

MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS

Educational Institution

«BELARUSIAN STATE MEDICAL UNIVERSITY»

**Контрольный
экземпляр**

APPROVED
by Rector of the Educational
Institution «Belarusian State
Medical University»
 S.P. Rubnikovich
01.12.2025
Reg. # UD-0912-01-14/256 edu.

TOXICOLOGICAL CHEMISTRY

**Curriculum of the educational institution
in the academic discipline for the specialty**

1-79 01 08 «Pharmacy»

Curriculum is based on the educational program «Toxicological Chemistry», approved 20.11.2024, registration # УД-0912-01-14/2425/уч.; on the educational plan in the specialty 1-79 01 08 «Pharmacy», approved 16.04.2025, registration # 7-07-0912-01/2526/mf.

COMPILERS:

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RECOMMENDED FOR APPROVAL:

by the Department of Pharmaceutical Chemistry with a course for advanced training and retraining of the Educational Institution «Belarusian State Medical University» (protocol # 4 of 21.10.2025);

by the Scientific and Methodological Council of the Educational Institution «Belarusian State Medical University» (protocol # 3 of 19.11.2025)

EXPLANATORY NOTE

«Toxicological Chemistry» is an academic discipline within the module «Pharmaceutical Chemistry and Pharmacognosy», comprising systematized scientific knowledge on the properties, methods of isolation, identification and quantitative determination of toxic substances and their metabolites in biological material, as well as the toxicological significance and methods of detoxification of major groups of toxicants responsible for poisonings and fatal outcomes.

The aim of the academic discipline «Toxicological Chemistry» is to develop specialized competencies necessary for the application of a complex of physicochemical, biological and chemical methods in the examination of biological objects for the presence of toxic substances.

The objectives of the academic discipline «Toxicological Chemistry» are to form students' scientific knowledge about:

- the legal foundations of forensic chemical examination;

- biochemical toxicology;

- methods for isolating toxic substances and their metabolites from biological objects and methods for their identification and quantitative determination.

The knowledge, skills and abilities acquired during the study of the academic discipline «Toxicological Chemistry» are necessary for successful mastering of the academic disciplines «Modern Methods of Analysis and Standardization of Drugs», «Pharmaceutical Development with the Fundamentals of Biopharmaceutics».

Studying the academic discipline «Toxicological Chemistry» should ensure the formation of students' specialized competency: use a complex of physicochemical, biological and chemical methods when conducting research of biological objects for the presence of toxic substances.

As a result of studying the academic discipline «Toxicological Chemistry» the student should

know:

- the organizational structure of the State Committee of Forensic Examinations of the Republic of Belarus and narcological dispensaries;

- the legal foundations of forensic chemical examination;

- the principles of biochemical toxicology;

- methods for isolating toxic substances and their metabolites from biological objects, methods of identification and quantitative determination;

- the toxicological significance of major groups of poisonous substances and methods of detoxification;

be able to:

- perform analytical diagnostics of acute poisonings;

- detect narcotic drugs, psychotropic substances, their precursors and other toxic substances in biological objects;

- interpret the results of chemical-toxicological examinations;

- document the process of forensic chemical examination and chemical-toxicological analysis;

- use regulatory, reference and scientific literature to solve professional tasks;

master:

isolating toxic substances from biological material;
 applying physical, chemical and instrumental analytical methods for the identification and quantitative determination of toxic substances;
 using rapid analytical methods for the diagnostic assessment of drug abuse, substance abuse and acute poisonings.

Total number of hours for the study of the discipline is 205 academic hours, of which 135 classroom hours and 70 hours of student independent work. Classroom hours according to the types of studies: lectures – 33 hours (including 12 hours of supervised student independent work (SSIW)), laboratory classes – 102 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (8 semester) and examination (9 semester).

Form of higher education – full-time.

ALLOCATION OF ACADEMIC TIME ACCORDING TO SEMESTERS OF STUDY

Code, name of the specialty	Semester	Total number of academic hours	Number of classroom hours				Out-of-class self-studies	Form of intermediate assessment
			Number of classroom hours	including				
				class lectures	SSIW	laboratory		
7-07-0912-01 «Pharmacy»	8	110	66	12	6	48	44	credit
	9	95	69	9	6	54	26	examination
Total hours		205	135	21	12	102	70	

THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures (incl. SSIW)	laboratory
1. General issues of toxicological chemistry	6	9
1.1. Goals and objectives of the academic discipline «Toxicological Chemistry». Organization of medical forensic examination in the Republic of Belarus	–	3
1.2. Introduction to clinical toxicology	3	3
1.3. Methodology of chemical-toxicological analysis	3	3
2. Fundamentals of biochemical toxicology	3	6
2.1. Absorption, distribution and elimination of toxic substances from the human body	1,5	3
2.2. Biotransformation of xenobiotics in the human body	1,5	3
3. Analytical toxicology of major groups of xenobiotics	24	87
3.1. Substances isolated from biological material by mineralization	3	12
3.2. Substances isolated from biological material by distillation	3	9
3.3. Substances determined directly in biological material	1,5	3
3.4. Substances isolated from biological material by aqueous extraction and substances requiring specific isolation methods	1,5	9
3.5. Modern methods used in chemical-toxicological analysis of medicinal products, narcotic drugs and psychotropic substances	3	8
3.6. Methods for isolation, purification and concentration of medicinal products, narcotic drugs, psychotropic substances and their precursors from biological material	3	8
3.7. Substances isolated from biological material by extraction with polar solvents	7,5	32
3.8. Substances isolated from biological material by extraction with non-polar solvents (pesticides)	1,5	6
Total hours	33	102

CONTENT OF THE EDUCATIONAL DISCIPLINE

1. General issues of toxicological chemistry

1.1. Goals and objectives of the academic discipline «Toxicological Chemistry». Organization of medical forensic examination in the Republic of Belarus

Goals and objectives of the academic discipline Toxicological Chemistry, its interrelation with other academic disciplines. History of the development of toxicological chemistry. Development of toxicological chemistry in the territory of modern Belarus. Current state of toxicological chemistry in the independent Republic

of Belarus. Main sections of the discipline. Rules and procedures for work in a toxicological laboratory, occupational health and safety requirements.

Organization of medical forensic examination in the Republic of Belarus. Structure of the State Committee of Forensic Examinations of the Republic of Belarus. Regulatory legal acts governing the performance of forensic chemical examinations in the Republic of Belarus. Rights and responsibilities of state medical forensic experts-chemists. Rules for conducting forensic chemical examination and chemical-toxicological investigation: grounds for initiating forensic chemical examination, selection of objects for forensic chemical examination, reception and storage of physical evidence and accompanying documentation, procedure for performing forensic chemical examinations and documentation in the course of forensic chemical examinations.

1.2. Introduction to clinical toxicology

Prevalence, nature and causes of acute poisonings. Poisonings caused by medicinal products, narcotic drugs, psychotropic substances and their precursors. Classification of poisonings according to cause and place of occurrence, routes of entry of the poison into the body and severity. Factors determining the development of acute poisonings. Clinical diagnosis of acute poisonings, types of diagnostic procedures: electroencephalography, electrocardiography, instrumental diagnostics of respiratory disorders.

Basic methods of detoxification of the body in acute poisonings. Methods of enhancing natural detoxification processes: gastric lavage, intestinal cleansing, forced diuresis, therapeutic hyperventilation of the lungs, regulation of enzymatic activity, therapeutic hypo- and hyperthermia, hyperbaric oxygenation.

Methods of artificial detoxification: apheresis methods, dialysis and blood (lymph) filtration, sorption, physiochemical hemotherapy.

Methods of antidotal detoxification. Specific features of antidotal therapy. Main groups of antidotes: chemical antidotes, biochemical antidotes, pharmacological antagonists, antitoxic sera. Role of the pharmacist in the treatment of poisonings.

Definitions of the concepts of drug addiction, toxicomania (substance abuse), narcotic drug, alcohol abuse, psychotropic substances, precursors. Physical and psychological dependence, tolerance. Epidemiology of alcoholism, drug addiction and toxicomania. Organization of work in institutions performing analytical diagnostics of drug addiction, toxicomania and alcoholism. Concept of substitution therapy in addiction medicine. Treatment and prevention of alcoholism. Role of the pharmacist in informing the public about the harm caused by alcohol, narcotic drugs, psychotropic substances and their precursors. Legislative foundations of treatment, prevention and control of drug addiction, toxicomania and alcoholism.

1.3. Methodology of chemical-toxicological analysis

General characteristics of toxic action. Formation of a toxic effect as a result of the interaction of the poison, the organism and the human environment. General and specific classifications of toxic substances: chemical, hygienic, toxicological, according to selective toxicity, pathomorphological, pathochemical, biological. Chemical-toxicological significance of the classification of toxic substances according to isolation methods. Medicinal products as toxic substances.

Chemical-toxicological laboratories: tasks, facilities, personnel, equipment. Qualification requirements for a forensic expert-chemist.

Review of data from forensic medical examination, clinical data and the preliminary diagnosis of poisoning. Specific features of chemical-toxicological analysis. Selection of analytical methods in accordance with the requirements of the investigation. Metrological characteristics of methods for determining toxicants: specificity, accuracy, linearity, reproducibility, range of application, convergence, repeatability, intra-laboratory precision, limit of detection, robustness and expression of the result.

Selection of objects of examination and methods for isolating toxic substances. General principles and rules for sampling and submitting objects for analysis, conditions of transportation and storage. Methods of preservation of biological objects. Primary processing of various objects of examination depending on the analytical method used. Specific features of processing blood and urine samples. Methods of isolation, concentration and separation of organic and inorganic toxic substances from various biological objects. Sequence of preliminary and confirmatory methods of identification and the need for quantitative analysis of toxicants. Evaluation of the results of forensic chemical examination.

2. Fundamentals of biochemical toxicology

2.1. Absorption, distribution and elimination of toxic substances from the human body

Fundamentals of toxicokinetics. Influence of physicochemical properties of toxic substances on their toxicokinetics and metabolism. Routes of entry of toxic substances into the human body. Absorption of toxicants, main types of transport of xenobiotics across biological membranes in the human body. Mechanisms of damage to biological membranes. Distribution of toxic substances in the human body and factors influencing distribution. Influence of various factors on the binding of xenobiotics. Interaction of toxic substances with receptors. Types of binding of toxic substances to plasma proteins and to components of organs and tissues.

Elimination of toxic compounds via the kidneys: glomerular filtration, passive and active tubular transport. Excretion of toxic substances through the gastrointestinal tract. Excretion of xenobiotics with bile. Other pathways of elimination of toxic substances (excretion through the respiratory tract, skin, etc.), including specific pathways (hair, nails). Influence of physicochemical properties of toxic substances and factors of the internal environment on the rate and nature of their elimination from the human body. Kinetics of xenobiotic elimination.

Fundamentals of toxicodynamics. Dose-dependent toxic effects. Median lethal doses. Toxicometry. Regulation of permissible levels of toxic substances in the environment. Molecular mechanisms of toxic effect development. Toxic effects resulting from interactions of medicinal products with each other, with food, tobacco, alcohol, etc.

2.2. Biotransformation of xenobiotics in the human body

Phases of xenobiotic metabolism. Major pathways of xenobiotic biotransformation, classification of metabolic transformations. Oxidation reactions catalyzed by microsomal enzymes: hydroxylation of aliphatic and aromatic

compounds, epoxidation, N-hydroxylation, N- and S-oxidation, dealkylation, deamination, desulfuration and others. Reduction reactions catalyzed by microsomal enzymes: reduction of nitro and azo compounds and others. Non-microsomal oxidation reactions: deamination, oxidation of alcohols and aldehydes, aromatization of aliphatic compounds and others. Non-microsomal reduction reactions: reduction of aldehydes, ketones and others. Hydrolysis reactions involving microsomal and non-microsomal enzymes: hydrolysis of esters, amides, etc. Other reactions of Phase I metabolism: cleavage of heterocyclic rings, oxidative cleavage of arenes, oxidative cyclization, dehydroxylation of hydroxamic acids, dehalogenation, reduction of disulfides to thiols and others. Synthetic reactions: formation of conjugates with glucuronic acid, sulfates, glutathione; acetylation, methylation, thiosulfate conjugation, conjugation with amino acids and others. Decomposition of biological material after death.

3. Analytical toxicology of major groups of xenobiotics

3.1. Substances isolated from biological material by mineralization

Prevalence of poisonings caused by compounds and general characteristics of «metallic» poisons. Prevalence of poisonings with heavy metals, arsenic, antimony and others. List of «metallic» poisons subject to mandatory forensic chemical examination when poisoning by an unidentified toxicant is suspected. Compounds of «metallic» poisons of toxicological significance. Clinical manifestations of poisonings and detoxification methods. Stability of the body's chemical composition. Essential and toxic trace elements. Concept of synergism and antagonism of trace elements in the human body. Role of chemical elements in the human body. Ecotoxics.

Methods of mineralization and removal of oxidizing agents. Objects of examination in suspected poisoning with «metallic» poisons. Sampling and preparation of samples for analysis. Classification of methods for isolating «metallic» poisons from biological objects and environmental samples. Rationale for the need for mineralization. General and specific mineralization methods: «wet» and «dry» mineralization, destructive methods for isolating mercury. Selection of the method and conditions for isolating «metallic» poisons. Procedures for mineralizing biological material using sulfuric and nitric acids; sulfuric, nitric and perchloric acids; fusion of biological material with sodium carbonate and sodium nitrate; simple combustion. Specific methods for mercury isolation. Preparation of the mineralizate for examination. Denitration methods: thermal denitration, denitration using reducing agents (formaldehyde, urea, sodium sulfite).

Methods of detection and quantitative determination of «metallic» poisons. Identification of «metallic» poisons. Fractional analysis of the mineralizate. Sequence of identification reactions for lead, barium, manganese, chromium, silver, copper, antimony, arsenic, bismuth, zinc, cadmium, thallium. Identification of mercury. Preliminary and confirmatory reactions for identifying «metallic» poisons. Methods for eliminating interference from foreign substances during analysis of the mineralizate: addition of complexing agents, selective extraction, redox reactions, etc. Use of organic reagents in the analysis of mineralizates. Characteristics of reagents and conditions for performing identification reactions for «metallic» poisons.

Quantitative determination of «metallic» poisons. Characteristics of instrumental methods used for analyzing mineralizates. Modern methods for separation

and determination of metal ions (thin-layer chromatography, ion-exchange chromatography, gas chromatography, polarography, electrophoresis, etc.). Use of spectrometric methods in the analysis of «metallic» poisons: atomic emission, atomic absorption, X-ray fluorescence, molecular emission, molecular absorption spectrometry, etc. Interpretation of the results of chemical–toxicological analysis taking into account the natural background levels of «metallic» poisons in the human body.

Organic mercury compounds and their toxicity. Isolation of ethylmercuric chloride from biological materials of animal and plant origin and from biological fluids. Qualitative and quantitative analysis of organic mercury compounds. Use of modern analytical techniques for organic mercury compounds.

3.2. Substances isolated from biological material by distillation

Group of substances isolated by distillation. Scheme of chemical-toxicological investigation of «volatile» poisons. Prevalence of poisonings with «volatile» poisons. List of «volatile» poisons subject to mandatory forensic chemical examination when poisoning by an unidentified toxicant is suspected. Clinical manifestations of poisonings, detoxification methods and antidotes.

Classification of «volatile» poisons according to acid–base properties. Selection of biological objects for testing for «volatile» poisons. Scheme of chemical analysis of the distillate. Isolation of «volatile» poisons by steam distillation. Methods of separating azeotropic mixtures. Apparatus for steam distillation. Conditions for isolating «volatile» poisons via steam distillation. Specific features of isolating hydrocyanic acid, acetic acid, ethylene glycol, methanol, tetraethyl lead. Methods of concentration, purification and isolation of «volatile» poisons.

Chemical analysis of the distillate. Toxicological significance, identification and quantitative determination of «volatile» poisons. Sequence of identification reactions for hydrocyanic acid, formaldehyde, methanol, acetone, ethanol, alkyl halides, phenol, cresols. Identification reactions for «volatile» toxicants that have negative forensic chemical value.

Specific issues in the chemical-toxicological analysis of individual groups of «volatile» poisons (hydrocyanic acid, aldehydes and ketones (formaldehyde, acetone), alkyl halides (chloroform, chloral hydrate, carbon tetrachloride, 1,2-dichloroethane); monohydric phenols (phenol, cresols), acetic acid, monohydric aliphatic alcohols, dihydric alcohols (ethylene glycol): properties and toxicological significance, prevalence of poisonings, symptoms of poisoning, toxicokinetics, objects of examination, sample preparation, identification and quantitative determination.

Analytical methods used in chemical–toxicological and forensic chemical examination of «volatile» poisons (qualitative and quantitative).

Gas chromatographic determination of «volatile» poisons. Forensic testing for alcohol intoxication. Gas chromatographic analysis of «volatile» poisons. General characteristics of gas chromatography. Chromatographic columns, adsorbents, stationary phases, mobile phases, detectors. Sample preparation in gas chromatographic analysis of «volatile» poisons: analysis of equilibrium headspace, solid-phase microextraction, dynamic gas extraction. Qualitative gas chromatographic analysis of «volatile» poisons. Features of gas chromatographic determination of

«volatile» toxicants. Interpretation of results obtained by gas chromatography.

Ethanol: properties and toxicological significance. Prevalence of ethanol and surrogate alcohol poisonings. Mechanism of ethanol action in the human body. Acute alcohol intoxication. Objects of examination and sampling procedures for living individuals and postmortem material in ethanol analysis. Preliminary determination of ethanol in exhaled air. Characteristic reactions for ethanol identification. Biochemical methods of ethanol determination. Gas chromatographic detection and quantitative determination of ethanol in biological fluids. Expert interpretation of ethanol concentrations in forensic chemical examination of internal organs, blood, urine, saliva, etc.

3.3. Substances determined directly in biological material

Carbon monoxide (CO), its properties and toxicological significance. Classification of carbon monoxide poisoning by severity. Clinical manifestations of carbon monoxide poisoning and provision of first aid. Routes of entry and distribution of carbon monoxide in the blood; mechanism of toxic action.

Methods for detecting carbon monoxide: spectrophotometric, microdiffusion, rapid chemical tests. Methods for quantitative determination of carbon monoxide: spectrophotometric and gas chromatographic. Forensic chemical interpretation of carboxyhemoglobin levels in blood.

3.4. Substances isolated from biological material by aqueous extraction and substances requiring specific isolation methods

General characteristics, properties and toxicological significance of sulfuric, nitric, hydrochloric and acetic acids; ammonia; sodium and potassium hydroxides; nitrates and nitrites. First aid measures.

Specifics of chemical-toxicological analysis of mineral acids (sulfuric, nitric, hydrochloric, acetic), alkalis (sodium and potassium hydroxides), ammonia, nitrates and nitrites: objects of examination; preparation of biological samples; isolation; dialysis; preliminary tests for the presence of analytes; quantitative determination; stability in postmortem material.

General characteristics, properties and toxicological significance of fluorine compounds (fluorides and silicofluorides), hydrogen sulfide, chlorine, bromine, iodine, bromides, iodides. Detoxification methods.

Specifics of chemical–toxicological analysis of fluorides, silicofluorides, hydrogen sulfide, chlorine, bromine, iodine, bromides, iodides: isolation, identification, quantitative determination.

3.5. Modern methods used in chemical-toxicological analysis of medicinal products, narcotic drugs and psychotropic substances

Capabilities of physicochemical methods of quantitative determination and their limitations in chemical-toxicological analysis. Metrological characteristics of methods for determining toxicants. Influence of various factors on analytical results (presence of endogenous compounds in biological matrices, putrefactive decomposition of tissues and organs, metabolic transformation of medicinal products).

Chromatographic methods (thin-layer chromatography, gas-liquid chromatography, high-performance liquid chromatography, etc.), their advantages and limitations.

Prospects for the use of gas chromatography and high-performance liquid chromatography in chemical-toxicological analysis of medicinal products in forensic chemical examination and chemical-toxicological analysis for the purposes of diagnosis and treatment of poisonings. Gas and liquid chromatography with mass spectrometric detection.

Thin layer chromatography (TLC) screening of medicinal products in general and specific solvent systems: chromatographic conditions, standards, visualization reagents, retention (R_f) values. Interpretation of TLC screening results for medicinal products.

Spectrometric methods for detection and quantitative determination of medicinal products. Spectrophotometry in the UV and visible regions. Classification of organic compounds according to their electronic absorption spectra. Direct and differential spectrophotometry (illustrated by barbituric acid derivatives), extractive photometry. Molecular emission analysis.

Chemical-toxicological analysis of substances using immunochemical methods: preliminary tests for the presence of toxic substances in biological fluids. Basic requirements for methods of quantitative determination of medicinal products in biological fluids.

Protein-binding analytical methods. Immunochemical methods of analysis: radioreceptor methods, enzyme immunoassays, fluorescence polarization immunoassay, etc. Prospects for the development of protein-binding and immunochemical methods of analysis as applied to the main areas of chemical-toxicological analysis.

Rapid diagnostics of poisonings with medicinal products, narcotic drugs, psychotropic substances and their precursors. Principle of operation of test strips for their detection.

3.6. Methods for isolation, purification and concentration of medicinal products, narcotic drugs, psychotropic substances and their precursors from biological material

Classification and toxicological significance of substances isolated with polar solvents. Chemical-toxicological significance of classifying medicinal products according to their acid-base properties. Physicochemical properties and behavior of acidic and basic medicinal products in solution. Objects of chemical-toxicological analysis. Specific features of determining medicinal products in biological matrices. Chemical-toxicological studies in doping control.

Sampling, preparation and storage of biological material; main stages of isolation of medicinal products from biological material in general and targeted analysis. Qualitative and quantitative factors influencing the isolation of medicinal products from internal organs. Methods of concentrating medicinal products: liquid-liquid extraction, solid-phase extraction.

Main stages of isolation of medicinal products from biological material in general and targeted analysis. Modern methods of isolation (extraction) of medicinal and narcotic drugs, psychotropic substances from tissues, organs and biological fluids, their characteristics and comparative evaluation. Factors determining extraction efficiency at all stages. Selection of optimal extraction conditions.

General methods of isolating medicinal products using polar solvents. Specific methods for isolating medicinal products: isolation of barbituric acid derivatives, phenothiazine derivatives and substances of basic and weakly basic character.

3.7. Substances isolated from biological material by extraction with polar solvents

General characteristics and toxicological significance of barbiturates (benzobarbital, phenobarbital, sodium thiopental, primidone): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods.

General characteristics and toxicological significance of pyridine and piperidine derivatives (nicotine). Modern nicotine delivery systems: metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods. Forensic chemical significance of reactions with general alkaloid precipitating reagents. Confirmatory methods for analysis of medicinal products: microcrystalline tests, color reactions, physicochemical analytical methods, pharmacological assays. Detoxification methods.

General characteristics and toxicological significance of tropane derivatives (atropine, scopolamine, cocaine) and cholinergic medicinal products (pilocarpine, neostigmine, pyridostigmine, etc.): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods. Detoxification methods.

General characteristics and toxicological significance of indole derivatives (reserpine, ergot alkaloids, triptans). Indole-containing psychedelics (LSD, psilocybin, psilocin, harmine, harmaline, N, N-dimethyltryptamine and its analogues): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of quinoline and isoquinoline derivatives (quinine, papaverine, drotaverine): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of xanthine derivatives (caffeine, theobromine, theophylline): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of p-aminobenzoic acid derivatives (procaine, procainamide): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of 1,4-benzodiazepine derivatives (chlordiazepoxide, diazepam, nitrazepam, oxazepam): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of phenothiazine derivatives (chlorpromazine, trifluoperazine, chlorprothixene, flupentixol, etc.) and other classes of neuroleptics (haloperidol, droperidol, sulpiride, amisulpride, clozapine,

olanzapine): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of antidepressants (amitriptyline, clomipramine, fluoxetine, sertraline, escitalopram, paroxetine, fluvoxamine, venlafaxine, maprotiline, mirtazapine): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods, detoxification methods.

General characteristics and toxicological significance of phenanthreneisoquinoline derivatives (morphine, hydromorphone, oxycodone, codeine, dextromethorphan, heroin). Synthetic opioids (fentanyl and its derivatives, trimeperidine, methadone): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods.

General characteristics and toxicological significance of phenylalkylamine derivatives (ephedrine, pseudoephedrine, norephedrine, amphetamine, methamphetamine, mephedrone). Psychedelic phenylethylamines (mescaline, substances of the 2C and 25NB families): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods.

General characteristics and toxicological significance of cannabinoids (cannabidiol, cannabinol, tetrahydrocannabinol, tetrahydrocannabinolic acid). Synthetic cannabinoids (substances of the AM, JWH and RCS series): metabolism, isolation from biological material, general and specific detection methods, instrumental determination methods.

Psychoactive medicinal products contributing to the development of dependence (diphenhydramine, chlorpyramine, promethazine, trihexyphenidyl, pregabalin, rimantadine, baclofen, tropicamide, tramadol, phenibut, zopiclone, etc.).

General characteristics and toxicological significance of selected groups of poisonous and potent medicinal products (antiepileptic drugs, non-steroidal anti-inflammatory drugs and analgesics-antipyretics, antituberculous agents, expectorants, angiotensin-converting enzyme inhibitors, calcium channel blockers; α -adrenergic agonists, β -adrenergic blockers, etc.).

General characteristics and toxicological significance of toxins of bacterial origin (botulinum toxin, diphtheria toxin, Shiga toxin, etc.), fungal origin (aflatoxins, ochratoxins, patulin, amanitins, phalloidins, etc.), animal origin (toxins of reptiles, amphibians, insects) and plant origin (cardiac glycosides, triterpenoids, coumarins, alkaloids).

3.8. Substances isolated from biological material by non-polar solvents (pesticides)

General overview of pesticides and their importance for the national economy. Prevalence and causes of pesticide poisonings. Classification of pesticides by chemical structure, application, toxicity and lethal dose.

Preparation of biological samples for analysis of pesticides. Rules for sampling and submission of objects for analysis. Scheme of systematic analysis of biological fluids for major groups of pesticides. Schemes for isolating certain groups of pesticides from biological tissues. Methods for analyzing pesticides isolated from biological material or environmental objects: chemical and biochemical analytical methods,

elemental analysis, TLC screening, gas-liquid chromatography.

Specific issues of chemical-toxicological analysis of individual groups of pesticides. Toxicological significance, metabolism, specific features of isolation, identification and quantitative determination of organophosphorus compounds (carbophos, metaphos, chlorophos, dichlorvos, etc.), organochlorine compounds (hexachlorocyclohexane, heptachlor, etc.), carbamic acid derivatives (sevin), synthetic pyrethroids (permethrin, cypermethrin, deltamethrin, cyhalothrin, etc.) and polychlorinated biphenyls.

EDUCATIONAL DISCIPLINE «TOXICOLOGICAL CHEMISTRY» CURRICULAR CHART

Section, topic #	Section (topic) name	Number of class hours		SSIW	Literature	Practical skill	Forms of control	
		lectures	laboratory				of practical skill	of current / intermediate assessment
8 th semester								
	Lectures	12	-	6				
1.2.	Introduction to clinical toxicology	1,5	-	1,5	1–3			Electronic testing
1.3.	Methodology of chemical-toxicological analysis	1,5	-	1,5	1–3			
2.1.	Absorption, distribution and elimination of toxic substances from the human body	1,5	-	-	1–3			
2.2.	Biotransformation of xenobiotics in the human body	1,5	-	-	1–3			
3.1.	Substances isolated from biological material by mineralization	1,5	-	1,5	1–3			
3.2.	Substances isolated from biological material by distillation	1,5	-	1,5	1–3			
3.3.	Substances determined directly in biological material	1,5	-	-	1–3			Electronic testing
3.4.	Substances isolated from biological material by aqueous extraction and substances requiring specific isolation methods	1,5	-	-	1–3			
	Laboratory classes	-	48	-				
1.1.	Goals and objectives of the academic discipline «Toxicological Chemistry». Organization of medical forensic examination in the Republic of Belarus	-	3	-	1–3	Expert conclusion preparation	Solving situational problems	Electronic testing

1.2.	Introduction to clinical toxicology	-	3	-	1–3			Interview
1.3.	Methodology of chemical-toxicological analysis	-	3	-	1–3			Interview
2.1.	Absorption, distribution and elimination of toxic substances from the human body	-	3	-	1–3			Interview
2.2.	Biotransformation of xenobiotics in the human body	-	3	-	1–3			Interview. Colloquium*
3.1.	Substances isolated from biological material by mineralization: prevalence of poisonings and general characteristics of «metallic» poisons	-	3	-	1–3	Sample preparation of biological material for the determination of «metallic» poisons	Account of laboratory work	Interview
	Substances isolated from biological material by mineralization: methods of mineralization and removal of oxidizing agents	-	3	-	1–3	Sample preparation of biological material for the determination of «metallic» poisons	Account of laboratory work	Interview
	Substances isolated from biological material by mineralization: methods for detecting «metallic» poisons	-	3	-	1–3	Detection of «metallic» poisons using chemical reactions in chemical-toxicological examination of biological material	Account of laboratory work	Interview
	Substances isolated from biological material by mineralization: methods for quantitative determination of «metallic» poisons	-	3	-	1–3	Photometric determination of copper, bismuth, lead, antimony, etc. in mineralizates	Account of laboratory work	Interview
3.2.	Substances isolated from biological material by distillation: scheme of chemical–toxicological investigation of «volatile» poisons. chemical analysis of the distillate	-	3	-	1–3	Detection of «metallic» poisons using chemical reactions in chemical-toxicological examination of biological material	Account of laboratory work	Interview
	Substances isolated from biological material by distillation: toxicological significance, identification and quantitative determination of «volatile» poisons	-	3	-	1–3	Identification of «volatile» poisons using qualitative reactions	Account of laboratory work	Interview
	Substances isolated from biological material by distillation: gas chromatographic determination of «volatile» poisons. Forensic examination of alcohol intoxication	-	3	-	1–3	Identification of «volatile» poisons by gas chromatography	Account of laboratory work	Interview
3.3.	Substances determined directly in biological material	-	3	-	1–3	1. Determination of Carboxyhemoglobin in Blood Using Chemical Reactions.	Account of laboratory work	Interview

						2. Spectrophotometric Determination of Carboxyhemoglobin in Blood		
3.4.	Substances isolated from biological material by aqueous extraction	-	3	-	1–3	Isolation of drugs from biological fluids by aqueous extraction	Account of laboratory work	Interview
	Substances requiring specific isolation methods	-	3	-	1–3	Specific methods for isolating toxicants from biological material	Account of laboratory work	Interview
		-	3	-	1–3			Colloquium*, control work*. Credit
9th semester								
	Lectures	9	-	6				
3.5.	Modern methods used in chemical-toxicological analysis of medicinal products, narcotic drugs and psychotropic substances	1,5	-	1,5	1–3			Electronic testing
3.6.	Methods for isolation, purification and concentration of medicinal products, narcotic drugs, psychotropic substances and their precursors from biological material	1,5	-	1,5	1–3			Control work
3.7.	Substances isolated from biological material by extraction with polar solvents: general characteristics and toxicological significance of barbiturates	1,5	-	1,5	1–3			Electronic testing
	Substances isolated from biological material by extraction with polar solvents: general characteristics and toxicological significance of alkaloids	1,5	-	-	1–3			Electronic testing
	Substances isolated from biological material by extraction with polar solvents: general characteristics and toxicological significance of 1,4-benzodiazepine derivatives	1,5	-	-	1–3			Electronic testing
	General characteristics and toxicological significance of phenanthreneisoquinoline and phenylalkylamine derivatives	1,5	-	-	1–3			Electronic testing

3.8.	Substances isolated from biological material by extraction with non-polar solvents (pesticides)	-	-	1,5	1–3			Electronic testing
	Laboratory classes	-	54	-				
3.5.	Modern methods used in chemical-toxicological analysis of medicinal products, narcotic drugs and psychotropic substances: chromatographic methods	-	4	-	1–3	Identification of toxic substances in biological fluids using TLC screening	Account of laboratory work	Electronic test
	Modern methods used in chemical-toxicological analysis of medicinal products, narcotic drugs and psychotropic substances: protein-binding and spectrometric methods	-	4	-	1–3	Identification of toxic substances in biological fluids using TLC screening	Account of laboratory work	
3.6.	Methods for isolation, purification and concentration of medicinal products, narcotic drugs, psychotropic substances and their precursors from biological material: sampling, preparation and storage of biological material	-	4	-	1–3	Isolation of medicinal products from biological fluids by extraction with organic solvents	Account of laboratory work	Interview
	Methods for isolation, purification and concentration of medicinal products, narcotic drugs, psychotropic substances and their precursors from biological material: main stages of isolation of medicinal products from biological material in general and targeted analysis	-	4	-	1–3	Isolation of medicinal products from biological fluids by extraction with organic solvents	Account of laboratory work	
3.7.	Substances isolated from biological material by extraction with polar solvents. general characteristics and toxicological significance of barbiturates	-	4	-	1–3	Isolation of medicinal products from biological fluids by extraction with organic solvents	Account of laboratory work	Interview
	General characteristics and toxicological significance of pyridine derivatives	-	4	-	1–3	1. Isolation of «volatile» poisons from biological material by steam distillation. 2. Isolation of medicinal products from biological fluids by extraction with organic solvents	Account of laboratory work	Interview

	General characteristics and toxicological significance of tropane derivatives	-	4	-	1–3	Identification of medicinal products in biological material using chemical reactions	Account of laboratory work	Interview
	General characteristics and toxicological significance of indole derivatives	-	4	-	1–3	Identification of medicinal products in biological material using chemical reactions	Account of laboratory work	Interview
	General characteristics and toxicological significance of quinoline and isoquinoline derivatives	-	4	-	1–3	Identification of medicinal products in biological material using chemical reactions	Account of laboratory work	Interview
	General characteristics and toxicological significance of xanthine derivatives	-	4	-	1–3	1. Isolation of medicinal products from biological fluids by extraction with organic solvents. 2. Identification of medicinal products in biological material using chemical reactions	Account of laboratory work	Interview
	General characteristics and toxicological significance of aminobenzoic acid derivatives and 1,4-benzodiazepine, phenothiazine derivatives, other classes of neuroleptics and antidepressants	-	4	-	1–3	Identification of toxic substances in biological fluids using TLC screening	Account of laboratory work	Colloquium* interview
	General characteristics and toxicological significance of phenanthreneisoquinoline derivatives, synthetic opioids and phenylalkylamines; cannabinoid derivatives and psychoactive medicinal products contributing to dependence	-	4	-	1–3	1. Identification of toxic substances in biological fluids using TLC screening. 2. Identification of medicinal products in biological material using chemical reactions	Account of laboratory work	Case-study, interview*
3.8.	Substances isolated from biological material by non-polar solvents (pesticides)	-	4	-	1–3	Identification of pesticides in biological material using chemical reactions	Account of laboratory work	Interview
		-	2	-	1–3			Colloquium*, control work*
	Total hours	18	108	9				Examination

*This is a mandatory form of current certification.

INFORMATION AND INSTRUCTIONAL UNIT

LITERATURE

Basic:

1. Lappas, N. T. Forensic Toxicology: Principles and Concepts / N. T. Lappas, C. M. Lappas. – 2nd ed. – Amsterdam: Academic Press, 2021. – 516 p.

Additional:

2. Flanagan, R. J. Fundamentals of Analytical Toxicology: Clinical and Forensic / R. J. Flanagan, E. Cuypers, H. H. Maurer, R. Whelpton. – 2nd ed. – Hoboken: Wiley, 2020. – 599 p.

Electronic courseware for the educational discipline «Toxicological Chemistry»:

3. <https://etest.bsmu.by/course/view.php?id=173>

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

The time allocated for independent work can be used by students for:

- preparing for lectures and laboratory classes;
- preparing for colloquia, credit and examination in the academic discipline;
- studying topics assigned for independent study;
- solving problems and case tasks;
- completing research and creative assignments;
- preparing thematic reports and presentations;
- taking notes from academic literature;
- preparing reports;
- compiling a review of scientific literature on a given topic;
- preparing informational and demonstration materials (posters, charts, tables, displays, newsletters, etc.);
- compiling a thematic selection of literary and internet sources;
- designing tests by students for peer assessment.

METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

APPROXIMATE LIST OF TASKS FOR SUPERVISED STUDENT INDEPENDENT WORK:

- preparation of thematic reports, abstracts and presentations;
- summarizing primary sources (collections of documents, monographs, textbooks, etc.);
- creating tests for peer-assessment activities;
- preparing informational and demonstrational materials (posters, charts, tables, wall newspapers, etc.);
- creating of models and laboratory-teaching aids

FORMS OF CONTROL OF SUPERVISED STUDENT INDEPENDENT WORK:

- control work;
- electronic testing.

LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms of current certification are used to diagnose competencies:
 control work;
 electronic test;
 colloquium;
 interview;
 case-study;
 account of laboratory work.

LIST OF AVAILABLE TEACHING METHODS

Traditional method;
 active (interactive) methods:
 Problem-Based Learning;
 Research-Based Learning.

LIST OF PRACTICAL SKILLS

Name of practical skills	Form of practical skills control
1. Expert conclusion preparation	Solving situational problems
2. Sample preparation of biological material for the determination of «metallic» poisons	Account of laboratory work
3. Detection of «metallic» poisons using chemical reactions in chemical-toxicological analysis of biological material	Account of laboratory work
4. Photometric determination of metal ions in the mineralizate	Account of laboratory work
5. Isolation of «volatile» poisons from biological material by steam distillation	Account of laboratory work
6. Identification of «volatile» poisons using qualitative reactions	Account of laboratory work
7. Identification of «volatile» poisons by gas chromatography	Account of laboratory work
8. Isolation of medicinal substances from biological fluids using organic solvent extraction	Account of laboratory work
9. Isolation of drugs from biological fluids by aqueous extraction	Account of laboratory work
10. Identification of medicinal substances in biological material using chemical reactions	Account of laboratory work
11. Determination of carboxyhemoglobin in blood using chemical reactions	Account of laboratory work
12. Spectrophotometric determination of carboxyhemoglobin in blood	Account of laboratory work

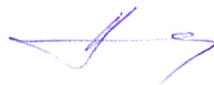
Name of practical skills	Form of practical skills control
13. Specific methods for isolation of toxicants from biological material	Account of laboratory work
14. Identification of toxic substances in biological fluids using TLC screening	Account of laboratory work
15. Identification of pesticides in biological material using chemical reactions	Account of laboratory work

**PROTOCOL OF THE CURRICULUM APPROVAL
BY OTHER DEPARTMENTS**

Title of the discipline requiring approval	Department	Amendments to the curriculum in the academic discipline	Decision of the department, which designed the curriculum (date, protocol #)
1. Modern Methods of Analysis and Standardization of Drugs	Department of Pharmaceutical Chemistry with a course for advanced training and retraining	None	protocol # 4 of 21.10.2025
2. Pharmaceutical Development with the Fundamentals of Biopharmaceutics	Department of Pharmaceutical Technology with a course for advanced training and retraining	None	protocol # 4 of 21.10.2025

COMPLIED BY:

Associate Professor of the Department of Pharmaceutical Chemistry with a course for advanced training and retraining of the Educational Institution «Belarusian State Medical University», PhD, Associate Professor



H.I. Harbatsevich

Head of the Department of Pharmaceutical Chemistry with a course for advanced training and retraining of the Educational Institution «Belarusian State Medical University», PhD, Associate Professor



R.I. Lukashou

Curriculum content, composition and the accompanying documents comply with the established requirements.

Head of the Office of Educational Activities of the Educational Institution «Belarusian State Medical University»

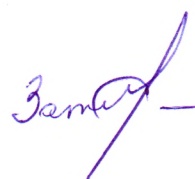
19.11.2025



I.L. Kotovich

Methodologist of the Educational and Methodological Department of the Office of Educational Activities of the Educational Institution «Belarusian State Medical University»

19.11.2025



S.V. Zaturanova