

## Faculty of Medicine

### Course: MEDICAL CHEMISTRY AND BIOCHEMISTRY I

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**Department:** Chemistry and Biochemistry

**Study programme:** Integrated Undergraduate and Graduate University Study of Medicine in English

**Year:** first

## SYLLABUS

**Course information (basic description, general information, teaching overview, required equipment and preparation, etc.)**

**Workload:** 35 L + 40 S + 30 P

**Course objectives:**

Acquiring the knowledge of chemical compounds - both inorganic and organic - that constitute living cells or are used in their synthesis, of chemical processes that arise during their transformations, of electrochemical processes, chemical kinetics and thermochemistry. Acquiring the capability to apply that knowledge on biological systems, which is important for understanding the human metabolism, both in physiological and pathological conditions.

**Development of general and specific competences (knowledge and skills):**

Developing awareness of the similarity and inseparability of chemical reactions within living and non-living matter, the relationship between structure and reactivity, chemical and energetic transitions, the laws of thermodynamics. Developing skills to use acquired knowledge for understanding the biochemical reactions in human organisms. Expanding the knowledge on relations between the structure and physical/chemical properties of matter based on simple molecules and applying it to biomolecules. Solving numerical and logical problems from the field of Medical Chemistry and Biochemistry. Developing skills necessary for experimental work, mastering the basic laboratory techniques and methods (chromatography, optical methods, pH-measurement). Encouraging students to apply information technology and use scientific literature. Building a sense of teamwork and developing their ability of creative and critical thinking needed for drawing conclusions based on data obtained through analysis. Developing methods and skills necessary for the presentation of obtained results.

**Course correlativity and correspondence:**

The content of the course Medical Chemistry and Biochemistry I correlates with and is complementary to the following courses: Medical Physics and Biophysics, Biochemistry II.

**Approaches to teaching and learning:**

Lectures, seminars, numerical and laboratory practicals.

**Assigned reading:**

Rupčić, J., Domitrović, R., Milin, Č., Tota, M. i Broznić, D.: Handbook for seminars and practicals in Medical Chemistry and Biochemistry I (translation from Croatian, group of authors), Univesity of Rijeka, Faculty of Medicine, Rijeka, 2017;  
R.H. Petrucci, F.G. Herring, J.D. Madura, C. Bissonette: General Chemistry - Principles and Modern Applications, 10th edition, Pearson Canada Inc., Toronto, Ontario, 2011;  
McMurry, J.: Fundamentals of Organic Chemistry, 8th Edition, Cengage Learning, 2017;  
Murray R.K., Bender D.A., Botham K.M., Kennelly P.J., Rodwell V.W., and Weil P.A. (Eds): Harper's Illustrated Biochemistry, 30th Edition, The McGraw-Hill Companies, 2015.

**Optional / additional reading:**

Reed, D.: Chemistry for Biologists, Pearson Education Ltd., Harlow, UK, 2013;  
McMurry, J., Ballantine, D.S., Hoeger, C.A. and Peterson, V.E.: Fundamentals of General, Organic and Biological Chemistry, 7th Edition, Pearson Education Inc., USA, 2013.  
Mahaffy, P., Tasker, R., Bucat, B., Kotz, J.C., Weaver, G.C. and Treichel, P.M.: Chemistry – Human activity, Chemical Reactivity, Nelson Education, USA, 2015.

**Course teaching plan:****The list of lectures (with the titles and learning outcomes):**

- L 1 The Meaning of Chemistry and Biochemistry in the Study of Medicine.
- L 2 Water and Solutions.
- Provide the basic facts about the quantity, distribution and the role of water in the body.
  - Explain the structure and properties of water.
  - Explain the dissolution of gasses and solid compounds in water.
- L 3 Solutions of Electrolytes.
- Distinguish electrolytes and nonelectrolytes.
  - Explain the properties of solutions of acids, bases, ampholytes and salts.
  - Explain the action of buffers in general.
- L 4 Complex Compounds. Complex Salts. Chelates. Biological Chelates. Application of Chelators in Medicine.
- Relate the structure and properties of apatite minerals (hydroxyapatite, fluorapatite).
  - Describe the role of chelation in biological systems.
  - Explain the effect of chelators and their use in medicine.
  - Explain the principles of the complexometric method.
- L 5 Colligative Properties.
- Define the principle of colligative properties.
  - Explain vapour-pressure lowering, freezing point depression and boiling point elevation.
- L 6 Colligative Properties. Colloids.
- Define osmotic pressure. Explain osmosis and dialysis.
  - Explain colloids.
  - Name and describe the types and properties of colloids.
  - Explain the difference between the sol and gel state of colloids.
  - Describe electrophoresis.
  - Explain the principle of Donnan equilibrium.
- L 7 Chemical Kinetics. Rate, Order and Molecularity of Reaction.
- Define the basic principles of chemical reaction kinetics.
- L 8 Factors Affecting the Rate of Reaction. Catalysis.
- Explain how various factors affect the rate of reaction.
  - Describe the mechanism of action of catalysts.
  - Explain the difference between chemical and biochemical catalysts.

#### L 9 Chemical Equilibrium

- Describe the law of mass action and the equilibrium constant.
- Define Le Chatelier's principle.
- Explain the impact of external factors on equilibrium.

#### L 10 Chemical Equilibrium.

- Define the equilibrium of homogeneous and heterogeneous systems and electrolyte solutions.
- Define Ostwald's dilution law. Define the solubility product.
- Describe calcified tissues and the formation of concrements.
- Distinguish dynamic equilibrium and consistent flow and its importance in biological systems.

#### L11 Equilibrium of Chemical Reactions. Hydrolysis. Buffers.

- Explain hydrolysis.
- Explain the mechanism of buffer action.

#### L12 Thermodynamics. The First Law of Thermodynamics. Thermodynamic Quantities, State Functions of Thermodynamic Systems. Extensive and Intensive Properties.

- Define the basic concepts of thermodynamics and basic thermodynamic quantities.
- Apply the first law of thermodynamics to biochemical systems.

#### L13 The Second Law of Thermodynamics. Free (Gibbs) Energy and the Direction of Chemical Reactions. Heat Capacity and Temperature.

- Explain the effect of  $\Delta G$ ,  $\Delta H$ ,  $\Delta S$  values on the spontaneity of reaction.
- Relate Gibbs' energy with the equilibrium constant.

#### L14 Electrochemical Reactions. Galvanic Cells. Standard Redox Potential.

- Define oxidation and reduction and reducing and oxidizing agents.
- Explain the structure of the galvanic cell.
- Explain the meaning of standard reduction potential.

#### L15 Electromotive Force. The Nernst Equation. Biological Redox Systems.

- Write down and explain the Nernst equation.
- Name biologically significant oxidation - reduction systems.
- Define the standard redox potential of biological systems.
- Explain Gibbs' energy of redox-systems.

#### L16 Structure of Organic Compounds. Types of Reactions in Chemistry of Organic Compounds.

- Classify organic compounds according to functional groups and explain their chemical properties.
- Define the types of reactions of organic compounds.
- Explain the concept of nucleophile and electrophile.

#### L17 Structure of Organic Compounds. Hybridization, Resonance, Inductive Effect.

- Explain hybridization, resonance and inductive effect.

#### L18 Isomerism

- Define isomerism. Explain the types of isomerism (structural, positional, stereoisomerism, geometrical isomerism and conformational isomerism).

#### L19 Stereoisomerism: Optical Isomerism.

- Define the chiral molecules.
- Explain D,L-steric order and R,S-system.

#### L20 Biologically Important Oxygen Compounds: Alcohols, Phenols and Ethers.

- Explain the chemical properties of these classes of compounds and their reactivity.
- Explain the reactions of oxygen compounds.

#### L21 Biologically Important Oxygen Compounds: Aldehydes and Ketones.

- Explain the significance of this group of compounds, their chemical properties and their reactivity.

#### L22 Biologically Important Oxygen Compounds: Aldehydes and Ketones.

- Define tautomerism.
- Explain aldol condensation.

#### L23 Carbohydrates

- Explain their structure and chemical properties.

#### L24 Carbohydrates

- Name and explain the structure of biologically most important monosaccharides, disaccharides and polysaccharides.

#### L25 Carboxylic Acids and their Derivatives.

- Explain the chemical properties of this class of compounds and their reactivity.
- Thioesters and acetyl-CoA
- Name biologically important mono- and polycarboxylic acids.

#### L26 Substituted Carboxylic Acids.

- Name the biologically significant representatives.
- Explain the structure and preparation of organic derivatives of carbonic acid.

#### L27 Lipids: Properties and Classification. Structure and Function of Simple Lipids.

- Define lipids and explain their classification.
- Explain the structure and function of simple lipids.

#### L28 Structure and Function of Complex Lipids.

- Explain the structure and function of phospholipids and sphingolipids.

#### L29 Structure and Function of Glycolipids. Isoprenoid Compounds.

- Define and explain the classification and structure of glycolipids.
- Explain the structure and function of steroids and carotenoids.

#### L30 Biologically Important Nitrogen and Sulphur Compounds: Amines, Thiols.

- Explain the chemical properties of this class of compounds and their reactivity.
- Name biologically significant representatives.

#### L31 Heterocyclic Nitrogen, Oxygen and Sulphur Compounds.

- Define heterocyclic compounds.
- Name biologically significant representatives.

#### L32 Proteinogenic Amino Acids: Structure, Properties and Reactions. Classification. Peptides: The Principle of Formation. Natural Peptides.

- Classify proteinogenic amino acids.
- Distinguish essential and nonessential amino acids and glucogenic and ketogenic amino acids.
- Explain the principle of peptide formation.
- Name the most important natural peptides and explain their role.

#### L33 Role and Structure of Proteins. Relation Between Protein Structure and Function. Primary Structure.

- Describe the structural levels in the architecture of proteins.
- Define the primary structure

#### L34 Conformation of Peptide Chain and Secondary Structure of Proteins. Tertiary Structure. Myoglobin.

- Define the secondary and tertiary structure of proteins.
- Explain the structure of myoglobin.

#### L35 Quaternary Protein Structure. Haemoglobin. Mechanism of Oxygen Binding. Allosteric Effect. Cooperative Binding. The Bohr Effect.

- Define the quaternary protein structure.
- Explain the allosteric properties of haemoglobin.
- Explain Bohr effect.

#### The list of seminars with descriptions:

##### S1 Elements and Compounds. Chemical Bonding

- Explain the structure of atoms, the periodic system and properties of elements that change periodically
- List the biogenic elements and define their biological role.
- Explain the structure and define the properties of compounds.

##### S2 Chemical Bonds and Intermolecular Forces

- Explain and identify chemical bonds and intermolecular forces.

### S3 Acids and Bases

- Define acids and bases according to Arrhenius, Brønsted and Lewis.

### S4 Salts. Buffers

- Define simple salts. Explain the hydrolysis of salts. Define amphoteric substances.
- Define buffers and explain the mechanism of buffer action.

### S5,6 Solutions. Solution Concentration.

- Define the concept of mole and the concentration of solutions (fractions, molar and mass concentration, molality).
- Solve the exercises with concentrations.
- Define saline solution (physiological solution).

### S7 Colligative properties (lowering of vapour pressure, elevation of boiling point, depression of freezing point and osmotic pressure)

- Define colligative properties.
- Solve exercises relating colligative properties.

### S8,9 Equilibrium in the solutions of weak electrolytes. Dissociation constants of acids and bases. The ionic product of water. Numeric exercises

- Define and write down the dissociation constants of acids and bases.
- Explain the ionisation of water and define the ionic product of water. Define pH.
- Define the pH of body fluids.
- Solve exercises using pH, the ionic product of water and dissociation constants.

### S10 Reactions of Organic Compounds

- Name and classify organic compounds.
- Describe the characteristic reactions of hydrocarbons and aromatic compounds.

### S11 Hydrocarbons

- Write down the characteristic reactions of hydrocarbons and aromatic compounds.

### S12 Alcohols, Ethers and Phenols

- Explain the chemical properties and reactivity of these groups of compounds.
- List biologically important representatives.

### S13 Thiols and Amines

- Explain the chemical properties and reactivity of these groups of compounds.
- List biologically important representatives.

### S14 Aldehydes and Ketones

- Explain the chemical properties and reactivity of these groups of compounds.

### S15 Monosaccharides and Disaccharides

- List biologically important representatives.
- Explain the formation of cyclic form.
- Explain the reactivity of monosaccharides and specify their stereoisomers.

### S16 Carboxylic Acids and their Derivatives

- Explain the chemical properties and reactivity of these compounds.

### S17 Substituted Carboxylic Acids

- Name and define substituted carboxylic acids (halogen-, oxo-, hydroxy-, amino acids).
- Explain their chemical properties.

### S18 Lipids. Fatty Acids.

- Explain the physical properties of lipids.
- Define fatty acids and name important biological representatives.
- Explain the chemical properties of fatty acids.

### S19 Amino Acids

- Define chemical properties and general reactions.
- Classify amino acids.
- Define and calculate the isoelectric point of amino acids.

### S20 Peptides

- Explain the principles of synthesis and determination of sequence.
- List the physiologically active peptides.
- List the methods of protein chemistry.

**The list of numerical practicals (NP) and laboratory practicals (LP) with short explanations:**

LP1 General Laboratory Safety Procedures and Rules. Introduction to Qualitative Analysis – Identification of Cations and Anions. Qualitative Inorganic Analysis: Testing Salt Solutions for Anions and Cations.

- Basic chemistry lab equipment and techniques.
- Detection and identification of different cations and anions in a solution.
- Detection and identification of cations and anions in salt solutions.

LP2 Quantitative Chemical Analysis.

- Name the main types of quantitative chemical analysis.
- Describe and exemplify the volumetric methods.  
Volumetric analysis.
- Employ the alkalimetric, manganometric and complexometric methods.

NP1 Chemical Kinetics

- Define the rate of reaction and reaction order.
- Describe the influence of temperature, concentration, pH and catalyst on the rate of reaction.
- Calculate the reaction rate and order.

LP3 Chemical Kinetics.

- Investigate experimentally the influence of temperature, concentration, pH and catalyst on rate of reaction.

NP2 pH and Buffer Solutions.

- Describe the mechanism of buffer action in body fluids.
- Calculate the pH value of solutions.
- Calculate the pH value of buffer solutions.

NP3 Redox Reactions.

- Define the oxidant and reductant in redox reactions.
- Balance the redox reactions.

LP4 Buffer Solutions.

- Prepare the phosphate buffer solution.
- Measure the pH and buffer capacity.

LP5 Qualitative Organic Analysis

- Detect and identify functional groups.
- Detect and identify amides and purines in solution.

LP6 Optical Methods

Spectrophotometry.

- Determine the wavelength of maximum absorbance.
- Determine the influence of a concentration on absorbance.
- Determine the concentration of  $\text{CuSO}_4$  in a solution using a spectrophotometer.

Polarimetry

- Determine the specific rotation angle of sugar.
- Make a calibration graph using sugar solutions with different concentrations.
- Determine the mass concentration of sugar in a sample by measuring the angle of rotation.

LP7 Qualitative Analysis of Proteins and Amino Acids. Detection and Identification of Different Amino Acids in Various Sample Solutions. Quantitative Determination of Serum Proteins. Isoelectric Point. Thin Layer Chromatography (TLC) of Amino Acids.

- Determine the isoelectric point of a given protein solution.
- Perform a TLC for a given amino acids mixture.
- Quantitatively determine the concentration of serum proteins using the Biuret method.

## Students' obligations:

### Students' obligations:

Class attendance including test attendance is mandatory. Students may be absent from 30% of each form of teaching provided they have a justifiable cause. Absence from laboratory practicals is compensated by an oral colloquy.

### Assessment of students' work:

Students can obtain a total of 100 credits (a maximum of 70 credits during the course of the semester and a maximum of 30 credits on the final exam). Students are allowed to take the final exam if they gain a minimum of 40 credits during the semester (**mandatory 40% of correct answers on each midterm exam**).

Students who did not obtain 40% on each midterm may retake the midterms, which will be held during the final exam period. Students who are not satisfied with the obtained credits are also allowed to retake their midterm exams, but thereafter only the credits gained from the retaken midterms will be considered.

On the final exam, the student must obtain at least 50% on the written part of the exam and meet the requirements of the oral part of the exam.

The student who gains between 30 – 39.99 credits during the semester is placed in the FX grade category.

## Exam (exam taking, detailed exam description of the oral/written/practical part, point distribution, grading criteria):

Evaluation of students' progress during classes, midterms and the final exam is shown in Table 1.

Table 1

		<b>CREDITS</b>
<b>Midterm exams</b>	I	17 (x score)
	II	11 (x score)
	III	28 (x score)
	<b>Total</b>	<b>56</b>
<b>Laboratory practicals</b>	Accepted practicals and reports	<b>14</b>
<b>TOTAL</b>		<b>70</b>
<b>Final exam</b>	Written exam	15 (x score)
	Oral exam	15
	<b>Total</b>	<b>30</b>
<b>TOTAL</b>		<b>100</b>

### Midterm exams:

Three midterm exams will be held during the semester. The first one covers the content of bioinorganic, general and physical chemistry, the second one covers stoichiometry and the third one covers organic chemistry and biochemistry (theory, nomenclature and structural formulas).

### Laboratory practicals:

Students can gain 14 credits throughout 7 laboratory practicals. Each completed practical and report is worth two credits.

### Final exam:

The final exam comprises a written exam (15 credits) and an oral exam (15 credits). Students are required to pass both parts of the final exam.

### Assessment of the oral part of the final exam:

1 – 4 credits: minimum criteria satisfied

5 – 8 credits: average criteria satisfied with noticeable errors

9 – 12 credits: answer with a few errors

13 – 15 credits: outstanding answer

**The ECTS grading system is defined by the following criteria:**

- A (5) – 80-100 credits
- B (4) – 70-79.99 credits
- C (3) – 60-69.99 credits
- D (2) – 50-59.99 credits
- E (2) – 40-49.99 credits

**Final exam FX grade category:**

The final exam of those students in the FX grade category comprises the entire course content. A student who meets the criteria of the written exam (50% of correct answers) can attend the oral exam. If the student passes the oral exam he is awarded 10 credits and graded with **E**.

**Other important information regarding the course:**

**Retaking the course:**

A student who gains less than 30 credits during the pre-exam part of the course has failed the course. He is graded with **F** and must retake the course.



## COURSE SCHEDULE (for academic year 2017/2018)

Date	Lectures	Seminars	Laboratory Practicals	Lecturer
			<b>Praktikum at the Department</b>	
04/10/2017	L 1-3 (08:00 -11:00)			Assoc. Prof. Branka Blagović
06/10/2017		S 1 (13:00-15:00)		Assist. Prof. Mima Petković Didović
11/10/2017	L 4,5 (09:00 -11:00)			Assoc. Prof. Branka Blagović
12/10/2017			LP 1 (12:00-16:00) LP 1 (16:00-20:00)	Assist. Iva Vukelić
13/10/2017		S 2 (13:00-15:00)		Assist. Prof. Mima Petković Didović
18/10/2017	L 6,7 (09:00 -11:00)			Assoc. Prof. Branka Blagović
19/10/2017		S 3 (13:00-15:00)		Assist. Prof. Mima Petković Didović
20/10/2017		S 4 (13:00-15:00)		Assist. Prof. Lara Batičić Pučar
25/10/2017	L 8,9 (09:00 -11:00)			Assoc. Prof. Branka Blagović
26/10/2017			LP 2 (12:00-16:00) LP 2 (16:00-20:00)	Assist. Iva Potočnjak
27/10/2017	L 10,11 (13:00-15:00)			Assoc. Prof. Branka Blagović Assoc. Prof. Marin Tota
02/11/2017		S 5,6 (13:00-16:00)		Assist. Prof. Mima Petković Didović
03/11/2017		S 6 (13:00-14:00) NP 1 (14:00-16:00)		Assist. Prof. Mima Petković Didović Assist. Prof. Damir Klepac
08/11/2017	L12,13 (09:00 -11:00)			Assist. Prof. Mima Petković Didović
9/11/2017			LP 3 (12:00-14:00)	Assist. Iva Vukelić
		NP 2 (14:00-16:00)		Assist. Prof. Lara Batičić Pučar
			LP 3 (16:00-18:00)	Assist. Iva Vukelić
10/11/2017		NP 3 (14:00-16:00)		Assist. Prof. Damir Klepac
15/11/2017	L14,15 (09:00-11:00)			Assoc. Prof. Branka Blagović
16/11/2017			LP 4 (15:00-17:00) LP 4 (17:00-19:00)	Assist. Iva Potočnjak
17/11/2017		S 7 (13:00-15:00)		Assist. Prof. Damir Klepac
22/11/2017	L16-18 (10:00-13:00)			Assist. Prof. Lara Batičić Pučar Assist. Prof. Gordana Čanadi Jurešić
23/11/2017		S8 (14:00-16:00)		Assist. Prof. Damir Klepac
24/11/2017		S9 (14:00-16:00)		Assist. Prof. Damir Klepac
29/11/2017	L 19-21 (10:00-13:00)			Assist. Prof. Gordana Čanadi Jurešić Assoc. Prof. Marin Tota

30/11/2017		S 10 (14:00-16:00)		Assist. Prof. Lara Batičić Pučar
01/12/2017		S 11 (14:00-16:00)		Assist. Prof. Lara Batičić Pučar
06/12/2017	L 22,23 (10:00-12:00)			Assist. Prof. Gordana Čanadi Jurešić
07/12/2017			LP 5 (12:00-16:00) LP 5 (16:00-20:00)	Assist. Sunčica Buljević
08/12/2017		S 12 (14:00-16:00)		Assist. Prof. Damir Klepac
12/12/2017	L 24 (10:00-11:00)			Assist. Prof. Gordana Čanadi Jurešić
13/12/2017	L 25,26 (10:00-12:00)			Assist. Prof. Lara Batičić Pučar
14/12/2017		S 13 (14:00-16:00)		Assist. Prof. Damir Klepac
15/12/2017		S 14 (14:00-16:00)		Assist. Prof. Damir Klepac
20/12/2017	L 27,28 (10:00-12:00)			Assoc. Prof. Branka Blagović
21/12/2017			LP 6 (12:00-16:00) LP 6 (16:00-20:00)	Assist. Prof. Mima Petković Didović
22/12/2017		S 15 (14:00-16:00)		Assist. Prof. Gordana Čanadi Jurešić
10/01/2018	L 29,30 (10:00-12:00)			Assoc. Prof. Branka Blagović Assoc. Prof. Marin Tota
11/01/2018		S 16 (14:00-16:00)		Assist. Prof. Lara Batičić Pučar
12/01/2018		S 17 (14:00-16:00)		Assist. Prof. Lara Batičić Pučar
17/01/2018	L 31,32 (10:00-12:00)			Assoc. Prof. Marin Tota Prof. Jadranka Varljen
18/01/2018			LP 7 (12:00-16:00) LP 7 (16:00-20:00)	Assist. Sunčica Buljević
19/01/2018		S 18 (14:00-16:00)		Assist. Prof. Gordana Čanadi Jurešić
23/01/2018	L 33 (12:00-13:00)			Prof. Jadranka Varljen
24/01/2018	L 34,35 (10:00-12:00)			Prof. Jadranka Varljen
25/01/2018		S 19 (14:00-16:00)		Assist. Prof. Dijana Detel
26/01/2018		S 20 (14:00-16:00)		Assist. Prof. Jelena Marinić