should be prepared for each experiment in the following format:

1) Name: Your name.
2) Title of experiment.
3) Date when experiment was performed.
4) Purpose of experiment.
5) Methods used.

Do not copy methods from manual. Refer to manual and write the method on your own, the way you have conducted the experiment.

Give reference of manual with page numbers.

6) Place a flow chart at the end.

7) Results:

Complete description of what you have observed; include graphs, tables, and photographs.

Each graph, table, figure, etc. should bear a title, a number and legend that contains all information needed to interpret data. Figures and tables should be placed immediately after respective paragraphs of description.

8) Discussion:

Interpret your data starting with a brief introduction which will give the purpose of the experiment and then your observation. If the data can be interpreted in more than one way (even negative ones) indicate all possibilities and mention the one, you think, to be correct. If an experiment did not work, find out what went wrong. Try to correct and mention about it.

9) Conclusions:

Conclude your results in one or two sentences.

10) Give the reference you used for the experiment.

Recommendations for preparing for the test:

When student is preparing for the test, it is necessary to work through the lecture material and the corresponding pages of the textbook, read additional literature, and need to:

- Work through the relevant pages of textbooks and teaching aids;
- Use lecture notes or practice notes;
- Solve situational problems of the module (section);
- Read the instructions for the test. Find out whether points will be deducted for wrong answers and whether you have to answer all of the questions.

-Scan the test to see which questions are worth the most points.
Prioritize the high-point questions, to make sure you get them done.

-Read each question completely.
You may think you know where a question is going, but it's better to be safe than sorry. Also, chemistry questions often have multiple parts. Sometimes you can get hints on how to work a problem by seeing where the question is going. Sometimes you can even find the answer to the first part of a question this way.

COURSE (MODULE) LOGISTICS.

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.

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

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.

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.