

**Summary to the working program of the discipline
"Organic chemistry"**

the main educational program of higher education (specialty) in the specialty 33.05.01 Pharmacy

1. The purpose of mastering the discipline is participation in the formation of the following competencies: UC-1, GPC-1

2. The place of discipline in the structure of the GEP

2.1. The discipline refers to the basic part of block 1 "Disciplines (modules)" of the **GEP HE**. The discipline is studied in III-IV semesters.

3. Requirements for the results of mastering the program of discipline (module) for the formation of competencies

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

№	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 carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy	How to put into practice the methods of humanitarian, natural sciences, biomedical and clinical sciences in various types of professional and social activities	Analyze socially significant problems and processes	The methods of humanitarian natural sciences, biomedical and clinical sciences	Tests, 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.	Ability and willingness to participate in the formulation of scientific problems and their experimental implementation Computer programs for constructing chemical and stereochemical formulas of organic compounds and other	Tests, multiply choice tests, colloquia, credits, exams

					types of illustrative material.	
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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. Spatial structure of organic compounds. Fundamentals of spectroscopy.	<p>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.</p> <p>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.</p> <p>1.3. Nomenclature of organic compounds. Basic principles of IUPAC nomenclature. The use of radical-functional nomenclature for certain classes of organic compounds.</p> <p>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\equivC) bonds; their main characteristics (length, energy, polarity, polarizability).</p> <p>1.5. Mutual influence of atoms in the molecules of organic compounds and methods of its transmission. inductive effect. mesomeric effect.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>1.10. Alkenes. Nomenclature. Isomerism. physical properties.</p>

		<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>1.14. Mononuclear arenes. 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.</p> <p>1.15. Condensed arenes. 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.</p> <p>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</p>
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			<p>depicting the spatial structure of molecules.</p> <p>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.</p> <p>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.</p> <p>Conformations. The emergence of conformations as a result of rotation around σ-bonds. Factors that hinder rotation.</p> <p>Relationship of spatial structure with biological activity.</p>
2.	UC-1 GPC-1	The main classes of mono- and polyfunctional organic compounds.	<p>2.1. Halogen derivatives of hydrocarbons. Classification depending on the number and arrangement of halogen atoms, the nature of the hydrocarbon radical. Nomenclature. physical properties.</p> <p>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.</p> <p>2.3. Halogenalkenes. Allyl and vinyl halides, causes of different reactivity in nucleophilic substitution reactions.</p> <p>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.</p> <p>Ethyl chloride, carbon tetrachloride, chloroform, iodoform, chlorobenzene, benzyl chloride.</p> <p>Identification of halogen derivatives of hydrocarbons.</p> <p>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.</p> <p>2.6. Acidic 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.</p> <p>2.7. Nucleophilic and basic properties of alcohols: obtaining haloalkanes, ethers and esters. Intermolecular and intramolecular dehydration of alcohols. Alcohol oxidation.</p> <p>2.8. Polyhydric alcohols, features of their chemical behavior.</p>

		<p>Unsaturated alcohols; prototropic tautomerism of enols. Eltekov rearrangement.</p> <p>Methanol, ethanol, propanols, butanols, benzyl alcohol, ethylene glycol, glycerin, glycerol trinitrate. Identification of alcohols.</p> <p>2.9. Phenols. Classification according to the number of hydroxyl groups. Nomenclature. physical properties. Spectral characteristics of phenols. Ways to get.</p> <p>Acidic properties: formation of phenolates. Nucleophilic properties of phenol: obtaining ethers and esters. Oxidation of phenols.</p> <p>Electrophilic substitution reactions in phenols: halogenation, nitration, sulfonation, nitrosation, carboxylation, hydroxymethylation.</p> <p>Phenol; 2,4,6-trinitrophenol; α- and β-naphthols; pyrocatechin, resorcinol, hydroquinone.</p> <p>Identification of phenolic compounds.</p> <p>2.10. Ethers. Nomenclature. physical properties. Ways to get. Basic properties, formation of oxonium salts.</p> <p>Nucleophilic cleavage with hydrohalic acids. Oxidation. Introduction to organic hydroperoxides and peroxides.</p> <p>Diethyl ether, anisole, phenetol.</p> <p>The concept of thioalcohols and thioethers.</p> <p>2.11. carbonyl compounds. Nomenclature. physical properties. Spectral characteristics. Methods for obtaining aliphatic and aromatic aldehydes and ketones.</p> <p>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.</p> <p>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).</p> <p>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.</p> <p>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.</p> <p>Formaldehyde (formalin), acetaldehyde, chloral (chloral hydrate), acrolein, benzaldehyde, acetone, cyclohexanone, acetophenone, benzophenone.</p> <p>Identification of aldehydes and ketones.</p> <p>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</p>
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		<p>properties of carboxylic acids; salt formation. Dependence of acidic properties on the nature of the radical.</p> <p>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.</p> <p>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.</p> <p>2.18. Esters. Receipt. Esterification reaction, the need for acid catalysis. Acid and alkaline hydrolysis of esters. Interesterification. Ammonolysis of esters.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Phospholipids (lecithins, cephalins): structure, relation to hydrolysis, biological significance. Waxes: structure, properties as esters, use in medicine.</p> <p>2.23. Amines. Classification. Nomenclature. physical properties. Spectral characteristics of amines. Methods for obtaining aliphatic and aromatic amines.</p> <p>Acid-base properties, formation of salts. Dependence of the basic properties of amines on the structure of hydrocarbon radicals and the solvation effect.</p> <p>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.</p>
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			<p>The activating effect of the amino group on the reactivity of the aromatic nucleus. Halogenation, sulfonation, nitration of aromatic amines.</p> <p>Methylamine, dimethylamine, trimethylamine, aniline, N-methylanils, N,N-dimethylanilines, toluidines, fenethidines. Amine identification.</p> <p>2.24. Diazo and azo compounds. Nomenclature. Diazotized reaction. conditions for conducting. The structure of diazonium salts, tautomerism.</p> <p>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.</p> <p>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.</p>
3.	UC-1 GPC-1	Heterofunctional and natural compounds (carbohydrates, terpenes, steroids).	<p>3.1. HYDROXY ACIDS OF THE ALIPHATIC SERIES. THE MAIN WAYS TO GET. CHEMICAL PROPERTIES AS HETEROFUNCTIONAL COMPOUNDS. SPECIFIC REACTIONS α-, β-, γ-HYDROXY ACIDS, LACTONES, LACTIDES. DECOMPOSITION OF α-HYDROXY ACIDS UNDER THE ACTION OF STRONG MINERAL ACIDS. MONOBASIC (LACTIC), DIBASIC (TARTARIC, MALIC) AND TRIBASIC (CITRIC) ACIDS.</p> <p>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).</p> <p>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.</p> <p>Aldehydo- (glyoxalic) and ketone acids (pyruvic, acetoacetic).</p> <p>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).</p> <p>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.</p> <p>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.</p> <p>3.5. n-Aminobenzoic acid; its derivatives used in medicine: anestezin, novocaine, novocainamide.</p> <p>3.6. Sulfanilic acid. Preparation, chemical properties. Sulfanilamide (streptocide), production method. The general principle of the structure of sulfanilamide drugs.</p>

		<p>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.</p> <p>3.8. Carbohydrates. General characteristics, distribution in nature, biological significance.</p> <p>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.</p> <p>3.10. Chemical properties of monosaccharides. Reactions involving alcohol hydroxyl groups (acylation, alkylation, phosphorylation). Reactions of hemiacetal hydroxyl: reducing properties of aldoses, 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).</p> <p>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.</p> <p>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.</p> <p>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).</p> <p>3.14. Steroids. The structure of gonane (cyclopentanperhydrophenanthrene). Nomenclature.</p>
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			<p>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.</p> <p>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: digitoxigenin, strophanthidine. The general principle of the structure of cardiac glycosides.</p> <p>Chemical properties of steroids due to functional groups: the formation of derivatives of hydroxyl, carbonyl, carboxyl groups; properties of unsaturated steroids.</p>
4.	UC-1 GPC-1	Heterocyclic compounds. Nucleic acids. Alkaloids.	<p>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.</p> <p>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.</p> <p>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.</p>

		<p>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.</p> <p>Synthesis of quinoline according to Skraup. 8-Hydroxyquinoline (oxin) and its derivatives used in medicine.</p> <p>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, quercetyp, rutin. Flavan and its hydroxy derivatives (catechins). Tocopherol (vitamin E).</p> <p>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).</p> <p>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.</p> <p>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.</p> <p>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.</p>
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5. The volume of the academic discipline and types of academic work

The total complexity of the discipline is 11 credit units (216 academic hours)

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