

**University of Debrecen  
Faculty of Science and Technology  
Institute of Chemistry**

**CHEMISTRYMSC PROGRAM**

**2020**

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## **DEAN'S WELCOME**

Welcome to the Faculty of Science and Technology!

This is an exciting time for you, and I encourage you to take advantage of all that the Faculty of Science and Technology UD offers you during your bachelor's or master's studies. I hope that your time here will be both academically productive and personally rewarding

Being a regional centre for research, development and innovation, our Faculty has always regarded training highly qualified professionals as a priority. Since the establishment of the Faculty in 1949, we have traditionally been teaching and working in all aspects of Science and have been preparing students for the challenges of teaching. Our internationally renowned research teams guarantee that all students gain a high quality of expertise and knowledge. Students can also take part in research and development work, guided by professors with vast international experience.

While proud of our traditions, we seek continuous improvement, keeping in tune with the challenges of the modern age. To meet our region's demand for professionals, we offer engineering courses with a strong scientific basis, thus expanding our training spectrum in the field of technology. Recently, we successfully re-introduced dual training programmes in our constantly evolving engineering courses.

We are committed to providing our students with valuable knowledge and professional work experience, so that they can enter the job market with competitive degrees. To ensure this, we maintain a close relationship with the most important companies in our extended region. The basis for our network of industrial relationships are in our off-site departments at various different companies, through which market participants - future employers - are also included in the development and training of our students.

Prof. dr. Ferenc Kun

Dean

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## UNIVERSITY OF DEBRECEN

**Date of foundation:** 1912 Hungarian Royal University of Sciences, 2000 University of Debrecen

**Legal predecessors:** Debrecen University of Agricultural Sciences; Debrecen Medical University; Warghalstván College of Education, Hajdúböszörmény; Kossuth Lajos University of Arts and Sciences

**Legal status of the University of Debrecen:** state university

**Founder of the University of Debrecen:** Hungarian State Parliament

**Supervisory body of the University of Debrecen:** Ministry of Education

**Number of Faculties at the University of Debrecen:** 14

Faculty of Agricultural and Food Sciences and Environmental Management

Faculty of Child and Special Needs Education

Faculty of Dentistry

Faculty of Economics and Business

Faculty of Engineering

Faculty of Health

Faculty of Humanities

Faculty of Informatics

Faculty of Law

Faculty of Medicine

Faculty of Music

Faculty of Pharmacy

Faculty of Public Health

Faculty of Science and Technology

**Number of students at the University of Debrecen:** 26938

**Full time teachers of the University of Debrecen:** 1542

207 full university professors and 1159 lecturers with a PhD.

## FACULTY OF SCIENCE AND TECHNOLOGY

The Faculty of Science and Technology is currently one of the largest faculties of the University of Debrecen with about 3000 students and more than 200 staff members. The Faculty has got 6 institutes: Institute of Biology and Ecology, Institute of Biotechnology, Institute of Chemistry, Institute of Earth Sciences, Institute of Physics and Institute of Mathematics. The Faculty has a very wide scope of education dominated by science and technology (10 Bachelor programs and 12 Master programs), additionally it has a significant variety of teachers' training programs. Our teaching activities are based on a strong academic and industrial background, where highly qualified teachers with a scientific degree involve student in research and development projects as part of their curriculum. We are proud of our scientific excellence and of the application-oriented teaching programs with a strong industrial support. The number of international students of our faculty is continuously growing (currently 570 students). The attractiveness of our education is indicated by the popularity of the Faculty in terms of incoming Erasmus students, as well.

### THE ORGANIZATIONAL STRUCTURE OF THE FACULTY

Dean: Prof. Dr. Ferenc Kun, University Professor  
E-mail: [ttkdekan@science.unideb.hu](mailto:ttkdekan@science.unideb.hu)

Vice Dean for Educational Affairs: Prof. Dr. Gábor Kozma, University Professor  
E-mail: [kozma.gabor@science.unideb.hu](mailto:kozma.gabor@science.unideb.hu)

Vice Dean for Scientific Affairs: Prof. Dr. Sándor Kéki, University Professor  
E-mail: [keki.sandor@science.unideb.hu](mailto:keki.sandor@science.unideb.hu)

Consultant on Economic Affairs: Dr. Sándor Alex Nagy, Associate Professor  
E-mail: [nagy.sandor.alex@science.unideb.hu](mailto:nagy.sandor.alex@science.unideb.hu)

Consultant on External Relationships: Prof. Dr. Attila Bérczes, University Professor  
E-mail: [berczesa@science.unideb.hu](mailto:berczesa@science.unideb.hu)

Quality Assurance Coordinator: Dr. Zsolt Radics, Assistant Professor  
E-mail: [radics.zsolt@science.unideb.hu](mailto:radics.zsolt@science.unideb.hu)

Dean's Office  
Head of Dean's Office: Mrs. Katalin Csománé Tóth  
E-mail: [csomane.toth.katalin@science.unideb.hu](mailto:csomane.toth.katalin@science.unideb.hu)

Registrar's Office  
Registrar: Ms. Ildikó Kerekes  
E-mail: [kerekes.ildiko@science.unideb.hu](mailto:kerekes.ildiko@science.unideb.hu)

English Program Officer: Mr. Imre Varga  
Address: 4032 Egyetem tér 1., Chemistry Building, A/101  
E-mail: [vargaimre@unideb.hu](mailto:vargaimre@unideb.hu)

## DEPARTMENTS OF THE INSTITUTE OF CHEMISTRY

**Department of Applied Chemistry** (home page: <http://applchem.science.unideb.hu/>)  
**4032 Debrecen, Egyetem tér 1, Chemistry Building**

Name	Position	E-mail	Room
Mr. Prof. Dr.SándorKéki, PhD, habil., DSc	University Professor Head of Department	keki.sandor@science.unideb.hu	E505
Mr. Dr.Ákos Kuki, PhD, habil.	Associate Professor	kuki.akos@science.unideb.hu	E517/A
Mr. Dr.Lajos Nagy, PhD, habil.	Associate Professor	nagy.lajos@science.unideb.hu	E517/A
Mrs. Dr.Katalin IllyésnéCzifrák, PhD	Assistant Professor	czifrak.katalin@science.unideb.hu	E503
Ms. Dr.Csilla Lakatos, PhD	Assistant Lecturer	lakatoscsilla@science.unideb.hu	E503
Mr. Marcell ÁrpádKordován	Assistant Lecturer	kordovan.marci@gmail.com	E516/A
Mr. Bence Vadkerti	Assistant Lecturer	bencevadkerti94@gmail.com	E516/A
Mrs. Anita Dékány- Adamoczky	Assistant Lecturer	adamoczki.anita@science.unideb.hu	E516/A
Mr. Gergő Róth	Assistant Lecturer	roth.gergo@science.unideb.hu	E516/A
Mr. Prof. Dr.ZsugaMiklós, PhD, habil., DSc	Professor Emeritus	zsuga.miklos@science.unideb.hu	E507
Mr. Dr.GyörgyDeák, PhD, habil.	Retired Associate Professor	deak.gyorgy@science.unideb.hu	E517/A

**Department of Inorganic and Analytical Chemistry** (home page: <http://www.inorg.unideb.hu>)  
**4032 Debrecen, Egyetem tér 1, Chemistry Building**

Name	Position	E-mail	Room
Mr. Prof. Dr.Attila Gáspár, PhD, habil., DSc	University Professor Head of Department	gaspar.attila@science.unideb.hu	D402
Mrs. Prof. Dr.Katalin ErdődinéKövé, PhD, habil., DSc	University Professor	kover@science.unideb.hu	E19
Ms. Prof. Dr.Katalin Várnagy, PhD, habil., DSc	University Professor Head of Institute	varnagy.katalin@science.unideb.hu	D406
Mr. Prof. Dr.IstvánFábián, PhD, habil., DSc	University Professor	ifabian@science.unideb.hu	D508
Mrs. Prof. Dr.Etelka Farkas, PhD, habil., DSc	Professor Emerita	efarkas@science.unideb.hu	D422
Mr. Prof. Dr.ImreSóvágo, PhD, habil., DSc	Professor Emeritus	sovago@science.unideb.hu	D422
Mr. Prof. Dr.ImreTóth, PhD, habil., DSc	Professor Emeritus	imre.toth@science.unideb.hu	D520

Mr. Dr.ZoltánTóth, PhD, habil.	Retired Associate Professor	toth.zoltan@science.unideb.hu	D323
Mr. Dr.PéterBuglyó, PhD, habil.	Associate Professor	buglyo@science.unideb.hu	D411
Mrs. Dr.GyöngyiGyémánt, PhD, habil.	Associate Professor	gyemant@science.unideb.hu	D518
Mr. Dr.IstvánLázár, PhD	Associate Professor	lazar@science.unideb.hu	D506
Mrs. Dr.Csilla Kállay, PhD, habil.	Associate Professor	kallay.csilla@science.unideb.hu	D428
Mr. Dr.JózsefKalmár, PhD, habil.	Associate Professor	kalmar.jozsef@science.unideb.hu	D524
Mrs. Dr.Melinda PokoraczkinéAndrási, PhD	Assistant Professor	andrasi.melinda@science.unideb.hu	D502
Mrs. Dr.Edina Baranyai, PhD	Assistant Professor	baranyai.edina@science.unideb.hu	D423
Mrs. Dr.Linda Földi-Bíró, PhD	Assistant Professor	linda.biro@science.unideb.hu	D411
Mr. Dr.IstvánTimári, PhD	Assistant Professor	timari.istvan@science.unideb.hu	B12
Ms. Dr.AnnamáriaSebestyén, PhD	Assistant Lecturer	sebestyen.annamaria@science.unideb.hu	D507
Ms. Dr.ÁgnesDávid, PhD	Assistant Lecturer	agnesdavid1376@gmail.com	D428
Mrs. Dr.ÁgnesHögyénéGrenács, PhD	Assistant Lecturer	grenacs.anges@science.unideb.hu	D431
Mr. Dr.Attila Forgács, PhD	Assistant Research Fellow	forgacs.attila@science.unideb.hu	D503
Mr. TamásGyöngyösi	Assistant Research Fellow	gyongyosi89@gmail.com	D12
Mr. Dr.Norbert Lihi, PhD	Research Fellow	lihi.norbert@science.unideb.hu	D503
Mrs. Krisztina Fehér	Senior Research Fellow	szabo.maria@science.unideb.hu	D503
Ms. MáriaSzabó	Assistant Research Fellow	szabo.maria@science.unideb.hu	D503
Mr. Dr.JánosElek, PhD	External lecturer	elek@scienceport.hu	D7
Mr. Dr.László Krusper, PhD	External lecturer	krusper.laszlo@science.unideb.hu	D521
Mr. SándorHarangi	Junior Researcher	harangi.sandor@science.unideb.hu	D423

**Department of Organic Chemistry** (home page: <http://szerves.science.unideb.hu/>)  
**4032 Debrecen, Egyetem tér 1, Chemistry Building**

<b>Name</b>	<b>Position</b>	<b>E-mail</b>	<b>Room</b>
Mr. Prof. Dr. Tibor Kurtán, PhD, habil., DSc	University Professor Head of Department	kurtan.tibor@science.unideb.hu	E405
Mr. Prof. Dr. Sándor Antus, PhD, habil., DSc	Professor Emeritus	antus.sandor@science.unideb.hu	E303
Mr. Prof. Dr. Gyula Batta, PhD, habil., DSc	University Professor	batta@unideb.hu	E18
Mrs. Dr. Éva Bokor, PhD	Assistant Professor	bokor.eva@science.unideb.hu	E423; E422
Mr. Dr. László Juhász, PhD, habil.	Associate Professor	juhasz.laszlo@science.unideb.hu	E409; E421
Mrs. Dr. Éva Juhászné Tóth, PhD	Assistant Professor	toth.eva@science.unideb.hu	E423; E408
Mr. Dr. Attila Kiss, PhD, habil.	Associate Professor	kiss.attila@science.unideb.hu	E325
Mrs. Dr. Anita Kónya-Ábrahám, PhD	Department Engineer	dulryc@unideb.hu	E325
Mrs. Dr. Krisztina Kónya, PhD	Assistant Professor	konya.krisztina@science.unideb.hu	E407
Mr. Dr. Sándor Kun, PhD	Assistant Professor	kun.sandor@science.unideb.hu	E423; E422
Mr. Dr. László Lázár, PhD, habil.	Associate Professor	lazar.laszlo@science.unideb.hu	E423; E422
Mr. Dr. Attila Mándi, PhD	Assistant Professor	mandi.attila@science.unideb.hu	E412; E424
Mr. Prof. Dr. László Somsák, PhD, habil., DSc	University Professor	somsak.laszlo@science.unideb.hu	E326
Mr. Prof. Dr. László Szilágyi, PhD, habil., DSc	Professor Emeritus	lszilagyi@unideb.hu	B18
Mrs. Dr. Tünde Zita Tóthné Illyés, PhD	Assistant Professor	illyes.tunde@science.unideb.hu	E20
Mrs. Dr. Marietta Vágvolgyiné Tóth, PhD, habil.	Associate Professor	toth.marietta@science.unideb.hu	E409, E421
Mr. János József	Assistant Lecturer	jozsef.janos@science.unideb.hu	E421
Mr. Sándor Balázs Király	Associate Lecturer	kiraly.sandor.balazs@science.unideb.hu	E423/A



**Department of Physical Chemistry** (home page: <https://fizkem.unideb.hu/>)  
**4032 Debrecen, Egyetem tér 1, Chemistry Building**

<b>Name</b>	<b>Position</b>	<b>E-mail</b>	<b>Room</b>
Mr. Dr. Gyula Tircsó, PhD, habil.	Associate Professor Head of Department	gyula.tircso@science.unideb.hu	D619
Mr. Prof. Dr. István Banyai, PhD, habil., DSc	University Professor	banyai.istvan@science.unideb.hu	D201
Mr. Prof. Dr. György Bazsa, PhD, habil., DSc	Professor Emeritus	bazsa@unideb.hu	D605
Mr. Dr. Attila Bényei, PhD, habil.	Associate Professor	benyei.attila@science.unideb.hu	D16
Ms. Dr. Dóra Beáta Buzetzký	Assistant Research Fellow	dorabeata@science.unideb.hu	D206
Mrs. Dr. Csilla Czégényi, PhD	Research Fellow	nagy.csilla@science.unideb.hu	D602
Mr. Zoltan Garda, PhD	Associate Professor	garda.zoltan@science.unideb.hu	D519
Ms. Dr. Réka Gombos, PhD	Assistant Lecturer	gombos.reka@science.unideb.hu	D607
Mrs. Dr. Henrietta Horváth, PhD	Senior Research Fellow	henrietta.horvath@science.unideb.hu	D602
Mr. Prof. Dr. Ferenc Joó, PhD, habil., DSc	Professor Emeritus	joo.ferenc@science.unideb.hu	D618
Mrs. Ágnes Kathó, PhD	Retired Research Lecturer	katho.agnes@science.unideb.hu	D603
Mr. Dr. Ferenc Krisztián Kálmán, PhD, habil.	Associate Professor	kalman.ferenc@science.unideb.hu	D622
Mrs. Dr. Mónika Kéri, PhD	Assistant Professor	keri.monika@science.unideb.hu	D202
Mrs. Dr. Virág Kiss, PhD	Assistant Research Fellow	kiss.virag@science.unideb.hu	D202
Mr. Prof. József Kónya, PhD, DSc	Retired University Professor	konya.jozsef@science.unideb.hu	D108
Ms. Dr. Eszter Mária Kovács, PhD	Assistant Research Fellow	kovacs.eszter.maria@science.unideb.hu	D206
Mrs. Dr. Natália Marozsán, PhD	Research Fellow	marozsan.natalia@science.unideb.hu	D607
Ms. Prof. Dr. Noémi Nagy, PhD, habil., DSc	University Professor	nagy.noemi@science.unideb.hu	D108
Mr. Dr. Levente Novák, PhD	Assistant Professor	novak.levente@science.unideb.hu	D201
Mr. Dr. Gábor Csaba Papp, PhD, habil.	Associate Professor	papp.gabor@science.unideb.hu	D603
Mr. Dr. Mihály Purgel, PhD	Assistant Professor	purgel.mihaly@science.unideb.hu	D617
Mr. Dr. Imre Tóth, PhD, DSc	Professor Emeritus	imre.toth@science.unideb.hu	D520
Mrs. Dr. Enikő Tóth-Molnár, PhD	Assistant Research Fellow	molnar.eniko@science.unideb.hu	D507
Mr. Dr. Antal Udvardy, PhD	Assistant Professor	udvardya@science.unideb.hu	D603

## ACADEMIC CALENDAR

General structure of the academic semester (2 semesters/year):

Study period	1 <sup>st</sup> week	Registration*	1 week
	2 <sup>nd</sup> – 15 <sup>th</sup> week	Teaching period	14 weeks
Exam period	directly after the study period	Exams	7 weeks

\*Usually, registration is scheduled for the first week of September in the fall semester, and for the first week of February in the spring semester.

For further information please check the following link:

[http://www.edu.unideb.hu/tartalom/downloads/University\\_Calendars\\_2019\\_20/1920\\_Science.pdf](http://www.edu.unideb.hu/tartalom/downloads/University_Calendars_2019_20/1920_Science.pdf)

# MASTER TRAINING IN CHEMISTRY AT UNIVERSITY OF DEBRECEN

**1. Title of the training:** Master of Science in Chemistry

**Program supervisor:** Dr. István Fábíán professor of chemistry

**Faculty:** Faculty of Science and Technology

## **2. The degree received**

- MSc in Chemistry

### **Electable specialization tracks and the corresponding supervisors**

Analytical Chemistry: Dr. Attila Gáspár, professor of chemistry

Synthetic Chemistry: Dr. Tibor Kurtán, professor of chemistry

Radiochemistry: Dr. Noémi Nagy, professor of chemistry

**3. Scientific area of the training:** natural sciences

## **4. Requirements for the admittance to the training program**

**4.1. The admittance is based on full credits earned in the following BSc trainings:**

Chemistry, chemical engineering, various fields of natural sciences and engineering

**4.2. Credit requirements can be satisfied primarily on the basis of the following subjects:** biology, physics, geography, geological sciences, environmental sciences, mathematics, bioengineering, material sciences, environmental engineering, civil engineering, molecular biology, biotechnology, medical laboratory analysis, medical diagnostic analysis.

**4.3. Credits from any field of basic training are subject to acceptance by the admittance committee or the program supervisor.**

**5. The duration of the training:** 4 semesters

**6. Required credits for earning the MSc degree:** 120

- credits earned in core and specialization courses are balanced (40 – 60 %),
- credits earned by the diploma work: 30
- credits from freely elected courses: 6

**7. Identification code of the training:** 442

## **8. The objectives of the training and competencies to be gained**

The main goal of the program is to train highly qualified chemists to satisfy the demands of the chemical industry. The students will gain high level knowledge in theoretical and practical aspects of chemistry. They will also receive excellent training in related fields such as mathematics, physics and informatics. The graduates of the MSc program will be prepared to use the chemical literature and solve various problems independently in both the chemical industry and chemical laboratories including research and development areas. They will be able to fill high level positions in the chemical and pharmaceutical industry as well as in companies and agencies active in related areas such as environmental protection and management, quality control and assurance, food safety etc. MSc graduates will develop the appropriate skills to continue their

studies in doctoral schools of chemistry at the University of Debrecen or at any university throughout the world.

### **8.1. Gained competencies**

#### **a) knowledge**

- understanding the main relationships between chemical phenomena and the ability to use theoretical and practical methods for the interpretation of them;
- the knowledge of the latest scientific results related to chemical bonding, structures, reactions; understanding the novel theories, models and appropriate computational methods for the interpretation of the new results.
- understanding the main trends and the limits of the developments in chemistry and the chemical industry;
- understanding the main principles and concepts of natural sciences;
- the ability to use laboratory methods, industrial systems and the corresponding apparatuses as well as understanding the related safety regulations;
- possessing sufficient knowledge to accurately interpret chemical phenomena and to solve practical chemical problems related to natural resources, living systems and natural sciences;
- the knowledge of the inquiring scientific and practical problems of a specific area of chemistry;
- broad knowledge of the relevant literature of a specific area of chemistry.

#### **b) skills**

- the ability to use the most important theories, practical tools in chemical research and development and the evaluation of the results obtained;
- the ability to evaluate chemical literature results objectively and recognize overall and specific relationships in chemistry;
- the ability to make a distinction between real scientific and pseudo scientific statements in chemistry.
- the ability to critically use novel chemical theories and principles in the practice and to design new laboratory and industrial procedures independently;
- the ability to perform new laboratory experiments supported by appropriate measurements, to synthesize new compounds, and to describe and confirm new chemical phenomena by utilizing analytical chemistry
- the ability to evaluate, interpret and analyze experimental data independently, to draw appropriate conclusions on the basis of the results and to identify the main directions of further development.
- the ability to communicate the main chemical problems in a specific area to other chemists and non-specialists in the fields of natural sciences and engineering.
- the ability to support a standpoint in scientific debates with appropriate scientific arguments;
- the ability to utilize her/his acquired chemical knowledge in scientific research and in producing new results;

#### **c) attitude**

- to accept the specific professional identity which originates in the natural sciences;
- commitment to give high priority to environmental protection during laboratory and industrial activities and communicate this attitude toward colleagues;
- a commitment to use the most environment friendly approach in solving a chemical problem;
- to follow the ethical norms while handling the intellectual properties produced by her/him or others;
- openness toward introducing and using novel chemical and environmental technologies;
- initiation and participation in professional consultations;
- openness toward inter- and multidisciplinary collaboration;
- appreciation of the skepticism in science;
- active communication of the concepts of natural sciences toward both professional and non-professional audiences;

- openness toward acquiring new knowledge and competences, as well as toward further professional development;
- refraining from taking undue advantage of professional knowledge and strictly following professional and societal ethical norms.

#### **d) autonomy and responsibility**

- acting independently in developing general and specific professional concepts;
- responsible collaboration with other professionals;
- independent approach toward personalized tasks and accepting responsibility for individual ideas, decisions and acts;
- understanding the direct and indirect risks of laboratory and industrial procedures and following prudent rules to minimize any potential hazard;
- objective evaluation of the work performed by subordinates;
- understanding the significance of the personal professional statements and taking responsibility for them;
- taking responsibility for operating the laboratory and industrial equipment and supervising the activities of the subordinates.

### **9. Features of the training**

#### **9.1. Professional features**

The disciplines used in the training:

- fundamental courses in natural sciences: 6-18 credits;
- courses in chemistry (inorganic chemistry at least 4 credits, organic chemistry at least 4 credits, physical chemistry at least 4 credits, analytical chemistry at least 4 credits, applied and industrial chemistry at least 4 credits) 30–50 credits;
- special courses: 20–40 credits.

#### **9.2 Contact classes**

The number of classes (depends on the specialization) mandatory: 1260-1300, freely elected: 350-660. This corresponds to 29 – 35 contact classes in a week.

#### **9.3. Minimum requirements to enter the MSc program:**

- general natural sciences (mathematics, physics, informatics, biology etc.): 15 credits;
- chemistry (general and inorganic chemistry: at least 10 credits, organic chemistry: at least 10 credits, analytical chemistry: at least 10 credits, physical chemistry: at least 10 credits,) at least 50 credits.

### **10. Specialization**

The optional specializations are detailed in Chapter 2. In this case, general and specific courses need to be taken as follows:

fundamental courses: 48 credits

specific freely elected courses: 30 credits

### **11. Work and Fire Safety Course**

According to the Rules and Regulations of University of Debrecen a student has to complete the online course for work and fire safety. Registration for the course and completion are necessary for graduation.

Registration in the Neptun system by the subject: MUNKAVEDELEM

Students have to read an online material until the end to get the signature on Neptun for the completion of the course. The link of the online course is available on webpage of the Faculty.

## 12. Physical Education

According to the Rules and Regulations of University of Debrecen a student has to complete Physical Education courses at least in two semesters during his/her Bachelor's training. Our University offers a wide range of facilities to complete them. Further information is available from the Sport Centre of the University, its website: <http://sportsci.unideb.hu>.

## 13. Pre-degree Certification

A pre-degree certificate is issued by the Faculty after completion of the master's (MSc) program. The pre-degree certificate can be issued if the student has successfully completed the study and exam requirements as set out in the curriculum, the requirements relating to Physical Education as set out in Section 10 in Rules and Regulations, internship (mandatory) – with the exception of preparing thesis – and gained the necessary credit points (120). The pre-degree certificate verifies (without any mention of assessment or grades) that the student has fulfilled all the necessary study and exam requirements defined in the curriculum and the requirements for Physical Education. Students who obtained the pre-degree certificate can submit the thesis and take the final exam.

## 14. Final exam

### *Objectives:*

The professional competencies and knowledge of the student is evaluated. The graduate needs to demonstrate proficiency in chemistry and the ability to perform high level chemical tasks independently. The preparedness for professional debates also needs to be shown.

### *Requirements:*

In order to participate in the final exam, the student needs to satisfy all formal and informal requirements. Thus, a minimum of 120 credits need to be earned. Further requirement is the submission of a thesis covering the diploma work of the graduate well before the final exam.

### *The diploma work*

It is based on the independent research activity of the student under the guidance of the supervisor.

### *The final exam:*

The final exam has two parts. First, the thesis based on the diploma work is presented in front of the examining committee. The graduating student gives a lecture, answers the remarks of the reviewer and the questions of the committee and the audience. In the second part, the student must demonstrate her/his knowledge in chemistry at the masters level. There are the following groups of questions:

- A: fundamental topics (inorganic, analytical, physical, organic, applied and biochemistry)
- B: specialization in analytical chemistry
- C: specialization in synthetic chemistry
- D: radiochemistry

The students need to answer one question from group A and another question from the group of her/his specialization. If no specialization was selected, two questions are answered from group A.

### *Final Exam Board*

Board chair and its members are selected from the acknowledged internal and external experts of the professional field. Traditionally, it is the chair and in case of his/her absence or indisposition the vice-chair who will be called upon, as well. The board consists of – besides the chair – at least two members (one of them is an external expert), and questioners as required. The mandate of a Final Examination Board lasts for one year.

### *Repeating a failed Final Exam*

If any part of the final exam is failed it can be repeated according to the rules and regulations. A final exam can be retaken in the forthcoming final exam period. If the Board qualified the Thesis unsatisfactory a student cannot take the final exam and he has to make a new thesis. A repeated final exam can be taken twice on each subject.

## **15. Diploma**

The diploma is an official document decorated with the coat of arms of Hungary which verifies the successful completion of studies in the Chemistry Master Program. It contains the following data: name of HEI (higher education institution); institutional identification number; serial number of diploma; name of diploma holder; date and place of his/her birth; level of qualification; training program; specialization; mode of attendance; place, day, month and year issued. Furthermore, it has to contain the rector's (or vice-rector's) original signature and the seal of HEI. The University keeps a record of the diplomas issued.

In Chemistry Master Program the diploma grade is calculated as the average grade of the results of the followings:

- Weighted average of the overall studies at the program (A)
- Average of grades of the thesis and its defense given by the Final Exam Board (B)
- Average of the grades received at the Final Exam for the two subjects (C)

$$\text{Diploma grade} = (A + B + C)/3$$

Classification of the award on the bases of the calculated average:

Excellent	4.81 – 5.00
Very good	4.51 – 4.80
Good	3.51 – 4.50
Satisfactory	2.51 – 3.50
Pass	2.00 – 2.50

The Chemistry Master Program of the University of Debrecen has been awarded the “Euromaster” qualification label by the European Chemistry Thematic Network.

## STRUCTURE OF THE CURRICULUM IN ECTS CREDITS

**Table 1. The general structure of training**

Group of subjects	Credit	
	MSc + BSc (required)	MSc (to be earned)
<i>Mandatory, apart from chemistry</i>		<b>6</b>
<i>Basic subjects of natural sciences</i>		
Mathematics	12	
Physics	9	
Informatics in chemistry	4	
Bio – Geo	5	
<i>Sum</i>	<b>30</b>	<b>6</b>
<i>Main subjects in chemistry</i>		
inorganic chemistry		9
physical chemistry		11
organic chemistry		12
analytical chemistry		10
engineering chemistry		6
<i>Sum</i>		<b>48</b>
<i>Differentiated professional knowledge</i>		<b>30</b>
Specialization		30
<i>Diploma work</i>		<b>30</b>
<b>Total</b>		<b>120</b>



**Table 2. Science Courses (Total 30 credits BSc + MSc)**

<b>Coursename Lecturer</b>	<b>Code</b>	<b>Hours/week (L+S+P)<sup>a</sup> examtype<sup>b</sup></b>	<b>Prerequisites</b>	<b>Credits</b>
<b>Science (6 credits)</b>				
Crystallography <i>Gábor Dobosi</i>	TTGME5101_EN	2e+0+0	none	3
BiochemistryII. <sup>c</sup> <i>Gyöngyi Gyémánt</i>	TTKML0304_EN	0+(1+2)p	minimum 3 credits of biochemistry	3
BiochemistryIII. <sup>c</sup> <i>Teréz Barna</i>	TTKME0304_EN	2e+0+0	minimum 3 credits of biochemistry	3
Ceramics and their applications <i>István Szabó</i>	TTFME0202	(2+1)p+0	no	5
Measurement Methods in Materials Science (lecture) <i>Lajos Daróczi</i>	TTFME0411_BT_EN	2e+0+0	minimum 3 credits of physics	3
Measurement Methods in Materials Science (practice) <i>Lajos Daróczi</i>	TTFML0411_BT_EN	0+0+2p	minimum 3 credits of physics	1
Atomic and Molecular Physics <i>András Csehi</i>	TTFME0101_EN	2e+1s+0	minimum 12 credits of physics	4
Computational Quantum Chemistry <sup>c</sup> <i>Mihály Purgel</i>	TTKMG0902_EN	0+2p+0	minimum 12 credits of mathematics	3

**Table 3. Basics of Professional Knowledge**

Coursename Lecturer	Code	Semester Hours/week (L+S+P) <sup>a</sup> examtype <sup>b</sup>				Credits
		I. (fall)	II. (spring)	III. (fall)	IV. (spring)	
InorganicChemistryBlock (10 cr)						
InorganicChemistry V. Péter Buglyó	TTKME0203_EN	3e+0+0				4
InorganicChemistry VI. Péter Buglyó	TTKML0203_EN	0+0+4p				4
InorganicChemistry VII. Katalin Várnagy	TTKME0204_EN		2e+0+0			3
PhysicalChemistryBlock (includingradio- and colloidchemistry) (10 cr)						
PhysicalChemistry VI. Attila Béneyi	TTKME0401_EN	3e+0+0				4
PhysicalChemistry VII. Ferenc Krisztián Kálmán	TTKML0405_EN	0+0+3p				3
PhysicalChemistry VIII. Levente Novák	TTKML0406_EN		0+0+3p			3
Organic and BiochemistryBlock (11 credits)						
SyntheticMethods in OrganicChemistry I. Marietta Tóth Vágvolgyi	TTKME0301_EN	2e+0+0				3

Course name Lecturer	Code	Semester Hours/week (L+S+P) <sup>a</sup> exam type <sup>b</sup>				Credits
		I. (fall)	II. (spring)	III. (fall)	IV. (spring)	
Synthetic Methods in Organic Chemistry II. Éva Bokor	TTKML0302_EN		0+0+4p			3
Heterocycles Tibor Kurtán	TTKME0327_EN		2e+0+0			3
Biochemistry IV. Teréz Barna	TTKME0303_EN		2e+0+0			2
<b>Analytical Chemistry and Structure Determination Block (10 credits)</b>						
Instrumental Analysis I. Attila Gáspár	TTKME0501_EN		2e+0+0			3
Instrumental Analysis II. Melinda András	TTKML0501_EN			0+0+3p		2
Spectroscopic Methods for Structure Investigation I. Katalin Erdődi Kövér	TTKME0502_EN		2e+0+0			3
Spectroscopic Methods for Structure Investigation II. Katalin Erdődi Kövér	TTKML0502_EN			0+0+3p		2
<b>Engineering Chemistry (6 credits)</b>						
Introduction to Chemical Engineering Sándor Kéki	TTKME0601_EN		2e+0+0			3
Advanced Chemical Technology Lajos Nagy	TTKME0602_EN			2e+0+0		3
Diploma Thesis I. István Fábián	TTKML0001_EN			0+0+15p		15
Diploma Thesis II. István Fábián	TTKML0002_EN				0+0+15p	15
Industrial placement Ákos Kuki	TTKMX0003_EN			4 weeks (summer)	s	0
Total (credits, hours/week, exams)		18 cr, 15h, 3e, 2p	23 cr 19h, 6e, 2p	7+15 cr 8+15h 1e, 3p	15 cr 15h 1p	48+30cr 42+30h 10e+8p

**Table 4. Compulsory and Optional courses on Analytical specialization (30 credits)**

Coursename <i>Lecturer</i>	Code	Semester Hours/week (L+S+P) <sup>a</sup> examtype <sup>b</sup>			Credits
		II. (spring)	III. (fall)	IV. (spring)	
CompulsoryCourses					23
Chemometrics I. <i>József Kalmár</i>	TTKME0511_EN	2e+0+0			3

Separation Techniques III. <i>Attila Kiss</i>	TTKME0315_EN	2e+0+0			3
Separation Techniques IV. <i>Attila Kiss</i>	TTKML0315_EN		0+0+4p		4
Inorganic Methods in Environmental Analysis I. <i>Edina Baranyai</i>	TTKME0503_EN		1e+0+0		1
Inorganic Methods in Environmental Analysis II. <i>Edina Baranyai</i>	TTKML0503_EN		0+0+4p		4
Quality Assurance in Analytical Chemistry <i>Melinda András</i>	TTKME0513_EN			1e+0+0	1
Mass Spectrometry <i>Sándor Kéki / Tibor Nagy</i>	TTKME0317_EN			(2+1)e+0	4
Electrophoretic Techniques <i>Attila Gáspár</i>	TTKME0504_EN		2e+0+0		3
<b>Optional Courses</b>					<b>7</b>
Sampling, Sample Treatment, Analytical Tests I. <sup>d</sup> <i>Edina Baranyai</i>	TTKME0514_EN			1e+0+0	1
Sampling, Sample Treatment, Analytical Tests II. <sup>d</sup> <i>Edina Baranyai</i>	TTKML0514_EN			0+0+4p	4
Nuclear Analysis I. <i>Noémi Nagy</i>	TTKME0523_EN		2e+0+0		3
NMR Operator Training II. <sup>e</sup> <i>Katalin Erdődi Kövér</i>	TTKML0530_EN		0+0+2p		2
Analytics in Pharma Industry <i>András Zékány</i>	TTKME0520_EN		0+4p+0		4

**Table 5. Compulsory and Optional courses on Synthetic specialization (30 credits)**

Course name <i>Lecturer</i>	Code	Semester Hours/week (L+S+P) <sup>a</sup> exam type <sup>b</sup>			Credits
		II. (spring)	III. (fall)	IV. (spring)	
<b>Compulsory Courses</b>					<b>27</b>
Reaction Mechanism <i>László Somsák</i>	TTKME0311_EN	3e+0+0			4
Asymmetric Syntheses <i>Attila Mándi</i>	TTKME0312_EN		2e+0+0		3
Synthetic Methods in Polymer Chemistry <i>Sándor Kéki</i>	TTKME0313_EN		2e+0+0		3

Chemical Aspects of Drug Design <i>László Somsák</i>	TTKME0314_EN		2e+0+0		3
Separation Techniques III. <i>Attila Kiss</i>	TTKME0315_EN	2e+0+0			3
Separation Techniques IV. <i>Attila Kiss</i>	TTKML0316_EN		0+0+2p		2
NMR Operator Training II. <sup>e</sup> <i>Katalin Erdődi Kövér</i>	TTKML0530_EN		0+0+2p		2
Mass Spectrometry <i>Sándor Kéki, Tibor Nagy</i>	TTKME0317_EN			(2+1)e+0	4
High Efficiency Synthetic Methods I. <i>László Juhás</i>	TTKML0319_EN			0+(1+3)p	3
<b>Optional Courses</b>					<b>3</b>
2D NMR Methods <sup>e</sup> <i>Katalin Erdődi Kövér</i>	TTKMG0318_EN		0+2p+0		2
Glycobiology <i>János Kerékgyártó</i>	TTKME0321_EN			2e+0+0	3
Stereochemical Structural Elucidation Methods <i>Tibor Kurtán</i>	TTKME0322_EN			2e+0+0	3
Carbohydrate Chemistry <i>László Somsák</i>	TTKME0323_EN			2e+0+0	3
Organic Chemistry of Drug Syntheses <i>Éva Juhász Tóth</i>	TTKME0324_EN		2e+0+0		3

**Table 6. Compulsory and Optional courses on Radiochemical specialization (30 credits)**

Table 6: Compulsory and Optional courses in radiochemical specialization (30 credits)					
Course name <i>Lecturer</i>	Code	Semester Hours/week (L+S+P) <sup>a</sup> exam type <sup>b</sup>			Credits
		II. (spring)	III. (fall)	IV. (spring)	
Compulsory courses					25
Radiochemistry <i>Noémi Nagy</i>	TTKME0410_EN	2e+0+0			3
Nuclear Methods for Environmental Protection <i>Mihály Molnár</i>	TTKME0426_EN	2e+0+0			3
Medical Applications of Radiopharmaceuticals <i>László Galuska</i>	TTKME0429_EN		2e+0+0		3
Nuclear Analysis I. <i>Noémi Nagy</i>	TTKME0523_EN		2e+0+0		3
Nuclear Analysis II. <i>Noémi Nagy</i>	TTKML0523_EN		Visit a power plant(p)		1
Production of Isotopes <i>István Kertész</i>	TTKML0437_EN		1+0+1p		3

Separation Techniques for Radiolabeled Compounds <i>István Józai</i>	TTKME0431_EN		(2+2)e+0		4
Dosimetry, Radiation Health Effects <i>István Hajdu</i>	TTKME0432_EN	2e+0+0			3
Radiochemical Exercises <i>Noémi Nagy</i>	TTKML0415_EN	0+0+2p			2
<b>Optional Courses</b>					<b>5</b>
Nuclear analytical methods in environmental studies <i>László Palcsu</i>	TTKME0433_EN TTKME433L_EN			2e+0+0 0+0+1p	3 1
Biological Application of Labelled Compounds <i>István Kertész</i>	TTKME0434_EN			2e+0+0	3
Syntheses and Quality Control of Radioactive Pharmaceuticals <i>István Józai</i>	TTKML0435_EN			0+0+2p	2
Investigation of Cellular and Tissue Metabolism With Radiochemical Methods <i>György Trencsényi</i>	TTKME0436_EN			2e+0+0	3

**Table 7. Optional Courses for all specialization (max. 30 credits from this table and other Compulsory/Optional Courses from others specialization)**

<b>Course name Lecturer</b>	<b>CODE</b>	<b>Hours/week (L+S+P)<sup>a</sup> exam type<sup>b</sup></b>	<b>Credits</b>
Complexes of Macrocyclic Ligands <i>Gyula Tircsó</i>	TTKME0212_EN	2e+0+0	3
Dangerous and Special Materials <sup>c</sup> <i>István Lázár</i>	TTKME0206_EN	2e+0+0	3
Biocolloids <sup>c</sup> <i>Levente Novák</i>	TTKME0411_EN	2e+0+0	3
Physical Chemistry of Living Systems <i>Henrietta Győrvári Horváth</i>	TTKME0417_EN	2e+0+0	3
Metal Complex Catalyzed Organic Syntheses <i>Gábor Papp</i>	TTKME0420_EN	2e+0+0	3
Environmental Chemistry II. <i>Mónika Kéri</i>	TTKME0414_EN	2e+1+1	4
Structure Determination by X-ray Diffraction <i>Attila Bényei</i>	TTKME0423_EN	2e+0+0	3
Chemistry of Secondary Metabolites I. <i>László Juhász</i>	TTKME0331_EN	2e+0+0	3
Chemistry of Secondary Metabolites II. <i>László Juhász</i>	TTKML0332_EN	0+0+4p	3
Enzyme Biotechnology <i>Teréz Barna</i>	TTKME0334_EN	2e+0+0	3
NMR Operator Training I. <sup>c</sup> <i>Gyula Batta</i>	TTKML0004_EN	0+0+2p	2
NMR Structure Determination <i>Krisztina Fehér</i>	TTKME0507_EN	1e+0+1	3

- <sup>a</sup> L: lecture, S: seminar P: laboratory practice;  
<sup>b</sup> e: oral or written exam p: mid-semester grade s: signature  
<sup>c</sup> Can be fulfilled on BSc as well, but only once (during BSc and MSc)!  
<sup>d</sup> Prerequisite: TTKME0501, Instrumental Analysis I.  
<sup>e</sup> Prerequisite: TKBL0004 or TKML0004, NMR Operator Training I.

## DESCRIPTION OF SUBJECTS

(in order of their appearance in the tables above)

<b>Title of course:</b> Crystallography <b>Code:</b> TTGME5104_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice:- - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice:- - laboratory: - - home assignment: 10 hours - preparation for the exam: 52 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:-</b>	

<b>Topics of course</b>
Position of crystallography among other fields of science. The definition of space lattice, unit cell and crystallographic axes. Bravais lattices. Unit cells and crystallographic axes in crystal systems. Calculation of Miller indices. Symmetry elements, crystal classes, point groups and space groups. Fundamentals of crystal chemistry and the different types of lattices. Rules of coordination and packing. Lattice defects and element substitutions in the lattice. Physical properties of crystals and their explanation through structural differences. The understanding of constitution of unit cells and symmetry elements will be supported by the in-class study of three-dimensional crystal models.
<b>Literature</b>
<i>Compulsory:</i> W. D. Nesse: Introduction to Mineralogy. Oxford University Press. Oxford-New York, 2012 (2nd edition) <i>Recommended:</i>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Subject of crystallography. Properties of crystalline substances, definition of space lattice. Principles of morphology and crystallography.
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*2<sup>nd</sup> week*

Bravais-type unit cells and crystal systems. Crystal cross in crystallography. Definition of directions, lattice planes and crystal faces. The Miller index.

*3<sup>rd</sup> week*

The visible symmetry elements of crystals, simple and combined symmetry elements. The stereographic projection. The translational symmetry.

*4<sup>th</sup> week*

Practicing of identification of symmetry elements

*5<sup>th</sup> week*

Point groups and the 32 crystal classes. Holohedral, hemihedral and tetrahedral crystal classes.

*6<sup>th</sup> week*

Mid-term test. Definition of crystal form. Crystal forms and symmetry elements in triclinic, monoclinic and orthorhombic systems.

*7<sup>th</sup> week*

Crystal forms and symmetry elements in trigonal, tetragonal and hexagonal crystal systems

*8<sup>th</sup> week*

Crystal forms and symmetry elements in cubic crystal system

*9<sup>th</sup> week*

Basics of crystal chemistry. X-ray diffraction and Bragg equation. Types of crystal lattices (atomic, ionic, metallic, molecular lattice). Coordination number, atomic, ionic radii.

*10<sup>th</sup> week*

Types of atomic lattices. Metallic lattice and close packing. Molecular lattices. Properties of ionic lattice substances.

*11<sup>th</sup> week*

Isodesmic, anisodesmic and mesodesmic ionic lattices. Structure of silicates. Ortho, ring, chain, sheet and framework silicates.

*12<sup>th</sup> week*

Isomorphism and polymorphism. Real lattice structures, lattice defects. Rules of element substitutions. Crystal growth.

*13<sup>th</sup> week*

Crystal physics. Cohesion properties. Cleavage and sliding. Mohs-type hardness scale. Thermoelectric and piezoelectric properties. Structural interpretation of physical properties.



14<sup>th</sup> week

Crystal optics. Isotropic and anisotropic crystals. Birefringency and optical activity. Summary

**Requirements:**

- *for a signature*

Participation at **lecture classes** is not compulsory but highly advised.

During the semester there will be two tests, the mid-term test in week 6, and the end-term test in week 15.

Students have to sit for the tests.

- *for a grade*

The course ends with a **writing examination** in the exam period, covering the whole material of the semester. The final grade for the course will be determined according to the followings: it is based on the average grade of the mid-term test and end-term test in 10 %, and based on the result of written exam in 90 %.

The minimum requirement for the average grade of end-term test and mid-term test and final exam is 50%, respectively. The examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-72	satisfactory (3)
73-87	good (4)
88-100	excellent (5)

If the score of the test is below 49, students can take a re-take test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *an offered grade:*

it may be offered for students if the average grade of mid-term test and end-term test is at least satisfactory (3).

**Person responsible for course:** Prof. Dr. Gábor Dobosi, university professor, DSc

**Lecturer:** Dr. Dávid Nagy, professor, PhD

<b>Title of course:</b> Biochemistry II <b>Code:</b> TTKML0304_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: 1 hours/week - laboratory: 2 hours/week Theoretical seminar (2 h), solving independent tasks (use of database, use of simulation program), practical laboratory work (5 h), evaluation and interpretation of results.	
<b>Evaluation:</b> Assessment methods: An assessment carried out with written examinations at the end of semester. Written examinations are used during the semester from the theoretical and practical part. The ratings are not checked by a second examiner. The examination papers are marked with name. There is not an examination board.	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 14 hours - laboratory: 36 hours - home assignment: 40 hours - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 3 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> A minimum of 3 credits biochemistry, during earlier studies (BSc).	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Enzymes and mechanisms of enzyme action. Stability of enzymes, the influence of the reaction conditions on enzymatic activity. The Michaelis-Menten model for the kinetic properties of enzymes. Definition, significance and determination of $K_M$ and $v_{max}$ . Specific inhibition of enzymes and determination of the type of inhibition. Regulation of enzymes with allosteric interaction or covalent modification. Preparation, activity measurement and kinetic investigation of some oxidoreductases and hydrolases.
<b>Literature</b>
Compulsory: - <i>Syllabus for biochemical practice</i> Recommended: - J. M. Berg, J. L. Tymoczko, L. Stryer: Biochemistry V. edition (W. H. Freeman and Co. 2002. ISBN 0-7167-4684-0) - A. Cornish-Bowden: Fundamentals of enzyme kinetics, 3. reprint (Portland Press, 2002, ISBN 1 85578 072 0)

**Schedule: practices - 2 hours/week, laboratory - 5 hours/week, two independent tasks**

*1<sup>st</sup> week*

Labor safety education. Semester schedule. Theory: The concept, structure and grouping of enzymes. Parameters influencing the speed of enzyme reactions. Occurrence, function, structure and activity of lipase enzyme.

*2<sup>nd</sup> week*

Laboratory practice: Extraction of lipase enzyme and determination of its activity.

*3<sup>rd</sup> week*

Enzyme activity measurement, reaction rate measurement for enzyme reactions. Enzyme structure and function relationship. Coenzymes, prosthetic groups. Enzyme regulation. The occurrence, function and structure of the catalase enzyme. Hem is a prosthetic group. Generation of hydrogen peroxide in living organisms, FADH<sub>2</sub> coenzyme, superoxide dismutase. Enzyme databases, molecular modelling.

*4<sup>th</sup> week*

Laboratory practice: Extraction of catalase enzyme from plant tissue, measurement of activity.

*5<sup>th</sup> week*

The mechanism of enzyme activity. Structural analysis of proteins. How can we develop an enzyme activity measurement method? The function and significance of the amylase enzyme, its mechanism of action and its activity. Definition and calculation of the subsite map.

*6<sup>th</sup> week*

Laboratory practice: Study of starch and oligosaccharide hydrolysis catalysed by amylase enzyme

*7<sup>th</sup> week*

Overview of the virtual laboratory program. Enzyme assays to investigate the effects of pH, time, amount of enzyme, incubation temperature and substrate concentration on the activity of different enzymes. Students can also investigate the effects of adding different inhibitors, as well. The students carry out the tasks independently at home.

*8<sup>th</sup> week*

Kinetics of enzymatic reactions, inhibition types. Methods for determining kinetic constants. Computer evaluation of enzyme kinetic measurements. The Grafit enzyme kinetic program. Function of emulsion beta-glucosidase, method of measuring activity.

*9<sup>th</sup> week*

Laboratory practice: Determination of kinetic parameters of almond emulsin beta-glucosidase. Enzyme and substrate concentration dependence of reaction rate. Determination of enzyme kinetic parameters  $K_M$  and  $v_{max}$  and inhibition assay.

*10<sup>th</sup> week*

Presentation and discussion of results obtained from a search for a given enzyme in the protein and enzyme databases.

*11<sup>th</sup> week*

End term test

**Requirements:**

- *for a signature*

Participation at **practice and laboratory classes** is compulsory. A student must attend the practice classes and may not miss more than one times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented.

Missed practice classes should be made up for at a later date, to be discussed with the tutor.  
During the semester there are tests in every week as a part of practice, which are mandatory.  
Students have to submit all the two tasks (database search and virtual laboratory) as a minimum on a sufficient level.

*- for a grade*

The course is evaluated based on the tests, designing tasks and the lab notebooks. The grade is calculated as an average.

The minimum requirement is 60%. The grade for the practice is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr.GyöngyiGyémánt, associate professor, PhD

**Lecturer:** Dr.GyöngyiGyémánt, associate professor, PhD

<b>Title of course:</b> Biochemistry III <b>Code:</b> TTKME0304_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> Biochemistry I	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The lectures cover the main features of the protein structures including fibrous proteins and the membrane proteins with their role in transport. There is an insight into the photosynthesis: the light reactions and the carbon-assimilation reactions. The nucleotide metabolism is summarized. The biosynthesis of macromolecules such as DNA, RNA and protein will also be described. Post-translational modification: N-glycosylation is also mentioned.
<b>Literature</b>
<i>Compulsory:</i> The lecture notes <i>Recommended:</i> Nelson D.L., Cox M.M.: Lehninger Principles of Biochemistry (W. H. Freeman Sixth edition, 2012) ISBN-13: 978-14234146. Berg J.M., Tymoczky J.L., Gatto G.J. and Stryer L.: Biochemistry (W. H. Freeman; Eighth edition, 2015), ISBN-13: 978-1464126109. Albert B., Bray D. Essential Cell Biology (Fourth edition, Garland Science, 2014) ISBN: 978-0-8153-4454-4.

<b>Schedule:</b>
1 <sup>st</sup> week The different structural level of proteins. Protein folding and chaperons. Protein misfolding. Structural classification of proteins. 2 <sup>nd</sup> week Fibrous proteins: $\alpha$ -keratin, fibroin and the structure of collagen fibrils. Structural feature of membrane

protein.

*3<sup>rd</sup> week*

The role of membrane proteins in transport processes of the cell. Facilitated diffusion by transport proteins. Primary and secondary active transport. The ion selective channels.

*4<sup>th</sup> week*

The role, the location and the components of photosynthesis. The light driven electron flow in Photosystem I and II. The function and structure of Cythochrome b<sub>6</sub>f complex.

*5<sup>th</sup> week*

The synthesis of ATP and NADPH in the light reactions of photosynthesis. The cyclic photophosphorylation. The water splitting complex. Comparing the light reactions of the photosynthesis with the oxidative phosphorylation taking place at the mitochondria.

*6<sup>th</sup> week*

Photosynthetic assimilation of carbon dioxide. The function, structure and regulation of Rubisco. The three stages of the Calvin cycle. Photorespiratory reactions and the C<sub>4</sub> pathway.

*7<sup>th</sup> week*

Nucleotide Metabolism. The biological function of nucleotides. The pyrimidine *de novo* biosynthesis. The interconversion of nucleoside mono- di- and triphosphates.

*8<sup>th</sup> week*

The purine *de novo* biosynthesis. The role of tetrahydrofolate in the nucleotide biosynthesis. The Salvage pathway. The function of ribonucleotide reductase in the generation of deoxyribonucleotides. Degradation of purin and pyrimidine nucleotides.

*9<sup>th</sup> week*

The biosynthesis of deoxyribonucleic acid. The helical structure of DNA. The Meselson-Stahl experiment. The stages of replication in prokaryotes. The replication forks. DNA synthesis on the leading and lagging strands.

*10<sup>th</sup> week*

The function of the protein factors and enzymes involved in the processes of replication including primase, DNA polymerases I and III, DNA ligase. Termination of chromosome replication in bacterial cell.

*11<sup>th</sup> week*

The biosynthesis of ribonucleic acids in prokaryotes. The function and characteristics of the DNA - dependent RNA polymerase. Transcription initiation, elongation and termination.

*12<sup>th</sup> week*

The biosynthesis of ribonucleic acids in eukaryotes. The function of the different RNA polymerases. Assembly of the Initiation Complex. RNA processing: 5' capping and 3' Poly(A) Tail. RNA splicing.

*13<sup>th</sup> week*

The biosynthesis of proteins. The genetic code. The structure and the function of tRNA. The components of the ribosome. The stages of the protein biosynthesis. Proofreading on the ribosome. Antibiotics inhibit translation.

*14<sup>th</sup> week*

Signal sequences and protein targeting. Protein translocation into the ER. Post-translational modification: N-glycosylation and its function.

### **Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

The grade for the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr.TerézBarna, assistant professor, PhD

**Lecturer:** Dr.TerézBarna, assistant professor, PhD

<b>Title of course:</b> Measurement Methods in Materials Science (lecture) <b>Code:</b> TTFME0411_BT_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> minimum 3 credits of physics	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The series of lectures are based on the topics of modern measurement methods in the materials science. It reviews the fundamentals, technical details, practical aspects of the different methods. Topics: mechanical testing: tensile test, hardness tests, Charpy-test. Microscopic methods: optical microscopy, transmission electron microscopy, scanning electron microscopy, field-electron and field-ion microscopy, scanning tunneling microscopy, atomic force microscopy. Magnetic methods: measurement of magnetization curves, magnetometers, Barkhausen-noise measurements. Ionometry: secondary ion mass spectrometry, secondary neutral mass spectrometry, Rutherford backscattering. X-ray spectrometry: electron probe micro analysis, X-ray fluorescence spectrometry, proton induced X-ray emission. Electron spectroscopy: electron energy loss spectroscopy, photoelectron spectroscopy, Auger-electron spectroscopy. Diffraction methods: X-ray diffraction, electron diffraction, neutron diffraction.</p>
<b>Literature</b>
<p><i>Compulsory:</i>  H. Czichos, T. Saito, L. Smith: Springer Handbook of Materials Measurement Methods, Springer Science+Business Media Inc. 2006  D.J. O'Connor, B.A. Sexton, R. St. C. Smart: Surface Analysis Methods in Materials Science, Springer-Verlag Berlin Heidelberg GmbH 1992</p> <p><i>Recommended:</i>  C. Giocavazzo: Fundamentals of Crystallography, Oxford University Press 1992  D.B. Williams and C.B. Carter: Transmission Electron Microscopy, Plenum Press 1996  J.A. Stroscio, W. J. Kaiser: Methods of Experimental Physics Vol.27 Scanning Tunneling Microscopy, Academic Press (1997)</p>



**Schedule:**

*1<sup>st</sup> week*

Mechanical tests: tensile test, hardness tests, Charpy-test

*2<sup>nd</sup> week*

Microscopy I: fundamentals of optical and transmission electron microscopy

*3<sup>rd</sup> week*

Microscopy II: Scanning electron microscopy, scanning tunneling microscopy, atomic force microscopy

*4<sup>th</sup> week*

Microscopy III.: field-electron and field-ion microscopy, atom-probe

*5<sup>th</sup> week*

Magnetic measurements: measurement of magnetization curves, magnetometers, Barkhausen-noise measurements

*6<sup>th</sup> week*

Secondary ion and secondary neutral mass spectrometry, Rutherford backscattering

*7<sup>th</sup> week*

X-ray spectrometry I.: origin of X-rays, X-ray spectra, emission and absorption

*8<sup>th</sup> week*

X-ray spectrometry II: electron-beam microanalysis, wavelength and energy dispersive detectors, qualitative and quantitative analysis.

*9<sup>th</sup> week*

X-ray spectrometry III: X-ray fluorescent analysis, proton induced X-ray emission

*10<sup>th</sup> week*

Electron spectrometry I.: fundamentals of electron spectroscopy, detectors, applications

*11<sup>th</sup> week*

Electron spectrometry II.: electron energy loss spectrometry, photoelectron spectrometry, Auger-electron spectrometry

*12<sup>th</sup> week*

Diffraction I.: fundamentals of diffraction, crystal systems, reciprocal lattice, Miller indices, Bragg-equation, Ewald construction

*13<sup>th</sup> week*

Diffraction II.: X-ray, electron and neutron diffraction, diffractometers, comparison of methods, applications

*14<sup>th</sup> week*

*Summar, discussion*

**Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory.

*- for a grade*

- The course ends in an **exam**.

The minimum requirement for the exam is 50%. The grade will be calculated according to the following table:

Score	Grade
0-50	fail (1)

51-62	pass (2)
63-75	satisfactory (3)
76-87	good (4)
87-100	excellent (5)
<b>Person responsible for course:</b> Dr.Lajos Daróczy, associate professor, PhD	
<b>Lecturer:</b> Dr.Lajos Daróczy, associate professor, PhD	

<b>Title of course:</b> Measurement Methods in Materials Science (practice) <b>Code:</b> TTFML0411_BT_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 2 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 28 hours - laboratory: - - home assignment :2 hours - preparation for the exam: - Total: 30 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> minimum 3 credits of physics	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The series of practices are based on the topics of modern measurement methods in the materials science. It reviews the fundamentals, technical details, practical aspects of the different methods. Selection of topics:: Mechanical tests: tensile test, hardness tests,. Microscopic methods: optical microscopy, transmission electron microscopy, scanning electron microscopy, atomic force microscopy. Magnetic methods: measurement of magnetization curves, magnetometers, Barkhausen-noise measurements. Ionometry:, secondary neutral mass spectrometry, Rutherford backscattering. X-ray spectrometry: electron probe micro analysis, proton induced X-ray emission. Electron spectroscopy:, photoelectron spectroscopy, Auger-electron spectroscopy. Diffraction methods: X-ray diffraction, electron diffraction.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          H. Czichos, T. Saito, L. Smith: Springer Handbook of Materials Measurement Methods, Springer Science+Business Media Inc. 2006          D.J. O'Connor, B.A. Sexton, R. St. C. Smart: Surface Analysis Methods in Materials Science, Springer-Verlag Berlin Heidelberg GmbH 1992</p> <p><i>Recommended:</i>          C.Giacavazzo: Fundamentals of Crystallography, Oxford University Press 1992          D.B. Williams and C.B.Carter: TransmissionElectronMicroscopy, Plenum Press 1996          J.A Stroscio, W. J. Kaiser:Methods of Experimental Physics Vol.27 Scanning Tunneling Microscopy, Academic Press (1997)</p>

**Schedule:***1<sup>st</sup> week*

Tensile test

*2<sup>nd</sup> week*

Hardness test

*3<sup>rd</sup> week*

Optical microscopy

*4<sup>th</sup> week*

Transmission electron microscopy

*5<sup>th</sup> week*

Scanning electron microscopy

*6<sup>th</sup> week*

Atomic force microscopy

*7<sup>th</sup> week*

Electron probe micro analysis

*8<sup>th</sup> week*

X-ray diffraction

*9<sup>th</sup> week*

Electron diffraction

*10<sup>th</sup> week*

Measurement of magnetization curves

*11<sup>th</sup> week*

Barkhausen-noise measurement

*12<sup>th</sup> week*

Secondary neutral mass spectrometry

*13<sup>th</sup> week*

Rutherford backscattering, proton induced X-ray emission

*14<sup>th</sup> week**Electron spectroscopy***Requirements:***- for a signature*

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Certificated missed practice classes should be made up for at a later date, to be discussed with the tutor.

In case of assigned practices submission of a written report is obligatory.

During the semester there are two compulsory home works.

Students have to submit both home works within the deadline. The scores have to be better than 50% in both cases.

*- for a grade*

The course ends in a practice mark.

.Based on the scores of the home works and the reports the grade will be calculated according to the following table:

Score

Grade

0-50	fail (1)
51-62	pass (2)
63-75	satisfactory (3)
76-87	good (4)
88-100	excellent (5)
<b>Person responsible for course:</b> Dr.Lajos Daróczy, associate professor, PhD	
<b>Lecturer:</b> Dr.Lajos Daróczy, associate professor, PhD	

<b>Title of course:</b> Atomic and molecular physics <b>Code:</b> TTFME0101_EN	<b>ECTS Credit points: 4</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: 1 hours/week - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: 14 hours - laboratory: - - home assignment: 40 hours - preparation for the exam: 38 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> introductory physics courses (at least 12 credits)	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>Electronic structure of one-electron atoms and ions. Energy levels, eigenstates, quantum numbers. Rydberg atoms. Interaction of one-electron atoms with electromagnetic field. Permanent and transition dipole moments of atoms. The dipole approximation. Einstein-coefficients. Selection rules. Intensity and broadening of spectral lines, life times of excited states. Fine- and hyperfine structure of one-electron atoms, Stark-effect, Lamb-shift. Electronic structure of two-electron atoms and ions. Double excitations, autoionization. Electronic structure of many-electron atoms. Central field approximation, LS- and jj-coupling schemes. Interaction of many-electron atoms with electromagnetic field. Selection rules, spectra of alkali metals. Helium atom and alkaline earth metals. Structure of molecules: separation of the electronic and nuclear motions. Rotation and vibration of diatomic molecules. Electronic structure of diatomic molecules. The aspect of polyatomic molecules. Electronic structure of the H<sub>2</sub><sup>+</sup> molecular ion, atomic and molecular orbitals, formation of the bond. Spectra of diatomic molecules: rotational energy levels, ro-vibrational spectral lines, transitions between electronic states. Atomic scattering processes, potential scattering, cross section, partial waves, the Born-approximation. Electron-atom scattering, elastic scattering, excitation of atoms, ionization, resonances.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          B.H. Bransden, C.J. Joachain: Physics of atoms and molecules, Longman Scientific &amp; Technical (1995)          D.J. Griffiths: Introduction to Quantum Mechanics, Prentice-Hall, New Jersey (1994)</p> <p><i>Recommended:</i>          I.N. Levine: Quantum Chemistry, Prentice Hall, New Jersey (2008)</p>

**Schedule:***1<sup>st</sup> week*

Electronic structure of one-electron atoms and ions. Energy levels, eigenstates, quantum numbers. Rydberg atoms.

*2<sup>nd</sup> week*

Interaction of one-electron atoms with electromagnetic field I.

Permanent and transition dipole moments of atoms. The dipole approximation. Einstein-coefficients.

*3<sup>rd</sup> week*

Interaction of one-electron atoms with electromagnetic field II.

Selection rules. Intensity and broadening of spectral lines, life times of excited states.

*4<sup>th</sup> week*

Fine- and hyperfine structure of one-electron atoms. Stark-effect, Lamb-shift.

*5<sup>th</sup> week*

Electronic structure of two-electron atoms and ions. Double excitations, autoionization.

*6<sup>th</sup> week*

Electronic structure of many-electron atoms. Central field approximation, LS- and jj-coupling schemes.

*7<sup>th</sup> week*

Interaction of many-electron atoms with electromagnetic field. Selection rules, spectra of alkali metals. Helium atom and alkaline earth metals.

*8<sup>th</sup> week*

Structure of molecules: separation of the electronic and nuclear motions. Rotation and vibration of diatomic molecules. Electronic structure of diatomic molecules. The aspect of polyatomic molecules.

*9<sup>th</sup> week*

Electronic structure of the H<sub>2</sub><sup>+</sup> molecular ion, atomic and molecular orbitals, formation of the bond.

*10<sup>th</sup> week*

Spectra of diatomic molecules: rotational energy levels, ro-vibrational spectral lines, transitions between electronic states.

*11<sup>th</sup> week*

Atomic scattering processes, potential scattering, cross section, partial waves, the Born-approximation.

*12<sup>th</sup> week*

Electron-atom scattering, elastic scattering, excitation of atoms, ionization, resonances.

*13<sup>th</sup> week*

Practical test.

*14<sup>th</sup> week*

Summary and consultation.

**Requirements:***- for a signature*

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course.

During the semester there are practical home works which have to be evaluated and submitted by the end of the 14<sup>th</sup> week of the semester. The requirement for a signature is a successful (> 50%) completion of the home works.

*- for a grade*

The course ends in an **examination**. The requirement for applying for an exam is to have a practical signature.

The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-75	satisfactory (3)
76-88	good (4)
89-100	excellent (5)

**Person responsible for course:** Dr.AndrásCsehi, senior lecturer, PhD

**Lecturer:** Dr.AndrásCsehi, senior lecturer, PhD



<b>Title of course:</b> Computational Quantum Chemistry <b>Code:</b> TTKMG0902_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 28 hours - laboratory: - - home assignment: 32 hours - preparation for the exam: 30 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> minimum 12 credits of mathematics	
<b>Further courses built on it:</b> -	

<b>Topics of course</b> - Hartree-Fock Theory. Density Functional Theory. Basis sets. Solvent effect, Polarizable Continuum Model. Geometry optimization. Structural analysis. Calculating energies of chemical reactions
<b>Literature</b> <i>Compulsory:</i> <a href="https://maker.pro/linux/tutorial/basic-linux-commands-for-beginners">https://maker.pro/linux/tutorial/basic-linux-commands-for-beginners</a> <a href="http://gaussian.com/keywords/">http://gaussian.com/keywords/</a> <i>Recommended:</i> <a href="http://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf">http://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf</a>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Basic theory of the Hartree-Fock method: approximations, LCAO-MO theory. Building structures by the GaussView program. <i>2<sup>nd</sup> week</i> Basic Linux commands, using the WinSCP and Putty programs, connecting by SFTP. Using the Gaussian program package, optimizing simple molecules. <i>3<sup>rd</sup> week</i> Geometry optimizations by different basis sets, comparing and calibrating the methods by structural parameters.
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4<sup>th</sup> week

Frequency analysis, calculating Gibbs free energies of simple reactions. Scanning a reaction pathway, finding the transition state, identifying the stationary points of the Potential Energy Surface.

5<sup>th</sup> week

Basic theory of the post-Hatree-Fock theories. Recalculating the previously studied systems and comparing them to the HF results.

6<sup>th</sup> week

Solvent effect, using Polarizable Continuum Models to refine the energies.

7<sup>th</sup> week

Basic theory of the Density Functional Theory. Recalculating the previously studied systems and comparing them to the (post-)HF results.

8<sup>th</sup> week

Systems with explicit solvent molecules.

9<sup>th</sup> week

Calculation on more difficult systems: metal complexes and relativistic effects.

10<sup>th</sup> week

Mid-term exam about calculations by using Gaussian.

11<sup>th</sup> week

Conformation analysis, more Linux commands.

12<sup>th</sup> week

Writing simple scripts in b shell.

13<sup>th</sup> week

Generating input files by scripts.

14<sup>th</sup> week

Exam of writing scripts in b shell.

Requirements:

- for a signature

Attendance is recommended, maximum 3 absences are accepted.

- for a grade

Class performance (33%)

Final examination (67%)

Based on the sum of the final practical exam of performing calculations and the class performance the practical grade is calculated.

The final grade is given according to the following table:

Score (%)	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of the final grade is below 50%, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. MihályPurgel, assistant professor, PhD

Lecturer: Dr. MihályPurgel, assistant professor, PhD

Dr. Attila Mándi, assistant professor, PhD

<b>Title of course:</b> Inorganic Chemistry V. <b>Code:</b> TTKME0203_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 3 hours/week	
<b>Evaluation:</b> examination	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 42 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 74 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b>	

<b>Topics of course</b>
<b>Literature</b> <i>Compulsory:</i> 1) Syllabus provided by the tutor <i>Recommended:</i> 2) R. H. Crabtree, THE ORGANOMETALLIC CHEMISTRY OF THE TRANSITION METALS (4th Edition), Wiley, 2005, ISBN 0-471-66256-9 (or later edition)
<b>Course objective/intended learning outcomes</b>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Brief history of organometallic chemistry. Definition, classification and general characterization of the organometallic compounds. <i>2<sup>nd</sup> week</i> General characterization of the p- and s-group organometallics, structure, physical and chemical properties, use. Methods for the preparation of them. <i>3<sup>rd</sup> week</i> Ionic (polar) organometallic compounds. <i>4<sup>th</sup> week</i> Organometallics containing multicenter bonding(s): organolithium, -magnesium, -boron and -aluminum compounds, their importance in the organic synthesis. <i>5<sup>th</sup> week</i> Organic compounds of the silicon, silicone polymers. <i>6<sup>th</sup> week</i> General characterization of the organotransition metal compounds: structure, physical and chemical properties, preparation. Definition of hapticity. <i>7<sup>th</sup> week</i>
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Transition metal alkyls and aryls: (cross)coupling reactions with Pd-alkyl catalysts (Heck, Negishi, Suzuki reactions). Transition metal carbonyls and their synthetic use (carbonylation reactions: Monsanto process, hydroformylation of alkenes).

8<sup>th</sup> week

Transition metal alkene and alkyne complexes and some selected applications (Wacker process, Ziegler-Natta polymerization process)

9<sup>th</sup> week

Important  $\eta^3$ - $\eta^8$  organotransition compounds and their practical use. Metallocenes.

10<sup>th</sup> week

Porous materials, general preparation routes. preparation of mesopores. Special features and practical use of non-silica mesoporous materials, special adsorbents. Procedures and materials based on sol-gel technologies. Aerogels, aerogel composites, hybrids. Silica-based aerogel nanocomposites and their use from catalysis to medical therapy.

11<sup>th</sup> week

General characterization of nanoparticles and nanowires, their special features. Preparation techniques for nanoparticles, special experimental techniques. Molecular magnets, one dimensional metals.

12<sup>th</sup> week

Metal-organic frameworks (MOF), properties, preparation and use of self-organising materials. Chemical materials with semiconducting properties. Features of quantum dots, their preparation, experimental techniques for their study and their practical applications.

13<sup>th</sup> week

Materials for transparent ceramics: ways of preparation, properties, practical use. Solid phase chemical reactions, solid electrolytes, fuel cells. Ceramic metal and metal ceramic composites, metal glasses.

14<sup>th</sup> week

Colour changing materials, interpretation of the electrochromic, thermochromic, chemochromic and solvatochromic properties. Composition, preparation and use of colour changing materials. Special modifications of carbon. Properties, preparation and use of single and multi-wall carbon nanotubes, graphenes, fullerenes, fullerites and carbon nanowires.

### Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

- for a grade

The course ends in an **examination**.

The minimum requirement for the examination is 40 score. Based on the score, the grade for the examination is given according to the following table:

Score	Grade
0-39	fail (1)
40-55	pass (2)
56-70	satisfactory (3)
71-85	good (4)
86-100	excellent (5)

If the score of any test is below 40, students can retake the test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Péter Buglyó, associate professor, PhD

**Lecturers:** Dr. Péter Buglyó, associate professor, PhD

Dr. István Lázár, associate professor, PhD

<b>Title of course:</b> Inorganic Chemistry VI. <b>Code:</b> TTKML0203_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 6 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - laboratory: 84 hours - home assignment: 36 hours - preparation for the exam: - Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b>	

<b>Topics of course</b>
Synthesis and characterization of non-metal and metal compounds and complexes using high/low temperature or pressure, vac-line technique. Qualitative and quantitative analysis of the compounds with classical and instrumental techniques.
<b>Literature</b>
1. Syllabus provided by the tutor. 2. Inorganic Experiments (ed. J. D. Woolins), 2 <sup>nd</sup> Edition, Wiley-VCH, 2003

<b>Schedule:</b> 2 h introduction + 9 x 6 h practice 1 <sup>st</sup> week: Introductory guidance, safety regulations and protection (2h)  2 <sup>nd</sup> week: Preparation of $[\text{Ni}(\text{NH}_3)_x]\text{Br}_2$ and determination of its stoichiometry via classical volumetric analysis.  3 <sup>rd</sup> week: Synthesis and characterization of a copper-oxalate complex, $\text{K}_a\text{Cu}_b(\text{C}_2\text{O}_4)_c \cdot d\text{H}_2\text{O}$  4 <sup>th</sup> week: Green chemical preparation of copper(I)-iodide and its study  5 <sup>th</sup> week: Synthesis and characterization of metal acetylacetonates  6 <sup>th</sup> week: Synthesis and characterization of transition metal phosphane complexes
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7 <sup>th</sup> week: Full sandwich type organometallic compounds of $\pi$ -donor areneligands
8 <sup>th</sup> week: Preparation and study of $[\text{MoO}_2\text{Br}_2(\text{H}_2\text{O})_2]\cdot\text{diglyme}$ and $[\text{MoO}_2\text{Br}_2(\text{DMF})_2]$
9 <sup>th</sup> week: Ni(II) complexes of Schiff-baseligands: templatesynthesis and NMR study
10 <sup>th</sup> week: A model compound for B <sub>12</sub> vitamin with direct Co-C bond: synthesis and characterization
<p><b>Requirements:</b></p> <p>- <i>for a signature</i></p> <p>Participation at practices is compulsory. Students must attend every practice during the semester. In case of absence(s), a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor.</p> <p>- <i>for a grade</i></p> <p>Grading is given by considering the following three separate grades:</p> <ul style="list-style-type: none"> <li>- the average grade of the short tests written at the beginning of the practices (an average of at least 2.0 is necessary to avoid a 'fail' final grade) (30 %)</li> <li>- the average grade of evaluation of the quality and quantity of the prepared compounds and the laboratory notebook prepared by the student (an average of at least 2.0 is necessary to avoid a 'fail' final grade) (30 %)</li> <li>- the grade of the oral discussion on the topics of the practice and the results of the student with the tutor in the second half of the semester (in case of 'fail' mark the oral discussion can once be repeated and an average grade will be taken into consideration) (40 %)</li> </ul>
<b>Person responsible for course:</b> Dr.PéterBuglyó, associate professor, PhD
<b>Tutor:</b> Dr.PéterBuglyó, associate professor, PhD

<b>Title of course:</b> InorganicChemistry VII. <b>Code:</b> TTKME0204_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 32 hours - preparation for the exam: 30 hours Total: 90 hours:	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Furthercoursesbuiltin:</b> TTKME0203_EN, TTKML0203_EN	

<b>Topics of course</b>
To understand the molecular basis of biological role of trace elements and the harmful effects of toxic inorganic compounds; to get to know the possibilities of using these knowledges in medicine, environmental protection and other areas of life.
<b>Literature</b>
<i>Compulsory:</i> 1. Robert Chrichton: BiologicalInorganicChemistry, An introduction, Elsevier, 2008, ISBN: 978-0444-52740-0 2. Rosette Roat-Malone: Bionorgaincchemistry, Wiley-Interscience, 2002, ISBN: 0-471-15976-X. 3. J.A. Cowan, InorganicBiochemistry, An introduction, Wiley-VCH, 1997, ISBN: 0-471-18895-6 <i>Recommended:</i> 1. ElichiroOchiai: Bioinorganicchemistry, Elsevier, 2008, ISBN: 978-0-12-088756-9 2. S.J. Lippard, J.M. Berg, Principles of BioinorganicChemistry, University Science Books, Mill Valley, CA 1994. 3. E.I. Ochiai, General Principles of Biochemistry of theElements, Plenum Press, New York, London (1987). 4. W. Kaim, B. Schwederski, BioinorganicChemistry, InorganicElements in theChemistry of Life, John Wiley and Sons, Chichester, 1994.

<b>Schedule:</b> 1 <sup>st</sup> week Classification of theelementsaccordingtotheirrole in biologicalsystems. Essential, beneficial and toxicelements and theirrole in biochemicalprocesses. The factorsthatdeterminedthenaturalselection of essentialelements
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*2<sup>nd</sup> week* The basis of coordination chemistry; chelate effect. The hard-soft theory. The crystal field theory. The crystal field theory.

*3<sup>rd</sup> week* Coordination chemistry of the most common bioligands including amino acids, peptides, proteins, carbohydrates, nucleotides and porphyrins. Characterization of metalloproteins and metalloenzymes.

*4<sup>th</sup> week* Membrane transport process: diffusion, passive and active transport. Cation distribution and membrane transport processes. Involvement of alkaline metal ions in biological processes:

*5<sup>th</sup> week* The role of magnesium in human body and in photosynthesis. The main roles of calcium in biological systems (with examples)

*6<sup>th</sup> week* Binding, transport and activation of oxygen. The role of iron in the transport and storage of oxygen.

*7<sup>th</sup> week* The role of iron in catalysis of redox processes: cytochromes and iron-sulphur proteins. The structure and properties of cytochromes.

*8<sup>th</sup> week* The structure and properties of iron-sulphur proteins. The transport and storage of iron.

*9<sup>th</sup> week* The structure and properties of copper proteins. The participation of copper in biological oxidation reactions. Disorders of copper metabolism. Wilson and Menkes diseases.

*10<sup>th</sup> week* Biochemistry of zinc: zinc-containing enzymes and zinc-finger proteins. The role of zinc in catalysis of acid-base processes (with examples) and in determination of protein structures (Cu, Zn-superoxide dismutase, zinc-finger proteins)

*11<sup>th</sup> week* Involvement of other essential elements in biological processes: the enzymes/coenzymes of manganese, cobalt, nickel, molybdenum, vanadium and selenium.

*12<sup>th</sup> week* Toxic elements: biochemistry and harmful effects of aluminium, thallium, lead and tin.

*13<sup>th</sup> week* 18. The role of metal ions in the brain. The use of inorganic compounds in therapy and diagnosis.

*14<sup>th</sup> week* Environmental aspects of inorganic substances.

### **Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

Preparation of a project including a bioinorganic chemistry theme (10 %)

Oral examination: discussion of two topics (90 %)

The minimum requirement is 50 %:

Score	Grade
0-50	fail (1)
51-60	pass (2)
61-75	satisfactory (3)



76-89	good (4)
90-100	excellent (5)
In the case of the exam is not successful, the exam is repeatable (two times).	
<b>Person responsible for course:</b> Prof.Dr. Katalin Várnagy, university professor, DSc	
<b>Lecturer:</b> Prof. Dr. Katalin Várnagy, university professor, DSc	

<b>Title of course:</b> Physical Chemistry VI. <b>Code:</b> TTKME0401_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 3 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 42 hours - practice: - - laboratory: - - home assignment: 40 hours - preparation for the exam: 38 hours Total: 102 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The series of lectures are based on selected topics of advanced physical chemistry.</p> <p>Main topics include:</p> <ul style="list-style-type: none"> <li>- Thermodynamics in axiomatic approach</li> <li>- Concepts and applications of irreversible thermodynamics</li> <li>- Concepts and applications of statistical thermodynamics</li> <li>- Radiochemistry</li> <li>- Photochemistry</li> <li>- Structure of matter and supramolecular chemistry.</li> </ul>
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- P.W. Atkins, J. de Paula (2006): Atkins' Physical Chemistry 8<sup>th</sup> Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8.</li> <li>- J. Kónya, N. M. Nagy (2018): Nuclear and Radiochemistry, Elsevier, ISBN: 9780128136430</li> <li>- P. Érdi, G. Lente (2014): Stochastic Chemical Kinetics, Springer, ISBN: 978-1493903863</li> <li>- Lecture notes and teaching material available via the e-learning system</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>-K. K. Rohatgi-Mukherjee: Fundamentals of Photochemistry (revised edition) - e-book; publisher: New Age International, 1978; 371 pages; ISBN: 0852267843, URL: <a href="http://www.ebook3000.com/Fundamentals-OfPhotochemistry_126059.html">http://www.ebook3000.com/Fundamentals-OfPhotochemistry_126059.html</a></li> </ul>

**Schedule:**

*1<sup>st</sup> week* Classical and rational thermodynamics. Axiomatic approach

Concepts: Logical discrepancies in the classical thermodynamics and the different ways of explanation and solution methods. 0<sup>th</sup>, 1<sup>st</sup> 2<sup>nd</sup> and 3<sup>rd</sup> law of thermodynamics, advanced perspective.

*2<sup>nd</sup> week* Irreversible thermodynamics, introduction

Concepts: Basic terminology of irreversible thermodynamics. Entropy production, thermodynamic forces and flows. Onsager relations. Seebeck-, Peltier- and Hall-effect

*3<sup>rd</sup> week* Irreversible thermodynamics. Applications.

The phenomenological equations and thermodynamic forces. Chemical affinity. De Donder inequality and direction of chemical processes in irreversible systems. Knudsen gases. Electro-osmosis. Electrokinetic phenomena. Non-equilibrium chemical systems, continuous model.

*4<sup>th</sup> week* Statistical thermodynamics, introduction and applications

Concepts: Molecular state, configuration. Internal energy and entropy in discrete systems. Partition functions. Calculation of translational, rotational and vibrational energy contributions. Calculation of heat capacity, zero point entropy and equilibrium constant, main formulas of partition functions. Thermodynamic information content of partition function.

*5<sup>th</sup> week* Chemical kinetics

Concepts: Rate equations, simplification methods, collision theory and transition state theory. Types of reactors. Processes in reactors. Continuous stirred tank reactor (CSTR), flow reactors, stochastic models of chemical kinetics

*6<sup>th</sup> week* Isotope effects. Interaction of nuclear radiation and matter. Energy transport between alpha particles and electrons.

Concepts: Types of isotope effects and their characterization in physics, chemistry, environmental science, and use in isotope separation. Mechanism of energy transfer between charged particles. Practical consequences. Physical background of the formulas.

*7<sup>th</sup> week* Nuclear reactions

Concepts: Nuclear reactions with neutrons and charged particles.

Thermonuclear reactions. Preparation of radioactive isotopes

*8<sup>th</sup> week* Environmental questions of nuclear energy production

Concepts: Nuclear waste, separation, and activity levels. Disposal of nuclear waste and spent fuel elements.

*9<sup>th</sup> week* Photochemistry. Interaction of electromagnetic radiation and molecules

Concepts: Franck-Condon principle. Electron transitions, oscillator strength and cross section.

*10<sup>th</sup> week* Photophysical processes

Concepts: Fluorescence, phosphorescence and other photophysical processes. Inter- and intramolecular energy transport. Kinetics of photophysical processes.

*11<sup>th</sup> week* Photochemistry

Concepts: Photodimerization, photoisomerization, photodissociation and photoaddition, photon induced redox processes. Examples.

*12<sup>th</sup> week* Experimental methods of photochemistry.

Concepts: Light sources, their characterization and types. Spectrophotometer, spectrofluorometer, flash photolysis, actinometry. Mathematical description of photochemical reactions.

*13<sup>th</sup> week* Critical comparison of structure determination methods.

Concepts: Modern structure determination methods, advantages and disadvantages. Spectroscopic and diffraction methods. Modern methods of surface studies.

*14<sup>th</sup> week* Secondary interactions – supramolecular chemistry, biological consequences.

Concepts: Types of secondary interactions and their role in stabilizing solid state structures. Structure

and function of biological macromolecules. Basic terminology of supramolecular chemistry.													
<p><b>Requirements:</b></p> <p><i>- for a signature</i></p> <p>Attendance at <b>lectures</b> is recommended, but not compulsory.</p> <p>During the semester there is a written end-term test in the 15<sup>th</sup> week. Students have to sit for the test.</p> <p><i>- for a grade</i></p> <p>The course ends in a <b>written or oralexamination</b>. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student. Questions of the exam with scoring system are provided for the students.</p> <p>The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and the examination is given according to the following table:</p> <table> <tr> <th>Score</th><th>Grade</th></tr> <tr> <td>0-59</td><td>fail (1)</td></tr> <tr> <td>60-69</td><td>pass (2)</td></tr> <tr> <td>70-79</td><td>satisfactory (3)</td></tr> <tr> <td>80-89</td><td>good (4)</td></tr> <tr> <td>90-100</td><td>excellent (5)</td></tr> </table> <p>If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.</p> <p><i>-an offered grade:</i></p> <p>It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).</p>		Score	Grade	0-59	fail (1)	60-69	pass (2)	70-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade												
0-59	fail (1)												
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80-89	good (4)												
90-100	excellent (5)												
<b>Person responsible for course:</b> Dr. Attila Bényei, associate professor, PhD													
<p><b>Lecturer:</b> Prof.Dr.Noémi Nagy, university professor, DSc</p> <p>Dr. Attila Bényei, associate professor, PhD</p> <p>Dr.MihályPurgel, assistant professor, PhD</p>													

<b>Title of course:</b> Physical Chemistry VII. <b>Code:</b> TTKML0405_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 3 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 42 hours - home assignment: 48 hours - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>This course is intended to stimulate students for independent work. This means that the students are supposed to have well established basic knowledge of laboratory work and capability to design, perform and elucidate physico-chemical experiments and their results as well as to prepare appropriate laboratory notebook. The tasks detailed here contain mainly thermodynamic, equilibrium and kinetic studies.</p> <p>Set of measurements:</p> <p>301. Examining the formation of complex ion by spectrophotometry</p> <p>302. Kinetic examination of the acetone–iodine reaction</p> <p>303. Determination of the equilibrium constant in the triiodine ion formation reaction by spectrophotometry</p> <p>304. Study of mutual solubility of three liquids</p> <p>305. Determining ion transport number with the Hittorf's and moving boundary method</p> <p>306. Determination of mean activity coefficient based on solubility measurements</p> <p>307. Promotor and inhibitor effect in the catalytic decomposition of H<sub>2</sub>O<sub>2</sub></p> <p>308. Effect of temperature and ionic strength on the reaction between iodide and persulfate ions</p> <p>309. Study of ultraviolet and visible spectra of metal complexes</p> <p>310. Kinetic analysis of an autocatalytic reaction by spectrophotometric method</p> <p>311. Study of vapour–liquid equilibrium in two component system</p> <p>312. Investigation of iodide–persulfate reaction by measuring the change of absorption</p> <p>313. Effect of ionic strength on the rate of reduction of hexacyanoferrate(III) by ascorbic acid</p>

## Literature

- Laboratory notes and additional teaching material available via the e-learning system.
- P.W. Atkins, J. de Paula: Atkins' Physical Chemistry 8<sup>th</sup> Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8, 2006
- Á. Kathó, V. Kiss, A. Udvardy, A. Bényei, Physical Chemistry laboratory measurements for MSc students, Egyetemi Kiadó
- K. Ösz, A. Bényei: Physical Chemistry Laboratory Measurements (for students of Pharmacy, Chemistry and Chemical Engineering). Debreceni Egyetemi Kiadó, ISBN: 978-963-318-143-0, 2011

**Schedule:** One of the measurements listed above (**Topics of course**) per week except the 1<sup>st</sup> practice (introduction, general information and safety training).

### Requirements:

Participation on the laboratory practice is compulsory. The measurements and knowledge of the associated theory are marked and an overall mark will be given. Safety training (1<sup>st</sup> week) is mandatory before the first lab practice (2<sup>nd</sup> week). Everybody should work individually according to the pre-set schedule (which will be provided on the 1<sup>st</sup> week). Lab practices are 6 hours long every week (from the 2<sup>nd</sup> until the 7<sup>th</sup> week). Being late or failed mark on the written test from the appropriate measurement is equivalent with an absence. In accordance with the regulations of University of Debrecen, attendance is compulsory with the exception of health or family problems (the reason of absence should be certified). In this case, the students should agree with the teacher on replacement dates for the missed experiments.

### Requirements for the grade:

The measurements (regularly) and written tests (occasionally) according to the knowledge of the associated theory are marked and the overall mark will be given based on these.

- All of the notebooks of the measurements have to be marked as "pass (2)" or better for the successful completion.

- The minimum requirement for the written tests is 60%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the average of written tests is below 60% the best grade for the course can be only "pass (2)" in any other cases the final mark is given with weighted average by means of the mark of the written tests and notebooks in 1 to 2 ratio.

**Person responsible for course:** Dr. Ferenc K. Kálmán, assistant professor, PhD

**Lecturer:** Dr. Ferenc K. Kálmán, assistant professor, PhD

<b>Title of course:</b> Physical Chemistry VIII. <b>Code:</b> TTKML0406_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 3 hours/week	
<b>Evaluation:</b> practice	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - hours - practice: - hours - laboratory: 42 hours (7 weeks, 6 hours/week) - home assignment: 48 hours - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The goal of this laboratory practice for the students is to make complex physical chemical measurements based on their theoretical and practical knowledge, beginning from the planning of the measurements, through the effective implementation, until the evaluation of the data and comparison with the literature. They have to be capable to perform these tasks by themselves, helped by a description containing short guidances about the theoretic background of the problem as well as practical advices. On the whole they have to acquire the necessary theoretical and practical proficiency for individual research work.</p> <p><i>Set of lab measurements:</i></p> <ul style="list-style-type: none"> <li>- Study of homogeneous isotope exchange in the ethyl iodide-I<sup>-</sup> ion system.</li> <li>- Determination of the average size and size distribution of suspended particles with sedimentation. Effect of the electrolyte on the sedimentation.</li> <li>- Determination of the electric surface charge of solid particles by potentiometric titration. The effect of pH and electrolytes on the interfacial electric double layer. Determination of the point of zero charge.</li> <li>- Preparation of a lyosol and study of its coagulation. Effect of electrolytes and polymers on the coagulation (steric and electrostatic inhibition). Validation of the Hardy-Schulze rule.</li> <li>- Preparation of emulsions. Effect of the amount of surfactant on the nature and stability of the emulsion. Rheological properties of emulsions.</li> <li>- Study of radioactive radiation with solid state trace detector.</li> </ul>

- Investigation of the absorption of a herbicide by radioactive tracer experiment. Familiarization with the measurement technique of low energy  $\beta$  radiation.

## Literature

### *Compulsory:*

- Laboratory manual downloadable from the Department's homepage (<http://fizkem.unideb.hu>)

### *Recommended:*

- J. Kónya and N. M. Nagy: Nuclear and radiochemistry, Elsevier, 1st edition, ISBN: 978-0-12-391430-9, 2012

- W. Bostock, J. *Scient. Instr.* 29: 209, 1952

- D.J. Shaw: Introduction to Colloid and Surface Chemistry. Butterworth-Heinemann, ISBN 978-0-08-050910-5, 1992

- P. W. Atkins, J. de Paula: Physical Chemistry, W. H. Freeman, ISBN 0-7167-8567-6 & ISBN 0-7167-8569-2, 2006

- Pashley, R. M.: Applied Colloid & Surface Chemistry. Wiley & Sons, ISBN 0-a470-a86883-aX, 2004

## Schedule:

One of the topics as listed above per week (see under **Topics of course**) except the 1<sup>st</sup> practice when an introduction, general information and safety training will be given.

## Requirements:

The measurements and the knowledge of the associated theory are marked and an overall mark will be given. Safety training (1<sup>st</sup> week) is mandatory before the first lab practice (2<sup>nd</sup> week). Everybody should work in small groups according to the pre-set schedule (which will be provided on the 1<sup>st</sup> week). Lab practices are 6 hours long every week (from the 2<sup>nd</sup> until the 7<sup>th</sup> weeks). Being late is equivalent to an absence. In accordance with the EDUCATION AND EXAMINATION RULES AND REGULATIONS of the University of Debrecen, the attendance is compulsory with the exception of health or family problems (the reason of the absence should be certified). In this case, the students should agree with the teacher on replacement dates for the missed experiments.

### *- for a signature*

Attendance at **all laboratory courses** is compulsory (for exceptions see above).

### *- for a grade*

The measurements (with appropriate lab notes) and written tests from the associated theory are marked and the overall mark will be given based on the weighted average these marks (a weight of 2 is assigned to the measurement's marks and a weight of 1 to the written test's marks).

- At least 5 notebooks of the measurements (from a total of 6) have to be marked as "pass (2)" or better for the successful completion.

- The minimum requirement for the overall mark is 50%. The grade for the laboratory practice is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)



75-89	good (4)
90-100	excellent (5)
<b>Person responsible for course:</b> Dr.LeventeNovák, assistant professor, PhD	
<b>Lecturer:</b> Dr.LeventeNovák, assistant professor, PhD	

<b>Title of course:</b> Synthetic Methods in Organic Chemistry I. <b>Code:</b> TTKME0301_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - laboratory: - - home assignment: 14 hours - preparation for the exam: 48 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- General characterization of organic syntheses. - Methods for introducing key functional groups and their interconversion. - The most important protecting groups and their application. - Retrosynthetic analysis and its application.
<b>Literature</b>
<i>Compulsory:</i> Lecture slides <i>Recommended:</i> 1. P. Wyatt, S. Warren: OrganicSynthesis: Wiley: Chischester, 2007 2. M. B. Smith: OrganicSynthesis, 3rd Ed., McGraw-Hill: New York, 2008 3. F. A. Carey, R. J. Sundberg: Advanced OrganicChemistry, 3rd Ed., Part B, Plenum Press: New York-London, 1990 4. M. B. Smith, J. March: Advanced OrganicChemistry, 6th Ed., Wiley: New Jersey, 2007 5. R. C. Larock: ComprehensiveOrganicTransformations, 2nd Ed., Wiley: New York, 1999 6. R. O. C. Norman, J. M. Coxon: Principles of OrganicSynthesis, 3rd Ed., BlackieAcademic& Professional: London, 1994 7. L. S. Starkey: IntroductiontoStrategiesforOrganicSynthesis, Wiley, 2012 8. T. W. Greene, P. G. M. Wuts: ProtectiveGroups in OrganicSynthesis, 4th Ed., Wiley: New Jersey, 2007 9. P. J. Kocienski: ProtectingGroups, 3rd Ed., Thieme: Stuttgart-New York, 2005 10. J. Pearson, W. R. Roush: ActivatingAgents and Protecting Groups. In: Handbook of ReagentsforOrganicSynthesis, Wiley: Chichester, 1999 11. S. Warren, P. Wyatt: <i>Organic Synthesis: The Disconnection Approach</i> , 2nd Ed., Wiley, 2008

**Schedule:**

*1<sup>st</sup> week*

Methods for the formation of C=C double bonds.

*2<sup>nd</sup> week*

Methods for the formation of C=C double bonds.

*3<sup>rd</sup> week*

Methods for the formation of C-Hlg derivatives, metallo-organic compounds and their application for C-C coupling, C-H activation.

*4<sup>th</sup> week*

Methods for the formation of C-OH and C-SH bonds.

*5<sup>th</sup> week*

Methods for the formation of C-NH<sub>2</sub>, C-NHR, C-NRR<sub>1</sub> bonds.

*6<sup>th</sup> week*

Methods for the formation of C=O bond.

*7<sup>th</sup> week*

Methods for the formation of COOH/COX groups.

*8<sup>th</sup> week*

General aspects of the use of protective groups.

*9<sup>th</sup> week*

Cleavage classes (Kocienski's classification). Protection of alcoholic / phenolic hydroxyl groups.

*10<sup>th</sup> week*

Protection of 1,2- and 1,3-diols.

*11<sup>th</sup> week*

Protection of carboxylic acids (carboxyl group).

*12<sup>th</sup> week*

Protection of amines (amino group) and carbonyl group.

*13<sup>th</sup> week*

Retrosynthesis: basic concepts, retrosynthetic analysis of aromatic compounds.

*14<sup>th</sup> week*

C-X disconnections.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in a written exam in the exam period. The exam grade is the result of the written exam.

The minimum requirement for the examination respectively is 50%. The grade for the written exam is given according to the following table:

Score	Grade
0-49	fail (1)
50-64	pass (2)
65-75	satisfactory (3)
76-87	good (4)
88-100	excellent (5)

If the score of any test below 50, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.
<b>Person responsible for course:</b> Dr. Marietta Vágvölgyin Tth, associate professor, PhD,habil
<b>Lecturer:</b> Dr. Marietta Vgvlgyin Tth, associate professor, PhD,habil

<b>Title of course:</b> SyntheticMethods in OrganicChemistry II. <b>Code:</b> TTKML0302_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 4 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 56 hours - home assignment: 34 - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The aim of the course is to enable students to learn the general synthetic methods of organic chemistry and their practical implementation, to practice the use of literature and the structural analysis of organic small molecules.</p> <p>The 4-hour laboratory practice is compacted in 7 × 8 hours. Students will get an individual list of tasks including six organic compounds to be synthesized, a literature search and a spectrum analysis task. The execution of the tasks and the order of their implementation are planned by the students.</p> <p>Preparative work includes:</p> <ul style="list-style-type: none"> <li>• synthesis of heterocycles</li> <li>• preparation of compounds with single and double carbon-carbon bonds</li> <li>• preparation of organic molecules having C-O and C-N bonds.</li> </ul>

## Literature

### Compulsory:

- J. R. Mohrig, D. G. Alberg, G. E. Hofmeister, P. F. Schatz, C. Noring Hammond:

**Laboratory Techniques in Organic Chemistry** (Supporting Inquiry-Driven Experiments), 4<sup>th</sup> edition, W. H. Freeman and Company. ISBN-13: 978-1-4641-3422-7.

### Recommended:

- E.K. Meislich, H. Meislich, J. Sharefkin: 3000 Solved problems in Organic Chemistry, McGraw-Hill INC, 1994.

- R.O.C: Norman, J.M. Coxon: Principles of Organic Synthesis, Blackie Academic & Professional, Glasgow, U.K., 1993.

## Schedule:

### 1<sup>st</sup> week

#### Introduction:

Timetable and requirements. Receiving of laboratory equipment and list of tasks. Safety education.

#### Preparative work:

Preparation and purification of a selected organic compound from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC,  $R_f$ ). Calculation of yield.

### 2<sup>nd</sup> week

#### Shortwritten test:

Topics: formation of carbon-carbon single and multiple bonds (Grignard reactions and their applications;  $\beta$ -dicarbonyl compounds as C-nucleophiles; ethinylation reactions; CN<sup>-</sup> as nucleophile; Wittig reaction; elimination reactions; reductive methods towards partial or complete saturation of multiple carbon-carbon bonds, Aldol condensation and related variants).

Safety rules, basic concepts of spectroscopy, definitions.

### 3<sup>rd</sup> week

#### Shortwritten test:

Topics: Formation of C-O, C-S, C-O-C, C-S-C bonds (syntheses of alcohols, phenols, ethers and their thioanalogs e.g. acid catalyzed hydration of double/triple bonds, oxymercuration, hydroxymercuration, hydroboration, halohydrin formation, Kucserov reaction, epoxidation, preparation of vicinal diols:  $OsO_4$ ;  $KMnO_4$ ; ring-opening of epoxides; formation of acetals and hydrates;  $S_N$  reactions with O-nucleophiles; Williamson ethers synthesis, preparations of thioanalogs).

Chromatographic purification techniques (TLC, column chromatography), recrystallization.

Spectral analysis of known organic compounds.

**Preparative work:** Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC,  $R_f$ ). Calculation of yield(s).

### 4<sup>th</sup> week

#### Shortwritten test:

Topics: formation of C-N, C=N and C $\equiv$ N bonds (synthetic routes towards aliphatic and aromatic amines wherein C-N bond is built up: Gabriel synthesis;  $S_N$  reactions with N-nucleophiles; Hofmann rearrangement; reductive amination; syntheses of imines, Schiff bases, oximes, hydrazones; syntheses of nitro and nitroso compounds; syntheses of azo- and diazo compounds and their transformations)

Extraction methods. Drying liquids and solids.

Spectral analysis of known organic compounds.

**Preparativework:**Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC,  $R_f$ ). Calculation of yield(s).

5<sup>th</sup> week

**Shortwritten test:**

Topics: Oxidative and reductivemethods in organicsyntheses: theirapplications, advantages and limitations. (*applications of Jones reagent; PCC;  $KMnO_4$ ;  $MnO_2$ ; peroxyacids;  $H_2O_2$ ; DMD (dimethyldioxirane);  $O_3$  in case of differentsubstrates; Baeyer-Villigeroxidation; Oppenaueroxidation;  $H_2/Pd$  (and itsvariants); Birchreduction; applications of metal hydrides ( $NaBH_4$ ;  $LiAlH_4$ ;  $NaCNBH_4$ , DIBAL-H etc.);  $Fe/HCl$ ;  $(NH_4)_2S_x$ ;  $SnCl_2$ ; Meerwein-Ponndorf-Verleyreduction; Stephen reduction; reductiveamination and theirreactionconditions*).

Classification of solvents and their effects on the outcome of the organic reactions.

Spectralanalysis of known organic compounds.

**Preparativework:**Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC,  $R_f$ ). Calculation of yield(s).

6<sup>th</sup> week

**Shortwritten test:**

Topics: Synthesis and transformation of carbonyl compounds (*syntheses of ketones, aldehydes, carboxylic acids and related derivatives; reactions of oxo derivatives with O, S- and N-nucleophiles reductive, oxidatives, condensation and hydrolytic transformations; interconversions of carboxylic acid derivatives*). Synthesis of heterocycles.

Spectralanalysis of known organic compounds.

**Deadline for submitting the spectrum analysis and literature task.**

**Preparativework:**Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC,  $R_f$ ). Calculation of yield(s).

7<sup>th</sup> week

**Shortwritten test:**

Topics: Complex synthesis designing (*Design of multi-step synthesis of a selected compound using the knowledge acquired during the semester. Detailed description and interpretation of the synthesis and isolation steps of the compound.*)

**Last occasion to present the synthesized product to the instructor.**

**Evaluation.**

**Requirements:**

Attendance at laboratory practice is mandatory.

Before starting to prepare a selected compound, students must give an oral report on their theoretical organic chemistry and practical knowledge as well as on the safety rules.

The synthetic work can only be started after a successful discussion.

Minimum requirements for signing the course:

- Syntheses and characterizations of the selected six organic compounds.
- Sufficient level of the discussion (pass, (2)) for each preparation.
- Minimum level of the written test: at least 50 % of the overall score.
- Submission of the spectroscopic task within the given time.
- Presentation of the result of the literature search within the given time.

<p>In case of failure of any subtask, the practice ends with a poor (1) grade.</p> <p>The final grade will be determined based on the average of the grades of tasks. A weighted average of the grades of subtasks will be calculated in the following manner:</p> <ul style="list-style-type: none"> <li>• Activity in laboratory practice, discussion (40 %)</li> <li>• Short written test (40 %)</li> <li>• Spectroscopic task (10 %)</li> <li>• Literature search (10 %)</li> </ul> <p>Final grade: excellent (5): 90 %; good (4): 75 %; satisfactory (3): 60 %; pass (2): 50 %; fail (1): below 50 %.</p>
<p><b>Person responsible for course:</b> Dr.ÉvaBokor, assistant professor, PhD</p>
<p><b>Lecturer:</b> Dr.ÉvaBokor, assistant professor, PhD</p>

<p><b>Title of course:</b>Heterocycles</p> <p><b>Code:</b> TTKME0327_EN</p>	<p><b>ECTS Credit points:</b> 3</p>
<p><b>Type of teaching, contact hours</b></p> <ul style="list-style-type: none"> <li>- lecture: 2 hours/week for day-time course, 8 hours/semester for reading course</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<p><b>Evaluation:</b> exam</p>	
<p><b>Workload (estimated), divided into contact hours:</b></p> <ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 10 hours</li> <li>- preparation for the exam: 52 hours</li> </ul> <p>Total: 90 hours</p>	
<p><b>Year, semester:</b> 1<sup>st</sup> year, 2<sup>nd</sup> semester</p>	
<p><b>Its prerequisite(s):</b> -</p>	
<p><b>Further courses built on it:</b> -</p>	

<p><b>Topics of course</b></p>
<ul style="list-style-type: none"> <li>- Classification and nomenclature of heterocyclic compounds.</li> <li>- Preparation and reactions of oxiranes, thiiranes and aziridines.</li> <li>- Characterization, preparation and reactions of four-membered heterocycles with one heteroatom.</li> </ul> <p>Preparation of azetidine-2-one derivatives and introduction of <math>\beta</math>-lactam antibiotics.</p> <ul style="list-style-type: none"> <li>- Description of five-membered heterocycles with one or more than one heteroatom</li> <li>- Characterization of benzene-condensed five-membered heterocycles.</li> <li>- Characterization, preparation and reactivity of 2H-pyran derivatives.</li> <li>- Characterization, preparation and reactivity of pyridine derivatives.</li> <li>- Six- and seven membered derivatives with one or two heteroatoms.</li> <li>- Representatives of flavonoids, their preparation and reactions.</li> </ul>

**Literature:***Compulsory:*

Lecture material available at the e-learning system.

*Recommended:*

TheophilEicher, Siegfried Hauptmann: The chemistry of heterocycles; structure, reactions, syntheses, and applications, 2nd edition, WILEY-VCH GmbH & Co. KGaA, 2003.

John A. Joule, Keith Mills: Heterocyclic chemistry, 5th edition, A John Wiley&Sons, Ltd., 2010.

**Schedule:***1<sup>st</sup> week*

Definition and importance of heterocycles. Classification and nomenclature of heterocycles.

*2<sup>nd</sup> week*

Preparation, occurrence and reactions of oxiranes. Enantioselective epoxidation.

The student gets acquainted with the three-membered, oxygen-containing heterocycles, their synthesis and reactivity.

*3<sup>rd</sup> week*

Characterization of thiiranes and aziridines, their preparation and reactions.

*4<sup>th</sup> week*

Description of four-membered heterocycles with one heteroatom, their preparation and reactions.

Preparation of azetidine-2-one derivatives and introduction of  $\beta$ -lactam antibiotics.

*5<sup>th</sup> week*

Characterization, preparation and reactions of furan and thiophene derivatives.

*6<sup>th</sup> week*

Synthesis and reactions of pyrrole derivatives.

*7<sup>th</sup> week*

Characterization of five-membered heterocycles with more than one heteroatom I.

*8<sup>th</sup> week*

Characterization of five-membered heterocycles with more than one heteroatom II.

*9<sup>th</sup> week*

Characterization of benzene-condensed five-membered heterocycles.

*10<sup>th</sup> week*

Characterization, synthesis and reactions of 2H-pyran derivatives.

*11<sup>th</sup> week*

Representatives, synthesis and reactions of flavonoids.

*12<sup>th</sup> week*

Characterization, synthesis and reactions of pyridine derivatives.

*13<sup>th</sup> week*

Six-membered heterocycles with more than one heteroatom.

*14<sup>th</sup> week*

Seven-membered heterocycles with one or more than one heteroatom.



**Requirements:**

- *for a signature*

Attendance at **lectures** is highly recommended, but not compulsory.

- *for a grade*

The course ends with a written **exam**. The list of short questions used for the written exam is available at the e-learning system. The minimum requirement for achieving the course is 50%.

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

**Person responsible for course:** Prof. Dr. Tibor Kurtán, university professor, DSc

**Lecturer:** Prof. Dr. Tibor Kurtán, university professor, DSc

<b>Title of course:</b> Biochemistry IV <b>Code:</b> TTKME0303_EN	<b>ECTS Credit points: 2</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: hours - preparation for the exam: 32 hours Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it: -</b>	

<b>Topics of course</b>
<p>Bioregulation at the molecular and at the cellular levels. <u>The function of hemoglobin and its regulation.</u> Different strategies in the regulation of enzyme activities: allostery, isoenzymes, reversible covalent modification, limited proteolysis and modulation by small regulatory proteins. Control by limiting the amount of enzyme: regulation of gene expression in prokaryotic and eukaryotic organisms at transcriptional levels. Hormonal regulation: sensing the environment in multicellular eukaryotic organisms. The interplay between metabolic and signaling pathways through heterotrimer G-protein coupled receptors and through insulin receptor. The phosphatidylinositol signaling.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          - The lecture notes.</p> <p><i>Recommended:</i>          Nelson D.L., Cox M.M.: Lehninger Principles of Biochemistry (W. H. Freeman, Sixth edition, 2012) ISBN-13: 978-14234146.          - Albert B., Bray D. Essential Cell Biology (Fourth edition, Garland Science, 2014) ISBN : 978-0-8153-4454-4.          - Gerhard Krauss: Biochemistry of Signal Transduction and Regulation (Wiley-VCH Verlag GmbH &amp; Co. KGaA, 2014) ISBN: 9783527333660.</p>

**Schedule:***1<sup>st</sup> week*

Bioregulation at the protein level. The storage and the transport of molecular oxygen by hemeproteins: myoglobin and hemoglobin. Cooperative binding of molecular oxygen to hemoglobin can be explained by concerted and sequential model. The fetal hemoglobin. Hydrogen ions and carbon dioxide promote the release of oxygen: the Bohr effect. Sickle-cell anemia.

*2<sup>nd</sup> week*

Allostery. The characteristics of the allosteric regulation is explained in the case of Aspartate Transcarbamoylase (ATCase). The quaternary structure of ATCase in T and R states. The sigmoidal kinetics of ATCase and its regulatory molecules. Comparison of the Michaelis-Menten kinetics with sigmoidal kinetics.

*3<sup>rd</sup> week*

Regulation of glycolysis. The role of the glucose transporters. The irreversible reactions of glycolysis are the regulatory points. The allosteric regulation of phosphofructokinase and pyruvate kinase in liver and in other tissues. The role of phosphofructokinase II and its hormonal regulation. The reciprocally regulated glycolysis and gluconeogenesis.

*4<sup>th</sup> week*

Isoenzymes, one of the ways of fine-tuning of metabolism in different cell types or cell compartments. Isoenzymes of hexokinases and lactate dehydrogenases (function, kinetic behaviour, regulation, substrate specificity, location).

*5<sup>th</sup> week*

Activation by limited proteolysis – zymogen activation. Pancreatic zymogens: the proteolytic cascade. Structural changes in chymotrypsinogen on its proteolytic cleavage. Substrate specificities and mechanism of serine proteases. Protein protease inhibitors.

*6<sup>th</sup> week*

Reversible covalent modification. Post-translational modification by phosphorylation. The driving force of phosphorylation and dephosphorylation. Kinases and phosphatases. The function and regulation of protein kinase A. The phosphorylation of muscle and liver glycogen phosphorylase as well as phosphorylase kinase.

*7<sup>th</sup> week*

The overview of signal transduction pathways. Classification of receptors and signal molecules. The receptor-ligand interactions.

*8<sup>th</sup> week*

The G protein signal cascade. The structure of the seven transmembrane helix receptors and the heterotrimeric G proteins. The G protein cycle. Turning off the signals. Bacterial toxins target G proteins. Glucagon and epinephrine.

*9<sup>th</sup> week*

The role of G-Protein coupled receptors in sensory perception. Signals which change the resting membrane potential of the nerve cells. Sensory transduction in vision. Light-induced hyperpolarization of rod cells. The termination of the visual signal. Signaling by olfactory receptor neurons.

*10<sup>th</sup> week*

Signal cascades based on the membrane lipid phosphatidylinositol. The domain structures of PLC and PKC and their function.  $\text{Ca}^{2+}$  as a secondary messenger and its sensor protein: Calmodulin.

*11<sup>th</sup> week*

Insulin signaling cascade. Processing and secretion of insulin. Insulin receptor and its tyrosine kinase activity. The role of SH2 domain. The activation of protein kinase B and the Glut4 translocation.

*12<sup>th</sup> week*

Regulation of blood glucose levels. The coordinated regulation of carbohydrate metabolism. Diabetes Mellitus and hyperglycemia.

*13<sup>th</sup> week*

Central dogma of Biology. The structure of DNA and RNA. Regulation of prokaryotic gene expression. Key players and steps of prokaryotic transcription. Promoter recognition. Operon model and its role in gene regulation. Lac operon is under the control of repressor and cataboliteactivator proteins.

*14<sup>th</sup> week*

Regulation of eukaryotic gene expression at different levels. Features of eukaryotic transcription. Cis-regulatory DNA sequence elements and transcription factors. Histone modifications - chromatin remodeling. DNA methylation.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

The grade for the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr.TerézBarna, assistant professor, PhD

**Lecturer:** Dr.TerézBarna, assistant professor, PhD

<b>Title of course:</b> Instrumental analysis <b>Code:</b> TTKME0501_EN	<b>ECTS Credit points: 2</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory:	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 48 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 42 Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1st semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b>	

<b>Topics of course</b>
The course surveys the history, methods, theories, fundamentals and some practical aspects of analysis of several instrumental analytical methods and techniques. Important additional topics are the sampling, electrophoresis, atomic spectrometry, sensors, immunoanalysis, labelling methods, thermal analysis, polarography. The course is connected to some topics of the Instrumental Analysis laboratory practices and complete the knowledge acquired in BSc level.
<b>Literature</b>
Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and Co.H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole

<b>Schedule:</b>
1 <sup>st</sup> week: Quality assurance, validation parameters, evaluation methods (2h)
2 <sup>nd</sup> week: Sampling, storing samples (2h)
3 <sup>rd</sup> week: Sample pretreatment methods (2h)
4 <sup>th</sup> week: Atomic emission methods. ICP-AES. Laser ablation sample introduction. ICP-MS. Graphite furnace atomic absorption methods. Background correction methods (2h)

5 <sup>th</sup> week: Labelling analytical methods. Immunoanalysis. ELISA (2h)												
6 <sup>th</sup> week: Ion exchange chromatography. Ion chromatography. Supercritical fluid chromatography. (2h)												
7 <sup>th</sup> week: Gel electrophoresis. Capillary electrophoresis. Electroosmosis. Detection on gels. (2h)												
8 <sup>th</sup> week: Microfluidic application in analytical chemistry. Lab-on-a-chip. Bioanalyzer 2100 (2h)												
9 <sup>th</sup> week: Characterization and classification of sensors. Electrochemical and semiconductive sensors (2h)												
10 <sup>th</sup> week: Attenuated total reflexion spectrometry. Surface plasmon resonance spectroscopy. Molecularly imprinted polymers and their analytical applications. (2h)												
11 <sup>th</sup> week: Fundamentals and instrumentation of polarography. Methods of polarography. Cyclic voltammetry. Inverse voltammetry. Bipotentiometry. (2h)												
12 <sup>th</sup> week: Continuous analysis. Kinetic analytical methods. (2h)												
13 <sup>th</sup> week: Methods of the thermal analysis (TG, DTG, DTA, DSC) (2h)												
14 <sup>th</sup> week: Consultations. Survey and classification of the analytical methods. (2h)												
<b>Requirements:</b> Attendance at lectures is recommended, but not compulsory. The course ends in an examination (written test). The minimum requirement for the examination is 50%. Based on the score of the test, the grade is given according to the following table: <table><tr><td>Score</td><td>Grade</td></tr><tr><td>0-50</td><td>fail (1)</td></tr><tr><td>50-69</td><td>pass (2)</td></tr><tr><td>70-79</td><td>satisfactory (3)</td></tr><tr><td>80-89</td><td>good (4)</td></tr><tr><td>90-100</td><td>excellent (5)</td></tr></table>	Score	Grade	0-50	fail (1)	50-69	pass (2)	70-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade											
0-50	fail (1)											
50-69	pass (2)											
70-79	satisfactory (3)											
80-89	good (4)											
90-100	excellent (5)											
<b>Person responsible for course:</b> Prof. Dr. Attila Gáspár, university professor, DSc												
<b>Lecturer:</b> Prof. Dr. Attila Gáspár, university professor, DSc												

<b>Title of course:</b> Instrumental analysis II <b>Code:</b> TTKML0501_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 3 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 42 hours - laboratory: - - home assignment: 18 hours - preparation for the exam: Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Furthercoursesbuiltin:</b> TTKME0501	

<b>Topics of course</b>
<p>The series of laboratory practices are based on the topics of different instrumental analysis like electrophoresis, atomic spectrometry, electroanalysis, validation, ion chromatography, circular dichroism. The instrumental laboratories are connected to the topics of the Instrumental Analysis lecture and the those complete the knowledge acquired in BSc level.</p>
<b>Literature</b>
<ol style="list-style-type: none"> <li>1. Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and CoH.H.</li> <li>2. Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988.</li> <li>3. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole</li> <li>4. Syllabuses provided by the tutor.</li> </ol>

<b>Schedule:</b> 1 <sup>st</sup> week: Introductory guidance, accident protection (2h)  2 <sup>nd</sup> week: Capillary electrophoresis (6h)  3 <sup>rd</sup> week: Graphite furnace atomic absorption spectrometry (6h)
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4 <sup>th</sup> week: Cyclic voltammetry (6h)												
5 <sup>th</sup> week: Validation of analytical methods (8h)												
6 <sup>th</sup> week: Circular dichroism spectroscopy (6h)												
7 <sup>th</sup> week: Ion chromatography (6h)												
8 <sup>th</sup> week: Final test (2h)												
<b>Requirements:</b> <ul style="list-style-type: none"><li>- for a signature</li></ul> <p>Participation at practices is compulsory. A student must attend every practices during the semester. Attendance at practices will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.</p> <ul style="list-style-type: none"><li>- for a grade</li></ul> <p>Grading is given by the average of 3 separate grades:</p> <ul style="list-style-type: none"><li>- the average grade of the short tests written at the beginning of the instrumental analysis lab practices (an average of at least 2.0 is necessary to avoid a 'fail' final grade)</li><li>- the average grade of evaluation of the analytical data measured by the instrument, the laboratory notebook prepared by the student and final discussion/conclusion made between the student and the supervisor at the end of the lab practice (an average of at least 2.0 is necessary to avoid a 'fail' final grade)</li><li>- the grade of the final test</li></ul> <p>The grade of the final test is calculated according to the following table:</p> <table><tr><td>Score</td><td>Grade</td></tr><tr><td>0-59</td><td>fail (1)</td></tr><tr><td>60-69</td><td>pass (2)</td></tr><tr><td>70-79</td><td>satisfactory (3)</td></tr><tr><td>80-89</td><td>good (4)</td></tr><tr><td>90-100</td><td>excellent (5)</td></tr></table>	Score	Grade	0-59	fail (1)	60-69	pass (2)	70-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade											
0-59	fail (1)											
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90-100	excellent (5)											
<b>Person responsible for course:</b> Dr.Melinda Andrási Assistant Professor PhD												
<b>Lecturer:</b> Dr.Melinda Andrási Assistant Professor PhD												



<b>Title of course:</b> Spectroscopic methods for structure investigation I. <b>Code:</b> TTKME0502_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 20 hours - preparation for the exam: 42 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TKBE0503_EN	
<b>Further courses built on it:</b> TTKML0502_EN, TTKMG0318_EN, TKML0530_EN,	

<b>Topics of course</b>
Basic principles of different spectroscopic and structure elucidation methods. Examples and applications for structural studies of organic compounds.
<b>Literature</b> <ol style="list-style-type: none"> <li>1. P.J. Hore, Nuclear Magnetic Resonance, Oxford Univ. Press (2002)</li> <li>2. N.E. Jacobsen, NMR Spectroscopy Explained: Simplified Theory, Applications and Examples for Organic Chemistry and Structural Biology, Wiley</li> <li>3. T.D.W. Claridge, High-Resolution NMR Techniques in Organic Chemistry, Elsevier</li> <li>4. J.R. Chapman: „Practical Organic Mass Spectrometry”, Wiley, 1995</li> <li>5. E. Pretsch, J.T. Clerc: „Interpretation of Organic Compounds”, VCH, 1997</li> </ol>
<i>Compulsory:</i> <i>Recommended:</i>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> The basic concepts of mass spectrometry. Isotopes in mass spectrometry. Resolution and its interpretation. Most important fragmentation processes. The use of nitrogen rule for different type of ions. <i>2<sup>nd</sup> week</i> Soft ionization techniques. Generation of CI spectra, interpretation of the spectra.
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*3<sup>rd</sup> week*

Soft ionization techniques. Ion formation in liquid chromatography-linked systems. Generation of ESI spectra, interpretation of spectra. Multiple charged ions and their presentation in the spectra.

*4<sup>th</sup> week*

Soft ionization techniques. Ion formation in liquid chromatography-linked systems. Generation of APCI spectra, interpretation of spectra.

*5<sup>th</sup> week*

pH, pKa, and their significance in MS studies. MS compatible eluent preparation rules.

*6<sup>th</sup> week*

Basics of tandem mass spectrometry. Construction and operation of a tandem device. Structure of MSMS experiments, rules for their use. Signal to noise ratio. The most important areas of application of tandem measurements with examples.

*7<sup>th</sup> week*

Principles of Fluorescence Spectroscopy and Applications. Fluorophores. Raman spectroscopy: principle and applications.

*8<sup>th</sup> week*

NMR - Macroscopic magnetization (M), phenomenological description of time dependence of macroscopic magnetization. Bloch equations in laboratory frame.

*9<sup>th</sup> week*

Introduction of rotating frame. Solutions of Bloch equations in the rotating frame in case of specific conditions: shape of resonance signal, concept and occurrence of saturation.

*10<sup>th</sup> week*

Relaxation phenomenon. Nuclear spin relaxation: spin-lattice and spin-spin relaxation times. Measurement of  $T_1$  and  $T_2$  relaxation times.

*11<sup>th</sup> week*

Relaxation mechanisms - dipolar (DD), chemical shift anisotropy (CSA), quadrupolar (Q), scalar coupling (SC), spin-rotation (SR) and paramagnetic (PR) relaxation. Relaxation and dynamics (molecular motion, rotational diffusion).

*12<sup>th</sup> week*

Relaxation and structure. Nuclear Overhauser (NOE) effect. Steady-state and transient NOE experiments. Applications of NOE in solving stereochemical – configurational and conformational - problems.

*13<sup>th</sup> week*

Principles of pulsed Fourier NMR spectroscopy. Basic principles of 2D NMR spectroscopy.

*14<sup>th</sup> week*

Principles and applications of dynamic NMR. Two- and multisite exchange. NMR time scale (fast, intermediate, slow motional regime) and its implications on spectral properties and parameters.

**Requirements:**

- *for a signature*

Attendance at **lectures** is highly recommended, but not compulsory.

- *for a grade*

The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
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0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)
If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.	
<b>Person responsible for course:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc	
<b>Lecturer:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc. Dr. Attila Kiss, associate professor, PhD	

<b>Title of course:</b> Spectroscopic methods for structure investigation II. <b>Code:</b> TTKML0502_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: 3 hours/week - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 42 hours - laboratory: - - home assignment: 18 hours - preparation for the exam: - Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKME0502_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The series of practise are based on the topics of <sup>1</sup>H and <sup>13</sup>C NMR. It reviews the fundamental relations of the nuclear Zeeman effect, Boltzmann-distribution, nuclear shielding-origin of the chemical shift- and scalar splitting pattern.</p> <p>There are two main tasks to elaborate: to obtain structural information from resonance frequencies and splitting patterns and to propose the correct structure based on <sup>1</sup>H and <sup>13</sup>C NMR data.</p> <p>Basic principles of different spectroscopic and structure elucidation methods (MS, IR, UV/Vis and NMR). Examples and applications for structural studies of organic compounds.</p>
<b>Literature</b> <ol style="list-style-type: none"> <li>1. R.M.Silverstein, F.X.Webster: "Spectrometric Identification of Organic Compounds", Wiley, 1998.</li> <li>2. J.P.Hore: "Nuclear Magnetic Resonance", Oxford Chemistry Primers, 1995.</li> <li>3. L.D.Field, S.Sternhell, J.R.Kalman: „Organic Structure from Spectra"</li> </ol>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Introduction, overview of theoretical basics of IR, UV and MS that are required for complex problem solving. <i>2<sup>nd</sup> week</i> Complex spectral analysis of open chain and branched chain aliphatic compounds, focusing on their IR, UV and MS spectra. Problem Solving. <i>3<sup>rd</sup> week</i> Complex spectral analysis of halogenated organic compounds, focusing on their IR, UV and MS spectra. Problem Solving.
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*4<sup>th</sup> week*

Complex spectral analysis of aromatic compounds, focusing on their IR, UV and MS spectra. Problem Solving.

*5<sup>th</sup> week*

Complex spectral analysis of oxygen containing organic compounds, focusing on their IR, UV and MS spectra. Problem Solving.

*6<sup>th</sup> week*

Complex spectral analysis of nitrogen containing organic compounds, focusing on their IR, UV and MS spectra. Problem Solving.

*7<sup>th</sup> week*

Spectral analysis of complex organic compounds, focusing on their IR, UV and MS spectra. Problem Solving.

*8<sup>th</sup> week*

Zeeman energy levels, Boltzmann-distribution, equilibrium macroscopic magnetization ( $M_0$ ). The selection rule for NMR.

*9<sup>th</sup> week*

Empirical rules for calculation of chemical shifts of different organic compounds (alkanes, alkenes, aromatics).

*10<sup>th</sup> week*

Case of strong coupling (second order effects). Examples, rules for chemical shift calculations. Process of  $^1\text{H}$  spectral analysis. Interpretation of simple and more complex  $^1\text{H}$  NMR spectra.

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*11<sup>th</sup> week*

Overlapping signals in  $^1\text{H}$  NMR spectra, extra information.  $^{13}\text{C}$  NMR analysis.

*12<sup>th</sup> week*

Problem solving: structure elucidation of an organic compound based on combined analysis of  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra.

*13<sup>th</sup> week*

$^1\text{H}$  and  $^{13}\text{C}$  NMR: applications for structure verification of complex organic structures.

*14<sup>th</sup> week*

Complex problem solving exercises.

**Requirements:** - for a signature

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course.

If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class. The course ends in an **end-term test**, the end-term test in the 15<sup>th</sup> week. Students have to sit for the tests.

- for a grade

The minimum requirement for end-term test is 60%. Based on the score of the test, the grade for the test is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Prof. Dr. Katalin E. Kövér, university professor, DSc.

**Lecturer:** Prof. Dr. Katalin E. Kövér, university professor, DSc

<b>Title of course:</b> Introduction to Chemical Engineering <b>Code:</b> TTKME0601_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - laboratory: - - home assignment: 30 - preparation for the exam: 32 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>Similitude. Physical quantities, units, dimensions. Scalars, vectors, tensors. Covariance. Similitude criteria and similitude invariables. Extensive and intensive properties. Balance equations. Currents. Uniqueness criteria. Theory of transport processes, generic transport equation – basic classification of engineering processes. Dimensional analysis: concepts and methods. Dimension matrices. Dimensionless numbers. Classes of dimensionless numbers and connections between them. Dimensional analysis and similitude. Aero- and hydrodynamics: fundamental equations, the Navier-Stokes equations, Bernoulli equation. Equation of momentum transport. Momentum balance. Similarity transformation. Free flow. Effect of changes in uniqueness criteria. Momentum transport in turbulent flow. Simultaneous flow of liquid and solid particles. Balance equations. Similarity transformation. Thermal conductivity and diffusion. Continuity equation for mass transport. Mass transport in a flowing liquid. Heat exchange in a flowing liquid. Thermal diffusion. Chemical reactions: stoichiometric equations, mass balance, energy balance, momentum balance. Principles of reactor technology. Thermal analysis of chemical reactors. Equilibria: phase equilibrium, equilibrium lines, working lines.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of Chemical Engineering (7th Ed) - McGraw-Hill  <u>Richard G. Griskey</u>: Transport phenomena and unit operations: a combined approach, (2002), Wiley, ISBN 0-471-43819-7  <u>Christie J Geankoplis</u>: Transport processes and unit operations (1993), 3rd edition, Prentice-Hall, ISBN 0-13-045253-X          J. M. Coulson, J. F. Richardson: Chemical Engineering. Volume 1-6. Third Edition. Pergamon Press. Oxford</p>

**Schedule:***1<sup>st</sup> week*

Definition and classification of unit operations. batch and continuous processes. Flowsheets.

*2<sup>nd</sup> week*

Physical quantities, units, dimensions. The SI system. Extensive and intensive quantities. Dimensional and tensorial homogeneity. Scalar-vector-tensor quantities.

*3<sup>rd</sup> week*

The fundamental equation of thermodynamics. Conditions of equilibrium, driving force, rate of processes. Degrees of freedom of a chemical system.

*4<sup>th</sup> week*

Flows and fluxes. Scalar and vector fields and their derivatives. The Nabla vector, gradient and divergence. The general transport equation. Differential and integral form of balance equations valid for one and two phase unit operations. The Damköhler equations. The Onsager theory.

*5<sup>th</sup> week*

The mathematical model. Initial and boundary conditions. Balance equations for simple systems: Fourier-I and Fick-I laws.

*6<sup>th</sup> week*

Similitude and modelling. Dimensional analysis, dimensionless numbers.

*7<sup>th</sup> week*

Mass and energy balances for simple and complex unit operations.

*8<sup>th</sup> week*

The heat equation. Types and calculation of heat transport. Steady state heat conduction in plane pipe walls. Fourier-I equation and thermal insulation. Heat exchangers. Stationary heat transmission with constant temperature difference through flat and cylindrical wall. Determination of heat flow and thermal resistances.

Direct and indirect heat exchange. Determination of the power requirement for a stationary recuperative heat exchanger. Temperature-space function of co-current and counter current heat exchangers. Logarithmic mean temperature difference. Types and apparatus of heat exchangers.

*9<sup>th</sup> week*

Flow in unpacked pipes and in pipelines: Fluids in rest, Pascal's law. Navier-Stokes equations. Bernoulli equation. Cavitation. Newtonian and non-Newtonian fluids. Newton's law of viscosity.

*10<sup>th</sup> week*

Basic types of fluid flow. Reynolds' experiment. Hagen-Poiseuille equation. Modified Bernoulli equation. Fanning equation. Moody diagram. Energy requirement of fluid transport. Types of pumps.



*11<sup>th</sup> week*

Mass transfer theories. Two-film and boundary layer theory of component transfer. Absorption-desorption: Concentration-space diagram of a continuous counter current absorption unit operation. Equation of operating line.

*12<sup>th</sup> week*

Basics of filtration. Darcy's law of filtration. Batch filtration using constant pressure, continuous filtration using constant flow rate. Filtration units. Filtration using centrifugal force. Types of centrifuges. Basics of membrane filtration. Concentration polarization.

*13<sup>th</sup> week*

Introduction to chemical reactors.

*14<sup>th</sup> week*

Classification of reactors based on flow, operation mode, component stream and heat. Operation time, residence time. Concentration-time and concentration-space functions of batch and continuous reactors. Heat balance of a reactor. Stability of reactors.

**Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor.

During the semester there are two tests: the mid-term test in the 8<sup>th</sup> week and the end-term test in the 15<sup>th</sup> week. Students have to sit for the tests.

*- for a grade*

The course ends in an **examination**.

The minimum requirement for the mid-term and end-term tests and the examination respectively is 60%. Based on the score of the tests separately, the grade for the tests and the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*-an offered grade:*

it may be offered for students if the average grade of the mid-term and end-term tests is at least satisfactory (3). The offered grade is the average of them.

**Person responsible for course:** Dr. Sándor Kéki University professor, DSc

**Lecturer:** Dr. Sándor Kéki University professor, DSc

<b>Title of course:</b> Advanced Chemical Technology <b>Code:</b> TTKME0602_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Introducing the procedures of chemical technology in the organic chemistry industry. Advanced petrochemical processes and the production of organic chemical raw materials. - Environment and industry relations. - Occurrence and extraction of petroleum, coal and natural gas. - More detailed discussion of oil processing. - Description of Petrochemical Procedures. - Production and transformation of paraffins, olefins and aromatic industries. - Production and transformation of polymeric raw materials. - Other areas of organic chemistry.
<b>Literature</b>
<i>Compulsory:</i> - P. J. Chenier: Survey of industrial chemistry, VCH, N.Y. 1992. - Ullmann's Encyclopedia of Industrial Chemistry, Wiley, 2000. - Ullman's Enciklopedia of Industrial Chemistry 5th ed, Weinheim, Federal republic of Germany, VCH, Volumes A1-A28.1985-1996. <i>Recommended:</i> - Ronald Bailey, Herbert Clark, James Ferris, Sonja Krause, Robert Strong:Chemistry of the Environment 2nd Edition, Academic Press.

<b>Schedule:</b> <i>1<sup>st</sup> week:</i> The relationship between industry and the environment. Know the 12 laws of environmentally friendly chemistry. Equipment used in the main organic chemical industry.
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The student gains knowledge of the relationship between industry and the environment. Know the equipment used in the organic chemical industry.

*2<sup>nd</sup> week:* The occurrence, composition and extraction of crude oil, natural gas and coal.

Basic concepts of combustion engineering.

Students acquire knowledge of major fossil fuels.

*3<sup>rd</sup> week:* A more detailed description of the atmospheric and vacuum distillation processing of crude oil. Motor fuels and lubricants.

The student gains knowledge of the steps of oil refining and the composition of the propulsion materials.

*4<sup>th</sup> week:* Description of petrochemical processes (viscosity breakdown, delayed chamber coking, flex coking, catalytic cracking, catalytic reforming).

The student gains knowledge of the catalytic petrochemical processes that are aimed at the production of motor carriers.

*5<sup>th</sup> week:* Description of Petrochemical Procedures (hydrocracking, aliphatic and aromatic alkylation procedures, isomerization procedures).

The student acquires knowledge of petrochemical processes, which aim to produce propellants by increasing hydrocarbons branching.

*6<sup>th</sup> week:* Description of catalysts used in petrochemical processes.

The student becomes acquainted with the construction and operation of catalysts in the industry.

*7<sup>th</sup> week:* Olefin production with thermal cracking (TVK olefin plant and technology used therein).

The student gets acquainted with the technology of olefin production in TVK.

*8<sup>th</sup> week:* Industrial production and use of synthetic gas.

Students acquire knowledge about synthesis gas production and utilization.

*9<sup>th</sup> week:* Methods of transformation of petrochemical products - paraffin hydrocarbons.

The student gets acquainted with the industrial production and conversion processes of paraffin hydrocarbons.

*10<sup>th</sup> week:* Transformations of petrochemicals - olefins into organic chemical raw materials. Students learn about the industrial conversion processes of olefins (ethylene, propylene).

*11<sup>th</sup> week:* Production of Petrochemicals Products Olefins Conversion-Polymers (PE, PPP, PVC ..) Students are familiar with the industrial production and properties of the major polymers.

*12<sup>th</sup> week:* Transformations of Petrochemicals - Aromatic (BTX Fraction) into organic chemical raw materials.

The student gets acquainted with the industrial transformations of the BTX fraction.

*13<sup>th</sup> week:* Other sectors of organic chemistry - plant protection products, pharmaceutical active ingredients.

The student becomes acquainted with the plant protection products, the most important known pharmaceutical active ingredients.

*14<sup>th</sup> week:* Other sectors of organic chemistry - dyes, surfactants and paper production.

The student is familiar with the industrial use of dyes, tensides and the paper manufacturing process.

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Presentation from a published topic is compulsory.

Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

Students have to **submit all the two designing tasks** as scheduled minimum on a sufficient level. Students must present the presentation before the written exam.

At the end of the semester there are a test: in the 15<sup>th</sup> week. Students have to sit for the tests  
- *for a grade*

The course ends in written **examination**. The final grade calculated on the average of the grades of oral presentation and the examination. The exam grade calculated from the result of examination.

The minimum requirement for examination respectively is 50%. Based on the score of the tests separately, the grade for the tests and the examination is given according to the following table:

Score	Grade
0-50	fail (1)
51-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 50, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Lajos Nagy, assistant professor, PhD

**Lecturer:** Dr. Lajos Nagy, assistant professor, PhD

<b>Title of course:</b> Diploma Thesis I. <b>Code:</b> TTKML0001_EN	<b>ECTS Credit points:</b> 15
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 15 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 210 hours - home assignment: 240 hours - preparation for the exam: - Total: 450 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> Diploma Thesis II. TTKML0002_EN	

<b>Topics of course</b>
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on chemical research performed by the graduate under the supervision of a senior staff member. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.
<b>Literature</b>
Provided by the supervisor.

<b>Schedule:</b> The student works by following the instructions of the supervisor.
<b>Requirements:</b> - <i>for a signature</i> The student have to take part in the research project coordinated by the supervisor. - <i>for a grade</i> The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.
<b>Person responsible for course:</b> Prof. Dr.IstvánFábián, university professor, DSc
<b>Lecturer:</b> supervisors are staff members of the Institute of Chemistry, UD

<b>Title of course:</b> Diploma Thesis II. <b>Code:</b> TTKML0002_EN	<b>ECTS Credit points:</b> 15
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 15 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 210 hours - home assignment: 240 hours - preparation for the exam: - Total: 450 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> Diploma Thesis I. TTKML0001_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on chemical research performed by the graduate under the supervision of a senior staff member. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.
<b>Literature</b>
Provided by the supervisor.

<b>Schedule:</b> The student works by following the instructions of the supervisor.
<b>Requirements:</b> - <i>for a signature</i> The student have to take part in the research project coordinated by the supervisor. - <i>for a grade</i> The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.
<b>Person responsible for course:</b> Prof. Dr.IstvánFábián, university professor, DSc
<b>Lecturer:</b> supervisors are staff members of the Institute of Chemistry, UD

<b>Title of course:</b> Industrial Placement <b>Code:</b> TTKMX0003_EN	<b>ECTS Credit points:</b> 0
<b>Type of teaching, contact hours</b> 4 weeks	
<b>Evaluation:</b> signature	
<b>Workload (estimated), divided into contact hours:</b> Total: 160 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester in the Summer	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>Industrial placement is an ideal opportunity to apply existing skills and to develop new ones whilst getting a practical insight into working life in chemical industry, it gives real world experience, and a possible step in a career and provides with the opportunities for the future. All these experiences greatly enhance career prospects for when students graduate.</p> <p>Industrial placement is an extraordinary opportunity to train and develop personal abilities with competent professionals and gain first hand experience of chemical industry and is an ideal grounding for a future career in chemical industry. It provides integrated industrial and professional training in an area such as operation of a chemical plant and a chance to sharpen skills and acquire work experience.</p>
<b>Literature</b>
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<b>Requirements:</b> The students are expected to write a report of about 15 pages on the work accomplished during the internship.
<b>Person responsible for course:</b> Dr. Ákos Kuki, associate professor, PhD

<b>Title of course:</b> Chemometrics I. <b>Code:</b> TTKME0511_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours / week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> –	
<b>Further courses built on it:</b> –	

<b>Topics of course</b>
<p>The material of the lecture covers the fundamental aspects of applied Chemometrics. The course begins with descriptive statistics covering the normal distribution and the Poisson distribution. This is followed by statistical hypothesis testing (Q-test, t-test, ANOVA). Mathematical modelling is demonstrated through linear and non-linear least-squares fitting (regression analysis). Some fundamental aspects of numerical mathematics are covered. Optimization and design of experiment approaches are overviewed. The use of principal component analysis (PCA) and cluster analysis is demonstrated for pattern recognition. Classification is realized by linear discriminant analysis (LDA). Finally, the fundamental strategies of calibration in chemical analysis are covered, including multivariate calibration by the methods of partial least squares and principal component regression.</p>
<b>Literature</b>
<p><i>Compulsory:</i></p> <p>1) Matthias Otto: Chemometrics WILEY-VCH Verlag GmbH, Weinheim, Germany, 1999.</p> <p>2) Richard G. Brereton: Applied Chemometrics for Scientists John Wiley &amp; Sons Ltd, Chichester, England, 2007.</p> <p>3) D. L. Massart, B. G. M. Vandeginste, S. N. Deming, Y. Michotte, and L. Kaufman: Chemometrics: A textbook. Elsevier, Amsterdam, The Netherlands, 1988.</p>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Introduction. The scope of Chemometrics. Interaction with related fields. <i>2<sup>nd</sup> week</i>
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Descriptive statistics. <i>3<sup>rd</sup> week</i> Statistical hypothesis testing I: Fundamentals, Q-test, t-test. <i>4<sup>th</sup> week</i> Statistical hypothesis testing II: ANOVA <i>5<sup>th</sup> week</i> Principal component analysis (PCA) I: Fundamentals, mathematics. <i>6<sup>th</sup> week</i> Principal component analysis (PCA) II: Practical examples. <i>7<sup>th</sup> week</i> Cluster analysis and linear discriminant analysis (LDA). <i>8<sup>th</sup> week</i> Mathematical modelling I: Regression analysis, linear least-squares fitting. <i>9<sup>th</sup> week</i> Mathematical modelling II: Non-linear least-squares fitting. Practical examples. <i>10<sup>th</sup> week</i> Design of experiment I: Screening. <i>11<sup>th</sup> week</i> Design of experiment II: Optimization. <i>12<sup>th</sup> week</i> Calibration in analytical chemistry. <i>13<sup>th</sup> week</i> Multivariate calibration (PLS, PCR).												
<b>Requirements:</b>  <i>- for a signature</i> Attendance at <b>lectures</b> is recommended, but not compulsory. Participating in an exam earns the signature.  <i>- for a grade</i> The course ends in an <b>oral examination</b> . Based on the score of the oral examination the grade is given according to the following table: <table><tr><td>Score</td><td>Grade</td></tr><tr><td>0-50</td><td>fail (1)</td></tr><tr><td>51-60</td><td>pass (2)</td></tr><tr><td>61-70</td><td>satisfactory (3)</td></tr><tr><td>71-80</td><td>good (4)</td></tr><tr><td>81-100</td><td>excellent (5)</td></tr></table> If the score of the oral exam is below 51%, students can take a retake the exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.	Score	Grade	0-50	fail (1)	51-60	pass (2)	61-70	satisfactory (3)	71-80	good (4)	81-100	excellent (5)
Score	Grade											
0-50	fail (1)											
51-60	pass (2)											
61-70	satisfactory (3)											
71-80	good (4)											
81-100	excellent (5)											
<b>Person responsible for course:</b> Dr. JózsefKalmár, assistant professor, PhD												
<b>Lecturer:</b> Dr. JózsefKalmár, assistant professor, PhD												

<b>Title of course:</b> Separation techniques III. <b>Code:</b> TTKME0315_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - laboratory: - - home assignment: 20 hours - preparation for the exam: 42 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>th</sup> semester	
<b>Its prerequisite(s):</b> TTKME0315_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Basic principles of different modern analytical methods in the field of HPLC, GC, SFC. Examples and applications for chromatographic studies of organic compounds.
<b>Literature</b> Effective Organic Compound Purification, Teledyne ISCO, Lincoln, USA (2010) D.A. Skoog, J.J. Leary: Principles of Instrumental Analysis, New York (1992) L.R. Snyder, J.J. Kirkland: Introduction To Modern Liquid Chromatography, Wiley, 1979 P. Schreider, A. Bernreuter, M. Huffer: Analysis of Chiral Organic Molecules, Walter de Gruyter, 1995

<b>Schedule:</b>  <i>1<sup>st</sup> week</i> Introduction, overview of major chromatographic concepts. Categorization of chromatographic techniques by stationary and mobile phase. Chromatographic stationary phases. Retention Volume, Retention Time, Peak Height, peak area, Half Width, Bandwidth, Theoretical Plate Number, Theoretical Plate Height, Resolution, Signal, Noise, Drift, Signal / Noise, LOD, LOQ, tailing factor, peak asymmetry. Definition and use of the Kováts index in analytical chemistry. <i>2<sup>nd</sup> week</i> Size Exclusion Chromatography. Principles and mechanism of separation. Stationary phases in chromatography, physical and chemical structures, the newest developments. Instrumentation and operation of the separation processes. <i>3<sup>rd</sup> week</i> Calibration of GPC-SEC. Eluents and detectors.
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4<sup>th</sup> week

Most common errors (GPC-HPLC comparison) and elimination of them.

5<sup>th</sup> week

Instruments of modern column chromatography and their use. How can a TLC data be used as a pre-experiment? Transfer of TLC data to column chromatography.

6<sup>th</sup> week

Chiral chromatographic methods. Introduction. Use of chiral GC, HPLC.

Basics of Stereochemistry from chromatographic point of view. The concept of chirality. Different chiral and achiral chromatographic systems.

7<sup>th</sup> week

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 1. Adapting methods from achiral systems to chiral stationary phases.

8<sup>th</sup> week

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 2. Adapting methods from achiral systems to chiral stationary phases.

9<sup>th</sup> week

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 1.

10<sup>th</sup> week

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 2.

11<sup>th</sup> week

Stationary Phases, Mobile Phases in Reverse Phase Liquid Chromatography. The role of pH in the separation of proton-active compounds. Preparation of liquid chromatographic buffer solutions, their properties and their application possibilities.

12<sup>th</sup> week

The usage of gradient chromatography. The possibilities of eliminating the difficulties and pitfalls of it.

13<sup>th</sup> week

Instrumentation of liquid chromatography.

14<sup>th</sup> week

Closing test.

**Requirements:** - *for a signature*

Attendance at **lectures** is highly recommended, but not compulsory.

- *for a grade*

The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

<b>Person responsible for course:</b> Dr. Attila Kiss, associate professor, PhD
<b>Lecturer:</b> Dr. Attila Kiss, associate professor, PhD Dr.GyörgyDeák, associate professor, PhD

<b>Title of course:</b> Separation techniques IV. <b>Code:</b> TTKML0315_EN	<b>ECTS Credit points: 4</b>
<b>Type of teaching, contact hours</b> - lecture: - - practice: - laboratory: 4 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - practice: - laboratory: 56 hours - home assignment: 20 hours - preparation for the exam: 44 hours Total: 120 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>th</sup> semester	
<b>Its prerequisite(s):</b> TTKME0315_EN	
<b>Further courses built on it:</b> TTKME0315_EN	

<b>Topics of course</b>
Basic principles of different modern analytical methods in the field of HPLC, GC, SFC. Examples and applications for chromatographic studies of organic compounds.
<b>Literature</b> Effective Organic Compound Purification, Teledyne ISCO, Lincoln, USA (2010) D.A. Skoog, J.J. Leary: Principles of Instrumental Analysis, New York (1992) L.R. Snyder, J.J. Kirkland: Introduction To Modern Liquid Chromatography, Wiley, 1979 P. Schreider, A. Bernreuter, M. Huffer: Analysis of Chiral Organic Molecules, Walter de Gruyter, 1995

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Basics of gas chromatography, most important measurement methods. Main parts of the GC device. Practical applications of different types of columns. Chromatographic indexes (Kováts index). Using the GC for quantification (in alcohol-water mixture, quantitative measurement of alcohol or determination of methane in air-methane gas mixtures). <i>2<sup>nd</sup> week</i> Using the GC for quantification (in alcohol-water mixture, quantitative measurement of alcohol or determination of methane in air-methane gas mixtures) <i>3<sup>rd</sup> week</i> Determination of caffeine or limonene using GC-FID and GC-MS methods after extraction of a solid sample (lemon or coffee). Using the Spectrum Library of the GC to identify an unknown compound. <i>4<sup>th</sup> week</i> Determination of molecular weight of polymer by GPC-SEC method (calibration and measurement). <i>5<sup>th</sup> week</i>
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Chiral method development 1. CSP-HPLC-UV coupling.

6<sup>th</sup> week

Chiral method development 2. CSP-HPLC-UV coupling.

7<sup>th</sup> week

Chiral method development 3. CSP-HPLC-MS coupling.

8<sup>th</sup> week

Chiral method development 3. CSP- SFC-UV coupling.

9<sup>th</sup> week

The basics of liquid chromatography, its most important methods of measurement, the construction of the HPLC apparatus. Waters Alliance Liquid Transmission System and UV + DAD Detectors. Things to do after turning on the power. Checking the fluid delivery system.

10<sup>th</sup> week

Checking the injector and detectors. Application of Empower software, writing of measuring methods, methods for integration of recorded chromatograms. Column types and their application possibilities.

11<sup>th</sup> week

Chromatographic behavior of acidic substances. The use of Pallas software and predict the logD function of the acids to be tested. Record chromatograms of the acid mixtures at different pH values.

12<sup>th</sup> week

Evaluation of the chromatograms recorded in the previous week, interpretation of the results. Produce a report on the results obtained. Understand the security features provided by the software.

13<sup>th</sup> week

Repeating lab practice. Discussing unclear questions.

14<sup>th</sup> week

Closing test.

### **Requirements:** - *for a signature*

Participation at **laboratory** is compulsory. A student must attend the practice classes and may not miss none of them during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at lab courses will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed lab courses should not to be made up for at a later date! Students are required to bring the drawing tasks and drawing instruments of the course to each lab courses. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

Students have to **submit all the two designing tasks** as scheduled minimum on a sufficient level.

During the semester there are two tests: the mid-term test in the 8<sup>th</sup> week and the end-term test in the 15<sup>th</sup> week. Students have to sit for the tests

- *for a grade*

The course ends in an **examination**. Based on the average of the grades of the designing tasks and the examination, the exam grade is calculated as an average of them:

- the average grade of the two designing tasks
- the result of the examination

The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
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0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)
If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.	
<b>Person responsible for course:</b> Dr. Attila Kiss, associate professor, PhD	
<b>Lecturer:</b> Dr. Attila Kiss, associate professor, PhD Dr.GyörgyDeák, associate professor, PhD	

<b>Title of course:</b> Inorganic Methods in Environmental Analysis I. <b>Code:</b> TTKME0503_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b> - lecture: 1 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam (essay and presentation)	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 14 hours - practice: - - laboratory: - - home assignment: 5 hours - preparation for the exam: 11 hours Total: 30 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The aim of this course is to give a general introduction to the inorganic methods of environmental analysis for chemistry master students. The most important steps from field sampling, sample storage, treatment and analysis techniques will be overviewed focusing on the analytics of inorganic pollutants such as toxic metals. Rules and theoretical background will be discussed of performing a complex environmental assessment with the corresponding regulations. The most important classical and instrumental possibilities will be introduced widely used in environmental analysis. Water quality parameters and biological indication will be discussed.
<b>Literature</b>
<i>Compulsory:</i> - J.R. Dean: Methods for Environmental Trace Analysis, Wiley, 2003. - R. Reeve: Introduction to environmental analysis, Wiley, 2002. <i>Recommended:</i> -Environmental Chemistry by banez, J.G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A., Singh, M.M., Springer-Verlag New York

<b>Schedule:</b> The lecture will be held in the first half of the semester, 2 hours/week <i>1<sup>st</sup> week</i> General introduction to the aims and objectives of environmental analysis. Grouping the available methods and stating their connections to other scientific fields. The steps of a complex analysis and the importance of environmental assessment and monitoring. Prevention possibilities. <i>2<sup>nd</sup> week</i> The basic types of environmental samples and their classification regarding spheres, state and
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<p>homogeneity. Discussion of the features of inorganic and organic compounds usually focused by environmental analysis, however the inorganic analytes will be highlighted. The general rules of sampling, sample storage and preservation. Sampling strategies.</p> <p><i>3<sup>rd</sup> week</i></p> <p>Sample pre-treatment strategies and basic rules of dissolution. Solubility features of the analyte, grouping of applied reagents and methods. High temperature reactions under acidic and basic conditions. Mineralization techniques of organic materials. Eliminating the sample matrix and mobilization of the measured compounds.</p> <p><i>4<sup>th</sup> week</i></p> <p>The most widely used sampling pre-treatment techniques: dilution, dry and wet digestion, wet digestion at atmospheric pressure and under high pressure, microwave digestion, extraction methods. Chemicals and reagents used to gain the inorganic analyte from the environmental samples. Advantages and disadvantages of the sample treatment possibilities.</p> <p><i>5<sup>th</sup> week</i></p> <p>The most important water quality parameters, the theoretical background of them and their direct connection to environmental assessment. Chemical oxygen demand, biological oxygen demand, ions affecting halobity, saprobity categories, oxygen saturation etc. Classical and instrumental analytical methods to determine these parameters. Limits and regulations connected to water quality control.</p> <p><i>6<sup>th</sup> week</i></p> <p>Biological indicators and their role in environmental analysis. Biotic and abiotic indicators, active and passive indication, accumulation, biomagnification, bioaccumulation factor. Indicator species and their application possibilities.</p> <p><i>7<sup>th</sup> week</i></p> <p>Elemental analytical techniques in environmental chemistry: destructive and non-destructive possibilities. FAAS. GFAAS, ICP-OES and ICP-MS applications in environmental chemistry. The importance of elemental speciation in environmental assessment (Cr, As and Hg species and their effect on biological systems).</p>
<p><b>Requirements:</b></p> <p><i>- for a signature</i></p> <p>Attendance at <b>lectures</b> is recommended, but not compulsory. However, a 5-6 minutes of power point presentation must be held from a chosen environmental issue and students will talk and discuss about it during the lecture. Giving the presentation is compulsory, missing it means signature denied in the electronic system and one must take the course in the next semester.</p> <p><i>- for a grade</i></p> <p>Students will put together a 5-6 minutes of power point presentation regarding a freely chosen environmental issue and also write a short, maximum 10 pages of essay discussing the problem. The average of the two grades will form the final one.</p> <p><i>- for an offered grade</i></p> <p>no grade will be offered</p>
<p><b>Person responsible for course:</b> Dr. Edina Baranyai, assistant professor, PhD</p>
<p><b>Lecturer:</b> Dr. Edina Baranyai, assistant professor, PhD</p>

<b>Title of course:</b> Inorganic Methods in Environmental Analysis II. <b>Code:</b> TTKML0503_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 4 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 56 hours - home assignment: 44 hours - preparation for the exam: 20 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p><b>The aim of the laboratory practice</b> is to introduce the most important chemical analysis to determine the inorganic components of environmental samples. Chemical oxygen demand, dissolved oxygen, anions and cations affecting the halobity will be determined from surface water, inorganic contaminants, trace minerals and macro elements from soil and plants, ammonia from the atmosphere. Students are working in groups and 2 occasions are available to finish one series of experiments. During the last 4 practices own project tasks will be carried out based on the supervisor's instructions.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          - Practical syllabus available at the Department's home page (inorg.unideb.hu)</p> <p><i>Recommended:</i>          -Environmental Chemistry by banez, J.G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A., Singh, M.M., Springer-Verlag New York          - R. Reeve: Introduction to environmental analysis, Wiley, 2002.          - J.R. Dean: Methods for Environmental Trace Analysis, Wiley, 2003.</p>

<p><b>Schedule:</b> 2 practical occasions (2*4 hours) are available to finish one series of experiments. During the last 3 practices own project tasks will be carried out based on the supervisor's instructions.</p> <p><i>1<sup>st</sup> week</i>          General introduction to the basic laboratory safety rules and applied pieces of laboratory equipment.</p> <p><i>2<sup>nd</sup> week</i>          Short test writing of the theoretical background of the laboratory material. Water sampling from the Botanical garden. Determination of the dissolved oxygen concentration and chemical oxygen demand of surface water by permanganometric and iodometric titration methods. Calculation of the oxygen</p>
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saturation. (Part I.)

*3<sup>rd</sup> week*

Water sampling from the Botanical garden. Determination of the dissolved oxygen concentration and chemical oxygen demand of surface water by permanganometric and iodometric titration methods. Calculation of the oxygen saturation. (Part II.) Laboratory manual due in.

*4<sup>th</sup> week*

Short test writing of the theoretical background of the laboratory material. Water sampling from the Botanical garden. Determination of the inorganic ion composition of standing surface water: chloride ion by argentometric titration, sulphate ion by spectrophotometry, carbonate and hydrogen carbonate ion by acid-base titration, sodium, potassium, calcium and magnesium ions by microwave plasma atomic emission spectrometry. Building up the Maucha type diagram indication the ionic concentration of water affecting halobity. (Part I.)

*5<sup>th</sup> week*

Water sampling from the Botanical garden. Determination of the inorganic ion composition of standing surface water: chloride ion by argentometric titration, sulphate ion by spectrophotometry, carbonate and hydrogen carbonate ion by acid-base titration, sodium, potassium, calcium and magnesium ions by microwave plasma atomic emission spectrometry. Building up the Maucha type diagram indication the ionic concentration of water affecting halobity. (Part II.) Laboratory manual due in.

*6<sup>th</sup> week*

Short test writing of the theoretical background of the laboratory material. Elemental analysis of plant samples. Comparison of atmospheric wet digestion carried out with the mixture of concentrated acids and oxidizing agents on an electric hot plate with dry digestion in crucibles placed in electric oven. Determination of concentration of a chosen element by flame atomic absorption spectrometry. (Part I.)

*7<sup>th</sup> week*

Elemental analysis of plant samples. Comparison of atmospheric wet digestion carried out with the mixture of concentrated acids and oxidizing agents on an electric hot plate with dry digestion in crucibles placed in electric oven. Determination of concentration of a chosen element by flame atomic absorption spectrometry. (Part II.) Laboratory manual due in.

*8<sup>th</sup> week*

Short test writing of the theoretical background of the laboratory material. Wet digestion of soils in either a microwave or a thermal block system by the mixture of concentrated acids and oxidation agents. The complex macro and micro elemental profile will be quantitatively determined by microwave plasma atomic emission spectrometry. (Part I.)

*9<sup>th</sup> week*

Determination the elemental composition of soil samples. Wet digestion of soils in either a microwave or a thermal block system by the mixture of concentrated acids and oxidation agents. The complex macro and micro elemental profile will be quantitatively determined by microwave plasma atomic emission spectrometry. (Part II.) Laboratory manual due in.

*10<sup>th</sup> week*

Short test writing of the theoretical background of the laboratory material. Nitrite ion detection from water samples by spectrophotometry. Determination of the Arany type texture coefficient as well as the carbonate content of soil samples (Scheibler type calcimeter). (Part I.)

*11<sup>th</sup> week*

Determination of ammonium from the laboratory air by absorption method combined with spectrophotometry. Nitrite ion detection from water samples by spectrophotometry. Determination of the Arany type texture coefficient as well as the carbonate content of soil samples (Scheibler type calcimeter). (Part II.) Laboratory manual due in.

12<sup>th</sup> week

Laboratory work on an own project in groups previously discussed with the supervisor where the studied techniques and methods can be applied. (Project work Part I)

13<sup>th</sup> week

Laboratory work on an own project in groups previously discussed with the supervisor where the studied techniques and methods can be applied. (Project work Part II)

14<sup>th</sup> week

General written test of the theoretical background and application of the gained knowledge. Finishing the project work, discussion of the results. Laboratory manual of the project work due in.

**Requirements:**

*- for a signature*

Attending the laboratory practices is obligatory. Only one absence is allowed but along with a medical certificate proving illness. Students write a short test before each experimental part (all together 5) and also a general test at the very last occasion. The average of the short tests also the general test result must be above 20% to gain a signature. If either the short tests or the general test is under 20%, the signature will be denied in the electronic system and the student must take the course again in the next semester.

*- for a grade*

Students write a short test before each experimental part (all together 5) and also a general test at the very last occasion which will be evaluated according to the following table:

Score	Grade
0-49	fail (1)
50-65	pass (2)
66-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

Students will also handle in 5 laboratory manuals considering the practical work and one extra about the chosen project work. They will receive one grade as the average of the laboratory manuals, one as the average of the short tests and one for the general test. The three individual grades will be averaged to get the final one.

If the final grade is not reaching the passing mark then students will have one more occasion to take a written exam in the examination period. The exam is in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*- for an offered grade*

no grade will be offered

**Person responsible for course:** Dr. Edina Baranyai, assistant professor, PhD

**Lecturer:** Dr. Edina Baranyai, assistant professor, PhD

<b>Title of course:</b> Quality Assurance in Analytical Chemistry <b>Code:</b> TTKME0513_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b> - lecture: 1 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 14 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 16 hours Total: 30 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> –	
<b>Further courses built on it:</b> –	

<b>Topics of course</b>
<p>The material of the lecture covers the fundamental aspects of Quality Assurance (QA) and Quality Control (QC) in the chemical and pharmaceutical industry, and chemical safety. The course begins with describing the controlling and technical requirements of the supporting analytical laboratories. The next chapter covers the most important aspects of quality assurance and quality control in the pharmaceutical industry. The directives and the fundamental requirements of Good Manufacturing Practice (GMP) and Good Laboratory Practice (LCP) are discussed. The rules concerning the active pharmaceutical ingredients and the final pharmaceutical formulations are reviewed. The last chapter is dealing with chemical safety. The rules of the hazard classification of chemicals and their environmental and toxicological effects are overviewed. Environment and health protection, workplace safety regulations (EHS) together with the directives of REACH are reviewed.</p>
<b>Literature</b>
<p><i>Compulsory:</i></p> <p>1) Matthias Otto: Chemometrics          WILEY-VCH Verlag GmbH, Weinheim, Germany, 1999.</p> <p>2) Richard G. Brereton: Applied Chemometrics for Scientists          John Wiley &amp; Sons Ltd, Chichester, England, 2007.</p> <p>3) D. L. Massart. B. G. M. Vandeginste, S. N. Deming, Y. Michotte, and L. Kaufman:          Chemometrics: A textbook. Elsevier, Amsterdam, The Netherlands, 1988.</p>

**Schedule:***1<sup>st</sup> week*

Quality Control systems. Requirements

*2<sup>nd</sup> week*

Controlling requirements for supporting analytical laboratories.

*3<sup>rd</sup> week*

Technical requirements for supporting analytical laboratories.

*4<sup>th</sup> week*

Good Manufacturing Practice (GMP) and Good Laboratory Practice (GLP).

*5<sup>th</sup> week*

Quality Assurance (QA) and Quality Control (QC) in the pharmaceutical industry.

*6<sup>th</sup> week*

Regulations concerning chemicals.

*7<sup>th</sup> week*

Chemical safety, REACH.

**Requirements:***- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Participating in an exam earns the signature.

*- for a grade*

The course ends in a **written examination**.

Based on the score of the written examination the grade is given according to the following table:

Score	Grade
0-50	fail (1)
51-60	pass (2)
61-70	satisfactory (3)
71-80	good (4)
81-100	excellent (5)

If the score of the oral exam is below 51%, students can take a retake the exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. JózsefKalmár, assistant professor, PhD**Lecturer:** Dr. JózsefKalmár, assistant professor, PhD

<b>Title of course:</b> Mass Spectrometry <b>Code:</b> TTKME0317_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: 1 hour/week - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: 14 hours - laboratory: - - home assignment: 30 hours - preparation for the exam: 48 hours Total: 120 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Operation of ion sources, such as EI, ESI, APPI, APCI, DART, MALDI, their applicability on different compounds. Analysis of additives in household goods and nicotine adsorbed on clothes using DART technique. Studying combined techniques, such as GC-MS and HPLC-MS. Application of combined techniques for the analysis of natural samples, such as hot peppers, tropical fruits, spirits, caffeine. Discussion of scientific articles on mass spectrometry in the literature.
<b>Literature</b>
<i>Compulsory:</i> - Edmond de Hoffmann, Vincent Stroobant: Mass Spectrometry: Principles and Applications (Wiley, 2013) ISBN: 978-0-470-03310-4 - Jürgen H. Gross: Mass Spectrometry – A Textbook (Springer, 2017) ISBN 978-3-319-54398-7 - Michael L. Gross, Richard M. Caprioli: The Encyclopedia of Mass Spectrometry (Elsevier, 2006) ISBN: 9780080438016 <i>Recommended:</i> - Alison E. Ashcroft: Ionization Methods in Organic Mass Spectrometry (RSC Publishing, 1997) ISBN: 978-0-85404-570-9

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Principles of Electrospray Ionization (ESI), its applications. <i>2<sup>nd</sup> week</i> Principles of Atmospheric Pressure Photoionization (APPI), its applications..
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*3<sup>rd</sup> week*

Principles of Atmospheric pressure chemical ionization (APCI), its applications.

*4<sup>th</sup> week*

Principles of Direct analysis in real time (DART), its applications.

*5<sup>th</sup> week*

Principles of Matrix-Assisted Laser Desorption Ionization (MALDI), its applications.

*6<sup>th</sup> week*

Review of combined techniques, their applicability.

*7<sup>th</sup> week*

Application of HPLC-ESI combined technique to determine the capsaicine concentration in different hot pepper samples.

*8<sup>th</sup> week*

Principles of Electron Ionization (EI), the basics of GC-MS technique.

*9<sup>th</sup> week*

Application of GC-MS for the identification of volatile oils in tropical fruits.

*10<sup>th</sup> week*

Quality analysis of spirits by GC-MS technique.

*11<sup>th</sup> week*

Analysis of additives in household goods by DART technique.

*12<sup>th</sup> week*

Studying passive smoking by the analysis of nicotine adsorbed on clothes using DART technique.

*13<sup>th</sup> week*

Analysis of caffeine in different coffee samples using HPLC-MS technique.

*14<sup>th</sup> week*

Discussion of the scientific articles found in the literature.

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Active participation is rewarded by the teacher in every class. Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor.

During the semester there is one end-term test in the 15<sup>th</sup> week for an offered grade (optional). Students have to sit for the tests.

*- for a grade*

The course ends in an **examination**.

The minimum requirement for the end-term test and the examination respectively is 50%. Based on the score of the test, the grade for the test and the examination is given according to the following table:

<u>Score</u>	<u>Grade</u>
0-49	fail (1)
50-61	pass (2)
62-74	satisfactory (3)
75-87	good (4)
88-100	excellent (5)

If the score the test is below 50, students can take a retake test in conformity with the Education and



Examination Rules and Regulations.

*-an offered grade:*

it may be offered for students if the grade of the end-term test is at least satisfactory (3).

**Person responsible for course:** Prof. Dr.SándorKéki, university professor, DSc Dr. Tibor Nagy, assistant professor, PhD

**Lecturers:** Prof. Dr.SándorKéki, university professor, DSc  
Dr. Tibor Nagy, assistant professor, PhD

<b>Title of course:</b> Electrophoretic techniques <b>Code:</b> TTKME0504_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory:	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, : 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b>	

<b>Topics of course</b>
The course surveys the history, methods, theories, fundamentals and some practical aspects of analysis of the electrophoresis. Important additional topics are the capillary electrophoresis, chip electrophoresis (lab-on-a-chips) and hyphenation of capillary electrophoresis with mass spectrometry. The course is connected to some topics of the Instrumental Analysis lecture and complete the knowledge acquired in BSc level.
<b>Literature</b>
1. H.Engelhardt, W.Beck, T.Schmitt: Capillary electrophoresis, Friedr.Vieweg & Sohn Verlagsgesellschaft mbH, Braunschweig/Wiesbaden, 1996 (ISBN 3-528-06668-7) 2. R.Kuhn, S.Hoffstetter-Kuhn: Capillary electrophoresis, Springer-Verlag, New York, 1993 (ISBN 0-387-56434-9) 3. F.Foret, L.Krivánková, P.Bocek: Capillary Zone Electrophoresis, VCH-Weinheim, 1993, (ISBN 3-527-30019-8) 4. D.N.Heiger: High Performance Capillary Electrophoresis, Hewlett-Packard GmbH, Waldbronn, 1992 (ISBN 12-5091-6199E)

<b>Schedule:</b>
1 <sup>st</sup> week: History and importance of electrophoresis, expected future trends (2h)
2 <sup>nd</sup> week: Theory of the electrophoretic migration (2h)

3 <sup>rd</sup> week: Paper electrophoresis, isoelectric focusing, isotachopheresis (2h)												
4 <sup>th</sup> week: Gel electrophoresis, polyacrilamide gel electrophoresis (2h)												
5 <sup>th</sup> week: DNA sequencing with automatic capillary electrophoretic systems. Human Genome Project (2h)												
6 <sup>th</sup> week: The construction and operation of capillary electrophoresis instrument (2h)												
7 <sup>th</sup> week: Detection methods applicable to capillary electrophoresis (UV-Vis, amperometry, conductometry, LIF, MS) (2h)												
8 <sup>h</sup> week: Techniques of capillary electrophoresis (2h)												
9 <sup>th</sup> week: Principles of optimization for capillary electrophoresis I. (2h)												
10 <sup>th</sup> week: Principles of optimization for capillary electrophoresis II. (2h)												
11 <sup>th</sup> week: Main application fields of capillary electrophoresis (2h)												
12 <sup>th</sup> week: Lab-on-a-chip technology, microfluidics, miniaturized analytical systems (2h)												
13 <sup>th</sup> week: Commercial microfluidic analytical devices (Bioanalyzer 2100, LabChip, HPLC-chip MS) (2h)												
14 <sup>th</sup> week: Detection methods applicable to capillary electrophoresis (UV-Vis, amperometry, conductometry, LIF, MS) (2h)												
<b>Requirements:</b> Attendance at lectures is recommended, but not compulsory. The course ends in an examination. The minimum requirement for the examination is 50%. Based on the score of the test, the grade is given according to the following table: <table><tr><td>Score</td><td>Grade</td></tr><tr><td>0-50</td><td>fail (1)</td></tr><tr><td>50-69</td><td>pass (2)</td></tr><tr><td>70-79</td><td>satisfactory (3)</td></tr><tr><td>80-89</td><td>good (4)</td></tr><tr><td>90-100</td><td>excellent (5)</td></tr></table>	Score	Grade	0-50	fail (1)	50-69	pass (2)	70-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade											
0-50	fail (1)											
50-69	pass (2)											
70-79	satisfactory (3)											
80-89	good (4)											
90-100	excellent (5)											
<b>Person responsible for course:</b> Prof. Dr. Attila Gáspár, university professor, DSc												
<b>Lecturer:</b> Prof. Dr. Attila Gáspár, university professor, DSc												

<b>Title of course:</b> Sampling, Sample Treatment, Analytical Tests <b>Code:</b> TTKME0514_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b> - lecture: 1 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 14 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 16 hours Total: 30 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The aim of the course is to introduce the sampling methods generally applied in environmental chemistry. The most important techniques for sampling soil, sediment, surface and underground water, gases, biotic and abiotic biological indicators, biological tissues and fluids, rocks and metal alloys will be discussed. All the relevant and most important pre-treatment techniques will be overviewed which are necessary to get rid of the matrix components prior to the quantitative and qualitative determination of organic and inorganic analytes (such as extraction and dilution techniques, atmospheric and microwave digestion, acidic and basic reactions under high pressure etc.). Sampling and sample pre-treatment methods will be discussed which are used for speciation analysis, for organometallic compounds and biomolecules.</p>
<b>Literature</b>
<p><i>Compulsory:</i>  -Fundamentals of environmental sampling and analysis by Chunlong Zhang (ISBN: 978-0-471-71097-4)</p> <p><i>Recommended:</i>  - N.T. Crosby, I. Patel: General principles of good sampling practice, RSC,1995  - S. Mitra: Sample Preparation Techniques in Analytical Chemistry, Wiley, 2003.  - Sampling for Environmental Data Generation; P. Grieco and R. Trattner, SciTech Publishers, Matawan, NJ 1990.  -<a href="https://web.njit.edu/~kebbekus/analysis/SAMPLING.htm">https://web.njit.edu/~kebbekus/analysis/SAMPLING.htm</a></p>

**Schedule:** The lecture will be held in the first half of the semester, 2 hours/week

*1<sup>st</sup> week*

The grouping of environmental samples, sample types. The thematic classification of the most commonly measured components from environmental samples. The basic rules of sampling and the general description of sampling techniques.

*2<sup>nd</sup> week*

General statistical aspects of sampling. Liquid sampling: surface and underground water, rivers and streams. Solid sampling of metals, alloys and rocks. General guidelines, homogenization methods.

*3<sup>rd</sup> week*

Sampling from gases at atmospheric and high pressure. Direct sampling of solid materials from gaseous substances: aerosols and particulate matter (PM 10, PM 2.5). Adsorption and absorption techniques to selectively gain compounds from gaseous state, gas filtration. Sampling of soil, sediment and biological tissues.

*4<sup>th</sup> week*

Introduction to basic sample pre-treatment methods: homogenisation and drying of solid substances, circumstances affecting the solubility of the analyte. Storage, preservation and dissolving methods. Extraction techniques.

*5<sup>th</sup> week*

Reactions to eliminate the matrix and mobilize the compounds to be determined: dry and wet digestion methods, ignition, digestion at atmospheric pressure, microwave assisted sample pre-treatment. Digestion under acidic and basic conditions, most commonly applied reagents and pieces of equipment.

*6<sup>th</sup> week*

General introduction to the sampling and sample pre-treatment carried out for speciation analysis and organometallic substances, as well as biomolecules. Elemental speciation.

*7<sup>th</sup> week*

Sample preparation of biological indicators and biological tissues, fluids. Exact examples of a complex sampling and sample pre-treatment process, discussing the steps of tasks to be carried out. Review and consultation possibility.

**Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. However, students attending 5 out of the 7 occasions will have the opportunity to write a written test after the last lecture: if it is successful **a grade will be offered** in the electronic system which can be accepted or denied by the student.

*- for a grade*

The course ends in an **examination**. The students will either successfully fulfil the requirements to write the written test for an offered grade or take an oral exam in the examination period.

The minimum requirement for the passing mark in the written test and the examination respectively is 50%. For the written test to gain the offered grade the following table will be applied to calculate the result:

Score	Grade
0-49	fail (1)
50-65	pass (2)
66-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the written test is below 50, students can take the oral exam in the examination period which is the same for those students not visiting the lectures regularly. The exam is in conformity with

the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *for an offered grade*

Please see above highlighted with bold characters.

**Person responsible for course:** Dr. Edina Baranyai, assistant professor, PhD

**Lecturer:** Dr. Edina Baranyai, assistant professor, PhD

<b>Title of course:</b> Sampling, Sample Treatment, Analytical Tests <b>Code:</b> TTKML0514_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 4 hours/week	
<b>Evaluation:</b> mid-semester grade based on laboratory manual and written test	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 56 hours - home assignment: 64 hours - preparation for the exam: - Total: 120 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
During the laboratory practice, the complex environmental assessment of a fishing lake will be carried out. Taken plant, water, soil and sediment samples will be analysed with the studied methods for the most important inorganic contaminants: chemical oxygen demand, cations and anions affecting halobity, dissolved oxygen, oxygen saturation, pH, conductivity, elemental composition. Both on site techniques, as well as classical and instrumental methods will be applied.
<b>Literature</b>
<i>Compulsory:</i> - Fundamentals of environmental sampling and analysis by Chunlong Zhang (ISBN: 978-0-471-71097-4) - University syllabus of environmental analysis (available at the Department's home page of inorg.unideb.hu) <i>Recommended:</i> - Sampling for Environmental Data Generation; P. Grieco and R. Trattner, SciTech Publishers, Matawan, NJ 1990. - <a href="https://web.njit.edu/~kebbekus/analysis/SAMPLING.htm">https://web.njit.edu/~kebbekus/analysis/SAMPLING.htm</a>

<b>Schedule:</b> The third occasion will be a whole day (8 hours) of sampling at a fishing lake which therefore equals with two practical occasions (2*4 hours). <i>1<sup>st</sup> week</i> Introduction to the general laboratory safety rules highlighting the safety considerations of on-site field study. Overview of the laboratory and on-site pieces of equipment and instruments. <i>2<sup>nd</sup> week</i>
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Introduction to the fishing lake to be sampled. The sample types to be taken and the compounds to be measured will be discussed, the analytical methods to be applied for the quantitative analysis will be chosen. Students will build up the sampling plan, make a map, indicate the sampling points and collect all the sampling tools from the laboratory which will be necessary to carry out the sampling and on-site measurements.

*3<sup>rd</sup> week (2\* 4 hours)*

A full day trip to the fishing lake where the collection of surface water, sediment, soil and plant samples will be carried out. On site measurements of water pH and electric conductivity, temperature, preservation of samples for elemental analysis as well as the titration for dissolved oxygen and chemical oxygen demand will be carried out. Samples will be then taken to the laboratory for further measurements.

*4<sup>th</sup> week*

Determination of cation (macro and micro elements) concentration of the surface water samples by microwave plasma atomic emission spectrometry (MP-AES). Dilution of standard solutions and calibration required for the quantitative measurements.

*5<sup>th</sup> week*

Determination of the anion concentration affecting halobity from surface water samples by classical analytical and instrumental methods: carbonate and hydrogen carbonate ion by acid-base titration, chloride ion by argentometric titration and sulphate ion by spectrophotometric analysis.

*6<sup>th</sup> week*

Grinding and drying of soil samples, homogenization. Determination of the moisture content and organic matter content of soil samples and preparing them for elemental analysis by microwave assisted wet digestion at elevated pressure.

*7<sup>th</sup> week*

The elemental analysis of soil samples by microwave plasma atomic emission spectrometry (MP-AES). Dilution of standard solutions and calibration required for the quantitative measurements.

*8<sup>th</sup> week*

Grinding and drying of plant samples, homogenization. Determination of the moisture content of plant samples and preparing them for elemental analysis by conventional wet digestion at atmospheric pressure.

*9<sup>th</sup> week*

The elemental analysis of plant samples by microwave plasma atomic emission spectrometry (MP-AES). Dilution of standard solutions and calibration required for the quantitative measurements.

*10<sup>th</sup> week*

Cutting, grinding and drying of sediment samples, homogenization. Determination of the moisture content and organic matter content of sediment samples and preparing them for elemental analysis by microwave assisted wet digestion at elevated pressure.

*11<sup>th</sup> week*

The elemental analysis of sediment samples by microwave plasma atomic emission spectrometry (MP-AES). Dilution of standard solutions and calibration required for the quantitative measurements.

*12<sup>th</sup> week*

Evaluation of the gained results – calculating the final concentration results from the primer data of samples.

*13<sup>th</sup> week*

Written test regarding the field and laboratory work of sampling, sample pre-treatment and analysis of important environmental factors. Discussion of statistical analysis for the final evaluation and interpretation of the gained data. Finishing the laboratory manuals to be handled in. Washing up all the



sample containers and pieces of equipment.													
<p><b>Requirements:</b></p> <p><i>- for a signature</i></p> <p>Attendance at <b>both the field study and laboratory practices are obligatory</b>. Maximum one occasion can be missed but only along with a medical certificate. The written test must be above 20% to get a signature, otherwise the student will receive a signature denied and must take the course again in the next semester.</p> <p><i>- for a grade</i></p> <p>The course ends in a written test. The minimum requirement for the passing mark in the written test is 50%. For calculating the grade of the test the following table will be applied:</p> <table> <tr> <th>Score</th><th>Grade</th></tr> <tr> <td>0-49</td><td>fail (1)</td></tr> <tr> <td>50-65</td><td>pass (2)</td></tr> <tr> <td>66-79</td><td>satisfactory (3)</td></tr> <tr> <td>80-89</td><td>good (4)</td></tr> <tr> <td>90-100</td><td>excellent (5)</td></tr> </table> <p>If the score of the written test is below 50, students can take one final exam in the examination period, which will be similar to the written test. The exam is in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.</p> <p>Students will also handle in an electronic laboratory manual interpreting the overall results of the complex environmental assessment of the fishing lake. Grade will be given to this laboratory manual as well.</p> <p>Final grade will be formed by taking the average of the results of the written test (or exam) and the laboratory manual.</p> <p><i>- for an offered grade</i></p> <p>no grade will be offered</p>		Score	Grade	0-49	fail (1)	50-65	pass (2)	66-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade												
0-49	fail (1)												
50-65	pass (2)												
66-79	satisfactory (3)												
80-89	good (4)												
90-100	excellent (5)												
<b>Person responsible for course:</b> Dr. Edina Baranyai, assistant professor, PhD													
<b>Lecturer:</b> Dr. Edina Baranyai, assistant professor, PhD													

<b>Title of course:</b> Nuclear Analysis I. <b>Code:</b> TTKME0523_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> TTKML0523_EN	

<b>Topics of course</b>
- Formation of nuclear, atomic and particle radiations. their interaction with matter, and analytical aspects. - Application of natural stable and radioactive isotope in natural sciences. - Tracer methods. - Nuclear and radioanalytical methods using the interactions of radiation with matter.
<b>Literature</b>
<i>Compulsory:</i> - Kónya, J., Nagy N.M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford. - Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4 <sup>th</sup> Edition, Elsevier, Amsterdam. - Kratz, J.-V., Lieser, K.H., 2013. Nuclear and Radiochemistry: Fundamentals and Applications, 3rd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany,

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Formation and production of nuclear, atomic and particle radiation. <i>2<sup>nd</sup> week</i> Interaction of nuclear, atomic and particle radiation with matter. <i>3<sup>rd</sup> week</i> Analytical methods using natural radioactivity: determination of geological and historical ages. <i>4<sup>th</sup> week</i> Separation of isotopes. Physical, chemical, geological, and biological information obtained by observing isotope separations.
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*5<sup>th</sup> week*

Basic rules of tracer studies

*6<sup>th</sup> week*

Selection of tracers. Production of tracer isotopes.

*7<sup>th</sup> week*

Chemical radioanalytical methods: isotope dilution analysis, radiometric titration, radio gravimetry, radiochemical separation methods.

*8<sup>th</sup> week*

Radioanalysis in living organisms: in-vitro and in-vivo methods.

*9<sup>th</sup> week*

Industrial radioanalysis.

*10<sup>th</sup> week*

Nuclear and radioanalytical methods based on radiation-matter interactions: classification, characterization on the basis of the irradiation and emitted particles/photons.

*11<sup>th</sup> week*

Applications of neutrons: activation analytical methods, neutron radiography and tomography, neutrons scattering.

*12<sup>th</sup> week*

Application of electromagnetic radiation with high energy (gamma, X-ray): X-ray fluorescence analysis, Mössbauer spectroscopy

*13<sup>th</sup> week*

Application of beta and electron radiation: beta backscattering, electron microscopes and microprobes.

*14<sup>th</sup> week*

Application of ions: Rutherford backscattering, particles induced X-ray and gamma spectroscopy.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. Based on the examination, the exam grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *an offered grade:*

It may be offered for students if they write a test on the 14<sup>th</sup> week and the score of it is at least 60%. The offered grade is calculated as the exam grade (see above).

**Person responsible for course:** Prof. Dr.Noémi Nagy, university professor, DSc

**Lecturer:** Prof. Dr.Noémi Nagy, university professor, DSc

<b>Title of course:</b> NMR Operator Training II. <b>Code:</b> TKML0530_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 28 hours - laboratory: - - home assignment: - - preparation for the exam: 32 hours Total: 60 hours:	
<b>Year, semester:</b> 2 <sup>nd</sup> year 1 <sup>st</sup> or 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TKBL0004_EN or TTKML0004_EN	
<b>Further courses built on it:</b> TTKMG0318_EN	

<b>Topics of course:</b> practical laboratory course with the aim that students accomplishing the course will be able to record basic 2D homo- and heteronuclear correlated spectra on the 400/500 MHz high field NMR spectrometers without external help.
<b>Literature</b>
Compulsory:P.J. Hore, Nuclear Magnetic Resonance, ISBN 963 19 4426 3 Bruker TopSpin 3.x manuals (free download) Recommended:James Keeler, Understanding NMR Spectroscopy, ISBN 0-470-01787-2 N.E. Jacobsen, NMR Spectroscopy Explained: Simplified Theory, Applications and Examples for Organic Chemistry and Structural Biology

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Safety rules in NMR laboratory with supercon magnets. Dangers for magnets and human beings. Principle of pulsed Fourier NMR. Hardware of 400/500 MHz spectrometers. Optimizing lock parameters, adjusting field homogeneity (shimming), tuning/matching of probehead for proton and carbon measurements. Calibration of 90 degree hard (non-selective) proton pulse. <i>2<sup>nd</sup> week</i> Principle of 2D NMR spectroscopy. Concept of indirectly detected, 2 <sup>nd</sup> dimension. Recording magnitude 2D COSY spectrum. Explanation of important experimental parameters. Choice of spectral window, number of acquired data points, number of incremented delays, number of transients, etc. Processing 2D raw data – 2D Fourier transformation. Explanation of signals, diagonal- and cross-peaks in resulting spectra. <i>3<sup>rd</sup> week</i> Exercising tuning/matching of probehead and pulse calibration. Exercising acquisition and processing of 2D COSY spectrum. <i>4<sup>th</sup> week</i> Principle of 2D TOCSY experiment. Explanation of relevant experimental parameters. Calculating and/or calibrating the optimal power level for the TOCSY mixing block. Recording phase sensitive 2D TOCSY spectrum. Processing phase-sensitive 2D data – 2D Fourier transformation, phase
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<p>correction in both dimensions. Explanation of signals in the resulting TOCSY spectra. Assignment of spin systems.</p> <p><i>5<sup>th</sup> week</i> Exercising tuning/matching of probehead and pulse calibration. Calculation of TOCSY power level. Exercising acquisition and processing of 2D TOCSY spectrum. Practicing phase correction.</p> <p><i>6<sup>th</sup> week</i> Principle of 2D HSQC experiment. Explanation of relevant experimental parameters. Recording gradient- and sensitivity enhanced, phase sensitive 2D HSQC spectrum. Processing phase-sensitive 2D data – 2D Fourier transformation, phase correction and chemical shift referencing in both dimensions. Explanation of signals in the resulting HSQC spectra.</p> <p><i>7<sup>th</sup> week</i> Exercising tuning/matching of probehead for proton and carbon frequencies, pulse calibration. Exercising acquisition and processing of 2D HSQC spectrum. Practicing phase correction and chemical shift calibration.</p> <p><i>8<sup>th</sup> week</i> Principle of 2D NOESY/ROESY experiments. Explanation of relevant experimental parameters. Calculating and/or calibrating the optimal power level for the ROESY mixing pulse. Recording phase sensitive 2D ROESY spectrum. Processing phase-sensitive 2D data – 2D Fourier transformation, phase correction in both dimensions. Explanation of signals (intensities and phases of diagonal and crosspeaks) in the resulting ROESY spectra. Merits and limitations: ROESY vs. NOESY.</p> <p><i>9<sup>th</sup> week</i> Exercising acquisition and processing of 2D ROESY spectrum. Practicing phase correction, calibration, chemical shift referencing.</p> <p><i>10<sup>th</sup> week</i> Principle of 2D HMBC experiment. Explanation of relevant experimental parameters. Recording magnitude 2D HMBC spectrum. Processing 2D raw data, chemical shift referencing in both dimensions. Explanation of signals in the resulting HMBC spectra.</p> <p><i>11<sup>th</sup> week</i> Exercising tuning/matching of probehead for proton and carbon frequencies, pulse calibration. Exercising acquisition and processing of 2D HMBC spectrum.</p> <p><i>12<sup>th</sup> week</i> Exercising acquisition and processing of 2D COSY spectrum, one by one.</p> <p><i>13<sup>th</sup> week</i> Exercising acquisition and processing of 2D HSQC spectrum, one by one.</p> <p><i>14<sup>th</sup> week</i> Exercising acquisition and processing of 2D spectra, one by one.</p>
<p><b>Requirements:</b></p> <p><i>- for a signature</i></p> <p>Attendance of laboratory exercises is compulsory. A student must attend the practice classes and may not miss more than two times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.</p> <p><i>- for a grade</i></p> <p>The course ends in a <b>practical exam</b>. Based on the average of the grades of two practical tasks, the exam grade is calculated as an average of them:</p> <ul style="list-style-type: none"> <li>- the average grade of the two tasks – recording and processing 2D COSY and HSQC spectra</li> </ul>
<p><b>Person responsible for course:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc</p>
<p><b>Lecturer:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc</p>

<b>Title of course:</b> Analytics in the Pharma Industry <b>Code:</b> TTKML0520_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 4 hours /week	
<b>Evaluation:</b> mid-semester grade based on laboratory manual and written test	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 56 hours - home assignment: 64 hours - preparation for the exam: - Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>Laboratory course series provided within pharmaceutical laboratories aim to present the basis of analytical investigations as well as pharma regulations (GMP=Good Manufacturing Practice) to the students. The course is focussed on the analysis of the active pharmaceutical ingredients (API) production applying classic and instrumental technics.</p> <p>The course reviews the significance of the analytical results and their documentation, the calibration of the balances and other instrumentation, the usage of certified weights and other certified standards. Students will deal with qualification of analytical standards and their use for determination of assay and related compound content of API including photometry, liquid chromatography, classic as well as instrumental titration. Non-related compounds of the API, such as counter ions, water and organic solvents will be determined by ion-chromatography, Karl-Fischer (KF) titration and headspace gas-chromatography (HSGC). Purity or composition of the solvents used in production will be analysed by gas-chromatography and near-infrared spectroscopy as an alternative technique. Volatile impurities are determined as loss on drying, the results will be compared with those obtained by HSGC and KF titration. Normal phase chromatography will be used as chiral chromatography for enantiomer separation.</p>
<b>Literature</b>
<p><i>Compulsory:</i></p> <p>- L. Nádasdi (editor) (2010): Laboratory course for pharmaceutical analysis (TEVA in-house publication course attendees)</p>

<b>Schedule:</b> 1 <sup>st</sup> week Safety training, handling of basic laboratory instruments and equipment (analytical
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balance, automatic pipettes, ultrasonic water bath) basic calculations, rules of rounding, evaluation and interpretation of the analytical results.

2<sup>nd</sup> week Basic gmp rules, documentation system of an R&D laboratory.

3<sup>rd</sup> week Determination of assay by photometry. Reference materials. UV-VIS spectroscopy

4<sup>th</sup> week Determination of assay by potentiometry. Komplexytometry and redox titrations.

5<sup>th</sup> week Determination of solvent composition by NIR spectroscopy. IR/NIR spectroscopy.

6<sup>th</sup> week Water content determination by Karl Fischer (KF) titration and as Loss on drying. Basic principal of the KF titration. Coulometry and direct titration.

7<sup>th</sup> week The basis of the analytical chromatography. The construction of the HPLC, autosampler, pump, degasser, injector and detector. Analytical columns. Eluent/diluent preparation.

8<sup>th</sup> week Determination of assay of an active pharmaceutical ingredient by HPLC. The Empower software

9<sup>th</sup> week Chiral chromatography: determination of optical purity. Normal-Phase chromatography.

10<sup>th</sup> week Counter-ion determination by ion-chromatography. The Chromeleon software

11<sup>th</sup> week Impurity content determination by HPLC

12<sup>th</sup> week Impurity identification and quantification by MS detection with HPLC

13<sup>th</sup> week Identification and chromatographic purity GC. The construction of a gas-chromatograph, autosampler, injector and detector. Analytical columns. The Openlab software

14<sup>th</sup> week Residual solvent determination by GC

### **Requirements:**

*- for a grade*

Attendance at **practical laboratory courses** is compulsory.

The student must attend the practical classes. If a course is missed, it has to be make up during the semester discussed with the lecturer. In case a student misses a course but does not make up, the subject will not be signed and the student must repeat the course. Being late is equivalent with being absent.

Before starting the lab course, the student has to prepare a lab notebook connected to the actual laboratory work including summary of theoretical principles and the short description of the practice. Before start of the manual work, short oral and/or written test is taken to ensure the lecturer if the student is aware of necessary knowledge to perform the tasks. After finishing the lab-work, the student completes the lab notebook and hand it in to the lecturer within one week. The lab notebook must include all calculations, results as well as the short summary/discussion of the results.

The course ends with a grade. Based on the grades of the individual courses and the oral/written tests, final grade will be calculated as their average.

Average	Final grade
<2.00	fail (1)
2.00-2.50	pass (2)
2.51-3.50	satisfactory (3)
3.51-4.50	good (4)
4.51-5	excellent (5)

**Person responsible for course:** András Zékány, TEVA Pharmaceutical Works Ltd

**Lecturer:** Levente Nádasdi, TEVA Pharmaceutical Works Ltd



<b>Title of course:</b> Reaction mechanisms <b>Code:</b> TTKME0311_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 4 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 56 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 64 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	
<b>Topics of course</b> The students will get acquainted with the most frequently applied methods and theories used to explain thermodynamic and kinetic aspects as well as specificity and selectivity relationships of organic chemical reactions. The following main topics will be handled: summary of thermodynamic and kinetic characteristics of chemical reactions; types of organic reactions and mechanisms; use of VB and MO methods to describe homo- and heteronuclear bonds; understanding of reactions by frontier orbital interactions; principles of least motion; stereoelectronic effects; characterization of solvents, solvent effects; application of the above principles to a range of selected ionic, pericyclic and radical reactions.	
<b>Literature</b> Fleming, I. <i>Frontier Orbitals and Organic Chemical Reactions</i> , Wiley, 1976. Rauk, A. <i>Orbital Interaction Theory of Organic Chemistry</i> , Wiley, 1994. Giese, B. <i>Radicals in Organic Synthesis: Formation of Carbon-Carbon Bonds</i> ; Pergamon Press: Oxford, 1986. Parsons, A. F. <i>An Introduction to Free Radical Chemistry</i> , Blackwell, 2000. Alabugin, I. V. <i>Stereoelectronic Effects - A Bridge Between Structure and Reactivity</i> , Wiley, 2016. Savin, K. <i>Writing Reaction Mechanisms in Organic Chemistry</i> , Academic Press, 2014. Moloney, M. G. <i>How to Solve Organic Reaction Mechanisms</i> , Wiley, 2015.	
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Repetitive survey of VB and LCAO-MO methods and their use for the description of homo- and heteronuclear bonds as well as electron shift phenomena (inductive and mesomeric effects,	

conjugation, hyperconjugation). Effects of substituents on the energy levels and electron densities of bonds/compounds/intermediates. Reactive intermediates and their properties. The Hammond-postulate and its applications. Interactions between particles, properties of solvents and solutions, classification of solvents. Solvent effects in organic reactions.

#### *2<sup>nd</sup> week*

Perturbation theory of chemical reactions, Klopman-Salem-equation and its explanation. The concept of stereoelectronic effects, their consequences, Baldwin's rules. Principle of least motion, and its use for understanding of chemical reactions.

#### *3<sup>rd</sup> week*

Substitution on tetrahedral carbon atoms. Aliphatic nucleophilic substitution. Characterization of nucleophiles and leaving groups. Kinetic and stereochemical characterization of the bimolecular mechanism, its stereoelectronic control. Ring closures by S<sub>N</sub>2 reactions.

Kinetic and stereochemical characteristics of the monomolecular mechanism. Stereochemical effects of ion-pairs, neighbouring group effects and their consequences. The Walden-cycle. Effects of the nucleophile, the solvent and the structure of the substrate. Ambident and  $\alpha$ -effect nucleophiles.

#### *4<sup>th</sup> week*

Eliminations. Types:  $\alpha$ -,  $\beta$ - and 1,n-eliminations. Mechanisms of  $\beta$ -eliminations. Syn- and anti-eliminations. Kinetic and stereochemical characterization of the bimolecular mechanism, its stereoelectronic control. Kinetic and stereochemical characteristics of the monomolecular mechanism. Effects of the substrate, the attacking base, and the leaving group in eliminations; orientation of the double bond. Solvent effects, ratio of substitution and elimination.

#### *5<sup>th</sup> week*

Substitutions on trigonal carbon atoms. Nucleophilic substitution on acyl-carbon. Reactivity order of carboxylic acid derivatives and its explanation. Tetrahedral mechanism and its proofs. Effects of the nucleophile and the structure of the substrate on the reactions. Stereoelectronic controls (Bürgi-Dunitz-trajectory, decomposition of the tetrahedral intermediate), and their consequences. Activation and catalysis in acyl nucleophilic substitutions. Ring-closures on acyl carbons.

#### *6<sup>th</sup> week*

Additions. Electrophilic additions on carbon-carbon multiple bonds. Cis- and trans additions, stereospecificity and stereoselectivity. Onium- and carbeniumion type intermediates, stereochemical and solvent effects.

Nucleophilic additions on carbonyl groups. Summary and categorization of the reactions: additions of heteroatomic, hydride, and metalorganic nucleophiles. Nucleophilic additions on

carbon-carbon multiple bonds. Preconditions, 1,2- and 1,4-additions, directing the regioselectivity. Ring-closures by addition reactions.

*7<sup>th</sup> week*

Concept and types of pericyclic reactions. The main methods used for their explanation (correlation diagrams, FMO analysis). Electrocyclic reactions. Cycloaddition reactions, normal and inverse electron demand Diels-Alder-reactions. Lewis-acid catalysis, position- and periselectivity.

*8<sup>th</sup> week*

1,3-Dipolar cycloadditions. Cheletropic reactions, sigmatropic rearrangements. Solvent effects in pericyclic reactions.

*9<sup>th</sup> week*

Pericyclic reactions in biological systems, their applications for bioorthogonal labeling.

*10<sup>th</sup> week*

Explanation of pericyclic reaction by the aromatic character of the transition states. Comparison of the methods for understanding the pericyclic reactions.

*11<sup>th</sup> week*

Concept of free radicals, methods for their generation. Chemical initiators. Structure and elemental reactions of free radicals. Transformations by chain and non-chain mechanisms. Thermodynamic and kinetic stability of carbon-centered radicals, effects of the substituents on the radical centre.

*12<sup>th</sup> week*

Abstraction reactions of free radicals: thermochemical, polar, stereoelectronic and steric effects.

*13<sup>th</sup> week*

Addition reactions of free radicals: thermochemical, polar, stereoelectronic and steric effects.

*14<sup>th</sup> week*

Fragmentations and rearrangements of free radicals. Generation of radical in place of functional groups. Synthetic applications of radicals, condition of selectivity and reactivity.

Comparison of synthetic applications of radical and ionic reactions. The SET mechanism. Determining the radical nature of a reaction.

**Requirements:**

Attendance at **lectures** is recommended, but not compulsory.

An oral exam to be absolved during the examination period closes the course. A list of topics is provided at the start of the semester, and at the exam two topics chosen randomly are discussed after an approx. 1 hour preparation time.

**Person responsible for course:** Prof. Dr. László Somsák, university professor, DSc

**Lecturer:** Prof. Dr. László Somsák, university professor, DSc

<b>Title of course:</b> Asymmetric syntheses <b>Code:</b> TTKME0312_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 20 hours - preparation for the exam: 42 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> / 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Chirality, stereo isomerism, determination of the relative and the absolute configuration</li> <li>- Biopolymers, readily available enantiopure natural products</li> <li>- Methods for the preparation of enantiopure compounds</li> <li>- „Chiral pool” synthesis</li> <li>- Models describing stereochemistry of reactions</li> <li>- First (substrate-controlled), second (auxiliary-controlled), third (reagent-controlled) and fourth generation (catalyst-controlled) methods</li> <li>- C-C bond-forming reactions</li> <li>- Asymmetric oxidation methods, asymmetric epoxidation</li> <li>- Asymmetric reduction</li> <li>- Multiple asymmetric induction</li> <li>- Organocatalysis</li> <li>- „Memory of chirality”</li> <li>- Kinetic and dynamic kinetic resolution</li> <li>- Enzymatic reactions</li> <li>- Asymmetric total synthesis</li> </ul>
<b>Literature</b>
<i>Compulsory:</i> 1. R. A. Aitken, S. N. Kilényi: Asymmetric Synthesis, Springer Science+Business Media Dordrecht, 1992. 2. R. E. Gawley, J. Aubé: Principles of Asymmetric Synthesis, Second Edition, Elsevier, 2012, Kidlington, Oxford.

*Recommended:*

1. J. P. Riehl: Mirror-Image Asymmetry - An Introduction to the Origin and Consequences of Chirality, John Wiley & Sons, 2010, Hoboken, New Jersey.
2. E. L. Eliel, S. H. Wilen: Stereochemistry of Organic Compounds, Wiley, New York, 1994.
3. Y. Izumi, A. Tai: Stereo-Differentiating Reactions - The Nature of Asymmetric Reactions, Kodansha Scientific Books & Academic Press, 1977, New York.
4. R. S. Ward: Selectivity in Organic Synthesis, Wiley, Chichester, 1999.
5. G. Q. Lin, Y. M. Li, A. S. C. Chan: Principles and Applications of Asymmetric Synthesis, Wiley-Interscience, New York, 2001.
6. D. Enders, K. E. Jaeger: Asymmetric Synthesis with Chemical and Biological Methods, Wiley-VCH, Weinheim, 2007.
7. M. Christmann, S. Bräse: Asymmetric Synthesis - The Essentials, Wiley-VCH, Weinheim, 2008.

**Schedule:**

*1<sup>st</sup> week*

Significance of chirality in living organisms. Biopolymers. Stereoisomerism. Determination of relative and absolute configuration. Examples for enantiomers / diastereomers with different biological effects from living organisms and synthetic medicines. Possibilities for the production of enantiomerically pure materials. Enantiomerically pure compounds available in large amounts from natural sources.

*2<sup>nd</sup> week*

Advantage, disadvantage and examples of "chiral pool" syntheses. Stereoselectivity, stereospecificity. The basic concepts of asymmetric synthesis. Topicity (groups, faces). Prochirality. Symmetry relationships of faces.

*3<sup>rd</sup> week*

Cram's rule, Bürgi-Dunitz trajectory, Felkin-Anh model, Conforth-Evans model, Cram-chelate model, Prelog's rule. First (substrate-controlled), second (auxiliary-controlled), third (reagent-controlled) and fourth generation (catalyst-controlled) methods.

*4<sup>th</sup> week*

Examples of first and second generation methods.

*5<sup>th</sup> week*

Carbon-carbon bond forming reactions (asymmetric alkylation, asymmetric Michael reaction, asymmetric nucleophilic addition of carbonyl compounds).

*6<sup>th</sup> week*

Carbon-carbon bond forming reactions (asymmetric nucleophilic addition of carbonyl compounds, asymmetric [2 + 2] cycloaddition, asymmetric Diels-Alder reaction).

*7<sup>th</sup> week*

Asymmetric oxidation reactions, epoxidation reactions.

*8<sup>th</sup> week*

Asymmetric reduction reactions.

*9<sup>th</sup> week*

Multiple asymmetric induction.

*10<sup>th</sup> week*

Organocatalysis. „Memory of chirality”

*11<sup>th</sup> week*

Kinetic resolution. Dynamic kinetic resolution. Enzymatic reactions.

*12<sup>th</sup> week*

Asymmetric total syntheses. <i>13<sup>th</sup> week</i> Short presentation and discussion of independently processed source literature. <i>14<sup>th</sup> week</i> Short presentation and discussion of independently processed source literature.												
<b>Requirements:</b> - <i>for a signature</i> Attendance at <b>lectures</b> is recommended, but not compulsory. - <i>for a grade</i> Presentation of an independently processed source literature (20%) Exam (80%) The course ends in an <b>examination</b> . Based on the sum of the exam and the presentation points the final grade is calculated. The final grade is given according to the following table: <table><tr><td>Score (%)</td><td>Grade</td></tr><tr><td>0-49</td><td>fail (1)</td></tr><tr><td>50-59</td><td>pass (2)</td></tr><tr><td>60-74</td><td>satisfactory (3)</td></tr><tr><td>75-89</td><td>good (4)</td></tr><tr><td>90-100</td><td>excellent (5)</td></tr></table> If the score of the final grade is below 50%, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS. - <i>an offered grade:</i> It may be offered for students taking a successful early exam.	Score (%)	Grade	0-49	fail (1)	50-59	pass (2)	60-74	satisfactory (3)	75-89	good (4)	90-100	excellent (5)
Score (%)	Grade											
0-49	fail (1)											
50-59	pass (2)											
60-74	satisfactory (3)											
75-89	good (4)											
90-100	excellent (5)											
<b>Person responsible for course:</b> Dr. Attila Mándi, assistant professor, PhD												
<b>Lecturer:</b> Dr. Attila Mándi, assistant professor, PhD												

<b>Title of course:</b> Synthetic Methods in Polymer Chemistry <b>Code:</b> TTKME0313_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 32 hours - preparation for the exam: 30 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>st</sup> year, 3 <sup>rd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Nitroxide-mediated radical polymerization (NMP). Atom transfer radical polymerization (ATRP). Reversible addition-fragmentation chain transfer (RAFT) polymerization. Ring opening polymerization (ROP). Ring opening metathesis polymerization (ROMP). Controlled step polymerization methods.
<b>Literature</b>
<i>Compulsory:</i> - George Odian: Principles of Polymerization (Wiley, 2004) ISBN: 978-0-471-27400-1 - Leslie H. Sperling: Introduction to Physical Polymer Science (Wiley, 2006) ISBN: 978-0-471-70606-9  <i>Recommended:</i> - Krzysztof Matyjaszewski, Thomas P. Davis: Handbook of Radical Polymerization (Wiley, 2002) ISBN: 978-0-471-39274-3

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Review of polymerization methods. <i>2<sup>nd</sup> week</i> Laboratory techniques for the exclusion of air and humidity. <i>3<sup>rd</sup> week</i> Nitroxide-mediated radical polymerization (NMP) I. <i>4<sup>th</sup> week</i>
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Nitroxide-mediated radical polymerization (NMP) II.

5<sup>th</sup> week

Atom transfer radical polymerization (ATRP) I.

6<sup>th</sup> week

Atom transfer radical polymerization (ATRP) II.

7<sup>th</sup> week

Reversible addition-fragmentation chain transfer (RAFT) polymerization I.

8<sup>th</sup> week

Reversible addition-fragmentation chain transfer (RAFT) polymerization II.

9<sup>th</sup> week

Ring opening polymerization (ROP) I.

10<sup>th</sup> week

Ring opening polymerization (ROP) II.

11<sup>th</sup> week

Ring opening metathesis polymerization (ROMP) I.

12<sup>th</sup> week

Ring opening metathesis polymerization (ROMP) II.

13<sup>th</sup> week

Controlled step polymerization methods I.

14<sup>th</sup> week

Controlled step polymerization methods II.

### Requirements:

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory. Active participation is rewarded by the teacher in every class.

During the semester there is one end-term test in the 15<sup>th</sup> week for an offered grade (optional). Students have to sit for the tests.

- *for a grade*

The course ends in an **examination**.

The minimum requirement for the end-term test and the examination respectively is 50%. Based on the score of the test, the grade for the test and the examination is given according to the following table:

<u>Score</u>	<u>Grade</u>
0-49	fail (1)
50-61	pass (2)
62-74	satisfactory (3)
75-87	good (4)
88-100	excellent (5)

If the score the test is below 50, students can take a retake test in conformity with the Education and Examination Rules and Regulations.

- *an offered grade:*

it may be offered for students if the grade of the end-term test is at least satisfactory (3).

**Person responsible for course:** Prof. Dr.SándorKéki, university professor, DSc

**Lecturer:** Prof. Dr.SándorKéki, university professor, DSc

<b>Title of course:</b> Chemical aspects of drug design <b>Code:</b> TTKME0314_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> oral examination	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The students will get acquainted with the complex process of finding and/or discovery, design and development of drugs. The following main topics will be handled: drugs as chemical, legal and commercial entities; Intermolecular interactions responsible for the development of drug action; characterization of interactions between a small molecule and a biological target; drug targets, pharmacodynamics and pharmacokinetics; structure-activity relationships. These topics will be illustrated by several case studies.
<b>Literature</b>
G. L. Patrick: An introduction to medicinal chemistry, 4th edition, Oxford University Press, New York, 2009. (978-0-19-923447-9) R. B. Silverman, M. W. Holladay: The organic chemistry of drug design and drug action, 3rd ed., Academic Press, 2012. (978-0-12-382030-3) H. J. Smith, C. Simons (Eds.): Enzymes and their inhibition – Drug development. CRC Press, Boca Raton, 2005.

<b>Schedule:</b>
<i>1<sup>st</sup> week</i>
Definition of drugs, their types, and modes of action. Intermolecular interactions, hydrophobic/solvophobic effects. Participation of proteinogenic amino acid side chains in secondary chemical bondings.
<i>2<sup>nd</sup> week</i>
Characterization of interactions between small molecules-biological macromolecules: binding energy

and its components (enthalpy, entropy), flexibility, solvation, repulsive forces, shape of the molecules, stereoisomerism (configuration, conformation). Enthalpy-entropy compensation. Isosterism, bioisosterism.

*3<sup>rd</sup> week*

Categories of drug targets. Receptors, characterization of small molecule-receptor complexes: affinity (dissociation constant), effectivity. Definition of agonists and antagonists, models.

*4<sup>th</sup> week*

Enzymes as drug targets. Characterization of enzyme catalysis on the molecular level. Cofactors, coenzymes and their ways of action.

*5<sup>th</sup> week*

Types of enzyme inhibitors: reversible (competitive, non-competitive, uncompetitive, transition-state analogues), irreversible (affinity labels, mechanism-based inactivators). Enzyme inhibitors in drug development.

*6<sup>th</sup> week*

Nucleic acids as drug targets. Interactions of small molecules with nucleic acids. Alkylation and chain splitting of DNA. Antisense therapy. Transport and structural proteins, lipids as drug targets.

*7<sup>th</sup> week*

Pharmacodynamics and pharmacokinetics. ADMET properties.

*8<sup>th</sup> week*

Drugs as merchandises. Chemical biology and drug design. The multi- and interdisciplinary process of drug design and development. Phases, current practice and problems of drug development.

*9<sup>th</sup> week*

Finding, discovery and design of drugs. Hits, lead molecules, optimized leads. Elements of the early drug development phase.

*10<sup>th</sup> week*

Optimization of pharmacodynamic properties.

*11<sup>th</sup> week*

Optimization of pharmacokinetic properties. Concept of prodrugs.

*12<sup>th</sup> week*

Structure-activity relationships.

*13<sup>th</sup> week*

Case studies.

*14<sup>th</sup> week*

Case studies.

**Requirements:**

Attendance at **lectures** is recommended, but not compulsory.

An oral exam to be absolved during the examination period closes the course. A list of topics is provided at the start of the semester, and at the exam two topics chosen randomly are discussed after an approx. 1 hour preparation time.

**Person responsible for course:** Prof. Dr. László Somsák, university professor, DSc

**Lecturer:** Prof. Dr. László Somsák, university professor, DSc

<b>Title of course:</b> Separation techniques III. <b>Code:</b> TTKME0315_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - laboratory: - - home assignment: 20 hours - preparation for the exam: 42 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>th</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b> -	
<b>Topics of course</b>	
Basic principles of different modern analytical methods in the field of HPLC, GC, SFC. Examples and applications for chromatographic studies of organic compounds.	
<b>Literature</b> Effective Organic Compound Purification, Teledyne ISCO, Lincoln, USA (2010) D.A. Skoog, J.J. Leary: Principles of Instrumental Analysis, New York (1992) L.R. Snyder, J.J. Kirkland: Introduction To Modern Liquid Chromatography, Wiley, 1979 P. Schreider, A. Bernreuter, M. Huffer: Analysis of Chiral Organic Molecules, Walter de Gruyter, 1995	
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Introduction, overview of major chromatographic concepts. Categorization of chromatographic techniques by stationary and mobile phase. Chromatographic stationary phases. Retention Volume, Retention Time, Peak Height, peak area, Half Width, Bandwidth, Theoretical Plate Number, Theoretical Plate Height, Resolution, Signal, Noise, Drift, Signal / Noise, LOD, LOQ, tailing factor, peak asymmetry. Definition and use of the Kováts index in analytical chemistry. <i>2<sup>nd</sup> week</i> Size Exclusion Chromatography. Principles and mechanism of separation. Stationary phases in chromatography, physical and chemical structures, the newest developments. Instrumentation and operation of the separation processes. <i>3<sup>rd</sup> week</i> Calibration of GPC-SEC. Eluents and detectors. <i>4<sup>th</sup> week</i> Most common errors (GPC-HPLC comparison) and elimination of them.	

*5<sup>th</sup> week*

Instruments of modern column chromatography and their use. How can a TLC data be used as a pre-experiment? Transfer of TLC data to column chromatography.

*6<sup>th</sup> week*

Chiral chromatographic methods. Introduction. Use of chiral GC, HPLC.

Basics of Stereochemistry from chromatographic point of view. The concept of chirality. Different chiral and achiral chromatographic systems.

*7<sup>th</sup> week*

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 1. Adapting methods from achiral systems to chiral stationary phases.

*8<sup>th</sup> week*

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 2. Adapting methods from achiral systems to chiral stationary phases.

*9<sup>th</sup> week*

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 1.

*10<sup>th</sup> week*

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 2.

*11<sup>th</sup> week*

Stationary Phases, Mobile Phases in Reverse Phase Liquid Chromatography. The role of pH in the separation of proton-active compounds. Preparation of liquid chromatographic buffer solutions, their properties and their application possibilities.

*12<sup>th</sup> week*

The usage of gradient chromatography. The possibilities of eliminating the difficulties and pitfalls of it.

*13<sup>th</sup> week*

Instrumentation of liquid chromatography.

*14<sup>th</sup> week*

Closing test.

**Requirements:** - *for a signature*

Attendance at **lectures** is highly recommended, but not compulsory.

- *for a grade*

The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Attila Kiss, associate professor, PhD

**Lecturer:** Dr. Attila Kiss, associate professor, PhD

Dr. György Deák, associate professor, PhD

<b>Title of course:</b> Separation techniques IV. <b>Code:</b> TTKML0316_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: - laboratory: 2 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - practice: - laboratory: 28 hours - home assignment: 10 hours - preparation for the exam: 22 hours Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>th</sup> semester	
<b>Its prerequisite(s):</b> TTKME0315_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Basic principles of different modern analytical methods in the field of HPLC, GC, SFC. Examples and applications for chromatographic studies of organic compounds.
<b>Literature</b> Effective Organic Compound Purification, Teledyne ISCO, Lincoln, USA (2010) D.A. Skoog, J.J. Leary: Principles of Instrumental Analysis, New York (1992) L.R. Snyder, J.J. Kirkland: Introduction To Modern Liquid Chromatography, Wiley, 1979 P. Schreider, A. Bernreuter, M. Huffer: Analysis of Chiral Organic Molecules, Walter de Gruyter, 1995

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Basics of gas chromatography, most important measurement methods. Main parts of the GC device. Practical applications of different types of columns. Chromatographic indexes (Kováts index). Using the GC for quantification (in alcohol-water mixture, quantitative measurement of alcohol or determination of methane in air-methane gas mixtures). <i>2<sup>nd</sup> week</i> Determination of caffeine or limonene using GC-FID and GC-MS methods after extraction of a solid sample (lemon or coffee). Using the Spectrum Library of the GC to identify an unknown compound. <i>3<sup>rd</sup> week</i> Determination of molecular weight of polymer by GPC-SEC method (calibration and measurement). <i>4<sup>th</sup> week</i> Chiral method development 1. CSP-HPLC-UV coupling. <i>5<sup>th</sup> week</i>
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Chiral method development 3. CSP-HPLC-MS coupling.

6<sup>th</sup> week

The basics of liquid chromatography, its most important methods of measurement, the construction of the HPLC apparatus. Waters Alliance Liquid Transmission System and UV + DAD Detectors. Things to do after turning on the power. Checking the fluid delivery system.

7<sup>th</sup> week

Checking the injector and detectors. Application of Empower software, writing of measuring methods, methods for integration of recorded chromatograms. Column types and their application possibilities.

8<sup>th</sup> week

Closing test.

**Requirements:** - *for a signature*

Participation at **laboratory** is compulsory. A student must attend the practice classes and may not miss none of them during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at lab courses will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed lab courses should not to be made up for at a later date! Students are required to bring the drawing tasks and drawing instruments of the course to each lab courses. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

Students have to **submit all the two designing tasks** as scheduled minimum on a sufficient level.

During the semester there are two tests: the mid-term test in the 8<sup>th</sup> week and the end-term test in the 15<sup>th</sup> week. Students have to sit for the tests

- *for a grade*

The course ends in an **examination**. Based on the average of the grades of the designing tasks and the examination, the exam grade is calculated as an average of them:

- the average grade of the two designing tasks
- the result of the examination

The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Attila Kiss, associate professor, PhD

**Lecturer:** Dr. Attila Kiss, associate professor, PhD

Dr. György Deák, PhD, associate professor, PhD



<b>Title of course:</b> High efficiency synthetic methods I. <b>Code:</b> TTKML0319_EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: - - practice: 1 hour/week - laboratory: 3 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - practice: 14 hours - laboratory: 42 hours - home assignment: 34 hours - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- Understanding the theory of the most important high-performance techniques, practice of methods capable for the synthesis of various organic compounds. - Use of microwave technology, various flow condition methods and cleaning techniques.
<b>Literature</b>
<i>Compulsory:</i> 1. Slides and experimental descriptions provided by the lecturer. <i>Recommended:</i> 2. O. Kappe: Microwaves in Organic and Medicinal Chemistry, Vol. 25, 2005. 3. O. Kappe: Microwaves in Organic and Medicinal Chemistry, Vol. 52, 2012. 4. Santiago V Luis: Chemical Reactions and Processes under Flow Conditions, 2009. 5. Stefan Bräse: Combinatorial Chemistry on Solid Supports, 2007.

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Theoretical background of the applied techniques 1. <i>2<sup>nd</sup> week</i> Theoretical background of the applied techniques 2. <i>3<sup>rd</sup> week</i> Use of a CEM microwave reactor 1. <i>4<sup>th</sup> week</i> Use of a CEM microwave reactor 2. <i>5<sup>th</sup> week</i> Use of a TECAN robot 1.
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<p>6<sup>th</sup> week</p> <p>Use of a TECAN robot 2.</p> <p>7<sup>th</sup> week</p> <p>Use of a BIOTAGE SP4 fluid chromatograph 1.</p> <p>8<sup>th</sup> week</p> <p>Use of a BIOTAGE SP4 fluid chromatograph 2.</p> <p>9<sup>th</sup> week</p> <p>Use of a H-cube reactor 1.</p> <p>10<sup>th</sup> week</p> <p>Use of a H-cube reactor 2.</p> <p>11<sup>th</sup> week</p> <p>Use of ASIA flow reactor 1.</p> <p>12<sup>th</sup> week</p> <p>Use of ASIA flow reactor 2.</p> <p>13<sup>th</sup> week</p> <p>Complex problem solving.</p> <p>14<sup>th</sup> week</p> <p>Exam including the theoretical background and the practice.</p>
<p><b>Requirements:</b> - <i>for a signature</i></p> <p>Participation at <b>laboratory</b> is compulsory. A student must attend the practice classes and may not miss none of them during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at lab courses will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed lab courses should not to be made up for at a later date! Students are required to bring the drawing tasks and drawing instruments of the course to each lab courses. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.</p> <p>- <i>for a grade</i></p> <p>The course ends in a term mark which is calculated as an average of:</p> <ul style="list-style-type: none"> <li>- Theoretical knowledge (70%)</li> <li>- Practical grade (30%)</li> </ul> <p>Grade:</p> <p>excellent (5) 90 %, good (4) 75 %, satisfactory (3) 60 %, pass (2) 50 %, fail (1) below 50 %</p>
<p><b>Person responsible for course:</b> Dr. László Juhász, Associate professor, PhD, habil</p>
<p><b>Lecturer:</b> Dr. László Juhász, Associate professor, PhD, habil</p>

<b>Title of course:</b> 2D NMR Methods <b>Code:</b> TTKMG0318_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - seminar: 2 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - seminar: 28 hours - laboratory: - - home assignment: - - preparation for the exam: 32 hours Total: 60 hours:	
<b>Year, semester:</b> 2 <sup>nd</sup> year 1 <sup>st</sup> or 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKME0502_EN, TTKML0530_EN	
<b>Further courses built on it:</b>	

<b>Topics of course:</b> seminar with the aim that students accomplishing the course will be able to analyse, evaluate and assign basic 2D homo- and heteronuclear correlated spectra without external help.
<b>Literature</b> Compulsary: P.J. Hore, Nuclear Magnetic Resonance, ISBN 963 19 4426 3 Recommended: James Keeler, Understanding NMR Spectroscopy, ISBN 0-470-01787-2 N.E. Jacobsen, NMR Spectroscopy Explained: Simplified Theory, Applications and Examples for Organic Chemistry and Structural Biology

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Principle of pulsed Fourier NMR. Basic principle of 2D NMR spectroscopy. General scheme of 2D experiments, main building blocks. Concept of indirectly detected, 2 <sup>nd</sup> frequency dimension. Concept of 2D Fourier transformation. <i>2<sup>nd</sup> week</i> Introduction of vector model (VM) and product operator formalism (PO). Simple examples and applications of PO. Explanation of 2D COSY (Correlation Spectroscopy) experiment. Clarification of signals - diagonal- and cross-peaks – appearing in the resulting spectra. <i>3<sup>rd</sup> week</i> Product operator description of COSY sequence. Concept of coherence transfer. Quadrature detection in the indirectly detected dimension. Magnitude and phase sensitive detection. Analysis of COSY spectrum, assigning coupling partners. Exercises on spectra of different complexity. <i>4<sup>th</sup> week</i> Principle of 2D TOCSY (Total Correlation Spectroscopy) experiment. Concept of isotropic mixing. Different mixing sequences (MLEV, DIPSI). Explanation of signals in the resulting TOCSY spectrum. Concept of spin system. Analysis of TOCSY spectrum, assigning spin systems. Exercises on spectra of different complexity. <i>5<sup>th</sup> week</i> Practicing proton assignment of simple bio-oligomers (peptides, carbohydrates) based on
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<p>combined analysis of COSY and TOCSY spectra.</p> <p><i>6<sup>th</sup> week</i> Origin of Nuclear Overhauser Effect (NOE). Dipolar relaxation, cross-relaxation, sign of NOE. Laboratory- and rotating-frame NOE. Steady-state and transient NOE experiments. Principle of 2D NOESY/ROESY experiments. Explanation of signals – integrated intensities and phases of diagonal and crosspeaks - in the resulting NOESY/ROESY spectra. Merits and limitations of different experiments: ROESY vs. NOESY.</p> <p><i>7<sup>th</sup> week</i> Practicing analysis of 2D ROESY/NOESY spectra. Estimation of relative proton-proton distances based on volume intensities of crosspeaks using the two-spin approximation.</p> <p><i>8<sup>th</sup> week</i> Homo- and heteronuclear spin-echo building blocks. PO analysis of basic elements. INEPT sequence. Principle of 2D HSQC experiment. Explanation of signals in the resulting HSQC spectra.</p> <p><i>9<sup>th</sup> week</i> PO description of HSQC sequence. Practicing analysis of 2D HSQC spectra.</p> <p><i>10<sup>th</sup> week</i> Principle of 2D HMBC experiment. Explanation of signals in the resulting HMBC spectra.</p> <p><i>11<sup>th</sup> week</i> Practicing assignment of 2D HSQC and HMBC spectra. Exercises on spectra of different complexity.</p> <p><i>12<sup>th</sup> week</i> Problem solving exercises with real life examples. Practicing proton and carbon assignment based on combined analysis of different 2D spectra.</p> <p><i>13<sup>th</sup> week</i> Problem solving exercises with real life examples. Practicing proton and carbon assignment based on combined analysis of different 2D spectra.</p> <p><i>14<sup>th</sup> week</i> Problem solving exercises with real life examples. Practicing proton and carbon assignment based on combined analysis of different 2D spectra.</p>
<p><b>Requirements:</b></p> <p><i>- for a signature</i></p> <p>Attendance of seminars is compulsory.</p> <p>A student must attend the seminar classes and may not miss more than two times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any seminar with another group. Attendance at seminar classes will be recorded by the seminar leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed seminar classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.</p> <p><i>- for a grade</i></p> <p>The course ends in a <b>written exam</b>. Based on the average of the grades of two tasks – <i>one theoretical</i> (basic concepts and principles of 2D NMR experiments) and <i>one practical</i> (i.e. assignment of 2D spectra), the exam grade is calculated as an average of them:</p>
<p><b>Person responsible for course:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc.</p>
<p><b>Lecturer:</b> Prof. Dr. Katalin E. Kövér, university professor, DSc</p>

<b>Title of course:</b> Glycobiology <b>Code:</b> TTKME0321_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - seminar:- - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 40 hours - preparation for the exam: 22 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):-</b>	
<b>Further courses built on it:-</b>	

<b>Topics of course</b>
<p>Carbohydrates. Biological role of carbohydrates. Monosaccharides are polyhydroxy aldehydes or ketons. Sucrose, lactose, and maltose are the common disaccharides. Polysaccharides. Glycoconjugates. Structure of glycolipids and glycoproteins occurring in cell membranes. Cell surface glycans mediate uncountable biological events such as viral and bacterial infection, tumorigenesis, immune response and receptor-mediated signaling processes. Specific glycosylation patterns are proven to serve as markers at the early stages of disease or malignancy prior to metastasis. Carbohydrate-lectin interactions and functional glycomics. Modern methods for the synthesis and analysis of oligosaccharides.</p>
<b>Literature</b>
<p><i>Compulsory:</i>          - Lubert Stryer, Biochemistry, W. H. Freeman and Company, New York, 2002, ISBN 1-7167-4684-0.</p> <p><i>Recommended:</i>          - Glycoscience-Chemistry and Chemical Biology, (Eds: B. Fraser-Reid, K. Tatsua, J. Thiem) 2001, Springer-Verlag, Berlin          - Essentials of glycobiology (Eds: A.Varki, R. Cummings, J. Esko, H. Freeze, G. Hart, J. Marth, 1999, Cold Spring Harbor, New York, ISBN 0-87969-559-5)</p>

<b>Schedule:</b> <i>1<sup>st</sup> week:</i> Carbohydrates. Biological role of carbohydrates. Monosaccharides, disaccharides, polysaccharides  <i>2<sup>nd</sup> week:</i> Glycoconjugates. Structures of glycolipids and glycoproteins occurring in cell
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<p>membranes. Biological role of carbohydrates.</p> <p><i>3<sup>rd</sup> week:</i> Cell surface glycans mediate uncountable biological events such as viral and bacterial infection, tumorigenesis, immune response and receptor-mediated signaling processes. Specific glycosylation patterns are proven to serve as markers at the early stages of disease or malignancy prior to metastasis.</p> <p><i>4<sup>th</sup> week:</i> Modern methods for the synthesis and analysis of oligosaccharides.</p> <p><i>5<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>6<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>7<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>8<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>9<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>10<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>11<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>12<sup>th</sup> week:</i> Project work: Finding scientific journals in the field of glycobiochemistry and work out a choosen topics of the course.</p> <p><i>13<sup>th</sup> week:</i> Consultation.</p> <p><i>14<sup>th</sup> week:</i> Evaulation of the papers.</p>
<p><b>Requirements:</b></p> <p>- <i>for a signature</i></p> <p>Attendance at <b>lectures</b> is recommended, but not compulsory.</p> <p>- <i>for a grade</i></p> <p>Students must summarize their projectwork in a written report of 8-10 pages.</p>
<p><b>Person responsible for course:</b> Dr. János Kerékgyártó, senior research fellow, PhD</p>
<p><b>Lecturer:</b> Dr. János Kerékgyártó, senior research fellow, PhD</p>

<b>Title of course:</b> Stereochemical structural elucidation method <b>Code:</b> TTKME0322_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 10 hours - preparation for the exam: 52 hours Total: 90 hours	
<b>Year, semester:</b> -	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Importance of asymmetry and chirality and stereochemical definitions.</li> <li>- Types of chirality. Conformational and configurational enantiomers and diastereomers</li> <li>- Assignment of absolute configuration. R/S and D/L descriptors, Chan-Ingold-Prelog system.</li> <li>- Chiral drugs and their preparation by enantioselective synthesis.</li> <li>- Methods for determining absolute and relative configuration. Chemical correlation and kinetic resolution.</li> <li>- NMR methods for determining absolute configuration. Mosher's method and its modifications.</li> <li>- Interaction of substance and light. Circular dichroism and circular birefringence. Chiroptical methods.</li> <li>- Optical rotation, optical rotatory dispersion and circular dichroism spectroscopy.</li> <li>- Semi-empirical ECD rules and exciton-coupled circular dichroism.</li> <li>- Vibrational circular dichroism and Raman optical activity.</li> </ul>
<b>Literature</b>
<b>Compulsory:</b> Supporting material with lecture slides available at the homepage of the Department of Organic Chemistry <b>Recommended:</b> -J. P. Riehl: Mirror-Image Asymmetry - An Introduction to the Origin and Consequences of Chirality, John Wiley & Sons, 2010, Hoboken, New Jersey. -E. L. Eliel, S. H. Wilen: Stereochemistry of Organic Compounds, Wiley, New York, 1994.
<b>Schedule:</b> <i>1<sup>st</sup> week</i>

Importance of asymmetry and chirality and stereochemical definitions. Types of chirality. Conformational and configurational enantiomers and diastereomers.	
<i>2<sup>nd</sup> week</i>	
Assignment of absolute configuration. R/S and D/L descriptors, Chan-Ingold-Prelog system.	
<i>3<sup>rd</sup> week</i>	
Axial chirality of biaryls and allenes. Planar chirality.	
<i>4<sup>th</sup> week</i>	
Chiral drug molecules. Different pharmacological activities of enantiomers.	
<i>5<sup>th</sup> week</i>	
Preparation of chiral non-racemic active ingredients with stereoselective synthesis.	
<i>6<sup>th</sup> week</i>	
Methods for determining relative and absolute configuration. Chemical correlation.	
<i>7<sup>th</sup> week</i>	
Determination of absolute configuration by methods based on kinetic resolution. Horeau and Prelog method.	
<i>8<sup>th</sup> week</i>	
NMR methods for the determination of absolute configuration. Mosher's method and its modifications.	
<i>9<sup>th</sup> week</i>	
Interaction of substance and light. Circular dichroism and circular birefringence. Chiroptical methods.	
<i>10<sup>th</sup> week</i>	
Optical rotation and optical rotatory dispersion spectroscopy for determining configuration.	
<i>11<sup>th</sup> week</i>	
Electronic circular dichroism spectroscopy. Rotatory strength, ellipticity.	
<i>12<sup>th</sup> week</i>	
Theory and application of exciton-coupled circular dichroism	
<i>13<sup>th</sup> week</i>	
Helicity rules, sector rules and their application for determining absolute configuration.	
<i>14<sup>th</sup> week</i>	
Vibrational circular dichroism and Raman optical activity and their applications for stereochemical analysis.	
<b>Requirements:</b> - <i>for a signature</i> Attendance at <b>lectures</b> is highly recommended, but not compulsory. - <i>for a grade</i> The course ends with a written <b>exam</b> . The list of short questions used for the written exam is available at the homepage of the Department of Organic Chemistry. The minimum requirement for achieving the course is 50%.	
Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)
<b>Person responsible for course:</b> Prof. Dr. Tibor Kurtán, university professor, DSc	
<b>Lecturer:</b> Prof. Dr. Tibor Kurtán, university professor, DSc	



<b>Title of course:</b> Carbohydrate chemistry <b>Code:</b> TTKME0323_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> oral examination	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>Occurrence and biological functions of carbohydrates. Categories and utilization of carbohydrates. Constitution, configuration and conformation of monosaccharides, ways for their depiction. Basics of carbohydrate nomenclature. Structural aspects of oligo- and polysaccharides. Microheterogeneity. Structural elucidation methods in carbohydrate chemistry (X-ray, UV, IR, MS, NMR, chiroptical methods). Conformational analysis of monosaccharides. The anomeric effects (endo-, exo and reverse) and their generalization. Transformations of free sugars in aqueous medium; oxidation, reduction, reactions with N-, S-, and C-nucleophiles. Reactions of free sugars with alcohols: formation and hydrolysis of glycosides. Protecting groups: carbohydrate ethers and esters, acetals and ketals. Formation and reactions of peracylated monosaccharides, glycosyl halides, Construction of unsaturated bonds and further carbonyl groups on carbohydrate skeletons. Nucleophilic substitutions on non-anomeric carbons. Formation and cleavage of epoxides.</p>
<b>Literature</b>
<ol style="list-style-type: none"> <li>1. El Khadem, H. S. Carbohydrate Chemistry – Monosaccharides and Their Oligomers; Academic Press, 1988.</li> <li>2. Stoddart, J. F. Stereochemistry of Carbohydrates; Wiley, 1971.</li> <li>3. Lichtenthaler, F. W. (Ed.) Carbohydrates as Organic Raw Materials; VCH, 1991.</li> <li>4. Kirby, A. J. The Anomeric Effect and Related Stereoelectronic Effect at Oxygen; Springer, 1983.</li> <li>5. Levy, D. E.; Fügedi, P. The Organic Chemistry of Sugars; CRC Press, 2006.</li> <li>6. Lindhorst, T. K. Essentials of Carbohydrate Chemistry; Wiley-VCH, 2000.</li> <li>7. Collins, P. M.; Ferrier, R. J. Monosaccharides - Their Chemistry and Their Roles in Natural Products; John Wiley &amp; Sons, 1995.</li> <li>8. Miljkovic, M. Carbohydrates – Synthesis, Mechanisms, and Stereoelectronic Effects; Springer, 2009.</li> </ol>

9. Stick, R. V.; Williams, S. J. Carbohydrates: The Essential Molecules of Life; Elsevier, 2009.
10. Gabius, H.-J. (Ed.) The Sugar Code – Fundamentals of Glycosciences; Wiley-Blackwell, 2009.
11. Transforming Glycoscience: A Roadmap for the Future - 2012 (PDF is available from the National Academies Press at [http://www.nap.edu/catalog.php?record\\_id=13446](http://www.nap.edu/catalog.php?record_id=13446))

**Schedule:***1<sup>st</sup> week*

Occurrence and biological functions of carbohydrates.

*2<sup>nd</sup> week*

Categorization and utility of carbohydrates.

*3<sup>rd</sup> week*

Constitution, configuration and conformation of monosaccharides, ways for their depiction.

*4<sup>th</sup> week*

Basics of carbohydrate nomenclature.

*5<sup>th</sup> week*

Structural properties of oligo- and polysaccharides.

*6<sup>th</sup> week*

Application of physical methods of structural elucidation to carbohydrates (X-ray, UV-VIS, IR, MS, ORD/CD, NMR).

*7<sup>th</sup> week*

Conformational analysis of monosaccharides. The anomeric effects (endo-, exo and reverse) and their explanation.

*8<sup>th</sup> week*

Transformations of free sugars in aqueous media, their oxidation and reduction.

*9<sup>th</sup> week*

Reactions of free sugars with alcohol, formation and hydrolysis of glycosides; reactions with N-, S-, and C-nucleophiles.

*10<sup>th</sup> week*

Carbohydrate ethers and esters.

*11<sup>th</sup> week*

Carbohydrate acetals and ketals.

*12<sup>th</sup> week*

Formation and reactions of peracylated monosaccharides and glycosyl halides.

*13<sup>th</sup> week*

Synthesis of glycosides with protected monosaccharide derivatives.

*14<sup>th</sup> week*

Formation of unsaturated monosaccharide derivatives, creation of further carbonyl groups, reactions of the non-anomeric carbons, formation and cleavage of epoxides.

**Requirements:**

Attendance at **lectures** is recommended, but not compulsory.

An oral exam to be absolved during the examination period closes the course. A list of topics is provided at the start of the semester, and at the exam two topics chosen randomly are discussed after an approx. 1 hour preparation time.

**Person responsible for course:** Prof. Dr. László Somsák, university professor, DSc

**Lecturer:** Prof. Dr. László Somsák, university professor, DSc

<b>Title of course:</b> Organic Chemistry of Drug Synthesis <b>Code:</b> TTKME0324_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated)</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>rd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>• History of the development of pharmaceutical chemistry</li> <li>• The evolution of the Hungarian pharmaceutical industry</li> <li>• The current state of drug research</li> <li>• The most important concepts of pharmacology</li> <li>• Central nervous system drugs (narcotics, sedative anesthetics, anxiolytics, analgesics)</li> <li>• Classification, structure and synthesis of antibiotics</li> <li>• Structure and synthesis of antiviral drugs</li> <li>• Structure and synthesis of antifungal drugs</li> <li>• Structure and synthesis of natural and synthetic chemotherapeutic agents</li> <li>• Types of diabetes, the biological background of its development, therapeutic options. Structure and production of insulin and synthetichypoglycemicagents.</li> </ul>
<b>Literature</b>
Compulsory: <ol style="list-style-type: none"> <li>1. Slides of the lecture by Éva Juhászné Tóth</li> <li>2. Ruben Vardanyan and Victor Hruby: Synthesis of Essential Drugs, ISBN: 978-0-444-52166-8, Elsevier 2006</li> <li>3. M. J. Neal: Medical Pharmacology at a Glance, 7th Edition, ISBN: 978-1-118-30647-5Wiley-Blackwell 2012</li> <li>4. Francis A. Carey: Organic Chemistry (4th Edition), ISBN 0-07-290501-8; The McGraw-Hill Companies, Inc. 2000 (<i>recommended</i>)</li> </ol>

**Schedule:***1st week*

The concept of pharmaceutical chemistry.  
History and development of drug chemistry.

*2<sup>nd</sup> week*

Hungarian pharmaceutical industry and pharmaceutical research.  
Current situation and problems of pharmaceutical research.  
Production of medicines.  
Risk and cost of drug therapy.

*3<sup>rd</sup> week*

The basics of the mechanism of action of drugs.  
Pharmacokinetic and pharmacodynamic principles.  
Drug-receptor interaction.  
Drug absorption, distribution and selection.  
Drug metabolism.  
Define concepts that are relevant to the distribution and judgment of medicines.  
Categorization of drugs according to their effects.

*4<sup>th</sup> week*

Medicinal products of the central nervous system; sedatives.  
Anatomical-functional division of the human nervous system.  
Causes of nervous system disorders and diseases.  
A historical overview of the use of narcotics.  
Surgical narcotics: structure of inhalation and injection narcotics.  
Synthesis of inhaled narcotics.

*5<sup>th</sup> week*

Synthesis of barbituric acid derivatives, steroids, benzodiazepines and other injectable narcotics.

*6<sup>th</sup> week*

Structure and synthesis of sedative-hypnotics; alkaloids, alcohols, glycols, polyalcohols, aldehydes, urethans and ureides.

*7<sup>th</sup> week*

Hypnotics and sedative drugs; Structure of the barbituric acid derivatives, their most important effect-structural relationships and their production. Preparation of Dioxo-piperidines. The Thalidomid "scandal"  
Anxiolytics; benzodiazepines and their structure and synthesis.

*8<sup>th</sup> week*

Analgesics; major and minor analgesics.  
Production of morphine and co-alkaloids from poppy straw (János Kabay's invention). Important discoveries about understanding the effects of opioids. Painkillers; grouping and production of strong analgesics (opioids, morphine and semi-synthetic derivatives, synthetic morphine analogs).

*9<sup>th</sup> week*

Definition and grouping of antibiotics. Beta-lactam antibiotics: penicillins, cephalosporins, monobactams, their structure and mechanism of action. Discovery, grouping of penicillins (natural and semi-synthetic derivatives) and their synthesis.

*10<sup>th</sup> week*

Penicillin resistance. Structure, mechanism of action and production of aminoglycosides, peptide, macrolide and polycyclic Antibiotics.

*11<sup>th</sup> week*

Mechanism of action, structure and production of antifungal drugs (polyenes, imidazoles, triazoles, allylamines and other molecules).

*12<sup>th</sup> week*

Viruses, viral infections and treatment options. Structure and production of antiviral drugs (amantadine, vidarabine, ribavirin, etc.).

*13<sup>th</sup> week*

Structure and production of natural (plant-derived) and synthetic (purine, pyrimidine derivatives, various alkylating agents, antibiotics) chemotherapeutic preparations.

*14<sup>th</sup> week*

Types of diabetes, the biological background of its development, therapeutic options. Structure and production of insulin and synthetic hypoglycemic agents.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

The exam grade is the result of the written exam.

The minimum requirement for the examination respectively is 50%. The grade for the written exam is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-75	satisfactory (3)
76-87	good (4)
88-100	excellent (5)

If the score of any test below 50, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. ÉvaJuhászTóth, assistant professor, PhD

**Lecturer:** Dr. ÉvaJuhászTóth, assistant professor, PhD

<b>Title of course:</b> Radiochemistry <b>Code:</b> TTKME0410_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> TTKML0415_EN	

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Properties of atomic nuclei, binding energy, fundamental and composite particles.</li> <li>- Kinetics of radioactive decay.</li> <li>- Mechanism and type of radioactive decay.</li> <li>- Interaction of radiation with matter.</li> <li>- Nuclear reactions, new trends in nuclear energy production.</li> <li>- Physico-chemical applications of radioisotopes.</li> <li>- Statistics of radioactive decay, measurement of radiation.</li> </ul>
<b>Literature</b>
<i>Compulsory:</i> <ul style="list-style-type: none"> <li>- Kónya, J., Nagy N.M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford.</li> <li>- Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4<sup>th</sup> Edition, Elsevier, Amsterdam.</li> <li>- Kratz, J. V., Lieser, K.H., 2013. Nuclear and Radiochemistry: Fundamentals and Applications, 3<sup>rd</sup> Edition, Wiley-VCH Verlag GmbH &amp; Co. KGaA, Weinheim, Germany,</li> </ul>

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Properties and constituents of atomic nuclei. Binding energy, Yukawa potential, meson field. Scientific model of atomic nucleus. <i>2<sup>nd</sup> week</i> Fundamental and composite particles. Models of atomic nucleus. Kinetics of radioactive decay.
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Statistical description of simple radioactive decay. Description of decay as a function of time.

*3<sup>rd</sup> week*

Branching and successive decay. Kinetics of successive decay. Radioactive equilibria and their measuring consequences. Measurement of radionuclides having branching and successive decay.

*4<sup>th</sup> week*

Mechanisms of radioactive decay. Alpha decay: recoil of nucleus, interpretation of alpha decay by the particle-wave duality. Application of particle-wave duality.

*5<sup>th</sup> week* Beta decays, electron capture, double beta decay, proton and neutron decays, exotic decay, spontaneous fission. Types of radioactive decay.

*6<sup>th</sup> week*

Interaction of radiation with matter: what happens to the radiation and matter. Kinetics of radiation-matter interactions. Interaction of alpha radiation with matter: energy loss and scattering. Characterization and classification of radiation-matter interactions.

*7<sup>th</sup> week*

Interaction of beta radiation with matter: interactions with electron shell, nuclear field and molecules. Measuring consequences. Interaction of gamma and X-ray radiation with matter: scattering, photoelectric effect, pair formation, Mössbauer effect. General aspects of the interaction of beta and electromagnetic radiation with matter

*8<sup>th</sup> week*

Production of neutrons, properties, interaction with matter. Chemical effects of radiation. Szilárd-Chalmers reactions. Properties and applications of neutrons. Chemical changes following irradiation.

*9<sup>th</sup> week*

Nuclear reactions, Conservation rules, kinetics. Nuclear reactions with neutrons. Nuclear reactions with charged particles Spallation reaction. Isotopes produced in nuclear reactor and cyclotron. Transformations of atomic nuclei.

*10<sup>th</sup> week*

Nuclear reactions. Thermonuclear reactions. Nucleogenesis. Production of transuranium elements. Transformations of atomic nuclei.

*11<sup>th</sup> week*

Nuclear reactors (energy production). Fission by thermal neutrons. Operation of nuclear reactors (energy production, breeding). Nuclear accidents. Types and operation of nuclear reactors

*12<sup>th</sup> week*

New trends in nuclear energy production. Fusion reactors. Natural nuclear reactors. Nuclear weapons. New trend in nuclear energy production

*13<sup>th</sup> week*

Radioisotopes in physical chemistry: isotope exchange reactions. Study of physico-chemical processes by radiotracers.

*14<sup>th</sup> week*

Detection and measurement of nuclear radiation. Detectors, electric units. Effect of statistics on the evaluation. Detection and measurement of radiation.

### **Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. Based on the examination, the exam grade is given according to the following table:

Score	Grade
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0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)
<p>If the score of the examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.</p> <p><i>-an offered grade:</i></p> <p>it may be offered for students if they write a test on the 14<sup>th</sup> week and the score of it is at least 60%. The offered grade is calculated as the exam grade (see above).</p>	
<b>Person responsible for course:</b> Prof. Dr.Noémi Nagy, university professor, DSc	
<b>Lecturer:</b> Prof. Dr.Noémi Nagy, university professor, DSc	

<b>Title of course:</b> Nuclear Methods for Environmental Protection <b>Code:</b> TTKME0426_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 22 hours - practice: - - laboratory: - - home assignment: 20 hours - preparation for the exam: 20 hours Total: 62 hours	
<b>Year, semester:</b> 1st year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> NA	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The series of lectures are based on the topics of natural and anthropogenic radioactivity. It reviews the sources and level of the natural and industrial radiation. It presents the environmental problems, which could be investigated using isotope analyses. It gives an overview about the applicable analytical methods and their basic parameters (sample matrix, sample amount and suitable physical forms, detection level). Introduction of the complex application of combined isotope methods targeting environmental problems.</p>

## Literature

### *Compulsory:*

Allegre, J.C. (2008) Isotope Geology. Cambridge University Press, Cambridge, pp: 534, ISBN-13 978-0-521-86228-8

### *Recommended:*

- Faure, G. (1998) Principles and Applications of Geochemistry. Prentice-Hall Inc., Upper Saddle River, New Jersey, pp: 600, ISBN: 0-02-336450-5

Brownlow, H.A. (1996) Geochemistry. Prentice-Hall Inc., Upper Saddle River, New Jersey, pp: 573, ISBN-13: 978-0133982725

## Schedule:

### *1<sup>st</sup> week*

Generation-II type NPP Reactors and their environmental impact.

### *2<sup>nd</sup> week*

Radioactive waste management in NNP systems, techniques and strategies.

### *3<sup>rd</sup> week*

Radioactive emissions during normal operation of NPPs and their impact.

### *4<sup>th</sup> week*

New generation of NPP reactors, perspective.

### *5<sup>th</sup> week*

Nuclear waste repository systems, technology and strategies.

### *6<sup>th</sup> week*

Application of noble gas isotope analyses for diagnostics of nuclear reactors and connected systems.

### *7<sup>th</sup> week*

Classification of nuclear waste streams, difficult-to-measure isotopes.

### *8<sup>th</sup> week*

Gas generation in nuclear waste, implications and methods.

### *9<sup>th</sup> week*

Normal and accidental isotope releases from NPPs. History, recent practice and future perspective.

### *10<sup>th</sup> week*

Groundwater monitoring systems around NPPs. Strategies and recent practice.

### *11<sup>th</sup> week*

Overview of isotope analytical methods for NPPs radiochemical purposes. Example of the HEKAL Laboratory at MTA Atomki.

### *12<sup>th</sup> week*

Cyclotrons for NPP investigations and medical applications.

### *13<sup>th</sup> week*

Environmental impact of Cyclotron laboratories.

### *14<sup>th</sup> week*

*Visit at the Cyclotron Lab of MTA Atomki, Debrecen.*

## Requirements:

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

The minimum requirement for the examination respectively is 60%. Based on the score of the tests separately, the grade of the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*-an offered grade:*

Not applicable.

**Person responsible for course:** Dr. MihályMolnár, senior research fellow, PhD

**Lecturer:** Dr. MihályMolnár, senior research fellow, PhD

<b>Title of course:</b> Medical applications of radiopharmaceuticals <b>Code:</b> TTKME0429_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 30 hours - preparation for the exam: 32 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The series of lectures are based on the different topics of preclinical and clinical Nuclear medicine. It reviews the physiological fundamentals of the radiopharmaceutical applications the essentials of instrumentation and diagnostic and therapeutic procedures of Nuclear Medicine,.
<b>Literature</b>
<i>Compulsory:</i> -A Concise Guide to Nuclear Medicine (Elgazzar, A. H., Springer, 2011)
<i>Recommended:</i> 1. A Clinician's Guide to Nuclear Medicine (Taylor A., Alazraki N., and Schuster D.M.; SNM, 2006, 2nd ed.) 2. Fred A., Mettler JR., Milton J.,Guiberteau essentials of Nuclear Medicine Imaging 5th. ed. Elsevier 2006

<b>Schedule:</b>
<i>1<sup>st</sup> week:</i> The anatomy, the developmental and physiological fundamentals of brain, endocrine system and heart and lung system from the aspects of used radiopharmaceuticals.
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<i>2<sup>nd</sup> week:</i> The anatomy, the developmental and physiological fundamentals of gastrointestinal tract, kidney's, inflammations. Oncology.
<i>3<sup>rd</sup> week:</i> Instrumentation of Nuclear medicine, single photon technics.

*4<sup>th</sup> week:* Instrumentation of Nuclear medicine, double photon (PET) technics.

*5<sup>th</sup> week:* Instrumentation of Nuclear medicine, multimodality (hybrid) imaging.

*6<sup>th</sup> week:* Nuclear Medicine investigations of illnesses of central nervous and endocrine systems.

*7<sup>th</sup> week:* Nuclear Medicine investigations of respiratory, circulatory systems and gastrointestinal and immunologic disorders

*8<sup>th</sup> week:* Imaging of separated kidney function. Oncology 1. Bone scintigraphy.

*9<sup>th</sup> week:* Onkologia 2. PET, PET-CT hybrid imaging.

*10<sup>th</sup> week:* Introduction into the field of preclinical interventions.

*11<sup>th</sup> week:* Visit the preclinical lab, try the instruments.

*12<sup>th</sup> week:* Visit the department of human clinical diagnostic and therapeutic nuclear medicine interventions. Patient booking and management from the aspects of Single photon radiopharmaceuticals. Imaging instrumentation (1 hour)

Patient booking and management from the aspects of PET isotope-labelled radiopharmaceuticals. PET Imaging instrumentation (1 hour)

*13<sup>th</sup> week:* Protocols of different isotope therapies. From isotope shielding to patient release.

*14<sup>th</sup> week:* Discussion, consultation before exam.,

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Students are required to bring the drawing tasks and drawing instruments of the course to each practice class. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

Students have to **submit all the designing tasks** as scheduled minimum on a sufficient level.

At the end of course there is a one written exam. Students have to sit for the tests

*- for a grade*

The course ends in an **examination**. Based on the average of the grades of the designing tasks and the examination, the exam grade is calculated as an average of them:

- the average grade of the two designing tasks

- the result of the examination

The minimum requirement for the mid-term and end-term tests and the examination respectively is 60%. Based on the score of the tests separately, the grade for the tests and the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*-an offered grade:*

it may be offered for students if the average grade of the two designing tasks is at least satisfactory (3) and the average of the mid-term and end-term tests is at least satisfactory (3). The offered grade is the average of them.

**Person responsible for course:** Prof. Dr. László Galuska professor emeritus, DSc

**Lecturer:** Prof. Dr. László Galuska professor emeritus, DSc

<b>Title of course:</b> Nuclear Analysis I. <b>Code:</b> TTKME0523_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> TTKML0523_EN	

<b>Topics of course</b>
- Formation of nuclear, atomic and particle radiations. their interaction with matter, and analytical aspects. - Application of natural stable and radioactive isotope in natural sciences. - Tracer methods. - Nuclear and radioanalytical methods using the interactions of radiation with matter.
<b>Literature</b>
<i>Compulsory:</i> - Kónya, J., Nagy N.M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford. - Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4 <sup>th</sup> Edition, Elsevier, Amsterdam. - Kratz, J.-V., Lieser, K.H., 2013. Nuclear and Radiochemistry: Fundamentals and Applications, 3rd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany,

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Formation and production of nuclear, atomic and particle radiation. <i>2<sup>nd</sup> week</i> Interaction of nuclear, atomic and particle radiation with matter. <i>3<sup>rd</sup> week</i> Analytical methods using natural radioactivity: determination of geological and historical ages. <i>4<sup>th</sup> week</i> Separation of isotopes. Physical, chemical, geological, and biological information obtained by observing isotope separations.
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*5<sup>th</sup> week*

Basic rules of tracer studies

*6<sup>th</sup> week*

Selection of tracers. Production of tracer isotopes.

*7<sup>th</sup> week*

Chemical radioanalytical methods: isotope dilution analysis, radiometric titration, radio gravimetry, radiochemical separation methods.

*8<sup>th</sup> week*

Radioanalysis in living organisms: in-vitro and in-vivo methods.

*9<sup>th</sup> week*

Industrial radioanalysis.

*10<sup>th</sup> week*

Nuclear and radioanalytical methods based on radiation-matter interactions: classification, characterization on the basis of the irradiation and emitted particles/photons.

*11<sup>th</sup> week*

Applications of neutrons: activation analytical methods, neutron radiography and tomography, neutrons scattering.

*12<sup>th</sup> week*

Application of electromagnetic radiation with high energy (gamma, X-ray): X-ray fluorescence analysis, Mössbauer spectroscopy

*13<sup>th</sup> week*

Application of beta and electron radiation: beta backscattering, electron microscopes and microprobes.

*14<sup>th</sup> week*

Application of ions: Rutherford backscattering, particles induced X-ray and gamma spectroscopy.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. Based on the examination, the exam grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *an offered grade:*

It may be offered for students if they write a test on the 14<sup>th</sup> week and the score of it is at least 60%. The offered grade is calculated as the exam grade (see above).

**Person responsible for course:** Prof. Dr.Noémi Nagy, university professor, DSc

**Lecturer:** Prof. Dr.Noémi Nagy, university professor, DSc



<b>Title of course:</b> Nuclear Analysis II. <b>Code:</b> TTKML0523_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 2 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 5 days/semester - home assignment: 20 hours - preparation for the exam: - Total: 30 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKME0523_EN (same semester)	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- Visits and laboratory practices in nuclear facilities.
<b>Literature</b>
<i>Compulsory:</i> - Descriptions of practices on the homepage of the department - Kónya, J., Nagy N. M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford. - Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4 <sup>th</sup> Edition, Elsevier, Amsterdam.

<b>Schedule:</b> <i>1<sup>st</sup> day</i> Visit of a nuclear power plant (Paks). Chemical task in a nuclear power plant (analysis, radiation protection) <i>2<sup>nd</sup> day</i> Visit of a nuclear waste disposal site (Bátaapáti). <i>3<sup>rd</sup> day</i> Visit of Isotope Institute Ltd. (Budapest). Production of radiopharmaceuticals. <i>4<sup>th</sup> day</i> Visit of Energy Science Research Institute (Budapest). Prompt gamma activation analysis laboratory practice. <i>5<sup>th</sup> day</i> Visit of Energy Science Research Institute (Budapest). ICP-MS analysis of uranium and transuranium elements.
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**Requirements:**

The measurements and knowledge of the associated theory are graded and an overall mark will be given.

Safety training is mandatory before the first lab practice. Everybody should work and do the measurement individually according to the pre-set schedule (it will be provided prior to the first lab. The laboratory practices are 4-hrs long. In accordance with the regulations of University of Debrecen, attendance is compulsory with the exception of health or family problems. In this case, the students should agree with the teacher on replacement dates for the missed experiments. Pregnant and breastfeeding women are not allowed to work in radioactive laboratory.

**Person responsible for course:** Prof. Dr.Noémi Nagy, university professor, DSc

**Lecturer:** Prof. Dr.Noémi Nagy, university professor, DSc

<b>Title of course:</b> Production of Isotopes <b>Code:</b> TTKML0437_EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: 1 hour/week - practice: - - laboratory: 1 hour/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 14 hours - practice: - - laboratory: 14 hours - home assignment: 62 hours - preparation for the exam: 0 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it: -</b>	

<b>Topics of course</b>
<p>The present course is aimed at providing knowledge for the students on the various aspects of production of radioisotopes by the use of cyclotrons, nuclear reactors or isotope-generators. They will obtain the basic overview about the practical aspects of producing biological relevant isotopes, some details about the technical limitations of the processes. They have also opportunity to get very basic practical knowledge about the handling of different isotopes. They will work under supervision of an experienced worker, but independently.</p>
<b>Literature</b>
<p><i>Compulsory:</i>  <i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- G. Stöcklin, V. Pike: Radiopharmaceuticals for Positron Emission Tomography, ISBN 978-94-015-8204-9</li> <li>- Cyclotron produced radionuclides, Physical characteristic and production IAEA TECHNICAL REPORTS SERIES No. 468 ISBN 978-92-0-106908-5</li> <li>- Handbook of Nuclear Chemistry, Editors: Vértes, A., Nagy, S., Klencsár, Z., Lovas, R.G., Rösch, F. ISBN 978-1-4419-0719-6</li> <li>- Michael J. Welch, Carol S. Redvanly: Handbook of radiopharmaceuticals: radiochemistry and applications ISBN: 978-0-471-49560-4</li> </ul>

<b>Schedule:</b> <i>1<sup>st</sup> week The requirements of nuclear reaction, basic definitions</i>  <i>2<sup>nd</sup> week Nuclear reactors and other neutron sources</i>
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*3<sup>rd</sup> week Production of isotopes with neutron excess*

*4<sup>th</sup> week Particle accelerators*

*5<sup>th</sup> week Production of isotopes with neutron deficient*

*6<sup>th</sup> week Targetry, classical PET isotopes*

*7<sup>th</sup> week Radionuclide generators*

*8<sup>th</sup> week Basic aspect of radiolabelling*

*9<sup>th</sup> week Production of a Gallium-68labelled molecule by means of an isotope-generator*

*10<sup>th</sup> week Production of a Gallium-68labelled molecule by means of an isotope-generator*

*11<sup>th</sup> week Production and application of Fluorine-18 isotope*

*12<sup>th</sup> week Production and application of Fluorine-18 isotope*

*13<sup>th</sup> week: Production and application of Carbon-11 isotope*

*14<sup>th</sup> week Production and application of Carbon-11 isotope*

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. The participation on the **practical part** is an obligation as well as the preparation of a laboratory report. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class. Students have to **submit all the 3 laboratory reports** as scheduled minimum on a sufficient level. In case a student does so, the subject will not be signed and the student must repeat the course.

*- for a grade*

The course ends in an **examination** of the theoretical part. Based on the average of the grades of the reports and the examination, the practical grade is calculated as an average of them:

- the average grade of the reports
- the result of the oral examination

Score	Grade
< 1.5	fail (1)
1.51-2.5	pass (2)
2.51-3.5	satisfactory (3)
3.51-4.5	good (4)
4.5<	excellent (5)

If the score of a report or the oral examination is below „pass”, students can take a chance to repeat it, in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*-an offered grade:*

It may be offered for students if the average grade of the reports is “excellent” and they prepare a 10 min. slide show in a high quality for the class, from a topic selected by the tutor. The offered grade is “excellent”.

**Person responsible for course:** Dr. István Kertész, research fellow, PhD

**Lecturer:** Dr. István Kertész, research fellow, PhD

Dr. Hajdú István, senior lecturer, PhD

Norbert Pótári, chemist

Noémi DénesStéfán, PhD. student

<b>Title of course:</b> Separation techniques for radiolabeled compounds <b>Code:</b> TTKME0431_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Characteristics of radiochemistry. Solvent exchange. Solvent elimination in radiolabelling processes. Solid phase extraction procedures. Chromatographic techniques. Liquid chromatography. Analytical and semi-preparative techniques. Radioactive detectors. Fast chromatography. Ultrahigh efficiency in chromatographic measurements of radioactive samples. Quality assurance.
<b>Literature</b>
<i>Compulsory:</i> - 1. Pharmaceutical Radiochemistry, Munich Molecular Imaging Handbook Series. Hans J. Wester. Scintomics, Print Media and Publishing. 2010. 2. J. M. Miller. J.B. Crowther. Analytical chemistry in a GMP environment. Wiley. 2000. <i>Recommended:</i> 1. L. Huber. Validation and qualification in Analytical Laboratories. Informa Healthcare. 2007.

<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Basic separation problems in the field of radiochemistry.
<i>2<sup>nd</sup> week</i> Elimination of solvents, solvent exchange, evaporation, lyophilisation.
<i>3<sup>rd</sup> week</i> Elimination of solid parts from liquid reaction mixtures. Filtration, centrifuging. Extraction, SPE, SPME techniques. Supercritical fluid extraction. Ion exchange.

*4<sup>th</sup> week*

Basics of chromatography. Retention, selectivity, dynamic partition coefficient. van Deemter equation.

*5<sup>th</sup> week*

Sample preparation. Extraction. SPE techniques. Filtration. Internal standards. Reverse phase chromatography. Separation of acids, basics and neutral compounds. Gradient elution. pH control.

*6<sup>th</sup> week*

Normal phase chromatography. HILIC. Ion exchange. Size exclusion. Chiral chromatography.

*7<sup>th</sup> week*

HPLC method development. Preparative separation.

*8<sup>th</sup> week*

Fast chromatography. Ultrahighperformance chromatography (UPLC)

*9<sup>th</sup> week*

Detection in HPLC. UV, RI, ELS, EC detectors.

*10<sup>th</sup> week*

Radioactive detectors. Gamma spectrometry. Liquid scintillation. Scintillation detectors. Coincidence detectors.

*11<sup>th</sup> week*

Gas chromatography. Type of injection, detection. Method development. GC-MS.

*12<sup>th</sup> week*

Performance of analytical devices. Troubleshooting. Maintenance.

*13<sup>th</sup> week*

Qualification of analytical devices: DQ/IQ/OQ/PQ.

*14<sup>th</sup> week*

Validation of analytical methods.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

**Person responsible for course:** Dr. István Józai, chemist, PhD

**Lecturer:** Dr. István Józai, chemist, PhD

Dr. Dezső Szikra, chemist, PhD

<b>Title of course:</b> Dosimetry, Radiation Health Effects <b>Code:</b> TTKME0432-EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 30 hours - preparation for the exam: 32 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The interactions of radiation with matter. Radiation detectors. Dose concepts. Devices for dosimetry. Constituents of population dose. The biological effects of radiation. Forms of radiation damage. Principles of nuclear safety. Protection against external radiation sources. Preparation for participating in handling nuclear incidents. System of dose limits. Requirements for staffing and equipments. Documentation, supervision by the authorities. Classification of isotope labs. Handling unsealed radioactive materials. Handling radioactive waste; decontamination. Attending the classes and passing the exam entitles the student to obtain an official certificate on radiation protection, advanced level, valid for 5 years.</p>
<b>Literature</b>
<p><i>Compulsory:</i> Diagnostic Radiology Physics  <a href="http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1564webNew-74666420.pdf">http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1564webNew-74666420.pdf</a>  Related chapters:  <i>Chapter 1. Fundamentals of Atomic and Nuclear Physics</i>  <i>Chapter 2. Interactions of Radiation with Matter</i>  <i>Chapter 3. Fundamentals of Dosimetry</i>  <i>Chapter 20. Radiation Biology</i>  <i>Chapter 21. Instrumentation for Dosimetry</i>  <i>Chapter 24. Radiation Protection</i></p>



**Schedule:***Week Topic*

1	Types and origin of ionizing radiation Interactions of charged particles with matter
2	Interactions of electromagnetic radiation with matter Detection of X-ray, gamma and beta radiation by inducing light
3	Gas ionization detectors Dose concepts and dosimeters
4	Consultation: physics of ionizing radiation How to use dosimeters (practice)
5	Biological effects of radiation Forms of radiation injury
6	Constituents of population dose Radiation protection rules, dose limits
7	How to work with unsealed radioactive preparations? Protection against external radiation
8	Classification and equipment of workplaces applying ionizing radiation. Handling of radioactive waste.
9	Radiation protection of patients. Consultation: radiation biology and protection
10	Nuclear safety. Operations in case of nuclear/radiological incidents
11	Radiation protection in and around a cyclotron facility. Demonstration of the radiation protection system.
12	Requirements for staffing.
13	Decay schemes and tables. Decontamination (practical)
14	Radiation protection of patients in nuclear medicine. Visit to the "in vivo" NM center

**Requirements:**

Attendance of at least 75% of the classes. Usable understanding of the basic physical phenomena, the concepts of radiation effects and protection, as well as the regulations and practical solutions is required.

Chance "A" is a computer-based exam. Chance "B" and "C" are oral.

**Person responsible for course:** Dr.István Hajdu, assistant professor, PhD

**Lecturer:** Dr.István Hajdu, assistant professor, PhD

Dr.JózsefVarga, associate professor, PhD

<b>Title of course:</b> Radiochemical exercises <b>Code:</b> TTKML0415_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 2 hours/week	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 28 hours - home assignment: 32 hours - preparation for the exam: - Total: 60 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKME0410_EN (same semester)	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- Measuring technique practices: adjust of optimal parameters, study of self-absorption, liquid scintillation spectrometry - Basic properties of radioactive decay (half-life, statistics) - Operations with un-sealed radionuclides : radiometric titration, self-absorption (sample preparation) - Simulation of nuclear energy production, computations
<b>Literature</b>
<i>Compulsory:</i> - Descriptions of practices on the homepage of the department - Kónya, J., Nagy N. M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford. - Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4 <sup>th</sup> Edition, Elsevier, Amsterdam.

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Operation of gas ionization detector, adjust of optimal measuring parameters Optimal parameters of radioactivity detector <i>2<sup>nd</sup> week</i> Liquid scintillation spectrometry Special technique of beta activity measurement, factors influencing the affectivity, absolute activity measurement
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<p><i>3<sup>rd</sup> week</i></p> <p>Statistics of radioactive decay</p> <p>Calculations on statistics of radioactive decay, measuring errors, spread-error rules, improvements of accuracy</p> <p><i>4<sup>th</sup> week</i></p> <p>Determination of short and long half-life</p> <p>Determination of short half-life by direct measurement. Determination of long half-life by comparing activity and number of radionuclides.</p> <p><i>5<sup>th</sup> week</i></p> <p>Absorption and self-absorption of radiation.</p> <p>Possibility of the (self-) absorption correction. Handling of unsealed radionuclide during the sample preparation.</p> <p><i>6<sup>th</sup> week</i></p> <p>Radiometric titration</p> <p>Special observation of endpoint of a titrimetric method. Operation with unsealed radionuclide</p> <p><i>7<sup>th</sup> week</i></p> <p>Comparison of different types of energy production. Simulation of nuclear reactor.</p> <p>Comparison of environmental impacts of energy production ways.</p>
<p><b>Requirements:</b></p> <p>The measurements and knowledge of the associated theory are graded and an overall mark will be given.</p> <p>Safety training is mandatory before the first lab practice.</p> <p>Everybody should work and do the measurement individually according to the pre-set schedule (it will be provided prior to the first lab. The laboratory practices are 4-hrs long. In accordance with the regulations of University of Debrecen, attendance is compulsory with the exception of health or family problems. In this case, the students should agree with the teacher on replacement dates for the missed experiments.</p> <p>Pregnant and breastfeeding women are not allowed to work in radioactive laboratory.</p>
<p><b>Person responsible for course:</b> Prof. Dr.Noémi Nagy, university professor, DSc</p>
<p><b>Lecturer:</b> Prof. Dr.Noémi Nagy, university professor, DSc</p>

<b>Title of course:</b> Biological application of labelled compounds <b>Code:</b> TTKME0434_EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hour/week - practice: 0 hours/week - laboratory: 0 hour/week	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: 0 hour - laboratory: 0 hours - home assignment: 7 hours - preparation for the exam: 55 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it: -</b>	

<b>Topics of course</b>
The present course is aimed at providing knowledge for the students on the application of different isotopes on the field of nuclear medicine and biological research. It will summarize the properties can be important for the biological application and provide a short survey about the chemical reactions common in radiolabelling.
<b>Literature</b>
<i>Compulsory:</i> <i>Recommended:</i> - Handbook of Nuclear Chemistry, Editors: Vértess, A., Nagy, S., Klencsár, Z., Lovas, R.G., Röscher, F. ISBN 978-1-4419-0719-6 - Michael J. Welch, Carol S. Redvanly: Handbook of radiopharmaceuticals: radiochemistry and applications ISBN: 978-0-471-49560-4 - HJ. Wester: Pharmaceutical Radiochemistry: 1 ISBN: 978-3-98135230-6

<b>Schedule:</b>
1 <sup>st</sup> week The classification of the chemical reactions useful for radiolabelling.
2 <sup>nd</sup> week Radiolabelling with Fluorine-18. Electrophile fluorination.
3 <sup>rd</sup> week Radiolabelling with Fluorine-18. Nucleophile fluorination.
4 <sup>th</sup> week Instrumental developments for improving the efficacy of radiolabelling.

5<sup>th</sup> week Peptide (sensitive biomolecules) radiolabelling with Fluorine-18.

6<sup>th</sup> week Peptide (sensitive biomolecules) radiolabelling with Gallium-68 or Technetium-99m. Comparison, benefits, drawbacks.

7<sup>th</sup> week Radiolabelling. Radiopharmaceutical aspects.

8<sup>th</sup> week Chemoselective way of radiolabelling. In vivo labelling.

9<sup>th</sup> week Radiolabelling with Carbon-11.

10<sup>th</sup> week Radiolabelling with Nitrogen-13, Oxygen-15. Radiohalogenation.

11<sup>th</sup> week Radiolabelling with therapeutic radiometals.

12<sup>th</sup> week “Non-common” radiometals for radiolabelling.

13<sup>th</sup> week: Radiolabelling with Carbon-14 or Tritium.

14<sup>th</sup> week Consultation. Measurement of radiation.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. During the oral examination students will get two topics and after the appropriate preparation time they will present their knowledge. The grade of the course will be calculated:

- 30% from the attitude during the lessons (it is possible due to a small number of participants)
- 70% the result of the oral examination

Score	Grade
	fail (1)
	pass (2)
	satisfactory (3)
good (4)	
	excellent (5)

If the score of the oral examination is below „pass”, students can take a chance to repeat it, in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *an offered grade:*

**Person responsible for course:** Dr. István Kertész, research fellow, PhD

**Lecturer:** Dr. István Kertész, research fellow, PhD

<b>Title of course:</b> Production and quality control of radiopharmaceuticals <b>Code:</b> TTKML0435_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: - - laboratory: 2 hours/week	
<b>Evaluation:</b> practice	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: - - laboratory: 28 hours - home assignment: 32 hours - preparation for the exam: - Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- Decontamination procedure. - Radiolabelling with PET isotopes. - Quality control of radiopharmaceuticals. Method development.
<b>Literature</b>
<i>Compulsory:</i> - 1. Pharmaceutical Radiochemistry, Munich Molecular Imaging Handbook Series. Hans J. Wester. Scintomics, Print Media and Publishing. 2010. 2. J. M. Miller. J.B. Crowther. Analytical chemistry in a GMP environment. Wiley. 2000. <i>Recommended:</i> 1. L. Huber. Validation and qualification in Analytical Laboratories. Informa Healthcare. 2007.

<b>Schedule:</b>  <i>1<sup>st</sup> week</i> Decontamination procedures.  <i>2<sup>nd</sup> week</i> Production of [ <sup>18</sup> F]FDG. Preparation of synthesis modules.
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*3<sup>rd</sup> week*

Production of [ $^{18}\text{F}$ ]FDG. Performance of radiolabelling procedure. Dispensing of radiopharmaceutical into vials.

*4<sup>th</sup> week*

Production of [ $^{11}\text{C}$ ]methionine. Preparation of synthesis modules.

*5<sup>th</sup> week*

Production of [ $^{11}\text{C}$ ]methionine. Performance of radiolabelling procedure. Dispensing of radiopharmaceutical into vials.

*6<sup>th</sup> week*

Preparation of other F-18 and C-11 labelled tracers.

*7<sup>th</sup> week*

Production of C-11 isotope in cyclotron.

*8<sup>th</sup> week*

Production of F-18 isotope in cyclotron.

*9<sup>th</sup> week*

Quality control of [ $^{18}\text{F}$ ]FDG. Determination of radiochemical and chemical purity by HPLC.

*10<sup>th</sup> week*

Quality control of [ $^{18}\text{F}$ ]FDG. Determination of radiochemical purity by thin layer chromatography.

*11<sup>th</sup> week*

Quality control of [ $^{11}\text{C}$ ]methionine. Determination of radiochemical, enantiomeric and chemical purity by HPLC.

*12<sup>th</sup> week*

Validation of HPLC methods.

*13<sup>th</sup> week*

Determination of solvent content in radiopharmaceuticals by GC.

*14<sup>th</sup> week*

Radionuclidic identification and purity test by gamma spectrometry.

**Requirements:**

*- for a signature*

Participation at **laboratory practices** is compulsory. A student can't make up any practice with another group. Attendance at practices will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practices should be made up for at a later date, to be discussed with the tutor. Students are required to bring laboratory coats, calculators and protective glasses. Active participation is evaluated by the teacher in

every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

*- for a grade*

Laboratory report must be prepared after completion of practical topic. The laboratory practice grade will be calculated as the average grade of reports.

**Person responsible for course:** Dr. István Józai, chemist, PhD

**Lecturer:** Dr. István Józai, chemist, PhD, Norbert Pótári, chemist, Enikő Németh chemist



<b>Title of course:</b> Investigation of Cellular and Tissue Metabolism With Radiochemical Methods <b>Code:</b> TTKME0436_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 30 - preparation for the exam: 32 Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
General characteristics of radionuclides, radiopharmaceuticals and their properties.General characterization of normal and pathological metabolic processes.Investigation of metabolic processes using radiopharmaceuticals.General characterization of receptor expression and their in vitro and in vivo detection using radiopharmaceuticals.Examination of diseases with radiopharmaceuticals in vivo.
<b>Literature</b>
<i>Compulsory:</i> - Sharp, Peter F., Gemmell, Howard G., Murray, Alison D. (Eds.): Practical Nuclear Medicine, Springer, 3rd ed. 2005, X, 382 p. 222 illus., 17 illus. in color. ISBN 978-1-84628-018-4. - Harvey A. Ziessman, MD and Janis P. O'Malley, MD: Nuclear Medicine: The Requisites, 4th Edition, 2014, ISBN: 978-0-323-08299-0. <i>Recommended:</i> - R. A. Powsner, E. R. Powsner: Essential Nuclear Medicine Physics Blackwell Publishing, 2006 (2nd ed.)Print ISBN: 9781405104845.

<b>Schedule:</b> 1 <sup>st</sup> week Introduction: Radioisotopes in medical biology. The structure and operation of a preclinical radiochemistry and imaging laboratory. Authorizations.  2 <sup>nd</sup> week Basic metabolic processes of cells and tissues. Receptors.  3 <sup>rd</sup> weekDevelopment of radiopharmaceuticals, experimental radioligands.
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4 <sup>th</sup> week	In vitro, ex vivo studies with radiopharmaceuticals.												
5 <sup>th</sup> week	Characterization and investigation of normal and pathological carbohydrate metabolism with radiopharmaceuticals.												
6 <sup>th</sup> week	Glucose metabolism measurement with <sup>18</sup> F-FDG radiopharmaceutical.												
7 <sup>th</sup> week	Characterization and investigation of normal and pathological amino acid metabolism with radiopharmaceuticals.												
8 <sup>th</sup> week	Characterization and investigation of normal and pathological lipid metabolism with radiopharmaceuticals.												
9 <sup>th</sup> week	Characterization and investigation of normal and pathological cell proliferation with radiopharmaceuticals.												
10 <sup>th</sup> week	Preclinical radiopharmaceuticals of oncological and immunological diseases.												
11 <sup>th</sup> week	Preclinical radiopharmaceuticals of neurological and cardiovascular diseases.												
12 <sup>th</sup> week	Radiopharmaceuticals in drug research and development.												
13 <sup>th</sup> week	Radiopharmaceuticals in receptor research, receptor-ligand binding assays.												
14 <sup>th</sup> week	Summary, review.												
<b>Requirements:</b> - for a signature Attendance at <b>lectures</b> is compulsory. A student may not miss more than two times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. In case of further absences, a medical certificate needs to be presented. The course ends in an <b>examination</b> . The minimum requirement for the examination is 60%. Based on the score the grade for the examination is given according to the following table: <table> <tr> <td>Score</td><td>Grade</td></tr> <tr> <td>0-59</td><td>fail (1)</td></tr> <tr> <td>60-69</td><td>pass (2)</td></tr> <tr> <td>70-79</td><td>satisfactory (3)</td></tr> <tr> <td>80-89</td><td>good (4)</td></tr> <tr> <td>90-100</td><td>excellent (5)</td></tr> </table> If the score of the examination is below 60, students can take a retake examination in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.		Score	Grade	0-59	fail (1)	60-69	pass (2)	70-79	satisfactory (3)	80-89	good (4)	90-100	excellent (5)
Score	Grade												
0-59	fail (1)												
60-69	pass (2)												
70-79	satisfactory (3)												
80-89	good (4)												
90-100	excellent (5)												
<b>Person responsible for course:</b> Dr.GyörgyTrencsényi, associate professor, PhD													
<b>Lecturer:</b> Dr.GyörgyTrencsényi, associate professor, PhD													

<b>Title of course:</b> Special and dangerous materials. <b>Code:</b> TTKME0206_EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> –4 <sup>th</sup> year, 1 <sup>st</sup> semesters	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Structure, composition, properties and handling/safe use of special materials, which may represent a personal, social or environmental risk or even a life-threatening danger in case of accidents, war, or illicit use.
<b>Literature</b>
<i>Compulsory:</i> 1) Chemical Warfare Agents Chemistry, Pharmacology, Toxicology, and Therapeutics, Edited by James A. Romano, Jr. Brian J. Lukey, Harry Salem, CRC Press, ISBN-13 978-1-4200-4661-8 2) High Energy Materials. Propellants, Explosives and Pyrotechnics, Jai Prakash Agrawal, 2010, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim <i>Recommended:</i> 3) Chemistry of Pyrotechnics, Basic Principles and Theory, 2 <sup>nd</sup> Edition, 2010, CRC Press, ISBN-13: 978-1-4200-1809-7 4) The Pleasure Instinct Why We Crave Adventure, Chocolate, Pheromones, and Music, Gene Wallenstein, 2009, John Wiley & Sons, Inc., ISBN 978-0-471-61915-4

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Narcotics, hard and soft drugs 1. General properties, groups, addiction, legal state. Treatment of addiction. Cannabis. <i>2<sup>nd</sup> week</i> Narcotics, hard and soft drugs 2. Opium, morphine, heroine, opioids. Treatment of addiction, withdrawal syndroms.
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*3<sup>rd</sup> week*

Narcotics, hard and soft drugs 3. LSD, mescaline, and related derivatives.

*4<sup>th</sup> week*

Narcotics, hard and soft drugs 4. Natural materials: Catinone, harmine, harmaline, bufotenine, ibogaine, ephedrine, LSA, safrole, iso-safrole, myristicyne.

*5<sup>th</sup> week*

Narcotics, hard and soft drugs 5. Synthetics 1. Amphetamine and derivatives, Extasy, etc..

*6<sup>th</sup> week*

Narcotics, hard and soft drugs 6. Synthetics 2. DON, DOB, STP, designer drugs.

*7<sup>th</sup> week*

Chemical weapons 1. Major groups, target organs, toxicity. Tear gases, lachrymators.

*8<sup>th</sup> week*

Chemical weapons 2. Blood poisons, lung poisons, vesicants..

*9<sup>th</sup> week*

Chemical weapons 3. Nerve gases. Floroorganic poisons.

*10<sup>th</sup> week*

Chemical weapons 4. Binary chemical weapons. Incendiaries, flame materials, heat source materials.

*11<sup>th</sup> week*

Explosives, pyrotechnics 1. Basic concepts, definitions, modes of action. Deflagration: gun powder. Energetic materials, propellants, high energy polymers.

*12<sup>th</sup> week*

Explosives, pyrotechnics 2. Initiators, shock and spark sensitive materials. Blasting caps, detonators. High energy explosives, binary explosives, and their civilian and military uses.

*13<sup>th</sup> week*

Explosives, pyrotechnics 3. Basic experimental techniques to determine explosive characteristics and stability of explosives and gun powders. Pyrotechnical materials and devices. Civilian pyrotechnics, fireworks.

*14<sup>th</sup> week*

Pheromones. Basic properties, mode of action, role in the behavior control and in the physiological signaling processes. Use of pheromones in the agriculture, and in the animal life. Pheromone-like materials, the Dirty 12.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**.

The minimum requirement for the examination is 50 score. Based on the score, the grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-75	satisfactory (3)
76-88	good (4)
89-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

<b>Person responsible for course:</b> Dr. István Lázár, associate professor, PhD
<b>Lecturer:</b> Dr. István Lázár, associate professor, PhD

<b>Title of course:</b> Biocolloids <b>Code:</b> TTKME0411_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> / 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The goal of this series of lectures is to give knowledge about the relationship between biological sciences and colloid/surface phenomena. A further goal is to deepen colloid chemical knowledge of students about biological phenomena related to colloids. It makes them able to approach biological problems from a colloid chemical perspective and to solve possible problems and tasks in this context.
<b>Literature</b>
<i>Compulsory:</i> - Lecture slides downloadable from the Department's homepage ( <a href="http://fizkem.unideb.hu">http://fizkem.unideb.hu</a> ) <i>Recommended:</i> - D. Fennell Evans, Hakan Wennerstrom: The Colloidal Domain: Where Physics, Chemistry and Biology Meet, 2nd Ed. , Wiley, 1999 - Pashley, R. M.: Applied Colloid & Surface Chemistry. Wiley&Sons, ISBN 0-a470-a86883-aX, 2004 - Cosgrove T.: Colloid science. Blackwell Publishing ISBN:978-a14051-a2673-a1, 2005

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Importance of colloidal state in biology. Hypotheses about the origin of life in the past and nowadays. Occurrence of organic matter in space. Hyperresistant organisms and survival under the conditions found in space. Shadow biosphere and "artificial life".
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*2<sup>nd</sup> week*

Formation of interfaces. Films and membranes. Langmuir-Blodgett films and liquid crystals. Membrane models, structure of the cell membrane.

*3<sup>rd</sup> week*

Diffusion and transport phenomena through membranes, osmosis and dialysis. Transport phenomena in living organisms. Function of the kidneys, artificial kidney.

*4<sup>th</sup> week*

Adsorption phenomena in biological systems, processes in biotechnology and separation sciences.

*5<sup>th</sup> week*

Surface tension and its importance in nature. Motion of striders on the surface of water. Reproduction using surface tension: ballistospores of fungi. Wetting, contact angle, influencing the surface tension. Capillarity, water transport in plants and the transpiration-adhesion-tension-cohesion hypothesis. The importance of capillarity under arid climates. Adhesion to smooth surfaces. Atherosclerosis and interfacial influences leading to atherosclerosis.

*6<sup>th</sup> week*

Association colloids, micelles and inverse micelles. Critical micelle concentration and its importance. Detergents and their uses. Biological detergents in the digestion: bile acids. Solubilization with polar molecules. Lung surfactants and their role in breathing.

*7<sup>th</sup> week*

Modern instrumental methods in the study of biomacromolecules (ultracentrifugation, electrophoresis, size exclusion chromatography, scanning confocal microscopy, electron microscopy, scanning probe microscopy, surface plasmon resonance, X-ray diffraction, NMR).

*8<sup>th</sup> week*

Macromolecules, types and importance of macromolecules. Characterization and importance of dispersity, shape, and conformation.

*9<sup>th</sup> week*

Important and interesting biomacromolecules, their properties, importance and uses (*polysaccharides*: cellulose, starch, chitin, etc.; *proteins*: collagen, silk, green fluorescent protein, etc.; *others*: lignin, chlorophylls, haemoglobin, etc.).

*10<sup>th</sup> week*

Dispersion colloids in nature. Bioaerosols and smokes. Importance of foams, emulsions, sols and their biological relevance. Making and breaking of dispersions in different biological, medical, pharmaceutical, etc. processes.

*11<sup>th</sup> week*

Coherent systems and lyogels. The eye as a natural lyogel system. Biocomposites: structure and formation of bones. A complex disperse system: the soil.

*12<sup>th</sup> week*

Electrokinetic effects, precipitation from liquids. Epitaxis. Kidney and bile stones, processes of their formation.

*13<sup>th</sup> week*

Flow properties. Biorheology. Rheology of blood and its importance in blood coagulation.

*14<sup>th</sup> week*

Nanotechnology and its development. Nanostructures from non-living matter. Natural nanostructures: diatoms and the fine structure of butterfly scales. Nanodevices. Natural nanomotors: kinesins, dyneins, the actomyosin complex. DNS machines, active molecular tweezers.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of any test is below 50%, students can make a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Levente Novák, assistant professor, PhD

**Lecturer:** Dr. Levente Novák, assistant professor, PhD



<b>Title of course:</b> Physical chemistry of living systems <b>Code:</b> TTKME0417_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The subject of biophysics-chemistry, thermodynamic concepts. Structure of macromolecules, interactions with small molecules. The concept of chemical potential, its effect on thermodynamic parameters, the properties of solutions. Definition and interpretation of pH in biological systems. The significance of electron transfer reactions in live systems. Simple and complex reactions, kinetic description of enzymatic catalysed reactions. Basic concepts related to biochemical pathways NMR spectroscopy in biological systems</p>
<b>Literature</b>
<p><i>Compulsory:</i>          lecture material on the Department of Physical Chemistry website  <i>Recommended:</i>          - P. W. Atkins: Physical Chemistry (8<sup>th</sup> ed.) Oxford University Press for, 2006. ISBN: 0-7167-8759-8          - P. W. Atkins. J. de Paula: Physical Chemistry for the Life Sciences (2<sup>nd</sup> ed.) Oxford University Press, 2011, ISBN:978-0-19-956428-6</p>
<b>Schedule:</b> <i>1<sup>st</sup> week</i> The subject of bio-physical chemistry. Environmental and environmentally-independent constraints of biological systems. The basics of thermodynamics. The system and the surroundings. Thermodynamic first and second law. Concept of internal energy, work, heat, enthalpy, entropy, Gibbs energy. Applications in biological systems: calculation of mechanical, electrical, extension work. (Bio)chemistry reactions, energy, enthalpy, and Gibbs energy changes. Introduction of standard conditions. Hess law The thermodynamics of ATP. <i>2<sup>nd</sup> week</i>

First, secondary, tertiary and quaternary structures of proteins. Secondary interactions that determine the tertiary structure of proteins. Interactions between hydrophobic side chains - the role of water. Elevation and repression of proteins change in entropy during conformational change. First and secondary structure of nucleic acid, interactions that determine the secondary structure. Changing of the Gibbs energy while the double-single DNA threads (fibers) transform.

#### *3<sup>rd</sup> week*

The concept of chemical potential, used to calculate a change in the free-enthalpy accompanying a chemical reaction or a transport process. Concentration dependence of the free-enthalpy, reaction rate and equilibrium constant. Temperature dependence of equilibrium constant.

#### *4<sup>th</sup> week*

Measuring the thermodynamic quantities of the reactions. Binding of small molecules to macromolecules, independent binding, cooperation. Dissociation macro- and microconstants. Average ligand number, saturation degree, number of binding sites. Hughes-Klotz-representation. Scatchard-representation.

#### *5<sup>th</sup> week*

Autoprotolysis of water. Acid-base theory Arrhenius and Bronsted. The pH scale in chemical and biochemical systems. Conjugated acids and bases. Determination of the strength of acids and bases, the concept of pK. Dissociation degree. pK values of free amino acids, pH change its charge, isoelectric focusing. Change of pK with (bio) chemical environment. pH control in biochemical systems: buffer systems, ion transport

#### *6<sup>th</sup> week*

Electron transition reaction. Electrochemical cell: Daniell cell. Electrodes, halfcell-reaction, electromotive force. Standard electrode potential and their application: electrochemical line. Concentration dependence of electromotive force: Nernst equation, hydrogen electrode, glass electrode, combined glass electrode. Electrochemical discussion of terminal oxidation.

#### *7<sup>th</sup> week*

Specifications of solutions. Chemical potential of the solvent. Colligative properties: boiling-point elevation, freezing point depression, osmosis. Vegetable water transport and water potential. Determination of the molecular weight of protein according to their osmotic properties. Osmolarity and tonicity of the solution. Chemical potential of the solute. pH determination with weak acids and bases penetrating the membrane. Membrane potential. Electrochemical gradient as energy storage in the cell. Theory of chemio-osmosis. Stoichiometry of proton pump and ATP synthesis during oxidative phosphorylation.

#### *8<sup>th</sup> week*

Ideal and real system. Properties of the perfect gas. Ideal solution features. Discussing a real, dilute solution. Activity coefficient and affecting its value in solution containing ions: Debye-Hückel's theory. The role of ion strength in practice.

#### *9<sup>th</sup> week*

Chemical reaction rates – kinetics. Thermodynamic and kinetic stability. Specify the velocity of a chemical reaction. The concentration dependence of the chemical reaction rate. Rate equation. Temperature dependence of chemical reaction rate. Ionic strength dependence of the reaction rate. Isotope substitution method for detecting the mechanism of the reaction. Effect of pH on reaction rate. Kinetics of sequential, parallel and reversible reactions.

#### *10<sup>th</sup> week*

Kinetics of enzymatic catalyzed reactions. Catalysis concept, catalysts. Classification of enzymes. Energy profile of enzyme catalysis. Use of steady-state approximation in enzyme-catalyzed reactions. The application and limitations of the Michaelis-Menten approach. Determination of  $K_M$  and  $V_{max}$ .

Expression of catalytic activity of enzymes. Temperature dependence of the rate of enzymatic catalysis. pH dependent on the rate of enzymatic catalysis reactions.

*11<sup>th</sup> week*

Kinetics of multi-substrate enzymes. Activation parameters of multi-substrated enzymatic catalyzed reactions. The role of antigen-specific antibodies in the formation of "artificial enzymes". Discussion of kinetics of dual substrate enzyme catalyzed reaction, three-molecule complex approach and ping-pong mechanism. Inhibition in the enzyme reactions. Interpretation of different inhibition types, changes in  $K_M$  and  $V_{max}$  for different types of inhibition. The Dixon representation and the information that can be gained from it.

*12<sup>th</sup> week*

Industrial utilization of enzymatic catalysis: applications. Myths and facts about the industrial enzyme application area. Basics of enzyme immobilization. Use of ionic liquids as a reaction medium. Enzyme catalysis in non-aqueous medium (ionic liquids): regioselectivity, enantioselectivity.

*13<sup>th</sup> week*

Associated chemical reactions and biochemical pathways. Consecutive (serial) coupling of chemical reactions. Parallel coupling of chemical reactions. Structure of biochemical pathways from coupled reactions. Kinetic and thermodynamic control of biochemical pathways. Systemic analysis of kinetic control of biochemical pathways. Metabolic control analysis: control coefficient, elasticity coefficient.

*14<sup>th</sup> week*

Briefly about quantum mechanics: particles, waves, quantization of energy. Limitations of classical mechanical description. Interaction of molecules by electromagnetic radiation. General characterization of spectroscopic methods. Electro-dissemination spectra and their biochemical applications. The basics of NMR spectroscopy and its biochemical, medical applications.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an oral or written **examination**. The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of any test is below 50%, students can make a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- *offered grade*

It may be offered for students if the student gives a 10-15 minute presentation related to the topic of the subject. The possible topics are discussed with the lecturer. The offered grade can be satisfactory (3) or better, in case of lower evaluation exam should be taken.

**Person responsible for course:** Dr. Henrietta Györfvári Horváth, senior research fellow, PhD

**Lecturer:** Dr. Henrietta Györfvári Horváth, senior research fellow, PhD

<b>Title of course:</b> Metal Complex Catalyzed Organic Syntheses <b>Code:</b> TTKME0420_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 28 hours - preparation for the exam: 34 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- General questions of activation of small molecules (H <sub>2</sub> , HCN, HSiR <sub>3</sub> , CO, CO <sub>2</sub> , O <sub>2</sub> ). Oxidative addition, reductive elimination. The 18 electron rule. Role of radical processes in metal complex catalyzed reactions. - Practice of homogeneously catalyzed organic synthesis. Recovery of the catalyst. Heterogenized complex catalysts, biphasic reactions, phase transfer assisted complex catalyzed syntheses. - Regio-, stereo-, and enantioselective catalysis. Hydrogenation, hydrocyanation, hydrosilylation of alkenes. Telomerization reactions. Hydrogenation and hydrosilylation of ketones, nitrocompounds and imines. Reductive amination. Dehydrogenation. Hydrogenolysis of C-X bonds (X: oxygen, halogen). Hydroformylation, carbonylation and decarbonylation. Oxidation. - Selected examples of complex catalyzed reactions for synthesis of biologically active compounds including heterocyclic derivatives (quinolines, beta-lactams, lactones, etc.).
<b>Literature</b>
Compulsory: - P. W. M. N. van Leeuwen, <i>Homogeneous Catalysis. Understanding the Art</i> . Kluwer, Dordrecht, 2004. - D. J. Adams, P. J. Dyson, S. J. Tavener, <i>Chemistry in Alternative Reaction Media</i> . Wiley-Interscience: Cambridge, 2004. Recommended: - A. Behr, P. Neubert: <i>Applied Homogeneous Catalysis</i> (Wiley-VCH, Weinheim, Germany, 2012)

**Schedule:**

*1<sup>st</sup> week* Definition and characteristics of catalysis. Catalysis as efficient means of green chemistry. General questions of activation of small molecules (H<sub>2</sub>, HCN, HSiR<sub>3</sub>, CO, CO<sub>2</sub>, O<sub>2</sub>), relation between molecular structure and reactivity.

*2<sup>nd</sup> week* Characteristic steps and mechanisms of homogeneous catalysis. Oxidative addition, reductive elimination. The 18 electron rule. Role of radical processes in metal complex catalyzed reactions.

*3<sup>rd</sup> week* Practice of homogeneously catalyzed organic synthesis. Recovery of the catalyst. Heterogenized complex catalysts, methods of heterogenization on solid supports.

*4<sup>th</sup> week* Reactions in liquid biphasic systems, phase transfer assisted complex catalyzed syntheses. Alternative solvents, their properties and their effect on catalytic processes.

*5<sup>th</sup> week* Selectivity of catalytic reactions. Explanation of selectivity. Enantioselective reactions. Kinetic resolution.

*6<sup>th</sup> week* Hydrogenation, hydrocyanation and hydrosilylation of alkenes. Catalytic dehydrogenation. Hydrogen transfer reactions. Catalytic isomerization of alkenes. Applications.

*7<sup>th</sup> week* Hydrogenation of aldehydes and ketones. Hydrosilylation of ketones. Reductive amination. Hydrogenation of nitrocompounds and imines. Redox isomerization of allylic alcohols.

*8<sup>th</sup> week* Hydrogenolysis of C-X (X: oxygen, halogen) bonds. Applications in destruction of environmentally harmful substances. Hydration of alkynes and alkenes. Telomerization.

*9<sup>th</sup> week* Hydroformylation. Cobalt-, rhodium- and platinum-based catalysts. Mechanisms of hydroformylations. Asymmetric hydroformylation. Industrial applications.

*10<sup>th</sup> week* Carbonylation and decarbonylation. Catalysts and mechanisms. Applications in manufacturing of fine chemicals.

*11<sup>th</sup> week* Homogeneously catalyzed oxidations. Catalysts and mechanisms. Practical applications.

*12<sup>th</sup> week* Formation of C-C bonds via homogeneous catalysis (Sonogashira-, Suzuki, Heck-cross couplings and other name reactions for catalytic C-C bond formation).

*13<sup>th</sup> week* Alkene metathesis. The various ways and mechanisms of the reaction. Most frequently used catalysts.

*14<sup>th</sup> week* Organic syntheses based on catalytic reactions of carbon dioxide: production of methanol, formic acid and its derivatives (formate esters, formamides), lactones and polycarbonates. Methods for fast optimization of reaction conditions.

**Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in a written **examination**.

The minimum requirement for the examination is 60%. Based on the score of the examination the grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Prof. Dr. Ferenc Joó, university professor, DSc

**Lecturer:** Prof. Dr. Ferenc Joó, university professor, DSc

<b>Title of course:</b> Environmental chemistry II. <b>Code:</b> TTKME0414_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: 1 hour/week - laboratory: 1 hour/week	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: 14 hours - laboratory: 14 hours - home assignment: 20 hours - preparation for the exam: 44 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<p>The aim of the subject is to recognize the physical chemical principles in the natural processes of the atmo-, hydro- and lithosphere, and to apply the acquired knowledge for the description of these processes. Methods of model calculations, correct usage of thermodynamic tables are studied. The lectures review the physical chemistry of energy and work production and supply (internal- and external-combustion engines, electric engines, etc.) and deal with hydrogen and methanol economy and biofuels as well. "Mental pollution" of the environment, i.e. the interpretation of deceiving information about environmental problems is also discussed.</p> <p>The practical part includes thermodynamic calculations, calculations in equilibrium and complex formation processes, speciation, chemical kinetics, transport processes, using the knowledge of the chemical processes in the atmo-, hydro- and lithosphere.</p> <p>In the laboratory, being connected with the lectures and using the acquired knowledge two environmental problems are studied through experimental work, data evaluation, and discussion of the results.</p>
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- G. W. van Loon, S. J. Duffy (2010): Environmental Chemistry: A global perspective, Oxford Univ. Press. ISBN 9780199228867</li> <li>- P. Brimblecombe, J. E. Andrews, T. D. Jickells, P. Liss, B. Reid (2003): An Introduction to Environmental Chemistry, Blackwell Publishing. ISBN 0-632-05905-2</li> <li>- I. Williams (2005): Environmental Chemistry, Wiley. ISBN 978-0-471-48942-9</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- T. G. Spiro, K. L. Purvis-Roberts, W. M. Stigliani (2011): Chemistry of the Environment, Univ. Sci. Books. ISBN 978-1-891389-70-2</li> </ul>

**Schedule:***1<sup>st</sup> week*

Definitions, development, significance, researching methods and relations of environmental chemistry to the other fields of science and economy. Principles of green chemistry. Basics of physical chemistry.

*2<sup>nd</sup> week*

Usage of thermodynamic tables, model calculations. "Mental pollution" of the environment, i.e. deceiving information about environmental problems.

*3<sup>rd</sup> week*

Physical chemistry of energy and work production and supply: internal- and external-combustion engines, electric motors, hydrogen and methanol economy, biofuels.

*4<sup>th</sup> week*

Composition and regions of the Earth's atmosphere. Properties of thermosphere, mesosphere, stratosphere and troposphere. Calculation of atmospheric pressure and energy of the light in the thermosphere.

*5<sup>th</sup> week*

Definition of climate. Application of the Planck-equation. Energy spectrum of solar radiation, calculation of the surface temperature. Greenhouse effect.

*6<sup>th</sup> week*

Definitions of smog types. Reactions and explanations in photochemical smog. Thermodynamic calculations of NO formation considerations of further reactions.

*7<sup>th</sup> week*

The chemistry and role of the stratospheric ozone. Environmental problems of ultraviolet radiation, chemical UV protection. Formation and depletion of ozone, an influencing factors. Stationary kinetics, principles of photochemistry. Kinetic modelling of ozone formation.

*8<sup>th</sup> week*

Composition of the hydrosphere, water resources. Sea water and fresh water. Solubility of gases, liquids and solids in water. Speciation in aqueous systems.

*9<sup>th</sup> week*

Chemical kinetics in the environment. Transport processes: flux, viscosity, diffusion. Cyan pollution on the Tisza river. Role of colloids in transport processes.

*10<sup>th</sup> week*

Characterization and significance of interfaces: surface charge and adsorption. Causes, effects, solution and elimination possibilities of the red sludge disaster.

*11<sup>th</sup> week*

Water treatment technologies: Arsenic removal and the treatment of arsenic sludge.

Laboratory practise 1. Treatment and elimination of water treatment arsenic sludge, measurements using mobile analytical methods.

*12<sup>th</sup> week*

Properties and composition of soils. Weathering processes, soil colloids. Soil colloids. Chemical properties of soils, acid/base buffer capacity. Calculations associated with soil pollution.

*13<sup>th</sup> week*

Structure and interfacial reactions of clay minerals.

Laboratory practise 2. Soil-forming minerals: particle size, metal adsorption, effect of pH.

*14<sup>th</sup> week*

Lithosphere, formation of rocks and minerals. Chemical aspects of volcanic activities.



**Requirements:**

*- for a signature*

Attendance at **lectures** is compulsory, since the **practical part** is integrated into the classes. A student must attend the classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at practice classes will be recorded by the lecturer. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented.

Students have to **submit a report task** at the end of the semester, the topic of which is chosen from a list. The grade of the report task reflects the processing of the literature and the creative solution of the relating model calculation.

During the semester there are two **laboratory practises** (11<sup>th</sup> and 13<sup>th</sup> weeks), where the attendance is compulsory. The students get grades for the lab reports.

*- for a grade*

The course ends in an **examination**. Based on the average of the grade of the report task, lab reports and the examination, the exam grade is calculated as a weighted average of them:

- the grade of the report task (25%)
- the average grade of the lab reports (25%)
- the result of the examination (50%).

The minimum requirement for the examination is 50%. Based on the score of exam test (70), the grade is given according to the following table:

Score	Grade
0-35	fail (1)
36-44	pass (2)
45-53	satisfactory (3)
54-62	good (4)
63-70	excellent (5)

If the score is below 35, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Mónika Kéri, assistant professor, PhD

**Lecturer:** Dr. Mónika Kéri, assistant professor, PhD  
Prof. Dr.IstvánBányai, university professor, DSc

<b>Title of course:</b> Structure determination by X-ray diffraction <b>Code:</b> TTKME0423_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: 30 hours - preparation for the exam: 32 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The series of lectures are based on the topics of X-ray diffraction. The purpose of the course to give strong theoretical background for the students on the methodology and applications of single crystal structure determination via X-ray diffraction. Part of the course of learning basic usage of software tools. Application of single crystal diffraction in preparative chemistry, interpretation and presentation of the results as well as use of crystallographic databases are also discussed. Fields of protein crystallography, polymorphism research as well as powder diffraction are also reviewed.
<b>Literature</b>
<i>Compulsory:</i> - J. P. Glusker, K. N. Trueblood (2010): Crystal Structure Analysis: a Primer (IUCR Texts on Crystallography), Oxford University Press, ISBN 13 978-0199576357 - <a href="http://www.iucr.org/education/pamphlets">http://www.iucr.org/education/pamphlets</a> - Lecture notes and teaching material available via the e-learning system <i>Recommended:</i> - W. Massa (2000): Crystal Structure Determination, Springer, ISBN 3-540-65970-6

<b>Schedule:</b>
1 <sup>st</sup> week      X-ray radiation Properties of X-rays, practical applications. Diffraction methods in general. Place of single crystal structure determination among structural studies. Fourier transformation and its properties. Least square methods. 2 <sup>nd</sup> week      Symmetry Structure of solids. Crystals. Unit cell, asymmetric unit, Miller indexes. Symmetry notation of IUCR,

systematic absences. Reciprocal space. The most frequent space groups and symmetry operators.

*3<sup>rd</sup> week* Crystal growing

Thermodynamics and kinetics of crystallization. Methods to grow single crystals. Applications of crystallization in pharmaceutical industry. Basics of neutron diffraction.

*4<sup>th</sup> week* X-ray diffraction methods

Generation of X-rays. Development of X-ray diffraction methods. Main parts of the diffractometer. Types of detectors, advantages and disadvantages. Area detectors.

*5<sup>th</sup> week* Structure determination

The main steps of structure determination by single crystal diffraction. Determination of the unit cell. Data collection, data/parameter ratio. Symmetry effects in data collection. Phase problem and methods to solve the phase problem for small molecules. Refinement of the structure.

*6<sup>th</sup> week* Publication

The Crystallographic Information Format and its advantages. Publication of single crystal structure determination results. Validation of the results. Interpretation and use of crystallographic results. Steps of publication in case of major journals.

*7<sup>th</sup> week* Computer programs in structure determination

Basic usage of WINGX and PLATON packages. The MERCURY program. The construction of shelx .ins files.

*8<sup>th</sup> week* Cambridge Structural Database

Basic terms of usage of CSD. Computer practice to search the database and making crystallographic calculations. Computer practice.

*9<sup>th</sup> week* Powder diffraction

Powder methods. Data collection, geometry, optics, possibility of structure determination from powder data.

*10<sup>th</sup> week* Polymorphism

Polymorphism phenomena. Definition of polymorphic forms. Consequences in pharmaceutical industry. Thermodynamic and structural considerations. Polymorphism in everyday life.

*11<sup>th</sup> week* Protein crystallography

Comparison of protein and small molecule crystallography. Solving the phase problem for proteins. Refinement of protein structures. Structural motifs and function of proteins. Intrinsically disordered proteins.

*12<sup>th</sup> week* Practical class

Determination of crystal and molecular structure for a relatively simple organometallic compound. Group work.

*13<sup>th</sup> week* Chirality and X-ray diffraction

Concepts and definitions. Types of chirality. Determination of absolute configuration. Anomalous dispersion.

*14<sup>th</sup> week* Student works

The student give short presentation on their chosen topic in the field of X-ray structure determination.

### **Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. Based on the average of the grades of the **written test or oral exam** the exam grade is calculated. It is the choice of the student to give written or oral exam.

Based on the scores, the grade for the tests and the examination is given according to the following

table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

*-an offered grade:*

it may be offered for students if the student prepare a short written report on literature search in the field of X-ray diffraction. The possible topics are discussed with the lecturer and preliminary versions of the paper are iterated to correct errors. The report should have a minimum of 10 A4 sheet and it should be presented at the last class. The offered grade can be satisfactory (3) or better, in case of lower evaluation exam should be taken.

**Person responsible for course:** Dr. Attila Bényei associate professor, PhD

**Lecturer:** Dr. Attila Bényei, associate professor, PhD

<b>Title of course:</b> Chemistry of secondary metabolites I <b>Code:</b> TKME0331_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - laboratory: - - home assignment: 20 hours - preparation for the exam: 42 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> or 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
- Classification of metabolic processes, and review the major building blocks, and basic reactions. - Isolation and structural determination of natural compounds. - The function of natural compounds and application them as lead compounds in in drug development. - Discussion of the retrosynthetic analysis and laboratory synthesis of natural compounds through the processing of selected examples.
<b>Literature</b>
<i>Compulsory:</i> 1. K. C. Nicolaou, E. J. Sorensen: Classics in Total Synthesis I., 4 <sup>th</sup> edition (Reprint), Wiley, 2003. 2. K. C. Nicolaou, S. E. Snyder: Classics in Total synthesis II., 1 <sup>st</sup> edition, Wiley, 2003. 3. K. C. Nicolaou, E. J. Sorensen: Classics in Total synthesis III., 1 <sup>st</sup> edition , Wiley, 2011. 4. Selected article by the lecturer

<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Classification of the most important metabolic processes and metabolites The definition of primary and secondary metabolites. The building blocks and biosynthetic processes of primary metabolites.
<i>2<sup>nd</sup> week</i> The building blocks and biosynthetic processes of secondary metabolites. Isolation and structural elucidation of natural compounds. The function of natural compounds and application them as lead compounds in in drug development.
<i>3<sup>rd</sup> week</i>

<p>Retrosynthetic analysis of the menthol and periplanone-B, bio- and chemical synthesis.</p> <p><i>4<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and synthesis of thestrychnine and quinine.</p> <p><i>5<sup>th</sup> week</i></p> <p>Retrosynthetic analysis of progesterone and estrone, bio- and chemical synthesis.</p> <p><i>6<sup>th</sup> week</i></p> <p>Retrosynthetic analysis of prostaglandins, bio- and chemical synthesis.</p> <p><i>7<sup>th</sup> week</i></p> <p>Retrosynthetic analysis of <math>\beta</math>-lactam antibiotics (Penicillin V, Thienamycin) and bio- and chemical synthesis.</p> <p><i>8<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of rapamycine, indalizomycine</p> <p><i>9<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of dynemicine.</p> <p><i>10<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of Bisorbicillinoids.</p> <p><i>11<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of Taxol</p> <p><i>12<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of (-)-FR182877</p> <p><i>13<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of Azaspiracid – I</p> <p><i>14<sup>th</sup> week</i></p> <p>Retrosynthetic analysis and chemical synthesis of Littoralisone, Oseltamivir (Tamiflu®), and Hirsutellone B</p>
<p><b>Requirements:</b></p> <p>- <i>for a signature</i></p> <p>Attendance at <b>lectures</b> is recommended, but not compulsory. A student may not miss the lecture more than three times during the semester. In case of further absences, a medical certificate needs to be presented. In case a student does not do this, the subject will not be signed and the student must repeat the course.</p> <p>- <i>for a grade</i></p> <p>The course ends in an oral exam in the exam period.</p>
<p><b>Person responsible for course:</b> László Dr. Juhász, associate professor, PhD</p>
<p><b>Lecturer:</b> László Dr. Juhász, associate professor, PhD</p>

<b>Title of course:</b> Chemistry of secondary metabolites II. <b>Code:</b> TKML0332_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: - - practice: 4 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - practice: 56 hours - laboratory: - - home assignment: 34 hours - preparation for the exam: - Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> or 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Isolation and derivatization of nicotine; Isolation of coffein; Isolation and hydrolysis of piperine; Essenes of the rosary resin; Isolation and derivatization of carvone; Isolation of betulin from birch bark, Isolation and derivatization of cholesterol; isolation of anethol and anisic acid; cinnamic acid and cinnamaldehyde; isolation of rutin and quercetin; Isolation and derivatization of hesperidine. Synthesis of azelaic acid; Triglyceride of nutmeg; Isolation of thymol.
<b>Literature</b>
<i>Compulsory:</i> <ol style="list-style-type: none"> <li>1. Satyajit D. Sarker, Zahid Latif, Alexander I. Gray; Natural Products Isolation, 2<sup>nd</sup> edition, Humana Press, 2006</li> <li>2. Corrado Tringali, Bioactive Compounds From Natural Sources: Isolation, characterisation and biological properties; Taylor and Francis, 2001.</li> <li>3. Corrado Tringali, Bioactive Compounds From Natural Sources: Natural Products as Lead Compounds in Drug Discovery, 2<sup>nd</sup> edition, CRC Press, 2012</li> <li>4. Jerry R. Mohrig, David Alberg, Gretchen Hofmeister, Paul F. Schatz, Christina Noring Hammond; Laboratory Techniques in Organic Chemistry; 4<sup>th</sup> edition; W. H. Freeman and Company</li> </ol>

<b>Schedule:</b>
1 <sup>st</sup> week
Isolation of nicotine from Tobacco leaves and derivatization with picric acid. Characterization of the product and calculation of nicotine contain of tobacco leaves.
2 <sup>nd</sup> week
Isolation of coffein from tea leaves and characterization of the product and calculation of coffein

contain of tea leaves.

*3<sup>rd</sup> week*

Isolation of piperine from black pepper and hydrolysis into piperic acid. Characterization of the product and calculation of piperine contain of black pepper

*4<sup>th</sup> week*

Isolation of essential oil from the rosin resin and characterization of the product.

*5<sup>th</sup> week*

Isolation of carvone from caraway and derivatization with 2,4-dinitrophenylhydrazone. Characterization of the product and calculation of carvone contain of caraway.

*6<sup>th</sup> week*

Isolation of betulin from birch bark and characterization of the product

*7<sup>th</sup> week*

Isolation of cholesterol from gall stone and transformation into dibromo derivatives. Characterization of the products.

*8<sup>th</sup> week*

Isolation of anethol from anise and transformation into anisic acid. Characterization of the products.

*9<sup>th</sup> week*

Isolation of cinnamic aldehyde from cinnamon and transformation into cinnamic acid. Characterization of the products.

*10<sup>th</sup> week*

Isolation of rutin from Japanese acacia flowers and transformation into quercetin. Characterization of the products.

*11<sup>th</sup> week*

Isolation of hesperidin from orange peel and transformation into hesperetin. Characterization of the products.

*12<sup>th</sup> week*

Isolation of azelaic acid from castor oil. Characterization of the products.

*13<sup>th</sup> week*

Isolation and saponification of the glyceride of nutmeg. Characterization of the products.

*14<sup>th</sup> week*

Isolation of thymol from thyme. Characterization of the products.

### **Requirements:**

A student must attend the laboratory classes and may not missed during the semester. In case of absences, a medical certificate needs to be presented, otherwise the subject will not be signed, and the student must repeat the course. Being late is equivalent with an absence. The knowledge of the students is controlled every week with a short written test at the beginning of the lab. The results of the experiments must be summarized in the laboratory notebook, which is checked and graded at the end of each practice.

*- for a signature*

Attendance at **laboratory** is compulsory. The student must be writing every short test and the laboratory notebook.

*- for a grade*

The minimum requirement for the short written tests respectively is 50%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-49	fail (1)
50-65	pass (2)



66-80	satisfactory (3)
80-89	good (4)
90-100	excellent (5)
The final mark will be calculated as an average of the grades of tests and laboratory notebooks.	
<b>Person responsible for course:.</b> László Dr Juhász, associate professor, PhD	
<b>Lecturer:</b> László Dr Lázár, associate professor, PhD	

<b>Title of course:</b> Enzyme biotechnology <b>Code:</b> TTKME0334_EN	<b>ECTS Credit points: 3</b>
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - home assignment: - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b>	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it: -</b>	

<b>Topics of course</b>
The lectures describe the effective catalytic properties of enzymes that have promoted their introduction into several biotechnological processes. From each enzyme class, there is a representative industrial enzyme, which is characterized in details. Approaches to improve enzyme function are also mentioned.
<b>Literature</b>
<i>Compulsory:</i> The lecture notes <i>Recommended:</i> Biocatalysts and Enzyme Technology (K. Buchholz, V. Kasche, U.T. Bornscheuer; Wiley-VCH, second edition, 2012, ISBN:978-3-527-32989-2). Biocatalysis biochemical Fundamentals and Applications (P. Grunwald; Imperial College Press, 2009, ISBN:978-1-86094-744-5). Enzyme Technology (Wu-Kuang Yeh, Hsiu-Chiung Yang and J. R. McCarthy; Wiley 2010, 9780470286241). Industrial enzyme (Ed. J. Polaina, A. MacCabe, Springer, 2007, ISBN: 978-1-4020-5377-1). Enzymatic reaction mechanism (P.A. Frey-A.D. Hegeman; Oxford University Press, 2007).

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Definition of biotechnology. The scope of biotechnology in energy usage. Sustainable development. Enzyme technology is green technology. The advantage of the application of biocatalysts <i>versus</i>
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conventional processes.

*2<sup>nd</sup> week*

Comparison of biocatalysis with other kinds of catalysis. Requirements for industrial enzymes. Industrial enzymes on the global market. Application of enzymes in molecular biology and enzymes used in immunoassays and as a therapeutic agent.

*3<sup>rd</sup> week*

Kinetics of enzyme catalyzed reactions. The integrated Michaelis-Menten equation. Substrate and end-product inhibition. *Reversible enzymatic reaction*. Conversion of enzyme processes. Two-substrate enzyme reactions.

*4<sup>th</sup> week*

Effect of environmental factors on enzyme activities. The environmental stability of enzymes. Enzyme assays.

*5<sup>th</sup> week*

Classification of enzymes, enzyme databases. Cofactor dependent enzymes in industrial application, the methods of cofactor regeneration. The advantage of the whole cell technology for enzyme catalysed processes.

*6<sup>th</sup> week*

The biotechnological importance of NAD(P) dependent dehydrogenases. Mechanism of oxidases. The hydrogen peroxide producing oxidases as industrial enzymes.

*7<sup>th</sup> week*

Industrial application of laccase and its enzymatic mechanism. Peroxidases. The enzymes involved in ROS elimination.

*8<sup>th</sup> week*

**Industrial hydrolases. Characterisation of glycoside hydrolases. CAZY database. Industrial hydrolysis of starch by starch processing enzymes. The cellulolytic and hemicellulolytic enzyme systems. The cellulosome. Enzyme catalysis in bioethanol production.**

*9<sup>th</sup> week*

Biotechnological application of isomerases. The importance of xilose izomerases in the production of high-*fructose* corn syrup.

*10<sup>th</sup> week*

Industrial application of aldolases. Enzymatic processes used for the production of amino acids.

*11<sup>th</sup> week*

Metabolic engineering. Improvement of pentose utilisation in yeast. Metabolic engineering of microbes for oligosaccharide synthesis.

*12<sup>th</sup> week*

Improving enzyme function by rational design versus directed evolution. Novel substrate specificity, product selectivity, increased stability, decreased protease sensitivity. Screening and selection.

*13<sup>th</sup> week*

Improving enzyme stability by immobilisation.classification of enzyme immobilization methods.Effects of enzyme immobilization on activity. Immobilization by entrapment and by carrier-binding.

*14<sup>th</sup> week*

Immobilization by crosslinking. Magnetic single-enzyme particles with high stability. Application of immobilized enzymes.

#### **Requirements:**

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

*- for a grade*

The course ends in an **examination**.

The grade for the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. TerézBarna, assistant professor, PhD

**Lecturer:** Dr. TerézBarna, assistant professor, PhD

<b>Title of course:</b> NMR Operator Training Practice I. <b>Code:</b> TTKML0004_EN, TTKBL0004_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 28 hours - laboratory: - - home assignment: - - preparation for the exam: 32 hours Total: 60 hours:	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester or 3 <sup>rd</sup> year, 1 <sup>st</sup> or 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b> TTKMG0530_EN	

<b>Topics of course:</b> practical laboratory course with aim that students would be able to pick up <sup>1</sup> H and <sup>13</sup> C NMR spectra on the 360MHz high field NMR spectrometer without external help
<b>Literature</b> Compulsory:P.J. Hore, Nuclear Magnetic Resonance, ISBN 963 19 4426 3 Bruker Topspin 3.x manuals (free download) Recommended:James Keeler, "Understanding NMR Spectroscopy" , 2009, ISBN 0-470-01787-2

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Safety rules in NMR labs. with supercon magnets. Dangers for magnets and human beings. Pulse Fourier measurement principle. Hardware of 360 MHz spectrometer: magnet, probeheads, RF preamplifier, electronic control unit, control PC, manual controls.  <i>2<sup>nd</sup> week</i> Sample preparation: use of deuterated solvents, quality and cleaning of NMR sample tubes, sample amount and dissolving rules. Positioning the samples before measurement, pneumatic transfer of samples into the magnet. Use of deuterium lock in automatic or manual mode. Lock power, field, phase, gain, finding the lock signal. Optimizing lock parameters avoiding saturation of the deuterium signal.  <i>3<sup>rd</sup> week</i> Homogenisation of the main magnetic field up to 10 <sup>-9</sup> -10 <sup>-10</sup> accuracy, using the lock signal amplitude. Sample spinning, use of z-shim coils. Non-spinning shims (x,y) combinations. Changing lock phase. Reading and writing shim files (rsh/wsh). Signs of bad shimming. Indicators of good shims
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in TMS signal.

*4<sup>th</sup> week* Recording proton NMR spectra. Measurement principles: pulse program zg and its visualisation. Acquisition parameters in eda and ased starting windows. Explanation of important parameters: digital sampling and connection between td, sw, aq parameters. Choice of p1 pulse and d1 relaxation delay for quantitative <sup>1</sup>H-NMR. Real-time FID shimming in gs mode.

*5<sup>th</sup> week* Processing proton NMR spectra. Math rules of Fourier transformation with FFT. TD and SI, zero filling. Window functions for S/N enhancement (em) or resolution (gm) enhancement. Phase correction to pure absorption phase - automatic or manual. Baseline correction for accurate integrals. Integration routine and calibration, correction of integrals.

*6<sup>th</sup> week* Recording carbon NMR spectra. Pulse programs zgdc and jmod. Explaining the double impact of proton decoupling: removing splittings caused by proton-carbon spin-spin couplings and heteronuclear NOE that improves carbon sensitivity. Explaining the proton channel power and dB scale, and heating effect danger. Exponential line broadening is a must (em) before FT. Explaining and running the jmod spin-echo sequence.

*7<sup>th</sup> week* Recording more carbon NMR spectra with gated (zgpg) and inverse gated (zgig) sequences. The former for measuring heteronuclear couplings with better sensitivity, the latter for quantitative <sup>13</sup>C-NMR. Adjusting optimal parameters for carbon NMR. Explaining signal multiplicity of deuterated organic solvents. Peak picking (ppm) of spectra.

*8<sup>th</sup> week* Exercising <sup>1</sup>H NMR signal acquisition and processing one by one.

*9<sup>th</sup> week* Exercising <sup>13</sup>C NMR signal acquisition and processing one by one.

*10<sup>th</sup> week* Exercising <sup>1</sup>H NMR signal acquisition and processing one by one.

*11<sup>th</sup> week* Exercising <sup>13</sup>C NMR signal acquisition and processing one by one.

*12<sup>th</sup> week* Exercising <sup>1</sup>H NMR and <sup>13</sup>C NMR signal acquisition and processing one by one.

*13<sup>th</sup> week* Exercising <sup>1</sup>H NMR and <sup>13</sup>C NMR signal acquisition and processing one by one.

*14<sup>th</sup> week* Exercising <sup>1</sup>H NMR and <sup>13</sup>C NMR signal acquisition and processing one by one.

### **Requirements:**

*- for a signature*

Attendance of laboratory exercises is compulsory.

A student must attend the practice classes and may not miss more than two times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate

his/her participation as an absence because of the lack of active participation in class.

- *for a grade*

The course ends in an **examination**. The student must produce an  $^1\text{H}$  NMR spectrum with quantitative integrals and a  $^{13}\text{C}$  NMR spectrum with peak list within one hour time limit, without external help. They may ask for tutor help, however this may result in lowering their mark.

- the result of the practical examination may be 1 (failed) 2,3,4,5 (passed)

**Person responsible for course:** Prof. Dr.BattaGyula, university professor, DSc

**Lecturer:** Prof. Dr.BattaGyula, university professor, DSc

<b>Title of course:</b> Reaction Kinetics/Catalysis <b>Code:</b> TTKME0437_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: 2 hours/week	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: 28 hours - home assignment: 28 hours - preparation for the exam: 36 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> /2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Basic principles, analysis of kinetic data.</li> <li>- Lindemann theory of unimolecular reactions; theory of associative reactions.</li> <li>- Specific kinetic effects characteristic to reactions in solution.</li> <li>- Basic principles and equations related to composite reactions.</li> <li>- Kinetics of photochemical reactions; governing principles.</li> <li>- Phenomenon, development and significance of catalysis.</li> <li>- Most important features of homogeneous and heterogeneous catalysis. Discussion of the importance of catalysis through industrial examples.</li> <li>- Major kinetic features of enzymatic catalysis and demonstration of its significance through examples.</li> <li>- Green chemistry and application of catalysis in green chemical processes.</li> </ul> <p>Every student has to work out the 4 laboratory practices (4 hours each) listed in the detailed course schedule. In these laboratory assignments they will use various methods and equipments, such as flow reactors, and will make measurements on acid-, metal ion-, metal complex-, and enzyme-catalyzed reactions.</p>
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- M. J. Pilling, P. W. Seakins: <i>Reaction Kinetics</i>, Oxford University Press, Oxford, UK, 1995</li> <li>- P. W. Atkins: <i>Physical Chemistry</i>, 6<sup>th</sup> ed., Oxford University Press, Oxford, UK</li> </ul> <p><i>Recommended:</i></p>



- K. J. Laidler, *Physical Chemistry*, 2<sup>nd</sup> ed., Houghton Mifflin Co., Boston, 1995
- B. C. Gates: *Catalytic Chemistry*, Wiley, 1991.
- G. Rothenberg: *Catalysis*, Wiley, 2008.

### Schedule:

*1<sup>st</sup> week* Basic principles and analysis of kinetic results: order of reactions, molecularity. Determination of rate constants and coefficients. Analysis of kinetic results: integral and differential methods, isolation method, method of half lives. Temperature dependence of the reaction rate. Connection between reaction kinetics and thermodynamics.

**Iodination of acetone:** determination of the order of reactants (or that of the activation energy of the reaction) using iodometry.

*2<sup>nd</sup> week* Kinetics and mechanism: principle of reaction mechanism. Rules for explanation of relation of the rate equation and reaction mechanism. Kinetically equivalent reaction schemes.

**Catalytic decomposition of H<sub>2</sub>O<sub>2</sub>:** Study of the effect of copper(II)-ion, of various anions, and that of the pH in decomposition of H<sub>2</sub>O<sub>2</sub> catalyzed by iron-ions. Determination of H<sub>2</sub>O<sub>2</sub> concentration by iodometry..

*3<sup>rd</sup> week* Lindemann theory of unimolecular reactions. Comparison of the theory to experimental results. Extrapolation to infinite pressure. Activation and the rate of dissociation. Theory of associative reactions.

*4<sup>th</sup> week* Kinetics of solution reactions. Role of the solvent: the cage effect. Formation of a collision complex. Diffusion controlled reactions. Kinetically controlled reactions. Effects of ionic strength and pressure on the rate coefficient.

*5<sup>th</sup> week* Kinetics of composite reactions: application of the Bodenstein-principle and that of the fast preequilibria for kinetic description of reaction systems. Parallel and consecutive reactions. Reactions leading to equilibrium. The most important reactions taking place in the atmosphere.

*6<sup>th</sup> week* Theory of chain reactions: general scheme of chain reactions. Definition of chain length. Reactions with open chain: hydrogen-halogen reactions, alkane pyrolysis, radical polymerizations. Thermal explosions. Chain reactions with branching: the H<sub>2</sub> + O<sub>2</sub> reaction, oxidation of hydrocarbons.

*7<sup>th</sup> week* Oscillating chemical reactions in closed systems. The Belouszov-Zhabotinsky reaction and the Field-Körös-Noyes mechanism. The Oregonator model and its dynamics. Chemical chaos.

*8<sup>th</sup> week* Kinetics of photochemical reactions: formation and decay of electronically excited molecules. Kinetic laws of photochemistry: Quantum yield coefficient. Lifetimes of fluorescence and phosphorescence. Stern-Volmer diagram.

*9<sup>th</sup> week* Definition and characteristics of catalysis. Historical overview of the most important catalytic processes. Principles of green chemistry and comparison of traditional and green processes. Green chemistry and catalysis. Atom efficiency and environmental factor (E-factor) – with examples



<b>Title of course:</b> NMR structure determination <b>Code:</b> TTKME0507_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 1 hours/week - practice: 1 hours/week - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 14 hours - practice: 14 hours - laboratory: - - home assignment: - preparation for the exam: 62 hours Total: 90 hours	
<b>Year, semester:</b> 1 <sup>nd</sup> year, 1 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b>	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The aim of the course is to acquaint the students with principles, possibilities and limitations of NMR based structure determination. During the course, the students will be introduced into the molecule mechanics, which forms the basis of NMR based structure determination process.
<b>Literature</b>
<i>Compulsory:</i> Andrew R. Leach: Molecular Modelling: Principles and Applications, 2nd Edition, 2001 Quincy Teng: Structural Biology - Practical NMR Applications G.C.K. Roberts: NMR of Macromolecules A Practical Approach

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Concepts related to structure: conformation, supramolecular structure, conformational ensemble - Boltzman distribution, correlation of structure and dynamics. Experimental methods of structure determination. Theoretical methods of modeling of structure. Principles of Molecular and Quantum Mechanics and their comparison. <i>2<sup>nd</sup> week</i> Molecular mechanics. Introducing the concept of a force field, describing terms. Bonding and non-bonding terms, Description functional forms of individual terms, Description of force constants. <i>3<sup>rd</sup> week</i> Definition of parameters and atom types. Topology. The advantages and limitations of molecular mechanics. Frequently used force fields and their characteristics. <i>4<sup>th</sup> week</i> The potential energy surface and its features. Simulation methods for mapping the potential energy
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surfaces. Geometry optimization and energy minimization.

*5<sup>th</sup> week*

Molecular dynamics. Thermodynamic ensembles. High temperature molecule dynamics, simulated annealing.

*6<sup>th</sup> week*

NMR parameters related to structure. Nuclear-Overhauser Effect or NOE.

*7<sup>th</sup> week*

Coupling constants. NMR parameters related to hydrogen bonds. Residual dipolar couplings. Paramagnetic relaxation effects. Structural parameters of proteins and peptides.

*8<sup>th</sup> week*

Process of the NMR structure determination. Methods for generating a structural ensemble. Distance geometry. Molecular dynamics with restraints. Variable Target Function algorithm.

*9<sup>th</sup> week*

Implementing restraints. Practical aspects of NOE restraints. Structure refinement. Selection and accuracy of the final ensemble.

*10<sup>th</sup> week*

Software for determining NMR structure. Validation of the structural ensemble and the programs applied to it. Structural statistics.

*11<sup>th</sup> week*

Structure and dynamics. Time scale of dynamic processes and their effects on NMR structural parameters. Modeling of dynamic structures.

*12<sup>th</sup> week*

Structure determination of Maganin in a secondary structure inducing solvent. Assignment of signals in the <sup>1</sup>H NMR spectra of Maganin acquired in TFE solvent using homonuclear 2D methods. Structural calculation and refinement with ARIA / CNS programs, structure validation and structural statistics.

*13<sup>th</sup> week*

Modeling the structural ensemble of Maganin peptide in aqueous medium without presence of secondary structure elements. Assignment of <sup>1</sup>H NMR spectra of Maganin with homonuclear 2D methods acquired in aqueous solution. Calculation Molecular Dynamics using explicit solvents with AMBER simulation engine and comparison of the trajectories with NMR parameters.

*14<sup>th</sup> week*

Consultation

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can't make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behaviour or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

*- for a grade*

The course ends in an **examination**. The exam grade depends on the performance of the examination

<b>Person responsible for course:</b> Dr. Fehér Krisztina, research fellow, PhD
<b>Lecturer:</b> Dr. Fehér Krisztina, research fellow, PhD