Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation

APPROVED
Vice-Rector for Academic Affairs
_____ E.S. Bogomolova
31 August 2021

WORKING PROGRAM

Name of the academic discipline: **ORGANIC CHEMISTRY**

Specialty: ***33.05.01 PHARMACY***

Qualification: ***PHARMACIST***

Department: GENERAL CHEMISTRY

Mode of study: **FULL-TIME**

Labor intensity of the academic discipline: **396 academic hours**

Nizhny Novgorod
2021

The working program has been developed in accordance with the Federal State Educational Standard for the specialty 33.05.01 PHARMACY approved by Order of the Ministry of Science and Higher Education of the Russian Federation No. 219 dated of March 27, 2018.

Developers of the working program:
1.Zhdanovich I.V, Ph.D., Associate Professor,
2.Gordetsov A.S., Doctor of Chemistry, Professor, Head of the Department of General Chemistry.

The program was reviewed and approved at the department meeting (protocol No.1, 26.08.2021)

Head of the Department of General Chemistry,
Doctor of Chemistry, Professor Gordetsov A.S. /Gordetsov A.S./

August 26, 2021

AGREED
Deputy Head of EMA ph.d. of biology _____ Lovtsova L.V.
(signature)

August 26, 2021

1. GOALS AND OBJECTIVES OF MASTERING THE DISCIPLINE

The purpose of the discipline is to prepare students for the assimilation of biomedical and special disciplines, for which, on the basis of modern scientific ideas and in accordance with the requirements of the Federal State Educational Standard of Higher Professional Education, to form knowledge about the patterns of chemical behavior of organic substances and about the relationship between the properties of compounds with their chemical structure, participation in the formation the following competencies:

UK-1: The ability to carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy

GPC-1: the ability to use basic biological, physico-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of medicines.

The tasks of the discipline are:

- study by students of the properties of organic substances;
- acquisition and consolidation of knowledge in the field of synthesis and analysis of organic compounds;
- formation of the ability to use modern methods for establishing the structure of organic compounds;
- acquiring the ability to work in a chemical laboratory using special equipment;
- formation of students' skills in studying scientific chemical literature;
- formation of students' skills for solving problematic and situational problems.

As a result of mastering the discipline, the student must:

Know:

1) principles of classification and nomenclature of the main classes of organic compounds;

2) types of isomerism of organic substances;

3) methods of obtaining and reactivity of the most important organic compounds;

4) chemical and physical methods for the identification of organic compounds;

5) rules for working with organic substances.

Be able to:

1) on the basis of the structure of substances, assign them to certain classes;

2) compile the names of organic compounds using the IUPAC nomenclature rules; build structural formulas of substances by their names;

3) depict the structural and spatial formulas of isomers, name the latter using D, L-, R, S- and E, Z-nomenclature systems;

4) predict methods of obtaining and chemical properties of compounds based on their structure;

5) establish the structure of substances based on their chemical properties and spectral characteristics;

6) describe in general terms and with specific examples the mechanisms of radical, electrophilic and nucleophilic substitution;

7) perform qualitative reactions to functional groups;

8) isolate and purify organic substances, determine their purity.

Possess:

1) the skills of safe work in a chemical laboratory, conducting experimental work using chemical glassware and equipment;
2) choose the optimal routes for the synthesis of given organic compounds;
3) skills of independent work with educational, scientific and reference literature;
4) find and use the necessary information to solve synthetic problems.

2. osition of the academic discipline in the structure of the General Educational Program of Higher Education (GEP HE) of the organization

1.1. The discipline Organic chemistry refers to the core part *(*or *the part formed by the participants of educational relations)* of Block 1 of GEP HE (Academic discipline index). The discipline is studied in III-IV semesters.

1.2. To study the discipline, knowledge, skills and abilities are required that are formed by previous disciplines: general and inorganic chemistry, physics, computer science, mathematics, physical and colloidal chemistry.

1.3. The study of the discipline is necessary for the knowledge, skills and abilities formed by the subsequent disciplines of the professional cycle: biochemistry, toxicological chemistry and such professional disciplines as biological chemistry, pharmaceutical chemistry, pharmacognosy, toxicological chemistry.

3. RESULTS OF MASTERING THE DISCIPLINE AND INDICATORS OF ACHIEVING COMPETENCES:

The process of studying the discipline is aimed at the formation of the following universal (UC), general professional (GPC):

№ п/п	Competence code	The content of the competence (or its part)	Code and name of the competence acquisition metric			
			know	be able to	possess	Evaluation tools
1.	UC-1	the ability to	How to put	Analyze	The methods	Tests,

		carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy	into practice the methods of humanitarian, natural sciences, biomedical and clinical sciences in various types of professional and social activities	socially significant problems and processes	of humanitarian natural sciences, biomedical and clinical sciences	multiply choice tests, colloquia, credits, exams
2.	GPC-1	the ability to use basic biological, physico-chemical, chemical, mathematical methods for the development, research and examination of medicines, the manufacture of medicines	How to apply the basic methods, methods and means of obtaining storage, processing of scientific and professional information; receive information from various sources, including using modern computer tools, network technologies, databases and knowledge	Work with scientific literature analyze information, conduct searches, turn what is read into tool for solving professional problems Use the rules for constructing chemical formulas, graphs, tables using appropriate computer programs, including for creating computer presentations.	Abili ty and willingness to participate in the formulation of scientific problems and their experimenta l implementat ion Com puter programs for constructing chemical and stereochemi cal formulas of organic compounds and other types of illustrative material.	Tests, multiply choice tests, colloquia, credits, exams

4. Sections of the academic discipline and competencies that are formed when mastering them

№ п/п	Competence code	Section name of the discipline	The content of the section in teaching units
1.	UC-1 GPC-1	General concepts of organic chemistry. Structure and reactivity of hydrocarbons.	1.1. Definition of organic chemistry. Development of ideas about the structure of organic compounds. Theory of the structure of A.M. Butlerov, its philosophical essence and development at the present stage. Organic chemistry as a basic discipline in the system of pharmaceutical education.

		Spatial structure of organic compounds. Fundamentals of spectroscopy.	1.2. Classification of organic compounds: functional group and structure of the carbon skeleton as classification features of organic compounds. Main classes of organic compounds. 1.3. Nomenclature of organic compounds. Basic principles of IUPAC nomenclature. The use of radical-functional nomenclature for certain classes of organic compounds. 1.4. Types of chemical bonds in organic compounds. Covalent σ- and π-bonds. The structure of double (C=C, C=O) and triple (C≡C) bonds; their main characteristics (length, energy, polarity, polarizability). 1.5. Mutual influence of atoms in the molecules of organic compounds and methods of its transmission. inductive effect. mesomeric effect. 1.6. Classification of organic reactions: addition, substitution, elimination, rearrangement. The concept of the reaction mechanism - ionic (electrophilic, nucleophilic), free radical. The structure of intermediate active particles (carbocations, carboanions, free radicals). Transition state. 1.7. Classification of organic reactions: addition, substitution, elimination, rearrangement. The concept of the reaction mechanism - ionic (electrophilic, nucleophilic), free radical. The structure of intermediate active particles (carbocations, carboanions, free radicals). Transition state. 1.8. Alkanes. Nomenclature. Structural isomerism. physical properties. Spectral characteristics of alkanes. Ways to get. Natural sources of hydrocarbons. Radical substitution reactions, mechanism. Methods for the formation of free radicals. The structure of free radicals and the factors that determine their stability. Regioselectivity of radical substitution. Isomerization, oxidation and dehydrogenation of alkanes. Vaseline oil, paraffin. 1.9. Cycloalkanes. Nomenclature. Ways to get. small cycles. Electronic structure of cyclopropane (σ-bonds). Features of the chemical properties of small cycles (addition reactions). normal cycles. substitution reactions. Conformations of cyclohexane. Energy difference of cyclohexane conformations (armchair, bath, half-chair). Axial and equatorial connections. 1.10. Alkenes. Nomenclature. Isomerism. physical properties. Spectral characteristics of alkenes. Ways to get. Electrophilic addition reactions, mechanism. The structure of carbocations. Spatial orientation of the connection. Addition of halogens, hydrohalogenation, hydration and the role of acid catalysis. Markovnikov's rule, its modern interpretation (static and dynamic approaches). Substitution reactions to the allyl position. Oxidation of alkenes (hydroxylation, ozonation, epoxidation). catalytic hydrogenation. Identification of alkenes. 1.11. Alkynes. Nomenclature. Isomerism. physical properties. Spectral characteristics of alkynes. Ways to get. Electrophilic addition reactions (hydrohalogenation, addition of halogens). Hydration of acetylene (Kucherov reaction). Comparison of the reactivity of alkynes and alkenes in electrophilic addition reactions. Substitution reactions

			(formation of acetylides) as a consequence of the CH-acid properties of alkynes. Cyclotrimerization of acetylene. Alkyne oxidation. Alkyne identification. 1.12. Conjugation (π-, π-conjugation). Conjugated open circuit systems. Conjugation energy. Conjugated dienes (butadiene, isoprene). Electrophilic addition reactions (hydrohalogenation, addition of halogens). Peculiarities of addition in the series of conjugated dienes. 1.13. Conjugation (π-, π-conjugation). Conjugated open circuit systems. Conjugation energy. Conjugated dienes (butadiene, isoprene). Electrophilic addition reactions (hydrohalogenation, addition of halogens). Peculiarities of addition in the series of conjugated dienes. 1.14. Mononuclear arenas. Nomenclature. Ways to get. aromatic properties. Spectral characteristics of aromatic hydrocarbons. Electrophilic substitution reactions, mechanism, π- and σ-complexes. Halogenation, nitration, sulfonation, alkylation, acylation of arenes. Influence of electron-donating and electron-withdrawing substituents on the direction and rate of the electrophilic substitution reaction. Orientants of the I and II kind, p,π-conjugation. Coordinated and non-coordinated orientation. Chemical properties of benzene homologues. Reactions proceeding with loss of aromaticity: hydrogenation, addition of chlorine. Oxidation. Benzene, toluene, xylenes. Arena identification. 1.15. Condensed arenas. Naphthalene, aromatic properties. Electrophilic substitution reactions (sulfonation, nitration) Orientation of substitution in the naphthalene series. Recovery (tetralin, decalin) and oxidation (naphthoquinones). Anthracene, phenanthrene; aromatic properties. Recovery, oxidation. 1.16. Spatial structure of organic compounds (basics of stereochemistry). Configuration and conformation are the most important concepts of stereochemistry. Elements of symmetry of molecules (axis, plane, center) and symmetry operations (rotation, reflection). Chiral and achiral molecules. Asymmetric carbon atom as a chiral center. Methods for depicting the spatial structure of molecules. Stereoisomerism of molecules with one center of chirality (enantiomerism). Glyceraldehyde as a configuration standard. Fisher projection formulas. Optical activity of enantiomers. Polarimetry as a method for studying optically active compounds. Relative and absolute configurations. D,L- and R,S-systems of stereochemical nomenclature. Racemates. Stereoisomerism of molecules with two or more centers of chirality (enantiomerism, σ- and π-diastereomerism). E,Z-stereochemical series. The difference between the properties of enantiomers and diastereomers. Methods for separating racemates. Conformations. The emergence of conformations as a result of rotation around σ-bonds. Factors that hinder rotation. Relationship of spatial structure with biological activity.
2.	UC-1	The main classes of mono- and	2.1. Halogen derivatives of hydrocarbons. Classification depending on the number and arrangement of halogen atoms,

	GPC-1	polyfunctional organic compounds.	the nature of the hydrocarbon radical. Nomenclature. physical properties. 2.2. haloalkanes and halocycloalkanes. Ways to get. Characterization of carbon-halogen bonds (length, energy, polarity, polarizability). Reactions of nucleophilic substitution; the mechanism of mono- and bimolecular reactions, their stereochemical orientation. Transformation of halogen derivatives of hydrocarbons into alcohols, ethers and esters, sulfides, amines, nitriles. nitro derivatives. Elimination reactions: dehydrohalogenation, dehalogenation. Zaitsev's rule. Competitiveness of nucleophilic substitution and elimination reactions. 2.3. Halogenalkenes. Allyl and vinyl halides, causes of different reactivity in nucleophilic substitution reactions. 2.4. Halogenarenes. Nucleophilic substitution of the halogen in the nucleus. The difference in the mobility of the halogen in the aromatic ring and the side chain. Deactivating and orienting effect of halogen in electrophilic substitution reactions. Ethyl chloride, carbon tetrachloride, chloroform, iodoform, chlorobenzene, benzyl chloride. Identification of halogen derivatives of hydrocarbons. 2.5. Alcohols. Classification according to the number and arrangement of hydroxyl groups, according to the nature of the radical. Nomenclature. physical properties. Spectral characteristics of alcohols. Ways to get. 2.6. Kacidic properties: the formation of alcoholates. Main properties: formation of oxonium salts. Intermolecular hydrogen bonds as a consequence of the amphoteric nature of alcohols. Influence of intermolecular association on physical properties and spectral characteristics. 2.7. Nucleophilic and basic properties of alcohols: obtaining haloalkanes, ethers and esters. Intermolecular and intramolecular dehydration of alcohols. Alcohol oxidation. 2.8. Polyhydric alcohols, features of their chemical behavior. Unsaturated alcohols; prototropic tautomerism of enols. Eltekov rearrangement. Methanol, ethanol, propanols, butanols, benzyl alcohol, ethylene glycol, glycerin, glycerol trinitrate. Identification of alcohols. 2.9. Phenols. Classification according to the number of hydroxyl groups. Nomenclature. physical properties. Spectral characteristics of phenols. Ways to get. Acidic properties: formation of phenolates. Nucleophilic properties of phenol: obtaining ethers and esters. Oxidation of phenols. Electrophilic substitution reactions in phenols: halogenation, nitration, sulfonation, nitrosation, carboxylation, hydroxymethylation. Phenol; 2,4,6-trinitrophenol; α- and β-naphthols; pyrocatechin, resorcinol, hydroquinone. Identification of phenolic compounds. 2.10. Ethers. Nomenclature. physical properties. Ways to get. Basic properties, formation of oxonium salts.

			Nucleophilic cleavage with hydrohalic acids. Oxidation. Introduction to organic hydroperoxides and peroxides. Diethyl ether, anisole, phenetol. The concept of thioalcohols and thioethers. 2.11. carbonyl compounds. Nomenclature. physical properties. Spectral characteristics. Methods for obtaining aliphatic and aromatic aldehydes and ketones. 2.12. Nucleophilic addition reactions, mechanism. Influence of the radical on the reactivity of the carbonyl group. Water connection. Factors determining the stability of hydrated forms. Addition of alcohols, sodium hydrosulfite, hydrogen cyanide, organometallic compounds (formation of primary, secondary and tertiary alcohols). Polymerization of aldehydes; paraform, paraldehyde. 2.13. Addition-cleavage reactions: the formation of imines (Schiff bases), oximes, hydrazones, arylhydrazones, semicarbazones: their use for the identification of aldehydes and ketones. Interaction of formaldehyde with ammonia (hexamethylenetetramine). 2.14. Reactions involving α-CH-acid center. Condensations of aldol and crotonic types, the role of acid and base catalysis. Haloform reaction, iodoform test. 2.15. Oxidation and reduction of aldehydes and ketones. The difference in the ease of oxidation of aldehydes and ketones, Popov's rule. catalytic hydrogenation. Formaldehyde (formalin), acetaldehyde, chloral (chloral hydrate), acrolein, benzaldehyde, acetone, cyclohexanone, acetophenone, benzophenone. Identification of aldehydes and ketones. 2.16. Carboxylic acids. Classification. Nomenclature. physical properties. Spectral characteristics. Ways to get. monocarboxylic acids. The structure of the carboxyl group and the carboxylate ion as p,π-conjugated systems. Acid properties of carboxylic acids; salt formation. Dependence of acidic properties on the nature of the radical. Reactions of nucleophilic substitution at the sp2-hybridized carbon atom; mechanism. Formation of functional derivatives of carboxylic acids. Acylation reactions. Anhydrides and acid halides as active acylating agents. 2.17. Reactions involving the hydrocarbon radical of carboxylic acids. Halogenation according to Gell-Volhard-Zelinsky. Use of α-halogenated acids for the synthesis of α-hydroxy, α-amino-, α, β-unsaturated acids. Formic, acetic, propionic, butyric, isovaleric, acrylic, benzoic acids. 2.18. Esters. Receipt. Esterification reaction, the need for acid catalysis. Acid and alkaline hydrolysis of esters. Interesterification. Ammonolysis of esters. 2.19. Amides of carboxylic acids. Receipt. The structure of the amide group. Acid-base properties of amides. Hydrolysis of amides in acidic and alkaline media. Cleavage by hypobromites. Dehydration to nitriles. Nitriles: obtaining, properties (hydrolysis, recovery); acetonitrile. Hydrazides of carboxylic acids. 2.20. Carbonic acid and its derivatives. Carbamide:

			preparation, properties (formation of salts, decomposition by nitrous acid and hypohalogenites, formation of biuret, hydrolysis). Ureido acids and ureides of acids. 2.21. Dicarboxylic acids; properties as bifunctional compounds. Specific properties of dicarboxylic acids: increased acidity of the first homologues; decarboxylation of oxalic and malonic acids, formation of cyclic anhydrides (succinic, glutaric, maleic acids). Phthalic acid, phthalic anhydride, phthalimide. Phenolphthalein. 2.22. Triacylglycerides (fats, oils). Higher fatty acids as structural components of triacylglycerides (palmitic, stearic, oleic, linoleic, linolenic). The relationship of the consistency of triacylglycerides with the structure of acids. Hydrolysis, hydrogenation, oxidation. Analytical characteristics of fats and oils (iodine number, saponification number). Soaps and their properties. Phospholipids (lecithins, cephalins): structure, relation to hydrolysis, biological significance. Waxes: structure, properties as esters, use in medicine. 2.23. Amines. Classification. Nomenclature. physical properties. Spectral characteristics of amines. Methods for obtaining aliphatic and aromatic amines. Acid-base properties, formation of salts. Dependence of the basic properties of amines on the structure of hydrocarbon radicals and the solvation effect. nucleophilic properties. Alkylation of amines. Acylation as a way to protect the amino group. Opening of the α-oxide ring by amines, formation of amino alcohols. Reactions of primary, secondary and tertiary aliphatic and aromatic amines with nitrous acid. Carbylamin reaction - an analytical test for the primary amino group. The activating effect of the amino group on the reactivity of the aromatic nucleus. Halogenation, sulfonation, nitration of aromatic amines. Methylamine, dimethylamine, trimethylamine, aniline, N-methylanils, N,N-dimethylanilines, toluidines, fenethidines. Amine identification. 2.24. Diazo and azo compounds. Nomenclature. Diazotized reaction. conditions for conducting. The structure of diazonium salts, tautomerism. Reactions of diazonium salts with nitrogen release. Synthetic possibilities of the reaction: replacement of a diazo group by a hydroxy group, an alkoxy group, hydrogen, halogens, a cyano group. Reactions of diazonium salts without nitrogen release: formation of azo compounds, triazenes, phenylhydrazines. Azo coupling as an electrophilic substitution reaction. Coupling conditions with amines and phenols. Use of the azo coupling reaction in pharmacoanalysis.
3.	UC-1 GPC-1	Heterofunctional and natural compounds (carbohydrates, terpenes, steroids).	3.1.HYDROXY ACIDS OF THE ALIPHATIC SERIES. THE MAIN WAYS TO GET. CHEMICAL PROPERTIES AS HETEROFUNCTIONAL COMPOUNDS. SPECIFIC REACTIONS A-. B-, Г-HYDROXY ACIDS, LACTONES, LACTIDES. DECOMPOSITION OF A-HYDROXY ACIDS UNDER THE ACTION OF STRONG MINERAL ACIDS. MONOBASIC (LACTIC), DIBASIC (TARTARIC, MALIC)

			AND TRIBASIC (CITRIC) ACIDS. 3.2. Phenolic acids. Salicylic acid, production method. Chemical properties as a heterofunctional compound. Esters of salicylic acid used in medicine: methyl salicylate, phenyl salicylate, acetylsalicylic acid, p-aminosalicylic acid (PASA). 3.3. Oxoacids. Ways to get. Chemical properties as heterofunctional compounds. Specific properties depending on the location of functional groups. Keto-enol tautomerism of β-dicarbonyl compounds. Aldehydo- (glyoxalic) and ketone acids (pyruvic, acetoacetic). 3.4. Amino acids. Ways to get. Chemical properties as heterofunctional compounds. Specific reactions of α-, β-, γ-amino acids. Lactams, diketopiperazines. β-alanine, γ-aminobutyric acid (aminalon). α-Amino acids, peptides, proteins. The structure and classification of α-amino acids that make up proteins. Stereoisomerism. Chemical properties as heterofunctional compounds. Bipolar structure, formation of chelate compounds. Reactions about nitrous acid, formaldehyde; their use in the quantitative analysis of amino acids. Structural features of the peptide group. Primary structure of peptides and proteins. Partial and complete hydrolysis. Introduction to peptide synthesis and amino acid sequence analysis in peptides and proteins. 3.5. n-Aminobenzoic acid; its derivatives used in medicine: anestezin, novocaine, novocainamide. 3.6. Csulfanilic acid. Preparation, chemical properties. Sulfanilamide (streptocide), production method. The general principle of the structure of sulfanilamide drugs. 3.7. Amino alcohols and aminophenols. Biogenic amines: 2-aminoethanol (colamine), choline, acetylcholine, epinephrine, norepinephrine. p-Aminophenol and its derivatives used in medicine: phenacetin, paracetamol. 3.8. Carbohydrates. General characteristics, distribution in nature, biological significance. 3.9. Monosaccharides. Classification (aldoses and ketoses, pentoses and hexoses). Stereoisomerism. D and L-stereochemical series. Open and cyclic forms. Cyclo-oxo-tautomerism. Oxide ring size (furanose and pyranose). Haworth formulas; α- and β-anomers. Mutarotation. Conformations; the most stable conformations of the most important D-hexopyranoses. 3.10. Chemical properties of monosaccharides. Reactions involving alcohol hydroxyl groups (acylation, alkylation, phosphorylation). Reactions of hemiacetal hydroxyl: reducing properties of addoses, formation of glycosides. Types of glycosides; their relation to hydrolysis. epimerization of monosaccharides. Oxidation of monosaccharides. Obtaining glyconic, glycaric and glycuronic acids. Recovery of monosaccharides to polyols (aldit). Qualitative reactions for the detection of hexoses and pentoses. Pentoses:

			D-xylose, D-ribose, D-2-deoxyribose, D-arabinose. Hexoses: D-glucose, D-galactose, D-mannose, D-fructose. Amino sugars: D-glucosamine, D-galactosamine. Alditol: D-sorbitol, xylitol. D-glucuronic, D-galacturonic, D-gluconic acids. Ascorbic acid (vitamin C). 3.11. Oligosaccharides. The principle of the structure; nomenclature. Reducing and non-reducing disaccharides. Tautomerism of reducing disaccharides. relation to hydrolysis. Maltose, cellobiose, lactose, sucrose. 3.12. Polysaccharides. The principle of construction. Homo- and heteropolysaccharides. Esters and ethers of polysaccharides: acetates, nitrates. The ratio of polysaccharides and their esters to hydrolysis. Starch (amylose, amylopectin), cellulose, glycogen, dextrans, inulin, pectins. 3.13.Terpenes and terpenoids. Isoprene rule. Classification according to the number of isoprene units and according to the number of cycles. Monoterpenes. Acyclic (citral and its isomers), monocyclic (limonene, terpinolene), bicyclic (α-pinene, borneol, camphor) terpenes. Synthesis of camphor from α-pinene and bornyl acetate. Menthane and its derivatives used in medicine: menthol, validol, terpinhydrate.. Diterpenes: retinol (vitamin A), retinal. Tetraterpenes (carotenoids): β-carotene (provitamin A). 3.14. Steroids. The structure of gonan (cyclopentanperhydrophenanthrene). Nomenclature. Stereoisomerism: cis-, trans-joint of cyclohexane rings. α, β-Stereochemical nomenclature, 5 α-, and 5 β-series. Ancestral hydrocarbons of steroids: estran, androstane, pregnane, cholan, cholestane. Cholestan derivatives (sterols): cholesterol, ergosterol; vitamin D2. Cholan derivatives (bile acids): cholic and deoxycholic acids, paired bile acids. Androstan derivatives (androgenic substances): testosterone, androsterone. Estrane derivatives (estrogenic substances): estrone, estradiol, estriol. Pregnane derivatives (corticosteroids): deoxycorticosterone, cortisone, hydrocortisone, prednisolone. Aglycones of cardiac glycosides: digitoxygenin, strophanthidine. The general principle of the structure of cardiac glycosides. Chemical properties of steroids due to functional groups: the formation of derivatives of hydroxyl, carbonyl, carboxyl groups; properties of unsaturated steroids.
4.	UC-1 GPC-1	Heterocyclic compounds. Nucleic acids. Alkaloids.	4.1. Five-membered aromatic heterocycles with one heteroatom: pyrrole, furan, thiophene as π-excess systems. Electronic structure. The concept of a heteroatom of the pyrrole type. Acidophobicity of pyrrole and furan. Acid-base properties of pyrrole. Reactions of electrophilic substitution, orientation of substitution. Features of reactions of nitration, sulfonation and bromination of acidophobic heterocycles. Hydrogenation of pyrrole and furan (pyrrolidine, tetrahydrofuran). Furfurol, semicarbazone 5-nitrofurfurol (furatsilin).

			Benzpyrrole (indole), tryptophan. Porphine as a stable tetrapyrrole aromatic system. 4.2. Five-membered aromatic heterocycles with two heteroatoms: pyrazole, imidazole. thiazole, oxazole as π-amphoteric systems. Electronic structure. The concept of a heteroatom of the pyridine type. Tautomerism of imidazole and pyrazole. Acid-base properties; association formation. Electrophilic substitution reactions in pyrazole and imidazole (nitration, sulfonation, halogenation). Reactions of nucleophilic substitution in thiazole (amination). Pyrazolone-5 and its tautomerism. Medicines based on pyrazolone-5: antipyrine, amidopyrine, analgin. Syntheses of antipyrine and amidopyrine based on diketene. Derivatives of imidazole; histidine, histamine, benzimidazole. dibazol. Thiazolidine. The idea of the structure of penicillin antibiotics. 4.3. Azins. Structure, nomenclature. Pyridine, quinoline, isoquinoline as π-deficient systems. Basic properties. Electrophilic substitution reactions (sulfonation, nitration, halogenation). Deactivating effect of the pyridine nitrogen atom, substitution orientation in pyridine and quinoline. Nucleophilic substitution reactions (amination - Chichibabin reaction, hydroxylation). Lactim-lactam tautomerism of pyridine hydroxy derivatives. Nucleophilic properties of pyridine. Pyridine homologues: α-, β-, γ-picolines; their oxidation. Nicotinic and isonicotinic acids. Nicotinic acid amide (vitamin PP), isonicotinic acid hydrazide (isoniazid), ftivazid. Piperidine. Basic properties. Synthesis of quinoline according to Skraup. 8-Hydroxyquinoline (oxin) and its derivatives used in medicine. 4.4. Piran group. Instability of α-, γ-pyrans. α-, γ-Pyrons. Pyrilium salts, their aromaticity. Benzopyrones: chromone, coumarin, flavone and their hydroxy derivatives. Flavonoids: luteolin, quercetype, rutin. Flavan and its hydroxy derivatives (catechins). Tocopherol (vitamin E). 4.5. Six-membered heterocycles in two heteroatoms. Structure; nomenclature. Representatives of diazines: pyrimidine, pyrazine, pyridazine. Pyrimidine and its hydroxy- and amino derivatives: uracil, thymium, cytosine are components of nucleosides. Lactim-lactam tautomerism of nucleic bases. barbituric acid; production, lactim-lactam and keto-enol tautomerism, acid properties. Derivatives of barbituric acid: barbital, phenobarbital. Thiamine (vitamin B1). 4.6. Condensed systems of heterocycles. Purine: aromaticity. Hydroxy- and amino derivatives of purine: hypoxanthine, xanthine, uric acid, adenine, guanine. Lactim-lactam tautomerism. Acid properties of uric acid, its salts (urates). Methylated xanthines: caffeine, theophylline. theobromine. Qualitative reactions of methylated xanthines. 4.7. Nucleosides, nucleotides. Purine and pyrimidine nucleosides. Structure; nomenclature. The nature of the

			connection of the nucleic base with the carbohydrate residue. Nucleotides. Structure; nomenclature of nucleoside monophosphates. Nucleoside polyphosphates. relation to hydrolysis. Ribonucleic acids (RNA) and deoxyribonucleic acids (DNA). The primary structure of nucleic acids. 4.8. Alkaloids. Chemical classification. Basic properties; salt formation. Alkaloids of the pyridine group: nicotine, anabazine. Alkaloids of the quinoline group: quinine. Alkaloids of the isoquinoline and isoquinoline-phenanthrene groups: papaverine, morphine, codeine. Tropane group alkaloids: atropine, cocaine. Connection of reactivity with the presence of specific functional groups. Identification of alkaloids.

5. Volume of the academic discipline and types of academic work

Type of educational work	Labor intensity		Labor intensity (AH) in semesters	
	volume in credit units (CU)	volume in academic hours (AH)	3	4
Classroom work, including	**5,6**	**202**	**108**	**94**
Lectures (L)	**1,67**	**60**	**28**	**32**
Laboratory practicum (LP)*	**3,94**	**142**	**80**	**62**
Practicals (P)	-	-	-	-
Seminars (S)				
Student's individual work (SIW)	**4,4**	**158**	**72**	**86**
exam	**1**	**36**	**-**	**36**
TOTAL LABOR INTENSITY	**11**	**396**	**180**	**216**

6. Content of the academic discipline

6.1. Sections of the discipline and types of academic work:

№	№ semester	Name of the section of the academic discipline	Types of academic work* (in AH)					Evaluation tools
			L	LP	P	S	SIW	
1	3	General concepts of organic chemistry. Structure and reactivity of hydrocarbons. Spatial structure of organic compounds.	20	80	-	50	150	Multiply choice tests, tests or colloquia, survey, exam

2	3, 4	Main classes of monofunctional organic compounds.	12	18	-	36	66	Multiply choice tests, tests or colloquia, laboratory works, survey, exam
3	4	Heterofunctional and natural compounds. Fundamentals of spectroscopy.	10	18	-	32	60	Multiply choice tests, tests or colloquia, laboratory works, survey, exam
4	4	heterocyclic compounds. Nucleic acids. Alkaloids.	18	26	-	40	84	Multiply choice tests, tests or colloquia, laboratory works, survey, exam
5	4	Exam					36	
		TOTAL	60	142	-	158	396	

* - L – lectures; LP – laboratory practicum; P – practicals; S – seminars; SIW – student's individual work.

6.2. Thematic schedule of educational work types:

6.2.1 Thematic schedule of lectures

№	Name of lecture topics	Volume in AH	
		semester 3	semester 4
1.	Organic chemistry as a basic discipline in the system of pharmaceutical education. Classification, nomenclature of organic compounds. Hybridization of the carbon atom, the structure of hydrocarbons. Covalent σ- and π-bonds, their formation and characteristics.	2	
2.	Fundamentals of stereochemistry of organic compounds. configurations and conformations. D,L-, R,S-, E,Z- rows.	2	
3.	Mutual influence of atoms in organic compounds. Inductive and mesomeric effects, classification of chemical reactions by type and mechanism.	2	
4.	Acid-base properties of organic compounds.	2	
5.	Reactivity of saturated hydrocarbons (alkanes, cycloalkanes).	2	
6.	Unsaturated hydrocarbons (alkenes, alkynes, alkodienes).	2	
7.	Reactivity of aromatic hydrocarbons (mononuclear and polynuclear arenes).	2	

8.	Reactivity, structure, production of halogen derivatives of hydrocarbons. Reactions of nucleophilic substitution and elimination.	2	
9.	Reactivity of alcohols and phenols.	2	
10.	Thiols and thiophenols. Ethers and their thio analogues.	2	
11.	Carbonyl compounds (aldehydes and ketones).	2	
12.	Reactivity of carboxylic acids.	2	
13.	Reactivity of dicarboxylic acids. Features of malonic acid and its ester.	2	
14.	Functional derivatives of carboxylic acids. Complex ethers. Saponifiable lipids.	2	
15.	Functional derivatives of carboxylic acids. Amides. Nitriles. Acid halides. Anhydrides. Hydrazines.		2
16.	Carbonic acid and its derivatives. Sulfonic acids.		2
17.	Amines. Gets and properties.		1
18.	Diazo and azo compounds.		1
19. 20.	Modern physico-chemical methods for establishing the structure. Electronic spectroscopy. infrared spectroscopy. Spectroscopy of nuclear magnetic resonance. Mass spectroscopy. Raman Spectroscopy. Radiography, electronography.		4
21. 22.	Heterofunctional organic compounds. Spatial isomerism.		4
23.	Amino acids. Squirrels.		2
24. 25.	Carbohydrates. Monosaccharides.		4
26.	Carbohydrates. Di-, poly- and heterosaccharides.		2
27.	Biologically active five-membered heterocyclic compounds with one and two heteroatoms.		2
28.	Biologically active six-membered heterocyclic compounds with one and two heteroatoms.		2
29.	Nucleic bases. Nucleosides. Nucleotides.Nucleic acids.		2
30.	Terpenes. Terpenoids. Steroids. Steroid hormones. Alkaloids.		2
	TOTAL (60 AH)	28	32

6.2.2. The thematic plan of laboratory practicums

№	Name of laboratory practicums	Volume in AH	
		Semester 3	Semester 4
1.	Classification, nomenclature of organic compounds. configurations and conformations. D,L-, R,S-, E,Z- rows.	4.2	
2.	Hybridization of carbon atoms. Types of chemical bonds in organic compounds. Fundamentals of stereochemistry of organic compounds.	4.2	
3.	Mutual influence of atoms in molecules of organic compounds. Inductive and mesomeric effects. Conjugation, types of conjugation.	4.2	
4.	Acid-base properties of organic compounds. Nucleophiles. Stability and basicity of nucleophiles. Factors affecting nucleophilicity	4.2	
5.	Control work or colloquium	4.2	

6.	Tripling, nomenclature, isomerism and reactivity of alkanes and cycloalkanes. Laboratory work.	4.2	
7.	Unsaturated compounds. Alkenes, alkynes, alkodienes. Structure, isomerism and reactivity. Reactions of electrophilic and radical addition. Laboratory work.	4.2	
8.	Aromatic hydrocarbons. Aromaticity of benzene homologues and polynuclear arenes. arena properties. Reactions of electrophilic substitution. Laboratory work.	4.2	
9.	Test or colloquium	4.2	
10.	Halogen derivatives of hydrocarbons. Reactions of nucleophilic substitution and elimination. Laboratory work.	4.2	
11.	Hydroxy derivatives. Alcohols and phenols. Thiols, thiophenols. Laboratory work.	4.2	
12.	Ethers and thioethers. Laboratory work.	4.2	
13.	Test or colloquium	4.2	
14.	Carbonyl compounds (aldehydes and ketones). Reactions of nucleophilic addition-elimination. Laboratory work.	4.2	
15.	Carboxylic acids. dicarboxylic acids. Synthesis from ester of malonic acid. Laboratory work.	4.2	
16.	Functional derivatives of carboxylic acids. Carbonic acid. Sulfonic acids. Aliphatic and aromatic. Laboratory work.	4.2	
17.	Azo and diazo compounds. Amines. Amino acids. Squirrels. Laboratory work. Test or colloquium	4.2	
18.	Obtaining bromoethane.	4.2	
19.	Obtaining benzoic acid.	4.2	
1.	Monosaccharides.		3.4
2.	Monosaccharides.		3.4
3.	Oligo- and polysaccharides. Laboratory work.		3.4
4.	colloquium		3.4
5.	Terpenes and terpenoids.		3.4
6.	Abstract protection		3.4
7.	Steroids.		3.4
8.	Abstract protection		3.4
9.	Abstract protection		3.4
10.	Five-membered heterocyclic compounds		3.4
11.	Six-membered heterocyclic compounds.		3.4
12.	Condensed heterocyclic compounds.		3.4
13.	Nucleosides, nucleotides, nucleic acids Laboratory work.		3.4
14.	Abstract protection		3.4
15.	Test or colloquiumAlkaloids of the pyridine group. Quinoline group alkaloids		3.4
16.	Alkaloids of the pyridine group. Quinoline group alkaloids		3.4
17.	Spectral characteristics of organic compounds. Abstract protection		3.4
18.	Spectral characteristics of organic compounds. Abstract protection		3.4
	TOTAL (total 142 AH)	80	62

6.2.3. Thematic plan of practicals: not provided for.

6.2.4. Thematic plan of seminars: not provided for.

6.2.5. Types and topics of student's individual work (SIW)

№	Types and topics of SIW	Volume in AH	
		Semester 3	Semester 4
1.	work with lecture material, providing for the development of lecture notes and educational literature, work with electronic literature;	20	23
2.	doing homework for class;	15	20
3.	preparation for control work;	15	20
4.	preparation for testing online;preparation for testing online;		
5.	work with Internet resources, including for the preparation of the report.	22	23
	TOTAL (total -158 AH)	72	86

6.2.6. Student's research work:

№	Student's research work:	Semester
1.	Acid-base properties of organic compounds. Theories of Bronsted and Lewis. Types of organic acids (OH, SH, NH, CH-acids) and bases (π-bases, n-bases).	3, 4
2	Conformations. The emergence of conformations as a result of rotation around σ-bonds; factors that hinder rotation. Newman's projection formulas. Relationship of spatial structure with biological activity.	
3	Regioselectivity of radical substitution reactions in alkanes.	
4	Fluorocarbons. Features of obtaining and chemical properties. The use of fluorocarbons.	
5	Halogenated hydrocarbons used in medicine: ethyl chloride, iodoform, halothane. Chemical properties used to identify these compounds.	
6	Limit and unsaturated monohydric alcohols: comparison of production methods and properties. Application in medicine and national economy.Thiols: obtaining, properties. Identification of thiols.	
7	Thiols: obtaining, properties. Identification of thiols.	
8	Ethers and sulfides: a comparison of methods of preparation and chemical properties. Identification methods.	
9	Dioxins as by-products of phenol processing, environmental problems of phenol chemistry.	
10	Comparison of production methods and chemical properties of mono- and dibasic carboxylic acids.	
11	Waxes as esters of higher carboxylic acids. Beeswax, spermaceti. Twins: structure, properties, application.	
12	Phospholipids: structure, properties, biological significance.	
13	Carbonic acid and its functional derivatives. Phosgene, chlorocarbon ether, carbamic acid and its esters (urethanes). Urea, ureido acids and ureides of acids. Methods for the determination of urea.	
14	Sulfonic acids: methods of obtaining and properties. Desulfurization of aromatic compounds. Nucleophilic substitution in arenesulfonic acids: obtaining phenols and functional derivatives.	
15	Heterofunctional derivatives of benzene - the founders of drugs. Relationship between structure and pharmacological action.	
16	Glucose as a starting material for the production of sorbitol, calcium	

	gluconate, ascorbic acid. Physical and chemical methods for identification of glucose and products of its transformation.	
17	Synthetic possibilities of Skraup's synthesis - obtaining quinoline and its derivatives.	
18	The concept of π-redundancy and π-deficiency in the chemistry of heterocyclic compounds.	
19	Proteins are the molecules of life: structure, biological role, chemical properties, some hormones and antibiotics as derivatives of peptides.	
20	The phenomenon of tautomerism in organic chemistry: keto-enol, lactim-lactam, cyclo-oxotautomerism. The reasons. Peculiarities of chemical properties of different tautomeric forms.	
21	Asymmetry of biological molecules.	
22	Heterofunctional derivatives of aromatic compounds are the founders of medicines.	

7. Types of assessment formats for ongoing monitoring and mid-term assessment

№	Semester No.	Types of control	Name of section of academic discipline	Competence codes		
					types	number of test questions
1.	3	Current monitoring	Fundamentals of the structure and general laws of the reactivity of organic compounds.	1, 2, 3- Current testing. Testing practical skills. test or colloquium	4	15
2.	3	Current monitoring	Reactivity of hydrocarbons.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium. 3 - Current testing. Oral individual survey.	5	15
3.	3	Current monitoring	Alcohols, phenols, ethers and their thioanalogues.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium. 3 - Current testing. Oral individual survey.	5	13
4.	3	Current monitoring	carbonyl compounds. Carboxylic acids and their derivatives.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium.	5	15

				3 - Current testing. Oral individual survey.		
5.	4	Current monitoring	Carboxylic (mono-, di- and heterofunctional) acids.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium. 3 - Current testing. Oral individual survey.	4	15
6.	4	Current monitoring	Carbohydrates: mono-, di- and polysaccharides.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium. 3 - Current testing. Oral individual survey.	4	15
7.	4	Current monitoring	heterocyclic compounds. Nucleosides, nucleotides, nucleic acids.	1 - Current testing. Oral individual survey. 2 - Current testing. Test work or colloquium. 3 - Current testing. Oral individual survey.	4	15
8.	4	Exam	All topics	Computer testing	12	60 (option is formed by random sampling)
				Exam cards	3	30

8. Educational, methodological and informational support for mastering the academic discipline (printed, electronic publications, the Internet and other network resources)

8.1. Key literature references

№	Name according to bibliographic requirements	Number of copies	
		at the department	in the library
1.	Zurabyan S.E. Fundamentals of bioorganic chemistry:Textbook for medical students. - Moscow 2003,2006.: GEOTAR-MED,-320p.	-	50
2.	Ebbing, D. D. General Chemistry / D. D. Ebbing, S. D. Gammon. – 11th ed. – Australia : Cengage Learning, 2019. – 864 p. : il. – ISBN 978-1-3055-8034-3.	-	50
3.	Zimina, S. V. General chemistry : practical manual / S. V. Zimina, A. S. Gordetsov, I. V. Zhdanovich ; Privolzhsky Research Medikal University, . – N. Novgorod : Publishing House of the Privolzhsky	-	61

	Research Medikal University, 2018. – 194 p.		
4.	Zimina, S. V. Chemistry : practical manual / S. V. Zimina, A. S. Gordetsov, I. V. Zhdanovich. – N. Novgorod : Publishing House of PRMU, 2019. – 194 p.	-	299
5.	Silberberg, M. S. Principles of general chemistry / M. S. Silberberg ; Silberberg Martin S. – 2nd ed. – Boston : McGraw-Hill Higher Education, 2007. – 891 c. : il. – ISBN 978-0-07-017263-0.	-	52
6.	Lister, T. New understanding chemistry for advanced level / T. Lister, J. Renshaw ; Lister, Ted ; Renshaw, Janet. – 3d ed. – Nelson thornes, 2000. – 680 c. : – ISBN 0-7487-3958-0.	-	50

8.2. Further reading:

8.3. Electronic educational resources for teaching academic subjects

8.3.1. Internal Electronic Library System of the University (IELSU)

№	*Name of the electronic resource*	*Brief description (content)*	*Access conditions*	*Number of users*
	General chemistry : practical manual / S. V. Zimina, A. S. Gordetsov, Nizhny Novgorod State Medical Academy, I. V. Zhdanovich ; Zimina, S. V. ; Zhdanovich, I. V. ; Gordetsov, A. S. ; Nizhny Novgorod State Medical Academy. – N. Novgorod : Nizhny Novgorod State Medical Academy, 2008. – Text : electronic.	Practical manual	Free	90

8.3.2. Electronic educational resources acquired by the University

№	*Name of the electronic resource*	*Brief description (content)*	*Access conditions*	*Number of users*
1.	International scientometric database "Web of Science Core Collection"	Web of Science covers materials on natural, technical, social, humanities; takes into account the mutual citation of publications developed and provided by Thomson Reuters; has built-in search, analysis and management of bibliographic information.	Free access from PIMU computers [Electronic resource] - Access to the resource at: http://apps.webofknowledge.com	Free access from PIMU computers

8.3.3 Open access resources

№	*Name of the electronic resource*	*Brief description (content)*	*Access conditions*
1.	Federal Electronic Medical Library (FEMB)	Includes electronic analogues of printed publications and original electronic publications that have no analogues recorded on other media (dissertations, abstracts, books, magazines, etc.). [Electronic resource] – Access mode: http://нэб.рф/	from any computer on the Internet
2.	Scientific electronic library eLIBRARY.RU	The largest Russian information portal in the field of science, technology, medicine and education, containing abstracts and full texts of scientific articles and publications. [Electronic resource] - Access mode: https://elibrary.ru/	from any computer on the Internet
3.	Scientific electronic library of open access CyberLeninka	Full texts of scientific articles with annotations published in scientific journals in Russia and neighboring countries. [Electronic resource] - Access mode: https://cyberleninka.ru/	from any computer on the Internet

9. Material and technical support for mastering an academic discipline

9.1. List of premises for classroom activities for the discipline

1. Lecture hall equipped with multimedia equipment and a microphone.
2. Rooms for laboratory workshops.

9.2. List of equipment for classroom activities for the discipline

1. Multimedia complex (computer and projection equipment)
2. Information stands.
3. Tables and directories.
4. Slides and multimedia presentations of lectures.
5. Chemical glassware (burettes, pipettes, flasks, glasses, refrigerators, chemical reagents).
6. Chemical reagents.
7. Hood.
8. Spirit lamps.
9. Electric stoves.
10. Analytical balance.
11. Water bath.
12. Test tube racks.
13. Reagent racks.
14. Magnetic stirrers..

9.3. A set of licensed and freely distributed software, including domestic production

Item no.	Software	number of licenses	Type of software	Manufacturer	Number in the unified register of Russian software	Contract No. and date
1	Wtware	100	Thin Client Operating System	Kovalev Andrey Alexandrovich	1960	2471/05-18 from 28.05.2018
2	MyOffice is Standard. A corporate user license for educational organizations, with no expiration date, with the right to receive updates for 1 year.	220	Office Application	LLC "NEW CLOUD TECHNOLOGIES"	283	without limitation, with the right to receive updates for 1 year.
3	LibreOffice		Office Application	The Document Foundation	Freely distributed software	
4	Windows 10 Education	700	Operating systems	Microsoft	Azure Dev Tools for Teaching Subscription	
5	Yandex. Browser		Browser	«Yandex»	3722	
6	Subscription to MS Office Pro for 170 PCs for FGBOU VO "PIMU" of the Ministry of Health of Russia	170	Office Application	Microsoft		23618/HN10030 LLC "Softline Trade" from 04.12.2020

10. List of changes to the working program (to be filled out by the template)

Federal State Budgetary Educational Institution of Higher Education
"Privolzhsky Research Medical University"
Ministry of Health of the Russian Federation
(FSBEI HE "PRMU" of the Ministry of Health of Russia)

Department of
General Chemistry

CHANGE REGISTRATION SHEET

working program for the academic discipline
Organic Chemistry

Field of study / specialty / scientific specialty: 33.05.01 "PHARMACY"

Training profile: PHARMACIST

Mode of study: Full-time

Position	Number and name of the program section	Contents of the changes made	Effective date of the changes	Contributor's signature
1				

Approved at the department meeting
Protocol No. 1, of August 26, 2020

Head of the Department
of General Chemistry,
Doctor of Chemistry, Professor Gordetsov A.S /Gordetsov A.S./