MEDICAL CHEMISTRY

Institute of Biochemistry and Molecular Biology
Department of Molecular Biology
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Course coordinator: Gergely Keszler MD, PhD (keszler.gergely@med.semmelweis-univ.hu)
Credit: 6
Number of lessons per week: lectures: 3; practicals: 3
Subject code: **AOKMBT829_1A**

The principal aim of the course is to prepare students for the understanding of the subjects of Biochemistry, Molecular cell biology, Physiology and Pharmacology. This requires a firm knowledge of the foundations of general, organic and inorganic chemistry.

Lectures:

General chemistry

1. Atomic structure; the periodic table of elements
2. Chemical bonds, hybrid states
3. Secondary bonds and interactions
4. Chemical equilibria
5. Acid-base theories, pH
6. pH of strong or weak acids and bases
7. The theory of buffers
8. Buffers of physiological importance, cation and anion hydrolysis, pH of salt solutions
9. Solubility of salts and bases, the solubility product
10. Laws of dilute solutions. Specific and equivalent conductivity
11. Thermodynamics 1 – Enthalpy
12. Thermodynamics 2 – Entropy
13. Thermodynamics 3 – Direction of reactions
14. Electrochemistry 1
15. Electrochemistry 2
16. Electrochemistry 3
17. Reaction kinetics
18. Complex compounds, reactive oxygen species

Organic chemistry

19. Principles of organic chemistry
20. Nomenclature of organic compounds, constitution of organic compounds
21. Configuration and conformation of organic compounds
22. Saturated and unsaturated hydrocarbons
23. Reactions of alkyl halides and aromatic compounds
24. Classification and reactions of hydroxyl compounds
25. Classification and reactions of oxo compounds
26. Structure, function and reactions of organic acids
27. Nitrogen-containing organic compounds
28. Sulphur or phosphorus-containing organic compounds

Practicals:

1. Introduction, acid-base titration 1 (titration of strong acids) ***(4×45 min)***

2. Concentration, pH, problems ***(2×45 min)***

3. Acid-base titration 2 (titration of weak acids). Relationship between conductivity and dissociation ***(4×45 min)***

4. Salts ***(2×45 min)***

5. Titration curves, consultation (buffers) ***(4×45 min)***

6. Physiological buffer systems ***(2×45 min)***

7. Electrochemistry, consultation ***(4×45 min)***

8. Thermochemistry, thermodynamics ***(2×45 min)***

9. Permanganometry ***(4×45 min)***

10. Electrochemistry ***(2×45 min)***

11. Determination of the ionization constant of phenol red by photometry ***(4×45 min)***

12. Structure of organic compounds ***(2×45 min)***

13. Complexometry. Precipitation titration ***(4×45 min)***

14. Isomers, molecule models ***(2×45 min)***

Lectures and practical lessons
Two lectures are held every week; practical lab lessons (duration: 4x45 min) and seminars (2x45 min) are held in alternating weeks. For detailed schedules see the Moodle website of the subject.

Prerequisites for acknowledging the semester
Attendance of at least 75% of the practical lessons is obligatory. Students not attending (i) more than 2 labs or (ii) more than 5 seminars or (iii) more than 1 lab and 3 seminars are not going to be allowed to sit for the semifinal exam. Missed practicals and seminars can only be made up in the same week with another group; certificate of participation issued by the host teacher needs to be presented by the student to his/her own teacher.

Midterm examination

An optional written midterm test (30 min) is held in week 13 about the laboratory experiments performed during the semester. Performance at the laboratory work during the whole semester is also taken into account at the evaluation.

Examination and grading system
The oral and written exam is based on the topic list announced in the beginning of the semester, and it takes place before a two-member committee (examiner and co-examiner). The exam can be passed if all these topics are sufficiently answered. Students pick 3 questions (general chemistry, organic chemistry, practice) and a calculation problem to be solved in writing. Students, who achieve at least 12 points at the practical midterm and at the labs during the semester, get exempted from picking the practical question. The bonus is valid during the whole exam period (in case of an unsuccessful exam).

Exemption from attending the course
Students who learned general, and organic chemistry at university levels prior to the commencement

of their studies at Semmelweis University might be exempted from attending the Medical Chemistry course. Students are kindly asked to present their official documents (academical transcripts and a detailed syllabus on the courses they have completed) to the tutor (Gergely Keszler).

Topic list

I. General chemistry

1. The periodic table of the elements, quantum numbers
2. The covalent bond, the molecular geometry of inorganic molecules (e.g. carbon monoxide, carbon dioxide, ammonia). Ionization energy, electron affinity, electronegativity. The ionic bond, hydroxylapatite and fluoroapatite
3. The structures of polyatomic ions, the complexes
4. The secondary bonds and intearctions between molecules
5. Laws of dilute solutions: vapor pressure, freezing point depression, boiling point elevation
6. The phenomenon of osmosis, its biological significance, isotonic, hypotonic and hypertonic solutions
7. Chemical equilibria, the equilibrium constant and the degree of dissociation, their correlation. The Le Châtelier principle (example: formation, properties, salts, practical use of hypochlorous acid.)
8. Gas mixtures: partial pressure, volume %. The composition of the air. Dissolution of gases in liquids, Henry's law, the decompression sickness
9. The structure and dissociation of water. Acid-base theories. The pH and pOH concept, calculation of the pH of strong acids or bases, and their titration curves. Acid-base indicators
10. The dissociation of weak acids and bases, the concept of specific and equivalent conductivity, their correlations with the dissociation. Titration curves of weak acids
11. Types of salts and their reactions with water. pH of salt solutions
12. The buffers: principle, mechanism of action, calculation of the pH. The titration curves of polyprotic acids (phosphoric acid)
13. Buffers of physiological importance
14. The solution equilibria of solid substances, the solubility product
15. The first law of thermodynamics. Heat of reaction, combustion heat, heat of formation. Hess' law
16. The second law of thermodynamics. The direction of the chemical reactions, Gibbs free energy
17. Oxidation, reduction, oxidation number, standard reduction potential
18. The galvanic cells: arrangement, reactions, calculation of the electromotive force
19. Types of electrodes, redox systems of biological importance
20. The concentration cells, the principle of measuring the pH
21. Reaction rate, order and molecularity, factors influencing the reaction rate

II. Organic chemistry

22. The electronic structure of the carbon atom, its hybrid states, the spatial structures of organic compounds
23. The concept of isomerism, types of structural isomerism, nomenclature of organic compounds
24. Geometric isomerism in unsaturated and cyclic compounds
25. Stereoisomerism, chiral compounds, optical activity, D–L and R–S nomenclature
26. Conformations of organic compounds, examples with open chain and cyclic molecules
27. Reaction types and mechanism in organic chemistry
28. Properties and reactions of alkanes
29. Properties and reactions of alkenes
30. Characteristics, reactions and biological roles of aromatic compounds
31. Alcohols, enols, phenols
32. Oxo compounds: aldehydes and ketones. Their chemical reactions, the mechanism of the nucleophilic addition. Oxo-enol tautomerism
33. Properties and reactions of compounds containing a carboxyl group
34. Substituted carboxylic acids (Halogenated, oxo-, hydroxy-; aromatic; mono-, di- and tricarboxylic acids)

35. Organic compounds containing sulfur or phosphorus
36. Nitrogen-containing organic compounds: classification and properties of amines
37. Carboamides, amides of the carbonic acid, imines

III. Laboratory

38. Principle of concentration determination by volume measurement: titrations
39. Titration of strong acids and bases
40. Titration of weak acids and bases
41. Conductivity measurement, determination of weak acid dissociation
42. Titration of gastric juice
43. Titration curves of mono- and polyprotic acids
44. Titration based on redox reaction: permanganometry
45. Complexometry: determination of copper concentration
46. Electrochemical measurements: the Daniell cell, concentration cell, redox and non-polarizable electrodes
47. Principle of spectrophotometry, areas of application: determination of the K_d value of the phenol red indicator
48. Precipitation titration