

**DANYLO HALYTSKY LVIV NATIONAL MEDICAL UNIVERSITY**  
**Department of Toxicological and Analytical Chemistry**



**APPROVED**

The Acting First Vice-Rector for scientific  
and pedagogical work  
Assoc. prof. I.I. Solonyenko

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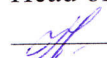
**CURRICULUM ON THE DISCIPLINE**  
**TOXICOLOGICAL AND FORENSIC CHEMISTRY**

training of specialists of the second (master's) level of higher education  
in the field of knowledge 22 "Public Healthcare"  
Specialty 226 "Pharmacy, Industrial Pharmacy"

**Discussed and approved**

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Head of the department

 Assoc. prof. I.Y. Halkevych

**«Approved»**

by profile methodical commission  
in chemical and pharmaceutical disciplines  
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Head of the profile methodical commission

 Assoc. prof. S.B. Bilous.

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AUTHORS:

Assoc. Prof., Ph.D. Halkevych I.Y.

Assoc. Prof., Ph.D. Bidnychenko Y.I.

Assist. Prof., Ph.D. Davydovych S.I.

REVIEWER:

Head of the Department of Pharmaceutical, Organic, and Bioorganic chemistry

Danylo Halytsky Lviv National Medical University

Prof., D.Sc., Lesyk R.B.

## INTRODUCTION

program of the discipline "Toxicological and Forensic Chemistry" in accordance with the standard of higher education of the second (master's) level of knowledge 22 "Public Healthcare" specialty 226 "Pharmacy, industrial pharmacy"  
of the educational program on Master of Pharmacy

### Course description (abstract)

"Toxicological and Forensic Chemistry" is one of the specialty pharmaceutical disciplines, which studies the properties of poisonous and potent substances, their behavior in the body and corpse, develops methods of isolation, identification and determination of toxic substances and their metabolites in objects of biological origin. It originated from the needs of toxicology and is one of its components. Its methods are widely used in various sections of toxicology, influencing their development.

The main sections of this discipline are: 1) forensic chemistry that serves forensic toxicology and elaborates forensic toxicology research methods for forensic poisoning; 2) chemical-toxicological analysis that serves clinical toxicology (for the diagnosis of acute intoxication); 3) biochemical toxicology, which studies the mechanisms of toxic action of substances on the body (kinetics of absorption of poisons; ways and mechanisms of transport and distribution of poisons in the body; mechanisms of metabolic transformation of substances, as well as the elimination of poisons and their metabolites from the body); 4) analytical toxicology - studies methods and methods of isolation, identification and quantification of toxic substances.

The program of toxicological and forensic chemistry has introduced some general, preventive and clinical toxicology issues. One of the features of toxicological chemistry is the constant expansion of the nomenclature of toxic and dangerous substances.

In teaching the theoretical course of toxicological chemistry, special attention is paid to the systematic approach to the study of toxicity of poisonous substances, which is based on taking into account the physicochemical properties of the poison, the ways of penetration to the organism, toxicokinetics, selective action, peculiarities of the victim's body, individual sensitivity, etc.), as well as methods of life-long and post-mortem laboratory diagnosis. This is of great importance for the correct interpretation of the results of the analysis and the prevention of poisoning.

The formation of students of chemical-expert thinking and the development of skills and skills from laboratory methods for determining xenobiotics and their metabolites in objects of biological origin are facilitated by laboratory classes. Important importance is attached to the solution of experimental problems, in the decision of which students learn to draw up a study plan for the isolation, detection and identification of poisons, to analyze and interpret the results and to draw up an act of forensic toxicological research.

According to the syllabus, "toxicological and forensic chemistry" is studied in the fourth year in the 7th and 8th semesters.

The distribution of study time (**6, 0 credits / 180 hours**) is as follows:

Full-time education	Number of credits, hours				Year of study / semester	Types of control
	Total credits / hour	Auditorium		ISW		
		Lectures (hours)	Practical classes (hours)			
Academic Year	6,0 credits / 180 hours	20	70	90	IV course (7-8 semesters)	Credit, exam
for semesters						
Module 1	3,0 credits / 90 hours	10	32	48	7 semester	Credit
Module 2	3,0 credits / 90 hours	10	38	42	8 semester	Exam

**The subject of study of the course "Toxicological and Forensic Chemistry" is:**

- toxic substances and mechanisms of their toxicity;
- classification of poisons and classification of poisons;
- clinical toxicology, toxicometry and basic toxicometric parameters;
- classification of poisonous substances by methods of their separation from objects of biological origin;
- biochemical toxicology and analytical toxicology;
- the ways of entering the poisons into the body and excretion, their toxicokinetics and distribution in the body;
- poison metabolism and its effect on xenobiotic toxicity;
- toxicodynamics of poisons, specific clinical symptomatology at intoxication of an organism;
- forensic toxicological and chemical toxicological analysis and their objects of study;
- safety and rules of work in the chemical-toxicological (forensic-toxicological) laboratory;
- theoretical bases of methods of extraction of toxic substances from biological material, their detection, identification and quantification by chemical and physico-chemical methods;
- interpretation of results obtained from experimental studies;
- medical care, methods of active and artificial detoxification, specific (antidote) therapy in acute intoxication.

**Interdisciplinary Relations:**

"Toxicological and Forensic Chemistry" as a discipline: based on the knowledge, skills and knowledge acquired by students in the study of previous disciplines, namely: inorganic, bioorganic, physical and colloidal chemistry (properties of elements and their compounds, basics of chemical kinetics, basics of chemical kinetics, solutions of electrolytes, ionic equilibrium, surface phenomena, methods of calculating chemical equilibrium at known starting concentrations and equilibrium constants, basics of extraction processes), organic and bioorganic chemistry (properties of organic compounds, nature of chemical bonds and electronic ideas about the structure of organic compounds, mechanisms of reactions of organic compounds in the body and outside the body, methods of analysis in organic chemistry), analytical chemistry (general issues of trace amounts analysis, modern chemical, physical and physico-chemical methods of analysis), biological chemistry (basic laws of drug metabolism, biochemical bases of individual variability of drug metabolism, cell membranes, their properties, for xenobiotics transport), pharmaceutical chemistry (drug properties and methods of their analysis), botany (diagnostic features of plants used in the determination of raw materials, basic physiological processes occurring in the plant organism), pharmacognosy (poisonous medicinal plants, medicinal plants, containing alkaloids, glycosides, toxins of animal origin, elements of pharmacognostic analysis), pharmacology, pharmacotherapy, clinical pharmacy, toxicology (principles of action of drugs, their interaction with medicine, pharmacodynamics, pharmacokinetics, fundamentals of mathematical modeling of pharmacokinetic processes, side effects of drugs, drug poisoning, drug dependence and drug abuse), medical and biological physics (physical research methods, fundamentals of optics, quantum mechanics, thermodynamics basics, idea phenomena - adsorption, desorption, biophysics of biological membranes and processes of transfer across membranes), basics of higher mathematics, statistics and informatics (statistical analysis of experimental data and modern mathematics of computer science and computer engineering), drug technologies (biopharmaceutical basics, influence of dosage forms on bioavailability of drugs, products of secondary metabolism), medical and pharmaceutical commodities (main stages of commodity analysis of pharmaceuticals), organization and economics of pharmacy (basic provisions of legislation), government regulations, public health orders and activities in the field of drug circulation, principles of legal and state regulation, wording of relations in the sphere of drugs, the structure and the functioning of the state system of quality control, effectiveness and safety of drugs, undue influence on the pharmaceutical companies), anatomy, normal and abnormal physiology and integrated with these disciplines;

## 1. Purpose and objectives of the discipline

1.1. **The purpose of the course "Toxicological and Forensic Chemistry"** is to provide students with the necessary knowledge and, on the basis of modern scientific ideas, to form the necessary theoretical knowledge in the field of forensic and toxicological chemistry. As well as the formation of students' chemical-expert thinking and development of skills and methods of methods of isolation of poisons from objects of biological origin, as well as the identification and determination of xenobiotics and their metabolites in carrying out chemical-toxicological or forensic toxicological studies.

1.2. **The main tasks of studying the discipline "Toxicological and Forensic Chemistry"** are: providing students with the basics of knowledge, skills and abilities to work in the field of chemical-toxicological, forensic-toxicological, sanitary-hygienic research (lifetime and post-mortem diagnostics of poisons, quality control of food raw materials, food and nutritional supplements, quality control of perfumery products household chemicals, environmental studies (water, air, soil, household items, etc.).

1.3 **Competencies and learning outcomes**, the formation of which contributes discipline (relationship with the normative content of training seekers of higher education, formulated in terms of learning outcomes in higher education).

According to the requirements of the Standard, the discipline "Toxicological and Forensic Chemistry" facilitates the acquisition of **competencies for** students :

**integral :**

➤ of usefulness to solve common and complex specialized tasks and practical problems in a professional pharmaceutical activities using the theoretical foundations provisions of biochemical processes in the body, chemical processes and methods of chemical and physical-chemical analysis (qualitative and quantitative), which provides experimental studies, introducing innovative methods of analysis, reasonably justifying the results of the definitions and clearly communicating their findings and knowledge to professional and non-professional audiences;

**common :**

- ✓ ability to apply knowledge in practical situations ;
- ✓ knowledge and understanding of the subject area and understanding of the profession;
- 🌐 ability to think abstractly, analyze and synthesize, to be able to learn and master modern knowledge;
- ✓ skills of using information and communication technologies;
- ✓ ability to evaluate and ensure the quality of work performed;
- 🌐 ability to conduct research at the appropriate level;
- ✓ desire to preserve the environment;

**with special (specialty, subject) :**

- ability to organize, provide and carry out chemical-toxicological analysis and forensic toxicological study of objects of biological origin for the presence and content of poisonous substances of different nature and nature.
- 🌐 ability to correctly select research objects for forensic toxicology studies.
- ability to properly draw up a plan for conducting chemical-toxicological and forensic toxicological studies.
- ability to determine the list of equipment and reagents for specific forensic and chemical toxicological studies.
- 🌐 ability to prepare reagents for the analysis of toxic substances by chemical and physico-chemical methods;
- 🌐 ability to develop methods of analysis suitable for the selection of poisons from the objects of study and methods of qualitative and quantitative analysis of these poisons.
- 🌐 ability to interpret and evaluate the results of forensic and chemical toxicological studies.

Detailing competencies according to the NQF descriptors in the form of the Competence Matrix.

### Competence Matrix

No	Competence	Knowledge	Skill	Communication	Autonomy and responsibility
1	2	3	4	5	6
<b>Integral competence</b>					
to solve typical and complex specialized problems and practical problems in professional pharmaceutical activity with application of theoretical principles of the basics of biochemical processes in the body, chemical processes and methods of chemical and physico-chemical analysis (qualitative and quantitative), which involves experimental research, implementation of innovative methods of analysis, reasonable justification of results of definitions and unambiguously communicate their conclusions and knowledge to professional and non-professional audience.					
<b>General competencies</b>					
GC2	Ability to apply knowledge in practical situations	To have specialized conceptual knowledge acquired in the learning process	To be able to solve complex problems and problems that arise in professional activities.	Clear and unambiguous communication of one's own conclusions, knowledge and explanations that substantiate them to specialists and non-specialists.	Responsible for making decisions in difficult conditions
GC3	The desire to preserve the environment	Know the problems of environmental protection and ways to preserve it	Be able to form requirements for themselves and others to protect the environment	Make suggestions to relevant authorities and institutions on measures to preserve and protect the environment	Be responsible for the implementation of environmental measures within its competence
GC4	Ability to abstract thinking, analysis and synthesis, the ability to learn and be modern.	To know the methods of analysis, synthesis and further modern learning.	To be able to analyze information, make informed decisions; be able to acquire modern knowledge.	Establish appropriate connections to achieve goals.	Be responsible for the timely acquisition of modern knowledge.
GC6	Knowledge and understanding of the subject area and understanding of professional activity	Have deep knowledge of the structure of professional activity	Be able to carry out professional activities that require updating and integration of knowledge	Ability to effectively form a communication strategy in professional activities	To be responsible for professional development, the ability to further professional training with a high level of autonomy
GC7	Ability to adapt and act in a new situation.	Know the methods of implementing knowledge in solving practical problems	Be able to use professional knowledge to adapt and act in a new situation	To establish links with the subjects of practical activities	To be responsible for the quality of professional tasks in a new situation
GC11	Ability to evaluate and ensure the quality of work performed	To know the methods of assessing the quality of activities	To be able to ensure the quality of work	Establish links to ensure the quality of work	To be responsible for the quality of work
GC12	Ability to conduct	Know the methods	Be able to plan and	Establish links to	Be responsible for

	research at the appropriate level.	of conducting research and evaluating their results	conduct research, evaluate their results	ensure research at the appropriate level	planning and conducting research at the appropriate level
<b>Special (specialized, subject) competences</b>					
FC6	Ability to identify drugs, xenobiotics, toxins and their metabolites in body fluids and tissues, to conduct chemical and toxicological studies to diagnose acute poisoning, drug and alcohol intoxication. Know the methods of isolation, identification and quantification of drugs, xenobiotics, toxins and their metabolites in body fluids and tissues.	Know the procedure for chemical and toxicological tests to diagnose acute poisoning, drug and alcohol intoxication. Be able to make a plan of chemical and toxicological analysis. Be able to isolate, identify and quantify drugs, xenobiotics, toxins and their metabolites. Be able to apply chemical and instrumental methods of analysis, conduct chemical and toxicological studies	Establish links to select optimal methods for isolation, identification and quantification of drugs, xenobiotics, toxins and their metabolites.	It is reasonable to evaluate and interpret the results of chemical, physico-chemical and physical methods in chemical-toxicological analysis. To be responsible for making decisions on evaluating the results of chemical and physico-chemical methods for detection and quantification of substances.	Be responsible for the interpretation of the results and the correctness and provability of the research.
FC19	Ability to organize and control the quality of medicines in accordance with the requirements of the current State Pharmacopoeia of Ukraine and good practices in pharmacy, determine methods of sampling for control of medicines and standardize them in accordance with current requirements, prevent the spread of counterfeit medicines.	Know the basic methods of quality control of medicines in accordance with the requirements of the current State Pharmacopoeia of Ukraine and good practices in pharmacy, determine methods of sampling for control of medicines and their standardization in accordance with current requirements, prevent the spread of counterfeit medicines. Be able to apply chemical and instrumental methods of analysis, control the quality of drugs in accordance with the	Be able to identify methods of sampling for the control of medicines and standardize them in accordance with current requirements and prevent the spread of falsified medicines. It is reasonable to evaluate and interpret the results of chemical, physico-chemical and physical methods in the quality control of medicines in accordance with the requirements of the current State Pharmacopoeia of Ukraine and good practices in pharmacy.	Use sampling links to control medicines and standardize them in accordance with current requirements, prevent the spread of falsified medicines. Be responsible for deciding on the evaluation of the results of chemical and physicochemical methods for the detection and quantification of substances	Be responsible for the interpretation of the results and the correctness and provability of the research.

		requirements of the current State Pharmacopoeia of Ukraine and good practices in pharmacy.			
FC20	Ability to develop methods for quality control of medicines, including active pharmaceutical ingredients, medicinal plant raw materials and excipients using physical, chemical, physicochemical, biological, microbiological, pharmacotechnological and pharmacoorganoleptic control methods. Know the basic methods of quality control of medicines, including active pharmaceutical ingredients, medicinal plant raw materials and excipients using physical, chemical, physicochemical, biological, microbiological, pharmacotechnological and pharmacoorganoleptic control methods.	Be able to select conditions for quality control of medicines, including active pharmaceutical ingredients, medicinal plant raw materials and excipients using physical, chemical, physicochemical, biological, microbiological, pharmacotechnological and pharmacoorganoleptic methods.	Select the links between the properties of the studied objects and the features of the method of analysis to develop methods for identification, purity and quantification of drugs, including active pharmaceutical ingredients, medicinal plant raw materials and excipients	Be responsible for deciding on the evaluation of chemical physico-chemical methods for detection and quantification of substances	Be responsible for the interpretation of the results and the correctness and provability of the research.

### Program learning outcomes

The discipline "Toxicological and Forensic Chemistry" is aimed at achieving the following program learning outcomes by students:

PLO1	Carry out professional activities in social interaction based on humanistic and ethical principles; identify future professional activities as socially significant for human health.
PLO2	Apply knowledge of general and professional disciplines in professional activities.
PLO3	Adhere to the norms of sanitary and hygienic regime and safety requirements in carrying out professional activities.
PLO4	Demonstrate the ability to independently search, analyze and synthesize information from various



	sources and use these results to solve typical and complex specialized tasks of professional activity.
PLO5	Position your professional activities and personal qualities in the pharmaceutical labor market; to formulate the purposes of own activity taking into account public and industrial interests.
PLO6	Argue information for decision-making, be responsible for them in standard and non-standard professional situations; adhere to the principles of deontology and ethics in professional activities.
PLO7	Perform professional activities using creative methods and approaches.
PLO8	Carry out professional communication in the state language, use the skills of oral communication in a foreign language, analyzing texts of professional orientation and translate foreign language information sources.
PLO11	Use methods for assessing performance indicators; identify reserves to increase labor efficiency.
PLO12	Analyze the information obtained as a result of scientific research, summarize, systematize and use it in professional activities.
PRN15	Provide home care to patients in emergencies and victims in extreme situations.
PLO16	To determine the influence of factors influencing the processes of absorption, distribution, deposition, metabolism and excretion of the drug and due to the condition, features of the human body and physicochemical properties of drugs.
PLO18	Select biological objects of analysis, determine xenobiotics and their metabolites in biological environments and evaluate the results based on their distribution in the body.
PLO24	To plan and implement professional activity on the basis of normative legal acts of Ukraine and recommendations of good pharmaceutical practices.
PLO25	Promote health, including disease prevention, rational use and use of medicines. Perform your professional duties in good faith, comply with the law on the promotion and advertising of medicines. Have psychological communication skills to build trust and understanding with colleagues, doctors, patients, consumers.

### **Learning outcomes :**

Integrative end programmatic learning outcomes facilitated by the Toxicological and Forensic Chemistry course:

#### ***common***

- apply knowledge of general and professional disciplines in professional activity;
- use the results of independent search of scientific and professional information using modern computer tools, network technologies, databases and knowledge;
- to reason information for decision-making, to be responsible for them in standard and non-standard professional situations; adhere to the principles of deontology and ethics in professional activity;
- to use methods of estimating quality of activity indicators; identify reserves for improving labor efficiency;
- to analyze the information obtained as a result of scientific researches, to generalize, systematize and use it in professional activity;
- independently apply the methods and means of cognition, training and self-control to acquire new knowledge and skills .

***professional***

- carrying out scientific researches both as a part of a group and independently, while realizing special means and methods of obtaining new knowledge;
- organization of functioning of the toxicology laboratory;
- ability to prepare reagents for the study of different classes of poisons using chemical, biological and physico-chemical methods in accordance with the requirement of methodological recommendations and other regulatory documents;
- organization of ensuring and controlling the correctness of the experimental studies;
- determination of the list of equipment and reagents for carrying out forensic toxicological and chemical toxicological investigations in accordance with the requirements of regulatory documents and timely metrological verification of the equipment;
- select the sampling method for the input control of the drugs according to the applicable requirements.
- to determine the main indicators of quality of medicines by modern physicochemical methods of analysis;
- carrying out research of poisons by means of preliminary tests (screening tests).
- conducting the extraction of poisons from the internal organs of corpses, blood and urine.
- carrying out the detection and identification of poisons isolated from the objects of study by chemical reactions (dyes, sediments, microcrystalloscopic), physico-chemical methods (spectrophotometric, chromatographic, electrophoretic, fluorescent), physiological tests and enzyme-linked methods of analysis.
- quantitative determination of poisons isolated from the objects of study.

***Learning outcomes for the course "Toxicological and Forensic Chemistry":***

**Student should know:**

- the subject, tasks and main sections of toxicological chemistry, its field of application;
- classification of poisons and poisons;
- classification of poisonous substances by methods of their separation from objects of biological origin;
- the main normative documents regulating forensic toxicological and chemical toxicological analysis;
- safety and rules of work in the chemical-toxicological (forensic-toxicological) laboratory;
- theoretical bases of methods of extraction of toxic substances from biological material, their detection, identification and quantification by chemical and physicochemical methods;
- ways of entering poisons into the body and excretion, their toxicokinetics, distribution in the body, storage in cadaveric material and the influence of these processes on the results of chemical and toxicological analysis;
- toxicodynamics of poisons in the body, mechanisms of toxic action of poisons;
- methods of active and artificial detoxification, specific (antidote) therapy;

**The student should be able to:**

- to analyze data from educational and specialized literature in solving professional problems related to forensic toxicological analysis and rapid diagnostics of acute poisoning;
- propose methods of isolation and analysis of poisons, based on their nature, nature and condition of the object of study;
- draw up a plan and choose the optimal course of chemical toxicological research;
- to isolate poisonous substances and their metabolites from objects of biological origin (isolation, purification, concentration);
- to identify and quantify isolated poisons using chemical, biochemical and physico-chemical methods of study;
- to evaluate the obtained results taking into account the circumstances of the case: toxicokinetics, corpse storage, medical measures during detoxification, age, sex and other factors;
- analyze and interpret the results obtained during the study;
- make the right conclusions in case of combined poisoning;
- conduct rapid analysis of acute intoxication in order to provide qualified medical assistance;
- to carry out differential diagnostics of acute poisonings;
- determine the tactics of preventive measures and emergency care.

- to document the conduct of forensic toxicological studies (keeping a working journal, writing an act of forensic toxicological research).

**Specific goals of toxicological chemistry:**

1. Know the basics of toxicology, toxicodynamics, toxicokinetics, toxicometry.
2. Know the types of toxic effects and the determination of toxic doses.
3. To determine the subject of toxicological chemistry, to learn the main sections of toxicological chemistry, features of chemical-toxicological analysis, the procedure of conducting and documentation of forensic toxicological (chemical-toxicological) examinations;
4. To master definitions of the terms "poison", "poisoning", classification of poisons and poisons;
5. To master the general patterns of behavior of poisonous substances of different groups in the body (ways of receipt, distribution, cumulation, excretion, metabolism);
6. Demonstrate external inspection and preliminary testing of the object using model biological fluids;
7. To learn the method of separation of mineral acids, alkalis and some salts (nitrates and nitrites) from biological material and detection of these substances in dialysates;
8. To learn the methods of detoxification in poisoning by volatile substances, mineral acids, alkalis and their salts.
9. To master the general characteristics of groups of volatile substances and pesticides, use in the economy and medicine, the basic patterns of behavior in the body (pathways, distribution, cumulation, excretion, metabolism, toxicity), specific antidotes for poisoning of these substances;
10. To learn the peculiarities of volatile matter separation by steam distillation method;
11. Demonstrate the detection and identification of volatile substances in distillates and phosphorous pesticides in chemical, biochemical and TLC extracts;
12. To acquire the features of gas chromatographic analysis of volatile substances, in particular alcohols (including fusel oils) in urine and blood by the method of vapor phase analysis (gas extraction);
13. Master the general principles of interpretation of the results of forensic toxicological studies;
14. To assimilate the general characteristics of metals, their chemical and toxicological significance (toxicity and use in the economy and medicine);
15. To master the features of methods of mineralization and destruction of biological objects when investigated for metals;
16. Demonstrate the analysis of minerals and destructates for the presence of metals;
17. Demonstrate the quantitative determination of metals in mineralization by the extraction-photocolorimetric method.
18. To acquire the chemical-toxicological value of the specified group of poisons, the peculiarities of behavior in the body (ways of receipt, absorption and distribution, excretion, metabolism, preservation in a living organism and body of corpses, toxic effect, presence of specific antidotes);
19. Demonstrate the release of biological substances from the biological material and purify the extract obtained using extraction and chromatographic methods;
20. Demonstrate the detection of a number of drugs of greatest chemical and toxicological importance in biological fluids by chemical reactions;
21. Demonstrate the determination of the sensitivity and specificity of chemical reactions used in chemical-toxicological studies;
22. Demonstrate the detection of substances of the specified group in purified hoods by chemical reactions and TLC;
23. Acquire features of the use of the enzyme-linked immunosorbent assay in rapid urine testing for opiates;
24. Demonstrate the quantitative determination of the substance of the specified group by the photocolorimetric method;
25. Demonstrate the isolation of mushroom poisons from biological objects and carry out hood analysis;
26. Evaluate the results of chemical and toxicological studies on the establishment of group or individual affiliation of toxic substances.
27. To assimilate the toxicological characteristics and the chemical-toxicological value of barbiturates, phenothiazines, 1,4-benzodiazepines, opiates and cannabinoids, their peculiarities of behavior in the body

- (pathways of entry, absorption and distribution, excretion, metabolism, persistence and toxicity specific antidotes);
28. Be able to carry out preliminary screening tests of the specified groups of poisonous substances for detection in blood, urine, saliva, hair and in other objects;
  29. Be able to perform TLC-screening of medicinal substances in biological fluids;
  30. Have the skills to properly draw up a plan for forensic toxicological analysis for rapid diagnosis of acute poisoning;
  31. Be able to isolate the substances of these groups from objects of biological origin;
  32. Demonstrate the isolation from the biological material of the substances of the specified group by infusion with water, acidified with oxalic acid (by OO Vasilyeva method) and purification of the extract obtained by extraction and TLC methods;
  33. Be able to detect these substances by chemical, physico-chemical and enzyme-linked immunosorbent methods;
  34. Acquire features of the use of the enzyme-linked immunosorbent assay in rapid urine testing for opiates;
  35. Demonstrate the detection of substances of the specified group in purified hoods by chemical reactions and TLC;
  36. Be able to quantify these poisons isolated from biological objects of study;
  37. Demonstrate quantitative determination of substances of this group by photocolometric method;
  38. Be able to predict the directions of metabolism of substances in order to take measures to prevent the negative impact of "lethal" synthesis on the body of the victim;
  39. Be able to predict the effect of poisons on the body in the somatogenic phase of poisoning and propose effective methods of detoxification of the body;
  40. Be able to predict the impact of combined poisoning on the victim's condition and on the course of chemical and toxicological research;
  41. Have the skills to perform differential rapid diagnosis of acute poisoning;
  42. Evaluate the results of chemical and toxicological studies to establish the group or individual affiliation of medicinal substances.
  43. Have the skills to interpret the results of the analysis correctly.
  44. Know the physical and chemical properties of pesticides and the mechanisms of toxic effects on humans;
  45. To assimilate the toxicological properties of FOPs, their biotransformation in humans and animals, and the ways of their excretion;
  46. Know the rules for the transportation, storage, release and use of pesticides and herbicides;
  47. Acquire safety when using pesticides in everyday life;
  48. Know the distribution of pesticides into groups according to their chemical structure and basic pesticide classifications;
  49. Know the dependence of FOP toxicity on warm-blooded animals on the chemical structure and structure of the molecule;
  50. To learn ways of isolating different groups of pesticides from biological material and body fluids;
  51. Acquire methods for cleaning and concentrating extracts containing pesticides;
  52. Know the principle of biological testing at FOP;
  53. Be able to detect FOPs using chemical, physicochemical and enzyme methods;
  54. Be able to quantify FOP.
  55. Know the toxic properties and mechanism of toxic action of carbon monoxide;
  56. Acquire chemical, spectroscopic and UV spectrophotometric methods for detection and determination of carbon (II) oxide (carbon monoxide) in the blood;
  57. To master methods of separation of fluorides, silicon fluorides, bromine, iodine from biological material, detection and determination of these substances in forensic toxicological studies;
  58. Know how to provide first aid for carbon monoxide poisoning.

**2. Information volume of the discipline:** 6 ECTS credits / 180 hours are allocated for the study of the subject .

*Content module 1*

**Fundamentals of toxicological and forensic chemistry, toxicology, clinical toxicology and environmental toxicology. Groups of toxic substances that are isolated from biological material by infusion**

**of the studied objects with water (mineral acids, alkalis and their salts), steam distillation (volatile substances) and mineralization (metals). Toxicodynamics, toxicokinetics and distribution of these toxins in body tissues. Methods of isolating these groups of poisons from research objects and their methods of analysis. A group of poisons that require special methods of isolation (fluorides, iodide bromides). A group of poisons that do not require isolation, but are studied directly in the object of study (carbon monoxide). Methods of detoxification in poisoning by these groups of substances.**

***Topic 1.** Forensic toxicological research and chemical toxicological analysis. Forensic chemical examination, its stages and tasks. Objects of research. Inspection of research objects, preliminary tests and preparation of a forensic toxicological research plan.*

Toxicological and forensic chemistry, their content and tasks. Stages of formation and development of toxicological and forensic chemistry. Legislation and organization of forensic examination in Ukraine. Ethics and deontology in toxicological and forensic chemistry. Directions, goals and objectives of chemical-toxicological and forensic-toxicological research. The main stages of chemical and toxicological analysis and forensic toxicological research. Use of chemical and toxicological analysis in theoretical toxicology, clinical toxicology, preventive toxicology and forensic toxicology. Forensic examination of poisoning, its tasks and stages. Forensic toxicological research as the main stage of forensic examination of poisonings.

Analysis of physical evidence. Objects of forensic toxicological research, their characteristics, means of preservation. Rules for selection, referral and acceptance of objects for forensic toxicological examination and storage of samples.

Review of objects of research and preliminary tests (screening researches) in the forensic toxicological analysis and their role in drawing up the plan of the chemical toxicological analysis. Objects of study and forensic toxicology study plan for unknown poison (non-targeted or targeted analysis) and suspected poisoning by a specific poison (targeted analysis).

Procedure for execution and documentation of forensic toxicological (chemical toxicological) examinations and forensic medical examinations in general. Drawing up a plan of chemical and toxicological analysis.

General principles of interpretation of forensic examination results.

***Topic 2.** Toxicological characteristics and analysis of a group of toxic substances that are isolated from biological material by infusion of the studied objects with water (mineral acids, alkalis and their salts). Isolation from biological material and detection and quantification of nitrates and nitrites.*

A group of toxic substances that are isolated by infusion with water (inorganic acids, alkalis, salts). General characteristics of the group. Physico-chemical properties. Application. Toxic effect of nitric (nitrate), sulfuric (sulfate), hydrochloric (hydrochloric) acids, salts of nitric and nitric acids (nitrates, nitrites), caustic alkalis (hydroxides of sodium, potassium, ammonium, calcium). Features of the release of acids, alkalis, salts from objects of biological origin. Methods of purification and separation using the phenomena of dialysis, electro-dialysis and osmosis. Methods for detection and quantification of acids, caustic alkalis, salts of nitric and nitric acids.

Storage of compounds of this group in biological material. Evaluation of analysis results.

***Topic 3.** A group of toxic substances those are isolated from biological material by steam distillation (volatile substances). Toxicological characteristics and methods of isolation of volatile substances from research objects.*

General and toxicological characteristics of the group of toxic substances isolated from biological material by distillation (volatile substances): hydrocyanic acid and cyanides, alkyl halides (chloroform, 1,2-dichloroethane, carbon tetrachloride, chloral hydrate, trichlorethylene), aliphatic ethylate including fusel oils (propyl, isopropyl, butyl, isobutyl, amyl and isoamyl alcohols), polyhydric alcohols (ethylene glycol), aldehydes (formaldehyde, acetaldehyde, polyacetaldehyde (metaldehyde or dry alcohols, aromatics), hydrocarbons (benzene, toluene, xylene), monoatomic phenols (phenol, cresol), aromatic amines (aniline and its derivatives), carboxylic acids (acetic or acetic acid), ethers (diethyl), esters (ethyl acetate, cetyl acetate, butyl acetate, butyl acetate) (ethylcellosolve), organometallic compounds (tetraethyl lead), phenol-formaldehyde resins, refined petroleum products (petrol, kerosene, diesel fuel, fuel oil, gas oils), adhesive components attic and chlorinated

hydrocarbons, alcohols, acetone, gasoline, dibutyl phthalate, dioctyl phthalate, etc.), components of perfumes and cosmetics (alcohols, benzyl benzoate, diethyl phthalate, propylene glycol, petroleum products, etc.).

Physico-chemical properties, structure and action of volatile substances on the body. Causes and frequency of volatile poisoning. Features of combined poisonings. Addiction. Directions and products of conversion of alkyl halides, aromatic amines, aromatic hydrocarbons and other volatile substances. General and toxicological characteristics of phosgene - the oxidation product of chloroform and trichlorethylene.

Methods of extraction of volatile substances from objects of biological origin, food and objects of the environment: steam distillation, air distillation, distillation with inert gases, distillation with carrier. Theoretical substantiation of methods, choice of method and conditions of distillation depending on the object and physicochemical properties of the test substance. Substances that are distilled from an acidic environment and substances that are distilled from an alkaline environment.

Chemical method of analysis of distillates. Types of chemical reactions used in the analysis, assessment of their sensitivity and specificity. Schematic diagram of the study of biological objects for volatile substances in directed and undirected analysis. Influence of time and conditions of storage of research objects on the results of the analysis.

Methods of group and individual identification of toxic substances using the method of gas-liquid chromatography (GC). Influence of compounds of endogenous origin on the sensitivity and specificity of the GC method in the analysis of volatile substances.

Examination of alcohol intoxication. Methods of detecting ethanol and its surrogates in biological fluids. Gas chromatographic determination of ethanol in biological fluids by the method of derivatization (alkyl nitrite method) and headspace. Calculation of the amount of alcohol consumed according to the Widmark formula.

The value of the results of chemical and toxicological analysis for the diagnosis of volatile poisoning. Means of detoxification of an organism at poisoning by volatile substances.

**Topic 4. Toxicological characteristics and methods of metal isolation. Investigation of mineralizate for the presence of metals.**

General characteristics, application and toxicity of metal compounds: barium, lead, manganese, chromium, silver, copper, zinc, cadmium, bismuth, thallium, antimony, arsenic and mercury. Ways of entering the body. Types of bonds formed by the interaction of toxic metals with proteins, peptides and amino acids in the body. Distribution and accumulation of metals in the body. Removal of metals from the body. Trace elements and macronutrients.

Theoretical substantiation of the need for mineralization of objects of biological origin in their study of metals. Characteristics of mineralization methods. The choice of mineralization method depending on the nature of the object of study and the metal under study. Denitration of mineralizate and its preparation for research.

Characteristics of metals that may be contained in the mineralized sediment. Detection of barium and lead cations in the mineralization. Separation of sediment from the liquid part of the mineralizate. Washing and recrystallization of sludge. Solubility of lead and barium salts. Separation of precipitates of barium sulfate and lead sulfate. Selection of conditions for complete separation of lead sulfate from barium sulfate. Conversion of barium sulfate into soluble compounds. Lead and barium cation detection reactions.

Systematic path of analysis of metals in mineralized. Method of fractional path of metals analysis in mineralizate. Theoretical provisions. Selection of research objects. Scheme of a separate study of metals in the mineralized (according to O.M. Krylova). Characteristics of reagents for masking interfering ions in a separate study of metals. Characteristics of reagents used for isolation and analysis of metals. Requirements for the sensitivity of reactions in the study of metals in mineralized.

Detection and quantification in the mineralization of cations of manganese (manganese), chromium, silver (argentum), copper (copper), zinc, cadmium, thallium, bismuth, antimony and arsenic.

Toxicological characteristics of mercury compounds, mechanisms of toxic action, binding to body cells, distribution and accumulation in the body. Features of mercury release from biological objects. The essence of the method of destruction. Detection of mercury in destructive. Methods for quantitative determination of mercury in destructate.

General characteristics of methods for quantitative determination of metals in mineralized. Methods of atomic absorption spectroscopy, non-diffraction X-ray fluorescence analysis and other physical methods in the study of metals in mineralizes and biological fluids.

Forensic medical evaluation of the results of forensic toxicological research taking into account the natural content of metals in the body. Possible errors in the analysis. Antidotes used in metal poisoning and mechanisms of their action.

**Topic 5.** *Toxicological characteristics and methods of analysis of toxic substances that require special methods of isolation (fluorides, silicon fluorides, bromine, iodine).*

A group of toxic substances that require special methods of isolation.

Physico-chemical properties of fluorides, silicon fluorides, bromine, iodine. Poisoning by substances of this group. Methods for isolating fluorine, bromine, iodine compounds. Methods for detection and quantification of fluorides, bromides, iodides. Features of fluorine detection in organofluorine compounds (freons). Evaluation of analysis results.

**Topic 6.** *Toxicological characteristics of carbon monoxide, features of its detection and determination in humans. Methods for detecting carboxyhemoglobin and carboxymyoglobin. Spectrophotometric determination of carboxyhemoglobin and carboxymyoglobin.*

A group of toxic substances that are determined directly in biological material without release. Toxicological characteristics of toxic gases: hydrogen sulfide, ammonia, sulfur oxides, carbon dioxide. Physico-chemical properties of carbon monoxide (carbon monoxide, carbon monoxide). Acute poisoning and classification of carbon monoxide poisoning by severity. Detection of carboxyhemoglobin directly in the blood by chemical, spectroscopic and spectrophotometric methods. Quantitative determination of carbon monoxide in the blood by spectrophotometric and spectroscopic methods.

Chemical, spectroscopic and UV spectrophotometric methods for detection and determination of carbon (II) oxide in blood.

Methods of natural and artificial detoxification of the body in acute carbon monoxide poisoning.

**Topic 7.** *Concept of poison. Characteristics and examples of xenobiotics. Classifications of poisons. Ways of penetration of poisons into an organism and transport mechanisms. Distribution of toxins in the body. Characteristics of poisons. Factors affecting the toxicity of chemical compounds. Removal of toxins from the body. Basic patterns of behavior of toxic substances in the body. Metabolism (biotransformation) of xenobiotics. The first and second phases of metabolism.*

Definition of the terms "xenobiotic", "poison". The main factors determining the toxicity of substances. General principles of poison classification: by chemical structure, by purpose, by degree of toxicity (hygienic), by type of toxic action (toxicological), by selective toxicity, pathophysiological (by type of hypoxia), pathochemical by Pokrovsky (by mechanism of interaction with enzyme systems), by the degree of carcinogenic activity (strong, medium and weak carcinogens), biological (by the nature of the biological consequences of poisoning - allergens, teratogens, mutagens, carcinogens), by methods of isolation from objects of biological origin (chemical and toxicological). Forensic classification of poisons.

Types of toxic effects. Embryotoxic, gonadotoxic, teratogenic and mutagenic effects of toxic substances. Toxic doses and concentrations of poisons.

Characteristics of xenobiotics (certain drugs, food additives, alcoholic beverages, preservatives, cosmetics, pesticides, detergents, toxic gases, alkalis, acids, "heavy metals", poisons of plant and animal origin, disinfectants, plant protection products, pesticides, mineral fertilizers, household chemicals for various purposes, technical fluids, organic solvents, industrial waste, etc.).

Ways of toxins entering the body (oral, parenteral, inhalation, percutaneous, through body cavities). The concept of toxicodynamics and toxicokinetics of poisons. Transport of poisons and their metabolites across cell membranes. Theory of nonionic diffusion. The concept of membrane toxins. Diseases and mechanisms of membrane damage. Toxicity receptor theory. The main types of connections between poisons and receptors that affect toxicity. Factors determining the distribution of toxic substances in the body (spatial, concentration and temporal). The relationship between the physical and chemical properties of poisons and their distribution in the organs and excretion from the body. The concept of accumulation and addiction to poisons. Combined action of toxic substances. Selective toxicity. Adaptation to poisons. Elimination of poisons - natural detoxification of the body. Removal of toxins from the body (excretion). Excretion through the lungs. Renal excretion. Isolation by the liver (hepatocyte uptake, biliary excretion). Excretion through the intestines. Other ways of withdrawal.

Ways of biotransformation of xenobiotics in the body. Metabolism and metabolites. The concept of "lethal synthesis" and "lethal inclusion". Microsomal and non-microsomal metabolism. Characteristics of metabolic processes in cells of various organs and tissues (liver, lungs, kidneys, placenta, blood, intestines). Participation and role in the enzymatic metabolism of oxyreductase, transferase, hydrolase, lyase, isomerase and ligase (synthetase). Regularities and mechanisms of reactions of the first phase of biotransformation (microsomal and non-microsomal oxidation, microsomal and non-microsomal reduction and hydrolysis). Mechanisms of phase II biotransformation reactions. Conjugation reactions.

Degradation of xenobiotics in corpses under the influence of environmental factors and microorganisms. Influence of products of biodegradation of poisons on the result of forensic chemical research and its interpretation.

### **Final (credit) lesson of content module 1.**

- Toxicological and Forensic Chemistry its contents, tasks and main sections (analytical toxicology and biochemical toxicology).
- Fundamentals of Toxicological Chemistry and Chemical Toxicological Analysis.
- Forensic chemistry and forensic toxicological analysis.
- Areas of use of methods of chemical-toxicological analysis. Use of chemical-toxicological analysis in theoretical toxicology, clinical toxicology, prophylactic toxicology and forensic toxicology.
- General principles of interpretation of results of forensic toxicological investigations.
- Basic toxicokinetic constants and their use for interpretation of results of chemical-toxicological analysis.
- Chemical-toxicological and forensic toxicological analyzes in the diagnosis of acute poisoning
- The relationship of toxicological chemistry with toxicology and other medical, biological, pharmaceutical and fundamental disciplines.
- Analytical and applied toxicology.
- Stages of formation and development of toxicological chemistry.
- The value of toxicological chemistry in the preparation of a pharmacist. Ethics and deontology in toxicological chemistry.
- Definition of "poisoning" and "poison". General principles of classification of poisons: by chemical structure, purpose of use, by the degree of toxicity (hygienic), type of toxic action (toxicological), selective toxicity, by methods of isolation from objects of biological origin.
- Classification of poisoning by origin, by conditions (place) of development, by clinical principle (acute, chronic, subacute poisoning), by the ways of penetration into the body; nosological classification.
- Classification of poisons in toxicological chemistry.
- Toxicokinetics. Ways of poison penetration into the body, transport mechanisms of absorption and interrelation with their physical and chemical properties and distribution in organs, excretion, cumulation. Influence of nature, concentration and ways of absorption of poison on the dynamics of growth of its concentration in blood and distribution in organs.
- The main patterns of behavior of toxic substances in the body. Metabolism (biotransformation) of poisons. The first and second phases of metabolism. Fatal Synthesis. Dependence of poison metabolism on species, age, sexual sensitivity, presence of other xenobiotics and other factors. Influence of metabolism processes on the results of chemical-toxicological study.
- Legislation and organization of forensic examination in Ukraine
- Procedure and documentation of forensic toxicological (chemical-toxicological) examinations.
- Features of chemical-toxicological and forensic toxicological analysis. General and targeted (targeted) chemical-toxicological analysis.
- Analysis of physical evidence. Objects of chemical-toxicological and forensic toxicological researches their characteristics, means of preservation. Rules for selection, referral and admission of objects for forensic toxicological examination and storage of samples. Features of the analysis of individual objects depending on their nature, condition, chemical properties of poisonous substances. Decay of biological material and major reactions of secondary metabolism.



- Carry out an external inspection of the objects of study and preliminary tests for the detection of ammonia, hydrogen sulfide, acids, alkalis, oxidizing agents, reducing agents and preservatives. The role of preliminary tests (screening studies) in drawing up a plan for chemical toxicological analysis.
- A group of poisonous substances that are isolated from biological material by infusion with water: inorganic acids (chloride, nitrate, sulfate), alkalis (sodium hydroxide, potassium, calcium, ammonium), nitrate and nitric acids (nitrates, nitrites). Isolation of biological material, purification of water extracts, detection and quantification. Evaluation of the results of the analysis.
- General and toxicological characteristics of the group of toxic substances that are isolated from biological material by the method of distillation (volatile substances): hydrocyanic acid and cyanides, alkyl halides (chloroform, 1,2-dichloroethane, tetrachloromethane, chloral hydrate, trichlorethylene) including fusel oils: propyl, isopropyl, butyl, isobutyl, amyl and isoamyl alcohols), polyhydric alcohols (ethylene glycol), aldehydes (formaldehyde, acetaldehyde, polyacetaldehyde (metaldehyde, or dry alcohol) they (acetone), aromatic hydrocarbons (benzene, toluene, xylene), monatomic phenols (phenol, cresol), aromatic amines (aniline and its derivatives), carboxylic acids (acetic or acetate), ethers (ethyl acetate), esters (ethyl acetate) butyl acetate, tricresyl phosphate), celosolve (ethylcellosolve), organometallic compounds (tetraethyl lead), phenol-formaldehyde resins, petroleum refining products (gasoline, kerosene, diesel fuel, fuel oil, gasoil), adhesive components (aromatics, benzytonyl, benzylethyl) dioctyl phthalate, etc.), a component and perfumes and cosmetics (alcohol, benzyl benzoate, diethyltalat, propylene glycol, oil products, etc.).
- General and toxicological characteristics of phosgene - a product of oxidation of chloroform and trichlorethylene.
- Physicochemical properties, structure and action on the body of volatile substances. Causes and frequency of poisoning by volatile substances. Features of combined poisoning. Substance abuse.
- Directions and products for the conversion of volatile substances (alkyl halides, aromatic amines, aromatic hydrocarbons and others).
- The value of the results of chemical-toxicological analysis for the diagnosis of poisonings by volatile substances.
- Means of detoxification of an organism at poisoning by volatile substances.
- Methods of extracting volatile substances from biological, food and environmental objects: steam distillation, dry air distillation, inert gas distillation, carrier distillation. Mechanisms of distillation of volatile substances which are soluble in water and volatile substances which are not miscible with water. Azeotropic mixtures. Dalton's Law. Theoretical substantiation of methods, choice of method and conditions of distillation depending on the object and physicochemical properties of the test substance. Characteristics of substances that are distilled from acidic medium and substances that are distilled from alkaline medium.
- Methods for purification and concentration of volatile substances in distillates.
- Schematic diagram of the study of biological objects for volatile substances in general and purposeful analysis.
- Chemical methods for the study of volatile substances in distillates, their sensitivity and specificity. Cyanide, chloroform, 1,2-dichloroethane, tetrachloromethane, chloral hydrate, trichlorethylene, methanol, ethanol, isoamyl alcohol, ethylene glycol, formaldehyde, acetone, phenol, aniline, acetic acid (acetate, acetate) acetate reactions
- The use of GCS for the analysis of volatile substances. Theoretical bases of gas chromatographic analysis. Characteristics of gas chromatograph systems and units (gas supply system, evaporator, chromatographic columns, thermostat system, detection system, signal recording system). Schematic diagram of chromatographic separation. Carrier gases, auxiliary gases, solid carriers, liquid stationary phases and gaskets in GCS and their characteristics. Temperature characteristics of the gas chromatographic process. Temperature programming. Devices for introducing samples into the evaporator. Characteristics of chromatographic columns ( materials, types, shapes, length, diameter). General requirements for detectors and their characteristics (sensitivity, detection limit, linearity, selectivity, specificity, inertia and versatility). Classification of detectors by nature of the signal. Equipment and methods for detecting detector signals. Characteristics that affect the chromatographic separation. Chromatographic peak parameters.
- Typical tasks and basic techniques of qualitative analysis. Parameters of qualitative gas chromatographic analysis. Methods of group and individual identification of volatile substances by the GC method.

- Tasks and methods of quantitative gas chromatographic analysis. Chromatographic peak parameters for quantification in GC. Methods of processing quantitative parameters of chromatograms. Methods of quantitative analysis in GCG (internal normalization, absolute calibration, internal standard, external standard).
- The use of GCS for the analysis of alcohols and fusel oils. The value of the relative ratio of ethanol in urine and blood for the diagnosis of alcohol poisoning and for the diagnosis of alcohol coma.
- Application of GCG for the analysis of phenol-formaldehyde resins, components of adhesives, components of perfumes, as well as components of oil, gasoline, kerosene and fuel oil.
- Group of toxic substances that are isolated from biological material by the method of mineralization (metals): compounds of barium, lead (plumbum), manganese (manganese), chromium, silver (argentum), copper (cuprum), zinc, cadmium, bismuth, thallium, stibium arsenic and mercury (mercury). General Characteristics of the Attachment and Toxicity of Metal Compounds. Ways of entering metals into the body. The types of bonds that are formed by the interaction of poison metals with proteins, peptides and amino acids in the body. Distribution and accumulation of metals in the body. Removal of metals from the body.
- Micronutrients and macronutrients, their role in the body and influence on forensic toxicological analysis.
- Dependence of metals toxicity on atomic mass, normal potential, degree of hydration, magnitude of ionic radius and number of electron shells, degree of oxidation, solubility in body fluids and other factors.
- Methods of extracting metals from objects of study. Characterization of mineralization methods. C posoby denitration mineralizatu.
- Characteristics of metals that may be contained in the minerals in the form of sediments. Separation of lead sulfate precipitate from barium sulfate. Lead and barium cation detection reactions in minerals.
- Method of fractional analysis of metals in mineralizate. Scheme of a separate study of metals in mineralization (by AM Krylova). Characteristics of Reagents for Masking Interfering Ions in Separate Investigation of Metals. Systematic course of analysis of metals (barium compounds, lead (plumbum), manganese (manganese), chromium, silver (argentum), copper (cuprum), zinc, cadmium, bismuth, thallium, stibium, arsenic and mercury (mercury) in mineralization.
- Characteristics of reagents used for ion masking, separation, detection and quantification of metals.
- Requirements for the sensitivity of reactions in the study of metals in minerals. Features and methods of quantitative determination of metals in objects of biological origin. Results of quantitative determination of metals and their importance for forensic chemical evaluation of research results.
- Forensic evaluation of the results of forensic toxicological study taking into account the natural content of metals in the body.
- Toxicological characteristics of mercury (mercury) compounds, mechanisms of toxic action, binding to cells of the body, distribution and accumulation in the body. Selection of mercury from objects of biological origin. The essence of the method of destruction. Detection and quantitative determination of mercury in destructate. Antidotes used in metal poisoning.
- Instrumental methods for the study of metals in minerals and biological fluids (atomic absorption spectroscopy, diffraction-free X-ray fluorescence analysis, etc.).
- A group of poisonous substances that require special isolation methods (fluorides, silicon fluorides, bromine, iodine). Physico-chemical properties, toxicological characteristics, poisoning and assistance. Methods of isolation of fluorine, bromine, iodine compounds. Methods for detection and quantification of fluorides, bromides, iodides. Features of detection of fluorine in organo-fluoro-compounds (freons). Evaluation of analysis results.
- A group of toxic substances that are directly identified in biological material - carbon monoxide (CO, carbon (II) oxide, carbon monoxide (II) or carbon monoxide). Physicochemical properties, toxicological characteristics mechanism of toxic action. Acute poisoning and classification of carbon monoxide poisoning by severity. Detection of carboxyhemoglobin and carboxymyoglobin by chemical, spectroscopic and spectrophotometric methods. Quantitative determination of carboxyhemoglobin and carboxymyoglobin by spectrophotometric and spectroscopic methods. Methods of natural and artificial detoxification of the body in acute carbon monoxide poisoning.

## *Content module 2*

**A group of toxic substances those are isolated from biological material by polar solvents. Medicinal substances and natural poisons (plants, fungi, animals, insects and algae). A group of toxic substances released from research objects by non-polar organic solvents (pesticides). Toxicodynamics, toxicokinetics and distribution of these toxins in the body. Methods of isolation of these poisons from the objects of research and methods of their analysis Express analysis of acute intoxications with these poisons. Methods of detoxification in poisoning.**

*Topic 8. Methods of isolation of medicinal substances of natural (alkaloids) and synthetic origin from biological material. Methods of cleaning extracts from biological material and concentrating toxic substances.*

General characteristics of the group. Physico-chemical properties, structure and effect on the body of toxic and potent substances of organic nature. Drug addiction and drug addiction. Diagnosis of narcotic conditions. Doping agents. Doping control. Methods of natural and artificial detoxification of the body in acute poisoning. Basic physicochemical constants (pH, pKa, partition coefficient, etc.). Extraction of substances with organic solvents from aqueous media, its importance for the isolation of this group of compounds, the dependence of its effectiveness on various factors. Modern general and individual methods of selection, their characteristics and comparative evaluation. Influence of various factors on the efficiency of research substances at different stages of this process (nature, condition and preliminary preparation of the object, nature of solvent, pH of solution, nature of acid and electrolyte, degree of ionization, methods of protein precipitation, nature of extractant, etc.). Characteristics of solvents that are most often used for insulation.

Special methods for isolating barbiturates (method of P. Valov, V.I. Popova), derivatives of 1,4-benzodiazepine (method of B.M. Izotov), derivatives of phenothiazine (method of E.M. Salomatin).

Methods of purification of extracts and separation of toxic substances from concomitant endogenous impurities of protein and lipid character, dyes, etc. (TLC, gel chromatography, salting out, electrophoresis, extraction, sublimation, dialysis and electro dialysis).

Methods of concentrating test substances from extracts: extraction with organic solvents, adsorption, evaporation, etc.

*Topic 9. Directed and non-directed analysis of extracts from biological material. Analytical and toxicological screening. Express methods of poison detection in forensic chemical and chemical toxicological research facilities. Preliminary and evidential methods of forensic chemical analysis.*

TLC screening as a preliminary stage of identification in undirected chemical and toxicological analysis. Group developers in TLC screening. Establishment of group and individual suitability of medicinal substances extracted from biological fluids by TLC screening. Scheme of identification and quantification of substances isolated by polar solvents.

Theoretical bases of chromatographic methods and their application in chemical and toxicological researches. Identification by TLC, GLC and HPLC methods.

Physical bases of spectrophotometric methods and features of their application at chemical and toxicological researches. Use of immunochemical methods (radioimmune and enzyme-linked immunosorbent assays) for detection and determination of toxic substances in biological fluids. Determination of group and individual affiliation of alkaloids using pharmacological tests (atropine, strychnine, nicotine). Evaluation of the specificity and sensitivity of these methods.

Methods of quantitative determination of medicinal substances isolated from biological material. Photometric: photoelectrocolorimetry (extraction photometry), UV spectrophotometry (direct, differential on the example of barbiturates). Extraction-photometric determination of medicinal substances in extracts. Chromatographic methods of quantitative determination of poisons: HPLC, GLC, TLC (densitometry, planimetry). Comparative evaluation of methods by sensitivity. Influence of various factors related to the peculiarity of biological objects on the results of quantitative determination of medicinal substances isolated from biological material in the course of chemical and toxicological research. Requirements for the degree of purification of biological extracts to be quantified.

Comparative evaluation of analysis methods, their sensitivity, specificity and possibility of use in the presence of some impurities of endogenous origin.

**Topic 10. Research of chloroform extracts from acidic environment ("acid" chloroform extracts).**

Toxicological characteristics and methods of analysis of medicinal substances and poisons of natural origin extracted from acidic media (substances of acidic, neutral and slightly basic nature). Chemical and toxicological analysis of "acid" chloroform extract (chloroform extract) for substances of acidic, neutral and weakly basic nature.

Chemical research methods. Types of reactions: color, sedimentary and microcrystalline reactions, features of their implementation. Sensitivity and specificity of reactions. The concept of false-positive and false-negative result.

Physico-chemical methods of analysis and their use for detection and quantification of drugs.

Use in medicine of medicinal substances: derivatives of indole, xanthine, pyrazolone, barbituric and salicylic acids. Physico-chemical properties and chemical structure, causes of poisoning, mechanisms of toxic action, the basic patterns of behavior in the body (routes of entry, metabolism, distribution, excretion).

*Medicinal substances (alkaloids and their synthetic analogues) and poisons of natural origin:*

- derivatives of indole (strychnine and brucine - alkaloids of chilibukha seeds; reserpine - alkaloid of plants of the genus Rauwolfia; physostigmine - alkaloid of beans of the plant physostigma; hallucinogenic mushrooms, bufotenin - alkaloid curare-like action of the skin of tropical frogs).
- xanthine derivatives (caffeine - an alkaloid of coffee tree, tea, holly, guarana, when; theobromine - alkaloid of cocoa, when, holly; theophylline - alkaloid of cocoa, camellia, holly).

*Medicinal substances of synthetic origin:*

- derivatives of barbituric acid (barbital, phenobarbital, benzonal, barbamil, etaminal sodium);
- uracil derivatives (5-fluorouracil);
- derivatives of salicylic acid (sodium salicylate, acetylsalicylic acid, methyl salicylate, phenylsalicylate, salicylamide, oxafenamide, sodium para-aminosalicylate);
- pyrazolone derivatives (analgin, antipyrine, amidopyrine, butadione).

**Topic 11. Investigation of chloroform extracts from alkaline media ("alkaline" chloroform extracts) using color, sediment and microcrystalline reactions. Investigation of "alkaline" chloroform extracts by chromatographic methods (TLC, GC, HPLC), spectrophotometric (UV, IR spectrophotometry) and enzyme-linked immunosorbent assays. Quantitative determination of medicinal substances in extracts from biological material. Express analysis of acute intoxications.**

Toxicological characteristics and methods of analysis of drugs extracted from alkaline media (basic and weakly basic substances).

Physico-chemical properties, chemical structure (classification by the structure of the heterocycle), the basic patterns of behavior in the body (pathways, distribution, excretion, metabolism), toxic effects. Chemical and toxicological analysis of "alkaline" chloroform extract (chloroform extract) for drugs of basic nature. Determination of group and individual affiliation of drugs using chemical reactions (sedimentary, color, microcrystalline).

Chemical and toxicological evaluation of the obtained results. Diagnosis of narcotic conditions. Doping agents. Doping control. Drug and drug addiction and their prevention.

Features of rapid analysis of biological fluids in acute poisoning: the direction of analysis, features of the release of drugs from biological fluids, requirements for sensitivity and specificity of analytical methods used in the analysis.

*Medicinal substances (alkaloids and their synthetic analogues) and poisons of natural origin:*

- pyridine and piperidine derivatives (anabasine, nicotine, arecoline, coniine, lobeline, pachycarpine);
- derivatives of tropan (alkaloids of belladonna and datura, atropine, scopolamine, cocaine);
- quinoline derivatives (quinine alkaloids, quinine, quinidine; quinozol, quiniophone);
- derivatives of isoquinoline (sleeping poppy alkaloids - opiates):
- tetrahydroisoquinoline derivatives (narcotics, narcein);
- benzyloisoquinoline derivatives (papaverine);
- phenanthrenisoquinoline derivatives (morphine, codeine, thebaine);

- semi-synthetic opioids (ethylmorphine, heroin, hydrocodone, oxycodone, levorphanol, etc.);
- derivatives of phenylalkylamine (acyclic alkaloids - ephedrine, pseudoephedrine and their oxidation products - ephedrone and norephedrone; amphetamines - phenamine (amphetamine), methamphetamine, MDMA (ecstasy), etc.).

*Medicinal substances of synthetic origin:*

- 1,4-benzodiazepine derivatives (chlordiazepoxide, diazepam, oxazepam, mezapam, phenazepam, nitrazepam, clonazepam);
- phenothiazine derivatives (aminazine, diprazine, etmosin, levomepromazine, thioridazine);
- derivatives of p-aminobenzoic acid (novocaine, novocainamide);
- derivatives of isonicotinic acid (isoniazid, iproniazid, flivazid);
- butyrophenone derivatives (haloperidol, droperidol, benperidol);
- imidazoline derivatives (clonidine);
- tricyclic antidepressants (imipramine, amitriptyline, trimipramine);
- synthetic opioids (tramadol, methadone, fentanyl, promedol, phencyclidine, ketamine, dextromethorphan, pentazocine, etc.);
- phenylalkylamine derivatives (amphetamines - phenamine (amphetamine), methamphetamine, MDMA (ecstasy), etc.);
- derivatives of lysergic acid (LSD / Lysergic acid diethylamide).

**Topic 12.** *Express analysis of acute cannabinoid intoxication.*

Characteristics and chemical composition of cannabinoids (marijuana, hashish and hashish oil). Toxic effects of cannabinoids. Ways of cannabinoids entering the body and their excretion from the body. The main pathways of cannabinoid metabolism. Characteristics of research objects in cannabinoid poisoning. Examination of saliva and skin of the hands for the presence of cannabinoids. Preliminary tests for cannabinoids in body fluids. Isolation of cannabinoids from research objects. Detection of cannabinoids by chemical methods, thin layer chromatography method and gas-liquid chromatography method.

**Topic 13.** *Poisons of natural origin (poisons of plants, fungi, algae, animals and insects). General and toxicological characteristics, isolation from biological material and methods of chemical and toxicological analysis. Diagnosis of poisoning and detoxification of the body.*

Characteristics of poisons of natural origin. Plant poisons (phytotoxins) – ricin, nicotine, strychnine, scopolamine, etc. Poisons of animal origin (zootoxins) – tetrodotoxin. Poisons of cap fungi and their classification. Mechanisms of toxic action and clinical symptoms of poisoning with the use of poisonous mushrooms (pale toadstool, red toadstool, false honeysuckle, false morels) and conditionally edible fungi (morels, stitches, piglets, woolly, russula). Diagnosis, emergency care, antidote and symptomatic therapy for mushroom poisoning. Methods of isolation from the objects of research and chemical-toxicological analysis of poisons of hat fungi.

Poisons of natural origin that require special methods of isolation from the objects of study: toxins of lower fungi or fungal poisons (mycotoxins), algae toxins (algotoxins) and microbial toxins.

**Topic 14.** *General characteristics of pesticides: classifications, toxicity, mechanisms of toxic action, biotransformation. Toxicological characteristics and methods of pesticide analysis. Toxicological characteristics and methods of isolation of organophosphorus pesticides (POP) and other organophosphorus compounds (POC) from biological material.*

General idea of pesticides. Classification of pesticides by direction of application, toxicity, form of use. Chemical classification. Application in the economy. Negative aspects of pesticide use for the environment and humans. The problem of pesticide residues. Means of pesticide poisoning prevention.

Pesticides from the group of organochlorine compounds: carbamic acid derivatives, synthetic pyrethroids, phenol derivatives. Chemical structure and physicochemical properties of hexachlorocyclohexane, heptachlor, carbaryl, permethrin, decamethrin, cypermethrin, effect on the body, characteristics of poisoning. Basic patterns of behavior in the body and corpse. Objects of chemical and toxicological analysis. Methods of

isolation from objects of biological origin. Chemical, physicochemical and enzymatic methods of analysis. Methods of quantification. Evaluation of analysis results.

Organomercury pesticides (ethyl mercuric phosphate, ethyl mercuric chloride). Physical and chemical properties. Application and toxicity. Ways of penetration into the body, distribution, biotransformation and excretion from the body. Methods of isolation from biological objects. Methods of detection and determination by native form and by mercury (II). Evaluation of analysis results.

Pesticides from the group of phosphoric acid derivatives (POC). Structure, physical and chemical properties of chlorophos, dichlorvos, metaphos, carbophos, phosphamide. Causes and frequency of POC poisoning, stages of POC poisoning. Ways of penetration into the body. Biotransformation of POP in humans and animals, characteristics of toxic properties of their metabolites. The main patterns of behavior of POC in the body during life and after death. Objects of chemical and toxicological analysis at POC.

Methods of POC isolating from corpse organs, biological fluids, food. The choice of extractant depending on the condition, nature of the object of study and the poison. The choice of method of cleaning hoods containing POC, depending on the nature and amount of coextractive substances.

Methods of POC analysis in extracts from biological material: cholinesterase test, chromatoenzyme and enzyme-linked immunosorbent assay. The role of enzymatic methods in the rapid diagnosis of acute and chronic intoxication of POC. Evaluation of analysis results.

Chemical methods of POC analysis in extracts from biological material. Detection of organophosphorus substances by phosphorus. Detection of phosphorylating activity. Detection of thio- and dithiophosphoric acid derivatives. Detection by functionally active groups and by hydrolysis products. Evaluation of analysis results.

Chromatographic methods of POC analysis in extracts from biological material. Detection and identification by TLC, GLC and HPLC. Evaluation of analysis results.

Methods of POP quantitative determination (photocolorimetric, photometric for phosphorus, planimetric, enzymatic, GC method). Characteristics of the main techniques of POP assay in extracts from biological material and their comparative evaluation.

First aid and antidote therapy for POC poisoning.

### **Final (credit) lesson of content module 2.**

- Medicinal substances. Physico-chemical properties, structure and action on the body of toxic and potent substances of organic nature. Medical dependence. Addiction and substance abuse and their prevention. Methods of natural and artificial detoxification of the body in acute poisoning. Antidote therapy.
- Modern general (classical) and separate methods of extraction of medicinal substances and poisons of natural origin. Characteristics and comparative evaluation of classical methods of isolation of alkaloids from objects of biological origin analysis (Stas-Otto, Vasilyeva, Kramarenko methods). Separate (special) methods of isolation of barbiturates (Valov, Popova method), 1,4-benzodiazepine derivatives (Izotov method), phenothiazine derivatives (Salomatin method).
- The influence of various factors on the efficiency of selection of test substances at different stages of this process (nature, condition and preliminary preparation of the object, the nature of the solvent, pH of the solution, the nature of the acid and electrolyte, the degree of ionization, methods of deposition of proteins, nature of the extractant, etc.). Characteristics of reagents and solvents used at different stages of separation (isolation, purification of the hood, concentration of the test substance and purification of the isolated substance).
- Methods for purification of extracts and separation of toxic substances from the concomitant endogenous impurities of protein and lipid character, dyes, etc. (TLC, gel chromatography, salting, electrophoresis, extraction, sublimation, dialysis and electro-dialysis). The choice of method depending on the condition, type of object of study and the method of isolation of poison from biological material.
- Methods for concentrating test substances from extracts: extraction with organic solvents, adsorption, evaporation and the like.
- Extraction of substances with organic solvents from aqueous media, its importance for the isolation of the specified group of compounds, dependence of its effectiveness on various factors. Basic physicochemical constants (pH, pKa, partition coefficient, etc.). Characterization of the solid phase extraction method.
- Physico-chemical properties, chemical structure, application, toxicological characteristics, causes of poisoning, mechanisms of toxic action, toxicodynamics and toxicokinetics (pathways of entry into the body,

metabolism, distribution, excretion) and methods of analysis of medicinal substances and poisons of natural origin:

***Alkaloids and their synthetic analogs:***

- indole derivatives (strychnine and brucine - alkaloids seed chilubuha, reserpine - alkaloid plants of Rauwolfia, physostigmine - alkaloid bean plants fizostyhmy, harmine and harmalin - alkaloids harmaly, ibohain - alkaloid ibohy, erhonin and ergotamine - ergot alkaloids, psilocin and psilocybin - alkaloids hallucinogenic mushrooms; buffotenin - alkaloid of curly-shaped skin of tropical frogs).
- xanthine derivatives (caffeine - alkaloid of coffee tree, tea, holly, guarana, when; theobromine - cocoa alkaloid, holly; theophylline - cocoa alkaloid, camellias, holly).
- derivatives tropanu (belladonna alkaloids and intoxication, atropine, scopolamine, cocaine);
- quinoline derivatives (quinoline alkaloids, quinine, quinidine; quinazole, quiniophone);
- isoquinoline derivatives (opiate poppy alkaloids - opiates):
- derivatives tetrahydroizohinolinu (narcotine, nartseyin);
- derivatives benzylozohinolinu (papaverine);
- derivatives fenantrenizohinolinu (morphine, codeine, tebayin);
- pyridine derivatives and piperidine (Anabasine, nicotine, arekolin, Coniine, lobeline, choice amounts);
- Acyclic alkaloids (ephedrine, pseudoephedrine) and their oxidation products - ephedrone and norephedrone).

***Synthetic drugs:***

- barbituric acid derivatives (barbital, phenobarbital, benzonal, barbamyly, sodium ethanol);
- derivatives of uracil (5-fluorouratsyl);
- salicylic acid derivatives (sodium salicylate, acetylsalicylic acid, methylsalicylate, phenylsalicylate, salicylamide, oxafenamide, para-aminosalicylate sodium, bespas);
- pyrazolone derivatives (analgin, antipyrine, amidopyrin, butadion).
- derivatives of 1,4-benzodiazepines (chlordiazepoxide, diazepam, oxazepam, mezepam, phenazepam, nitrazepam, clonazepam);
- phenothiazine derivatives (chlorpromazine, Promethazine, etmozyn, levomepromazine, thioridazine)
- original *claim* -aminobenzoynoyi acid (Novocain, novokainamid);
- isonicotinic acid derivatives (isoniazid, iproniazide, ftivazide);
- derivatives butyrofenonu (haloperidol, droperidol, benperydol);
- imidazoline derivatives (clonidine);
- phenylalkylamine derivatives (phenamine and other amphetamines);
- tricyclic antidepressants (imipramine, amitriptyline, trimipramine);
- opioids:
  - ✓ *semi-synthetic* (ethylmorphine, heroin, hydrocodone, oxycodone, levorphanol, etc.);
  - ✓ *synthetic* (methadone, fentanyl, promedol, phencyclidine, ketamine, dextromethorphan, pentazocin, tramadol, etc.).
- Chemical-toxicological analysis of "acidic" chloroform extract (chloroform extract) for substances of acidic, neutral and slightly basic character and "alkaline" chloroform extract (chloroform extract) for medicinal substances of basic character. Chemical research methods. Types of reactions: colored (colored), sedimentary and microcrystalloscopic reactions, features of their implementation. Sensitivity and specificity of reactions. Determination of group and individual membership of alkaloids by chemical reactions. Chemical-toxicological evaluation of the results.
- Physico-chemical methods for the study of drugs and natural poisons: chromatography in thin layers of sorbent (TLC), high-performance liquid (HPLC) and gas-liquid chromatography (GCM). TLC-screening as a preliminary identification step in non-directional chemical-toxicological analysis. Group developers in TLC. Establishing the group and individual suitability of medicinal substances extracted from biological fluids by TLC screening. TLC-screening of salicylates, barbiturates, pyrazolone derivatives, xanthine derivatives, opiates, phenothiazine derivatives, 1,4-benzodiazepine derivatives, tropane derivatives, quinoline derivatives.
- Photometric methods: spectrophotometry in the visible, UV and IR regions of the spectrum, photoelectrocolorimetry, fluorimetry, chromatographic mass spectrometry. Bouguer-Lambert-Beer law. Use

of immunochemical methods (radioimmunoassay and enzyme immunoassay) for the detection and determination of toxic substances in biological fluids. Classification of immunochemical methods of analysis.

- Pharmacological studies. Determination of group and individual membership of alkaloids by pharmacological tests (atropine, strychnine, nicotine).
- Comparative evaluation of methods of analysis, their sensitivity, specificity and the possibility of using in the presence of some impurities of endogenous origin.
- Methods for quantitative determination of medicinal substances isolated from biological material. Photometric: photoelectrocolorimetry (extraction photometry), UV spectrophotometry (direct, differential with the example of barbiturates). Extraction and photometric determination of medicinal substances in extracts. Selection of optimal conditions for extraction-photometric determination of basic substances by reaction with acid dyes (for example, sulfophthalein dyes) (selection of the most sensitive dye, light filter, thickness of the absorption layer, destruction of the ionic associate and re-extraction of the dye layer) analysis of medicinal substances in biological fluids.
- Chromatographic methods for the quantitative determination of poisons: HPLC, GLC, TLC (densitometry, planimetry). Comparative evaluation of sensitivity methods. Influence of various factors related to the peculiarity of biological objects on the results of quantitative determination of medicinal substances isolated from biological material in the course of chemical-toxicological study. Requirements for the degree of purification of biological extracts to be quantified.
- Characterization and analysis of poisons of natural origin. Plant poisons (phytotoxins) - ricin, ditilin, nicotine, strychnine, scopolamine and the like. Animal poisons (zootoxins) - tetrodotoxin. Hat mushroom poisons and their classification. Mechanisms of toxic action and clinical symptoms of poisoning by the use of poisonous mushrooms (pale toadstool, red fly agaric, false foam, false wrinkles) and conditionally edible mushrooms (wrinkles, stitches, pigs, lupus, whey).
- Methods of isolation of venoms of hat mushrooms from objects of research and chemical-toxicological analysis. Diagnosis, emergency care, antidote and symptomatic therapy for mushroom poisoning.
- Poisons of natural origin that require special methods of isolation from the objects of study: toxins of lower fungi or fungal poisons (mycotoxins), algae toxins (algotoxins) and microbial toxins.
- The tasks of laboratory rapid analysis of acute poisoning. Features of rapid analysis of biological fluids in acute poisoning: the focus of the analysis, features of the separation of medicinal substances from biological fluids, requirements for the sensitivity and specificity of analytical methods used in the analysis.
- Express analysis of acute barbiturate intoxication. Toxic effects, mechanism of toxic action and clinical picture of acute barbiturate poisoning (prolonged action: barbital, phenobarbital, barbital-sodium; medium duration: barbamy, cyclobarbital, ethaminal-sodium; short-acting: hexobarbital). Toxicokinetics (ways of penetration into the body, distribution in the body, directions of metabolism, ways of excretion from the body) of barbiturates of different spectra of action. Preliminary tests for rapid laboratory diagnostics of acute poisoning. Methods for isolation of barbituric acid derivatives and their metabolites from blood, urine and other biological objects. Methods for detection of barbiturates and their metabolites in rapid - diagnosis of acute poisoning by chemical reactions, method of chromatography in a thin layer of sorbent. Effect of etho-enol and lactam-lactim tautomerism on UV spectrophotometric analysis of barbiturates. Analysis of barbituric acid derivatives in biological fluids by gas-liquid chromatography (GC). Quantitative determination of barbiturates isolated from blood and urine (photocolorimetric, spectrophotometric and gas chromatographic methods). Interpretation of the results of laboratory express diagnostics of poisoning with barbituric acid derivatives. First aid and antidote therapy for acute barbiturate poisoning.
- Express analysis of acute intoxication with 1,4-benzodiazepine derivatives. Toxicological characteristics and mechanisms of toxic action of 1,4-benzodiazepine derivatives (chlordiazepoxide, mepapam, diazepam, nitrazepam, clonazepam, phenazepam, oxazepam, lorazepam, lormetazepam, etc.). Pharmacodynamics and pharmacokinetics. Directions of metabolism of 1,4-benzodiazepine derivatives. Preliminary tests for the detection of 1,4-benzodiazepine derivatives in blood and urine in acute poisoning. Methods for the separation of 1,4-benzodiazepine derivatives and their metabolites from blood and urine. Detection of 1,4-benzodiazepine derivatives and their metabolites by color reactions, thin-layer sorbent chromatography, UV spectrophotometry, fluorescence and GCM . Possibilities of using the reaction on a blocked aromatic amino



group of 1,4-benzodiazepine derivatives with their preliminary hydrolytic cleavage to benzophenones. Quantitative determination of 1,4-benzodiazepine derivatives. Interpretation of analysis results.

- Express analysis of acute intoxication by phenothiazine derivatives. Toxicological characteristics and mechanisms of toxic action of phenothiazine derivatives (aminazine, propazine, diprazine, levomepromazine, chloracizine, fluorocyzine, thioridazine, mepazine, etmosin, fluorophenazine, etaperazine, triflazine, mterazine, thietylperazine, nonahlazine, etc.) . Pharmacodynamics and pharmacokinetics. The directions of metabolism of phenothiazine derivatives . Preliminary tests for the detection of phenothiazine derivatives in blood and urine in acute poisoning. Methods for extracting phenothiazine derivatives and their metabolites from blood and urine. Detection of phenothiazine derivatives and their metabolites by color reactions, thin-layer sorbent chromatography, and UV spectrophotometry . Quantitative determination of phenothiazine derivatives. Interpretation and evaluation of analysis results.
- Express analysis of acute opiate intoxication . Toxicological characteristics, mechanism of toxic action and clinical picture of acute poisoning with opium alkaloids and their synthetic analogues (morphine, codeine, thebaine, papaverine, narcotine, ethylmorphine, heroin). Metabolism of opium alkaloids and opioids. Preliminary tests for the detection of opium alkaloids and their synthetic analogues in biological fluids. Isolation of opium alkaloids and opioids from blood and urine. Detection of opiates and their synthetic analogues by chemical reactions, thin-layer sorbent chromatography, UV spectrophotometry, enzyme immunoassay, gas-liquid chromatography and high-performance liquid chromatography . Quantitative determination of opiates and opioids in extracts. Conclusions and interpretation of results of rapid analysis of acute opiate intoxication.
- Express analysis of acute intoxication by cannabinoid derivatives. Characteristics and chemical composition of cannabinoids (marijuana, hashish and hashish oil). Toxic effect of cannabinoids. Ways of entering cannabinoids in the body and their removal from the body. The main metabolic pathways of cannabinoids. Characteristics of study objects in cannabinoid poisoning. Investigation of saliva and skin of hands for the presence of cannabinoids. Preliminary tests for the detection of cannabinoids in biological fluids. Isolation of cannabinoids from study objects. Detection of cannabinoids by chemical methods, thin-layer sorbent chromatography method and gas-liquid chromatography method.
- Pesticides: application, environmental, animal and human impact. Environmental consequences of pesticide use. The problem of pesticide residues. Ways and means of preventing pesticide poisoning.
- Types of pesticides. Groups (generation) of pesticides. Classification of pesticides by application, toxicity, form of use, chemical structure. Classification of insecticides.
- Toxicological value of chlorine-containing pesticides: organochlorine pesticides (COP) and chlorine-containing carboxylic acid derivatives. General and toxicological characteristics, mechanism of toxic action, biotransformation, distribution in the body and excretion of COP. Methods of isolation from the objects of study and methods of chemical-toxicological analysis of chlorine-containing pesticides (hexachlorigexen, heptachlor, DDT, methoxychlor, kelton, pertane, 2,4-D, 2,4,5-T, etc.). Diagnosis of acute COP poisoning and medical care.
- Characteristics of organophosphorus pesticides (POP), which are derivatives of phosphoric acids and belong to organophosphorus compounds (POC). Individual representatives of the POP. Structure, physical and chemical properties of chlorophos, dichlophos, metaphos, carbophos, phosphamide. Causes and frequency of POC poisoning, ways of penetration into the body, pathogenesis (mechanism of development) of POC poisoning. Stages and signs (clinic) of organophosphorus poisoning. Biotransformation of POC in humans and animals and characterization of the toxic properties of their metabolites. Basic patterns of behavior in the body and corpse. Objects of chemical-toxicological analysis on POC. Methods of isolation of POC from organs of a corpse, biological liquids, food. The choice of extractant depending on the condition, nature of the object of study and poison. The choice of method of purification of extracts containing POC, depending on the nature and amount of co-extractive substances. Methods and methods of assisting with pesticide poisoning of different groups. Antidote therapy for POC poisoning.
- Enzyme methods for the analysis of POC in extracts from biological material: cholinesterase test, chromatoenzyme and enzyme immunoassay. The role of enzymatic methods in the rapid diagnosis of acute and chronic POC intoxication. Evaluation of the results of the analysis.
- Chemical methods of analysis of POC in extracts from biological material. Detection of organophosphorus by phosphorus. Detection of phosphorylating activity. Detection of thio- and dithiophosphoric acid derivatives. Detection by functional groups and by hydrolysis products. Evaluation of the results of the analysis.

- Detection and identification of POC in extracts from biological material by TLC, GLC and HPLC. Evaluation of the results of the analysis.
- Methods for quantitative determination of POC (photocolorimetric, photometric for phosphorus, planimetric, enzymatic, GLC method) and their comparative evaluation.
- Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derived from urea. Methods of isolation from the objects of study and methods of chemical-toxicological analysis of monuron, malorane and crisside ( $\alpha$ -naphthylthiourea). Diagnosis of acute poisoning with urea derivatives and medical care.
- Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derived from sim-triazine (atrazine, prometrin, prometon, simazin) and non-sim-triazine (metribuzin). Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.
- Toxicological characteristics and methods of chemical-toxicological analysis of phenol derivatives pesticides (DNOC, PCF). Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.
- General and toxicological characteristics, toxicological value, mechanism of toxic action, biotransformation distribution and excretion of pesticides of carbamic acid derivatives (propoxur, carbaryl, oxamyl, phenmedipham, benomyl), as well as derivatives of thio- and dithiocarbamate, cybothiocarbamate, cybothiocarbaminat. Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.
- Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derivatives of chloroacetanilide (propachlor, pretilachlor, metolachlor). Diagnosis of acute poisoning and medical care.
- Toxicological characteristics and methods of chemical-toxicological analysis of synthetic pyrethroids - pesticides of cyclopropanecarboxylic acid derivatives (aletrin, resmethrin, tetrameter, phenotrin, permethrin, cypermethrin, deltamethrin, cyhalothrin, etc.). Diagnosis of acute poisoning and medical care.
- Toxicological characteristics and methods of chemical-toxicological analysis of pesticides - organic compounds of tin and mercury.
- Organic mercury pesticides (ethyl mercurphosphate, ethyl mercuric acid). Physical and chemical properties. Use and toxicity. Ways of penetration into the body, distribution, biotransformation and excretion. Methods of selection from biological objects. Methods for detection and determination by native form and mercury (II). Evaluation of the results of the analysis.

### 3. The structure of the discipline

Topics	Hours			
	Lectures	Practice	CPC	Individual work
1	2	3	4	5
<b>Content Module 1.</b> <i>Fundamentals of Toxicological and Forensic Chemistry, Toxicology, Clinical Toxicology and Environmental Toxicology. Groups of poisonous substances those are isolated from biological material by infusion of the studied objects with water (mineral acids, alkalis and their salts), distillation with water vapor (volatile substances) and mineralization (metals). Toxicodynamics, toxicokinetics and distribution of these poisons in body tissues. Methods of isolation of these groups of poisons from objects of research and their methods of analysis. A group of poisons that require special isolation methods (fluorides, iodide bromides). A group of poisons that do not need to be isolated but are investigated directly in the object of study (carbon monoxide). Detoxification methods for poisoning by these groups of substances.</i>				
<b>Topic 1.</b> Forensic toxicological research and chemical toxicological analysis. Forensic chemical examination, its stages and tasks. Objects of research. Inspection of research objects, preliminary tests and preparation of a forensic toxicological research plan.	1	2	4	
<b>Topic 2.</b> Toxicological characteristics and analysis of a group of toxic substances those are isolated from biological material by	1	4	2	

infusion of the studied objects with water (mineral acids, alkalis and their salts). Isolation from biological material and detection and quantification of nitrates and nitrites..				
<b>Topic 3.</b> A group of toxic substances those are isolated from biological material by steam distillation (volatile substances). Toxicological characteristics and methods of isolation of volatile substances from research objects.	2	10	20	
<b>Topic 4.</b> Toxicological characteristics and methods of metal isolation. Investigation of mineralizate for the presence of metals.	2	10	4	
<b>Topic 5.</b> Toxicological characteristics and methods of analysis of toxic substances that require special methods of isolation (fluorides, silicon fluorides, bromine, iodine).	1	2	6	
<b>Topic 6.</b> Toxicological characteristics of carbon monoxide, features of its detection and determination in humans. Methods for detecting carboxyhemoglobin and carboxymyoglobin. Spectrophotometric determination of carboxyhemoglobin and carboxymyoglobin.	1	2	4	
<b>Topic 7.</b> Concept of poison. Characteristics and examples of xenobiotics. Classifications of poisons. Ways of penetration of poisons into an organism and transport mechanisms. Distribution of toxins in the body. Characteristics of poisons. Factors affecting the toxicity of chemical compounds. Removal of toxins from the body. Basic patterns of behavior of toxic substances in the body. Metabolism (biotransformation) of xenobiotics. The first and second phases of metabolism.	2	2	8	
<b>Total content module 1</b>	<b>10</b>	<b>32</b>	<b>48</b>	
<i><b>Content module 2.</b> A group of toxic substances those are isolated from biological material by polar solvents. Medicinal substances and natural poisons (plants, fungi, animals, insects and algae). A group of toxic substances released from research objects by non-polar organic solvents (pesticides). Toxicodynamics, toxicokinetics and distribution of these toxins in the body. Methods of isolation of these poisons from the objects of research and methods of their analysis Express analysis of acute intoxications with these poisons. Methods of detoxification in poisoning.</i>				
<b>Topic 8.</b> Methods of isolation of medicinal substances of natural (alkaloids) and synthetic origin from biological material. Methods of cleaning extracts from biological material and concentrating toxic substances.	2	2	2	
<b>Topic 9.</b> Directed and non-directed analysis of extracts from biological material. Analytical and toxicological screening. Express methods of poison detection in forensic chemical and chemical toxicological research facilities. Preliminary and evidential methods of forensic chemical analysis.	2	4	2	
<b>Topic 10.</b> Research of chloroform extracts from acidic environment ("acid" chloroform extracts).	1	6	2	
<b>Topic 11.</b> Investigation of chloroform extracts from alkaline media ("alkaline" chloroform extracts) using color, sediment and microcrystalline reactions. Investigation of "alkaline" chloroform extracts by chromatographic methods (TLC, GC, HPLC), spectrophotometric (UV, IR spectrophotometry) and enzyme-linked immunosorbent assays. Quantitative determination of medicinal substances in extracts from biological material. Express analysis of acute intoxications.	1	6	10	

<b>Topic 12.</b> Express analysis of acute cannabinoid intoxication.	1	2	2	
<b>Topic 13.</b> Poisons of natural origin (poisons of plants, fungi, algae, animals and insects). General and toxicological characteristics, isolation from biological material and methods of chemical and toxicological analysis. Diagnosis of poisoning and detoxification of the body.	1	4	8	
<b>Topic 14.</b> General characteristics of pesticides: classifications, toxicity, mechanisms of toxic action, biotransformation. Toxicological characteristics and methods of pesticide analysis. Toxicological characteristics and methods of isolation of organophosphorus pesticides (POP) and other organophosphorus compounds (POC) from biological material.	2	10	14	
<b>Final (credit) lesson of content module 2. Enrollment of acts of forensic chemical examination</b>		2	2	
<b>Total content module 2</b>	<b>10</b>	<b>38</b>	<b>42</b>	
<b>Total</b>	<b>20</b>	<b>70</b>	<b>90</b>	

#### 4. Thematic plan of lectures

No	Theme	Hours
<i>Content Module 1. Fundamentals of Toxicological and Forensic Chemistry, Toxicology, Clinical Toxicology and Environmental Toxicology. Groups of poisonous substances those are isolated from biological material by infusion of the studied objects with water (mineral acids, alkalis and their salts), distillation with water vapor (volatile substances) and mineralization (metals). Toxicodynamics, toxicokinetics and distribution of these poisons in body tissues. Methods of isolation of these groups of poisons from objects of research and their methods of analysis. A group of poisons that require special isolation methods (fluorides, iodide bromides). A group of poisons that do not need to be isolated but are investigated directly in the object of study (carbon monoxide). Detoxification methods for poisoning by these groups of substances.</i>		
1.	Subject and tasks of toxicological chemistry, analytical toxicology and forensic chemistry. Forensic chemical examination of poisoning, its purpose and main stages. Legal bases of forensic chemical examination. Procedure and plan of forensic toxicological research. Evidence. Objects of research.	2
2	Relationship between structure and toxicity of substances. Forensic chemical classification of poisons. A group of toxic substances those are isolated from biological material by infusing the studied objects with water (mineral acids, alkalis and their salts). Toxicological characteristics, features of their isolation from biological material, their detection and quantification.	2
3	A group of toxic substances those are isolated from biological material by steam distillation (volatile organic compounds). Toxicological characteristics and features of the release of volatile substances from the objects of study. Forensic chemical analysis of "volatile poisons".	2
4.	A group of toxic substances those are isolated from biological material by mineralization (heavy metals). Toxicological characteristics, peculiarities of isolation and methods of forensic toxicological analysis of "metal poisons".	2
5.	Toxicological characteristics and studies of groups of poisons that require special methods of isolation (fluorides, bromides, iodides) and groups of poisons that do not require isolation from the objects of study (carbon monoxide). Methods of detoxification in poisoning by these groups of substances. Basic patterns of behavior of toxic substances in the body. Toxicokinetics and toxicodynamics of xenobiotics. Biotransformation of toxic substances.	2
<b>Total</b>		<b>10</b>
<i>Content module 2. Group of poisonous substances isolated from biological material polar solvents. Medicinal substances and natural poisons (plants, fungi, animals, insects and algae). A group of toxic substances released</i>		

*from the objects of study by non-polar organic solvents (toxic chemicals). Toxicodynamics, toxicokinetics and distribution of these poisons in the body. Methods of isolation of these poisons from the objects of study and methods of their analysis Express analysis of acute intoxication with these poisons. Methods of detoxification in poisoning.*

6.	A group of toxic substances that are isolated by polar solvents ("medicinal poisons"). Chemical structure and toxicological characteristics of drugs, mechanisms of toxic action, behavior and distribution in the body, preservation in the organs of corpses, methods of isolation from the objects of study.	2
7.	Preliminary tests and toxicological screening of drugs. Express diagnosis of acute poisoning. Express analysis of acute intoxications by various groups of drugs and poisons of natural origin. Immunochemical methods of analysis.	2
8.	Toxicological characteristics of medicinal substances subject to mandatory forensic chemical testing. Methods of qualitative and quantitative analysis of drugs used in chemical and toxicological research.	2
9.	Poisons of natural origin (poisons of plants, fungi and animals). Classifications of natural poisons, toxicological characteristics, mechanisms of toxic action, distribution in the body, methods of isolation from the objects of study and chemical and toxicological analysis in the diagnosis of poisoning.	4
10.	A group of toxic substances those are isolated from biological material by non-polar organic solvents (pesticides). General characteristics of pesticides: application, classifications, toxicity, mechanisms of toxic action, biotransformation. Preliminary tests and methods of analytical screening in the diagnosis of acute pesticide poisoning. Features of chemical and toxicological analysis of pesticides in extracts from biological material.	2
	<b>Total</b>	<b>10</b>
	<b>TOTAL</b>	<b>20</b>

### 5. Thematic plan of practical classes

No	Theme	Hours
<i><b>Content module 1. Fundamentals of Toxicological and Forensic Chemistry, Toxicology, Clinical Toxicology and Environmental Toxicology. Groups of poisonous substances those are isolated from biological material by infusion of the studied objects with water (mineral acids, alkalis and their salts), distillation with water vapor (volatile substances) and mineralization (metals). Toxicodynamics, toxicokinetics and distribution of these poisons in body tissues. Methods of isolation of these groups of poisons from objects of research and their methods of analysis. A group of poisons that require special isolation methods (fluorides, iodide bromides). A group of poisons that do not need to be isolated but are investigated directly in the object of study (carbon monoxide). Detoxification methods for poisoning by these groups of substances.</b></i>		
1	Forensic chemical research and chemical toxicological analysis. Objects of research. Inspection of research objects, preliminary tests and drawing up a plan of forensic chemical research.	2
2.	Isolation of toxic substances from biological material by infusing with water. Detection of acids and alkalis in dialysates.	2
3.	Isolation from biological material, detection and quantification of nitrates and nitrites.	2
4.	Isolation of volatile organic compounds from biological material by steam distillation.	2
5.	Detection of the main classes of "volatile poisons" in the distillate. Drawing up a scheme of forensic chemical research of distillate.	2
6.	Analysis of distillate for the presence of volatile toxic substances using chemical reactions.	2
7.	Qualitative analysis of volatile toxic substances in the distillate by gas-liquid chromatography.	2
8.	Quantitative analysis of volatile toxic substances in the distillate by gas-liquid	2

	chromatography.	
9	Isolation of heavy metals from biological material.	2
10.	Investigation of mineralized sediment for the presence and content of barium and lead.	2
11.	Investigation of the liquid part of the mineralizate for the presence of manganese, chromium, silver, copper and zinc.	2
12.	Investigation of the liquid part of the mineralizate for the presence of cadmium, thallium, bismuth, antimony and arsenic.	2
13.	Isolation of mercury from biological material and its study in destruct.	2
14.	Toxic substances that require special methods of isolation. Detection and determination of fluorides, silicon fluorides, bromine and iodine in biological material.	2
15	Toxic substances those are determined directly in the biological material. Toxic gases. Toxicological characteristics of carbon monoxide.	2
16.	Detection of carboxyhemoglobin in the blood by qualitative reactions. Spectrophotometric determination of carboxyhemoglobin and carboxymyoglobin.	2
	<b>Total content module 1</b>	<b>32</b>
<i><b>Content module 2.</b> Group of poisonous substances isolated from biological material polar solvents. Medicinal substances and natural poisons (plants, fungi, animals, insects and algae). A group of toxic substances released from the objects of study by non-polar organic solvents (toxic chemicals). Toxicodynamics, toxicokinetics and distribution of these poisons in the body. Methods of isolation of these poisons from the objects of study and methods of their analysis Express analysis of acute intoxication with these poisons. Methods of detoxification in poisoning.</i>		
17.	Isolation of "medicinal poisons" from biological material by infusion with acidified water.	2
18.	Investigation of extracts from biological material using enzyme-linked immunosorbent assays.	2
19.	Screening of "acid" extracts from biological material using chemical reactions and thin-layer chromatography.	2
20.	Investigation of chloroform extracts from acidic media ("acid" chloroform extracts) using qualitative and microcrystalline reactions.	2
21.	Investigation of "acid" chloroform extracts using physicochemical methods of analysis.	2
22.	Quantitative determination of barbiturates in extracts from biological material.	2
23.	Screening of "alkali" extracts from biological material using chemical reactions and thin-layer chromatography.	2
24.	Investigation of chloroform extracts from alkaline media ("alkaline" chloroform extracts) using qualitative and microcrystalline reactions.	2
25.	Quantitative determination of "medicinal poisons" in extracts from biological material.	2
26.	Express analysis of acute cannabinoid intoxication.	2
27.	Isolation of mushroom poisons from biological material.	2
28.	Investigation of extracts from biological material for the presence of mushroom poisons.	2
29.	Isolation of pesticides from biological material by infusion with non-polar organic solvents.	2
30.	Investigation of extracts from biological material on the pesticides presence by enzymatic methods (chromatoenzyme method, enzyme-linked immunosorbent assay (ELISA), cholinesterase test).	2
31.	Investigation of extracts from biological material on the content of POC by chemical reactions.	4
32.	Investigation of extracts from biological material on the content of POC by chromatographic methods.	2
33.	Quantitative determination of organophosphorus pesticides in research objects.	
34.	<b>Final lesson of content module 2. Crediting the act of forensic chemical examination</b>	<b>2</b>
	<b>Total content module 2</b>	<b>38</b>

	<b>TOTAL</b>	<b>70</b>
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## 6. Thematic plan of students' independent work

No	Topic	Hours	Kind of control
<i><b>Content module 1.</b> Fundamentals of Toxicological and Forensic Chemistry, Toxicology, Clinical Toxicology and Environmental Toxicology. Groups of poisonous substances that are isolated from biological material by infusion of the studied objects with water (mineral acids, alkalis and their salts), distillation with water vapor (volatile substances) and mineralization (metals). Toxicodynamics, toxicokinetics and distribution of these poisons in body tissues. Methods of isolation of these groups of poisons from objects of research and their methods of analysis. A group of poisons that require special isolation methods (fluorides, iodide bromides). A group of poisons that do not need to be isolated but are investigated directly in the object of study (carbon monoxide). Detoxification methods for poisoning by these groups of substances.</i>			
1.	Fundamentals of toxicological and forensic chemistry. Forensic examination of poisonings and forensic toxicological examination. Ethics and deontology of forensic examination. Classifications of poisons.	4	Current control over practical classes
2.	Fundamentals of toxicology (mechanisms of toxic effects of substances on the body: kinetics of absorption, distribution, excretion, mechanisms of metabolic reactions, ways and mechanisms of transport of substances and elimination). Classifications of poisonings.	8	
3.	Toxicological characteristics and methods of analysis of toxic substances isolated from the objects of study by infusion with water and purification of water extracts by dialysis.	2	
4.	Forensic toxicological study of a group of toxic substances isolated from biological material by steam distillation (volatile substances).	4	
5.	Forensic toxicological study of cyanides, alkyl halides and aliphatic monohydric alcohols.	4	
6.	Forensic toxicological study of aldehydes and ketones.	2	
7.	Forensic toxicological study of aromatic hydrocarbons, monoatomic phenols, phenol-formaldehyde resins and aromatic amines. Methods of detoxification in case of poisoning by these substances.	2	
8.	Forensic toxicological study of carboxylic acids, ethers, esters and cellosolves. Methods of detoxification in case of poisoning by these substances.	4	
9.	Forensic toxicological study of refined products and adhesive components. Methods of detoxification in case of poisoning by these substances.	4	
10.	Forensic toxicological study of the components of perfumes and cosmetics.	2	
11.	Forensic toxicological study of phosgene.	2	
12.	Investigation of volatile poisons by gas-liquid chromatography (GC).	2	
13.	A group of poisons isolated from objects of biological origin by mineralization (metal poisons).	2	
14.	Investigation of mineralizate on the presence of metal poisons.	2	
15.	A group of poisons that require special methods of isolation from research objects during forensic toxicological analysis.	2	
16.	A group of poisons that are studied directly in biological material, without their prior isolation (carbon monoxide, carbon monoxide).	2	
<b>Total content module 1</b>		<b>48</b>	
<i><b>Content module 2.</b> Group of poisonous substances isolated from biological material polar solvents. Medicinal substances and natural poisons (plants, fungi, animals, insects and algae). A group of toxic substances released from the objects of study by non-polar organic solvents (toxic chemicals). Toxicodynamics,</i>			

<i>toxicokinetics and distribution of these poisons in the body. Methods of isolation of these poisons from the objects of study and methods of their analysis Express analysis of acute intoxication with these poisons. Methods of detoxification in poisoning.</i>			
18	General and toxicological characteristics, mechanisms of pharmacological and toxic action of drugs. Classical methods of isolation of medicinal substances from biological material during forensic toxicological examination.	2	Current control over practical classes
19	Forensic toxicological study of medicinal substances and natural poisons of indole, pyridine and piperidine derivatives.	2	
20	Forensic toxicological study of imidazoline derivatives (clonidine).	2	
21	Forensic toxicological study of poisons of natural origin: phytotoxins, zootoxins, algotoxins (algae toxins) and microbial toxins. Diagnosis of poisoning and detoxification of the body.	6	
22	Forensic toxicological study of fungal poisons and lysergic acid derivatives.	4	
23	Forensic toxicological study of phenethylalkylamine derivatives. Express diagnosis of acute amphetamine intoxications.	2	
24	Forensic toxicological study of opium alkaloids and synthetic opioids.	4	
25	Forensic toxicological study of cannabinoids.	2	
26	Forensic toxicological study of tricyclic antidepressants.	2	
27	Forensic toxicological study of chlorine-containing pesticides.	2	
28	Forensic toxicological study of pesticides of urea derivatives.	2	
29	Forensic toxicological study of pesticides derived from sim-triazine.	2	
30	Forensic toxicological study of pesticides derived from phenol.	2	
31	Forensic toxicological study of pesticides of carbamic acid derivatives, as well as thio- and dithiocarbamic acid derivatives.	2	
32	Forensic toxicological study of pesticides derived from chloroacetanilide.	2	
33	Forensic toxicological study of synthetic pyrethroids - pesticides derived from cyclopropanecarboxylic acid.	2	
34	Toxicological characteristics and methods of chemical and toxicological analysis of pesticides - organic compounds of tin and mercury. Biopesticides (microbiological, plant and pheromones).	2	
<b>Total content module 2</b>		<b>42</b>	
<b>TOTAL</b>		<b>90</b>	

**7. Individual tasks for full-time students** – writing acts of forensic chemical examination for both content modules based on the model samples research during laboratory work.

#### **Tasks for individual work To the content module 1**

**Topic 1.** The purpose and objectives of toxicological and forensic chemistry. Tasks and stages of forensic examination of poisoning. Basics of forensic toxicological research.

General principles of classification of poisons: by chemical structure, purpose of use, by the degree of toxicity (hygienic), type of toxic action (toxicological), selective toxicity, by methods of isolation from objects of biological origin.

**Topic 2.** Ways of poison penetration into the body, transport mechanisms of absorption and the relationship with their physical and chemical properties of poisonous substances. The main patterns of behavior and distribution of toxic substances in the body and excretion.

Classifications of poisoning: by cause, by conditions (place) of development, by clinical principle (acute, chronic, subacute poisoning), by the ways of penetration into the body; nosological classification.



**Topic 3.** Toxicological value, release from biological material, methods of detection and quantitative determination of hydrochloric, sulfuric and nitric acids, as well as nitrates and nitrites.

**Topic 4.** General and toxicological characteristics of a group of toxic substances that are isolated from biological material by the method of steam distillation (volatile substances). Methods of forensic toxicological study of volatile poisons. Means of detoxification of the body in case of poisoning by volatile substances.

**Topic 5.** General and toxicological characteristics, methods of forensic toxicological study of hydrocyanic acid and cyanides, alkyl halides, aliphatic monohydric alcohols (methyl, ethyl, propyl, isopropyl, butyl, isobutyl, amylamyl and amylamyl). Fusel oils. Detoxification methods for poisoning with these substances.

**Topic 6.** General and toxicological characteristics, methods of forensic toxicological study of aldehydes (formaldehyde, acetaldehyde, polyacetaldehyde (metaldehyde or dry alcohol) and ketones (acetone). Detoxification methods for poisoning by these substances.

**Topic 7.** General and toxicological characteristics, methods of forensic toxicological study of aromatic hydrocarbons (benzene, toluene, xylene), monatomic phenols (phenol, cresol), phenol-formaldehyde resins and aromatic amines (aniline and its derivatives). Detoxification methods for poisoning with these substances.

**Topic 8.** General and toxicological characteristics, methods of forensic toxicological study of carboxylic acids (acetic acid), ethers, esters, celosolvams. Detoxification methods for poisoning with these substances.

**Topic 9.** General and toxicological characteristics, methods of forensic toxicological research of refined products (gasoline, kerosene, diesel fuel, fuel oil, gasoils), components of adhesives (aromatic and chlorinated hydrocarbons, alcohols, acetone, gasoline, dibutyl phthalate, dioctylphthalate). Detoxification methods for poisoning with these substances.

**Topic 10.** General and toxicological characteristics, methods of forensic toxicological research of components of perfumery and cosmetics (alcohols, benzylbenzoate, diethyl phthalate, propylene glycol, oil refining products, etc.). Detoxification methods for poisoning with these substances.

**Topic 11.** General and toxicological characteristics of phosgene - a product of oxidation of chloroform and trichlorethylene (under the action of light and oxygen of air). Express method of phosgene detection .

**Topic 12.** Theoretical bases of gas-liquid chromatography method. Chromatographs. Solid media in chromatography. Stationary liquid phases (NRF). Chromatographic columns. Types and characteristics of detectors. Processes that undergo chromatographic separation. Factors affecting chromatographic separation. Influence of endogenous compounds on the sensitivity and specificity of the GC method in the analysis of volatile substances. Delay options. Methods of qualitative analysis in GC. Methods of group and individual identification of poisonous substances by the method of gas-liquid chromatography (GCM).

Tasks of quantitative gas chromatographic method of analysis: a) determination of the content of one, several or all components of the mixture; b) determination of the content of micro-impurities in individual substances and different media; C) determining the total composition of the mixture.

Parameters of chromatographic peak for the quantitative determination of HRH: area of the peak (S), peak height (h), product of peak height at a retention and product of peak height detained in volume. Methods of processing quantitative parameters of chromatograms. Methods of quantitative determination in GC.

Examination of alcohol intoxication.

**Topic 13.** General and toxicological characteristics of metals: application, properties, toxic effects, clinical picture of acute poisoning, metabolism, distribution in the body and excretion. Macronutrients and trace elements. Methods of extracting metals from objects of biological origin. Preparation of mineralization for analysis.

**Topic 14.** Features of the study of mineral deposit on the presence of barium and plumbum. Investigation of the liquid part of the mineralizate for the presence and content of manganese, chromium, silver, copper, zinc, cadmium, thallium, bismuth, stybium and arsenic by physical and physico-chemical methods (atomic absorption spectroscopy, X-ray fluorescence-free method).

**Topic 15.** General and toxicological characteristics and methods of analysis of poisonous substances that require special methods of separation (fluorides, silicon fluorides, bromine, iodine).

**Topic 16.** Toxicological characteristics of carbon monoxide, features of its detection and determination in humans. Methods for detecting carboxyhemoglobin and carboxymyoglobin. Spectrophotometric determination of carboxyhemoglobin and carboxymyoglobin.

**To the content module 2**

**Topic 18.** Characteristics of classical methods of extraction of medicinal substances and natural poisons from biological objects of research. Separate (special) methods of isolation of barbiturates (P. Valov method), 1,4-benzodiazepine derivatives (BM Izotov method), phenothiazine derivatives (EM Salomatin method).

The influence of various factors on the efficiency of the selection of test substances at different stages of this process (nature, condition and preliminary preparation of the object, the nature of the solvent, the pH of the solution, the nature of the acid and electrolyte, the degree of ionization, methods of deposition of proteins, etc.).

Methods for purification and separation of toxic substances from related endogenous impurities (proteins, fats, lipids, dyes, etc.): different types of chromatography, electrophoresis, extraction, dialysis and electro dialysis, sublimation, etc.

Methods of natural and artificial detoxification of the body in acute poisoning with medicinal substances.

**Topic 19.** Toxicological characteristics and methods of forensic toxicological analysis of indole derivatives (strychnine and brucin - chilibuchy seed alkaloids; reserpine - Rauwolfia plant alkaloid; physostigmine - alkaloid beans physostigm; and ergotamine - alkaloids of horns; psilocin and psilocybin - alkaloids of hallucinogenic fungi; bufotenin - alkaloid of curly-shaped skin of tropical frogs). Toxicological characteristics and methods of forensic toxicological investigation of pyridine and piperidine derivatives (anabazine, nicotine, arecolin, conine, lobelin, pachicarpine).

**Topic 20.** Application, general and toxicological characteristics and methods of forensic toxicological analysis of imidazoline derivatives (clonidine).

**Topic 21.** Toxicological characteristics and methods of chemical-toxicological analysis of poisons of natural origin: phytotoxins (ricin, ditilin, nicotine, atropine, scopolamine, etc.), zootoxins (tetrodotxin), algae toxins (algotoxins) and microbial toxins. Diagnosis of poisoning and detoxification of the body.

**Topic 22.** General and toxicological characteristics of poisonous mushrooms, toxins of lower fungi or fungal poisons (mycotoxins). Hat mushroom poisons and their classification. Mechanisms of toxic action and clinical symptoms of poisoning by the use of poisonous mushrooms (pale toadstool, red fly agaric, false foam, false wrinkles) and conditionally edible mushrooms (wrinkles, stitches, pigs, lupus, whey). Diagnosis, emergency care, antidote and symptomatic therapy for mushroom poisoning. Methods of isolation of venoms of hat mushrooms from objects of research and chemical-toxicological analysis.

Properties, application and mechanism of toxic action of derivatives of lysergic acid (LSD). Diagnosis of poisoning and detoxification of the body.

**Topic 23.** General and toxicological characteristics of phenylalkylamine derivatives (ephedrine, phenamine, amphetamines): properties, applications, toxic effects, clinical presentation of acute poisoning, metabolism, distribution in the body and excretion. Preliminary tests and rapid analysis of acute amphetamine intoxication.

**Topic 24.** General and toxicological characteristics of opium alkaloids (morphine, codeine, thebaine, papaverine, etc.) and synthetic opioids (heroin, dionine, tramadol, methadone, fentanyl, promedol, phencyclidine, ketamine). Physical and chemical properties properties, applications, toxic effects, clinical presentation of acute poisoning, metabolism, distribution in the body and excretion. Methods of detoxification. Preliminary tests and rapid analysis of acute opiate intoxication.

**Topic 25.** General and toxicological characteristics of cannabinoids: properties, uses, toxic effects, clinical picture of acute poisoning, metabolism, distribution in the body and excretion. Preliminary samples and rapid analysis of acute cannabinoid intoxication. Detoxification methods for cannabinoid poisoning.

**Topic 26.** General and toxicological characteristics of tricyclic antidepressants (imipramine, amitriptyline, trimipramine) : properties, use, toxic effect, clinical presentation of acute poisoning, metabolism, distribution in the body and excretion. Preliminary tests and rapid analysis of acute intoxication. Diagnosis of acute poisoning and medical care.

**Topic 27.** Toxicological significance of chlorine-containing pesticides: organochlorine pesticides (COP) and chlorine-containing carboxylic acid derivatives. General and toxicological characteristics, mechanism of toxic action, biotransformation, distribution in the body and excretion of COP. Methods of isolation from the objects of study and methods of chemical-toxicological analysis of chlorine-containing pesticides (hexachlorocyclohexane, heptachlor, DDT, methoxychlor, kelton, pertane, 2,4-D, 2,4,5-T, etc.). Diagnosis of acute poisoning and medical care.

**Topic 28.** Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derived from urea. Methods of isolation from the objects of study and methods of forensic toxicological analysis of monuron, malorane and crisside ( $\alpha$ -naphthylthiourea).

Diagnosis of acute poisoning and medical care.

**Topic 29.** Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derived from sim-triazine (atrazine, prometrin, prometon, simazine) and non-sim-triazine (metribuzin). Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.

**Topic 30.** Toxicological characteristics and methods of chemical-toxicological analysis of pesticides derivatives of phenol (DNOC, PCF). Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.

**Topic 31.** General and toxicological characteristics, toxicological significance, mechanism of toxic action, biotransformation distribution and excretion of pesticides of carbamic acid derivatives (propoxur, carbaryl, oxamyl, phenmedipham, benomyl), as well as derivatives of thio- and dithiobicothiocarb tiram, cineb). Methods of isolation from the objects of research and methods of chemical-toxicological analysis. Diagnosis of acute poisoning and medical care.

**Topic 32.** Application, toxicological characteristics and methods of chemical-toxicological analysis of pesticides derivatives of chloroacetanilide (propachlor, pretilachlor, metolachlor). Diagnosis of acute poisoning and medical care.

**Topic No. 33.** Application, toxicological characteristics and methods of chemical-toxicological analysis of synthetic pyrethroids - pesticides of cyclopropanecarboxylic acid derivatives (aletrin, resmethrin, tetrameter, phenotrin, permethrin, cypermethrin, deltamethrin, cyhalothrin, etc.). Diagnosis of acute poisoning and medical care.

**Topic 34.** Application, toxicological characteristics and methods of chemical-toxicological analysis of pesticides - organic compounds of tin and mercury. Organic mercury pesticides (ethyl mercurphosphate, ethyl mercuric acid ). Physical and chemical properties. Use and toxicity. Ways of penetration into the body, distribution, biotransformation and excretion. Methods of selection from biological objects. Methods for detection and determination by native form and mercury (II). Evaluation of the results of the analysis.

Biopesticides (microbiological, plant and pheromones), their properties and advantages over other classes of pesticides.

## 8. Learning methods

In the course of studying the discipline "Toxicological and Forensic Chemistry" the following teaching methods of students are used:

*by sources of knowledge:*

- verbal - lectures, explanations, coaching;
- visual - demonstration, illustration;
- practical - practical work, situational tasks.

*by the nature of the logic of cognition :*

- analytical,
- synthetic,
- analytical and synthetic,
- inductive, deductive.

*by level of independent mental activity :*

- problematic,
- partially searchable,
- research.

*by the main stages of the process :*

formation of knowledge,  
developing skills,  
applying knowledge,  
generalization,

fixing,  
audit

*on a systematic approach :*  
stimulation and motivation,  
control and self-control

## 9. Control methods

**Continuous control** is carried out at each practical session according to the specific objectives of the topic. Control of knowledge and level of students' mastering theoretical material, independent work and the level of acquired skills and practical skills is carried out in practical classes by oral questioning of students; by means of test, graphic and written control; solving situational problems; by evaluating the practical experimental work performed, by assessing the student's ability to correctly interpret the research results obtained, and by evaluating the laboratory protocols drawn up.

At each practical session, the student answers standard questions from the material of the current topic of the lesson, the questions of the lecture course and independent work that relate to the current lesson. The student demonstrates knowledge and skills of practical skills in accordance with the topic of the practical lesson.

**The form of current control during training sessions is determined by the course's work curriculum.**

A **form of final control** in the study of Toxicological and Forensic Chemistry **is the exam**. Final control is allowed for students who have completed all types of work required by the curriculum, have completed all training sessions, and have earned points above the minimum level when studying the module.

### Methods and tools for standardized assessment of the final control

#### **Examination Regulations**

The form of final control is standardized and includes control of theoretical and practical training. *The final control* is a written answer to 5 questions that are in each exam ticket.

Each written answer question is rated

- 5 points - "**excellent**"
- 4 points – "**good**"
- 3 points - "**satisfactory**"
- 0 points - "**unsatisfactory**"

**"Excellent"** - the student logically, competently, thoroughly, deeply and in detail presented material on all tasks, correctly wrote formulas of substances and chemisms of reactions, showed the schemes of metabolism of substances, substantiated the correct choice of methods of forensic toxicological analysis, correctly solved situational problems.

**"Good"** - the student logically, competently essentially provides incomplete answers to all theoretical questions, with minor errors in chemical formulas, chemisms of reactions and in calculations and conclusions.

**"Satisfactory"** - the student answers the theoretical questions without detail, admits inaccuracies and incorrect formulations in the answers, violates the logic of the material, makes mistakes in the chemical formulas of calculations and in the chemisms of reactions and in situational problems.

**"Unsatisfactory"** - the student makes significant mistakes, does not cover the essence of the question posed, does not answer the tasks.

The score for the written answer to each question in the exam ticket, where there are 5 questions, is converted according to the scale below:

Rating	Scores	The maximum number of points	The minimum number of points
"Excellent"	16	80 (16 x 5)	
"Good"	13		

<i>"Satisfactorily"</i>	<b>10</b>		<b>50 (10 x 5)</b>
<i>"Unsatisfactory"</i>	<b>0</b>		

The **toxicological chemistry exam score** is the sum of the scores for the answer to each of the 5 questions after converting them from a 4-point to a 200-point scale. The maximum score for the exam is **80**. The minimum score is **50**.

**10. Current control** is carried out during the training sessions and is aimed at checking students' mastering of educational material. Forms of assessment of current educational activities are standardized and include control of theoretical and practical training.

**10.1 Evaluation of current learning activities.** Every practical activity is subject to ongoing monitoring. Student answers 10 tests and 3 theoretical questions on the topic of the practical lesson, knowledge of which is necessary for understanding the current topic, questions of the lecture course and independent work related to the current lesson, demonstrates knowledge and skills of practical skills in accordance with the topic of the practical lesson.

#### **Evaluation criteria**

**I. Current control.** Each class assesses students' knowledge on a 4-point (national) scale. This takes into account all types of work provided by the discipline program. The student receives a grade on each topic to further convert the grades into scores on a multi-scale (200-point) scale.

#### **Criteria for evaluating test tasks.**

**Excellent ("5").** Student correctly answered 100-90% of A-format tests

**Good ("4").** Student correctly answered 70-89% of A. tests.

**Satisfactory ("3").** Student correctly answered 50-69% of A tests.

**Unsatisfactory ("2").** Student answered less than 50% of A-format tests

#### **Criteria for evaluating answers to theoretical questions.**

**Excellent ("5").** The student correctly, clearly, logically and completely answers the standardized questions of the current topic, including the questions of the lecture course and independent work. Closely binds theory to practice and correctly demonstrates the implementation (knowledge) of practical skills. Fluent in the studied material, solves situational problems of increased complexity, has methods of chemical-toxicological analysis, is able to correctly interpret the results of the analysis.

**Good ("4").** The student correctly and essentially answers the standardized questions of the current topic, lecture course and independent work. Demonstrates the implementation (knowledge) of practical skills, correctly uses theoretical knowledge in solving practical problems. Able to solve light and medium complexity situational problems. Possesses the necessary practical skills and techniques of their implementation in the amount that exceeds the required minimum.

**Satisfactory ("3").** Student with additional questions gives incomplete answer, answers standardized questions of the current topic, lecture course and independent work. Can not independently build a clear, logical answer. The student makes mistakes while answering and demonstrating practical skills. The student solves only the easiest tasks, has only the obligatory minimum of methods of research.

**Unsatisfactory ("2").** The student does not know the material of the current topic, can not construct a logical answer, does not answer additional questions, does not understand the content of the material. He makes significant, grave mistakes while answering and cannot demonstrate practical skills.

**The total score** for the current achievement is the arithmetic mean (CA) of the sum of the scores for the test control and the answers to the questions.

#### **Independent work of student.**

The student's self-study material, which is provided in the subject of the practical lesson at the same time as the classroom work, is evaluated during the ongoing control of the topic in the relevant practical lesson.

Assessment of topics that are presented for self-study and not included in the topics of classroom training, are controlled during the final (credit) classes and exam.

### **11. Form of final control.**

The form of final control of the success of studies in the study of "Toxicological and Forensic Chemistry" in the 7th semester is a semester credit, and in the 8th semester there is a semester exam.

**Semester credit** is a form of final control that consists in assessing the student's learning of a course material from a particular discipline solely on the basis of the results of the completion of all types of educational work provided by the work curriculum. The semester credit is set according to the results of the current control.

**The assessment of toxicological and forensic chemistry in the 7th semester** is based on the results of the current educational activity and is expressed on a two-point scale "enrolled" or "not enrolled". For enrollment, the student must receive at least **72 points** for the current academic activity (ie 60% of 120 points - the maximum amount of points in the discipline).

**The semester exam** is a form of final control of the student's acquisition of theoretical and practical material in toxicological and forensic chemistry. A student is considered to be admitted to the semester examination in a discipline, if he has attended all the academic curriculum provided by the discipline, completed all types of work stipulated by the curriculum of this discipline, and in his study during the semester he scored less than the minimum score "Satisfactory" (**72 points**).

The semester exam is conducted in writing during the exam session, according to the schedule. The examination form is standardized and includes control of theoretical and practical training.

Each *exam ticket* includes 5 tasks. It takes 2 hours to take the exam.

*Assessment of the answers to the exam questions is given in Section 10.*

**The maximum number of points** a student can earn when taking the exam is **80**.

**The minimum score** for the exam is 50.

## 12. Scheme of calculation and distribution of points that students receive:

*The maximum number of points* that a student can earn for his / her current academic activity upon obtaining a *semester credit* in the 7th semester is - 120 points.

*The minimum number of points* that a student must earn for his / her current academic activity in the 7th semester (to receive a *semester credit*) is 72 points (60% of 120 - maximum points).

*The maximum number of points* that a student can earn for his / her current educational activity for the 8th semester with admission to the *semester exam* is 120 points.

*The minimum number of points*, which student can get for current activity and 8th semester for admission to the compilation of *semester exam* - is 72 points.

*The calculation of the number of points* is made on the basis of the student's scores on the traditional 4-point scale during the study of the discipline, by calculating the arithmetic mean (CA), rounded to two decimal places. The resulting value is converted to scores on a multicolor scale as follows:  $x = CA \times 120 / 5$

The average score for the current activity is converted into a multi-scale scale using the table below.

**Recalculation of the average score on "toxicological and forensic chemistry" for the current activity into a multi-scale scale.**

4-point scale	200-point scale	4-point scale	200-point scale	4-point scale	200-point scale	4-point scale	200-point scale
5	120	3.37	81	3.91	94	3.37	81
4.95	119	3.33	80	3.87	93	3.33	80
4.91	118	3.29	79	3.83	92	3.29	79
4.87	117	3.25	78	3.79	91	3.25	78

4.83	116	3.2	77	3.74	90	3.2	77
4.79	115	3.16	76	3.7	89	3.16	76
4.75	114	3.12	75	3.66	88	3.12	75
4.7	113	3.08	74	3.62	87	3.08	74
4.66	112	3.04	73	3.58	86	3.04	73
4.62	111	3	72	3.54	85	3	72
4.58	110	Less than 3	not enough tatno	3.49	84	Less than 3	not enough tatno
4.54	109			3.45	83		
4.5	108			3.41	82		

**Independent work of the student**, which are presented for self-study, but not included in the topics of classroom training, are monitored during the final (credit) classes and examination.

#### **Final assessment of the discipline "toxicological and forensic chemistry".**

Initially, they summarize traditional estimates of current control over the entire course (two semesters) and calculate the arithmetic mean, to the second decimal place. The calculated arithmetic mean is converted to points on the scale above. And then to these points are added the points obtained for the final control (for the exam). **The sum of these points (for current achievement and for final control) is the final estimate for the course of toxicology and forensic chemistry.**

The points obtained by students in the final assessment of the discipline are converted into the traditional 4-point scale by the absolute criteria, which are given in the table below:

Score from discipline	Score on a 4-point scale
170 to 200 points	5
From 140 to 169 points	4
From 139 points to the minimum number of points a student must score	3
Below is the minimum number of points a student must score	2

**To determine the ECTS score**, a ranking is made by the number of points earned by the student in the final assessment of the discipline.

Ranking with assignments of grades "A", "B", "C", "D", "E" is made for students of this course, who study in one specialty and have successfully completed the study of the discipline.

The objectivity of the evaluation of students' educational activity is verified by statistical methods (the correlation coefficient between the ECTS grade and the national scale grade).

#### **Conversion of rating point to ECTS success scale:**

ECTS grade	Statistics	Calculations
A	Top 10%	200 - 110 = 90 points 90 b. × 10% = 9 b.
B	Next 25%	90 b. × 25% = 23 b.
C	Next 30%	90 b. × 30% = 27 b.
D	Next 25%	90 b. × 25% = 23 b.
E	Last 10%	90 b. × 10% = 9 b.
Fx	Resubmission	The gap between "folded - not folded" and the minimum tolerance score
F	Compulsory re-training	Less than the minimum tolerance score

Students who have received grades F<sub>x</sub> and F (“unsatisfactory”) are not included in the list of students who are ranked. Students with an F<sub>x</sub> score automatically receive an "E" grade upon transfer. Upon receipt of the F<sub>o</sub> rating, it is necessary to undergo a second course of study.

***The ECTS score is not converted to the traditional scale because the ECTS scale and the four-point scale are independent .***

### **13. Methodological support**

The list and content of educational and methodological support for the study of the discipline "Toxicological and Forensic Chemistry" includes:

- synopsis or extended lesson plan;
- thematic plans of lectures, practical classes, independent work of students;
- tasks for laboratory work and independent work of students;
- questions, tasks, tasks for current and final control of students' knowledge and skills, complex control work, post-certification monitoring of acquired knowledge and skills in the discipline.

### **14. Recommended literature**

#### **Compulsory course literature**

1. Bidnychenko Y. Toxicological chemistry: Handbook for students. – Lviv, 2009. – 175 p.
2. Bidnychenko Y. Toxicological chemistry: Practical recommendations. – Lviv, 2009. – 43 p.
3. Bondar V.S. Toxicological chemistry. Schemes and tables: Handbook for students of higher school / V.S. Bondar, S.A. Karpushina – Kharkiv: NUPh:Golden Pages, 2009. – 120 p.
4. Fundamentals of Analytical Toxicology / R.J. Flanagan, A.A. Taylor, I.D. Watson, R. Whelpto. – John Wiley & Sons, 2008 p. – 544 p.
5. Hodgson E. A Textbook of Modern Toxicology, 4th Edition – John Wiley & Sons, 2004. – 672 p.

#### **Auxiliary literature**

1. Karpushyna S.A. Collection of Multiple Choice Questions on Toxicological Chemistry with answers and explanations: for self-training foreign students in specialty 8.12020101 «Pharmacy». – Kh.: NUPh Publishing, 2017. – 92 p.
2. Cazes J., Scott R.P.W. Chromatography Theory. - Avon, Connecticut: CRC Press, 2002. – 496 p.
3. Clark's isolation and identification of drugs. – London: The Pharmaceutical Press, 1986. – 1224 p.
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### **15. Information resources:**

**libraries**

**internet resource**

**lecture materials**