

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

BANK OF ASSESSMENT TOOLS FOR DISCIPLINE

ORGANIC CHEMISTRY

Training program (specialty): 33.05.01 PHARMACY

Department: General Chemistry

Mode of study: full-time

Nizhniy Novgorod
2021

Bank of assessment tools for the current monitoring of academic performance, mid-term assessment of students in the discipline "Organic Chemistry"

This Bank of Assessment Tools (BAT) for the discipline "Organic Chemistry" is an integral appendix to the working program of the discipline "Organic Chemistry". All the details of the approval submitted in the WPD for this discipline apply to this BAT.

(Banks of assessment tools allow us to evaluate the achievement of the planned results stated in the educational program.

Assessment tools are a bank of control tasks, as well as a description of forms and procedures designed to determine the quality of mastering study material by students.)

A list of competencies indicating the stages of their formation in the process of mastering the educational program and the types of evaluation tools

№	Controlled sections (topics) of the discipline	Controlled competency code	Learning outcomes by discipline	Name of the evaluation tool	
				form	amount
1	General concepts of organic chemistry. Spatial structure of organic compounds. Structure and reactivity of hydrocarbons.	UC-1, GPC-1	Know General concepts of organic chemistry. Structure and reactivity of hydrocarbons. Spatial structure of organic compounds. Fundamentals of spectroscopy. Be able to Classify organic compounds. Compose formulas of structural and spatial isomers. Give names to organic compounds basic principles of IUPAC nomenclature. Distinguish types of chemical bonds in organic compounds. Determine inductive and mesomeric effects. Own Skills for safe work in a chemical laboratory and the ability to handle chemical glassware, reagents. Basic information conversion technologies, text and spreadsheet editors, Internet techniques for professional activities; The ability to measure the rate of chemical reactions.	Tests Test No. 1 "Fundamentals of the structure and general patterns Reactivity of organic compounds" Test No. 2 "Relationship between the structure and reactivity of hydrocarbons"	65 15 options with 4 tasks each 15 options with 5 tasks each
2	Main classes of monofunctional organic compounds.	UC-1, GPC-1	Know the genetic relationship of halogen-substituted derivatives with derivatives of other classes due to their	Tests Examination No. 3 "Halogen derivatives of hydrocarbons" Alcohols, phenols,	55 15 options with 5 tasks each

			<p>high reactivity, the structure and properties of alcohols, phenols, thiols and their derivatives, the structure of the carbonyl group. Know the chemical properties of aldehydes and ketones, the properties of carboxylic acids and their role in biochemical processes, explain the reactivity of carboxylic acids based on the structure of the carboxyl group</p> <p>Be able to determine the directions of chemical reactions, compare the reactivity of aldehydes and ketones and show differences in chemical properties, the main types of chemical reactions, classify organic acids according to the radical, the number of carboxyl groups.</p> <p>Own The skills of predicting the properties of halogen derivatives, alcohols, phenols, thiols and their derivatives, classification, nomenclature (systematic, rational, trivial) for aldehydes and ketones.</p>	<p>ethers and their thioanalogues.</p> <p>Examination No. 5 “Carbonyl compounds. Carboxylic acids and their derivatives</p>	<p>70</p> <p>15 options with 4 tasks each</p>
3	Carboxylic (mono-, di- and heterofunctional) acids	UC-1, GPC-1	<p>3nat theoretical material on the chemistry of heterofunctional derivatives of oxo-, hydroxy- and other derivatives</p> <p>Be able to present the results of experiments and observations</p> <p>own n skills in predicting the properties of heterofunctional derivatives</p>	<p>Tests</p> <p>Examination No. 5 “Heterofunctional derivatives of carboxylic acids. Amino acids»</p>	<p>60</p> <p>15 options with 4 tasks each</p>

4	heterocyclic compounds. Nucleosides, nucleotides, nucleic acids.	UC-1, GPC-1	<p>Know structure of carbon and nitrogen atoms; classification of heterocyclic compounds, nucleosides, nucleotides, nucleic acids, chemical properties of heterocyclic compounds, their biomedical significance</p> <p>Be able to Compose formulas of heterocyclic compounds, nucleosides, nucleotides, nucleic acids.</p> <p>Own Skills for safe work in a chemical laboratory and the ability to handle chemical glassware, reagents. Basic information conversion technologies, text and spreadsheet editors, Internet techniques for professional activities.</p>	<p>Tests</p> <p>Examination No. 6 "Heterocyclic compounds. Nucleosides, nucleotides, nucleic acids."</p>	29 16 options with 4 tasks each
5	CARBOHYDRATES: mono, di and polysaccharides.	UC-1, GPC-1	<p>Know structure and classification of mono, di and polysaccharides, chemical properties of mono, di and polysaccharides, their biomedical significance</p> <p>Be able to Formulate mono, di and polysaccharides.</p> <p>Own Skills for safe work in a chemical laboratory and the ability to handle chemical glassware, reagents. Basic information conversion technologies, text and spreadsheet editors, Internet techniques for professional activities.</p>	<p>Tests</p> <p>Examination No.7 "CARBOHYDRATES: mono, di and polysaccharides."</p>	30 16 options with 4 tasks each

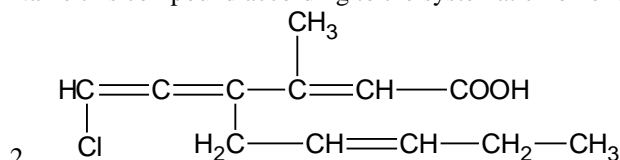
Test tasks for second-year students of the Faculty of Pharmacy in the discipline:

" ORGANIC CHEMISTRY".

Intermediate and boundary control.

**TOPIC 1: "BASICS OF STRUCTURE AND GENERAL REGULARITIES
REACTIVITY OF ORGANIC COMPOUNDS»**

1. a) Name this compound according to the systematic nomenclature:



- b) The systematic name of sarcocollin is
2-amino-3-(4-[bis(2-chloroethyl)amino]phenyl)propanoic acid.

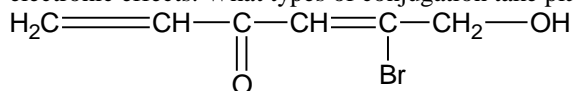
Give its structure. Select the parent structure in the molecule. Label and name the functional groups.

2. Do the presented compounds have spatial isomers?

- a) $\text{ClCH}=\text{CH}-\text{CH}_2\text{CH}_2\text{Cl}$
 b) $\text{ClCH}_2-\text{CH}_2-\text{CH}(\text{OH})-\text{C}(\text{O})\text{OH}$
 c) $\text{CH}_3-\text{CH}(\text{OH})-\text{CH}(\text{OH})-\text{CH}_3$

Give the structures of isomers and give them systematic names taking into account the spatial structure (R,S nomenclature).

3. Designate graphically electronic effects of functional groups in the given molecule. Indicate the type and sign of electronic effects. What types of conjugation take place in a molecule. Identify basic and acid sites.



4. Draw the conformations of the compound using Newman's formulas $\text{ClCH}_2-\text{C}(\text{CH}_3)_2-\text{C}(\text{O})\text{OH}$, arising from rotation around a bond C1-C2. Compare the stability of the above conformations.

TOPIC 2: "INTERRELATION OF THE STRUCTURE AND REACTIVITY OF HYDROCARBONS"

1. Choose the correct answer. Alkanes can be obtained:

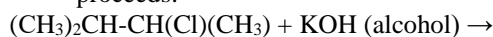
1. Hydrogenation of alkenes	A. Only 1,2 and 3
2. Wurtz reaction	B. Only 4 and 5
3. Recovery alkyl halides	C. Only 2,3 and 4
4. Alkyne hydration	D. Only 1 and 4
5. Oxidation of alkenes	E. All

Give examples of all possible reactions

2. What structure do the initial alkene, alkyne and alkadiene have, if at their interaction with hydrogen chloride in equimolecular amounts are formed, respectively the following products:
 3-methyl-2-chloropentene-1, 3-methyl-4-chloropentene-1, 3-methyl-2-chloropentane.
 3. Write at least three reactions for the preparation of acetylene.
 4. Compare reactivity in electrophilic substitution reactions the following pairs of compounds: aniline and benzene; chlorobenzene and toluene; benzene and benzaldehyde; benzoic acid and phenol.
 5. Describe the mechanism of toluene sulfonation step by step.

TOPIC 3: «HALIDEDERIVATIVES OF HYDROCARBONS. ALCOHOLS, PHENOLS, ETHERS AND THEIR THIO ANALOGUES»

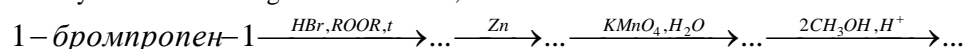
1. Give the reaction scheme and analyze the mechanism by which it proceeds:



2. Write a reaction scheme for the production of phenol by cumene oxidation.

3. Write a reaction scheme for the qualitative detection of hydroperoxides.

4. Carry out the following transformations, indicate the reaction mechanisms:



5. Name compounds according to international nomenclature:

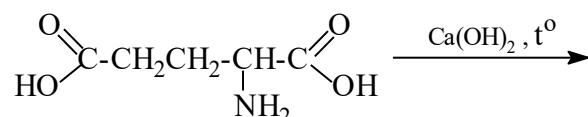
- a) $\text{CH}_3-\text{CH}(\text{CH}_3)-\text{CH}_2-\text{S}-\text{S}-\text{CH}_2\text{CH}_3$;
 b) $\text{CH}_3-\text{O}-\text{CH}_2-\text{SH}$.

TOPIC 4: «CARBONYL COMPOUNDS. CARBOXY ACIDS AND THEIR DERIVATIVES»

1. What carboxylic acids are present in vitamin F? Give formulas and names of acids.
2. Write the reaction equation for the production of glycerol linoleodiolate. By what mechanism does it proceed? Write the scheme of its alkaline hydrolysis.
3. How to determine the presence of glycerol in a fat hydrolyzate. Give the reaction scheme.
4. Give the equations of chemical reactions proving the unsaturation of dilinolenobutyrate. By what mechanism do they proceed? Give an example.
5. Write the structural formula of phosphatidylcholine containing residues of palmitic, oleic acids. And the mechanism of education.

TOPIC 5: "CARBOXY (MONO-, DI- AND HETEROFUNCTIONAL) ACIDS"

1. Optical isomerism of lactic acid.
2. Difference between α , β and γ -amino acids.
3. Hydrolysis of urea.
4. Implement reaction:



TOPIC 6: "HETEROCYCLIC COMPOUNDS. NUCLEOSIDES, NUCLEOTIDES, NUCLEIC ACIDS»

1. Pyrrole and pyridine. Electronic structure and properties. General and differences.
2. Pyrrole and pyridine nitrogen atoms in imidazole.
3. DNA nucleotides: 5'-uridyl, 5'-guanyl, 5'-thymidyl. The chemical meaning of complementarity.
4. Write the compound whose acid hydrolysis yielded phosphoric acid, ribose, and guanine in the ratio 1:1:1. Indicate ester and glycosidic bonds. State the mechanism by which the reaction proceeds.

TOPIC 7: "CARBOHYDRATES: MONO-, DI- AND POLYSUGAR"

1. Structure, tautomerism and chemical properties of maltose.
2. Scheme of the reaction for the formation of 1,6-diphosphate- \square -fructofuranose.
3. Cyclo-oxo tautomerism and reducing ability of cellobiose.
4. Connective tissue polysaccharides. The structure of hyaluronic acid.

Final control

Questions for the exam in the discipline "Organic Chemistry"

1. Definition of organic chemistry. Theory of the structure of A.M. Butlerov. Organic chemistry as a basic discipline in the system of pharmaceutical education.
2. Classification of organic compounds. Functional group and structure of the carbon skeleton as classification features of organic compounds. Main classes of organic compounds.
3. Nomenclature of organic compounds. Basic principles of the IUPAC nomenclature (substitutive and radical-functional nomenclature).
4. Types of chemical bonds in organic compounds. Covalent σ - and π -bonds. The structure of double (C=C, C=O, C=N) and triple bonds; their main characteristics (length, energy, polarity, polarizability).
5. Mutual influence of atoms in the molecules of organic compounds and methods of its transmission. inductive effect. Conjugation (π , π - and p, π -conjugation). Conjugate systems with open and closed circuit. Conjugation energy. mesomeric effect. Electron donor and electron acceptor substituents. Resonance theory as a qualitative way to describe the electron density delocalization.
6. Spatial structure of organic compounds. Configuration and conformation are the most important concepts of stereochemistry.
7. Configuration. Types of molecular models. stereochemical formulas. Chiral and achiral molecules. Asymmetric carbon atom as a center of chirality. Stereoisomerism of molecules with one center of chirality (enantiometry). Fisher projection formulas. Optical activity of enantiomers. Polarimetry and spectropolarimetry as methods for studying optically active compounds. Relative and absolute configuration. D,L- and R,S-systems of stereochemical nomenclature. Racemates.
8. Stereoisomerism of molecules with two or more centers of chirality. The difference between the properties of enantiomers and diastereomers. Methods for separating racemates. Conformations. The emergence of conformations as a result of rotation around bonds; factors that hinder rotation. Newman's projection formulas. Types of stresses. Energy characteristics of eclipsed, skewed, hindered conformations of open chains. Relationship of spatial structure with biological activity.

9. Acid and basic properties of organic compounds; theories of Bronsted-Lowry and Lewis. Types of organic acids (SH, OH, NH and CH acids). Factors determining acidity and basicity: electronegativity and polarizability of an atom of the acidic and basic centers, electronic effects of substituents, solvation effect.
10. Classification of organic reactions according to the result (addition, substitution, elimination, rearrangement). The concept of reaction mechanisms - ionic (electrophilic, nucleophilic), free radical, coordinated. The structure of intermediate active particles (carbocations, carbanions, free radicals). Transition state. Reducing the energy barrier in catalytic processes.
11. Methods of isolation and purification: extraction, recrystallization, distillation, chromatography. Criteria for the purity of a substance: melting point, boiling point, density, refractive index, chromatographic data. Chemical functional analysis.
12. Modern physical and chemical methods for establishing the structure. Electronic spectroscopy (UV and visible): types of electronic transitions and their energies; main parameters of absorption bands, band shifts (bathochromic and hypsochromic shifts) and their causes.
13. Infrared (IR) spectroscopy: types of vibrations of atoms in a molecule (valence, deformation); characteristic frequencies.
14. Spectroscopy of nuclear magnetic resonance (NMR). Proton magnetic resonance (PMR): chemical shift, spin-spin splitting.
15. Mass spectrometry: types of ions (molecular, fragmentation, rearrangement). Isotopic composition. Establishment of the molecular formula. Mass spectral series of ions of the main classes of organic compounds. The main types of fragmentation. Introduction to Raman spectroscopy (RS), X-ray diffraction, electron diffraction.
16. Alkanes. Nomenclature. Physical and chemical properties. Radical substitution reactions (halogenation), mechanism. Methods of formation of free radicals and factors determining their stability. Regioselectivity of radical substitution. The concept of chain processes. Vaseline oil, paraffin. Oxidation of alkanes.
17. Cycloalkanes. Nomenclature. small cycles. Features of the chemical properties of small cycles (addition reactions). regular cycles. substitution reactions. Conformations of cyclohexane. Types of stresses. Axial and equatorial connections. 1,3-diaxial interaction as a cause of ring inversion in cyclohexane derivatives.
18. Identification of alkanes and cycloalkanes. Spectral characteristics of alkanes. The concept of polycyclic systems (adamantane).
19. Alkenes. Nomenclature. diastereomerism. E,Z-system of stereochemical nomenclature. physical properties. Electrophilic addition reactions, mechanism. Addition of halogens, hydrohalogenation, hydration and the role of acid catalysis. Markovnikov's rule, its modern interpretation. Oxidation of alkenes (hydroxylation, ozonation, epoxidation).
20. Identification of alkenes. Spectral characteristics of alkenes. Radical addition reactions in the alkene series. Reactions of nucleophilic addition in a series of alkenes.
21. Dienes. Nomenclature. Conjugated dienes. Electrophilic addition reactions (hydrohalogenation, addition of halogens). Peculiarities of addition in the series of conjugated dienes. Reactions with dienophiles (diene synthesis).
22. The concept of macromolecular compounds. Polyethylene. The concept of the stereoregular structure of polymers (polypropylene). Synthetic rubbers (butadiene, chloroprene). Stereoregular structure of natural rubber and gutta-percha.
23. Alkynes. Nomenclature. physical properties. Electrophilic addition reactions (hydrohalogenation, addition of halogens). Hydration of acetylene (Kucherov reaction). Comparison of the reactivity of alkynes and alkenes in electrophilic addition reactions. Formation of acetylenides as a consequence of the CH-acid properties of alkynes. Alkyne identification. Spectral characteristics of alkynes.
24. Mononuclear arenes. Nomenclature. aromatic properties. Electrophilic substitution reactions, mechanism. 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 I and II kind. Coordinated and non-coordinated orientation. Reactions proceeding with loss of aromaticity: hydrogenation, addition of chlorine. Oxidation. Benzene, toluene, xylenes, styrene. Polystyrene. Arena identification. Spectral characteristics of aromatic hydrocarbons. Multinuclear arenes (biphenyl, diphenylmethane, triphenylmethane).
25. 2Condensed arenes. Naphthalene, aromatic properties. Reactions of electrophilic substitution (sulfonation, nitration). Recovery (tetralin, decalin) and oxidation (naphthoquinones). Anthracene, phenanthrene; aromatic properties. Recovery, oxidation. Higher condensed arenes. 3,4-benzopyrene.
26. Halogen derivatives of hydrocarbons. Classification. Nomenclature. physical properties. haloalkanes and halocycloalkanes. 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. Cleavage (elimination) reactions: dehydrohalogenation, dehalogenation. Zaitsev's rule. Competitiveness of nucleophilic substitution and elimination reactions. Ethyl chloride, carbon tetrachloride, chloroform, vinyl chloride, polyvinyl chloride. chlorobenzene, benzyl chloride. Identification of halogen derivatives of hydrocarbons.
27. Allyl - and benzyl halides. Causes of increased reactivity in nucleophilic substitution reactions. Vinyl and aryl halides. The reason for the low mobility of the halogen. Fluorocarbons. Features of obtaining and chemical properties. Fluorotan. Fluoroplastics (Teflon).
28. Alcohols. Classification. Nomenclature. physical properties. Acid properties; the formation of alcoholates. Basic properties; formation of oxonium salts. Intermolecular hydrogen bonds and their influence on physical properties and spectral characteristics. Nucleophilic and basic properties of alcohols; production of haloalkanes, ethers and esters. Intramolecular dehydration of alcohols. Alcohol oxidation. Methanol, ethanol, propanols, butanols, benzyl alcohol. Identification of alcohols. Spectral characteristics of alcohols.

29. Polyhydric alcohols. Features of their chemical behavior. Ethylene glycol, glycerin. Unsaturated alcohols. Vinyl alcohol. Vinyl acetate, polyvinyl acetate, polyvinyl alcohol.
30. Phenols. Classification. Nomenclature. physical properties. Acid properties, obtaining phenolates. Nucleophilic properties of phenol: obtained
31. Carboxylic acids. Classification. Nomenclature. physical properties. monocarboxylic acids. The structure of the carboxyl group and the carboxylate ion as π, π -conjugated systems. acid properties. Reactions of nucleophilic substitution at the sp^2 -hybrid carbon atom; mechanism. The role of acid and base catalysis. Formation of functional derivatives of carboxylic acids. Acylation reactions. Anhydrides and haloanhydrides as active acylating agents.
32. Esters. Esterification reaction, the need for acid catalysis. Acid and alkaline hydrolysis of esters. Ammonolysis of esters.
33. Amides of carboxylic acids. The structure of the amide group. Acid-base properties of amides. Hydrolysis of amides, acid and alkaline catalysis. Cleavage of amides by hypobromites and nitrous acid. Dehydration to nitriles. Hydrolysis, reduction of nitriles. Hydrazides of carboxylic acids. hydroxamic acids. Reactions involving the hydrocarbon radical of carboxylic acids. Halogenation according to Gell-Volhard-Zelinsky. Use of halogenated acids for the synthesis of α -hydroxy-, α -amino-, unsaturated acids. Identification of carboxylic acids, their spectral characteristics. Formic, acetic, propionic, butyric, isovaleric, acrylic, methacrylic, benzoic and cinnamic acids. Polyacrylates, polymethyl methacrylate.
34. Esters of carboxylic and inorganic acids used in pharmacy. Triacylglycerols (fats, oils). Higher fatty acids as structural components of triacylglycerols (palmitic, stearic, oleic, linoleic, linolenic). Hydrolysis, hydrogenation, oxidation of fats and oils (iodine number, saponification number). Waxes. Structure. Higher monohydric alcohols (cetyl, myricyl). Beeswax. Spermaceti. Twins. Phosphatic acid. Phospholipids (phosphatidylcolamines, phosphatidylcholines).
35. Dicarboxylic acids; their properties as bifunctional compounds. Specific properties of dicarboxylic acids. Increased acidity of the first homologues; decarboxylation of oxalic and malonic acids. CH-acid properties of malonic ester. Carboanions as reacting particles. Syntheses based on malonic ester (obtaining carboxylic acids). Formation of cyclic anhydrides of succinic, glutaric, maleic acids. Phthalic acid. Phthalic anhydride, phthalimide. Phenolphthalein, indicator properties.
36. Carbonic acid and its functional derivatives. Phosgene, chlorocarbon ether, carbamic acid and its esters (urethanes). Carbamide (urea). Basic and nucleophilic properties. Acylureas (ureides), ureido acids. hydrolysis of urea. Interaction of urea with nitrous acid and hypobromites. Biuret formation; biuret reaction. Guanidine, basic properties.
37. Sulphonic acids. Nomenclature. Ways to get. Acid properties, formation of salts. Desulfurization of aromatic compounds. Nucleophilic substitution in arenesulfonic acids; obtaining phenols. Functional derivatives of sulfonic acids: esters, amides, acid chlorides.
38. Polycondensation macromolecular compounds. Polycondensation of dicarboxylic acids with diamines as a method for obtaining polyamides. Nylon. Polymerization of caprolactam (nylon). Polycondensation of dicarboxylic acids with ethylene glycol (lavsan). Polysiloxanes. The structure of the siloxane bond, the properties of polysiloxanes (thermal stability, hydrophobicity, biological inertness).
39. Poly- and heterofunctionality as one of the characteristic features of organic compounds involved in vital processes. Hydroxy acids of the aliphatic series. Chemical properties as heterofunctional compounds. Specific reactions of α -, β - and γ -hydroxy acids. Lactones, lactides. Monobasic (lactic), dibasic (tartaric, malic) and tribasic (citric) acids.
40. Phenolic acids. Salicylic acid. Chemical properties as a heterofunctional compound. Esters of salicylic acid used in medicine: methyl salicylate, phenyl salicylate, acetylsalicylic acid. n-Aminosalicylic acid (PASA). Coumaric, gallic acids. The concept of tannins.
41. Oxoacids. Chemical properties as heterofunctional compounds. Specific properties depending on the mutual arrangement of functional groups. Keto-enol tautomerism of dicarbonyl compounds: acetylacetone, acetoacetic ester, oxaloacetic acid. Synthesis of carboxylic acids and ketones based on acetoacetic ester. Aldehyde- (glyoxylic) and ketone acids (pyruvic, acetoacetic, oxaloacetic, alpha-ketoglutaric).
42. Amino acids. Chemical properties as heterofunctional compounds. Specific reactions of α -, β - and γ -amino acids. Lactams, diketopiperazines. α -Amino acids, peptides, proteins. The structure and classification of α -amino acids that make up proteins. Stereoisomerism. Bipolar structure, formation of chelate compounds. Chemical properties as heterofunctional compounds. The structure of the peptide group. Primary structure of peptides and proteins. Partial and complete hydrolysis.
43. Polysaccharides. The principle of construction. Complex and ethers of polysaccharides: acetates, nitrates, methyl-, carboxymethyl- and di-ethylaminoethylcellulose; their use in medicine. The ratio of polysaccharides and their esters to hydrolysis. Starch (amylase, amylopectin), cellulose, dextrans, pectins. The concept of heteropolysaccharides (hyaluronic acid, heparin, chondroitin sulfates).
44. Five-membered heterocycles with one heteroatom. aromatic representatives. Acid-base properties of pyrrole. Reactions of electrophilic substitution, orientation of substitution. Features of reactions of nitration, sulfonation and bromination of acidophobic heterocycles. Pyrrole, thiophene, furan, pyrrolidine, tetrahydrofuran. Furfurol, semicarbazone 5-nitrofurfurol (furatsilin). Benzopyrrole (indole), β - indoleacetic acid. Five-membered heterocycles with two heteroatoms. Aromatic representatives: pyrazole, imidazole, thiazole, oxazole. Acid-base properties: formation of associates. Electrophilic substitution reactions in pyrazole and imidazole. Pyrazolone and its tautomerism. Medicines based on pyrazolone-3. Imidazole derivatives: histidine, histamine, benzimidazole, dibazol. Thiazolidine. The idea of the structure of penicillin antibiotics.
45. Six-membered heterocycles with one heteroatom. Azins. Aromatic representatives: pyridine, quinoline, isoquinoline. Basic properties. Reactions of electrophilic substitution. Reactions of nucleophilic substitution (amination, hydroxylation). Lactim-lactam tautomerism of pyridine hydroxy derivatives. Nucleophilic properties of pyridine. Alkylpyridinium ion and

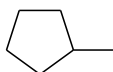
its interaction with hydride ion as a chemical basis for the redox action of the NAD⁺ coenzyme. Pyridine homologues: α -, β - and γ -picolines; their oxidation. Nicotinic and isonicotinic acids. Nicotinic acid amide (vitamin PP), isonicotinic acid hydrazide (isoniazid), ftivazid. Piperidine. 8-Hydroxyquinoline (oxin) and its derivatives used in medicine.

46. Piran group. Instability of α - and β -pyrans. α - and γ -Pyrans. Pyrilium salts, their aromaticity. Benzopyrones: chromone, coumarin, flavone and their hydroxy derivatives. Flavonoids: luteolin, quercetin, rutin. Flavan and its hydroxy derivatives (catechins). Tocopherol (vitamin E).
47. Six-membered heterocycles with two heteroatoms. Aromatic representatives of diazines: pyrimidine, pyrazine, pyridazine. Pyrimidine and its hydroxy- and amino derivatives: uracil, thymine, cytosine are components of nucleosides. Lactim-lactam tautomerism of nucleic bases. barbituric acid; lactim-lactam and keto-enol tautomerism, acid properties. Derivatives of barbituric acid: barbital, phenobarbital, thiamine (vitamin B1). Oxazine, phenoxazine. Thiazine, phenothiazine. Seven-membered heterocycles. Diazepine, benzodiazepine. Medications of the benzodiazepine series.
48. 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.
49. Nucleosides, nucleotides. Purine and pyrimidine nucleosides. 5-fluorouracil, 3'-azidothymidine as drugs. Nucleotides. relation to hydrolysis. Conferments ATP, NAD⁺, NADP⁺. Ribonucleic (RNA) and deoxyribonucleic (DNA) acids. The primary structure of nucleic acids.
50. Alkaloids. Chemical classification. Basic properties; salt formation. Pyridine group alkaloids: nicotine, anabazine. Alkaloids of the quinoline group: quinine. Alkaloids of the isoquinoline and isoquinoline-phenanthrene groups: papaverine, morphine, codeine. Tropane group alkaloids: atropine, cocaine.
51. Terpenoids. Isoprene rule. Classification. Monoterpenes. Acyclic (citral and its isomers), monocyclic (limonene), bicyclic (α -pinene, borneol, camphor) terpenes. Menthane and its derivatives used in medicine: menthol, terpene. Diterpenes: retinol (vitamin A), retinal. Tetraterpenes (carotenoids), α -carotene (provitamin A).
52. Steroids. The structure of gonane (perhydrocyclopentanophenanthrene). Nomenclature. Stereoisomerism: cis-trans articulation of cyclohexane rings (cis- and trans-decalin). α , β - stereochemical nomenclature, 5 α - and 5 β -series. Ancestral hydrocarbons of steroids: estrane, androstane, pregnane, cholan, cholestane. Cholestan derivatives (sterols): cholesterol, ergosterol; vitamin D2.
53. Cholan derivatives (bile acids): cholic and deoxycholic acids. Glycocholic and taurocholic acids, their amphiphilic character. Androstan derivatives (androgenic substances): testosterone, androsterone. Estrane derivatives (estrogenic substances): estrone, estradiol, estriol. Pregnane derivatives (corticosteroids): deoxycorticosterone, hydrocortisone, prednisolone. Aglycones of cardiac glycosides: digitoxigenin, strophanthidine. The general principle of the structure of cardiac glycosides. Chemical свойства стероидов, обусловленные функциональными группами: производные по гидроксильной, карбонильной, карбоксильной группам.

EXAMPLES OF TESTS.

1. Which of the following substituents is a functional group?

CH₂=CH-
 (CH₃)₂CH-
 C₆H₅-
 -C(O)H



1. Which of the compounds listed in column 2 contains fragments, the nature of conjugation of which is indicated in column 1

column 1	column 2
1. π, π - conjugation	a) CH ₃ CH ₂ -N(CH ₃) ₂
2. p, π - conjugation	b) HOOC-CH=CH-COOH
	d) CH ₃ -COCH ₂ -COH
	e) CH ₂ =CH-OC ₂ H ₅

2. From the list of bond lengths and energies given in the column, select the one that corresponds to $c^{sp}-c^{sp}$ bonds:

814 kJ/mol; 0.120 nm

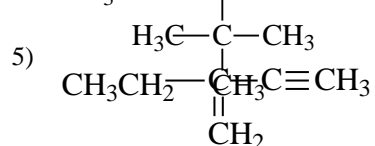
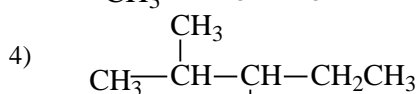
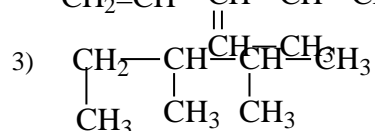
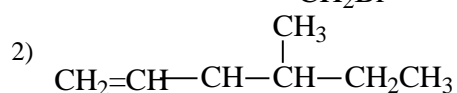
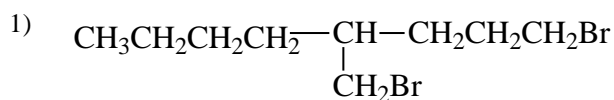
334 kJ/mol; 0.143 nm;

348 kJ/mol; 0.154 nm

694 kJ/mol; 0.123 nm

620 kJ/mol; 0.134 nm

3. In which of the following compounds is pentane the main carbon chain?



Choose one of the answer options:

only 2 and 5;
 only 3 and 4;
 All

only 1 and 5;

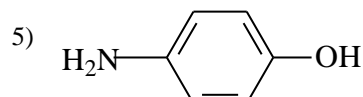
only 1 and 3;

3. 3. For the compounds listed in column 1, select from column 2 the names corresponding to them according to the replacement nomenclature iupak.

1) $\text{CH}_3\text{CH}_2\text{CH}_2\text{-O-CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	a) 2-ethoxypropane
2) $\begin{array}{c} \text{CH}_3-\text{CH}-\text{O}-\text{CH}_2\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$	b) Butyl propyl ether
	c) 1-Propoxybutane
	d) 1-Isopropoxyethane
	e) 1-butoxypropane

4. Which of the following compounds are heterofunctional?

- 1) $\text{HOCH}_2\text{-CHOH-CH}_2\text{OH}$
 2) $\text{HOOC}-\text{C}(\text{OH})-\text{CH}_2\text{CH}_2\text{COOH}$
 3) $\text{HOOC-CH}_2\text{-COOH}$
 4) $\text{H}_2\text{NCH}_2\text{-CH}_2\text{SO}_3\text{H}$



Choose one of the answer options:

- only 2, 4 and 5
 only 1 and 3
 only 2 and 4
 only 1, 3 and 5
 All

5. Which acids can exist as enantiomers?

- 1) $\text{C}_2\text{H}_5\text{CH(OH)CH}_2\text{COOH}$
 2) $\text{HOCCOCH}_2\text{CH}_2\text{COOH}$
 3) $\text{CH}_3\text{CH}_2\text{C(CH}_3)_2\text{COOH}$
 4) $\begin{array}{c} \text{CH}_3-\text{CH}-\text{COOH} \\ | \\ \text{COOH} \end{array}$

Choose one of the answer options:

- All
 only 1 and 2
 only 1,4
 only 1
 only 2

6. The following provisions are valid for diastereomers:

- a. Their molecules are compatible in space;
 b. diastereomers differ in physical properties;
 c. enter into chemical reactions at different rates;
 d. a mixture of equal amounts of two diastereomers is called a racemic mixture;
 e. a pair of diastereomers always has opposite signs of rotation.

Choose one of the answer options:

- All
 only 2,3 and 5
 only 1,2,3 and 5
 only 2,3,4 and 5
 only 2 and 3

7. Bronsted acids are compounds that (select the most general definition)

- contain a carboxyl group;
 stain red litmus;
 remove a proton in the presence of a base
 have a pK_a less than 15.

8. Which of the following statements do not agree with the structure and properties of benzyl bromide?

- 1) has an aromatic character;
- 2) a carbon atom is bonded to sp^2 - a hybridized carbon atom;
- 3) enters into nucleophilic addition reactions;
- 4) hydrolyzes in an alkaline environment;
- 5) is formed by the interaction of toluene with bromine in the presence of aluminum bromide.

Choose one of the answer options:

only 1, 2 and 3

only 3, 4 and 5

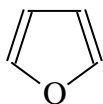
only 1,2,4 and 5

only 2 and 5

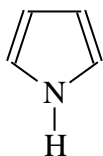
only 1,2 and 4

9. In which of the following combinations is there no correspondence between the name of the heterocycle and the structural formula of the heterocycle?

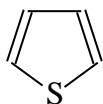
furan



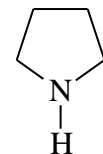
pyrrole



thiophene



pyridine



10. Which of the following statements are consistent with the structure and properties of uric acid?

- a) refers to purine derivatives.
- b) is a weak acid.
- c) lactim-lactam tautomerism is characteristic.
- d) with PCl_5 forms 2,6,8-trichloropurine.
- e) salts are called urates.

Choose one of the answer options:

only 1,2 and 3

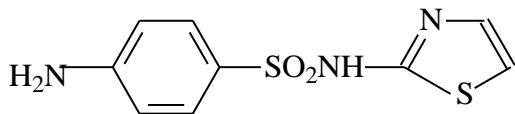
All

only 3,4 and 5

only 1,3 and 5

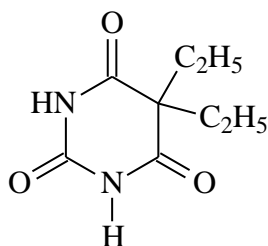
only 2,3 and 4

11. Which of the following heterocycles is included in the molecule of the bacteriostatic drug - norsulfazole?



pyrazole;
imidazole
thiophene;
pyrrole;
thiazole

12. Which of the following statements do not agree with the structure and properties of barbital?



- 1) is a cyclic diethylmalonic acid ureide;
- 2) forms salts with sodium hydroxide;
- 3) capable of lactim-lactam tautomerism;
- 4) is 3,3-diethylbarbituric acid;
- 5) is capable of keto-enol tautomerism.

Choose one of the answer options:

only 2,3 and 4

only 1 and 2

only 4 and 5

only 2 and 3

only 1

13. From column 2, select the side radicals corresponding to α - amino acids listed in column 1.

column 1	column 2
1) leucine	a) $(\text{CH}_3)_2\text{CH}-\text{CH}_2-$
2) isoleucine	b) $(\text{CH}_3)_2\text{CH}-$
	c) $\text{CH}_3-\text{CH}_2-\text{CH}(\text{CH}_3)-$
	d) $\text{H}_2\text{N}-(\text{CH}_2)_4-$

14. Which of the following structural formulas corresponds to the structure of the compound with the molecular formula C₂H₅NO₂, which is easily soluble in acids and alkalis, and forms diketopiperazine when heated?

- CH₃CH₂NO₂
- CH₂OH-CONH₂
- CH₂NH₂-COOH
- CH₂OH-CH₂NO₂

15. Threo- and erythro-stereoisomerism is associated with the presence in the molecule

- chiral carbon atom
- cyclohexene radical
- secondary alcohol hydroxyl
- several chiral carbons
- two neighboring chiral carbon atoms.

16. Which of the following compounds is formed by monodecarboxylation of glutamic acid?

- 3-aminobutanoic acid
- 4-aminobutanoic acid
- 2-aminobutanoic acid
- 3-aminopropanoic acid
- 2-aminopropanoic acid

17. Which statements are correct regarding the process of cyclo-oxo-tautomerism of monosaccharides?

- 1) it is based on the ability of monosaccharides to form ethers;
- 2) it is based on the ability of monosaccharides to form five- and six-membered cyclic hemiacetals;
- 3) it is based on the ability of monosaccharides to epimerize in a weakly alkaline medium;
- 4) the basis is the ability of monosaccharides to the reaction of intramolecular nucleophilic addition.

Choose one of the answer options:

only 1 and 4;

only 2 and 3;

only 2 and 4

only 1, 3 and 4;

only 2, 3 and 4.

18. Select homopolysaccharides from the named polysaccharides.

- 1) dextran;
- 2) amylopectin;
- 3) glycogen;
- 4) hyaluronic acid;
- 5) amylose.

Choose one of the answer options:

only 1 and 3;

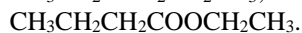
only 2 and 5.

only 2,3 and 5.

only 1, 2, 3 and 5

All.

19. Which of the following compounds is called propyl acetate? $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{OC}_2\text{H}_5$



20. Common in the structure of camphor, prednisolone and pregnin is the presence

keto groups

hydroxyl groups;

alpha-ketol group;

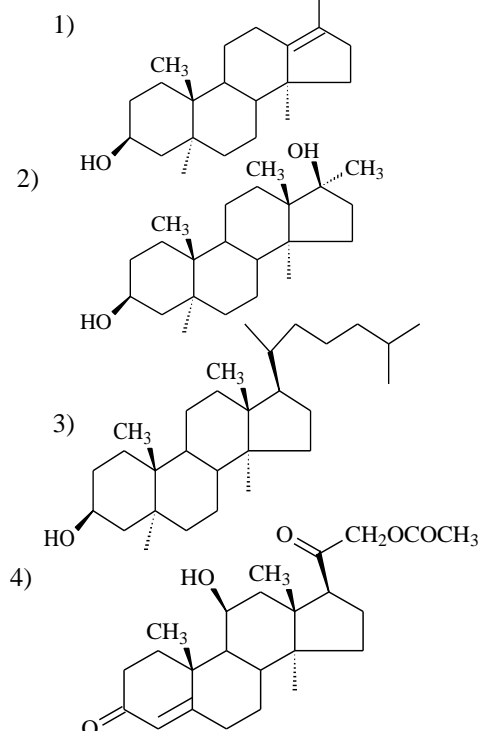
cyclopentanepiperhydrophenanthrene cores;

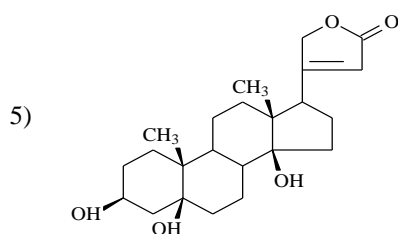
systems of conjugated double bonds.

21. Which hydrocarbons in column 2 underlie the steroid groups listed in column 1?

column 1	column 2
1) corticosteroids	a) cholestan
2) bile acids	b) estran
	c) androstane
	d) pregnane
	e) cholane

22. In which of the following compounds are the rings a, b, c, d joined in the trans-type?





Choose one of the answer options:

only 1, 2 and 3

only 1 and 5

only 2 and 3

only 1, 2, and 4

All

23. Specify the compounds in which the electron density in the ethylene fragment is higher than in ethylene:

1) $\text{H}_2\text{C}=\text{CH}-\text{COOH}$;

2) $\text{H}_2\text{C}=\text{CH}-\text{OCH}_3$;

3) $\text{H}_2\text{C}=\text{CH}-\text{NO}_2$;

4) $\text{H}_2\text{C}=\text{CH}-\text{CF}_3$;

5) $\text{H}_2\text{C}=\text{CH}-\text{NH}$

Choose one of the answer options:

only 1 and 2

only 1 and 4

only 2 and 5

only 3 and 4

only 3 and 1

24. Specify the sequence in which the acid properties of water (1), methanol (2), 2-propanol (3), 2-methyl-2-propanol (4) decrease in the liquid phase.

1>2>4>3

3>4>2>1

1>2>3>4

2>3>4>1

1>4>2>3

25. Specify the sequence in which the increase in the basic properties of $\text{C}_2\text{H}_5\text{OH}$ (1), $\text{C}_2\text{H}_5\text{NH}_2$ (2), $(\text{C}_2\text{H}_5)_2\text{NH}$ (3), $(\text{C}_2\text{H}_5)_3\text{N}$ (4), NH_3 (5) occurs.

1<2<3<4<5

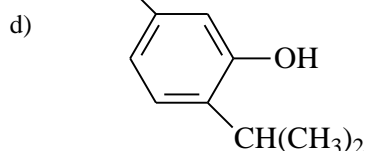
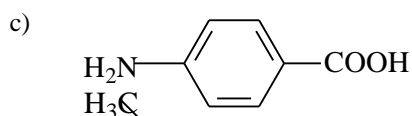
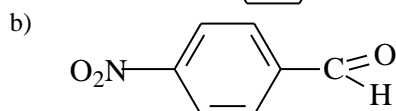
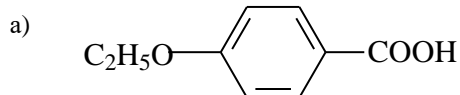
2<1<4<3<5

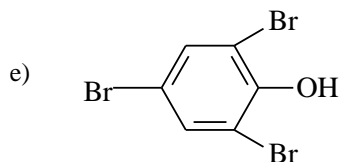
1<4<5<2<3

4<5<2<3<1

3<2<4<5<1

26. In which of the following compounds do all the substituents exhibit electron-donating properties?

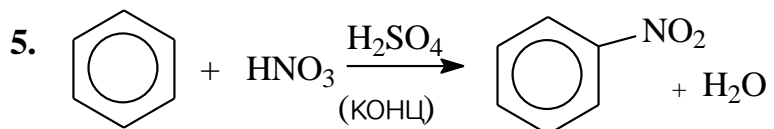
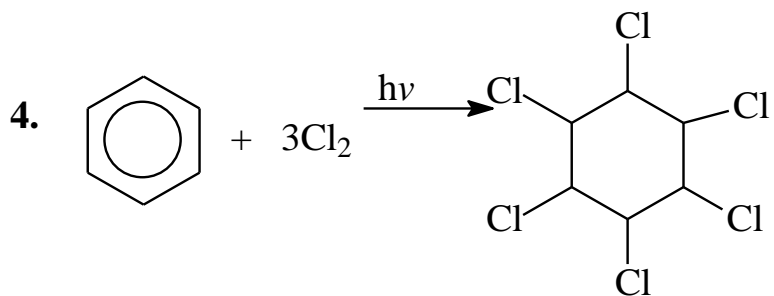
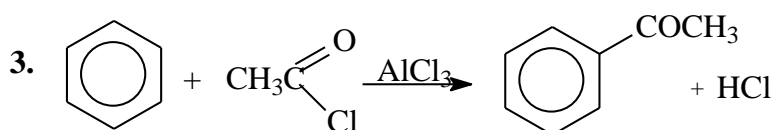
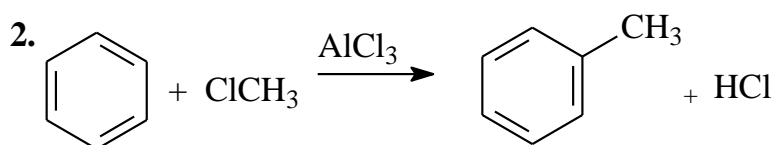
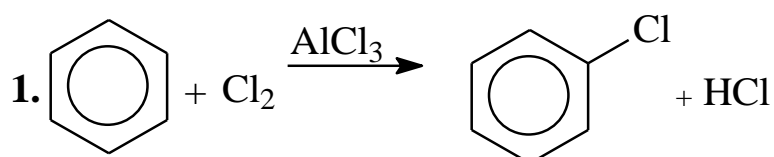




27. Which of the compounds listed in column 2 are capable of interacting with the reagents listed in column 1?

column 1	column 2
1) aqueous solution of copper (II) hydroxide	a) $\text{CH}_2\text{OH}-\text{CH}_2-\text{CH}_2\text{OH}$
2) an aqueous solution of sodium hydroxide.	b) $\text{C}_6\text{H}_5\text{OH}$
	c) $\text{CH}_2\text{OH}-\text{CHOH}-\text{CH}_2\text{OH}$
	d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

28. The Friedel-Crafts reactions are:



Choose one of the answer options:

only 1 and 2;

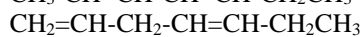
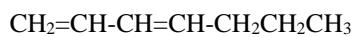
All;

only 2 and 3

only 2 and 4;

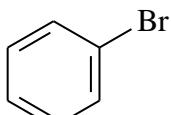
only 4 and 5.

Какой из диеновых углеводородов при эквимолекулярном взаимодействии с бромом образует 2,5-дибромгептен-3?

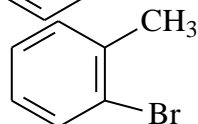


29. A mixture of benzene and toluene is brominated in the presence of aluminum bromide. Select the products of this reaction.

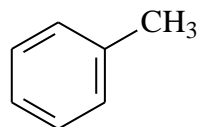
1)



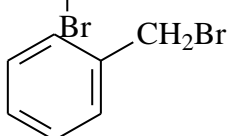
2)



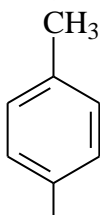
3)



4)



5)



Choose one of the answer options:

only 1, 2 and 5

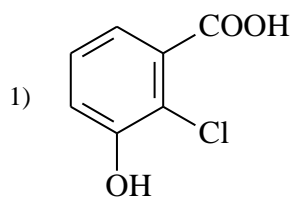
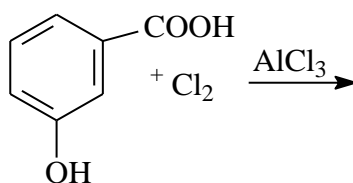
only 1, 2 and 3

only 4 and 5

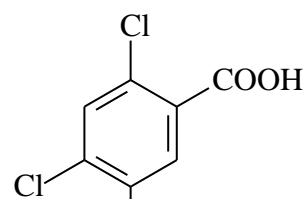
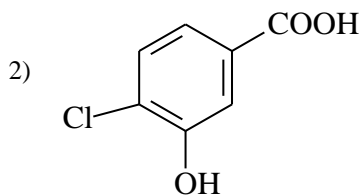
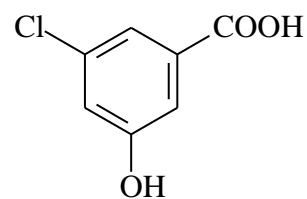
only 2 and 4

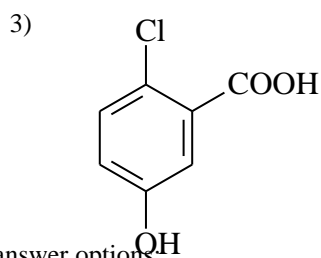
All

30. The following compounds are products of mismatched orientation in this reaction:



4)





5)

Choose one of the answer options:

- only 1,2,3 and 5
- only 1 and 2;
- only 2 and 3;
- only 2,4 and 5;
- only 1,2 and 4.

31. From the given starting compounds, select the pair of compounds whose interaction in an acidic medium yields 1-methoxybutanol-1.

- $\text{H}_2\text{C}=\text{O}$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- CH_3OH , $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}=\text{O}$
- CH_3OH , $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- HCOOH , $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- CH_3OH , $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$

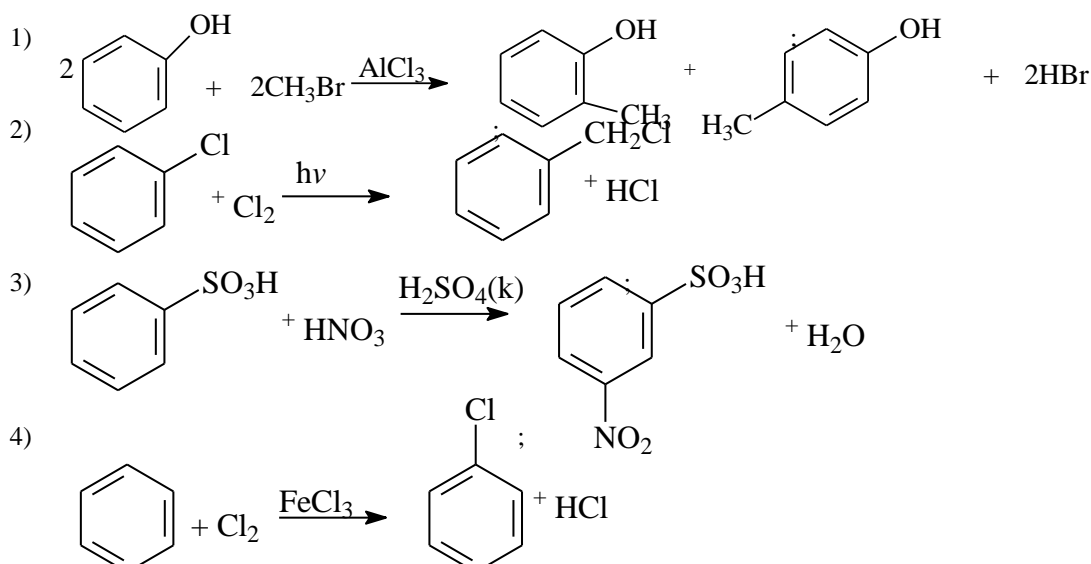
32. Which of the following compounds is the product of an aldol addition reaction?

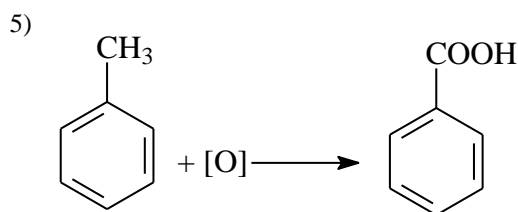
- $\text{CH}_2(\text{OH})\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}=\text{O}$
- $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CH}_3)\text{CH}=\text{O}$
- $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{OH})\text{CH}=\text{O}$
- $\text{CH}_3\text{COCH}_2\text{CH}=\text{O}$

33. Which compounds in the pairs listed in column 2 can be distinguished from each other using the reagents listed in column 1?

column 1	column 2
1) $[\text{Ag}(\text{NH}_3)_2]\text{OH}$	a) benzophenone and 2-methylpropanol-2
2) $\text{CuSO}_4 / \text{NaOH}$	b) propanone and 2-methylpropanol-2
	c) ethylene glycol and butene-1
	d) butanal and butanone
	e) propanal and ethanal

34. From the following reactions, select the reactions of electrophilic substitution.



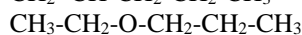
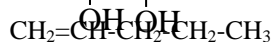


Choose one of the answer options:

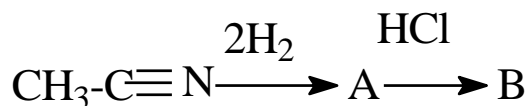
- only 1, 2 and 3
- only 2 and 5
- only 1,3 and 4
- only

1

35. Which of the following compounds is the main product of the interaction of pentanol-2 with concentrated sulfuric acid at 140°C?

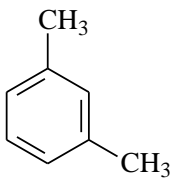
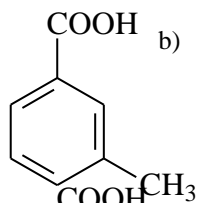
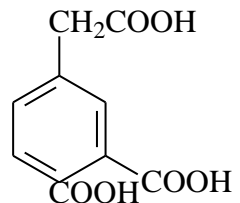
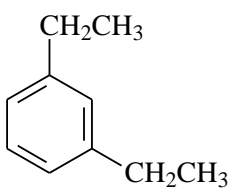
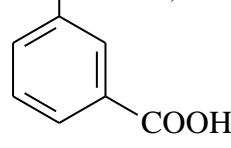
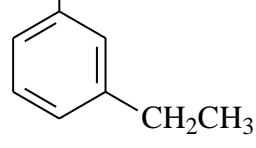


36. What is the product of the following transformations:

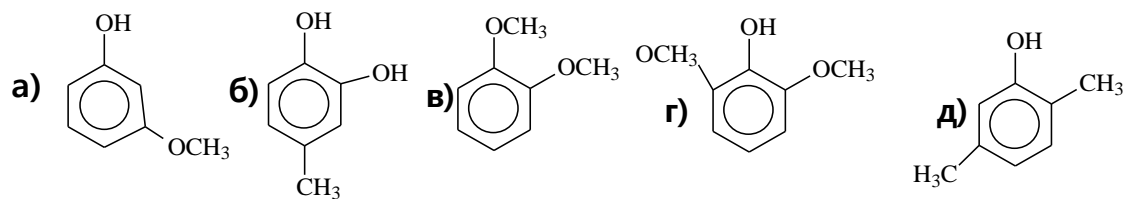


- 1) [CH₃N⁺H₃]Cl⁻
- 2) [C₂H₅-N⁺H₃]Cl
- 3) C₂H₆ + N⁺H₄Cl⁻
- 4) 2CO + N⁺H₄Cl⁻
- 5) CH₃-CH₂-NH₂

37. Select from column 2 the products of the oxidation reactions of aromatic hydrocarbons listed in column 1.

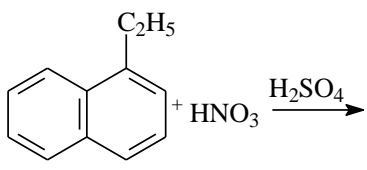
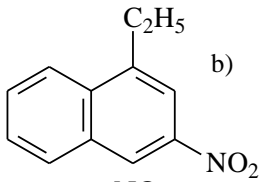
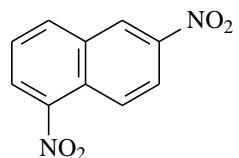
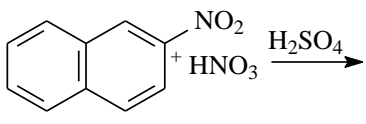
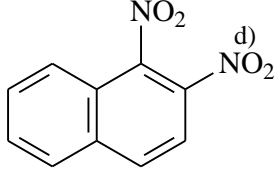
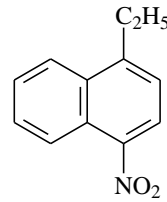
column 1	column 2
1) 	a)  b) 
2) 	c)  d) 

38. Which of the following compounds is the product of pyrocatechol (1,2-dihydroxybenzene) alkylation with methyl iodide in the presence of Lewis acid?



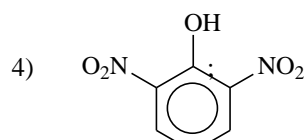
(+)

39. From the compounds listed in column 2, select the products resulting from the chemical reactions listed in column 1.

column 1	column 2
1) 	a)  b) 
2) 	c)  d) 

40. Diethylamine and triethylamine can be distinguished by reactions with the following reagents::

- a. HNO₃;
- b. CHCl₃ + 3NaOH;
- c. C₆H₅SO₂Cl;



5) H₂SO₄.

Choose one of the answer options:

- only 1,3 and 4
- only 3,4 and 5;
- only 1,2,4 and 5
- only 2,3 and 5

All

41. Select the reactions that can be used for the qualitative detection of glucose in solutions.

hydrogen reduction

interaction with Fehling's reagent

interaction with ammonia solution of silver

interaction with alcohols in the presence of an acid catalyst

nitric acid oxidation

42. Select from column 2 examples of interactions that occur through the mechanisms named in column 1.

column 1	column 2
1) nucleophilic substitution at the sp ² -hybridized carbon atom	a) $\text{CH}_3\text{CH}=\text{CH}_2 + \text{Br}_2, h\nu$
2) electrophilic addition	b) $\text{CH}_3\text{CH}_2\text{CH}=\text{O} + \text{NH}_2\text{C}_2\text{H}_5$
	c) $\text{CH}_3\text{COCl} + \text{NH}_2\text{C}_2\text{H}_5$
	d) $\text{CH}_3\text{COONa} + \text{CH}_3\text{OH}$
	e) $\text{CH}_3\text{CH}=\text{CH}_2 + \text{Br}_2$

43. Which statement about amides of carboxylic acids is not true?

hydrolyzed in an alkaline environment;

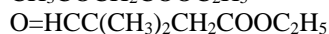
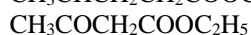
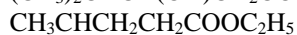
formed when a carboxylic acid chloride reacts with ammonia

enter into reactions with alcohols by the reaction of nucleophilic substitution;

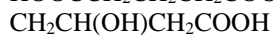
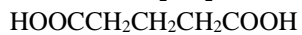
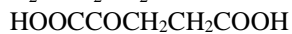
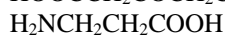
hydrolyzed in an acidic environment;

enter into nucleophilic substitution reactions.

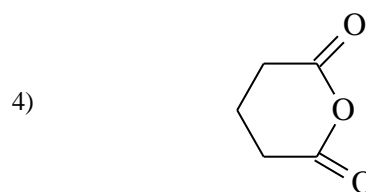
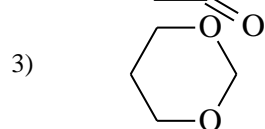
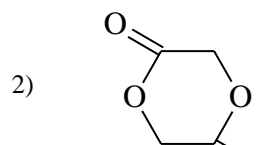
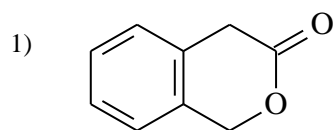
44. Which of the compounds can be obtained as a result of an ester condensation reaction?



45. Which of the following acids undergoes decarboxylation more easily than the others?



46. Which of the following compounds hydrolyze in an alkaline medium?



Choose one of the answer options:

All;

only 1, 2,4 and 5

only 1, 3 and 5;

only 2 and 3;

only 3 and 4.

Criteria for evaluating learning outcomes

Learning outcomes	Assessment of competence developed			
	unsatisfactory	satisfactory	good	excellent
Completeness of knowledge	The level of knowledge is below the minimum requirements. There were bad mistakes	The minimum acceptable level of knowledge. A lot of light mistakes were made	The level of knowledge in the volume corresponding to the training program. A few light mistakes were made	The level of knowledge in the volume corresponding to the training program, without errors
Availability of skills	Basic skills are not demonstrated when solving standard tasks. There were bad mistakes	Basic skills are demonstrated. Typical problems with light mistakes have been solved. All tasks have been completed, but not in full.	All basic skills are demonstrated. All the main tasks have been solved with light mistakes. All tasks have been completed, in full, but some of them with shortcomings	All the basic skills were demonstrated, all the main tasks were solved with some minor shortcomings, all the tasks were completed in full
Availability of skills (possession of experience)	Basic skills are not demonstrated when solving standard tasks. There were bad mistakes	There is a minimal set of skills for solving standard tasks with some shortcomings	Basic skills in solving standard tasks with some shortcomings are demonstrated	Skills in solving non-standard tasks without mistakes and shortcomings are demonstrated
Characteristics of competence formation*	The competence is not fully formed. The available knowledge and skills are not enough to solve professional tasks. Repeated training is required	The formation of competence meets the minimum requirements. The available knowledge and abilities are generally sufficient to solve professional tasks, but additional practice is required for most practical tasks	The formation of competence generally meets the requirements, but there are shortcomings. The available knowledge, skills and motivation are generally sufficient to solve professional tasks, but additional practice is required for some professional tasks	The formation of competence fully meets the requirements. The available knowledge, skills and motivation are fully sufficient to solve complex professional tasks
The level of competence formation*	Low	Below average	Intermediate	High

For testing:

Mark "5" (Excellent) - points (100-90%)

Mark "4" (Good) - points (89-80%)

Mark "3" (Satisfactory) - points (79-70%)

Less than 70% – Unsatisfactory – Mark "2"