# MEDICAL UNIVERSITY – PLOVDIV

# FACULTY OF MEDICINE

## SYLLABUS

## IN

# Chemistry

**Approved by the Department Council on 30.05.2025**

**Confirmed by the Faculty Council - Protocol № 6/18.06.2025**

**Syllabus**

| Discipline | Final exam/ semester | Auditorium classes | | | | ECTS non-auditorium classes | ECTS total | Academic hours in years and semesters | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1st year | |
| | | Total | Lectures | Practices | ECTS | | | I | II |
| Chemistry | 1 | 90 | 45 | 45 | 3 | 3 | 6 | 90 | … |

**DISCIPLINE: CHEMISTRY**

**TYPE OF DISCIPLINE ACCORDING TO THE UNIFORM STATE REQUIREMENTS: Mandatory**

**LEVEL OF QUALIFICATION: Master's degree /MS/**

**FORMS OF TRAINING: Lecture course, laboratory classes, and self-study**

**YEAR OF TRAINING: First year**

**DURATION OF TRAINING: One semester**

**ACADEMIC HOURS: 90**

**TECHNICAL EQUIPMENT APPLIED IN THE TRAINING:**
Multimedia presentations, links to scientific papers on the studied topics, work with common laboratory equipment and glassware, UV-VIS spectrophotometers, HPLC system, GC system, other tools and technical devices for demonstration of the application of modern methods of quantitative chemical analysis in medicine, text book for the practical course, lecture handouts.

**FORMS OF EVALUATION:**
Ongoing evaluation – oral examination during practical lessons, writing colloquiums based on the studied topics and individual tasks. The current average grade for the semester is formed based on the colloquiums and individual tasks.
Final evaluation – written and oral examination at the end of the semester. The final exam is cumulative, covering all of the same material tested previously.

**EVALUATION CRITERIA:**
Participation in discussions during the lectures and practical lessons, and evaluation of the written papers from the colloquiums and individual tasks. The final mark is determined on the basis of the written exam on the subject, the oral exam and the current average grade.

**ASPECTS OF EVALUATION CRITERIA:**
The final grade formation includes an assessment of the colloquiums and individual tasks and the final written and oral exam. The final grade is calculated with the formula:
**Q( final mark) = 0.2xQ (average mark from the colloquiums and individual tasks) + 0.5xQ (mark from the final written exam) + 0.3xQ (mark from the oral exam)**

**SEMESTER EXAM:**
**Yes (written and oral examination)**

**STATE EXAM:**
**NO**

**LECTURER: ASSOCIATE PROFESSOR FROM THE DEPARTMENT OF BIOORGANIC CHEMISTRY**

**DEPARTMENT: BIOORGANIC CHEMISTRY**

## ANNOTATION

The course takes place in the first year and lasts one semester. The major objective of the course is the formation of systemic knowledge about the relationship between the structure, chemical properties and functions of biologically important classes of natural and synthetic organic compounds and to prepare the students for subjects studied in the following years of tuition such as biochemistry, pharmacology, clinical medicine and physiology. During the course of training modern means of equipment are used.

## BASIC AIMS OF THE DISCIPLINE

Master the basic concepts related to the chemical characteristics of metabolic processes in the body including: buffers, enzymes, biological oxidation, chemical aspects of carbohydrate, amino acid and lipid metabolism; basic types of heterocyclic compounds and biologically active derivatives. Introduction to instruments for the analysis of biological objects.

## EXPECTED RESULTS

At the end of course students must have the following knowledge and skills:

- To understand the meaning and content of such concepts as: concentration of solutions, pH and its definition, and the meaning and effect of buffer systems in the human body.
- To be acquainted with the classification of enzymes, their structure and action.

- To know the nature of redox processes in the body (biological oxidation) and the basic principles of biological metabolism
- To have a basic knowledge of high energy compounds and their place in the metabolism of substances in the human body
- To have a basic knowledge of main classes of organic compounds
- To have a basic knowledge of carbohydrate, amino acid and lipid metabolism
- To have an understanding of basic types of heterocyclic compounds and mostly their biologically active derivatives: coenzymes, vitamins, medicines and hormones.
- To be acquainted with the analytical equipment used during the practical classes and the possibilities it provides for studying biological objects.

## LECTURES

### *LECTURE 1*

### CHEMISTRY – INTRODUCTION IN THE COURSE. COORDINATION COMPOUNDS. CHELATES

1. Chemistry – introduction in the course.
2. Coordination compounds – definition, structure and classification. Stability constant of coordination compounds. Biologically active coordination compounds.
3. Chelates – structure. Chelates formed by polyhydroxy alcohols, phenols, hydroxycarboxylic acids, amino acids, peptides, protoporphyrins (hemoglobin, cytochrome, vitamin $B_{12}$).

### *LECTURE 2*

### ACIDS AND BASIS

1. Brønsted-Lowry theory of acids and bases. Acid ionization constant. Base ionization constant. Self-ionization of water. Ionic product constant of water. The pH scale. Buffers. Calculation of the pH of the buffers. Buffers in the human body
2. Lewis theory of acids and bases.

### *LECTURE 3*

### CHEMICAL KINETICS. ACTIVATION ENERGY DIAGRAM. ARRHENIUS EQUATION. CATALYSIS. CHEMICAL EQUILIBRIUM

1. Chemical kinetics – rate law, factors affecting the rate of reaction. Order and molecularity of reaction. Activation energy diagram. Arrhenius Equation.
2. Catalysis – principals of homogeneous and heterogeneous catalysis.
3. Chemical equilibrium - basic conceptions, principle of Le Chatelier's. Factors, influencing on the chemical equilibrium.

### *LECTURE 4*

### OXIDATION-REDUCTION REACTIONS, BIOLOGICAL OXIDATION. CHEMICAL THERMODYNAMICS. BIOENERGETICS

1. Oxidation-reduction reactions, biological oxidation and reduction, redox potentials. Redox pair in biological oxidation and reduction. Respiratory chain.
2. Chemical thermodynamics. The first and second laws of thermodynamics.
3. Bioenergetics – principals. Energy, enthalpy, entropy, free energy.
4. Endergonic and exergonic reactions. Compounds with high-energy bonds – ATP, creatine phosphate, phosphoenolpyruvate etc.

***LECTURE 5***

**ORGANIC COMPOUNDS – MAIN CLASSES. REACTIONS OF ORGANIC COMPOUNDS. ISOMERISM**

1. Classification of organic compounds. Substitution reactions, addition reactions, elimination reactions, oxidation. Reactions between different functional groups.
2. Isomerism – structural and stereoisomerism.

***LECTURE 6***

**HYDROXYL DERIVATIVES OF HYDROCARBONS – ALCOHOLS AND PHENOLS**

1. Alcohols and phenols – classification; isomers; physical and chemical properties. – acid-base reactions, substitution reactions, dehydration**,** oxidation of alcohols to aldehydes, ketones and carboxylic acids; oxidation of phenols; fofrmation of chelates. Esters of phosphoric acid and esters of nitric acid. Biological oxidation of alcohols and phenols.
2. Thioalcohols, coenzyme A – biological functions.

***LECTURE 7***

**CARBONYL COMPOUNDS – ALDEHYDES AND KETONES**

1. Aldehydes and ketones – classification, isomerism, physical and chemical properties – addition reactions, substitution reactions, oxidation, Cannizzaro reaction, aldol reaction.
2. Biologically active carbonyl compounds – coenzyme Q, vitamin K, retinal, ketone bodies.

***LECTURE 8***

**CARBOXYLIC ACIDS. ALIPHATIC AND AROMATIC MONO-CARBOXYLIC ACIDS.**

1. Carboxylic acids-classification. Isomerism.
2. Physical and chemical properties of mono-carboxylic acids.
3. Biological oxidation of long chain carboxylic acids (β-oxidation).

***LECTURE 9***

**DICARBOXYLIC ACIDS. HYDROXY- AND KETO ACIDS.**

1. Carboxylic acids-classification. Isomerism.

2. Saturated and unsaturated dicarboxylic acids – oxalic, malonic, glutaric and adipic acids. Fumaric and maleic acid – chemical reactions and biological functions.
3. Hydroxy- and keto acids – chemical reactions and biological functions.

*LECTURE 10*

**AMINES. BIOGENIC AMINES. ALPHA AMINO ACIDS: PHYSICAL AND CHEMICAL PROPERTIES. CHEMICAL ASPECTS OF AMINO ACID METABOLISM.**

1. Amines – definition, structure and classification. Important chemical properties of amines. Biogenic amines. Sulfonamides.
2. Alpha amino acids – classification, isomerism. Important physical and chemical properties. Chemical aspects of amino acid metabolism.

*LECTURE 11*

**PEPTIDES AND PROTEINS. BIOCATALYSIS**

1. Peptides – structure, disulphide bridges. Biological activity of peptides.
2. Proteins – bonding in proteins; strucutural levels of proteins; functions; hydrolysis and denaturation. Basic principles of protein metabolism.
3. Biocatalysts: enzymes and co-enzymes; classification; mechanism of action; rate of enzymatic reaction – Michaelis-Menten constant. Specificity and regulation of enzyme activity. Medical significance of enzymes.

*LECTURE 12*

**CARBOHYDRATES – CHEMICAL PROPERTIES. CARBOHYDRATE METABOLISM – CHEMICAL ASPECTS**

1. Carbohydrates. Monosaccharides – classification, structure, configuration, isomerism;. Chemical reactions of monosaccharides.
2. Disaccharides and polysaccharides – functions, hydrolisysis, medical significance.
3. Glycolysis – basic concept.

*LECTURE 13*

**LIPIDS. BASIC PRINCIPLES OF LIPID METABOLISM**

1. Lipids – classification. Fatty acids – saturated, nonsaturated.
2. Triacylglycerols. Fats and oils. Chemical aspects of fat burning. Phospholipids. Waxes
3. Terpenes and steroids – structure; biosynthesis; biologically active derivatives - vitamins, hormones.

*LECTURE 14*

**HETEROCYCLIC COMPOUNDS WITH FIVE-MEMBERED RINGS – FURAN, THIOPHENE, PYRROLE, PYRAZOLE, IMIDAZOLE, THIAZOLE AND THEIR BIOLOGICALLY ACTIVE DERIVATIVES.**

1. Heterocyclic compounds – classification.
2. Five-membered ring heterocyclic compounds with one heteroatom (pyrrole, furan and thiophene) – structure (π-sextet) and chemical properties.
3. Important biological molecules containing pyrrole ring – heme, hemoglobin, bilirubin, cytochrome, proline, hydroxyproline
4. Heterocyclic compounds with five-membered ring and two heteroatoms (pyrazole, imidazole, and thiazole) – structure and important chemical properties.
5. Important biological molecules containing pyrazole, imidazole, and thiazole ring – histidine, antipyrin, pyramidone, analgin, vitamins.

*LECTURE 15*

**HETEROCYCLIC COMPOUNDS WITH SIX-MEMBERED RING AND FUSED RINGS.**

1. Heterocyclic compounds with six-membered ring and one or two heteroatom-pyridine and pyrimidine, structure and major chemical properties.
2. Important biological molecules containing pyridine ring – nicotine, nicotinamide, medicines, vitamins, alkaloids. Biomolecules containing pyrimidine ring – nucleotides, vitamins, drugs.
3. Heterosyclic compounds with fused rings – indole, quinoline, isoquinoline and their derivatives. Purine and its derivatives. Uric acid. Nucleic acids.

## PRACTICES

*LABORATORY CLASS 1*

**CONCENTRATION OF SOLUTIONS. PREPARATION OF SOLUTIONS**

1. Ways of expressing concentration
2. Solving problems concerning solution concentration
3. Preparation of solutions

*LABORATORY CLASS 2*

**COORDINATION COMPOUNDS. COORDINATION CHEMISTRY OF SOME BIOLOGICAL METAL IONS**

1. Structure of coordination compounds
2. Stability of coordination compounds
3. Chelates. Structure and functions of biologically significant chelates
4. Preparation of coordination compounds

*LABORATORY CLASS 3*

**BRONSTED-LOWRY THEORY OF ACIDS AND BASES. IONIC PRODUCT OF WATER. PH AND METHODS FOR ITS MEASUREMENT. BUFFER SOLUTIONS**

1. Discussion on the concepts “acid” and “base” according to existing theories. Buffers
2. Demonstrating different ways of measuring pH
3. Testing the action of a given buffer solution

*LABORATORY CLASS 4*

**OXIDATION-REDUCTION REACTIONS. BIOLOGICAL OXIDATION AND REDUCTION. REDOX POTENTIALS**

1. Discussion on principles of redox reactions, types of redox reactions
2. Biological oxidation
3. Experiments demonstrating redox processes with inorganic and organic compounds

*LABORATORY CLASS 5*

**FUNDAMENTALS OF UV-visible spectrophotometry**

1. Discussion on Fundamentals of UV-visible spectrophotometry
2. Determination of the concentration of salicylic acid in aspirin tablets.

*LABORATORY CLASS 6*

**COLLOQUIUM 1.**

*LABORATORY CLASS 7*

**CARBONYL COMPOUNDS. KETONE BODIES IN HUMAN PATHOLOGY**

1. Experiments demonstrating nucleophilic and redox properties of aldehydes and ketones.
2. Some tests for detection of aldehydes and ketones.
3. Tests for ketone bodies in biological samples

*LABORATORY CLASS 8*

**CARBOXYLIC AND HYDROXY CARBOXYLIC ACIDS. KETOCARBOXYLIC ACIDS**

1. Comparing the degree of ionization of carboxylic acids in water solution;
2. Demonstration of some chemical properties of carboxylic acids
3. Demonstration of keto-enol tautomerism

*LABORATORY CLASS 9*

**COLLOQUIUM 2**

*LABORATORY CLASS 10*

**AND AMINES. DERIVATIVES OF CARBONIC ACID: UREA, CREATINE AMINO ACIDS AND PROTEINS. DIALYSIS**

1. Some important chemical properties of amines and amino acids
2. Qualitative reactions for testing amino acids and proteins in a solution
3. Dialysis
4. Urea and Creatine medical significance.

*LABORATORY CLASS 11*

**BIOCATALYSIS. ENZYMATIC HYDROLYSIS OF PROTEINS**

1. Discussion on kinetics of enzyme reaction
2. Spectrophotometric determination of enzyme activity

*LABORATORY CLASS 12*

**CARBOHYDRATES – STEREOCHEMISTRY AND PROPERTIES OF MONO-, DI-, AND POLYSACCHARIDES**

1. Stereochemistry of carbohydrates
2. Chemical reactions of carbohydrates
3. Some tests for monosaccharides and polysaccharides

*LABORATORY CLASS 13*

**HETEROSYCLIC COMPOUNDS. LOW MOLECULAR WEIGHT BIOREGULATORS: VITAMINS AND ALKALOIDS**

1. Discussion on heterocyclic compounds – structure and biological significance
2. Reactions for testing some vitamins, alkaloids and medicines
3. Presentations on the individual tasks

*LABORATORY CLASS 14*

**PRINCIPLE OF CHROMATOGRAPHY – COLUMN, PAPER, THIN-LAYER AND HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY. APPLICATION TO BIOMEDICAL SCIENCE**

1. Principles of chromatography
2. Identification of medicines and alkaloids by means of TLC
3. Presentations on the individual tasks

*LABORATORY CLASS 15*

**PRESENTATIONS ON THE INDIVIDUAL TASKS**

## BIBLIOGRAPHY


1. Ouellette R J, Introduction to General, Organic and Biological Chemistry, Prentice-Hall 1997 and new editions
2. Bruice P.Y., Organic Chemistry, 2003, Prentice Hall PTR eight and previous editions

**Students can use any other textbook in chemistry covering above topics.**


## CONSPECTUS

1. Solutions – definition and types. Molecular and ionic solutions, solubility. Types of concentration (percent concentration, molarity, normality, osmolarity). Solutions in the human body.
2. Brønsted-Lowry theory of acids and bases. Acid ionization constant (Ka). Base ionization constant (Kb). Lewis' theory of acids and bases.
3. Self-ionization of water, ionic product of water. The pH scale, methods of measuring pH. Buffers – definition, buffer action. Calculation of the pH of buffers – Henderson-Hasselbalch's equations. Buffers in the human body.
4. Chemical kinetics – reaction rate, rate law. Order of chemical reactions. Activation energy. Arrhenius Equation. Mechanism and molecularity of the chemical reaction.
5. Catalysis. Homogeneous and heterogeneous catalysis. Autocatalysis. Chemical equilibrium - basic conceptions, principle of Le Chatelier's. Factors influencing on the chemical equilibrium.
6. Chemical thermodynamics. The first and second laws of thermodynamics. Energy, enthalpy, entropy, free energy. Endergonic and exergonic reactions. High energy bonds. High energy compounds and their significance in metabolism (ATP, creatine phosphate, phosphoenolpyruvate, thioesters, acylphosphates).

7. Oxidation-reduction reactions-definitions. Disproportionation and comproportionation reactions – definition and examples. Biological oxidation and reduction, redox potentials. Redox pair in biological oxidation and reduction. Catabolic and anabolic reactions. Respiratory chain.
8. Coordination compounds – definition, classification, structure, naming. Stability constant.
9. Chelates. Chelates formed with polyols, hydroxycarboxylic acids, amino acids, polypeptides and proteins. Chelates with protoporphyrins – hemoglobin, chlorophyll, cytochrome c, vitamin $B_{12}$.
10. Alcohols and phenols – classification, isomerism. Chemical properties – acid base properties, esterification, oxidation of alcohols and phenols. Reactions of the aromatic ring, dehydration, formation of chelates. Biological oxidation of alcohols (methanol, ethanol, 1,2-ethandiol, glycerol). Esters of phosphoric acid and esters of nitric acid – biological significance. Thioalcohols - definition and chemical properties. Coenzyme A, thioesters.
11. Carbonyl compounds – aldehydes and ketones. Chemical properties of aldehydes and ketones – nucleophile addition reactions, addition-elimination reactions, reactivity of α-carbon atom (tautomerism, aldol reaction). Cnnizzaro reaction, oxidation of carbonyl compounds. Substitution reactions. Biologically active substances with quinone structure - coenzyme Q, K vitamins. Glycerolaldehyde, 11-cis retinal. Ketone bodies.
12. Carboxylic acids-classification. Chemical properties of aliphatic and aromatic mono-carboxylic acids. Biological oxidation of long chain carboxylic acids (β-oxidation).
13. Saturated and unsaturated carboxylic acids – properties: oxalic acid, malonic acid, succinic acid, glutaric acid and adipic acid. Fumaric acid and maleic acid-isomerism and significance in metabolism.
14. Hydroxycarboxilic acids and ketocarboxylic acids – overview. Isomerism, chemical reactions. Important compounds of this group and their biological significance – lactic acid, salicylic acid, malic acid, tartaric acid, citric acid; pyruvic acid, acetoacetic acid, oxaloacetic acid, α-ketoglutaric acid.
15. Amines-definition, structure and chemical properties. Sulfonamides. Biogenic amines GABA, histamine, serotonin, catecholamines: dopamine, noradrenaline, adrenaline. Derivatives of carbonic acid-urea, guanidine, creatine.
16. α–Amino acids - classification. Chemical properties of α-amino acids. Chemical aspects of amino acid metabolism – deamination of α-amino acids; ketogenic and glucogenic amino acids.
17. Peptides and proteins – classification, structure, properties, functions. Peptide hormones – examples and functions.
18. Biocatalysts – definition and structure of enzymes. Classification of the enzymes. Factors affecting enzyme activity – temperature, pH; influence of substrate concentration on the rate of enzymatic reaction – Michaelis-Menten constant. Zymogenes and isoenzymes. Specificity and regulation of enzyme activity - competitive and irreversible inhibitors.
19. Carbohydrates. Monosaccharides – structure, isomerism and chemical properties. Examples of aldoses and ketoses. Cyclic forms of monosaccharides. Glycolysis – basic concept. Disaccharides and polysaccharides – examples and some functions.
20. Classification of lipids. Hydrolyzable lipids-examples. Chemical aspects of biological oxidation of fats and oils. Phospholipids – types and biological significance.
21. Classification of lipids. Non-hydrolyzable lipids. Terpenes and steroids. Examples of biologically significancant compounds: β-carotene, retinol (vitamin A). Retinal – visual perception in humans. Cholesterol and D group vitamins. Sex hormones. Bile acids.
22. Heterocyclic compounds-classification. Five-membered heterocyclic compounds with one hetero atom– furan, thiophene, and pyrrole – structures, reactions. Biologically active substances containing pyrrole ring.

23. Five-membered heterocyclic compounds with two hetero atoms - pyrazole, imidazole and thiazole - structures. Biologically active derivatives of the above mentioned compounds.
24. Six-membered heterocyclic compounds with one hetero atom (pyridine, pyran, thiopyran): structure. Biologically active substances containing pyridine ring $NAD^+$, vitamin B6, niacin, medicines and alkaloids; vitamin E.
25. Pyrimidine, piridazine, pirazine-structure. Biologically active substances with pyrimidine ring – pyrimidine bases, nucleotides, medicines, vitamins and enzymes.
26. Heterocyclic compounds with fused rings. Indole and some of its derivatives – structure and functions. Purine and its derivatives – purine bases, uric acid (tautomers), caffeine, theobromine -structure. Biological activity of purine and its derivatives. Nucleic acids – structure (nucleosides and nucleotides).

Prepared by: Assoc.Prof. Y. Uzunova, PhD

Assoc. Prof. Stela Dimitrova, PhD
Head of Department of Bioorganic Chemistry