

**Federal State Autonomous Educational Institution of Higher Education "Moscow  
Institute of Physics and Technology  
(National Research University)"**

**APPROVED**  
**Vice Rector for Academic Affairs**

**A.A. Voronov**

**Work program of the course (training module)**

**course:** Fundamentals of Toxicology/Основы токсикологии  
**major:** Biotechnology  
**specialization:** Biomedical Engineering/Биомедицинская инженерия  
Phystech School of Biological and Medical Physics  
кафедра физической химии  
**term:** 3  
**qualification:** Bachelor

Semester, form of interim assessment: 5 (fall) - Grading test

Academic hours: 60 АЧ in total, including:

lectures: 30 АЧ.

seminars: 30 АЧ.

laboratory practical: 0 АЧ.

Independent work: 30 АЧ.

In total: 90 АЧ, credits in total: 2

Author of the program: V.I. Skorobogatova, candidate of chemical sciences

The program was discussed at the кафедра физической химии 30.03.2024

## Annotation

The purpose of this course is to give students the working knowledge of the toxic effect of chemical agents on the human body, the mechanisms of the poisoning, the principles of identification and countermeasures from toxic substances. The course has a modern structure and is conducted in the form of lectures and seminars. During the seminars students learn how to establish quantitative characteristics of the toxicity of chemical substances, take into account factors affecting toxicity, and develop a system of measures to save the life and health of people in contact with toxic chemicals.

### 1. Study objective

#### Purpose of the course

- to study the basic principles of the toxic effect that a chemical substance might produce within a human body, the mechanisms and health symptoms of the poisoning, the principles of identification and medical countermeasures from toxic substances.

#### Tasks of the course

- to give students working knowledge about the mechanisms of the toxic effect that a chemical substance might produce within a human body, establish the link between toxicity and chemical structure and physicochemical properties of the chemical agents, the knowledge of the interaction of toxic chemicals and living organisms, i.e. toxicokinetics and toxicodynamics;
- to provide the skills to establish quantitative characteristics of toxicity, to consider the factors affecting toxicity, to develop the system of countermeasures to save the life and health of people in contact with toxic chemicals.

### 2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
	Gen.Pro.C-1.2 Build mathematical models, make quantitative measurements and estimates
	Gen.Pro.C-1.3 Determine the applicability limits of the obtained results
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.1 Adopt methods of statistical process and scientific data analysis
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions

### 3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- general principles of toxicology; classification of poisoning; classification of toxic chemicals;
- fundamentals of toxicokinetics and toxicodynamics, toxicometric characteristics of toxic substances;
- the main routes of entry and removal of the toxic substances;
- the biotransformation mechanisms of the main groups of toxic agents in a human body;
- the mechanisms and health effects of the main groups of toxic agents on a human body;
- the basic principles of antidote action.

be able to:

- to determine the toxicity and hazard class of chemical substances based on the materials of the establishment of MPC in the air of the working area.

master:

- to determine the toxicity and hazard class of chemical substances based on the materials of the establishment of MPC in the air of the working area.

#### 4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

##### 4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Basic definitions and terminology.	8	8		8
2	Toxicodynamics and toxicokinetics.	8	8		8
3	Acute poisoning with toxic chemicals.	8	8		8
4	Antidotes, their classification, mechanisms of action.	6	6		6
AH in total		30	30		30
Exam preparation		0 AH.			
Total complexity		90 AH., credits in total 2			

##### 4.2. Content of the course (training module), structured by topics (sections)

Semester: 5 (Fall)

###### 1. Basic definitions and terminology.

The subject and objectives of toxicology. The history of the toxicology. The structure of toxicology. Toxicological terminology and definitions. Criteria of the toxicity of toxic substances. Classification of toxic substances. Classification of poisonings. A toxic process. Mechanisms of the toxic process formation and development. Forms of the toxic process.

###### 2. Toxicodynamics and toxicokinetics.

Factors for the determining the distribution of toxic substances in a living organism. General principles of the distribution of poison in the body. Properties of biological membranes. Transport of toxic substances through cell membranes. Absorption, distribution, biotransformation and excretion of toxic substances. The theory of toxicity receptors. Toxicokinetic features of oral, percutaneous, inhalation poisoning.

###### 3. Acute poisoning with toxic chemicals.

Drugs poisoning. Poisoning with ethanol, industrial liquids. Organophosphate poisoning. Poisoning with cytotoxic substances. Blood and choking chemical agents poisonings. Poisoning with plant and animal poisons, snake bites, insects, etc. The principle of action of psychotomimetic and riot control agents.

###### 4. Antidotes, their classification, mechanisms of action.

Mechanisms of the antidote effect. Characteristics of modern antidotes. Antidotes that bind toxic substances (chemical antagonists). Biochemical antagonists. Physiological antagonists. Metabolic modifiers.

## **5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)**

- classrooms for lectures / seminars;
- computer and multimedia equipment (projector, sound system);
- individual computing facilities of students (personal computers) for homework.

## **6. List of the main and additional literature, that is necessary for the course (training module) mastering**

### Main literature

Предоставляется на кафедре:

Основная литература:

A textbook of modern toxicology / Ernest Hodgson. – Fourth edition. Published by John Wiley & Son, 2010. - 672 p.

The Basic Science of Poisons / Casarett & Doull's Toxicology – Ninth edition (Kindle Edition) by Curtis Klaassen - University Distinguished Professor & Chair, Department of Pharmacology, Toxicology, and Therapeutics, 2018. - 1648 p.

### Additional literature

Предоставляется на кафедре:

Дополнительная литература:

Environmental toxicity of CWAs and their metabolites / Morten Swayne Storgaard, Ilias Christensen, Hans Sanderson by Aarhus University. - 2018, 105-128 p.

## **7. List of web resources that are necessary for the course (training module) mastering**

<https://scholar.google.com/>

<https://www.ncbi.nlm.nih.gov>

## **8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)**

Some of the classes will require Zoom. Google Drive to access course materials. Smartphones/laptops are welcome during classes to participate in interactive exercises.

## **9. Guidelines for students to master the course**

A student studying the discipline must, on the one hand, master the general conceptual apparatus, and, on the other hand, must learn how to apply theoretical knowledge in practice.

As a result of studying the discipline, the student must know the basic definitions of the discipline, be able to apply the knowledge gained to solve various tasks.

Successful completion of the course requires:

- attendance of all classes provided for in the curriculum of the discipline;
- keeping a lesson summary;
- intense independent work of the student.

Independent work includes:

- reading recommended literature;
- study of educational material, preparation of answers to questions intended for self-study;
- solving problems offered to students in the classroom;
- preparation for the tasks of the current and intermediate certification.

An indicator of material proficiency is the ability to answer questions on discipline topics without a synopsis.

It is important to gain an understanding of the material being studied, and not to memorize it mechanically. If it is difficult to study certain topics, questions, you should consult a teacher.

Intermediate control of students' knowledge is possible in the form of solving problems in accordance with the subject of classes.

**Assessment funds for course (training module)**

**major:** Biotechnology  
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кафедра физической химии  
**term:** 3  
**qualification:** Bachelor

Semester, form of interim assessment: 5 (fall) - Grading test

**Author:** V.I. Skorobogatova, candidate of chemical sciences

## 1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
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	Gen.Pro.C-1.3 Determine the applicability limits of the obtained results
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.1 Adopt methods of statistical process and scientific data analysis
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions

## 2. Competency assessment indicators

As a result of studying the course the student should:

### know:

- general principles of toxicology; classification of poisoning; classification of toxic chemicals;
- fundamentals of toxicokinetics and toxicodynamics, toxicometric characteristics of toxic substances;
- the main routes of entry and removal of the toxic substances;
- the biotransformation mechanisms of the main groups of toxic agents in a human body;
- the mechanisms and health effects of the main groups of toxic agents on a human body;
- the basic principles of antidote action.

### be able to:

- to determine the toxicity and hazard class of chemical substances based on the materials of the establishment of MPC in the air of the working area.

### master:

- to determine the toxicity and hazard class of chemical substances based on the materials of the establishment of MPC in the air of the working area.

## 3. List of typical control tasks used to evaluate knowledge and skills

1. The spread of poisoning by metal compounds.
2. Poisoning by metal compounds (general toxicological information).
3. Features of chronic poisoning by metals.
4. The spread of toxic gas poisoning.
5. Acute carbon monoxide poisoning.
6. Hydrogen sulfide poisoning.
7. Carbon disulfide poisoning.
- 8 Poisoning by natural poisons.
9. Poisoning with plant poisons.
10. The main types of organic ecotoxins, their sources.
11. The main types of inorganic ecotoxins, their sources.
12. Toxicants and their specific biogeochemical features.
13. Environmental factors affecting the toxicity of chemicals.
14. Characteristics of modern antidotes.
15. Mechanisms of antidote action.

#### 4. Evaluation criteria

1. The subject and objectives of toxicology.
2. Characteristics of the main directions of toxicology.
3. Characteristics of the main parameters of toxicometry.
4. Classification of poisons.
5. Basic principles of poisoning classification.
6. Stages of acute poisoning.
7. Factors determining the development of acute poisoning.
8. Mechanisms of the effects of poisons on the body and their types.
9. The theory of toxicity receptors.
10. Characteristics of the venom-receptor bond.
11. Transport of poisons through cell membranes.
12. The concept of membranotoxins and membrane diseases.
13. Toxicokinetic features of oral poisoning.
14. Toxicokinetic features of inhalation poisoning.
15. Toxicokinetic features of percutaneous poisoning.
16. The relationship of the toxicity of a substance with its molecular weight, size and structure of molecules.
17. The dependence of toxicity on the chemical groupings and atoms included in the substance.
18. The spread of drug poisoning.
19. Poisoning with psychotropic drugs (barbiturates).
20. Chronic drug poisoning.
21. Acute alcohol poisoning.
22. Poisoning with alcohol surrogates.
23. The spread of acute nerve agents poisoning.
24. Organophosphate poisoning (general toxicological information).
25. Chronic poisoning of nerve agents.
26. The spread of poisoning with substances of cauterizing effect.
27. Poisoning with acetic acid.
28. Poisoning by inorganic acids.
29. Alkali poisoning.
30. Poisoning with oxidizing agents.

Excellent grade (10 points) is given to a student who has shown comprehensive, systematic, in-depth knowledge of the discipline's curriculum, who is interested in this subject area, who has demonstrated the ability to confidently and creatively apply them in practice when solving specific tasks, and free and correct justification of decisions made.

Excellent grade (9 points) is given to a student who has shown comprehensive, systematic, in-depth knowledge of the discipline's curriculum and the ability to confidently apply them in practice when solving specific tasks, free and correct justification of decisions made.

Excellent grade (8 points) is given to a student who has shown comprehensive, systematic, in-depth knowledge of the discipline's curriculum and the ability to confidently apply them in practice when solving specific tasks, the correct justification of decisions made, with some shortcomings.

Good grade (7 points) - it is given to the student if he firmly knows the material, competently and substantially expounds it, knows how to apply the knowledge gained in practice, but does not competently substantiate the results obtained.

Good grade (6 points) - it is given to the student if he firmly knows the material, competently and substantially expounds it, knows how to apply the knowledge gained in practice, but admits some inaccuracies in the answer or in solving problems.

Good grade (5 points) is given to a student if he mostly knows the material, competently and substantially expounds it, is able to apply the knowledge gained in practice, but admits a sufficiently large number of inaccuracies in the answer or in solving problems.



Satisfactory grade (4 points) - it is given to the student who has shown the fragmentary, disparate nature of knowledge, insufficiently correct formulations of basic concepts, violations of logical sequence in the presentation of program material, but at the same time he has mastered the main sections of the curriculum necessary for further study, and can apply the acquired knowledge according to the model in a standard situation.

Satisfactory grade (3 points) - it is given to a student who has shown a fragmentary, disparate nature of knowledge, makes mistakes in the formulation of basic concepts, violations of logical sequence in the presentation of program material, has a weak command of the main sections of the curriculum necessary for further study and hardly applies the knowledge acquired even in a standard situation.

Unsatisfactory assessment (2 points) is given to a student who does not know most of the main content of the discipline's curriculum, makes gross mistakes in the formulation of basic principles and does not know how to use the knowledge gained in solving typical tasks.

Unsatisfactory assessment (1 point) is given to a student who does not know the main content of the discipline's curriculum, makes gross mistakes in the formulation of basic concepts of the discipline and generally does not have the skills to solve typical practical problems.

## **5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience**

When conducting an assessment, the student is given 60 minutes to prepare. The student's answer for the assessment should not exceed one astronomical hour.