MEDICAL UNIVERSITY OF PLOVDIV

FACULTY OF DENTAL MEDICINE

PROGRAMME

IN

CHEMISTRY

Course in English

Accepted by the Departmental Council on 19 May 2023

Approved by the Faculty Board on 24.04.2024 Protocol № 5

MEDICAL UNIVERSITY-PLOVDIV

FACULTY OF PHARMACY

CURRICULUM

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	2	60	30	30	2.5	2.6	5.1	-	60

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: 60

TECHNICAL EQUIPMENT APPLIED IN THE TRAINING:
Multimedia presentations, common laboratory equipment and glassware, UV-VIS spectrophotometer, 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. The current average grade for the semester is formed based on the colloquiums.
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, and evaluation of the written papers from the colloquiums. 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 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 dental materials, biochemistry, pharmacology 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, solubility product, pH and its definition, and the meaning and effect of buffer systems in the human body.

- To be acquainted with the nature of chemicals used as components of dental composites and other dental materials.
- 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 carbohydrate, amino acid and lipid metabolism.
- To have an understanding of basic types of heterocyclic compounds and mostly their biologically active derivatives: coenzymes, medicines, vitamins.
- To be acquainted with the analytical equipment used during the practical classes and the possibilities it provides for studying biological objects.

LECTURE COURSE IN CHEMISTRY FOR STUDENTS IN DENTAL MEDICINE
I year, II semester

№	TOPIC	HOURS
1.	Chemistry –introduction to course. Coordination compounds. Chelates	2
2.	Acids and bases	2
3.	Oxidation-reduction reactions, biological oxidation. Chemical thermodynamics. Bioenergetics	2
4.	Organic chemistry-introduction	2
5.	Alcohols and phenols	2
6.	Carbonyl compounds – aldehydes and ketones	2
7.	Carboxylic acids. Application of unsaturated carboxylic acids and their derivatives in dental medicine. Composite materials	2
8.	Carboxylic acids. Hydroxy- and ketocarboxylic acids	2
9.	Amines. Biogenic amines. Alpha amino acids: Physical and chemical properties. Derivatives of Carbonic acid	2
10.	Peptides and Proteins. Biocatalysis	2
11.	Carbohydrates. Monosaccharides-structure and chemical properties	2
12.	Carbohydrates. Oligosaccharides and polysaccharides. Chemical aspects of carbohydrate metabolism	2
13.	Lipids. Basic principles of lipid metabolism	2
14.	Heterocyclic compounds with five-membered rings and one or two heteroatoms	2
15.	Heterocyclic compounds with six membered ring and fused rings.	2

Total:30 hrs

PRACTICAL CLASSES

I year, II semester

№	TOPIC	HOURS
1.	Concentration of solutions. Preparation of solutions	2
2.	Coordination compounds. Coordination chemistry of some biological metal ions	2
3.	Acids and bases. Ionic product of water. pH and methods for its measurement. Buffers	2
4.	Oxidation-reduction reactions. Biological oxidation and reduction. Re potentials	2
5.	Fundamentals of UV-visible spectroscopy	2
6.	Isomerism of organic compounds	2
7.	Alcohols and phenols – Chemical reactions and biological activity	2
8.	Carbonyl compounds. Ketone bodies in human pathology.	2
9.	Carboxylic acids. Esters of methacrylic acid in dental materials. Quantification of residual monomers in polymerized dental composites.	2
10.	Amines. Derivatives of carbonic acid: urea, creatine	2
11.	Amino acids and proteins	2
12.	Biocatalysis. Enzymatic hydrolysis of proteins	2
13.	Carbohydrates – stereochemistry and properties of mono-, di-, and polysaccharides	2
14.	Heterosyclic compounds. Low molecular weight bioregulators: vitamins and alkaloids	2
15.	Principle of chromatography – column, paper, thin-layer and high-performance liquid chromatography. Application to biomedical science. Solving problems in chemistry	2

Total: 30 hrs

LECTURES – THESES

LECTURE 1 – 2 hrs

CHEMISTRY –INTRODUCTION TO COURSE. COORDINATION COMPOUNDS. CHELATES

1. Introduction to course.
2. Coordination compounds – classification and structure. Stability constant of coordination compounds. Biologically active coordination compounds.
3. Chelates – structure. Chelates formed by polyols, hydroxycarboxylic acids, amino acids, peptides, protoporphyrins (hemoglobin, cytochrome, vitamin B_{12}).

LECTURE 2 – 2 hrs

ACIDS AND BASES

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

LECTURE 3 – 2 hrs

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, thioesters.

LECTURE 4 – 2 hrs

ORGANIC CHEMISTRY-INTRODUCTION

1. Main classes of organic compounds.
2. Reactions in organic chemistry – addition, substitution, polymerization, oxidation.
3. Isomerism – constitutional and stereo isomerism.

LECTURE 5 – 2 hrs

ALCOHOLS AND PHENOLS

1. Alcohols and phenols – classification, naming, isomerism, physical properties and chemical reactions.
2. Biological oxidation of alcohols.
3. Thioalcohols - chemical reactions, coenzyme A.

LECTURE 6 – 2 hrs

CARBONYL COMPOUNDS – ALDEHYDES AND KETONES

1. Aldehydes and ketones – classification, naming, isomerism, physical properties and chemical reactions. Aldol reaction in living systems.
2. Biologically active molecules with carbonyl groups-coenzyme Q, vitamin K, camphorquinone, phenylpropanedione, ketone bodies.

LECTURE 7 – 2 hrs

CARBOXYLIC ACIDS. APPLICATION OF UNSATURATED CARBOXYLIC ACIDS AND THEIR DERIVATIVES IN DENTAL MEDICINE. COMPOSITE MATERIALS

1. Carboxylic acids-classification, naming, isomerism.
2. Chemical reactions of mono-carboxylic aliphatic and aromatic acids.
3. Esters of acrylic and methacrylic acids in dental materials. Chemical and photochemical polymerization of these materials.

LECTURE 8 – 2 hrs

CARBOXYLIC ACIDS. HYDROXY- AND KETOCARBOXYLIC ACIDS

1. Biological oxidation of long chain carboxylic acids (β-oxidation).
2. Hydroxy- and ketocarboxylic acids – chemical reactions and biological significance.
3. Claisen condensation in biological systems-ketone bodies-an overview.

LECTURE 9 – 2 hrs

AMINES. BIOGENIC AMINES. ALPHA AMINO ACIDS: PHYSICAL AND CHEMICAL PROPERTIES. DERIVATIVES OF CARBONIC ACID

1. Amines – classification, naming, isomerism.
2. Important chemical reactions of amines. Sulfonamides. Biogenic amines.
3. Alpha amino acids – classification. Acid-base properties, zwitterion, important chemical reactions. Chemical aspects of amino acid metabolism.
4. Deivatives of carbonic acid-urea, creatine, creatine phosphate.

LECTURE 10 – 2 hrs

PEPTIDES AND PROTEINS. BIOCATALYSIS

1. Peptides and proteins-structure, hydrolysis. Small-chain peptides-activity.
2. Biocatalysis- structure of enzymes; classification; models of enzyme action; enzyme specificity; rate of enzyme reaction and factors affecting it; isoenzymes, zimogens; enzymes in diagnostic.

LECTURE 11 – 2 hrs

CARBOHYDRATES. MONOSACCHARIDES-STRUCTURE AND CHEMICAL PROPERTIES

1. Carbohydrates-classification. Monosaccharides-classification, names, isomerism.
2. The hemiacetal (cyclic) structure of monosaccharides.
3. Chemical reactions of monosaccharides.

LECTURE 12 – 2 hrs

CARBOHYDRATES. OLIGOSACCHARIDES AND POLYSACCHARIDES. CHEMICAL ASPECTS OF CARBOHYDRATE METABOLISM

1. Disaccharides-structure, hydrolysis, properties.
2. Polysaccharides-homoplysaccharides and heteropolysaccharides, structure and properties.
3. Glycolysis-basic concept.

LECTURE 13 – 2 hrs

LIPIDS. BASIC PRINCIPLES OF LIPID METABOLISM

1. Classification of lipids.
2. Triacylglycerols. Fats and oils. Chemical aspects of fat burning.
3. Phospholipids.
4. Prostaglandines.
5. Terpenes and steroids
6. Lipid soluble vitamins.

LECTURE 14 – 2 hrs

HETEROCYCLIC COMPOUNDS WITH FIVE-MEMBERED RINGS AND ONE OR TWO HETEROATOMS

1. Heterocyclic compounds – classification.
2. Aroamtic heterocyclic compounds-criteria for aromatacity
3. Five-membered heterocyclic compounds with one heteroatom (pyrrole, furan and thiophene) acid-base properties and some other reactions.
4. Important biological molecules containing pyrrole ring – heme, hemoglobin, bilirubin, cytochrome, proline, hydroxyproline, vitamins.
5. Heterocyclic compounds with five-membered ring and two heteroatoms (pyrazole, imidazole, and thiazole) – structure, important chemical properties and derivatives with pharmacological activity.

LECTURE 15 – 2 hrs

HETEROCYCLIC COMPOUNDS WITH SIX MEMBERED RING AND FUSED RINGS.

1. Heterocyclic compounds with six-membered ring and one heteroatom-pyridine, pyrane, thiopyrane. Pyridine – structure and major chemical properties. Important biological molecules containing pyridine ring.
2. Pyrimidines. Biomolecules containing pyrimidine ring – nucleosides and nucleotides, vitamins, drugs.
3. Purine and its derivatives-uric acid, alkaloids, nucleic acids.
4. Quinoline, isoquinoline, indole-structure and derivatives with pharmacological activity.

LABORATORY CLASSES –THESES

LABORATORY CLASS 1 -2 hrs

CONCENTRATION OF SOLUTIONS. PREPARATION OF SOLUTIONS

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

LABORATORY CLASS 2 – 2 hrs

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 – 2 hrs

ACIDS AND BASES. IONIC PRODUCT OF WATER. PH AND METHODS FOR ITS MEASUREMENT. BUFFERS

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 – 2 hrs

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 – 2 hrs

FUNDAMENTALS OF UV-VISIBLE SPECTROSCOPY

1. Discussion on Fundamentals of UV-visible spectroscopy
2. Quantification of residual salicylic acid in aspirin tablets

LABORATORY CLASS 6 – 2 hrs

ISOMERISM OF ORGANIC COMPOUNDS

1. Discussion on constitutional isomerism. Examples with different classes organic compounds.
2. Stereoisomerism-geometrical isomers, optical isomers. Examples with different classes organic compounds.

LABORATORY CLASS 7 – 2 hrs

ALCOHOLS AND PHENOLS–CHEMICAL REACTIONS AND BIOLOGICAL ACTIVITY

1. Discussion on the structure and chemical reactions of alcohols and phenols.
2. Preparation of an ester.
3. Tests for alcohols and phenols

LABORATORY CLASS 8 – 2 hrs

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 9 – 2 hrs

CARBOXYLIC ACIDS. ESTERS OF METHACRYLIC ACID IN DENTAL MATERIALS. QUANTIFICATION OF RESIDUAL MONOMERS IN POLYMERIZED DENTAL COMPOSITES.

1. Discussion on the reactions of carboxylic acids
2. Quantification of residual monomers in polymerized dental composites.

LABORATORY CLASS 10 – 2 hrs

AMINES. DERIVATIVES OF CARBONIC ACID: UREA, CREATINE

1. Some important chemical properties of amines and urea.
2. Creatine, creatinephosphate-structure and significance for the body.

LABORATORY CLASS 11 – 2 hrs

AMINO ACIDS AND PROTEINS

1. Measurement of pH of water solution of amino acids.
2. Qualitative reactions for testing amino acids and proteins in a solution.

LABORATORY CLASS 12 – 2 hrs

BIOCATALYSIS. ENZYMATIC HYDROLYSIS OF PROTEINS

1. Discussion on kinetics of enzyme reaction.
2. Determination of proteolytic enzyme activity.

LABORATORY CLASS 13 – 2 hrs

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

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

LABORATORY CLASS 14 – 2 hrs

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

LABORATORY CLASS 15 – 2 hrs

PRINCIPLE OF CHROMATOGRAPHY – COLUMN, PAPER, THIN-LAYER AND HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY. APPLICATION TO BIOMEDICAL SCIENCE. SOLVING PROBLEMS IN CHEMISTRY

1. Principles of chromatography
2. Identification of medicines and alkaloids by means of TLC
3. Solving problems in chemistry

RECOMMENDED TEXTBOOKS

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 forth and following editions

3. Karen C. Timberlake, Chemistry: An Introduction to General, Organic, and Biological Chemistry-Twelth edition, 2014, Pearson and following editions

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

Chemistry-syllabus for first year students of dental medicine

1. Solutions – definition and types. Molecular and ionic solutions, solubility, solubility product. Types of concentration (percent concentration, molarity, osmolarity).
2. Brønsted-Lowry theory of acids and bases. Acid ionization constant (Ka). Base ionization constant (Kb). Strength of acids and bases – Ka, pKa; Kb, pKb. Lewis' theory of acids and bases.
3. Self-ionization of water, ionic product of water (Kw). The pH scale, methods of measuring and calculating pH. Physiological pH and pH of some body fluids (saliva, blood etc.). Critical pH of saliva.
4. Buffers-definition, buffer action. Calculation of pH of buffers – Henderson-Hasselbalch's equations. Buffers in the human body.
5. 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.
6. Chemical thermodynamics. The first and second laws of thermodynamics. Internal energy, enthalpy, entropy, free energy. Endergonic and exergonic reactions. High energy bonds – examples. High energy compounds and their significance in metabolism (ATP, creatine phosphate, phosphoenolpyruvate, thioesters, acylphosphates).
7. Coordination compounds – definition, classification, structure. Stability constant. Application in medicine.
8. Chelates. Chelates formed with polyols, hydroxycarboxylic acids, amino acids, polypeptides and proteins (carboxypeptidase). Chelates with protoporphyrins – hemoglobin, chlorophyll, cytochrome c, Vitamin B_{12}.
9. Alcohols and phenols – classification, isomers. Chemical properties – acid base properties, esterification, phosphate esters of alcohols, oxidation of alcohols and phenols, dehydration, reactions of the aromatic ring formation of chelates. Biological oxidation of alcohols (methanol, ethanol, 1,2-ethandiol, glycerol). Thioalcohols - definition and chemical reactions; coenzyme A and other compounds with sulfhydryl (-SH) group.
10. Carbonyl compounds (aldehydes and ketones)-classification, isomerism. Chemical reactions of aldehydes and ketones – nucleophile addition reactions, addition-elimination reactions.
11. Carbonyl compounds (aldehydes and ketones). Reactivity of α-carbon atom-tautomerism, aldol condensation-examples in living systems. Cannizzaro reaction, oxidation of carbonyl compounds. Substitution reactions. Biologically active substances with carbonyl group-coenzyme Q, K vitamins, camphorquinone, glycerolaldehyde, 11-cis retinal. Ketone bodies.
12. Carboxylic acids-classification. Chemical reactions 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. Esters of acrylic and methacrylic acids - application in dental practice (dental composites).
14. Hydroxycarboxilic acids and ketocarboxylic acids – overview. Comparison of their chemical properties. 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. Ketone bodies.
15. Amines-classification, structure and chemical reactions. Sulfonamides. Biogenic amines GABA, histamine, serotonin, catecholamines: dopamine, noradrenaline, adrenaline.
16. α–Amino acids – classification, isomerism. Zwitterion, isoelectric pH. Chemical reactions of α-amino acids. Chemical aspects of amino acid metabolism – deamination of α-amino acids; ketogenic and glucogenic amino acids. Peptides and proteins – classification, structures, properties. Peptide hormones – examples and functions.
17. 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.
18. Carbohydrates-classification. Monosaccharides-classification (aldoses and ketoses-examples), structure, steroisomerism and chemical reactions. Cyclic forms of monosaccharides. Disaccharides-examples, glycosidic bond, hydrolysis. Polysaccharides – examples, glycosidic bonds, hydrolysis, aminomonosaccharides in polysaccharides. Glycolysis – basic concept.
19. Classification of lipids. Triacylglycerols (fats and oils). Chemical aspects of biological oxidation of fats and oils. Glycerophospholipids-biological significance, biological membranes.
20. Classification of lipids. Sphingolipids, terpenes and steroids. Examples of biologically significancant compounds: β-carotene, retinol (vitamin A). Retinal – visual perception in humans, vitamins K and E. Cholesterol and D group vitamins, corticosteroids and sex hormones.
21. Heterocyclic compounds-classification. Five-membered heterocyclic compounds with one hetero atom– furan, thiophene, and pyrrole - structures. Biologically active substances containing pyrrole ring-hemoglobin, cytochrome c, vitamin B12, proline, medicines.
22. Five-membered heterocyclic compounds with two hetero atoms - pyrazole, imidazole and thiazole - structures. Biologically active derivatives of the above mentioned compounds – amino acids, medicines, vitamins.
23. Six-membered heterocyclic compounds with one hetero atom (pyridine, pyran, thiopyran): structure. Biologically active substances containing pyidine ring NAD^+, vitamin B6, niacin, medicines, and alkaloids; vitamin E.
24. Pyrimidine, piridazine, pirazine-structure. Biologically active substances with pyrimidine ring – pyrimidine bases, nucleotides, vitamins and medicines.
25. 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).