Federal State Autonomic Educational Institution of Higher Education «Peoples' Friendship University of Russia» (RUDN University)

ANNOTATIONS OF DISCIPLINES (MODULES) OF GP HE

The study of disciplines is carried out as part of the development of the general professional educational program of higher education (GP HE)

«Chemistry of heterocyclic compounds (Химия гетероциклических соединений)»
(name (profile/specialization) GP HE)

implemented in the direction of training / specialty:

04.04.01 «Chemistry»
(code and name of the direction of training / specialty)

2022

Discipline name	«Actual problems of modern chemistry»
Scope of discipline, cred/ac.h.	11/396
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction.	Theme 1.1. Genesis of problems in organic chemistry. Various strategies for the search for biologically active organic compounds: targeted synthesis and creation of molecular diversity.
Section 2. Modern methods for the isolation of organic compounds.	Theme 2.1. Classical methods for the isolation of organic compounds (filtration, distillation, recrystallization, extraction, chromatography). Solid phase synthesis. Use of ionic liquids. Perfluorinated systems.
Section 3. Modern approaches to carrying out chemical reactions.	Theme 3.1. The use of microwave irradiation and ultrasound. Flow synthesis. Reagents based on hypervalent iodine.
Section 4. The use of protective groups in organic synthesis.	Theme 4.1. Basic principles for the introduction and removal of protective groups. Hydroxyl protection. Amino group protection. Protection of the carboxyl group.
Section 5. Modern approaches to the development of new synthetic methods.	Theme 5.1. Basic principles of green chemistry, atom economy, industrial chemistry.
Section 6. Introduction to metal complex catalysis.	Theme 6.1. Fundamentals of complex formation. Catalytic hydrogenation methods. Catalytic methods of oxidation. Cross-coupling reactions. Metal-catalyzed reactions of creating C-C bonds and C-heteroatom bonds. C-H Activation.
Section 7. Introduction to organocatalysis.	Theme 7.1. Basic principles of organocatalysis. Reactions catalyzed by Lewis organic bases; Lewis acids; Bronsted bases; Bronsted acids.
Section 8. Cycloaddition reactions in organic synthesis.	Theme 8.1. The most important classes of cycloaddition in organic chemistry. [2+4] Cycloaddition. [2+3] Cycloaddition. Basic principles of click chemistry.

Discipline name	The Foreign (Russian) language in professional activities
Scope of discipline	6 /216
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introductory phonetic-grammar course	Theme 1.1. Pronunciation and spelling
	Theme 1.2. Course of introductory listening and speaking
	Theme 1.3. The formation of the plural of nouns. Expression of request
Section 2. Elementary level	Theme 2.1. The gender of nouns. Possessive pronouns.
	Theme 2.2. Time expression in a simple sentence
	Theme 2.3. The concept of the Russian verb. Instrumental case of nouns.
	Theme 2.4 Instrumental case of nouns. Verb WANT.
	Theme 2.5. A model for the formation of the past tense from verbs with constant stress on the basis.

	Theme 2.6. Model of the formation of the past tense from verbs with variable stress.
	Theme 2.7. Constructions need + infinitive, can + infinitive, What you need (can) + infinitive
	Theme 2.8. The complex future tense of verbs.
	Theme 2.9. The verb to learn in the present, past and future tenses.
	Theme 2.10. The verb to speak in present, past and future tenses. Imperative.
	Theme 2.11. The verb to teach in the present, past and future tenses.
	Theme 2.12. Expression of the absence of the subject (it does not exist). Telephone etiquette.
	Theme 2.13. Constructions I have (was, will be) and I do not have (was not, will not be).
	Theme 2.14. Construction I like it. Comparison of typical contexts for the use of the verbs love and like.
	Theme 2.15. Prepositional case of place.
	Theme 2.16. Expression of time in a simple sentence. Prepositional verbs.
	Theme 2.17. Telephone etiquette. Formation of a simple comparative degree of adverbs.
	Theme 2.18. Instrumental case in the meaning of action compatibility.
	Theme 2.19. General understanding of verbs of motion. Accusative case to indicate the direction of movement.
	Theme 2.20. Group verbs go and walk in the future and past tenses.
Section 3. Basic level.	Systematization of cases. Prepositional case and its meanings. Verbs that require a prepositional case. Genitive case and its meanings. Genitive case with prepositions for, without, from, about, from, at, with, around, past. Verb types. The use of NSV and NE in the past tense, infinitive and imperative.
	Accusative case and its meanings. Transitive verbs. Accusative direction. Verbs of motion with prefixes.
	The dative case and its meanings. Verbs requiring the dative case. Dative case in impersonal constructions. Predicative adverbs denoting the feelings and state of a person.
	Instrumental case and its meanings. Instrumental case in the meaning of an instrument of action. Instrumental case with prepositions with, next to, over, under, next to, in front of, between. Verbs requiring instrumental case.

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction	Theme 1. Methods of organic chemistry as the basis of theoretical and experimental organic chemistry. Classification of reagents: electrophilic, nucleophilic and radical reagents. Classification of reactions in organic chemistry: heterolytic and homolytic reactions. Order of reactions. Types of reactions.
Section 2. Nitration	Theme 2.1. Direct and indirect nitration. Nitrating agents. Nitration of aromatic compounds. The concept of the reaction mechanism. Nitronium cation. Effect of substituents on the nitration of aromatic compounds. Nitration of benzene, toluene, phenol, aniline, naphthalene, benzoic acid, chlorobenzene. Protection of the amino group and aldehyde group during nitration. Side reactions during nitration of aromatic compounds. Nitration of furan, pyrrole, thiophene, pyridine. Nitrocompounds of the aliphatic series. Konovalov's reaction. Parophase. The concept of the mechanism of nitration of aliphatic compounds. Indirect nitration. The reaction of the replacement of a halogen and a sulfo group by a nitro group.
	Theme 2.2. Synthesis of 5-nitrofuran-2-carbaldehyde (5-nitrofurfural)
Section 3. Sulfonation	Theme 3. Sulphonating agents. Sulfonation of aromatic compounds. reversibility of reactions. Influence of sulfuric acid concentration and temperature on the course of sulfonation. Sulfonation of benzene, toluene, phenol, anthraquinone. Influence of catalysts. Obtaining sulfanilic acid. Side reactions during sulfonation. Preparation of sulfonic acid chlorides. Features of isolation and identification of sulfonic acids. Exchange of the sulfo group for H, OH and CN groups. Sulfonation of paraffins and olefins. Sulfochlorination reactions. Sulfonation of heterocyclic compounds.
Section 4. Halogenation	Theme 4.1. Halogenation agents: free halides, hydrohalic acids, phosphorus halides, thionyl chloride, dioxane dibromide, N-bromosuccinimide, dichloromonoxide. Halogenation of aromatic compounds as an electrophilic substitution reaction. The reaction mechanism, the role of the catalyst. Conditions for the introduction of a halogen into the aromatic nucleus and into the side chain. Dichloromonoxide as a selective reagent with respect to benzyl chlorination. The difference in the mechanisms of both reactions and in the properties of the resulting halogen derivatives. Halogenation of heterocyclic compounds. Halomethylation reaction. Radical substitution of hydrogen by halogen. Methods for introducing a halogen into olefins in the allyl position. Thermal chlorination of propylene. Addition of hydrogen bromide to C=C bond in the presence of peroxides (Harash effect).

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	Polyhalogen derivatives. Telomerization reaction and its mechanism. Electrophilic addition of a halogen and hydrogen halides via a multiple bond. Addition of halogens to olefins. Conditions for this reaction and its mechanism. Stereospecificity of the reaction of halogenation of cycloolefins. Addition of halogens to acetylenes and diene hydrocarbons. Hydrohalogenation of olefins. The dependence of the course of this reaction on the nature of the olefin, hydrogen halide, reaction conditions. Markovnikov's rule. Mechanism of the hydrohalogenation reaction. Halogenation of carbonyl compounds. Obtaining α - and β - halogen-substituted carbonyl compounds. haloform reaction. The method of introducing halogens into α - the position of carboxylic acids (Gel-Volhard-Zelinsky reaction). Substitution of halogens in alkyl halides. Mobility of halogens. Hydrolysis of alkyl halides as a nucleophilic substitution reaction. Mechanisms of S_N l and S_N 2. Influence on the rate and type of nucleophilic substitution by various factors: the structure of the starting substance (electronic and spatial factors), the nucleophilic activity of the substituent group, the nature of the substituting group and the solvent.
	Theme 4.2. Synthesis of 1,5-bis(2-hydroxyphenoxy)-3-(oxopentane). Synthesis of crown ether (reaction of catechol with 1,5-dichloro-3-pentane)
Section 5. Reduction of the nitro group	Theme 5. Reduction of the nitro group in the aromatic series. Reduction agents. Reduction in alkaline, neutral and acidic media. The products of incomplete reduction are nitroso compounds, arylhydroxylamines, azoxy-, azo- and hydrazo compounds. Rearrangement of incomplete reduction products. Benzidine and semidine rearrangements. Reduction in an acidic environment. Technical production of aniline. Partial recovery. Obtaining nitroamines, diamines, aminophenols.
Section 6. Amination	Theme 6.1. Introduction of an amino group by replacing a hydrogen atom in an aromatic or heterocyclic ring. Chichibabin reaction. Replacing a halogen with an amino group (Hoffmann reaction). Synthesis of primary amines from potassium halides and phthalimide, halides and urotropine. Synthesis of secondary amines by interaction of halides with metal cyanamides. Replacing a hydroxyl group with an amino group. Reaction conditions. Joint catalytic dehydration of butanediol and ammonia (amines). Replacement of a hydroxyl group with an amino group in the aromatic series (Bucherer reaction). Reactions of ethers and oxides with ammonia and amines. Preparation of ethanolamines. Synthesis of amines from aldehydes and ketones. Reductive amination. Recovery of oximes and Schiff bases. Leuckart reaction. Beckmann rearrangement, its mechanism. Aminomethylation of ketones,

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	phenols, heterocyclic compounds (Mannich reaction). Preparation of amines from acid derivatives. Hoffmann, Curtius, Schmidt rearrangements. Recovery of nitriles.
	Theme 6.2. Synthesis of furfurylideneaniline
Section 7. Reduction of oxygen-containing compounds	Theme 7. General ideas about redox processes in organic chemistry. reductive agents; metals: sodium, sodium amalgam, magnesium, zinc, aluminum; complex metal hydrides: lithium aluminum hydride, alkali metal borohydrides; aluminum alcoholates; hydroiodic acid. Organic reductive agents. Reduction of acids and their derivatives to aldehydes, alcohols and hydrocarbons. Reduction of acid chlorides according to Rosenmund-Zaitsev. Preparation of aldehydes from nitriles and acid hydrazides. Preparation of alcohols from acids and esters by the action of lithium aluminum hydride. Reduction of aldehydes and ketones. Preparation of alcohols by the action of aluminum isopropoxide (Meerwein-Pondorff-Werley). Reduction by the action of sodium, sodium amalgam and amalgamated magnesium. Pinacon formation, reaction mechanism. Cannizzaro reaction, Cannizzaro "cross" reaction. Tishchenko's reaction. Reduction of carbonyl compounds by the action of lithium aluminum hydride and metal borohydrides. Preparation of hydrocarbons from carbonyl compounds by the action of amalgamated zinc (Clemmensen) and hydrazine hydrate (Kizhner). Modifications of the Kizhner reaction. Recovery of α-, β-unsaturated carbonyl compounds. Reduction of quinones.
Section 8. Oxidation	Theme 8. Oxidizing agents: oxygen, ozone; metal oxides - chromic anhydride, manganese dioxide, lead dioxide, osmium tetroxide, silver oxide, selenium dioxide; peroxide compounds: hydrogen peroxide, peracetic and monoperphthalic acid, Caro's acid; salts: potassium permanganate, dichromates, sodium hypochlorite, lead tetraacetate; acids; nitrogen, sulfuric, hypochlorous, iodine. Oxidation of the double carbon-carbon bond. Catalytic production of ethylene oxide. Effect of peracids on olefins (Prilezhaev's reaction). Trans opening of the epoxy ring as an S_N2 reaction. The formation of cis-glycols by the Wagner reaction. Double bond ozonation. Determination of the structure of olefins by ozonolysis. Oxidation of hydrocarbons to alcohols, aldehydes and ketones, acids. Selenium dioxide as a specific reagent for oxidation in the allyl position and for the production of aldehydes. Special cases of hydrocarbon oxidation. cumene process. Formation of cumene hydroperoxide and its decomposition to phenol and acetone. Oxidation of aromatic hydrocarbons to

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	quinones. Obtaining maleic anhydride from benzene and phthalic anhydride from naphthalene. Oxidation of alcohols and diols. Oxidation with a Beckmann mixture; possible side reactions. Oppenauer oxidation. Catalytic dehydrogenation of alcohols. Oxidation of glycols with cleavage of the carbon-carbon bond (lead tetraacetate and iodic acid). Obtaining acids from alcohols. Oxidation of aldehydes and ketones. Autooxidation of benzoic aldehyde. Oxidation of the aldehyde group in carbohydrates. Popov's rule for the oxidation of ketones. Oxidation of ketones by the action of peracids (Bayer-Villiger). The concept of biochemical oxidation.
Section 9. Diazotization	Theme 9. Importance of diazo compounds in organic synthesis and azo dye industry. Diazotization reaction, its mechanism. The role of mineral acid in the diazotization reaction. Diazotization of weakly basic amines and diamines. Various forms of diazo compounds. Reactions of diazo compounds with nitrogen release. Replacing diazo groups with hydrogen, hydroxyl, halides, cyano and nitro groups. Homolytic arylation reactions (Gomberg-Bachmann). Decomposition of double diazonium salts (A.N. Nesmeyanov). Reactions of diazo compounds without nitrogen release. Reduction to arylhydrazines. Azo coupling as an electrophilic substitution reaction. The choice of pH of the medium in azo coupling with amines and phenols. Influence of substituents in the benzene ring on the activity of diazo and azo components in the azo coupling reaction.
Section 10. Alkylation	Theme 10.1. Alkylating agents: alkyl halides, unsaturated hydrocarbons, alcohols. Friedel-Crafts alkylation reaction mechanism. Alkylation catalysts and their activity. Isolation of σ-complexes. Influence of substituents in the aromatic nucleus on the ease of alkylation. Side reactions during alkylation: alkyl radical isomerization, polyalkylation, disproportionation reaction. Reactions of di- and polyhalogen derivatives with aromatic hydrocarbons. Carbenes, their formation, structure. Singlet and triplet methylene. Reactions of insertion of carbenes into CH bonds and addition to olefins. Reactions of carbenes with aromatic compounds (Simmons-Smith reagent).
	Theme 10.2. Synthesis of 1,5-bis(2-hydroxyphenoxy)-3-(oxapentane). Synthesis of crown ether (reaction of catechol with 1,5-dichloro-3-pentane)
Section 11. Acylation	Theme 11.1. Acylating agents. Obtaining ketones by Friedel-Crafts reaction; reaction mechanism. Intramolecular acylation. Preparation of heterocyclic ketones. Synthesis of aromatic aldehydes using carbon monoxide and hydrogen chloride (Gattermann-Koch), hydrocyanic acid and hydrogen chloride (Gattermann), formylation using

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	dimethylformamide and phosphorus oxychloride (Vilsmeier reaction). Obtaining aromatic acids. Synthesis of salicylic acid (Kolbe-Schmitt).
	Theme 11.2. Synthesis of 1-(2-thienyl)ethanone (2-acetylthiophene).
Section 12. Condensation of aldehydes and ketones	Theme 12.1. Aldol and croton condensations. Reaction mechanism, role of catalysts (bases and acids). Comparative activity of aldehydes and ketones. Condensations of aldehydes with malonic acid, esters of halogenated acids, nitro compounds, acetylene, cyclopentadiene, hydrocyanic acid. Condensation of aromatic aldehydes with acid anhydrides (Perkin reaction), with aromatic amines and phenols. Benzoin condensation, its mechanism. Effect of substituents on benzoin condensation.
	Theme 12.2. Synthesis of furfurylideneaniline
	Theme 12.3. Synthesis of 1-phenyl-2-nitropropene
Section 13 Ester Condensation	Theme 13. Synthesis of esters of β-keto acids (Claisen condensation). Reaction mechanism for the synthesis of acetoacetic ester. Condensing agents. Reversibility of the reaction. The use of esters of formic and oxalic acids in the Claisen reaction. Condensation of dicarboxylic acid esters (Dickmann cyclization). Condensation of esters with ketones and nitriles. Acyloin condensation. Ziegler cyclization of dinitriles. The use of acetoacetic ester for the synthesis of ketones and acids.
Section 14. Diene synthesis (Diels-Alder reaction)	Theme 14.1. Diene components of the Diels-Alder reaction. Aliphatic, cyclic and heterocyclic dienes (divinyl and its homologues, cyclopentadiene, cyclohexadiene, furan, vinylcyclohexene). Dienophiles: acrolein, acrylic acid and its derivatives, unsaturated nitro compounds, maleic anhydride, fumaric acid, quinones, acetylenedicarboxylic acid. Influence of electron-donating and electron-withdrawing groups on the activity of diene and dienophile in the Diels-Alder reaction. Reversibility of the Diels-Alder reaction. Structural orientation of diene synthesis. Stereospecificity of the reaction (endo- and exoforms). Reaction conditions, formation of mono- and diadducts (quinones, acetylenedicarboxylic acid). Synthesis of

Discipline name	«Methods of organic chemistry»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	bridge structures (endoxo- and endomethylenecyclohexane systems). Substitutional addition reaction.
	Theme 14.2. Azadiene synthesis: condensation of furfurylideneaniline and dihydrofuran

Discipline name	«Theoretical organic chemistry»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Chemical bond in organic compounds. Electronic effects.	Theme 1.1. Types of chemical bonds. Hybridization. Localized and delocalized chemical bonds. Multicenter bonds. Method of molecular orbitals.
	Theme 1.2. Inductive effect and conjugation effect. The effects of superconjugation. Dependence of effects on the structure of molecules.
Section 2. Acid-base properties and spatial structure of organic compounds.	Theme 2.1. Organic acids and bases, influence of steric and electronic effects on acid-base properties, solvation. The principle of hard and soft acids and bases.
	Theme 2.2. Conformations of acyclic and cyclic molecules. Influence of conformation on reactivity. Chirality and symmetry. Optical activity. Types of chiral molecules. Enantiomers and diastereomers.
Section 3. Mechanisms of organic reactions. Nucleophilic substitution in the aliphatic series, Elimination and addition reactions by multiple bonds.	Theme 3.1. General ideas about the mechanisms of organic reactions. Intermediate particles in transformations of organic compounds. Methods for establishing and studying the mechanisms of organic reactions.
	Theme 3.2. Reactions S_N1, S_N2, S_Ni. Influence of the structure, substrate and reaction conditions on the mechanism. E1 and E1cB mechanisms, E2-mechanism. Factors affecting the mechanism of cleavage reactions. Mechanisms of electrophilic addition at C=C-bond and nucleophilic at C=O-bond. The role of the acidity of the medium upon addition to C=O.
Section 4. Aromaticity. Substitution in the aromatic series. Pericyclic reactions. Rearrangements	Theme 4.1. Types of aromatic systems. Aromaticity criteria. Antiaromatic. Electrophilic substitution: reagents, π- and σ-complexes. Nucleophilic substitution: mechanism of the process, Meisenheimer complexes. Arin mechanism.
	Theme 4.2. [4+2]-Cycloaddition, process synchronism, influence of substituents. Woodward-Hoffmann rules. Rearrangements: nucleophilic, electrophilic and free-radical. Cope and Claisen rearrangements.

Discipline name	«Domino-reactions in the synthesis of heterocycles»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction. Classification of domino reactions	Theme 1.1. The concept of domino reactions. Terminological contradictions – “cascade”, “tandem” and domino processes.
	Theme 1.2. Anionic, cationic, radical, pericyclic domino processes - the principle of referring to one or another type.
Section 2. Anionic domino reactions	Theme 2.1. General description Anion-anion processes, anion-radical reactions. Anionic-pericyclic domino reactions.
	Theme 2.2. Anionic reactions and transition metal catalysis.
Section 3. Cationic domino reactions	Theme 3.1. General characteristics. Cation - cationic processes.
	Theme 3.2. Cationic-pericyclic reactions. Cationic-reductive domino reactions
Section 4. Radical domino reactions	Theme 4.1. General description
	Theme 4.2. Radical-radical domino processes. Radical pericyclic reactions.
Section 5. Multicomponent domino reactions	Theme 5.1. General description. Strecker, Biginelli, Hanch, Ugi, Passerini reactions. Examples of reactions and analysis of mechanisms.
Section 6. Domino reactions based on Knoevenagel condensation	Theme 6.1. General example of a reaction. Study of the mechanism and analysis of typical cases of application.
	Theme 6.2. Various combinations of this reaction with others in the synthesis of more complex structures.
Section 7. Knoevenagel Condensation - Cycloaddition	Theme 7.1. Examples of the combination of the Knoevenagel condensation and various types of cycloadditions ([1+4], [2+3], [2+4]) in the synthesis of five-membered and six-membered heterocyclic compounds.
Section 8. Knoevenagel Condensation - Cycloaddition	Theme 8.1. Examples of the combination of Knoevenagel condensation and Michael addition in the synthesis of five-membered and six-membered heterocyclic compounds.

Discipline name	«NMR of organic compounds»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction and theoretical foundations of the NMR method	Theme 1.1. NMR spectroscopy and its place among physical methods for studying the processes and products of organic chemistry. Elements of the theory of the NMR phenomenon.
	Theme 1.2. The history of the development of the method (I. Rabi, F. Bloch, E. Purcell). Spin numbers and magnetic moment of atoms, Zeeman effect, Larmor frequencies.
	Theme 1.3. Magnetic resonance conditions. Decay of free induction. Times of longitudinal and transverse relaxation.
Section 2. The structure of the NMR spectrometer	Theme 2.1. Types of NMR spectrometers. Schematic diagram of the apparatus. Opportunities.

Discipline name	«NMR of organic compounds»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	Theme 2.2. Description of the method of analysis, the output data obtained after the removal of the spectrum.
Section 3. Parameters of 1H and 13C NMR spectra	Theme 3.1. Solvents used, internal and external standards. Parameters of NMR spectra, their informative value. Width and intensity of the NMR line.
	Theme 3.2. Integration. Chemical shift. Chemical shifts of 1H and 13C nuclei of organic molecules.
	Theme 3.3. The concept of the fine structure of the 1H and 13C NMR spectra, SSCC. Spin-spin interaction.
Section 4. NMR features of various classes of organic compound	Theme 4.1. Characteristic signals in proton and carbon spectra of alkenes, alkynes, arenes, carboxylic acids and carbonyl compounds. Their use to establish structure.
Section 5. Trial Program	Theme 5.1. Acquaintance and basic methods of working in Trial programs: Fourier transform of spectra, adjustment of phases of the 1st and 2nd orders, integration, correlation of signals, editing of spectra, etc.
Section 6. Decoding of 1H spectra of unknown compound	Theme 6.1. Transformation of 1H NMR fids for further work with the spectrum: determination of the spatial structure of organic compounds from the data
Section 7. Decoding of 13C spectra of unknown compounds	Theme 7.1. Transformation of 1H NMR fids for further work with the spectrum: determination of the spatial structure of organic compounds from 13C NMR data.
Section 8. Decoding the spectra of unknown compounds from the totality of NMR data.	Theme 8.1. Transformation of 1H NMR fids for further work with the spectrum: determination of the spatial structure of organic compounds from the totality of 1H and 13C NMR data, taking into account the SSCC values.

Discipline name	«Experimental methods in the chemistry of heterocyclic compounds»
Scope of discipline, cred/ac.h.	21/756
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Fundamentals of safety in the chemical laboratory	Theme 1.1. Basic concepts of safety when working in a chemical laboratory.
	Theme 1.2. Equipment operating principles. Fundamentals of first aid.
Section 2. Current state of research in organic chemistry, comparison of expected results with the world level	Theme 2.1 The choice of the topic of the literature review together with the supervisor. Collection, processing and systematization of literary material. Drawing up a plan for a literary review of a qualifying work.
Section 3. Chemical experiment	Theme 3.1. Discussion of experimental details of performing scientific research. Mastering experimental methods of work in chemical laboratories.
	Theme 3.2. Performing experiments corresponding to the chosen research topic.
	Theme 3.3. Fundamentals of chemical experiment, basic synthetic methods for the preparation and study of

Discipline name	«Experimental methods in the chemistry of heterocyclic compounds»
Scope of discipline, cred/ac.h.	21/756
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	heterocyclic compounds and reactions; methods for recording and processing the results of chemical experiments.
Section 4. Analysis and generalization of the obtained results	Theme 4.1. Analysis and generalization of the obtained results using modern literature data and processing methods.

Discipline name	«Stereochemistry»
Scope of discipline, cred/ac.h..	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction. Basic concepts of stereochemistry	Theme 1.1. Stereochemical features of the atom of carbon, silicon, nitrogen, phosphorus, oxygen, sulfur.
	Theme 1.2. Stereochemical models and formulas.
	Theme 1.3. Conformation. Configuration.
Section 2. Chiropractic phenomena and their structural prerequisites	Theme 2.1. Chirality. Plane polarized light. Polarimetry.
	Theme 2.2. Enantiomerism and diastereomerism. Enantiotopia, diastereotopia. Types of elements of chirality.
Section 3. Racemates	Theme 3.1. Racemates. Classification and properties of racemic mixtures. Methods for the cleavage of racemates.
	Theme 3.2. Racemization. The use of natural optically active substances for the separation of racemates.
Section 4. Nomenclature of spatial isomers.	Theme 4.1. Nomenclature of spatial isomers, enantiomers and diastereomers.
Section 5. Methods for determining the configuration of asymmetric centers. Chiropractic methods.	Theme 5.1. Relative and absolute configuration. Methods for determining the absolute configuration: X-ray diffraction analysis, quasi-racemates, chemical correlation, chiroptic methods (practical application).
	Theme 5.2. Dispersion of optical rotation. Circular dichroism. Cotton effect. DOV and CD curves. Classification of chromophores.
Section 6. Conformations of alkanes. Stereochemistry of SN reactions	Theme 6.1. Conformation of alkanes (ethane, butane), mono- and dihaloalkanes. Conformations of diastereomers.
	Theme 6.2. Stereochemistry of nucleophilic substitution reactions in the series of alkanes, alkyl halides, alcohols.
Section 7. Stereochemistry of reactions for obtaining alkenes and processes of electrophilic addition to the double bond.	Theme 7.1. Alkene nomenclature. Stability and interconversions of stereoisomeric alkenes. Obtaining π-diastereomers.
	Theme 7.2. Stereochemistry of reactions of alkenes (electrophilic addition and oxidation). Addition reactions.
Section 8. Stereochemistry of dienes and cycloalkanes. Triple bond addition reactions.	Theme 8.1. Conjugated dienes. Diene synthesis (Diels-Alder reaction). Cumulenes (allenes, ketenimines). Cycloalkanes: cyclopropane, cyclobutane, cyclopentane, cycloheptane.
	Theme 8.2. Higher cycles. Cyclization reactions, Thorp-Ingold effect. Obtaining alkynes, nucleophilic and electrophilic addition to the triple bond.

Discipline name	«Stereochemistry»
Scope of discipline, cred/ac.h..	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 9. Cyclohexane and its derivatives	Theme 9.1. Cyclohexane. Cycloalkenes and cycloalkynes. Substituted cycloalkanes.
	Theme 9.2. Stereochemical features of reactions in six-membered cycles.
Section 10. Stereochemistry of carbonyl addition reactions	Theme 10.1. Cyclohexanones and their reactions. Syntheses based on carbonyl compounds.
	Theme 10.2. Hydrindane. Dekalin. Rule of Krum, Felkin-On.
Section 11. Spatial structure of bridge and frame systems	Theme 11.1. Stereochemistry of bridged, condensed and framework cyclic systems.
	Theme 11.2. Propellans, rotaxanes, catenanes, Möbius strips.
Section 12. Features of the conformation of saturated oxygen-containing heterocycles	Theme 12.1. Oxygen-containing heterocycles with one and two oxygen atoms.
	Theme 12.2. Optically active nitrogen-containing compounds. Monosaccharides. Spatial structure.
Section 13. Cyclo-chain tautomerism in mono- and disaccharides	Theme 13.1. Cyclo-chain tautomerism. Disaccharides, mutarotation.
Section 14. Conformation, Preparation and reactivity of derivatives with multiple C=N bonds. Saturated nitrogen-containing heterocycles	Theme 14.1. Nitrogen-containing heterocycles. Piperidine and its derivatives. Decahydroquinoline.
	Theme 14.2. Compounds with a C=N (N=N) bond: oximes, hydrazines, azomethines, diazo compounds.
	Theme 14.3. The conformation of amides and their analogues.
Section 15. Stereochemical features in a series of arenes	Theme 15.1. The conformation of aromatic compounds. Optically active compounds of the biphenyl type.
	Theme 15.2. Atropisomerism. Cyclophanes and ansa-compounds. Helicenes. Metallocenes. Molecular propellers. Spirany.
Section 16. Asymmetric synthesis and catalysis. Approaches to enantio- and diastereoselective synthesis.	Theme 16.1. Asymmetric synthesis. Syntheses based on chiral starting materials. asymmetric catalysis. Syntheses in chiral media.
	Theme 16.2. Examples of enantio- and diastereoselective synthesis. Wittig reactions. Electrocyclic reactions. Baldwin rules. Iodolactonization.

Discipline name	«Chemistry of heterocyclic compounds»
Cope of discipline, cred/ac.h..	5/180
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction. Nomenclature of heterocyclic compounds. Small cycles.	Theme 1.1. Classification of heterocycles: according to the size of the cycle, according to heteroatoms, their number and mutual arrangement in the cycle. Heteroatoms of pyrrole and pyridine type.
	Theme 1.2. Heterocycle nomenclature: trivial names; Hantzsch-Wildmann system, IUPAC nomenclature and substitute nomenclature.

Discipline name	«Chemistry of heterocyclic compounds»
Cope of discipline, cred/ac.h..	5/180
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	Theme 1.3. Small cycles: methods of synthesis. Reactions with electrophiles and nucleophiles.
Section 2. Five-membered heterocyclic compounds with one heteroatom	Theme 2.1. Pyrrole, furan, thiophene: characteristics of the electronic structure, aromaticity and reactivity, methods of preparation.
	Theme 2.2. Indole, indolizine: methods of synthesis, reactivity.
Section 3. Five-membered heterocycles with two heteroatoms	Theme 3.1. 1,3-Azoles: imidazole, oxazole, thiazole. Electronic structure and reactivity, methods of synthesis
	Theme 3.2. 1,2-Azoles: pyrazole, isoxazole, isothiazole. Electronic structure and reactivity, methods of synthesis
Section 4. Six-membered heterocyclic compounds	Theme 4.1. Six-membered hetarenes: pyridine, azines and benzazines. Electronic structure, aromaticity and reactivity.
	Theme 4.2. Quinoline, isoquinoline: characteristics of the electronic structure, aromaticity and reactivity, methods of preparation.

Discipline name	«The method of working with databases»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. “Classical” sources of chemical information - abstract journals RZh Chem., Chemical Abstracts, Beilshtein.	Theme 1.1. Acquaintance of students with the main sources of searching for chemical information in the submitted abstract journals, methods of searching for information of interest, the possibilities of presenting and searching for chemical information on the Internet.
	Theme 1.2. Opportunities provided by the electronic version of Chemical Abstracts.
Section 2. Search for patent information in the Chemical Abstracts Patent Index.	Theme 2.1. Acquaintance with the features of the presentation of patent information.
	Theme 2.2. Acquaintance with the peculiarities of searching for patent information.
Section 3. Search for the necessary synthetic methods on the orgsyn server	Theme 3.1. Acquaintance of students with other electronic free sources of scientific information.
	Theme 3.2. Work with the server http://www.orgsyn.org/ and the possibility of searching for methods for the synthesis of compounds of interest.
Section 4. Free electronic versions of organic chemistry journals: ARKIVOC, Beilshtein Journal of organic chemistry, Bulletin of the Korean chemical society.	Theme 4.1. Work with full-text free electronic journals on the net, features of searching for articles of interest in this publication.
	Theme 5.1. Work with full-text journals of the American Chemical Society.

Discipline name	«The method of working with databases»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 5. Site of the American Chemical Society publishing house.	Theme 5.2. Ways to search for information on the ACS website.
Section 6. Patent information	Theme 6.1. Search for patents on the USPTO website
	Theme 6.2. Search for patents on the website of the European Patent Office
Section 7. Search capabilities for chemical information provided by paid services	Theme 7.1. Sci-Finder
	Theme 7.2. Reaxys
Section 8. SCOPUS searching system.	Theme 8.1. Work in the SCOPUS search engine.

Discipline name	«Fundamentals of drug design»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction. Methodological bases for the creation of drugs.	Theme 1.1. Sciences related to the creation and study of drugs. Classification of drugs. Pharmacokinetics and pharmacodynamics. Activity and selectivity of drugs. Absorption, distribution, metabolism and excretion of the drug.
	Theme 1.2. Stages of drug development. Preclinical developments and clinical trials. Strategies for finding the leader connection. The general scheme for creating a drug based on continuous bioscreening. Fragment-oriented design. Ligand- and structure-oriented design. Virtual bioscreening. "*De novo*" design.
Section 2. Targets of drug action. Techniques for modifying the structure of the leader compound.	Theme 2.1. The main types of biomolecules - targets of drug action. General ideas about the spatial structure of proteins and nucleic acids. Three-dimensional models of protein molecules. Protein Data Bank database. Types of biotarget–ligand interaction. Pharmacophore. Lipophilicity.
	Theme 2.2. Modification of functional groups. Homologization. Restriction of conformational mobility and cyclo-chain transformations. Isosteres and bioisosteres. Privileged structures. Peptidomimetics. Structural modifications to increase oral bioavailability. Lipinsky's rule. The principle of prodrugs. Feedback in the regulation of biosynthesis. The principle of antimetabolites in the speculative design of drugs. Sulfonamide antibiotics. Antifolates in cancer therapy.
Section 3. Design of drugs acting on biological membranes.	Theme 3.1. The structure of biological membranes. Detergents, ionophores, channel-forming compounds as antimicrobials and antiseptics.
	Theme 3.2. The mechanism of nerve impulse conduction. Drugs for anesthesia. Local anesthetics.

Discipline name	«Fundamentals of drug design»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 4. Design of drugs acting on protein molecules.	Theme 4.1. Medicinal substances - enzyme inhibitors: irreversible, reversible competitive and allosteric. Penicillins are bacterial transpeptidase inhibitors. β-lactamase inhibitors. Organophosphorus compounds are nerve poisons and acetylcholinesterase reactivators. HIV protease inhibitors.
	Theme 4.2. Receptors. Classification of receptors. Agonists, partial agonists and antagonists. Affinity. Techniques for creating agonists and antagonists. acetylcholine receptors. Amino acids and biogenic amines as receptor ligands.

Discipline name	«Experimental methods in organic chemistry»
Scope of discipline, cred/ac.h.	21/756
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Fundamentals of safety in the chemical laboratory	Theme 1.1. Basic concepts of safety when working in a chemical laboratory with various substances.
	Theme 1.2. Principles of operation of the equipment. First aid basics.
Section 2. Current state of research in organic chemistry, comparison of expected results with the world level	Theme 2.1. Choosing a literature review topic together with the supervisor. Collection, processing and systematization of literary material. Drawing up a plan for a literary review of a qualifying work.
Section 3. Chemical experiment	Theme 3.1. Discussion of experimental details of performing scientific research. Mastering experimental methods of work in chemical laboratories.
	Theme 3.2. Performing experiments corresponding to the chosen research topic.
	Theme 3.3. Fundamentals of a chemical experiment, basic synthetic methods for obtaining and studying chemicals and reactions; methods for recording and processing the results of chemical experiments.
Section 4. Analysis and generalization of the obtained results	Theme 4.1. Analysis and generalization of the obtained results using modern literature data and processing methods.

Discipline name	«Fundamentals of pharmaceutical chemistry»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Introduction. Nomenclature, classification of drugs.	Theme 1. History of occurrence, definition, areas of research and objects of pharmaceutical chemistry. Classification of drugs. International non-proprietary names (INN) of medicinal substances.
Section 2. Sources and methods for the synthesis of drugs.	Theme 2. Isolation of drug substances from natural raw materials; inorganic raw materials; herbal medicinal raw materials, raw materials of animal origin. Biological synthesis

Discipline name	«Fundamentals of pharmaceutical chemistry»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	of medicinal substances. Thin organic synthesis of medicinal substances and prospects for its development.
Section 3. Methods for the study of drugs.	Theme 3. Pharmaceutical analysis. Chemical and physico-chemical methods. Qualitative and quantitative analysis. UV and IR spectroscopy, NMR spectroscopy, mass spectrometry. Thin layer chromatography, gas and high performance liquid chromatography.
Section 4. Inorganic drug substances.	Theme 4. Oxygen and peroxides. Iodine and its alcohol solutions. Salts of alkali and alkaline earth metals. Aluminum compounds. Boron compounds. Silver nitrate, collargol, protargol, copper sulfate. Complex compounds of iron and platinum.
Section 5. Organic drug substances. Aliphatic and alicyclic compounds.	Theme 5. Halogen derivatives. Aldehydes and their derivatives. Carbohydrates. Carboxylic acids and their derivatives. Lactones of unsaturated polyhydroxycarboxylic acids. Amino acids and their derivatives. Antibiotics as drugs. Aminoglycosides. macrolides and azalides. Terpenes.
Section 6. Organic drug substances. Aromatic compounds. Heterocyclic compounds of natural and synthetic origin.	Theme 6. Phenols, quinones and their derivatives. Derivatives of naphthoquinones (vitamins of K group). Aromatic acids and their derivatives. Benzoic, salicylic, phenylacetic acids and their derivatives. Aminobenzoic acids and their derivatives. Anestezin. Novocaine. Dekain. Benzenesulfonamides and their derivatives. Oxygen-containing heterocycles. Furan derivatives. Derivatives of pyrrole and tetrahydropyrrole. Derivatives of pyrazole, imidazole and imidazoline. Derivatives of pyridine and quinoline. Quinine, quinidine and their salts. Isoquinoline derivatives. Pyrimidine and phenothiazine derivatives. Benzodiazepines.

Discipline name	«Molecular spectral analysis»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Principles of molecular spectral analysis	Theme 1.1. Electromagnetic spectrum. Basic characteristics of radiation. Interaction of radiation with matter. Main features of atomic and molecular spectra.
	Theme 1.2. Classification of methods of molecular spectral analysis. Significance of molecular spectral analysis in chemistry.
Section 2. Principles of IR spectroscopy	Theme 2.1. Features of the structure of polyatomic molecules. Hooke's law and the Schrödinger equation as applied to polyatomic molecules. The main tasks of the theory of vibrations of molecules. Vibrations of a polyatomic molecule as an interconnected system. The number of possible oscillations. Normal oscillations and their properties. Classification of normal vibrations.
	Theme 2.2. Symmetry of molecules. Elements of the classical theory of infrared absorption spectra. Fundamentals of the

Discipline name	«Molecular spectral analysis»
Scope of discipline, cred/ac.h.	3/108
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
	classical theory of Raman scattering. Selection rules. Frequency characteristic in the vibrational spectrum of a molecule. Peculiarities of Quantum-Chemical Consideration of Vibrations of Polyatomic Molecules.
Section 3. Principles of quantitative IR spectroscopy	Theme 3.1. Law of light absorption. Methods for representing spectrophotometric quantities. Instrumental and physico-chemical causes of deviation from the Bouguer-Lambert-Beer law. Factors determining the integrated intensity of absorption bands in infrared spectra. Extrapolation method of Burgen and others. Method of direct integration. Amendment method
	Theme 3.2. On the accuracy of measuring the intensities of infrared absorption bands. Absolute intensities in the infrared spectra of molecules.
Section 4. Practical aspects of measuring IR spectra	Theme 4.1. General characteristics of spectrometers for the analysis of IR spectra. Sources of radiation. Monochromators. Infrared receivers. Amplifying and recording devices. Modern models of infrared spectrometers. Calibration of prism spectrometers.
	Theme 4.2. Sample preparation technique for analysis.
Section 5. IR spectroscopy of organic compounds	Theme 5.1. IR spectroscopy of saturated hydrocarbons, olefinic hydrocarbons, acetylenic hydrocarbons, aromatic hydrocarbons, halo-organic compounds, carbonyl- and hydroxyl-containing compounds, amines.
Section 6. Principles of UV spectroscopy	Theme 6.1. The nature of the EAS (electronic absorption spectra). Classification of electronic transitions in a molecule and their assignment. EAS band intensities and selection rules.
	Theme 6.2. The concept of chromophores, auxochromes and conjugated chromophores.

Discipline name	«Mass spectrometry of organic compounds»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 1. Principles of fragmentation of medicinal organic compounds under conditions of electron ionization (IE)	Theme 1.1. Basic methods of ionization and separation of ions in mass spectrometry.
	Theme 1.2. The main mechanisms of bond breaking and splitting of organic compounds under the conditions of mass spectrometry with electron ionization, possible rearrangement processes. Basic mass spectral rules.
Section 2. Fragmentation of hydrocarbons under IE conditions	Theme 2.1 Characteristic features of the fragmentation of alkanes, alkenes, alkynes, cycloalkanes, aromatic hydrocarbons under the conditions of mass spectrometry with electron ionization.
Section 3. Fragmentation of heterocyclic compounds under IE conditions	Theme 3.1. Characteristic features of the fragmentation of nitrogen-, oxygen- and sulfur-containing aliphatic and aromatic heterocyclic compounds under the conditions of mass spectrometry with electron ionization, ortho-effect.

Discipline name	«Mass spectrometry of organic compounds»
Scope of discipline, cred/ac.h.	4/144
CONTENT OF THE DISCIPLINE	
Sections	**Themes**
Section 4. Fragmentation of halogen derivatives under IE conditions	Theme 4.1. Characteristic features of the fragmentation of halogen derivatives under the conditions of mass spectrometry with electron ionization.
	Theme 4.2. Polyisotope elements and calculation of their content.
Section 5. Fragmentation of compounds with an amino group under IE conditions	Theme 5.1. Characteristic features of the fragmentation of aliphatic and aromatic amines under the conditions of mass spectrometry with electron ionization. Using derivatization to study amines with GC/MS.
Section 6. Fragmentation of compounds with a hydroxyl group under IE conditions	Theme 6.1. Characteristic features of the fragmentation of aliphatic alcohols and phenols, dialkyl, alkyl aryl and diaryl ethers under conditions of mass spectrometry with electron ionization.
	Theme 6.2. Analogies between electron ionization and tandem mass spectrometry.
Section 7. Fragmentation of compounds with a carboxyl group under IE conditions	Theme 7.1. Characteristic features of the fragmentation of carboxylic acids, alkyl and aryl esters, phthalic acid derivatives under conditions of mass spectrometry with electron ionization.
Section 8. Fragmentation of compounds with several functional groups under IE conditions	Theme 8.1. Characteristic features of the fragmentation of amino acids and their derivatives under the conditions of mass spectrometry with electron ionization.
	Theme 8.2. Use of Husek's reagents for the analysis of amino acids and protozoan peptides by GC/MS. Analysis of hydroxy and oxo acids.

HEAD OF GP HE:

Dean of Science faculty, Chief of the Department of organic chemistry		**L.G. Voskressensky**
Position, BEU	signature	Full name