

2023/2024. ACADEMIC YEAR	
PROGRAM OF STUDY	
Full (Hungarian) name of the subject: Analitikai kémia II.	
Program: Undivided program (pharmaceutical)	
Schedule: full time	
Short name of the subject: Anal. Chem. II.	
English name of the subject: Analytical Chemistry II.	
German name of the subject: Analytische Chemie II.	
Type of registration: <u>obligatory</u> /obligatory elective/elective/criteria requirement	
Neptun code of the subject:	
Responsible Department: Department of Pharmaceutical Chemistry	
Responsible tutor Prof. Dr. Balogh György Tibor Contact information: Department of Pharmaceutical Chemistry, Semmelweis University address: H-1092 Budapest, Hőgyes Endre u. 9. phone: +36-1-217-0891 e-mail: balogh.gyorgy.tibor@semmelweis.hu Csörgeiné Dr. Kurin Krisztina Contact information: Department of Analytical Chemistry, Eötvös University address: H- 1117 Budapest, Pázmány P. sét. 1/a phone: +36-1-372-2500/1241 e-mail: krisztina.kurin@ttk.elte.hu	Title, academic degree: director, professor, DSc associate professor, Ph.D, Dr. Habil.
Name of the persons responsible for the teaching of the subject: Krisztina Kurin-Csörgei Viktor Mihucz István Molnár Gergő Tóth Anikó Vasanits Lúcia Torma	Title, academic degree: associate professor, Ph.D, Dr. Habil head of department, associate professor, DsC research assistant, PhD assistant professor, Ph.D, assistant professor, PhD Ph.D. student
Classes per week: 4 lecture(s) 4 practice(s)	Credit point(s): 4+4
Professional content, intent of acquirement and it's function in order to implement the goals of the program: Analytical Chemistry is an essential field of science that develops and implements various strategies, methodologies, and instrumentation to derive insightful information about the composition and structure of matter in space and time. This course emphasizes the integration of theoretical knowledge with practical applications in analytical chemistry, fostering an analytical mindset in both qualitative and quantitative substance analysis. Students will be engaged in cultivating their logical thinking abilities, enabling them to apply their theoretical knowledge and practical skills cohesively to the qualitative and quantitative examination of inorganic (and organic) materials. The course will not only strengthen their foundation in analytical chemistry methods but also expand their horizon by infusing analytical thinking and problem-solving skills into their scientific journey.	

Short description of the subject:

The principal objective of Analytical Chemistry is to glean both qualitative and quantitative insights into the chemical composition and structural framework of various materials. The course explores the classification and characterization of chemical reactions employed in qualitative analysis, as well as methodologies based on various chemical and basic instrumental (spectroscopy, chromatography, electroanalytical), employed in quantitative chemical analysis.

Course data

Recommend ed term	Contact hours (lecture)	Contact hours (practice)	Contact hours (seminar)	Individu al lectures	Total number of contact hours/sem ester	Normal course offer	Consult ations
3 semester	56	56	-	-	112	<u>Autumn semester*</u> Spring semester Both semesters (* Please underline)	--

Program of semester**

Topics of theoretical classes (pro week):

- 1. week:** Introduction. Analytical Chemistry (Quantitative): definition, aim. Steps of chemical analysis. Chemical methods (continuation of the previous semester's material).
- 2. week:** Complex formation equilibria. Stepwise complex formation, stability constants. Effect of pH and auxiliary foreign ligands on the apparent (conditional) stability constant. Complex formation with monodentate and polydentate ligands. The chelate and entropy effect. Complexometric titrations with monodentate ligands. Chelatometry: titration curves. Calculation of $p[M^{n+}]$ at different points and regions of the curve.
- 3. week:** Chelatometric titrations: standard solutions and standardization. Methods for end point detection at direct and back titrations. Metal ion indicators. Types and applicability of EDTA titrations: direct, back, displacement and indirect titrations.
- 4. week:** Precipitation equilibria. The solubility product and the common ion effect. Effect of pH and complex formation on the solubility of precipitates (examples). Calculation of argentometric titration curves. Standard solutions and standardization. Possibilities of end point detection. The main methods of argentometric titrations. Gravimetry (brief summary). Electrogravimetry.
- 5. week:** Redox reactions, oxidizing and reducing agents (examples). The redox potential and its calculation. Classification of redox titrations. Requirements for redox reaction to be used. The effect of pH, complex- and precipitate formation and electrolyte concentration on redox potentials (examples). Redox titration curves. Calculation of the redox potential at different points and regions of the curve.
- 6. week:** Permanganometry: standard solution, mechanism of $KMnO_4$ reduction. Titration in acidic, neutral and basic solutions. Chromatometry and cerimetry: standard solutions, end point detection, applications. Reductometric titration methods. Bromatometry: methods, standard solutions, end point detection, determinations (examples for direct, back titrations).
- 7. week:** TEST I. Iodometric titrations: standard solutions, end point detection, pH-dependence of the titrations. Determination of reductants. Iodometry: direct and indirect determination of oxidants.
- 8. week:** Possibilities of instrumental end point detections (summary). Conductometry (principle and applications for the titration of strong and weak acids with different titrants). RETAKE TEST I.
- 9. week:** Potentiometry: potentiometric titrations and direct potentiometry (with examples). Amperometry (Dead stop titration) and coulometry
- 10. week:** Emission and absorption of electromagnetic radiation by atoms and molecules. Physical backgrounds of spectroscopy. Molecular absorption spectroscopy: theory and applications of UV-VIS spectrophotometry.
- 11. week:** Molecular emission spectroscopy: theory and applications of fluorescence analysis. Infrared and Raman spectroscopy. Atomic emission and absorption spectroscopy. Additional spectroscopic methods.
- 12. week:** Separation techniques (summary). Separations by chromatography. Types of sorption. Chromatogram. Classical column chromatography. Gas chromatography (GC). Paper and thin layer chromatography.
- 13. week:** High-performance liquid chromatography(HPLC): theory and application. Parts of the instrument. Ion chromatography (IC). Parts of the instrument. Separation of cations and anions (examples). Additional chromatographic methods. TEST II.
- 14. week:** Evaluation of the measurement results. Random error and its calculation. Reliability limits. Regular error. Quality assurance. Literature of analytical chemistry. Summary. RETAKE TEST II.; RE-RETAKE TEST I., II.

Topics of practical classes (pro week):	
1. week:	Laboratory bench and equipments inventories; Safety and order in the laboratory; The schedule of the semester; Practical and theoretical requirements in the semester; Chelatometry (introduction); Determination of bismuth ions.
2. week:	Chelatometric determination of calcium and magnesium ions in the presence of each other (in mineral water). Determination of aluminum ions in "Aluminium aceticum tartaricum solutum";
3. week:	Chelatometry: Determination of copper and zinc ions in the presence of each other. (1/2 group) Determination of mercury and zinc ions in the peresence of each other (1/2 group)
4. week:	Argentometry: Determination of bromide ions by Volhard's and Fayans' methods.
5. week:	Redox titrations; Permanganometry: Standardization of potassium permanganate standard solution; Determination of hydrogen peroxide content in tablet "Hyperol"; Determination of the total iron content by Zimmermann-Reinhardt method (1/2 group); Determination of bromide ions (Winkler' method).
6. week:	Chromatometry: Determination of Mohr salt; Cerimetry: Determination of amidazophene (Aminophenazonum). (Supplementary lab).
7. week:	Bromatometry: Determination of ascorbic acid (Vitamin C) in tablets (e.g. VitC, Rutascorbin, Béres C); Determination of azophene.
8. week:	Bromatometry/Iodometry: Determination of acetyl salicylic acid content in tablets (e.g. Aspirin, Kalmopyrin, Istopyrin) by Koppeschaar's method. Standardization of sodium-thiosulfate titrant; Iodometric determination of copper (II)-ions.
9. week:	Iodometry/Iodimetry: Determination of iodide by Winkler's method; Determination of mannitol by Malaprade's reaction with periodate.
10. week:	Potentiometric titration of acetic acid; Titration with automatic titrator, computer control: potentiometric measurement of Cl^- and I^- in the presence of each other; argentometric titration of bromide content of "Elixirium thymi composita"; Direct potentiometric determination of fluoride content. in tooth paste. (Supplementary lab).
11. week:	Conductometric determination of Betaine hydrochloride; Conductometric determination of acid contents in red wine; Water determination by Karl Fischer' titration.
12. week:	Spectrofluorencency: Determination of quinine in "Tonic"; Spectrophotometric determination of phosphate content in egg shell.
13. week:	HPLC measurement (theory, separation of medicine sample); Ion chromatographic measurement (theory and determination of anions in "Evian" water).
14. week:	Supplementary lab; Closing
Schedule of consultations: at the request of students (in the period prior to the tests; during the examination period, etc.)	
Course requirements	
Prerequisites: Analytical chemistry I., General and Inorganic Chemistry II.	

Conditions of attending the classes, amount of acceptable absents, way of presentation of leave, opportunity for makeup:

Students must be present at minimum of 75% of the total number of laboratory practices scheduled during the semester (i.e. a maximum of 3 absences is allowed). Timeliness is mandatory. Arriving more than 15 minutes late will be considered equivalent to absence from the laboratory practice.

All exercises and measurements listed in the schedule must be completed before the end of semester. A make up ("supplementary lab") to complete the measurements labs missed will be provided during the semester; and at the end of the semester for justified cases.

Number, topics and dates of tests during the semester, opportunities of makeup and improvement of results*:**

In order to assess the mastery of the course material, two (2) major test-papers are administered during the semester scheduled for weeks 7. and 13. Each test will include a different set of topics on the theoretical background of measurements covered at the lectures or performed at laboratory practices, as well as numerical problems. Opportunities to correct the marks of each major test will be provided (retake), as well as an additional retake at the end of semester (re-retake). If written, the marks of the retakes will be used to determine the final grade. Shorter oral or written quizzes at the time of the laboratory practices can occur throughout the entire semester. All written tests and oral answers will be evaluated according to a five-scale grading system. Minimum of 50% of the total score is required for earning a passing mark (2) on the tests. A non-programmable calculator is required to complete the numerical problems in tests, calculators cannot be shared between students. Mobile phones, smart watches, tablets, etc. may not be utilized during tests under any circumstances. Students caught using any kind of forbidden aid during oral or written tests will automatically earn an "unsatisfactory" signature at the end of semester.

Requirements of signature:

A satisfactory knowledge of the theoretical aspects of the analytical chemistry (including knowledge of the subject-matter of analytical chemistry covered at lectures and laboratory practices, writing/balancing equations, proven knowledge of stoichiometric and equilibrium calculations, familiarity with the principles of the measurements, etc).

The final grade (practical mark) of the laboratory training on analytical chemistry will be established by considering both the theoretical and practical requirements as set forth next.

The theoretical requirement for passing the semester is that both marks obtained on the major tests (or that of the retakes) must be at least passing (2).

Practical requirements: are fulfilled only if the number of absences did not exceed the permitted limit (see above) and all exercises or measurements must be performed as scheduled, and accepted with as satisfactory.

Requirement for allowing to take the final oral exam is to have the signature.

Number and type of projects students have to perform independently during the semester and their deadlines:

Each measurement is completed at satisfactory accuracy (at most $\pm 4\%$ error for quantitative determinations in most cases).

Unsuccessful measurements can be repeated twice during the "supplementary lab" time.

A written report must be prepared upon the completion of each laboratory exercise. The calculated results of the measurements must be presented for evaluation to the supervising teacher within a week after completion of the exercises. Failure to hand in lab reports on time will result in "unsatisfactory" mark for the corresponding measurement and therefore it must be repeated during the "supplementary lab" time.

<p>Type of the semester-end examination: <u>signature</u>*/practical grade*/semi-final*/<u>final</u>* (* Please underline)</p> <p>Examination requirements: as published by the education-research department on the MOODLE interface at the start of the academic term. The final examination consists of 3 parts (graded independently): 2 theoretical questions from the „topics of final examination” issued in advance, and <u>numerical problems</u>. The list topics can be downloaded from the Moodle E-learning interface. The numerical problems part include stoichiometric and equilibrium calculations (calculation of the result of analytical measurements, standardization, calculation of titration curves points of various kind etc.) as well as knowledge of principles of calculations related to the analytical measurements, balancing equation, etc. <u>In order to pass the exam a passing mark (2) must be achieved in all three parts of the exam</u> (two theoretical questions + problem solving).</p>
<p>Form of the semester-end examination: written*/<u>oral</u>*/combined examination* (* Please underline)</p>
<p>The possibility and conditions for offering grades: At the end of semester students have the opportunity to request the average of the two major tests (not those of the retakes) written during the semester as the grade for the problem solving part of the final exam.</p>
<p>Scientific, course related researches, publications, essays: Materials of the lectures and laboratory practices and additional notes (solved calculation problems, videos, etc.) <u>can be downloaded from Moodle E-learning interface</u>. According to the program of semester, the slides of the lectures, and materials required to complete the laboratory exercises, other documents, sample reports, etc. will be uploaded to the Moodle system no later than the week before a topic covered herein is discussed at the laboratory practices. Additional material for the theoretical lectures and laboratory exercises (list of textbooks, hand-outs, scripts, etc.): Buvári-Barcza: Quantitative Analytical Chemistry. Bp. (SE) Skoog, West, Holler: Fundamentals of Analytical Chemistry. Saunders College Publishing.</p>
<p>In the case of a subject lasting more than one semester, the position of the teaching/research department on the possibility of parallel enrolment and the conditions for admission****: yes*/<u>no</u>*/on and individual assessment basis* (* Please underline)</p>
<p>The course description was prepared by: György Tibor Balogh, Krisztina Kurin-Csörgei</p>