

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

**CHEMICAL ENGINEERING BSC PROGRAM**

**2023**

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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 the demand of the job market for professionals, we offer engineering courses with a strong scientific basis, thus expanding our training spectrum in the field of technology. Based on the fruitful collaboration with our industrial partners, recently, we successfully introduced dual-track 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 national and international companies. 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

## 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; WarghaIstván College of Education, Hajdúbószörmény; 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:** 13

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 Science and Technology

**Number of students at the University of Debrecen:** 29,777

**Full time teachers of the University of Debrecen:** 1,587

203 full university professors and 1,249 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 2,500 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 (12 Bachelor programs and 14 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 ~790 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

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Vice Dean for Scientific Affairs: Prof. Dr. Sándor Kéki, Full Professor  
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Consultant on External Relationships: Prof. Dr. Attila Bérczes, Full Professor  
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Consultant on Talent Management Programme: Prof. dr. Tibor Magura, Full Professor  
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E-mail: [toth.katalin@science.unideb.hu](mailto:toth.katalin@science.unideb.hu)

English Program Officer: Mrs. Alexandra Csatáry  
Address: 4032 Egyetem tér 1., Chemistry Building, A/101, E-mail: [acsatary@science.unideb.hu](mailto:acsatary@science.unideb.hu)

## DEPARTMENTS OF THE INSTITUTE OF CHEMISTRY

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## 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> – 14 <sup>th</sup> week	Teaching period	13 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:

[https://www.edu.unideb.hu/tartalom/downloads/University\\_Calendars\\_2023\\_24/University\\_calendar\\_2023-2024-Faculty\\_of\\_Science\\_and\\_Technology.pdf?\\_ga=2.243703237.1512753347.1689488152-28702506.1689488059](https://www.edu.unideb.hu/tartalom/downloads/University_Calendars_2023_24/University_calendar_2023-2024-Faculty_of_Science_and_Technology.pdf?_ga=2.243703237.1512753347.1689488152-28702506.1689488059)

# THE CHEMICAL ENGINEERING BACHELOR PROGRAM

## Information about the Program

Name of BSc Program:	Chemical Engineering BSc Program
Specialization available:	-
Field, branch:	Science
Qualification:	Chemical Engineer
Mode of attendance:	Full-time
Faculty, Institute:	Faculty of Science and Technology Institute of Chemistry
Program supervisor:	Prof. Dr. Sándor Kéki, University Professor
Program coordinator:	Dr. Csilla Lakatos, assistant professor
Duration:	7 semesters
ECTS Credits:	210

### Objectives of the BSc program:

The aim of the Chemical Engineering BSc program is to train professional chemical engineers, who have deep insight into spatial processes. Relying on strong chemistry-, engineer and process control base graduates of the program they are able to understand the natural, environmental, technical and social phenomena and to develop applied science-based solutions

### Professional competences to be acquired

#### A Chemical Engineer:

##### a) Knowledge:

- He/she has a mathematical and scientific background to understand processes in chemical and chemistry related industries.
- He/she knows the properties of the most important chemicals, their productions and applications.
- He/she knows the basic principles, the planning and controlling options in the technology of chemical processes and industrial tasks.
- He/she knows the principles of instruments in chemical industries and technologies, and their operative parts, and their connections.
- He/she knows the chemical methods for measurements or analysis, their principles and instrumental background, and their applicabilities.
- He/she knows the chemistry and chemical technology related economic, management environmental safety, quality assurance (QC/QA), informatics and intellectual property rules and laws.

- He/she knows has a knowledge on the data mining, relevant literature and the ethical concerns of chemical engineering.

**b) Ability:**

- He/she able to apply the learned methods, models and plannings of chemical technology and chemical processes through calculations.
- He/she understands and is able to describe the elements of industrial and technological units, their operations including the connectivity options.
- He/she is able to apply those directives that are necessary to operate instruments and control processes in a safe, cost effective way as well as avoid any problems causing health issues.
- He/she is able to follow and control chemical processes and other technological steps concerning quality management and quality control.
- He/she is able to recognize the possible error symptoms, run diagnostic routines and offer solution based on the results.
- He/she is able to use documentation (either online or printed) related to the current field, including the scientific literature both in his/her native language and English.
- He/she is able to treat new or unknown systems based on the previous studies and experiences, learn and install new technologies and recognize mechanisms related to human health.
- He/she is able to run measurements both on laboratory and scaled up systems, and evaluate the derived data at all steps in the development.
- He/she is capable on conducting basic chemical engineering tasks.
- He/she is able to collect, organize, and understand information about health prevention, keeping track of new results, and apply them to make cost and environmentally effective, healthy working areas.

**c) Attitude:**

- He/she makes effort to keep his/her chemical engineering knowledge updated related to his/her professional goals.
- He/she is open to accept environmentally efficient technologies, and for the application of new, innovative and advanced methods in economy.
- During everyday work and installation of new technologies He/she is always concerned about sustainable development.
- He/she makes an effort to improve and apply the practical methods with new results and experiences.
- During his/her work He/she is committed to apply the quality concerns including the new assurances.
- He/she can collaborate with other people and discuss their opinions in problem-solving processes before making new decisions.
- In each technological or laboratory step He/she is always concerned about the current rules/laws of health prevention, safety and environmental questions.

**d) Autonomy and responsibility:**

- Following directions He/she can work without supervision considering all quality and safety rules.
- He/she tends to establish new solutions and technologies.
- He/she can manage work and worker resources, follow and control the instruments and measuring units.
- He/she can evaluate the work of other persons and make decisions based on the outcome.
- He/she works towards personal improvements and helps others to achieve their professional goals.
- He/she shares experiences with others to help them.
- He/she makes decisions according to his/her positions, makes suggestions to qualify his/her colleagues involving their promotions.

## **Completion of the BSc Program**

### *The Credit System*

Majors in the Hungarian Education System have generally been instituted and ruled by the Act of Parliament under the Higher Education Act. The higher education system meets the qualifications of the Bologna Process that defines the qualifications in terms of learning outcomes: statements of what students know and can do on completing their degrees. In describing the cycles, the framework uses the European Credit Transfer and Accumulation System (ECTS).

ECTS was developed as an instrument of improving academic recognition throughout the European Universities by means of effective and general mechanisms. ECTS serves as a model of academic recognition, as it provides greater transparency of study programs and student achievement. ECTS in no way regulates the content, structure and/or equivalence of study programs.

Regarding each major the Higher Education Act prescribes which professional fields define a certain training program. It contains the proportion of the subject groups: natural sciences, economics and humanities, subject-related subjects and differentiated field-specific subjects.

During the program students have to complete a total amount of 120 credit points. It means approximately 30 credits per semester. The curriculum contains the list of subjects (with credit points) and the recommended order of completing subjects which takes into account the prerequisite(s) of each subject. You can find the recommended list of subjects/semesters in chapter “Model Curriculum of Chemical Engineering BSc Program”.

*Model Curriculum of Chemical Engineering BSc Program*

	semesters								EC TS cre dit poi nts	evaluation								
	1.	2.	3.	4.	5.	6.	7	Preequisite										
	contact hours, types of teaching (l – lecture, p – practice), credit points																	
<b>Science subject group</b>																		
<i>Mathematics modul</i>																		
1.Mathematics I. <i>Zoltán Muzsnay</i>	56 l / 5cr 42 p / 2cr								7	exam								
2.Mathematics II. <i>Zoltán Muzsnay</i>		28 l /3cr 42 p /2cr						TTMBE0808_EN, TTMBG0808_EN	5	exam								
<i>Physics modul</i>																		
1. Physics for Engineers I. <i>Balázs Ujvári</i>	42 l /3cr								3	exam								
2. Physics for Engineers II <i>Balázs Ujvári</i>		42 l /3cr						TTFBE2111_EN	3	exam								
<i>Chemistry modul</i>																		
1.General Chemistry I (lect and sem) <i>József Kalmár</i>	42 l /4cr. 42 p /3cr								7	exam								
2. General Chemistry (lab) II.		42 p /3cr.						TTKBE0101_EN, TTKBG0101_EN	3	mid-semester grade								
3. Inorganic Chemistry I. <i>István Lázár</i>		28l /3cr.						TTKBE0101_EN	3	exam								
4. Inorganic Chemistry II. <i>Péter Buglyó</i>	.		28 l /3cr.					TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	3	exam								
5. Organic Chemistry I. (lect and sem) <i>Tibor Kurtán</i>		28 l /3cr. 14 p /1cr.						TTKBE0101_EN	4	exam								

6. Organic Chemistry II. <i>Tibor Kurtán, Marietta Vágvölgyiné Tóth</i>			42 l/4cr. 42 p/2cr.					TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN TTKBL0101_EN	6	exam
7. Organic Chemistry III. <i>László Juhász</i>				28 l/3cr./				TTKBE0302_EN	3	exam
8. Biochemistry I. <i>János Kerékgyártó</i>					28 l/3cr			TTKBE0303_EN	3	exam
<b>Economic and Human Sciences subject group</b>										
<i>Micro- and Macroeconomic modul</i>										
1. Introduction to Economics <i>Levente Sándor Nádasdi</i>	28 l/3cr.		.						3	exam
<i>Management and Business modul</i>										
1. Introduction to Business <i>András Nábrádi</i>	28 l/3cr								3	exam
<i>Business Law modul</i>										
1. Basics of Civil Law I. <i>Tamás Fézer</i>		28 l/2cr.							2	exam
2. Basics of Civil Law II. <i>Tamás Fézer</i>		.	28 l/2cr					TTBEBVVM-JA1	2	exam
3. History and Structure of European Union <i>Károly Teperics</i>	14 l/1cr		.						1	exam
<i>Economic and Human Sciences module</i>										
1. Management of Value Creating Processes <i>Miklós Pakurár</i>		28 l/3cr.							3	exam
<b>Basics of Professional Knowledge subject group</b>										
<i>Physical, Analytical Chemistry and Material Science modul</i>										
<i>Analytical Field</i>										
1. Analytical Chemistry I. <i>Péter Buglyó</i>			28 l/3cr		.			TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	3	exam

2. Inorganic and Qualitative Analytical Chemistry <i>Csilla Kállay</i>			56 p /4cr.					TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN, TTKBL0101_EN	4	mid-semester exam
3. Application of Instrumental Analysis (lect.) <i>István Lázár</i>					14 1/1cr.			TTKBE0501_EN	1	exam
4 Application of Instrumental Analysis (lab.) <i>Attila Gáspár</i>						42 p /3cr.			1	mid-semester exam
Physical Chemistry and Material Science Field										
1.Physical Chemistry I. (lect. and sem.) <i>Attila Bényei</i>		28 1/3cr. 28 p/2cr.						TTKBE0101_EN, TTFBE2111_EN, TTMBE0808_EN parallel registration to TTKBE0401_EN	5	exam, mid-semester grade
2. Physical Chemistry II. (lect. and sem.) <i>Attila Bényei</i>			28 1/3cr. 28 p/2cr	.				TTKBE0401_EN, TTKBE0201_EN, TTKBE0301_EN parallel registration to TTKBE0402_EN	5	exam, mid-semester grade
3. Physical Chemistry II. (lab.) <i>Ferenc Krisztián Kálmán</i>				28 p /2cr.				TTKBL0101_EN, TTKBE0402_EN	2	mid-semester grade
4 Physical Chemistry III. <i>Noémi Nagy</i>				28 1/3cr	.			TTKBE0402_EN	3	exam
5.Macromolecular Chemistry <i>Sándor Kéki</i>				28 1/3cr				TTKBE0302_EN	3	exam
6.Materials of Construction <i>Sándor Kéki</i>					28 1/3cr			TTKBE0611_EN	3	exam
7.Plastics and Processing I <i>Sándor Kéki</i>						28 1/2cr 28 p/2cr.		TTKBE0302_EN TTKBE0611_EN	4	exam, mid-semester grade
<i>Measurement and Processing modul</i>										
Informatics Field										
1. Informatics for Engineers <i>Ákos Kuki</i>			28 p /2cr						2	mid-semester grade

Processing Field										
1. Process Control I. <i>Lajos Nagy</i>				28 1/42pr.				TTKBG0911_EN	4	mid-semester grade
2. Process Control II. <i>Lajos Nagy</i>			.		281 /42pr.			TTKBG0612_EN	3	mid-semester grade
<i>Mechanics and Unit Operation modul</i>										
Mechanics Field										
1. Mechanics for Chemical Engineers I. <i>Zsolt Tiba</i>			28 1/14pr.					TTFBE2111_EN, TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	3	mid-semester grade
2. Mechanics for Chemical Engineers II. <i>Sándor Pálinkás</i>				28 1/14pr.				MFVGE31V03_EN	3	mid-semester grade
3. Mechanics for Chemical Engineers III. <i>Gábor Balogh</i>					28 1/14pr			MFVGE31V03, MFVGE32V03	3	mid-semester grade
Unit Operation Field										
1. Unit Operation I. <i>Sándor Kéki</i>			70 1/6cr.		.			TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	6	mid-semester grade
2. Unit Operation II <i>Katalin Margit Illýésné Czifrák</i>				70 1/6cr.				TTKBG0614_EN	6	mid-semester grade
3. Unit Operation III. <i>Katalin Margit Illýésné Czifrák</i>					70 1/6cr.			TTKBG0615_EN	6	mid-semester grade
<i>Technology Module</i>										
Planing Field										
1. Computer Modeling of Chemical Technology Systems I <i>Ákos Kuki</i>						28 p/ 2cr.		TTKBG0616_EN	2	mid-semester grade
2. Computer Modeling of Chemical Technology Systems II <i>Ákos Kuki</i>							28 p/2cr.	TTKBG0912_EN	2	mid-semester grade
Chemical Technology Field										

1. Chemical Technology I. <i>Lajos Nagy</i>				28 l/3cr. 56 p/4cr.	.			TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	7	exam, mid-semester grade
2. Chemical Technology II. <i>Lajos Nagy.</i>					28 l/3cr. 56 p/4cr.	r		TTKBE1111_EN, TTKBL1111_EN	7	exam, mid-semester grade
13. Chemical Technology III. <i>Lajos Nagy</i>							28 l/3cr	TTKBE1112_EN, TTKBL1112_EN	3	exam
3. Environmental Technology <i>Katalin Margit IllyésnéCzifrák</i>					28 l/3cr 28 l/2cr.			TTKBL1111_EN TTKBE1114_EN parallel recording	5	exam, mid-semester grade
4. Pilot Plant Work <i>Tibor Nagy</i>						70 p/5c		TTKBE1111_EN TTKBL1111_EN TTKBG0614_EN	5	mid-semester grade
Safety Field										
1. Safety <i>Sándor Kéki</i>							28 l/3cr.	TTKBE1112_EN	3	exam
Special Courses										
1. Basics of Petrolchemistry <i>Tibor Nagy</i>					28 l/3cr.			TTKBE1111_EN	3	exam
2. Waste Management <i>Sándor Kéki</i>					28 l/3cr			TTKBE1111_EN	3	exam
3. Spectroscopic Methods I. <i>Gyula Batta</i>					28 l/3cr.			TTKBE0302_EN, TTFBE2113_EN	3	exam
4. Quality Management <i>Ágnes Kotsis</i>					28 l/3cr.		TTBEBVM-KT4_EN		3	exam
5. Design of Experiments <i>Ákos Kuki</i>					28 l/3cr.			TTKBE0403_EN	3	mid-semester grade
<b>BSc Thesis I.</b>				.	<b>2cr.</b>		Completion of 140 credits		2	mid-semester grade
<b>BSc Thesis II.</b>							<b>13cr.</b>	TTKBG2011_EN	13	mid-semester grade

*Optional chemistry courses (10cr.)*

1.Crystallography <i>Gábor Dobosi</i>	28 1/3cr. fall semester						3	exam		
2.Basics of Environmental Science <i>István Gyulai</i>	14 1/1cr. fall semester						1	exam		
3.History of Chemistry <i>Ágnes Dávid</i>	28 1/3cr. spring semester					TTKBE0101_EN	3	exam		
4.Macroeconomics <i>Pál Czeglédi</i>	28 1/3cr fall semester					TTBEBVVM-KT1_EN	3	exam		
5.Applied Radiochemistry <i>Noémi Nagy</i>	28 1/3cr. spring semester					TTKBE0403_EN	3	exam		
6.Plastics and Processing II. <i>Sándor Kéki</i>	28 p/2cr.					TTKBE0611_EN	2	mid-semester grade		
7. Basic Chemical Informatics <i>Attila Mándi</i>	2 cr, 0+2p+0							-		
8.Colloid Chemistry <i>Levente Novák</i>	28 1/3cr.					TTKBE0402_EN	3	exam		
9..Biochemistry III. <i>Teréz Barna</i>	28 1/3cr.					Biochemistry I	3	exam		
10.Biocolloids <i>Levente Novák</i>	28 1/3cr. spring semester					TTKBE0402_EN	3	exam		
11..NMR Operator Training I. <i>Gyula Batta</i>	28 p/2cr.					TTKBE0503_EN	2	mid-semester grade		
12.Plastics and Processing III. <i>Sándor Kéki</i>	42 p/3cr.					TTKBE0611_EN	3	mid-semester grade		
13.Organic Chemistry Seminar I. <i>László Juhász</i>	14 p/1cr.						TTKBE0101_EN	1	mid-semester grade	
14. Organic Chemistry Seminar II. <i>László Juhász</i>		14 p/1cr						TTKBE0201_EN TTKBE0301_EN TTKBE0401_EN	1	mid-semester grade
<i>Other requirement</i>										

Visits at Chemical Companies <i>Ákos Kuki</i>				28p			Paralel registration to ITKBE1111_EN	<i>3 days</i>	signature
Industrial Placement <i>Inthernship</i> <i>Ákos Kuki</i>								<i>6 weeks</i>	signature

### *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.

### *Internship*

Students majoring in the Chemical Engineering BSc Program have to carry out a 6 weeks internship involved in the model curriculum. The internship course must be signed up for previously via the NEPTUN study registration system (Industrial Placement:TTKBG1119\_EN) in the spring semester (6<sup>th</sup> semester). Its execution is the criteria requirement of getting the pre-degree certificate (absolutorium).

#### *Objective of the internship, competences*

Students get acquainted with professional work in conformity with their major at the company or institution and join in the daily working process. They have to resolve tasks independently assigned by their supervisor and gain experiences may be utilized later in the labour market. During the internship common and professional competences may be acquired. Common competences: precise working on schedule either individually or in team, talk shop applying correct technical terms. Professional competences: applying the professional skill gained during the training and acquiring new knowledge.

#### *Places suitable for internship*

All the organizations, institutions and companies in Hungary or abroad, provide students with the opportunity to acquire proficiency in accordance with their specialization in the field of operation, repairing technology, installation, management and development of different machines and vehicles, may be a suitable place.

### *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>.

### *Pre-degree Certification*

A pre-degree certificate is issued by the Faculty after completion of the bachelor's (BSc) 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 (210). 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.

### *Thesis*

Students have to write a thesis in the 6th and 7th semester. Writing this is the precondition of the entrance to the final exam.

The thesis is the solution of a chemical engineering task which the student should solve relying on previous studies and secondary literature under the guidance of a tutor in one semester. The thesis must prove that the author can apply the acquired theoretical knowledge.

The student can choose any topic for a thesis suggested by the faculty or in occasional cases individual topics acknowledged by the head of the department. Only those tasks can be given as thesis that can be accomplished within the allowed time limit relying on the skills acquired during the years of study. The topics of the thesis should be given in completely uniform manner and based on the system of requirements set up by the head of the institute and the head of the department responsible for the specialization. Students must be informed of the thesis topics in the first academic week of the first semester the latest. The theses are written with the close collaboration of the candidate and the supervisor.

The formal requirements of the thesis are detailed in the “manual for writing theses” which is handed out to every candidate when they decide upon their topic. The theses must be handed into the department responsible minimum ten days before the beginning of the final exam period. The thesis paper is evaluated by the supervisor who gives a grade as well as a short written comment on it. The head of the department makes a proposal for the final evaluation of the thesis based on the comments. The thesis receives a grade from the final exam committee. In case the thesis is not accepted he/she cannot carry on with the exam.

### *Final Exam*

Students of the major receive an absoloratorium after they have been satisfied every aspect of their educational and examinational requirements. The student can only register on the final exam if the thesis is already submitted, it is accepted and evaluated by the supervisor. The final

exam is essential for anyone who wants to get a Chemical Engineer BSc diploma. The final exam must be taken in front of the Final Exam Board.

***Subjects of the Final Exam:***

- Physical Chemistry
- Chemical Technology
- Unit Operation

***Procedure of the Final Exam***

Conditions on taking part of the final exam:

- Acquired absolutorium
- Submitted thesis
- Submitted evaluation sheet for the thesis, with a minimum grade of pass (2).

***Parts of the Final Exam***

- Drawing a question card of each topic, preparation (30 minutes)
- Brief presentation of the results of the thesis (6 minutes)
- Answering the questions about the thesis (6 minutes)
- Answering the questions about the 3 subjects (3x6 minutes)

**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.

## **Diploma**

The diploma is an official document decorated with the coat of arms of Hungary which verifies the successful completion of studies in the Chemical Engineering Bachelor 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 Chemical Engineering Bachelor 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)

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

## Course Descriptions of Chemical Engineering BSc Program

<b>Title of course:</b> Mathematics I. <b>Code:</b> TTMBE0808	<b>ECTS Credit points: 5</b>
<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: 44 hours - preparation for the exam: 50 hours Total: 150 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> TTMBE0809_EN, TTMBG0809_EN	

<b>Topics of course</b>
Sets. Real numbers. Complex numbers. Sequences and series. Convergence, limits. Real functions. Limit, continuity and differentiation of functions. Monotonicity, convexity, inflection. Approximation with polynomials, Taylor formula. Definition and calculation of definite, indefinite and improper integrals. Ordinary differential equations. Vector spaces. Matrices, operations with matrices. Determinants and properties; the matrix rank. Linear equation systems. Euclidean spaces and their transformations.
<b>Literature</b>
<i>Compulsory:</i> - <i>Recommended:</i> Thomas, Weir& Hass: Thomas' Calculus, K. A. Stroud: Calculus and Mathematical Analysis, K. A. Stroud: Engineering Mathematics, E. Mendelson: Schaum's 3000 Solved Problems in Calculus,
<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Operations with sets, set algebra. Descartes product, relations, functions. Special functions: injectivity, surjectivity, bijectivity. The inverse of a function. Real numbers. Exact lower and upper bounds. Open and closed sets. Bolzano-Weierstrass theorem. <i>2<sup>nd</sup> week</i> Complex numbers. The algebraic structure of the set of complex numbers. The complex plane. Trigonometric form of complex numbers, multiplication, division, n-th power, n-th root.

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

Sequences. Convergence and limit of real sequences. Monotonous, bounded, convergent sequences, Cauchy's convergence criteria. Algebraic operations with convergent sequences. Squeezing theorem. The generalization of the notion of limit.

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

Series. The convergence of series. Arithmetic series and geometric series. The harmonic series. Leibniz type series. Convergence tests: ratio and root tests. Power series.

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

Limits and continuity of functions. Properties of continuous functions. Continuity of the composition and the inverse function. Special properties of continuous functions defined on an interval. Elementary functions.

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

Differentiation. The geometric meaning of the derivative. Rules of differentiation. Derivative of a function of a function: the chain rule. The derivative of the inverse function. Relationship of monotonicity and the derivative. Roll's theorem and Lagrange's theorem. Conditions for the existence of extreme values. Derivative of elemental functions.

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

Higher order derivatives. Convexity and the derivatives. Approximating with polynomials, Taylor formula. Conditions for the existence of extreme value.

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

Primitive functions, the indefinite integral. Integration methods. Definite integral. Basic properties of the definite integrals. Integration of a continuous functions. The Newton-Leibniz formula.

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

Improper integrals. Applications.

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

Ordinary differential equations. The solution of separable, homogeneous and linear differential equations.

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

Vector space. Linear dependent and independent system of vectors. Base, dimension. Subspace. Vector space generated by a set of vectors. Rank of a system. Linear maps.

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

Matrices, matrix algebra. Determinants and their calculation. The rank of a matrix. The inverse of a matrix. Matrix representation of linear maps.

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

System of linear equations. Homogeneous and inhomogeneous systems. Gauss elimination, Cramer rule. Applications.

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

Euclidean spaces. Inner product, standard, angle, distance. Schwarz and Minkowski inequality. Orthogonality. Orthogonal projection. Symmetrical and orthogonal transformations.

**Requirements:**

Only students who have the grade from the practical part can take part of the exam. The exam is written. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-74	satisfactory (3)

75-86	good (4)
87-100	excellent (5)
<b>Person responsible for course:</b> Dr.ZoltánMuzsnay, associate professor, PhD	
<b>Lecturer:</b> Dr.Zoltán Muzsnay, associate professor, PhD	

<b>Title of course:</b> Mathematics I. <b>Code:</b> TTMBG0808_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 3 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 42 hours</li> <li>- laboratory: -</li> <li>- home assignment: 18 hours</li> <li>- preparation for the exam:</li> </ul>	
Total: 60 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> TTMBE0809_EN, TTMBG0809_EN	

<b>Topics of course</b>
Sets. Real numbers. Complex numbers. Sequences and series. Convergence, limits. Real functions. Limit, continuity and differentiation of functions. Monotonicity, convexity, inflection. Approximation with polynomials, Taylor formula. Definition and calculation of definite, indefinite and improprius integrals. Ordinary differential equations. Vector spaces. Matrices, operations with matrices. Determinants and properties; the matrix rank. Linear equation systems. Euclidean spaces and their transformations.
<b>Literature</b>
<p><i>Compulsory:</i> -</p> <p><i>Recommended:</i></p> <p>Thomas, Weir&amp; Hass: Thomas' Calculus,      K. A. Stroud: Calculus and Mathematical Analysis,      K. A. Stroud: Engineering Mathematics,      E. Mendelson: Schaum's 3000 Solved Problems in Calculus,</p>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i></p> <p>Operations with sets, set algebra. Descartes product, relations, functions. Special functions: injectivity, surjectivity, bijectivity. The inverse of a function. Real numbers. Exact lower and upper bounds. Open and closed sets. Bolzano-Weierstrass theorem.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Complex numbers. The algebraic structure of the set of complex numbers. The complex plane. Trigonometric form of complex numbers, multiplication, division, n-th power, n-th root.</p> <p><i>3<sup>rd</sup> week</i></p>

Sequences. Convergence and limit of real sequences. Monotonous, bounded, convergent sequences, Cauchy's convergence criteria. Algebraic operations with convergent sequences. Squeezing theorem. The generalization of the notion of limit.

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

Series. The convergence of series. Arithmetic series and geometric series. The harmonic series. Leibniz type series. Convergence tests: ratio and root tests. Power series.

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

Limits and continuity of functions. Properties of continuous functions. Continuity of the composition and the inverse function. Special properties of continuous functions defined on an interval. Elementary functions.

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

Differentiation. The geometric meaning of the derivative. Rules of differentiation. Derivative of a function of a function: the chain rule. The derivative of the inverse function. Relationship of monotonicity and the derivative. Roll's theorem and Lagrange's theorem. Conditions for the existence of extreme values. Derivative of elemental functions.

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

Higher order derivatives. Convexity and the derivatives. Approximating with polynomials, Taylor formula. Conditions for the existence of extreme value.

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

Test.

Primitive functions, the indefinite integral. Integration methods. Definite integral. Basic properties of the definite integrals. Integration of a continuous functions. The Newton-Leibniz formula.

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

Improper integrals. Applications.

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

Ordinary differential equations. The solution of separable, homogeneous and linear differential equations.

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

Vector space. Linear dependent and independent system of vectors. Base, dimension. Subspace. Vector space generated by a set of vectors. Rank of a system. Linear maps.

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

Matrices, matrix algebra. Determinants and their calculation. The rank of a matrix. The inverse of a matrix. Matrix representation of linear maps.

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

System of linear equations. Homogeneous and inhomogeneous systems. Gauss elimination, Cramer rule. Applications.

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

Test.

#### **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.

*- for a grade*

During the semester one test is written. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-84	good (4)
85-100	excellent (5)
<b>Students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.</b>	
<b>Person responsible for course:</b> Dr.Zoltán Muzsnay, associate professor, PhD	
<b>Lecturer:</b> Dr.Zoltán Muzsnay, associate professor, PhD	

<b>Title of course:</b> Mathematics II. <b>Code:</b> TTMBE0809_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> TTMBE0808_EN, TTMBG0808_EN	
<b>Further courses built on it:</b>	

<b>Topics of course</b> Functions of several variables. Limit value, continuity, differentiation. Total derivative, partial derivatives, directional derivative. Partial Differential Equations. Multiple Integral. Elements of vector analysis. Curves, surfaces. Vector Fields. Gradient, rotation, divergence. Line, surface and volume integrals. Stokes', Green's and Gauss' theorems. Probability. Conditional probability. Total probability theorem, Bayes' theorem. Independence of events. Random variables. Discrete and continuous random variables. Probability distribution, density function. Expected value, standard deviation. Elements of statistics.
<b>Literature</b> <i>Compulsory:</i> - <i>Recommended:</i> Thomas, Weir& Hass: Thomas' Calculus, P. Sahoo: Probability and Mathematical Statistics E. Mendelson: Schaum's 3000 Solved Problems in Calculus,
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Rn: the n-dimensional Euclidean space. Sequences in Rn. Function of several variables with real and vector values. <i>2<sup>nd</sup> week</i> Limit and continuity of multivariable functions. <i>3<sup>rd</sup> week</i> Total derivative and partial derivatives of a multivariable functions. Chain rule. Inverse function theorem. The implicit function theorem.

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

Directional derivative. Gradient and its application. Extreme values of real functions of several variables.

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

Multiple integral. Calculation of multiple integral, successive integration. Integration in normal domains.

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

Partial differential equations and systems of differential equations. Basic definitions and examples. Some elementary examples and problems.

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

Elements of vector analysis. Curves, surfaces. Vector Fields. Gradient, rotation, divergence.

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

Line integral. Basic properties. Applications.

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

Surface integral. Volume integral. Basic properties. Stokes', Green's and Gauss' theorems.

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

Element of the probability theory. Conditional probability. Total probability theorem, Bayes' theorem. Independence of events.

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

Concept of random variables. Probability distribution. Discrete probability variables. Some special discrete probability distributions: Bernoulli distribution, Binomial distribution, Geometric distribution, Binomial, Hypergeometric, and Poisson distribution. Continuous probability distributions, density function. Some special continuous distribution: uniform, normal, and exponential distributions.

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

Expected value of random variables, Variance of random variables. Examples. Markov and Chebychev inequality, the law of large numbers.

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

Two Random Variables. Bivariate discrete and continuous random variables. Covariance of bivariate random variables. Correlation and independence.

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

Element of statistics.

**Requirements:**

Only students who have the grade from the practical part can take part of the exam. The exam is written. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-74	satisfactory (3)
75-86	good (4)
87-100	excellent (5)

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

**Lecturer:** Dr. Zoltán Muzsnay, associate professor, PhD

<b>Title of course:</b> Mathematics II. <b>Code:</b> TTMBG0809_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 3 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 42 hours</li> <li>- laboratory: -</li> <li>- home assignment: 18 hours</li> <li>- preparation for the exam:</li> </ul>	
Total: 60 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTMBE0808_EN, TTMBG0808_EN	
<b>Further courses built on it:</b>	

<b>Topics of course</b>
Functions of several variables. Limit value, continuity, differentiation. Total derivative, partial derivatives, directional derivative. Partial Differential Equations. Multiple Integral. Elements of vector analysis. Curves, surfaces. Vector Fields. Gradient, rotation, divergence. Line, surface and volume integrals. Stokes', Green's and Gauss' theorems. Probability. Conditional probability. Total probability theorem, Bayes' theorem. Independence of events. Random variables. Discrete and continuous random variables. Probability distribution, density function. Expected value, standard deviation. Elements of statistics.
<b>Literature</b>
<i>Compulsory:</i> - <i>Recommended:</i> Thomas, Weir& Hass: Thomas' Calculus, P. Sahoo: Probability and Mathematical Statistics E. Mendelson: Schaum's 3000 Solved Problems in Calculus,
<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Rn: the n-dimensional Euclidean space. Sequences in Rn. Function of several variables with real and vector values.
<i>2<sup>nd</sup> week</i> Limit and continuity of multivariable functions.
<i>3<sup>rd</sup> week</i> Total derivative and partial derivatives of a multivariable functions. Chain rule. Inverse function theorem. The implicit function theorem.
<i>4<sup>th</sup> week</i>

Directional derivative. Gradient and its application. Extreme values of real functions of several variables.

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

Multiple integral. Calculation of multiple integral, successive integration. Integration in normal domains.

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

Partial differential equations and systems of differential equations. Basic definitions and examples. Some elementary examples and problems.

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

Test.

Elements of vector analysis. Curves, surfaces. Vector Fields. Gradient, rotation, divergence.

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

Line integral. Basic properties. Applications.

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

Surface integral. Volume integral. Basic properties. Stokes', Green's and Gauss' theorems.

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

Element of the probability theory. Conditional probability. Total probability theorem, Bayes' theorem. Independence of events.

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

Concept of random variables. Probability distribution. Discrete probability variables. Some special discrete probability distributions: Bernoulli distribution, Binomial distribution, Geometric distribution, Binomial, Hyper-geometric, and Poisson distribution. Continuous probability distributions, density function. Some special continuous distribution: uniform, normal, and exponential distributions.

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

Expected value of random variables, Variance of random variables. Examples. Markov and Chebychev inequality, the law of large numbers.

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

Two Random Variables. Bivariate discrete and continuous random variables. Covariance of bivariate random variables. Correlation and independence.

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

Test. Element of statistics.

#### **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.

*- for a grade*

During the semester one test is written. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-84	good (4)
85-100	excellent (5)

**Students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.**

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

**Lecturer:** Dr.Zoltán Muzsnay, associate professor, PhD

<b>Title of course:</b> Physics for Engineers I <b>Code:</b> TTFBE2111_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> <ul style="list-style-type: none"><li>- lecture: 2 hours/week</li><li>- practice: 1 hours/week</li><li>- laboratory: -</li></ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"><li>- lecture: 28 hours</li><li>- practice: 14 hours</li><li>- laboratory: -</li><li>- home assignment: 24 hours</li><li>- preparation for the exam: 24 hours</li></ul> 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> TTFBE2113_EN, TTKBE0401_EN, TTKBG0401_EN, MFVGE31V03_EN	

<b>Topics of course</b>
Physical quantities, standards, units. Kinematics in one dimension. Kinematics in three dimensions. Dynamics. Force laws. Ballistic motions. Center of mass, constrained motion. Collisions. Work and energy. Oscillations. Elasticity. Wave motion. Temperature.
<b>Literature</b>
J.W. Jewett Jr, R.A. Serway: Physics for Scientists and Engineers
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Physical quantities, standards, units: definition of length, equivalence relations and classes, scales, standards of length, time and mass, basic and derived physical quantities, units and prefixes in SI, physical dimensions, dimensional analysis <i>2<sup>nd</sup> week</i>

Kinematics in one dimension: Cartesian, spherical and cylindrical coordinate systems, vectors, operations with vectors, position vector, position function, average and instantaneous speed, average and instantaneous acceleration in one dimension

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

Kinematics in three dimensions: displacement vector and path, average and instantaneous velocity, average and instantaneous acceleration in three dimensions, circular motion, tangential and normal acceleration, angular velocity, angular acceleration, relative motions, Galilean transformation, Coriolis acceleration

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

Dynamics: Newton's first law, inertial frames, experimental laws of two-body interactions, inertial mass, momentum, conservation of momentum, Newton's second law, Newton's third law

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

Force laws: basic interactions in nature, the role of force laws in equations of motion, force law of gravitation, force law of electrostatic interaction between two point charges, force law of a charged particle moving in magnetic field, force law of an idealized spring, force law of friction, force law of drag forces

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

Ballistic motions: analytic solution of the equation of motion near the surface of the Earth, describing the path, calculating the parameters of the special points of the path, numerical solution of the equation of motion near the surface of the Earth

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

Center of mass, constrained motion: center of mass defined in the discrete and in the continuum limit, density, internal and external forces, constrained motion on a slope, constrained motion of a pendulum

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

Collisions: describing collisions in the center-of-mass and in the laboratory frame, elastic and inelastic collisions, kinetic energy, collisions in one dimension, special cases of one-dimensional collisions

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

Work and energy: work, work-energy theorem, work of the gravitational pull of the Earth, work of an idealized spring, power, potential energy, conservation of total mechanical energy, conservative and dissipative forces, potential energy of a body under the influence of an idealized spring, potential energy of a body under the influence of gravitation

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

Oscillations: analyzing the motion of a pendulum, simple harmonic oscillations, addition of two simple harmonic oscillations, Lissajous figures, damped oscillations, forced oscillations, coupled oscillations

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

Elasticity: tensile stress, shearing stress, uniform compression, relative deformation, Young's modulus, shear modulus, compression modulus, Hooke's law, elastic energy, elastic energy density

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

Wave motion: mechanical waves, transverse and longitudinal waves, one-dimensional wave motion in a stretched string, wave speed, wave function, wave equation, harmonic waves, wavelength, wave number, time period, energy transports in wave motion, kinetic and potential energy density of an elastic medium, energy density current, intensity

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

Wave motion: multi-dimensional wave motion, wavefronts, spherical waves, plane waves, principle of linear superposition, interference, coherent waves, standing waves, sound waves, intensity, pitch and tone, fundamental frequency and overtones, diffraction, Huygens' principle, Huygens-Fresnel principle

14<sup>th</sup> week

Temperature: extensive and intensive quantities, thermal equilibrium, zeroth law of thermodynamics, empirical measuring scales, Celsius scale, Kelvin scale, triple-point temperature, Gay-Lussac's law, constant-volume gas scales, ideal gas

**Requirements:**

The course exam is a written examination. In the exam theoretical questions and practical problems must be answered and solved in 100 minutes. The evaluation of the exam occurs based on the following grading:

0–49 % → 1,  
50–62 % → 2,  
63–75 % → 3,  
76–88 % → 4,  
89–100 % → 5

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

**Lecturer:** Dr.Balázs Ujvári, assistant professor, PhD

**Title of course:** Physics for Engineers II

**Code:** TTFBE2113\_EN

**ECTS Credit points:** 3

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: 1 hours/week
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: 14 hours
- laboratory: -
- home assignment: 24 hours
- preparation for the exam: 24 hours

Total: 90 hours

**Year, semester:** 1<sup>st</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTFBE2111\_EN

**Further courses built on it:** TTKBE0503\_EN

<b>Topics of course</b>
Geometrical optics. Wave properties of light. Electrostatics. Gauss' law. Electric potential. Capacitors. Electric current. Direct current circuits. Magnetic field. Sources of magnetic field. Solenoids, displacement current. Induction. LC and RLC circuits. Electromagnetic waves.
<b>Literature</b>
J.W. Jewett Jr, R.A. Serway: Physics for Scientists and Engineers
<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Geometrical optics: law of reflection, law of refraction, total reflection, imaging by concave and convex mirrors, imaging by a single spherical refractive surface, imaging by converging and diverging thin lenses, lens distortions
<i>2<sup>nd</sup> week</i> Wave properties of light: coherent light waves, interference, diffraction, Young's double-slit experiment, thin-film interference, single-slit diffraction, diffraction gratings
<i>3<sup>rd</sup> week</i> Electrostatics: electric charge, insulators, conductors and semi-conductors, Coulomb's law, electric field, field vector, field lines, electric field of a point charge, electric dipoles, linear, surface and volume charge distributions
<i>4<sup>th</sup> week</i> Gauss' law: electric flux through open and closed surfaces, Gauss' law and its applications, electric field of a uniformly charged infinite line, electric field of a uniformly charged infinite plane, electric charge of a uniformly charged spherical volume
<i>5<sup>th</sup> week</i> Electric potential: comparison of the force laws of gravitational and electrostatic interactions, work done by electric field, potential energy, potential energy of two-body and many-body systems, potential, potential due to a single point charge and charge distributions
<i>6<sup>th</sup> week</i> Capacitors: parallel-plate, cylindrical and spherical capacitors, capacitance, energy and energy density stored by the electrostatic field, capacitors with dielectrics, equivalent capacitance of capacitors connected in parallel and series
<i>7<sup>th</sup> week</i> Electric current: electric current, electric current density, resistance, resistivity, conductivity, differential and integral form of Ohm's law, temperature dependence of resistivity, electric power
<i>8<sup>th</sup> week</i> Direct current circuits: equivalent resistance of resistors connected in parallel and series, ideal and non-ideal batteries, electromotive force, Kirchhoff's junction law, Kirchhoff's loop law, transient phenomena in RC circuits
<i>9<sup>th</sup> week</i> Magnetic field: magnetic field, field vector, field lines, electric charge moving in magnetic field, Lorentz's force, cyclotron, magnetic force acting on a current-carrying conductor
<i>10<sup>th</sup> week</i> Sources of magnetic field: Biot–Savart law, magnetic field of a current-carrying straight wire, magnetic force between two parallel conductors, definition of the unit of electric current, Ampere's law

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

Solenoids, displacement current: magnetic field of a solenoid, magnetic flux through open and closed surfaces, Gauss' law of magnetism, displacement current, Ampere–Maxwell law

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

Induction: induced electromotive force, Faraday's law of induction, Lenz's law, eddy currents, self-induction, inductance, transient phenomena in RL circuits

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

LC and RLC circuits: energy conditions in LC circuits, analogy to free harmonic oscillations of a mechanical system, energy conditions in RLC circuits, analogy to damped oscillations of a mechanical system

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

Electromagnetic waves: differential and integral form of Maxwell's equations, linearly polarized plane electromagnetic waves

**Requirements:**

The course exam is a written examination. In the exam theoretical questions and practical problems must be answered and solved in 100 minutes. The evaluation of the exam occurs based on the following grading:

0–49 % → 1,  
50–62 % → 2,  
63–75 % → 3,  
76–88 % → 4,  
89–100 % → 5

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

**Lecturer:** Dr.Balázs Ujvári, assistant professor, PhD

<b>Title of course:</b> General Chemistry I. <b>Code:</b> TTKBE0101_EN	<b>ECTS Credit points:</b> 4
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**Type of teaching, contact hours**

- lecture: 3 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam**Workload (estimated), divided into contact hours:**

- lecture: 42 hours
- practice: -
- laboratory: -
- home assignment: -
- preparation for the exam: 78 hours

Total: 120 hours

**Year, semester:** 1<sup>st</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** -

**Further courses built on it:** TTKBL0101\_EN, TTKBE0201\_EN, (TTKBE0007\_EN)

<b>Topics of course</b>
History and development of chemistry and its relation to other natural sciences. Development of atomic and molecular theory. The structure of atom. Basics of radioactivity. Discovery of the periodic table and periodically changing properties. Introduction to quantum chemistry. Primary and secondary chemical bonds. Description of gaseous, liquid and solid states of matter. Phase changes. Chemical equilibrium. Acid-base theories. Basics of thermochemistry, reaction kinetics and electrochemistry.
<b>Literature</b>
<p><b>Compulsory:</b></p> <ul style="list-style-type: none"> <li>- John McMurry, Robert C. Fay: Chemistry, 7th ed., Prentice Hall ISBN: 0321943171.</li> <li>- Darrell D. Ebbing: General Chemistry, 9th ed. Belmont, CA, ISBN: 1439049829</li> <li>- James E. Brady, Gerard E. Humiston: General chemistry: principles and structure, 3rd ed., New York, Wiley, ISBN: 0471808164</li> </ul>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i></p> <p>Classification of natural sciences, history and development of chemistry. The concept of chemical change. The SI system of units, the most important physical quantities and units. Conservation of mass and energy. The law of definite proportions, the law of multiple proportions, law of combining gas volumes, Avogadro's law. Dalton's atomic theory. Relative atomic and molecular weights. Amount of substance and the definition of mole. Notations for elements and compounds, symbol, empirical formula, molecular formula, structure, isomerism.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Valency and oxidation number. Oxidation number in inorganic compounds. Types of chemical reactions. Latin names of compounds. Experimental background of the atomic theory, discovery of the nucleus. Discovery and basic properties of subatomic particles (electron, proton, neutron). Isotopes.</p> <p><i>3<sup>rd</sup> week</i></p> <p>Types and properties of radioactive radiation. Laws of radioactive decay, decay series. Medical and other practical importance of radioactive isotopes. The mass defect. Einstein's equation on mass-energy equivalence. Nuclear energy, nuclear fission and fusion. Quantized changes in the energy states of atoms. The photon hypothesis. The Bohr model of the atom. Characteristics of electromagnetic radiation, atomic line spectra, X-ray radiation.</p> <p><i>4<sup>th</sup> week</i></p> <p>The dual nature of matter. Heisenberg's uncertainty principle. Schrödinger's equation and its application for the hydrogen atom. Quantum numbers and their importance. The shape of atomic orbitals. Characterization of polyelectronic atoms. Principles of the periodic table.</p> <p><i>5<sup>th</sup> week</i></p> <p>Electronegativity, ionization energy, electronaffinity, atomic and ionic radii and their change across the periodic table. The ionic bond. Calculation of the lattice energy. Metallic bonding.</p> <p><i>6<sup>th</sup> week</i></p> <p>The covalent bond. Basic characteristics of the molecular orbital (MO) theory and its application for diatomic molecules. The valence shell electron pair repulsion (VSEPR) model. The shape of molecules, bond angles, bond orders, hybridization. Polarity of covalent bonds, polar and nonpolar molecules.</p> <p><i>7<sup>th</sup> week</i></p>

Intermolecular forces. London forces, dipole-dipole interaction. Hydrogen bond and its importance in inorganic and organic chemistry. General characterization of molecular, ionic, metallic, and network atomic solids.

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

Classification and structure of chemical systems. General characterization of different states of matter. The kinetic molecular theory of gases, ideal and real gases. Gas laws: Boyle's law, Charles's law, the ideal gas law. Gas mixtures, partial pressure. General characterization of liquids, surface tension, viscosity. General characterization and classification of solids. Changes of state: melting, freezing, evaporation, condensation, sublimation.

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

Classification of multicomponent systems, properties of solutions and mixtures. Solubility and units of concentration. Vapor pressure, freezing and boiling point of solutions. Osmosis pressure. Determination of molecular weight. Phase diagrams, critical temperature and pressure.

Thermodynamic temperature.

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

Basics of thermochemistry. Heat of reaction, Hess's law. The importance of heat of formation. Heat of reaction and bond energies. The direction of spontaneous chemical reactions: internal energy, enthalpy, free energy and entropy.

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

Dependence of reaction rates on concentrations and the temperature. Order of reactions. Activation energy. Catalysts, homogeneous and heterogeneous catalytic reactions. Enzymes. Photochemical processes. The equilibrium condition and the equilibrium constant. Possibilities to shift the composition of equilibria. Dependence of the equilibrium constant on temperature and pressure. Le Chatelier's principle.

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

Solubility equilibria, solubility product. Temperature dependence of solubility. Gas-liquid and liquid-liquid equilibria. Extraction. Different theories of acid-base reactions (Arrhenius, Brønsted, Lewis). Characterization of aqueous solutions, electrolytic dissociation. Strength of acids and bases. Super acids. Dissociation constant and degree of dissociation.

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

Self-ionization of water. Ionic product of water. The definition and calculation of pH. Amphoteric substances. Buffer solutions and acid-base indicators. Acid-base properties of salts. Complex ion equilibria. Pearson's hard-soft theory.

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

Basics of electrochemistry. Galvanic cells and the concept of electrode potential. Standard electrode potentials, oxidizing and reducing agents. Water as a redox system. Electrolysis, voltage needed in electrolytic cells, overvoltage. Quantitative laws of electrolysis. Galvanic cells and batteries.

### **Requirements:**

#### *- for a signature*

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

#### *- for a grade*

The course ends in an **examination**. The result of the examination determines the final grade. The minimum requirement for the examination is 50%. Based on the score of the exam, the grade 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 case of failure, students can take retake exam(s) in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. József Kalmár, associate professor, PhD,habil

**Lecturer:** Dr. József Kalmár, associate professor, PhD,habil

<b>Title of course:</b> General Chemistry I. (seminar)	<b>ECTS Credit points:</b> 3
<b>Code:</b> TTKBG0101_EN	
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 4 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> middle-term and final exams	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 44 hours</li> <li>- laboratory: -</li> <li>- home assignment: 26 hours</li> <li>- preparation for the exam: 20 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Furthercoursesbuiltonit:</b> TTKBL0101_EN	

<b>Topics of course</b>
The main objective of the seminar is to give the basic knowledge and background for students to solve general calculation problems strictly connected to the general chemistry laboratory practice: calculations connected to mass and volume measurements, concentration and its units, crystallization, acid-base and redox equilibria, balancing chemical equations.
<b>Literature</b>
<b>Compulsory:</b>
<ul style="list-style-type: none"> <li>- The collection of calculation problems will be available at the Department's home page (inorg.unideb.hu)</li> </ul>
<b>Recommended:</b>
<ul style="list-style-type: none"> <li>- Darrell Ebbing, Steven D. Gammon: General Chemistry 10<sup>th</sup> edition</li> <li>- Darrell Ebbing, Steven D. Gammon: General Chemistry – Standalone book</li> </ul>

**Schedule:** The seminar will be held in 11 weeks.

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

Determination of atomic weight, molecular weight, empirical formula, molecular formula, amount of substance. Determination of empirical formula based on weight percent composition and on elemental analysis.

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

General introduction to the units of concentration. Interconversion of units. Calculation problems connected to solution preparation. Introduction of the SI system. Mass concentration, molarity, mass percent composition, molar percent composition.

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

Review exercises concerning on the first two weeks. Interconversion of concentration units. Density measurements. Mixing equations. Theoretical background of crystallization. Exercises calculation problems of crystallization.

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

Theoretical backgrounds of gas and solids. Composition of solid and gas mixtures. Introduction to basic chemical equations. Stoichiometric calculations based on chemical equations.

Preparation of salts, calculation of theoretical and percent yield. Dissolving of metal mixtures in acids.

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

Acid-base equilibria. Theory of acid-base reactions and titrations. Exercises based on acid-base titrations. Stoichiometric calculations based on chemical equations. Determination of molar weight based on titration results.

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

Review exercises in stoichiometry and concentration calculations.

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

Introduction to basic gas laws. Laboratory preparation of gases. Calculation problems connected to evolution of gases based on chemical equations.

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

Theory of redox reactions. Balancing of redox reactions. Calculations based on redox reactions. Preparation of salts from its metal. Review exercises in balancing of redox and acid-base reactions.

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

Definition of pH. Theoretical background of pH calculation. Introduction to water ionisation constants. Relationship between the  $K_w$  and  $H^+$ . Calculation of pH of strong acids and strong bases.

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

Calculation of pH of weak acids and weak bases. Determination of dissociation rate. Theoretical background of buffer systems, buffer capacity. Calculation problems regarding the pH of buffer systems.

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

Electrochemical exercises. Fundamental of galvanic cells (Daniell cell). The concept of electromotive force, redox potential, standard redox potential. Nernst equation. Review exercises of pH calculations.

**Requirements:**

Students are required to write two general tests (after week 6 and after week 11) which are based on the course material for weeks 1-5 and 7-11, respectively. Each general test is worth 50 points. Grading is based on a five-level scale: 1 (fail), 2 (pass), 3 (average), 4 (good), 5 (excellent). The

final course grade is given based on the results of these tests. The score from the general tests must be above 50 % to avoid a 'fail' final course grade. In order to pass the seminar, a student should collect minimum 50 points from the general tests. Students with 'fail' final course grade due to low test results can re-take once a comprehensive test exam in the examination period.

It is not allowed to miss any seminars. If a student misses two seminars even for any medical reasons, the student's lecture book won't be signed and she or he has to retake the course next year.

**Person responsible for course:** Dr. Linda Földi-Bíró Assistant Professor, PhD

**Lecturer:** Dr. Linda Földi-Bíró Assistant Professor, PhD

<b>Title of course:</b> General Chemistry II. (laboratory practice)	<b>ECTS Credit points:</b> 3
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**Code:** TTKBL0101\_EN

**Type of teaching, contact hours**

- lecture: -
- practice: -
- laboratory: 4 hours/week

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: -
- practice: -
- laboratory: 44 hours
- home assignment: 32 hours
- preparation for the exam: 14 hours

Total: 90 hours

**Year, semester:** 1<sup>st</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTKBE0101\_EN, TTKBG0101\_EN

**Further courses built on it:** TTKBL0511\_EN

### **Topics of course**

The objective of the laboratory practice is to introduce first-year students of different background to laboratory work, the use of basic laboratory equipment, simple laboratory operations and measurements. In addition, students are expected to prepare certain simple chemicals and run various basic experiments to familiarize themselves with chemical laboratory work.

### **Literature**

#### *Compulsory:*

- General chemistry laboratory practice (laboratory manual)

#### *Recommended:*

- Darrell Ebbing, Steven D. Gammon: General Chemistry 10<sup>th</sup> edition
- Darrell Ebbing, Steven D. Gammon: General Chemistry – Standalone book

**Schedule:** The laboratory practice will be held in 11 weeks.

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

General introduction to the laboratory rules and laboratory work. Safety training. Introduction to laboratory pieces of equipment. The use of gas burners. Overview of pieces of the received laboratory equipment.

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

Mass and volume measurements: weighing on analytical and standard laboratory balances; introduction to volume measurement devices (pipette, burette, volumetric flask). Calibration of volumetric measuring equipment (pipette or volumetric flask). Calculation the standard error between the measured and nominal values.

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

Introduction to solution preparation: grinding, use of mortal, pestle, volumetric flask. Preparation of a standard solution from a crystalline salt. Introduction to a density measurement. The use of the pycnometer. Determination of the density of the prepared solution by the help of the pycnometer. Calculating the weight percent composition of the prepared solution.

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

Introduction to separation methods: decantation, centrifuging, filtration. Purification of solids. Theoretical background heating, cooling and the use of hot water bath. Purification of a benzoic acid sample contaminated with sodium chloride. Preparation of a double salt from simple salts and basic laboratory procedures.

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

Writing the general mid-term test based on the studied material of the laboratory practice and seminar until week 4. Determination of the composition of mixture of potassium chloride and potassium chlorate. Review of different methods used to temperature measurements. Introduction to the measurements of melting point of the solid substances. Determination of the melting point of the purified benzoic acid sample. Determination of the contamination percentage of the purified benzoic acid sample.

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

Demonstration of acid-base titration. Preparation of a standard solution of NaOH. Concentration determination of the standard NaOH solution by acid-base titration. Determination of the molar weight of the recrystallized sample of benzoic acid by acid-base titration. Comparing the result with the literature value and calculating the standard error between the given and measured data. Purified benzoic acid due in.

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

Laboratory work with gases: introduction to the use of gas cylinders, simple gas generator, Kipp's apparatus. Studying the chemical and physical properties of gases. Demonstration of hydrogen preparation. The hydrogen explosion test. Preparation of oxygen in a laboratory gas generator and burning of sulphur in oxygen. Study of the observations during the reaction (oxidation product of sulphur). Determination of molecular weight based on the ideal gas law.

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

Practice the basic laboratory techniques considering the preparation of a salt. Preparation of salts from its metal. Studies of reactions involving gas formation and precipitation.

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

Quantitative study of a precipitation reactions to determine the stoichiometric composition of water insoluble precipitates using the method of continuous variation. Dependence of reaction rate of concentration of reactants. Studying the factor affecting the reaction rates. Determination of the reaction rate and the rate law of the studied reaction. Metal salts preparations due in.

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

Theoretical background of liquid-liquid extractions and demonstration of the separation techniques. Introduction to buffer systems, buffer capacity by studying a particular buffer system (acetic acid/acetate ion buffer; ammonium ion/ammonia buffer). Hydrolysis of salts to study the acid-base properties of ionic and covalent compounds in aqueous solutions or in reactions with water. Writing of the ionic equations based on the observed chemical reactions.

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

General test from week 5 to week 10. General introduction to electrochemistry. Study of redox reactions. Prediction of the direction of spontaneous processes based on standard potentials. Factors affecting the order of the deposition of different metals during electrolysis (study of Daniell cell). Return of the received pieces of laboratory equipment.

**Requirements:**

Each week the laboratory session begins with a short test (not more than 20 minutes) based exclusively on the preparatory material of that week and the previous week and the results of the experiments carried out the previous week. With each short test a student can collect 25 points. Altogether there are eight short tests during the semester. Students are also required to write two general tests (week 5 and week 11) which are based on the course material for weeks 1-4 and 5-10, respectively. Each general test is worth 50 points. Grading is based on a five-level scale: 1 (fail), 2 (pass), 3 (average), 4 (good), 5 (excellent). The final course grade is given based on the results of these tests, the quality of the laboratory notes and the quality of laboratory work. The average score from both the short tests and the general tests must be above 50 % to avoid a 'fail' final course grade. In order to pass the laboratory practice, a student should collect minimum 100 points from the short tests and minimum 50 points from the general tests. Students with 'fail' final course grade due to inadequate laboratory work have to retake the course the next year. Students with 'fail' final course grade due to low test results can re-take a comprehensive test exam in the examination period.

Those students, whose results are lower than 25% either from the short test or from the general test, cannot write a final exam, they will receive a 'fail' final course grade.

It is not allowed to miss any laboratory practices/seminars. If a student misses one or two lab practices, medical certification is needed. If a student misses three lab practices/seminars even for any medical reasons, the student's lecture book won't be signed and she or he has to retake the course next year. It is not possible to miss short tests at the beginning of the laboratory practice. If a student misses more than two short tests, the laboratory practice will not be accepted for him or her. The students cannot miss either of the general tests, otherwise no signature and final grade is given to the student.

**Person responsible for course:**

**Lecturer:**

<b>Title of course:</b> Inorganic Chemistry I <b>Code:</b> TTKBE0201_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, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0101_EN	
<b>Furthercoursesbuiltoin:</b> TTKBE0202_EN, TTKBL0201_EN, TTKBE0501_EN, TTKBE0502_EN, TTKBL0502_EN, TTKBE0204_EN	

<b>Topics of course</b>
<b>Literature</b>
<p><i>Compulsory:</i></p> <p>1) N. N. Greenwood, A. Earnshaw: Chemistry of the Elements, 2nd Edition, 1997 (or later ed.)</p> <p><i>Recommended:</i></p> <p>2) Geoff Rayner-Canham, Tina Overton: Descriptive Inorganic Chemistry (5th Edition), W. H. Freeman and Company, New York, 2010, ISBN-13: 978-1-4292-2434-5 (or later edition)</p> <p>3) Glen E. Rodgers, Descriptive Inorganic, Coordination and Solid-Phase Chemistry, (3rd Edition), Brooks/Cole, 2012, ISBN-13: 978-0-8400-6846-0 (or later edition)</p>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i></p> <p>Origin of the elements in the periodic table. Abundances of the elements in the Universe and on the Earth. Energy production by nuclear reactions. Development of atmosphere on Earth.</p> <p>Major chemical forms of elements, grouping elements by their oxidation state. Production and exploitation methods of the chemical elements.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Chemical, physical and atomic properties of the element hydrogen. Solubility of hydrogen in different materials. Hydrogen isotopes, their nuclear properties, nuclear spin isomers, practical application of isotopes and nuclear isomers. Electronic structure, oxidation number, and chemical reactivity, and major reactions of hydrogen. Laboratory and industrial production of hydrogen. Hydrogen as an environment-friendly fuel. Binary hydrides, their most important groups,</p>

properties. Hydrogen bonding and its role in the structure and properties of the materials. The most important hydrogen compounds and their use in the practice.

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

Noble gases. General characterization, special physical and chemical properties. Electronic structure of noble gases. Correlation between electronic structure and chemical reactions. Noble gas compounds. The history of xenon compounds, structure, electronic structure, characteristic reactions. Xenon oxides and oxoacids and their salts. Preparation and practical use. Separation of noble gases from natural sources.

General properties of the halogens. Physical properties, electronic structure, chemical reactivity, possible oxidation numbers. Interaction of the halogens with different solvents. Hydrate formation, chemical hydrolysis.

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

Characteristic chemical reactions of the halogens, interhalogen compounds, polyhalogenium ions, polyhalide anions. Structural aspects of interhalogen compounds, VSEPR theory to describe geometric structures. Halogen-containing minerals, natural resources. Biological role of halides. Laboratory scale and industrial production of the halogen elements. Most important groups of halides regarding their chemical bondings and lattices, physical properties.

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

Halogen-oxygen compounds, physical and chemical properties of halogen oxides, and methods of their synthesis, and practical uses. Halogen oxyacids and their salts. Oxidation numbers of the component atoms, laboratory scale and industrial productions. Chemical reactions of halogen oxides and oxoacids. Sterilization, drinking water treatment with halogen oxides and oxoacids.

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

Elements of the oxygen group. Electronic structure, physical and chemical properties, characteristic oxidation numbers. Allotropic forms of dioxygen. Structure of dioxygen, explanation of the magnetic properties. Solubility of oxygen in water and its biological role, solubility in water. Ozone, physical and chemical properties, formation of ozone in the high atmosphere. Ozone depletion, ozone hole in the arctic region. The role of ozone shield. Ozone precursors, chemicals that can destroy the ozone shield. Chemical reactions of ozone. Practical applications. Sulfur, selenium, tellurium, allotropic forms, physical properties, oxidation numbers, electronic structures. Chemical reactivity of the elements. Acid-base properties of the sulfides. Laboratory scale and industrial production techniques of the elements. Biological role of the oxygen group elements and their compounds. Oxygen and sulfur cycles in the biosphere.

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

Binary hydrides of the oxygen group elements. Water, physical and chemical properties, its role in the life and the environment. Types of water in the nature. Gas hydrates. Water purification techniques, water hardness and water treatment. Water wars.

Hydrogen peroxide. Structure, electronic structure, characteristic physical and chemical properties, appearance and role in the living organisms. Synthesis of hydrogen peroxide, in the laboratory and in the industry. Practical uses of hydrogen peroxide.

Binary hydrides of sulfur, selenium, tellurium and lead. Stabilities, chemical properties, synthesis, toxicity, practical uses. Analytical system based on hydrogen sulfide.

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

Halides of the calcogenic elements. Synthesis of sulfur chlorides, their properties, reactivities and practical uses. Sulfur oxides, their structure, synthesis, physical and chemical properties, production in the industry. Sulfur-containing oxoacids and their salts: structure, properties,

reactivities, practical uses. Peroxi sulfuric acids and S-S bond-containing sulfur oxoacids and their salts: structure, reactivity, preparation, practical uses.

Environmental concerns regarding the concentration of atmospheric sulfur dioxide: formation and effect of acid rain.

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

Elements of the nitrogen group: appearance, electronic structure, physical properties, allotropes, chemical properties, oxidation states, hybridization. Synthesis and isolation of the elements.

Industrial production, air liquifaction and fractionated distillation. Physical methods of nitrogen generation. Practical uses of the elements.

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

Hydrides of the nitrogen-group elements. Ammonia and hydrazine: composition, structure, electronic properties, molecular movements. Physical and chemical properties, reactivities, acid-base properties, redox states, characteristic chemical reactions. Synthesis of ammonia and hydrazine in the laboratory and in the industry. Haber-Bosch and Raschig processes. Practical uses of ammonia and hydrazine.

Halides and halogeno-complexes of the nitrogen-group elements. Composition, formation, structure, characteristic physical and chemical properties, reactivities. Practical uses.

Oxides and oxo-compounds of the nitrogen-group elements. Structure, formation, composition, physical and chemical properties. Electronic structure, spectral and magnetic properties.

Laboratory-scale and industrial production, Ostwald synthesis. Acid-base properties.

Environmental and health issues of nitrogen oxides, role of NO in the human body.

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

Nitrogen and phosphorus oxoacids. Chemical composition, oxidation states, stabilities, physical properties, characteristic reactions, most important salts. Practical uses of nitric and phosphoric acids. Other oxides, oxoacids and oxoanions of other elements of the nitrogen group. Compounds with sulfur: sulfur nitrides, phosphorus sulfides, molecular structures, stabilities, physical and chemical properties, practical uses.

Elements of the carbon group. Electronic structure, oxidation states, hybridization, types of chemical bondings. Stereochemistry of carbon. Comparison of the structure of analogous carbon and silicon compounds.

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

Carbon allotropes, structural properties, characteristic physical and chemical properties. Natural carbon sources. Synthesis of carbon allotropes. Isotopes of carbon, stability, properties, practical uses, radiocarbon method. Silicon and other elements: natural sources, properties, synthesis, practical uses. Production and purification of semiconductor grade silicon and germanium. Tin and lead: allotropes, preparation/production, properties, toxicity, practical uses.

Comparison of the structure and stability, hydrolytic properties of the binary hydrides of the carbon group elements. Preparation of the hydrides, practical uses in the analytical chemistry.

Halides of the carbon group elements: Composition, hydrolysis, complex formation, geometry, nature of the bonds, redox properties and stabilities of the halides.

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

Oxides and oxoacids of carbon and silicon. Composition and electronic structure of carbon oxides and oxoacids. Binding modes and coordination chemistry of carbon monoxide, the most important carbonyl complexes. Properties, toxicity and environmental issues of carbon dioxide. Carbonic acid and their salts, carbonates in the nature. Greenhouse effect, increase of atmospheric carbon dioxide, climate changes, global warming, and the role of technical

civilization. Silicic acids and silicates. Types of natural and synthetic silicates. Polymeric and 3D structures, basic types, appearance in the nature. Special silicon oxides and silicates, silica gels and aerogels. Oxides of tin and lead.

Carbon-nitrogen bond containing inorganic compounds: Cyanic acid and isocyanic acid and their salts. Thiocyanic acid and isothiocyanic acid and their salts. Properties, practical uses.

Carbon and silicon sulfides. Comparison of oxo and thio compounds. Thio-bases and thio-acids.

Types of carbides, ionic, covalent and interstitial carbides. Properties, practical uses.

#### 14<sup>th</sup> week

Elements of the boron group. Appearance, natural resources, most important minerals. Electronic structure, Lewis-acidity, physical and chemical properties, most important chemical reactions.

Hybridization. Halides of the boron group elements. Properties, hydrolysis, complex formation, structure, practical uses. Industrial production of aluminum.

Binary and complex hydrides of boron group elements. Special structural characteristics and bonding mode of diborane: 2-electron-3-center binding mode. Synthesis, physical and chemical properties of hydrides and complex hydrides. Comparison of hydrolytic and thermal stabilities.

Practical uses of the complex hydrides. Reduction, hydroboration. Polyhedral boron hydrides, structure, stability, carboranes. Boron oxides, boric acid, aluminum oxide and hydroxide.

Practical use of aluminum oxide and high surface area alumina.

#### Requirements:

- *for a signature*

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

- *for a grade*

The course ends in an **examination**.

The examination starts with a qualification test. The minimum requirement to qualify for the examination is: 60 score. Below score 60 Grade 1 (Fail) is given.

Score	Grade
0-59	fail (1)
60-100	qualified to the exam

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.

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

**Lecturer:** Dr.István Lázár, associate professor, PhD

<b>Title of course:</b> Inorganic Chemistry II <b>Code:</b> TTKBE0202_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, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Furthercoursesbuiltof:</b> TTKBL0201_EN, TTKBE0501_EN, TTKBE0502_EN, TTKBL0502_EN, TTKBE0204_EN	

<b>Topics of course</b>
<b>Literature</b>
<p><i>Compulsory:</i></p> <p>1) N. N. Greenwood, A. Earnshaw: Chemistry of the Elements, 2nd Edition, 1997 (or later ed.)</p> <p><i>Recommended:</i></p> <p>2) Geoff Rayner-Canham, Tina Overton: Descriptive Inorganic Chemistry (5th Edition), W. H. Freeman and Company, New York, 2010, ISBN-13: 978-1-4292-2434-5 (or later edition)</p> <p>3) Glen E. Rodgers, Descriptive Inorganic, Coordination and Solid-Phase Chemistry, (3rd Edition), Brooks/Cole, 2012, ISBN-13: 978-0-8400-6846-0 (or later edition)</p>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i> General characterization of the metals, structure of the metals, metallic bond. Principles of band theory, conductors, semiconductors and insulators. Characteristic physical and chemical properties of the metals.</p> <p><i>2<sup>nd</sup> week</i> Alkali metals: general characterization, physical and chemical properties, abundance, preparation and use. Hydrides, halogenides, oxides, hydroxides of alkali metals, salts formed with the most important oxoanions. Complexes of alkali metal ions, crown ethers and cryptands. Covalent compounds of the alkali metals.</p> <p><i>3<sup>rd</sup> week</i></p>

Alkali earth metals: general characterization, physical and chemical properties, abundance, preparation and use. Role of the alkali earth metals in the nature, biological effect of the metals and their ions. Special features of beryllium and its compounds. Hydrides, halogenides, oxides, hydroxides of alkali earth metals, salts formed with the most important oxoanions. Covalent compounds and complexes of the alkali metals.

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

General characterization of the transition (d-block) metals. Important trends in the change of electronic configuration, electronegativity, atomic and ionic radii for the elements in the d-block. Physical and chemical properties of the transition metals, their similarity. Abundance of d-block metals and general methods for the preparation of transition metals. Theoretical and practical aspects of the selection of reducing agents.

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

Basic terms in coordination chemistry, coordination number, geometry of complexes. Isomerism and nomenclature of complex compounds. Factors influencing the stability of complexes.

Fundamentals of the Hard-Soft Acid-Base (HSAB) theory. Classification of complex compounds and ligands, mono- and multidentate ligands,  $\sigma$ -donor and  $\pi$ -acceptor ligands. Chelate- and macrocycle effect, their importance. Inert and labile complexes.

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

Fundamentals of the crystal field theory, interpretation of the colors and magnetic behaviour of the complex compounds. High and low spin complexes. Definition and importance of crystal field stabilization energy (CFSE). Types of transition metal hydrides and their practical importance. Classification of transition metal halogenides based on their composition, structure and binding types. Some important halogenides of the transition metals.

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

Oxides, hydroxides and oxoacids of transition metals. Classification of oxides based on their composition and binding types. Physical and chemical properties of the oxides, their acid-base and redox reactions. Methods for the preparation of oxides. Transition metal sulphides, their importance in the environment and analytical chemistry. Carbides. Simple complexes of the transition metals: hydroxido, halogenido and cyano complexes.

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

Metals of the titanium and vanadium group and their most important compounds. General characterization, trends in oxidation numbers, physical and chemical properties, occurrence, preparation and use. Industrial preparation of titanium, practical importance of the metal.

Properties of titanium-dioxide and –tetrachloride, their derivatives. Properties of vanadium oxides and their derivatives.

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

Members of the chromium group, some important compounds. General characterization, trends in oxidation numbers, physical and chemical properties, occurrence, preparation and use.

Halogenides and coordination chemistry of chromium, molybdenum and tungsten. Oxides and their derivatives. Thermal stability, acid-base and redox reactions of the oxides. Formation trends and structure of the iso- and heteropolyacids.

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

Members of the manganese and iron groups, some important compounds. General characterization, trends in oxidation numbers, physical and chemical properties, occurrence, preparation and use. Manganese oxides, their derivatives and redox reactions of them. Industrial preparation of iron and steel. Oxides, halogenides and important complex compounds of iron, cobalt and nickel.

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

General characterization of the platinum group metals, trends in oxidation numbers, physical and chemical properties. Theoretical aspects of their preparation, some important practical use.

Oxides and halogenides. Coordination chemistry of platinum group metal ions: oxidation states and practical use.

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

Members and the most important compounds of the copper and zinc groups. General characterization, trends in oxidation numbers, physical and chemical properties, occurrence, preparation and use. Practical importance of the metals, alloys. Oxides and halogenides. Chemical background of black and white photography. Important complex compounds. Environmental and biological role of the metals and their cations.

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

General characterization of the lanthanides and actinides, electronic configuration, oxidation numbers, physical and chemical properties, occurrence, preparation and use. Oxides and halogenides, important complex compounds. Physical and chemical properties of thorium and uranium, important compounds. Theoretical aspects of the use of nuclear power.

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

Fundamentals of bioinorganic chemistry. Classification of the elements based on their biological role. Metalloenzymes and their role. Fundamentals of the medicinal and environmental use of metal ions and their complexes. Classification of organometallic compounds. Definition of hapticity. Covalent organometallic compounds. Carbonyls, alkenes and cyclopentadiene compounds of the transition metals.

**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, university professor, PhD, habil

**Lecturer:** Dr. Péter Buglyó, university professor, PhD, habil

<b>Title of course:</b> OrganicChemistry I. <b>Code:</b> TTKBE0301_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching</b> - lecture: 2 hours/week - practice: 1 hours/week - laboratory: -	
<b>Evaluation:</b> exam	
<b>Workload (estimated)</b> - lecture: 28 hours - practice: 14 hours - laboratory: - - home assignment: 28 hours - preparation for the exam: 50 hours Total: 120 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> General Chemistry I. TTKBE0101_EN	
<b>Further courses built on it:</b> TTKBE0202_EN, TTKBL0201_EN, TTKBE0402_EN, TTKBG0402_EN, TTKBL0401_EN, TTKBE0302_EN, TTKBE0501_EN, TTKBE0502_EN, TTKBE0601_EN, TTKBG0601_EN, TTKBE0204_EN, TTKBE0417_EN, TTKBG0614_EN, TTKBG0312_EN, MFVGE31V03_EN, TTKBE1111_EN	
<b>Topics of course</b>	
<ul style="list-style-type: none"> <li>• Types and theories of chemical bonds</li> <li>• Acid-base theories</li> <li>• Basic concepts of isomerism and stereochemistry.</li> <li>• Classification of organicreactions.</li> <li>• Structure, nomenclature, preparation and reactivity of aliphatic compounds</li> <li>• Aromatic compounds, benzene and its derivatives, polycyclic aromatic compounds and heteroarenes.</li> </ul>	
<b>Literature</b>	
<b>Compulsory:</b> 1. Lecture material and seminars available in the e-learning system. <b>Recommended:</b> 2. T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder; OrganicChemistry, 12 <sup>th</sup> edition, John Wiley&Sons, Inc., 2016. 3. John McMurry: Organic Chemistry (8 <sup>th</sup> Edition), 2012, Brooks/Cole 4. Herbert Meislich, Estelle Meislich, Jacob Sharefkin - 3000 Solved Problem in Organic Chemistry (1994)	

**Schedule:***1st week*

The definition and brief history of organic chemistry. Theories of the chemical bond, Lewis-Kössel theory, covalent and ionic bonds, LCAO-MO theory, types of atomic and molecular orbitals. Resonance contributors.

*2nd week*

VB theory, Hybridization. Electron shift phenomena, inductive and mesomeric effects, conjugation and hyperconjugation. Intermolecular interactions, hydrogen bond, dipole-dipole, dipole-induced dipole interactions.

*3rd week*

Description of functional groups in organic compounds. Classification of organic reactions based on the reagent and type of the reaction.

*4th week*

The basic nomenclature systems in organic chemistry: common or trivial names and systematic nomenclature. Basic rules to generate systematic names of organic compounds; substitutive and functional class nomenclature. The rules to generate the names of groups derived from hydrocarbons. The rules to generate the name of unbranched and branched (saturated and unsaturated) hydrocarbons. Elemental reactions. Definitions of transition state, intermediates, Gibbs energy, kinetical and thermodynamical parameters of chemical reactions.

*5th week*

Multi-step reactions (consecutive reactions), intermediates. Parallel (competitive) reactions. Thermodynamic and kinetic control. Reactivity and selectivity. Reagents and reactive intermediates. Brönsted-Lowry, Lewis and Oláh acid-base theories, effects influencing acidity.

*6th week*

Stereochemistry: characterization of constitutional, conformational and configuration isomers. Chirality, types of chiral molecules. The concept of enantiomers and diastereomers, general comparison of their chemical and physical properties. Absolute and relative configuration. Optical activity. The representation of organic molecules. The absolute configuration of chiral compounds, Fischer and Cahn-Ingold-Prelog convention. The role of chirality in drug chemistry.

*7th week*

Characterization of the structures of alkanes and cycloalkanes. Preparation, conformation and physical properties. Reactions of alkanes, combustion, radical substitution with different halogens, chain reaction. Statistical and regioselective halogenation.

*8th week*

Sulphonation, sulphochlorination, nitration and oxidation of alkanes. The basic petrochemical processes (pyrolysis, cracking, isomerization) and their industrial significance. The most important natural sources and the synthetic methods of alkanes.

*9th week*

The characterization of the structure of alkenes, cycloalkenes, di- and polyenes. The hindered rotation: characterization of E / Z isomers. Synthesis of alkenes, cycloalkenes. Physical and chemical properties of alkenes and cycloalkenes. Electrophilic and radical addition reactions and practical significance. Interpretation of the regioselectivity of the addition reactions; the Markovnikov rule.

*10th week*

Types of polymerization. Substitution in allylic position, interpretation of the stability of allylic intermediates. Oxidation of alkenes. Addition of conjugated dienes, partial and complete

addition. 1,2 and 1,4 addition and its interpretation based on kinetic and thermodynamic control. Diels-Alder cycloaddition.

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

Characterization of the structure of alkynes and their physical properties. The stability and synthesis of alkynes. Chemical transformations of alkynes: C-H acidity, addition reactions and their significance. The role of acetylene in the chemical industry, coal-based chemical industry.

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

The concept and the interpretation of aromaticity. Neutral and charged homo and heteroaromatic systems. The type and mechanism of the most important aromatic electrophilic substitution reactions (halogenation, nitration, sulphonation, Friedel-Crafts acylation and alkylation).

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

The  $S_{EA}$ -reactions of substituted benzene derivatives –the reactivity and regioselectivity. Classification of substituents and interpretation of their effect on reactivity and regioselectivity.

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

Electrophilic substitution reactions of five- and six-membered heteroaromatic base compounds. Addition reactions of monocyclic aromatic hydrocarbons. Reactions of aromatic hydrocarbons containing alkyl substituents, the stability of benzyl-type reactive intermediates. Most important representatives of polycyclic aromatic hydrocarbons.

**Requirements:**

*- for a signature*

Attendance of **lectures** is highly recommended and lecturer may make it compulsory for one-third of the lectures.

Attendance at seminars is compulsory. A student may not miss the seminar more than three times during the semester or the semester is not approved, and the student must repeat the course.

*- for a grade*

The course ends in an **examination**.

The exam grade is the result of a written exam.

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

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-84	good (4)
85-100	excellent (5)

If the score of any test is below 50%, the student may repeat the exam in accordance with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Tibor Kurtán, associate professor, PhD,

<b>Title of course:</b> Organic chemistry II. <b>Code:</b> TTKBE0302_EN	<b>ECTS Credit points:</b> 4
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 3 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 42 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 18 hours</li> <li>- preparation for the exam: 60</li> </ul>	
Total: 120 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Further courses built on it:</b> TTKBE0303_EN, TTKBE0611_EN, TTKBE1212_EN, TTKBL1212_EN, TTKBE0503_EN, TTKGB0313_EN	

<b>Topics of course</b>
Structure, physical and chemical properties of organic derivative containing heteroatoms such a halogenated hydrocarbons, organometallic derivatives, alcohols, phenols, ethers, sulfur analogues; amines, nitro derivatives, diazonium salts, aldehydes, ketones, carboxylic acids and their derivatives, derivatives of carbonic acid.
<b>Literature</b>
<p><b>Compulsory:</b></p> <ol style="list-style-type: none"> <li>1. Lecture material and seminars are available in the e-learning system.</li> </ol> <p><b>Recommended:</b></p> <ol style="list-style-type: none"> <li>2. T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder; OrganicChemistry, 12<sup>th</sup>edition, John Wiley&amp;Sons, Inc., 2016.</li> <li>3. John McMurry: Organic Chemistry (8<sup>th</sup> Edition), 2012, Brooks/Cole</li> <li>4. Herbert Meislich, Estelle Meislich, Jacob Sharefkin - 3000 Solved Problem in Organic Chemistry (1994)</li> </ol>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i></p> <p>Classification of halogenated hydrocarbons, characterization of their structure and physical properties. The effect of the structure of the hydrocarbon skeleton, and the quality of the halogen on the strength of the C-Hlg bond and reactivity. Synthesis of halogenated hydrocarbons.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Reactions of halogenated hydrocarbons. Interpretation of decreased, normal and high reactivity of halogenated hydrocarbons. Nucleophilic substitution and elimination of halogenated hydrocarbons. Interpretation of the mechanism of these reaction (S<sub>N</sub>1, S<sub>N</sub>2; <math>\alpha</math>- and <math>\beta</math>-elimination; E1, E2). Reaction of halogenated compounds with metals.</p>

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

The basics of chemistry of organometallic compounds. Their bonding system, the term "umpolung". Synthesis and reactivity of organometallic compounds. Organometallic compounds as nucleophiles and carbanion equivalents. C-C bond formation with organometallic reagents: Grignard compounds and their application. Synthesis and interconversion of organometallic compounds, transmetallation.

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

Classification and characterization of hydroxyl derivatives of hydrocarbons (alcohols, phenols) and their thio analogues. Interpretation of their physical properties derived from their bonding system. The acid-base properties of alcohols, phenols and thio analogues. Preparation of alcohols, ethers, phenols and thio analogues.

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

Alcohols and phenols as nucleophiles: alkylation, acylation, formation of sulphonate and inorganic esters; acid catalyzed transformations of alcohols (conversion of alcohols to halogenated derivatives, elimination reactions). Oxidation of alcohols and phenols. The characterization of ethers; synthesis and cleavage of ethers. Characterization of the special ether derivatives: epoxides, semi-acetals, acetals and enolettes. Cumene-based phenol synthesis.

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

Overview of the organic compounds possessing C-N single bond. Classification of amines and characterization of their bonding systems. Interpretation of their physical properties derived from their bonding system. Synthesis of aliphatic and aromatic amines; industrial methods.

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

Review and interpretation of basicity of amines. Chemical transformation of amines: alkylation, acylation of amino group. Synthesis of sulfonamide and reaction with nitric acid. Oxidation of the amines.  $S_EAr$  reactions of anilines.

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

Characterization of nitro compounds: the bonding system, interpretation of electron-withdrawing effect and C-H acidity. Synthesis of nitro compounds. Preparation of diazonium salts, reactions of diazonium salts and their practical significance. Azo compounds and their industrial significance.

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

Classification and characterization of oxo compounds: the bonding system and stability of carbonyl group. Physical properties of oxo compounds. Acid-base properties of aldehydes and ketones: acidity of the  $\alpha$ -hydrogen, keto-enol tautomerism. Synthesis of aldehydes and ketones.

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

Reactions of aldehydes and ketones. Nucleophilic addition with O-, S-, N- and C-nucleophiles, the reversibility of the additions. Condensation reactions. Oxidation and reduction. Reactions on  $\alpha$ -carbon; aldol dimerization,  $\alpha$ -halogenation. Nucleophilic addition reactions of  $\alpha,\beta$ -unsaturated oxo compounds.

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

Classification of carboxylic acids and their derivatives, description and comparison of their bonding systems. Stability and reactivity of the carboxylic acid derivatives. Physical properties and synthesis of carboxylic acids.

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

Review and interpretation of the acid-base properties of carboxylic acids and their derivatives (O-H, N-H and C-H acidity). Interconversion of the carboxylic acid derivatives, acyl

nucleophilic substitution. Reductive transformations of carboxylic acid derivatives, transformation of their carbon skeleton.

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

$\beta$ -Dicarbonyl and  $\beta$ -oxo-carboxylic acid derivatives, C-H acidity and basic of enolate chemistry: formation of carbon-carbon bond, malonic ester, acetoacetic ester and cyanoacetic ester syntheses.

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

Substituted (halogenated, hydroxy and oxo) carboxylic acid derivatives and their interconversion.

Synthesis and interconversion of carbonic acid derivatives and their major representatives.

Practical significance of carbonic acid derivatives.

**Requirements:**

*- for a signature*

Attendance of **lectures** is highly recommended and the lecturer may make it compulsory for one-third of the lectures.

Attendance at seminars is compulsory. A student may not miss the seminar more than three times during the semester or the semester is not approved, and the student must repeat the course.

*- for a grade*

The course ends in an **examination**.

The exam grade is the result of a written exam.

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

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-84	good (4)
85-100	excellent (5)

If the score of any test is below 50%, the student may repeat the exam in accordance with the **EDUCATION AND EXAMINATION RULES AND REGULATIONS**.

**Person responsible for course:** Dr. Tibor Kurtán, University professor, PhD

**Lecturer:** Dr. Tibor Kurtán, University professor, PhD

<b>Title of course:</b> Organic chemistry II. <b>Code:</b> TTKBL0311_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: -</li> <li>- laboratory: 3 hours/week</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: -</li> <li>- laboratory: 42 hours</li> <li>- home assignment: 18 hours</li> <li>- preparation for the exam: -</li> </ul>	
Total: 60 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBL0101_EN, TTKBE0301_EN, TTKBE0401_EN, TTKBE0201_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The aim of the course is to enable students to become familiar with the theoretical background of basic organic chemistry laboratory techniques and to learn how to apply them in practice, to deepen the theoretical knowledge gained in organic chemistry lectures and to understand the reactivity of functional groups by synthesizing simple preparations on a semi-micro scale and by carrying out test tube reactions. The other goal is to provide students with the right material knowledge and to understand and apply cleaning and identification techniques as typical organic chemistry activities.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ol style="list-style-type: none"> <li>1. L. Juhász: Organic Laboratory Techniques and Manuals for Pharmacist Students, Debrecen, 2009</li> <li>2. 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.</li> </ol> <p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>1. H. Meislich, E. K. Meislich, J. Sharefkin: 3000 Solved Problems in Organic Chemistry, 1<sup>st</sup> Edition, 1994, McGraw-Hill Companies; ISBN-13: 978-0070564244</li> <li>2. R. O. C. Norman, J. M. Coxon: Principles of Organic Synthesis, 3<sup>rd</sup> Edition, 1993, Blackie Academic &amp; Professional, Glasgow, UK; ISBN-13: 9780751401264</li> <li>3. J. McMurry: Organic Chemistry, 8<sup>th</sup> Edition, 2012, Brooks/Cole; ISBN-13: 9780840054449</li> <li>4. J. Clayden, N. Greeves, S. Warren: Organic Chemistry, 2<sup>nd</sup> Edition, 2012, Oxford University Press; ISBN-13: 9780199270293</li> <li>5. F. A. Carey: Organic Chemistry, 4<sup>th</sup> Edition, 2000, The McGraw-Hill Companies; ISBN-10: 0072905018</li> </ol>

6. J. G. Smith: OrganicChemistry, 5<sup>th</sup> Edition, 2016, McGrow Hill; ISBN-13: 9780077354725

**Schedule:**

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

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

Presentation of the device for recrystallization.

Presentation of gravity and vacuum filtration equipment.

Description of the operation of the rotary vacuum evaporator.

Recrystallization of acetanilide from water.

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

Short written test.

Presentation of thin layer chromatography (TLC).

Presentation of determination of meltingpoint.

Check of the purity of the compound recrystallized in previous practice by meltingpoint and TLC. Calculation of the yield of recrystallization.

Recrystallization of benzanilide from methanol.

Check of the purity of the recrystallized benzanilide by TLC.

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

Short written test.

Description of liquid-liquid extraction.

Control the purity of the compound recrystallized in previous practice by meltingpoint.

Calculation of the yield of recrystallization.

Use of liquid-liquid extraction to separate m-dinitrobenzene and m-nitroaniline. Checking the success of the separation using TLC.

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

Short written test.

Presentation of equipment used for distillation at atmospheric and reduced pressure.

Distillation of acetone from KMnO<sub>4</sub> at atmospheric pressure.

Distillation of water in vacuum.

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

Short written test.

Presentation of steam distillation

Isolation of S-(+)-Carvone from caraway and preparation of its 2,4-dinitrophenylhydrazone derivative.

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

Short written test.

Description of column chromatography. Separation of the mixture of acetanilide and m-dinitrobenzene by column chromatography.

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

Short written test.

Identification of hydrocarbons and organic halides using test tube reactions.

Reaction of hydrocarbons with bromine.

Reaction of hydrocarbons with bromine in the presence of UV light.

Friedel-Crafts test of aromatic hydrocarbons.

Baeyer test of unsaturated hydrocarbons.

Beilstein and alcoholic silver nitrate test of organic halides.

Identification of unknown compounds.

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

Short written test.

Presentation of a device used in reaction with three-necked round bottom flasks.

Preparation of 3-nitroaniline and recrystallization of the product from water.

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

Short written test.

Check of the purity of 3-nitroaniline by TLC and melting point measurement.

Calculation of the yield.

Preparation of cyclohexanone and cyclohexanone 2,4-dinitrophenyl-hydrazone (test tube variant).

Preparation of benzotriazole (test tube variant).

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

Short written test.

Preparation of acetylsalicylic acid and purification of the product by recrystallization.

Check of the purity of the product by TLC and melting point measurement.

Calculation of the yield.

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

Short written test.

Preparation of 4-chlorobenzoic acid and 4-chlorobenzyl alcohol. Check the purity of the product using TLC and melting point measurement.

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

Short written test.

Identification of hydroxyl derivatives of hydrocarbons using test tube reactions.

Solubility of alcohols and phenols.

Determination of order of substitution of the carbon carrying the OH group by Lucas probe.

Oxidation of alcohols with Jones reagent.

Reaction of diols or polyols with copper(II) ions.

Reaction of phenols and enols with iron(III) ions.

Iodoform test of 2-alkanols.

Identification of unknown compounds.

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

Short written test.

Identification of amino derivatives of hydrocarbons using test tube reactions.

The Hinsberg test.

Reactions of amines with nitrous acid.  
The Rimini reaction of aliphatic primary amines  
Complex formation of amine with Cu(II) ions.  
Identification of unknown compounds.

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

Performing missed identification tasks (melting point measurement, TLC), yield calculation.  
Cleaning and handovering of equipments.  
Present the synthesized products to the instructor.  
Evaluation.

**Requirements:**

Attendance at laboratory practice is mandatory.  
Before starting the laboratory work, students must write a short written test on their theoretical organic chemistry and practical knowledge as well as on the safety rules about the previous laboratory practice (15-20 minutes).

On the one hand, the term mark consists of the marks obtained for the identification of the unknowns and on the other hand the marks written before the practice, which are closely related to the laboratory exercises carried out the week before (15-20 minutes). Of course, a prerequisite for successful laboratory practice is the synthesis of all preparations.

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:

- Short written test (70%)
- Activity in laboratory practice (15%)
- Identification of unknown compounds (15%)

Final grade: excellent (5): 85%; good (4): 75%; satisfactory (3): 60%; pass (2): 50%; fail (1): below 50%.

**Person responsible for course:** Dr. Marietta Vágvölgyiné Tóth, associate professor, PhD

**Lecturer:** Dr. Marietta Vágvölgyiné Tóth, associate professor, PhD

<b>Title of course:</b> Organic chemistry III. <b>Code:</b> TTKBE0303_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> term mark	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 14 hours</li> <li>- preparation for the exam: 48 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0302_EN	
<b>Further courses built on it:</b> TTBBE2035_EN	

<b>Topics of course</b>
Characterization of the building blocks of biomacromolecules (peptides and proteins, carbohydrates, nucleic acids, lipids) that form biological structures. Description and characterization of the most important biochemical reactions. Characterization of the structure of the biomacromolecules. Overview of the chemical and instrumental methods which can be used for the structure elucidation of these type of compounds. Review the basic of their information storage and storage capacity, the relationship between structure and function. Chemical properties of their monomers and synthesis of biopolymers. The structure and biological effect/function of some other significant natural compounds (isoprenoids, flavonoids, alkaloids, antibiotics, vitamins, porphinase compounds).
<b>Literature</b>
<p><i>Compulsory:</i></p> <ol style="list-style-type: none"> <li>1. Coursematerial, concept and taskcollectionforlectures, seminars in the e-learningsystem.</li> </ol> <p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>2. J. G. Smith: OrganicChemistry, 5<sup>th</sup> Edition, 2016, McGrow Hill; ISBN-13: 9780077354725</li> <li>3. C. Stan Tsai: Biomacromolecules, John Wiley &amp; Sons, New Jersey (2007)</li> <li>4. A. Miller-J. Tanner: Essentials of Chemical Biology, John Wiley &amp; Sons, Chichester (2008)</li> <li>5. P. M. Dewick: Medicinal Natural Products: A Biosynthetic Approach, 3<sup>rd</sup> Edition. John Wiley &amp; Sons, Chichester (2009)</li> </ol>

<b>Schedule:</b>
<i>1<sup>st</sup> week</i>
Primary and secondary metabolism. Classification of natural compounds. Types of biological structural materials, general characterization. Common features of the synthesis of biopolymers: group protection, activation, coupling reactions, requirements for protective groups, orthogonality

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

Structure, synthesis and chemical properties of amino acids. Characterization of  $\alpha$ -amino acids which are forming protein/peptides. Structure and determinations of peptides. Determination of amino acid sequence by chemical and enzymatic methods, possibility of automation.

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

Synthesis of peptides. The basic protecting groups and activation methods for peptide synthesis. Solid phase synthesis, automation. The occurrence, classification and functions of proteins. Levels of protein structure: primary, secondary, tertiary and quaternary structures, structure formation. Structure and function relationship.

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

Classification, structure and nomenclature of carbohydrates. Basic configuration and conformational conditions of monosaccharides. Most important chemical properties of monosaccharides: mutarotation, transformation of oxo group and hydroxyl groups, synthesis of glycosides.

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

Most important representatives of di- and oligosaccharides (sucrose, maltose, cellobiose, lactose, cyclodextrins), factors determining their structure. Synthesis of di- and oligosaccharides, basic protecting groups and activation methods.

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

Derivatives of Peptides / proteins and low molecular weight carbohydrates: peptidoglycans, glycoproteins, their biological significance. The carbohydrate code.

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

Polysaccharides (cellulose, chitin, starch, glycogen, pectin, mucopolysaccharides). Polysaccharides as structural materials and reserve nutrients. Derivatives of polysaccharides and proteins (proteoglycans). The industrial significance of polysaccharides.

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

Classification and characterization of nucleic acids, their building blocks. Synthesis of nucleosides and nucleotides. Primary, secondary and tertiary structure and biological function of DNA and RNA. The genetic code. Information content of the nucleotide, amino acid and carbohydrate code and their correlation. Nucleotide coenzymes.

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

Classification and characterization of lipids, their structure, their biological role. Basics of the biosynthesis of fats, phospho- and glycolipids.

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

Isoprenes, terpenoids and carotenoids. The basics of their biosynthesis, and most important representatives of terpenoids. The chemical background of vision. Structure, classification of steroids, basics of their biosynthesis, their major representatives and their biological function.

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

Classification and structure of phenylpropanoids. The chemical synthesis of their basic skeletons. Structure and biological significance of flavonoids.

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

Classification of alkaloids and structure and function of their most important representatives. Alkaloids as drugs and medicines.

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

Definition of symbiosis, antibiosis. Definition and classification of antibiotics:  $\beta$ -lactam, amino acid or peptide, glycoside type antibiotics, polycyclic antibiotics. Preparation of antibiotics:

fermentation, semi-synthetic and synthetic derivatives. The most important mode of action of antibiotics.

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

The structure, biosynthesis and biological role of porphyrins. Structure, biological role and metabolism of chlorophyll and hemoglobin. Classification of vitamins, their structure, their natural sources and their biological functions.

**Requirements:**

*- for a signature*

Attendance at **lectures** 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.

*- for a grade*

The course ends in an oral exam in the exam period.

**Person responsible for course:** : Dr. László Juhász PhD, Associate professor

**Lecturer:** : Dr. László Juhász PhD, Associate professor

<b>Title of course:</b> Biochemistry I. <b>Code:</b> TTBBE2035_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- seminar: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 22 hours</li> <li>- preparation for the exam: 40 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 3 <sup>st</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0303_EN	
<b>Further courses built on it:</b> TTKBL0303_EN, TTBE0304_EN	

<b>Topics of course</b>
Molecular design of life. Protein structure and function. Oxygen-transporting proteins: Myoglobin and Hemoglobin. Carbohydrates. Glycoconjugates. Glycobiology. Introduction to biological membranes. Enzymes. Metabolism: basic concepts and design. Glycolysis. Gluconeogenesis. Cori cycle. Citric acid cycle. Oxidative phosphorylation. The pentose phosphate pathway. Glycogen metabolism. The coordinated control of synthesis and breakdown. Fatty acid metabolism. Oxidation of fatty acids and unsaturated fatty acids. Synthesis of ketone bodies. Biosynthesis of fatty acids. Digestion of proteins. Amino acid degradation. The urea cycle. The link between the urea and the citric acid cycle. The fates of the carbon skeletons of amino acids.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Lubert Stryer, Biochemistry, W. H. Freeman and Company, New York, 2002, ISBN 1-7167-4684-0.</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- Glycoscience-Chemistry and Chemical Biology, (Eds: B. Fraser-Reid, K. Tatsuta, J. Thiem) 2001, Springer-Verlag, Berlin</li> <li>- 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)</li> </ul>
<b>Schedule:</b> 1 <sup>st</sup> week: Introduction to Biochemistry. Molecular design of life. Amino acids. Peptides. Primary, secondary, tertiary, quaternary structures.

*2<sup>nd</sup> week:* Determination of peptide structures. Protein structure and function. Oxygen-transporting proteins: Myoglobin and Hemoglobin.

*3<sup>rd</sup> week:* Carbohydrates. Biological role of carbohydrates. Monosaccharides, disaccharides. polysaccharides. Glycoconjugates. Glycobiology.

*4<sup>th</sup> week:* Introduction to biological membranes. Lipids. Classification and functions of lipids. Neutral fats, oils and waxes. The major classes of membrane lipids. Membrane models.

*5<sup>th</sup> week:* Enzymes. Classification. Coenzymes. Mechanism of enzyme action. Control of enzyme activity.

*6<sup>th</sup> week:* The kinetic properties of enzymes. The Michaelis-Menten model. Graphic evaluation of the kinetic parameters. Inhibition of enzyme activity. Diagnostic importance of enzymes.

*7<sup>th</sup> week:* Metabolism: basic concepts and design. Purine and pyrimidine bases, nucleosides and nucleotides. cAMP, ATP. Nucleotide coenzymes. Metabolism of carbohydrates. Glycolysis. The fate of pyruvate. Entry of fructose and galactose into glycolysis.

*8<sup>th</sup> week:* Gluconeogenesis. Cori cycle. The pentose phosphate pathway.

*9<sup>th</sup> week:* Citric acid cycle. Pyruvate dehydrogenase complex. The citric acid cycle is a source of biosynthetic precursors. Control of the citric acid cycle.

*10<sup>th</sup> week:* Oxidative phosphorylation. The four enzyme complexes of the respiratory chain. Synthesis of ATP. The ATP yield of the complete oxidation of glucose.

*11<sup>th</sup> week:* Glycogen metabolism. Glycogen degradation and synthesis. The coordinated control of synthesis and breakdown.

*12<sup>th</sup> week:* Fatty acid metabolism. Oxidation of fatty acids and unsaturated fatty acids. Energetics of fatty acid oxidation. Synthesis of ketone bodies.

*13<sup>th</sup> week:* Biosynthesis of fatty acids. The elongation cycle. Biosynthesis of cholesterol.

*14<sup>th</sup> week:* Digestion of proteins. Amino acid degradation. Transamination and oxidative deamination. The urea cycle. The link between the urea and the citric acid cycle. The fates of the carbon skeletons of amino acids.

#### **Requirements:**

- *for a signature*

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

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 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 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:** Dr. János Kerékgyártó, senior research fellow, PhD

**Lecturer:** Dr. János Kerékgyártó, senior research fellow, PhD

<b>Title of course:</b> Introduction to economics <b>Code:</b> TTBEBVVM-KT1-EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> <ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: -</li> <li>- preparation for the exam: 62 hours</li> </ul> Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 1 <sup>st</sup> semester (or any later fall semester)	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> TTBEBVVM-KT3_EN	

<b>Topics of course</b>
10 principles of economics, how markets work: demand and supply analysis, the effects of governmental interventions, cost of production, profit-maximizing behaviour of firms, analysis of perfect competition and monopoly
<b>Literature</b>
Mankiw, Gregory: Principles of Economics. Fifth Edition. South-Western, Mason, USA, 2009. Heyne, Paul – Boettke, Peter – Prychitko, David: The Economic Way of Thinking. Twelfth Edition. Pearson Education International, New Jersey, 2010.
<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Introduction: Basic concepts and fundamental questions of economics SR: Understanding the basic concepts and the economic way of thinking
<i>2<sup>nd</sup> week</i> Human needs, scarcity, inputs, trade and its benefits SR: Knowing the concept of scarcity and how free-will trade makes everyone better off
<i>3<sup>rd</sup> week</i> Principles of economics SR: Understanding the meaning of the 10 main principles
<i>4<sup>th</sup> week</i> Production possibilities frontier, opportunity cost

SR: Knowing the role of opportunity cost in the model of PPF curve

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

Demand and Supply

SR: Understanding the model of market, able to derive the changes of variables

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

Market allocation

SR: Able to characterize the equilibrium and disequilibrium

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

Welfare economics

SR: Concept of consumer and producer surplus and Dead Weight Loss

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

Application: Governmental interventions

SR: Able to identify the effects of government's interventions on market and the welfare of the society

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

Cost of production

SR: The main types of cost and their relationship

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

Competitive industry I.

SR: Criteria of perfect competition, and profit-maximization

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

Competitive industry II.

SR: Welfare effects and industry in the long run

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

Monopoly I.

SR: Criteria of monopoly, and profit-maximization

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

Monopoly II.

SR: Understanding the welfare effects of monopoly

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

Summary, discussion of questions emerging during the semester.

SR: --

**Requirements:**

- *for a signature*

There is no requirement for a signature.

- *for a grade*

Assessment is based on a written exam which will be evaluated according to the following grading schedule:

0 -50% – fail (1)

50%+1 point -63% – pass (2)

64% -75% – satisfactory (3)

76% -86% – good (4)

87% -100% – excellent (5)

**Person responsible for course:** Dr. Levente Sándor Nádasi, Assistant Professor, PhD

**Lecturer:** Dr. Levente Sándor Nádasi, Assistant Professor, PhD

<b>Title of course:</b> Introduction to Business <b>Code:</b> TTBEVVM-KT2_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 12 hours</li> <li>- preparation for the exam: 50 hours</li> </ul>	
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 course explores the question 'what is a business'; and investigates the business functions of human resource management, marketing, operations management, accounting and finance. Different internal and external elements of a business are introduced, and the context in which a business operates explained. Students will explore the common aims and characteristics of business – investigating what makes them different. Business structures, cultures and functions are identified and the political, social, economic, and technological considerations affecting business are introduced. Students get an insight into the international competition, too.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Nickels, William G. – McHugh, James M. – McHugh, Susan M. (2008): Understanding Business. Eighth edition, McGraw-Hill/Irwin, New York, pp.1-87, 116-147, 180-319, 348-543, ISBN 978-0-07-310597-0</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- Ferrell, O. C. – Hirt, Geoffrey (1993): Business – A Changing World. Irwin, Homewood, pp.1-29, 80-471, 502-633, ISBN 0-256-11683-0</li> <li>- Skinner, Steven J. – Ivancevich, John M. (1992): Business for the 21<sup>st</sup> Century. Irwin, Homewood, pp.1-121, 188-701, 736-771, ISBN 0-256-09222-2</li> </ul>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i></p> <p>Introduction. Managing within the Dynamic Business Environment</p> <p><i>2<sup>nd</sup> week</i></p>

How Economics Affects Business
<i>3<sup>rd</sup> week</i>
Competing in Global Markets
<i>4<sup>th</sup> week</i>
Choosing a Form of Business Ownership
<i>5<sup>th</sup> week</i>
Management, Leadership and Employee Empowerment
<i>6<sup>th</sup> week</i>
Adapting Organizations to Today's Markets
<i>7<sup>th</sup> week</i>
Producing Word-Class Goods and Services
<i>8<sup>th</sup> week</i>
Motivating Employees and Building Self-Managed Teams
<i>9<sup>th</sup> week</i>
Human Resource Management: Finding and Keeping the Best Employees
<i>10<sup>th</sup> week</i>
Marketing: Building Customer Relationships; Developing and Pricing Product and Services
<i>11<sup>th</sup> week</i>
Distributing Products Quickly and Efficiently Using Effective Propotional Techniques
<i>12<sup>th</sup> week</i>
Understanding Financial Information and Accounting; Financial Management
<i>13<sup>th</sup> week</i>
Security Markets: Financing and Investing Opportunities
<i>14<sup>th</sup> week</i>
Summary

**Requirements:**

*- for a signature*

Attendance at **lectures** is compulsory.

Students have to **submit their solutions to two hypotheticals as home work assignments during the semester.**

*- for a grade*

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

The minimum requirement for the written exam is 60%. Based on the score of the exam, 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 exam is below 60, students can retake it in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Prof.Dr.András Nábrádi, university professor, DSc

<b>Title of course:</b> Basics of Civil Law I <b>Code:</b> TTBEBVVM-JA1_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: 12 hours - preparation for the exam: 20 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> Basics of Civil Law II. (TTBEBVVM-JA2)	

<b>Topics of course</b> The course introduces students to the basic principles of civil law in order to provide up to date knowledge on the most important institutions of private law to engineers. During the course, the following topics of civil law are discussed: - law of natural persons (legal capacity, capacity to act); - personality rights and their protection; - company laws in the EU (formation, structure); - consumer protection laws in the EU; - general rules on contracts and obligations; - proprietary rights.
<b>Literature</b> <i>Compulsory:</i> - Trstenjak, V. – Weingeri, P. (2016): The Influence of Human Rights and Basic Rights in Private Law, Springer, ISBN 978-3319253350 - Twigg-Flesner, C. (2010): The Cambridge Companion to European Union Private Law, Cambridge University Press, ISBN 978-0521736152 - Sauter, W. – Schepel, H. (2009): State and Market in European Union Law: The Public and Private Spheres of the Internal Market Before the EU Courts, Cambridge University Press, ISBN 978-0521674478
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Distinction between private and public laws. <i>2<sup>nd</sup> week</i>

General principles of civil law: good faith, fault-based liability
<i>3<sup>rd</sup> week</i>
Law of natural persons: legal capacity and capacity to act
<i>4<sup>th</sup> week</i>
Law of legal entities (company law) I.: Formation
<i>5<sup>th</sup> week</i>
Law of legal entities (company law) I.: Structure
<i>6<sup>th</sup> week</i>
Personality rights and privacy laws
<i>7<sup>th</sup> week</i>
Consumer rights in the EU
<i>8<sup>th</sup> week</i>
Distance selling, e-commerce laws
<i>9<sup>th</sup> week</i>
Contract formation
<i>10<sup>th</sup> week</i>
Breach of the contract
<i>11<sup>th</sup> week</i>
Remedies to a breach scenario
<i>12<sup>th</sup> week</i>
Calculation of damages
<i>13<sup>th</sup> week</i>
Rights to property
<i>14<sup>th</sup> week</i>
Summary

**Requirements:**

*- for a signature*

Attendance at **lectures** is compulsory.

Students have to **submit their solutions to two hypotheticals as home work assignments during the semester.**

*- for a grade*

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

The minimum requirement for the written exam is 60%. Based on the score of the exam, 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 exam is below 60, students can retake it in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr.Tamás Fézer, associate professor, PhD

<b>Title of course:</b> Basics of Civil Law II <b>Code:</b> TTBEBVVM-JA2_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> <ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 12 hours</li> <li>- preparation for the exam: 20 hours</li> </ul> Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> Basics of Civil Law I. (TTBEBVVM-JA1)	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The course introduces students to intellectual property laws and their protection in a European and international level. The rules of international sales law, dispute settlement mechanisms and transportation are also discussed in order to grant better understanding on the legal background of technological inventions and commercial activities related to them..
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Pila, J. – Wadlow, C. (2015): The Unitary EU Patent System, Hart Publishing, ISBN 978-1849466196</li> <li>- Stamatoudi, I. – Torremans, P. (2014): EU Copyright Law, EdardElgar, ISBN 978-1781952429</li> <li>- Sauter, W. – Schepel, H. (2009): State and Market in European Union Law: The Public and PrivateSpheres of theInternal Market Beforethe EU Courts, Cambridge University Press, ISBN 978-0521674478</li> </ul>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i> The nature of IP laws in Europe.</p> <p><i>2<sup>nd</sup> week</i> Copyright law in the EU I.</p> <p><i>3<sup>rd</sup> week</i> Copyright law in the EU II.</p> <p><i>4<sup>th</sup> week</i> Patent rights.</p> <p><i>5<sup>th</sup> week</i> Patent restrictions and commercial chains.</p>

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

Trademark protection.

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

Contractual relations to IP law.

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

Insurance Laws.

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

Dispute settlement mechanisms.

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

International commercial arbitration.

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

International Sales Law I.

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

International Sales Law II.

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

Transportation laws.

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

Summary

**Requirements:**

*- for a signature*

Attendance at **lectures** is compulsory.

Students have to **submit their solutions to two hypotheticals as home work assignments during the semester.**

*- for a grade*

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

The minimum requirement for the written exam is 60%. Based on the score of the exam, 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 exam is below 60, students can retake it in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr.Tamás Fézer, associate professor, PhD

<b>Title of course:</b> History and Structure of the EU <b>Code:</b> TTTBE0030-K1	<b>ECTS Credit points: 1</b>
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 1 hour/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 14 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: -</li> <li>- preparation for the exam: 16 hours</li> </ul>	
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 the course is to give an overall picture for the students of the history of the development of the Community and the operation of its institutional system. It also aims at introducing the students to the enlargement process and the most important cooperation areas. On the level of EU policies, the issues of agriculture, regional policy, Economic and Monetary Union and the Schengen Area are discussed. The primary goal is that the future diploma holders have realistic knowledge about the functioning of the European Union, and of the international background of the Hungarian EU membership.
<b>Literature</b>
<ol style="list-style-type: none"> <li>1. Bergmann, Julian – Niemann, Arne (2013): Theories of European Integration and their Contribution to the Study of European Foreign Policy, <i>Paper prepared for the 8th Pan-European Conference on International Relations, Warsaw 2013.</i> p22.</li> <li>2. Ott, Andrea – Vos, Ellen (eds.) (2009): Fifty Years of European Integration: Foundations and Perspectives. T.M.C. Asser Press, Springer. 480pp. ISBN: 978-90-6704-254-3</li> </ol>
Official website: <a href="https://europa.eu/european-union/about-eu_en">https://europa.eu/european-union/about-eu_en</a>
<b>Schedule:</b>
<i>1<sup>st</sup> week</i>
<b>History of the Integration.</b> Integration theories, stages of integration around the world. Specific features of the European integration process before the Second World War. Impacts of the Second World War on the history of the cooperation. Predecessors, impacts of the European Coal and Steel Community (ECSC) on the foundation of the European Economic Community. Steps towards the European Union.
<i>2<sup>nd</sup> week</i>

**Process of the enlargement of the organisation.** Preconditions of the enrolment of new members. Events of the period prior to the First Enlargement (1973). Steps, principles, causes and consequences of the Enlargements. Relationships between the decision-making mechanism and the Enlargement.

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

**Specific features of the enlargements after the turn of the millennium.** Transformation of East Central Europe, and the unique features of its membership. Copenhagen criteria, pre-accession funds, prolonged negotiation process. Brexit.

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

**History and principles of the creation of the institutional system.** Taking-over the institutional system of the European Coal and Steel Community. Tasks of the most important institutions, operational mechanism, democratic deficit. Reform process of the institutional system, concepts laid down in the Constitutional Treaty. Decision-making in the EU.

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

**Agricultural policy.** History of the development of the CAP. The most important tools and sources of the funds. Horizontal measures. Current state of the common agricultural policy and its expected future. Reform attempts in agriculture. Hungary and common agricultural policy. Sharing the fish stocks of the seas.

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

**Regional policy in the European Union.** History of the regional policy. Regionalism – regionalisation in the EU Member States. General features of the regional policy. NUTS nomenclature. Regional disparities in the Community. Funds and main objectives. Decision-making in regional policy. Hungary and the regional policy.

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

**Economic and Monetary Union (EMU).** History of the European monetary co-operation. The European Monetary System (EMS). Role of the Maastricht Treaty in the monetary co-operation. Stages on the development of the Monetary Union. Convergence criteria. The euro and the currency market. Hungary and the Monetary Union.

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

**Judicial co-operation in the Community.** Legal order in the European Union. Role of the primary EU legislation in the European Community. European Community justice. Institutions serving the needs of judicial co-operation.

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

**History of co-operations in home affairs.** Schengen Convention. Regulations related to crossing state borders. Border checks. Checks between state borders, migration policy.

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

**External relations.** Principles of the common foreign trade policy. Autonomous import and export regulation. Issues related to the impediment to trade. External relations: African, Caribbean and Pacific Group of States (ACP), Global Mediterranean Policy, associated countries.

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

**EU Budget: revenue side.** Components of the EU budget and recent changes in the proportions. History of the EU budget. Budget revenues: duties, value-added tax (VAT), gross national product (GNP) sources.

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

**Expenditures:** agricultural policy, structural funds, external aid, research and development, pre-accession assistances, administrative expenditures. Economic characteristics. Budget procedure.

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

**Migration and the European Union.** Theoretical background to the migration crisis in 2015 and its practical consequences. History of the migration routes and movements. Natural and social (political) causes contributing to the crisis situation.

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

**Common vision for the European co-operation.** Possible development paths in the future of the European Union. Federal Europe or Europe of Nations? Reform options. Problem-solving attempts. Brexit.

**Requirements:**

*- for a signature*

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

*- for a grade*

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

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

**Lecturer:** Dr. Klára Czimre, assistant professor, PhD

<b>Title of course:</b> Management of Value Creating Processes <b>Code:</b> TTBEBVM-KT4_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> <ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 22</li> <li>- preparation for the exam: 40 hours</li> </ul> Total: 90 hours	
<b>Year, semester:</b> 1st year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> -	
<b>Further courses built on it:</b> TTBEBVM-KT6_EN	

<b>Topics of course</b>
Introduction to operations management. Strategy. Decision analysis support tools. Quality management. Process capability and statistical process control. Acceptance sampling. Designing products. Designing services. Process design. Capacity and facility planning. Facility location. HR management, Work measurement. Project management.
<b>Literature</b>
<i>Compulsory:</i> <ul style="list-style-type: none"> <li>– Russell, R. S. - Taylor, B. W. : Operations Management, 8th Edition, Wiley &amp;Suns, INC., ISBN10 1118808908 ISBN13 9781118808900, 2014</li> </ul>

- Heizer, J. - Barry R. - Chuck M.: Operations Management: Sustainability and Supply Chain Management (12th Edition), Pearson, ISBN-13: 978-0134130422, ISBN-10: 0134130421, 2016

*Recommended:*

- Lee J. Krajewski, L. J. - Malhotra, M. K. - Larry P. Ritzman, L. P.: Operations Management: Processes and Supply Chains, 11th Edition, ISBN-13: 9780133872132, Pearson, 2016

**Schedule:**

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

Introduction. The structure of value creating processes. Production processes. Service processes. The role of the operations manager. The evolution of operations management. Supply chain management. Globalisation. Productivity and competitiveness.

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TE: Should know the basic functions and features of the value creating processes. Should understand the process of the evolution of management.

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

Strategy. The steps of strategy formulation: primary task, core competencies, order winners and order qualifiers, positioning the firm, and strategy deployment. Hoshin kanri and balance scorecard as methods of strategy deployment. Operations strategy.

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TE: Should know the steps of strategy formulation. Should understand the relationships between strategy deployment and business development.

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

Decision analysis support tools and processes. Optimist and pessimist decision maker. The meaning and usage of coefficient of optimism. Decision making criteria: maximax, maximin, equal likelihood, and Hurwitz.

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TE: Should use the decision criteria to mitigate the risk. Should know the difference between pessimistic and optimistic decisions.

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

Quality and quality management. The TQM and quality management systems. Quality tools. The focus of quality management: the customer. Quality improvement. Lean six sigma. ISO 9000.

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TE: Should know the methods of quality measurement and the techniques of quality improvements. Should be able to conform to the changing demand of the customer.

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

Process capability and statistical process control. The role of process control in the quality management. Attribute data and variable data. Construction and usage of process control charts: p, c, x mean and R diagrams. Tolerances and process capability.

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TE: Should know how to control production and service processes using process control charts. Should understand the importance of preventing production and service processes from defects.

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

Acceptance sampling as decision support analysis. Single-sample attribute plan. The risk of producer and consumer. The operating characteristic curve. Average outgoing quality. Double- and multiple-sampling plans.

TE: Should know the risk of product acceptance and the techniques of sample taking as well as should be able to deduce the features of the base population from the analysis of the samples.

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

Product design. The product design process, idea generation, feasibility study, form design, functional design, reliability, maintainability, usability, and production design. Design for environment, and design for robustness.

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TE: Should know the steps and interrelations of the product design. Should understand the importance of product development to adapt to the continuously changing demand of customers.

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

Service design. The service economy. The service design process. Tools for service design. Waiting line analysis for service improvement. Operating characteristics of the queueing system, traditional cost relationships in waiting line analysis. Psychology of waiting, queuing models.

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TE: Should know the characteristics of services and the tools for service design. Should be able to understand the effect of waiting lines on the service provider and can improve the queueing system.

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

Process design and technology. Outsourcing, process selection with break even analysis. Process analysis, using process flowcharts, process development. Technology decisions: financial justification and technology primer.

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TE: Should know the steps of process design. Should know how to select the best production or service process using adequate methods. Should understand the interrelations between the importance of process plan, process selection and business competitiveness.

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

Capacity and facilities planning. The basics of facility layouts. Basic layouts: process layouts, product layouts, and fix position layouts. Planning of process layouts, service layouts, product layouts, and hybrid layouts.

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TE: Should know the main types of facility layouts and the means of their designs. Should understand the relationship between the facility layout and the capacity utilization.

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

Facility location decision support tools. The types of facilities. Site selection. The factors of the global supply chain. Location analysis techniques: location factor rating, center-of-gravity technique, and load-distance technique.

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TE: Should know the types of facilities, the factors that influence facility locations and the techniques of facility locations. Should understand the relationship between geographic location of facilities and efficient operation of facilities.

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

Human resources in the operations management. HR and quality management. The changing nature of HR management. Contemporary trends in HR management. Management of diversities in HR. Job design, job analysis and the learning curve.

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TE: Should know the characteristics of modern HR management and the methods of work design and work analysis. Should understand the role of human resources as the primary resource in business operations.

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

Work measurement decision analysis support Tools. Time studies: stopwatch study, normal time, number of cycles, elemental time files, and predetermined motion times. Work sampling.

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TE: Should know the traditional work measurement methods, stopwatch study and work sampling. Should understand that the traditional methods are needed presently mainly in services.

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

Project management. The elements of a project plan. Global differences in project management. The control of projects: time, cost, performance, and communication. Project planning with Gantt chart and CPM/PERT. Microsoft Project. Project crashing, time-cost analysis.

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TE: Should know the characteristics of projects, the procedure of project planning and the methods (Gantt diagram, CPM/PERT, Microsoft Project). Can control the project implementation. Should understand the importance of project management in the areas of production, services and researches.

#### **Requirements:**

*- For a signature*

Attendance at lectures is recommended, but not compulsory.

*-For a grade*

The course ends in an examination in the exam period.

The minimum requirement for the examination is 60%. 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)

*-An offered grade:*

It may be offered to students if they solves problems at lectures and attend lectures on a regular basis (do not miss more than 1/3 of the lectures). The grade is the average of the papers filed in the semester, the grade is in accordance with the table above.

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

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**Lecturer:** Dr.Miklós Pakurár, associate professor, PhD

<b>Title of course:</b> Analytical Chemistry I. <b>Code:</b> TTKBE0501_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week	
<b>Evaluation:</b> 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, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Furthercoursesbuiltonit:</b> TTKBL0512_EN	

<b>Topics of course</b>
<b>Literature</b>
<i>Compulsory:</i> 1) Syllabus provided by the tutor 2) Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and Co. 3) Vogel's Qualitative Inorganic Analysis, (ed. Gy. Svehla), Longmann, 2007
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Introduction to analytical chemistry. Measurements. Basic equations of equilibrium calculations. <i>2<sup>nd</sup> week</i>

Acids and bases, acid-base theories. The Broensted equation. Buffers.

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

Basic terms related to titrations. Practice of acid-base titrations.

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

Basics of complexometry. Complexometric titrations.

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

Solubility equilibria. Precipitation titrations, argentometry.

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

Redoxi equilibria. Permanganometry.

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

Chromatometry. Bromatometry. Iodometry.

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

Simple separation techniques I. Gravimetry.

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

Simple separation techniques II. Extraction.

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

Chromatographic separations and techniques.

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

Classification of instrumental analytical methods. Evaluation of analytical chemical results.

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

Spectroscopy I. Atomic spectroscopy.

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

Spectroscopy II. UV-Vis spectroscopy.

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

Potentiometry and conductometry.

#### **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, university professor, PhD

**Lecturer:** Dr. Péter Buglyó, university professor, PhD

<b>Title of course:</b> Inorganic and qualitative analytical chemistry laboratory practice <b>Code:</b> TTKBL0511-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: 26 hours - preparation for the exam: 38 hours Total: 120 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN, TTKBL0101_EN	
<b>Further courses built on it:</b> TTKBL0512_EN	

<b>Topics of course</b>
This practice trains the students in qualitative and quantitative inorganic analytical chemistry laboratory operations. In the first 5 practices some experiments and test tube reactions will be performed with inorganic materials. Until Practice 5 the sequence of the analytical topics follows the classical Fresenius system. In the first part of the practices it is required to obtain experience in the identification and separation of inorganic anions and cations. This work is followed by the analysis of "unknown samples". From Practice 6 the students will perform quantitative analytical measurements using classical titration methods. Acid-base titrations, redox titrations and complexometric titrations will be performed. In each practice the students have to analyse an unknown sample and hand in the results for evaluation.
<b>Literature</b>

**Compulsory:**

- 1) Róbert Király and Gábor Lente: Inorganic and Qualitative Analytical Chemistry: Supplementary material for laboratory course  
Department of Inorganic and Analytical Chemistry, University of Debrecen, Hungary, 2011.
- 2) G. Svehla (reviser): Vogel's Qualitative Inorganic Analysis, 6th ed.  
Longman Scientific & Technical Co published in the United States with John Wiley & Sons, Inc.,  
New York, 1994.
- 3) N. N. Greenwood and A. Earnshaw: Chemistry of the Elements  
Butterworth-Heinemann, Reed Educational and Professional Publishing Ltd, 2nd ed. 1997.

**Schedule:**

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

Safety training. General laboratory procedures.

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

Anion group I and II. Qualitative analysis of an unknown sample.

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

Anion group I, II, III and IV. Qualitative analysis of an unknown sample.

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

Cation group I and III. Qualitative analysis of an unknown sample.

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

Cation group I, III, IV and V. Qualitative analysis of an unknown sample.

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

Acid-base titrations. Quantitative analysis of a borax sample.

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

Acid-base titrations. Quantitative analysis of an oxalic acid sample.

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

Titrations with  $\text{AgNO}_3$ . Quantitative analysis of a  $\text{KCl} + \text{KBr}$  sample.

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

Redox titrations with  $\text{KMnO}_4$ . Quantitative analysis of a  $\text{H}_2\text{O}_2$  sample.

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

Iodometric titrations. Quantitative analysis of a  $\text{Cu(II)}$  sample.

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

Iodometric titrations. Quantitative analysis of a  $\text{NaI}$  sample.

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

Complexometric titrations with EDTA. Quantitative analysis of a  $\text{Bi(III)}$  sample.

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

Complexometric titrations with EDTA. Quantitative analysis of a  $\text{Zn(II)} + \text{Cu(II)}$  sample.

**Requirements:**

*- for a signature*

Participation at **practice classes** is compulsory.

*- for a grade*

At the beginning of every practice the students are required to write a short test related to the theoretical background and practical questions of the current experiments. For these tests and for

the analysis of samples, scores are given. The results of the qualitative analytical tasks are also scored. Based on the average score of the above, 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. Csilla Kállay, associate professor, PhD, habil

**Lecturer:** Dr. Csilla Kállay, associate professor, PhD, habil

**Title of course:** Application of Instrumental Analysis I.

**ECTS Credit points:** 1

**Code:** TTKBE0512\_EN

**Type of teaching, contact hours**

- lecture: 1 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 14 hours
- practice: -
- laboratory: -
- home assignment: -
- preparation for the exam: 16 hours

Total: 30 hours

**Year, semester:** 3<sup>rd</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBE0501\_EN

**Further courses built on it:** TTKBL0512\_EN

**Topics of course**

Basic concepts, theoretical and practical aspects, carry-out and use of fundamental laboratory and industrial scale separation processes related to the instrumental analytical chemistry. Set-up, major components and basic operation principles of modern analytical instruments using separation methods in their working methods.

**Literature**

*Compulsory:*

- 1) Separation process principles: chemical and biochemical operations / J. D. Seader, Ernest J. Henley, D. Keith Roper.—3rd ed. 2011, ISBN 978-0-470-48183-7, John Wiley & Sons, Inc.

2) Modern analytical chemistry / David Harvey. — 1st ed., 2000, ISBN 0-07-237547-7, The McGraw-Hill Companies, Inc.

*Recommended:*

- 3) Modern HPLC for practicing scientists / by Michael W. Dong., 2006, John Wiley & Sons, Inc., Hoboken, New Jersey, ISBN-13: 978-0-471-72789-7
- 4) Modern size-exclusion liquid chromatography / André M. Striegel et al., 2nd ed., 2009 by John Wiley & Sons, Inc., ISBN 978-0-471-20172-4
- 5) Modern practice of gas chromatography., 4th ed. / edited by Robert L. Grob, Eugene F. Barry. 2004 by John Wiley & Sons, Inc., ISBN 0-471-22983-0
- 6) Affinity Chromatography Methods and Protocols, 2<sup>nd</sup> Ed., Ed. by Michael Zachariou, 2008, Humana Press, a part of Springer Science+Business Media, LLC, ISBN: 978-1-58829-659-7
- 7) Gel Electrophoresis of Proteins A Practical Approach, 3<sup>rd</sup> Edition, B. D. Hames, Oxford University Press, 1998, ISBN 0-19-963641-9

**Schedule:**

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

Basic concepts of separation processes. Removal of solvents from a mixture by different techniques: partial evaporation, batch and continuous mode thin film evaporators and concentrators. Partial evaporation by a rotating and circulating gas flow. Centrifugal evaporators.

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

Partial freezing, removal of frozen solvent crystals, increase of concentration. Spray drying, freeze drying. Instruments of spray drying, practical use of spray dryin for the production of drugs, and foods. Instruments of freeze drying, laboratory scale to industrial production. Freeze-dried food production and use.

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

Separation of solid mixtures by physical methods: air flow sedimentation, selective dissolution, magnetic separation, flotation. Separation by solubilities, fractionated crystallization, crystallization. Stoke's law. Removal of solids from liquids and gases: sedimentation, centrifugation, cyclons, ultracentrifugation. Separation of emulsions by special centrifuges. Gas separation and isotopes enrichments with gas centrifuges.

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

Filtration: basic concepts, formation and role of filter cakes. The good laboratory practice of filtration. Removal of dust from gas streams, industrial sack-type filteres, filter candles, electrostatic dust collectors. Types of filter media, filter papers, filter membranes. Filtration apparatuses. Vacuum filtration, pressure filtration. Tangential filtration.

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

Extraction: liquid-liquid liquid-solid and liquid-gas processes. From laboratory scale to undustrial liquid-liquid extractors, the role of density, practical uses. Basic rules of extraction, disribution coefficients, selectivites, design of an extraction scheme. Soxhlet extractors, heated and non-heated types. Solid phase extraction (SPE) and solid phase microextraction (SPME), use of SPME in sample preparation. Osmosis, dialysis, reverse osmosis instruments and their use in drinking water production. Membrane dialysis, separation of molecules by size, medical application, hemodialysis.

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

General aspects and types of different chromatographic techniques. Grouping of techniques by the dimension of the separating medium. Layerchromatographies: paper chromatography (PC), thin layer chromatography (TLC). Basics of TLC: tools, chambers, separation modes, geometry,

types of layers, calculations, visualization and evaluation methods. Computer aided analysis of TLC and HPTLC plates. Two-dimensional TLC.

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

Gas chromatography 1: Definition, basics of instruments. Sample preparation for chromatographic analysis: concentration, dissolution, filtration, extraction, head-space sampling, SPME, derivatization, adsorption. General setup, gas supply system, rotating and robot arm sample holders, injectors. The inlet: the key role of rapid sample evaporation.

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

Gas chromatography 2: Types of inlets, oven, temperature control, gas chromatography detectors (FID, ECD, MS). Types of analytes that can be measured by the given detectors. Working principles of FID ECD and MS detectors. Preparative gas chromatography. Web communication within and outside of laboratories. 2D-gas chromatography (2D-GCxGC).

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

High pressure liquid chromatography (HPLC) 1. Basic principles, structure, potential fields of applications. Separation mechanisms and separation modes. Most important structural units and components of the HPLC instrument. Solvent supply system, degass station. Role of degassing, different degassing modes. Gradient formation unit. HPLC pumps, working principles, types, role of depulser. Major types of HPLC columns. Stationary phases, normal phase and reversed phase.

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

HPLC detectors, their working principles, structure, mode of use. (UV-Vis, scanning UV-Vis, diode array, refractive index, fluorescence, evaporative light scattering, and mass spectrometry detectors). Isocratic and gradient elutions. Characterization of the chromatograms. Preparative HPLC.

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

Low pressure chromatography. Traditional, classic column chromatography, dry column chromatography, flash chromatography. Basic operating techniques, limits of separations, hardware requirements, manualmode and instrumentation.

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

Affinity chromatography. General principles, hardware requirements, special interaction between the stationaryphase and the analytes. Elution of the analytes. Operation in column mode and in the batch mode.

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

Gel chromatography. Basic principles, working concepts. Dead volume, gel volume, exclusion limit, penetration. Measurement of the bedvolume, separation of large molecules. Bed making, conditioning. Separation of smaller molecules in organic solvent gel system. Characterization of the gel chromatograms, calculation of the molar mass.

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

Gel electrophoresis. Basic principles, translation of ions within a gel by the external electric potential. Types of gel materials, their use in the separation of proteins and nucleic acids. Vertical and horizontal electrophoresis chamber, gel casting, use of the comb. Loading of samples. Development of the gel. Visualization of the gelectroferograms, blotting. Computer aided evaluation and documentation.

**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.

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

**Lecturer:** Dr. István Lázár, associate professor, PhD

<b>Title of course:</b> Instrumental analysis II <b>Code:</b> TTKBL0512_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> 3 <sup>rd</sup> year, 2 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0501, TTKBL0501	
<b>Further courses built on it:</b>	

#### Topics of course

The series of laboratory practices are based on the topics of different instrumental analysis like electrophoresis, atomic spectrometry, electroanalysis, validation, spectroscopic methods (atomic spectrometry, UV/vis, HPLC). The instrumental laboratories are connected to the topics of the Instrumental Analysis lecture.

#### Literature

1. Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and Co.H.H.

2. Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988.
3. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole
4. Syllabuses provided by the tutor.

**Schedule:**

1<sup>st</sup> week: Introductory guidance, accident protection (2h)

2<sup>nd</sup> week: Evaluation of chromatograms (8h)

3<sup>rd</sup> week: UV-vis spectroscopy (6h)

4<sup>th</sup> week: High Performance Liquid Chromatography II (6h)

5<sup>th</sup> week: Atomic spectroscopy (6h)

6<sup>th</sup> week: pH-metry (6h)

7<sup>th</sup> week: Thin layer chromatography (6h)

8<sup>th</sup> week: Final test (2h)

**Requirements:**

*- for a signature*

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.

*- for a grade*

Grading is given by the average of 3 separate grades:

- 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)
- 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)
- the grade of the final test

The grade of the final test is calculated 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)

**Person responsible for course:** Prof. Dr. Attila Gáspár, university professor, DSc

**Lecturer:** Prof. Dr. Attila Gáspár, university professor, DSc

<b>Title of course:</b> Physical Chemistry I <b>Code:</b> TTKBE0401_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> <ul style="list-style-type: none"><li>- lecture: 2 hours/week</li><li>- practice: -</li><li>- laboratory: -</li></ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"><li>- lecture: 28 hours</li><li>- practice: -</li><li>- laboratory: -</li><li>- home assignment: -</li><li>- preparation for the exam: 62 hours</li></ul> Total: 90 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0101_EN, TTFBE2111_EN, TTMBE0808_EN	
<b>Further courses built on it:</b> TTKBE0402_EN, TTKBE0202_EN, MFVGE31V03_EN, TTKBG0402_EN, TTKBE0302_EN, TTKBE0501_EN, TTKBE1111_EN, TTKBL1111_EN, TTKBE0204_EN, TTKBG0614_EN, TTKBG0312_EN, TTKBL0311_EN, TTKBL0511_EN	

### Topics of course

The series of lectures are based on the topics of chemical thermodynamics and equilibrium studies. It reviews the fundamental relations of physical chemistry. The course help to build and strengthen the concepts of physical chemistry in the students' scientific view. In this way the basic concepts and phenomena learned, especially in the General Chemistry course (prerequisite) will be placed into more exact and mathematically well-established surrounding. Application of the approach of physical chemistry in chemical engineering is discussed through examples. The main chapters include: Description of gases. Laws of thermodynamics. Thermochemistry. Description of one component and multicomponent systems. Equilibrium.

### Literature

#### *Compulsory:*

- P.W: Atkins, J. de Paula (2006): Atkins' PhysicalChemistry 8th Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8.
- J. M. Smith, H. C. van Ness, M. M. Abbott (2003): Introduction to Chemical Engineering Thermodynamics 6<sup>th</sup> Edition, McGraw-Hill, ISBN 0-07-240296-2 ISBN:978-0070494862.
- Lecture notes and teaching material available via the e-learning system.

- Leo Lue (2009): Chemical Thermodynamics, Leo Lue and Ventus Publishing, ISBN: 9788776814977. Can be downloaded from bookboon.com

*Recommended:*

- A. J. Fletcher (2012): Chemistry for Chemical Engineers, ISBN: 9788740302493. Can be downloaded from bookboon.com
- Other corresponding books from bookboon.com

**Schedule:**

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

Ideal and real gases

Concepts: Ideal gas and the state equation. Isotherm, isobar and isochor changes. Pressure of gases and its statistical interpretation. Mixture of ideal gases, molar fraction and partial pressure Dalton's law. Real gases, isotherms. Compressibility factor. Real gases and van der Waals equation. Molecular explanation of the pressure and volume correction. The virial equation. List of mathematical tools used during the course. Phenomenological and statistical approach. SI system and units. Dimension analysis. The 0th law of thermodynamics

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

The 1<sup>st</sup> law of thermodynamics

Concepts: Description and formulation of 1<sup>st</sup> law of thermodynamics. Internal energy and molecular explanation. Work and energy. Volume and other work. Heat. Enthalpy. Internal energy of ideal gases. Joule expansion experiment. Enthalpy and internal energy of real gases. Joule-Thomson experiment and Joule-Thomson coefficient. Liquefaction of gases. . Conservative force fields in physics. Exact differential.

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

Thermochemistry

Concepts: Thermochemical equations. Standard state. Reaction heat and its thermodynamic definition. Hess' law. Enthalpy of formation and enthalpy of combustion. Experimental determination of reaction enthalpy. Heat capacity. Temperature dependence of heat capacity. Kirchoff's law.

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

2<sup>nd</sup> law of thermodynamics

Concepts: Description and formulation of the 2nd law. Definition of entropy in thermodynamics and statistical definition. The entropy change of the system and the surrounding during reversible and irreversible isotherm, expansion of ideal gases. Entropy change of adiabatic processes. Transformation of heat into work. Efficiency. Heat engines, refrigerators, heat pumps. Temperature as integral dividend.

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

3<sup>rd</sup> law of thermodynamics

Concepts: Entropy and molar heat capacity. Heat capacity at extreme low temperatures. Absolute zero degree. Description and formulation of the 3<sup>rd</sup> law. Temperature dependence of entropy. Absolute and standard entropy. Standard reaction entropy. Comparison of phenomenological and statistical approach.

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

Potential functions in thermodynamics

Concepts: Unification of the 1<sup>st</sup> and 2<sup>nd</sup> laws. Maximum useful work and its molecular explanation Free energy (Helmholtz) and free enthalpy (Gibbs) Potential function and their properties. Direction of spontaneous processes. Equilibrium in closed and open systems. Equilibrium and steady state.

#### 7<sup>th</sup> week

##### Chemical potential

Concepts: Chemical potential and its calculation one component and multicomponent systems. Gibbs–Duhem equation. Chemical potential in two component gas and liquid mixtures, ideal and real solutions Raoult's law and Henry's law. Fugacity and activity and its thermodynamic importance. Choice of standard state. The fundamental equation.

#### 8<sup>th</sup> week

##### Thermodynamics of one component systems

Concepts: Phase and component. Types of phase transitions. Application of chemical potential in the description of equilibrium of multiple phase one component systems. Phase stability and phase transition. Clapeyron's and Clausius–Clapeyron equation. Liquid-vapour systems, evaporation, boiling, enthalpy of evaporation, boiling point, saturated vapour pressure, entropy of evaporation. Trouton's law and phase diagram. Phase diagram of CO<sub>2</sub> and water.

#### 9<sup>th</sup> week

##### Thermodynamics of two component mixtures and dilute solutions

Concepts: Ideal and real mixtures. Partial molar quantities. Partial molar volume and its determination. Thermodynamics of mixing. Excess functions of mixing, enthalpy and entropy of mixing. Colligative properties: melting point depression, boiling point elevation and osmosis. Practical importance and applications of colligative properties.

#### 10<sup>th</sup> week

##### Mixture of volatile components

Concepts: Vapour pressure of liquid mixtures. Vapour pressure and composition, boiling point-composition equilibrium plots for ideal and real mixtures. Distillation, azeotropic mixtures. Distribution equilibrium, Vapour pressure of non-miscible liquids. Steam distillation.

#### 11<sup>th</sup> week

##### Phase rule

Concepts: component, phase, degree of freedom. Phase rule. Phase diagram of partially miscible liquids. Eutectics, phase diagram of two component solids. Cooling of two component mixtures. Three component systems and their presentation in triangle diagram.

#### 12<sup>th</sup> week

##### Thermodynamic equilibrium in reactive systems.

Concepts: Chemical equilibrium. Reaction free energy. Exergonic and endergonic processes. Equilibrium constant. Standard reaction enthalpy and its relation to equilibrium constant and chemical potentials. Determination of equilibrium constant from thermodynamic data. Types of equilibrium constant: K<sub>p</sub>, K<sub>x</sub>, K<sub>a</sub>. Reaction quotient and equilibrium constant.

#### 13<sup>th</sup> week

##### Effect of parameters on chemical equilibrium

Concepts: Dynamic nature of equilibrium, La-Chatalier principle. Effect of pressure and temperature on the equilibrium constant, van't Hoff equation. Effect of addition of reactants and products. Practical applications.

#### 14<sup>th</sup> week

##### Chemical equilibrium in various systems.

Concepts: Types of equilibria: one step, multiple step, parallel, consecutive equilibrium. Equilibrium in homogeneous systems: acid-base, redoxy and stepwise equilibrium. Dissociation in solution and gas phase, equilibrium of reaction systems. Thermodynamics of ATP.

Heterogeneous equilibrium, solubility product, decomposition of solids, adsorption of gases on solids. Buffers. pH scale and calculation of pH. Haber process.

**Requirements:**

- *for a signature*

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

During the semester there is a written end-term test in the 14<sup>th</sup> week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- *for a grade*

The course ends in a **written or oralexamination**. 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.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or 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 on the basis of the result of the end-term test if the grade is at least satisfactory (3).

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

**Lecturer:** Dr. Attila Bényei, associate professor, PhD

<b>Title of course:</b> Physical Chemistry I. <b>Code:</b> TTKBG0401_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: 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> TTKBE0101_EN, TTFBE2111_EN, TTMBE0808_EN, parallel registration to TTKBE0401_EN
<b>Further courses built on it:</b> -

<b>Topics of course</b>
The problem solving classes are based on the topics of the lectures in the field of chemical thermodynamics and equilibrium studies. Calculations are made for better understanding the fundamental relations of physical chemistry. The course help to build and strengthen the concepts of physical chemistry in the students' scientific view. In this way the basic concepts and phenomena learned, especially in the General Chemistry course (prerequisite) will be placed into more exact and mathematically well-established surrounding. Application of the approach of physical chemistry in chemical engineering is discussed through examples. The main chapters include: Description of gases. Laws of thermodynamics. Thermochemistry. Description of one component and multicomponent systems. Equilibrium.
<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. M. Smith, H. C. van Ness, M. M. Abbott (2003): Introduction to Chemical Engineering Thermodynamics 6<sup>th</sup> Edition, McGraw-Hill, ISBN 0-07-240296-2 ISBN:978-0070494862.</li> <li>- List of problems, their solutions and other teaching material available via the e-learning system.</li> <li>- L. Lue (2009): Chemical Thermodynamics, Leo Lue and Ventus Publishing, ISBN: 9788776814977. Can be downloaded from bookboon.com</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- A. J. Fletcher (2012): Chemistry for Chemical Engineers, ISBN: 9788740302493. Can be downloaded from bookboon.com</li> <li>- Other corresponding books from bookboon.com</li> </ul>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i>      Ideal and real gases</p> <p>Problem solving and calculations in the following topics: Ideal gas and the state equation. Isotherm, isobar and isochor changes. Pressure of gases and its statistical interpretation. Mixture of ideal gases, molar fraction and partial pressure Dalton's law. Real gases, isotherms. Compressibility factor. Real gases and van der Waals equation. Molecular explanation of the pressure and volume correction. The virial equation. List of mathematical tools used during the course. Phenomenological and statistical approach. SI system and units. Dimension analysis. The 0th law of thermodynamics</p> <p><i>2<sup>nd</sup> week</i>      The 1<sup>st</sup> law of thermodynamics</p> <p>Problem solving and calculations in the following topics: Description and formulation of 1<sup>st</sup> law of thermodynamics. Internal energy and molecular explanation. Work and energy. Volume and other work. Heat. Enthalpy. Internal energy of ideal gases. Joule expansion experiment. Enthalpy and internal energy of real gases. Joule-Thomson experiment and Joule-Thomson coefficient. Liquefaction of gases. . Conservative force fields in physics. Exact differential.</p>

<i>3<sup>rd</sup> week</i>	Thermochemistry
Problem solving and calculations in the following topics: Thermochemical equations. Standard state. Reaction heat and its thermodynamic definition. Hess' law. Enthalpy of formation and enthalpy of combustion. Experimental determination of reaction enthalpy. Heat capacity. Temperature dependence of heat capacity. Kirchoff's law.	
<i>4<sup>th</sup> week</i>	2 <sup>nd</sup> law of thermodynamics
Problem solving and calculations in the following topics: Description and formulation of the 2 <sup>nd</sup> law. Definition of entropy in thermodynamics and statistical definition. The entropy change of the system and the surrounding during reversible and irreversible isotherm, expansion of ideal gases. Entropy change of adiabatic processes. Transformation of heat into work. Efficiency. Heat engines, refrigerators, heat pumps. Temperature as integral dividend.	
<i>5<sup>th</sup> week</i>	3 <sup>rd</sup> law of thermodynamics
Problem solving and calculations in the following topics: Entropy and molar heat capacity. Heat capacity at extreme low temperatures. Absolute zero degree. Description and formulation of the 3 <sup>rd</sup> law. Temperature dependence of entropy. Absolute and standard entropy. Standard reaction entropy. Comparison of phenomenological and statistical approach.	
<i>6<sup>th</sup> week</i>	Potential functions in thermodynamics
Problem solving and calculations in the following topics: Unification of the 1 <sup>st</sup> and 2 <sup>nd</sup> laws. Maximum useful work and its molecular explanation Free energy (Helmholtz) and free enthalpy (Gibbs) Potential function and their properties. Direction of spontaneous processes. Equilibrium in closed and open systems. Equilibrium and steady state.	
<i>7<sup>th</sup> week</i>	Chemical potential
Problem solving and calculations in the following topics: Chemical potential and its calculation one component and multicomponent systems. Gibbs–Duhem equation. Chemical potential in two component gas and liquid mixtures, ideal and real solutions Raoult's law and Henry's law. Fugacity and activity and its thermodynamic importance. Choice of standard state. The fundamental equation.	
<i>8<sup>th</sup> week</i>	Thermodynamics of one component systems
Problem solving and calculations in the following topics: Phase and component. Types of phase transitions. Application of chemical potential in the description of equilibrium of multiple phase one component systems. Phase stability and phase transition. Clapeyron and Clausius–Clapeyron equation. Liquid-vapour systems, evaporation, boiling, enthalpy of evaporation, boiling point, saturated vapour pressure, entropy of evaporation. Trouton's law and phase diagram. Phase diagram of CO <sub>2</sub> and water.	
<i>9<sup>th</sup> week</i>	Thermodynamics of two component mixtures and dilute solutions
Problem solving and calculations in the following topics: Ideal and real mixtures. Partial molar quantities. Partial molar volume and its determination. Thermodynamics of mixing. Excess functions of mixing, enthalpy and entropy of mixing. Colligative properties: melting point depression, boiling point elevation and osmosis. Practical importance and applications of colligative properties.	
<i>10<sup>th</sup> week</i>	Mixture of volatile components
Problem solving and calculations in the following topics: Vapour pressure of liquid mixtures. Vapour pressure and composition, boiling point-composition equilibrium plots for ideal and real mixtures. Distillation, azeotropic mixtures. Distribution equilibrium, Vapour pressure of non-miscible liquids. Steam distillation.	
<i>11<sup>th</sup> week</i>	Phase rule

Problem solving and calculations in the following topics: component, phase, degree of freedom. Phase rule. Phase diagram of partially miscible liquids. Eutectics, phase diagram of two component solids. Cooling of two component mixtures. Three component systems and their presentation in triangle diagram.

*12<sup>th</sup> week* Thermodynamic equilibrium in reactive systems.

Problem solving and calculations in the following topics: Chemical equilibrium. Reaction free energy. Exergonic and endergonic processes. Equilibrium constant. Standard reaction enthalpy and its relation to equilibrium constant and chemical potentials. Determination of equilibrium constant from thermodynamic data. Types of equilibrium constant:  $K_p$ ,  $K_x$ ,  $K_a$ . Reaction quotient and equilibrium constant.

*13<sup>th</sup> week* Effect of parameters on chemical equilibrium

Problem solving and calculations in the following topics: Dynamic nature of equilibrium, La-Chatelier principle. Effect of pressure and temperature on the equilibrium constant, van't Hoff equation. Effect of addition of reactants and products. Practical applications.

*14<sup>th</sup> week* Chemical equilibrium in various systems.

Problem solving and calculations in the following topics: Types of equilibria: one step, multiple step, parallel, consecutive equilibrium. Equilibrium in homogeneous systems: acid-base, redox and stepwise equilibrium. Dissociation in solution and gas phase, equilibrium of reaction systems. Thermodynamics of ATP. Heterogeneous equilibrium, solubility product, decomposition of solids, adsorption of gases on solids. Buffers. pH scale and calculation of pH. Haber process.

### **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. 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 calculators or computers pencil and ruler to each practice class. 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.

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. The problems to be solved and calculated are highly analogous with the ones made available in e-learning system. Scoring system is also provided, i.e. possible maximum points for the given problem.

*- for a grade*

The course ends with signature and mark. The mark is based on the result of the two tests scored according to pre-set maximum points for each sub-problems.

The minimum requirement for the mark 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 score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

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**Lecturer:** Dr. Attila Bényei, associate professor, PhD

<b>Title of course:</b> Physical Chemistry II. <b>Code:</b> TTKBE0402_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: -</li> <li>- preparation for the exam: 62 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0401_EN, TTKBE0201_EN, TTKBE0301_EN	
<b>Further courses built on it:</b> TTKBE0403_EN, TTKBL0411_EN, TTKBE0405_EN	
<b>Topics of course</b>	
<p>The series of lectures are based on the topics of electrochemistry and reaction kinetics. It reviews the fundamental relations of physical chemistry. The course helps to build and strengthen the concepts of physical chemistry in the students' scientific view. Application of the approach of physical chemistry in chemical engineering is discussed through examples. The main chapters include: Homogeneous and heterogeneous equilibrium electrochemistry. Transport processes. Kinetics of homogeneous and heterogeneous reactions.</p>	
<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 8th Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8.</li> <li>- H. S. Fogler (2011): Elements of Chemical Reaction Engineering, 4<sup>th</sup> Edition, Prentice Hall, ISBN: 0-13-047394-4. ISBN: 9780130473943.</li> <li>- R.M. Pashley, M. E. Karaman: Applied Colloid and Surface Chemistry. ISBN 13 978-0-470-86882-9(HB) Teaching material is available via the e-learning system</li> <li>- R. Kandiyoti (2009): Fundamentals of Chemical Reaction Engineering, R. Kandiyoti and Ventus Publishing, ISBN: 9788776815103. Can be downloaded from bookboon.com</li> </ul>	
<i>Recommended:</i>	

-R. Kandiyoti (2009): Fundamentals of Chemical Reaction Engineering- Examples, R. Kandiyoti and Ventus Publishing, ISBN: 9788776815127. Can be downloaded from bookboon.com

**Schedule:**

*1<sup>st</sup> week* Homogeneous equilibrium electrochemistry. Thermodynamics of electrolyte solutions  
Concepts: Thermodynamic functions of ions. Standard state of ions. Activity in electrolyte solutions. Mean activity coefficient and its experimental determination. Debye-Hückel limiting law. Ionic strength. Solubility equilibria of salts and effect of ionic strength on the solubility. Calculation of solubility from thermodynamic tables Ostwald's law of dilution.

*2<sup>nd</sup> week* Heterogeneous equilibrium electrochemistry. Thermodynamics of electrodes.  
Concepts: Processes on electrodes. Main types of electrodes, gas electrodes, first and second kind electrodes, redox electrodes. Dependence of electrode potential on concentrations. Nernst equation. Standard electrode potential. Measurement of pH, glass electrode. Redox potentials and their application. Half reactions. Electrochemical series. Electrolysis, industrial applications.

*3<sup>rd</sup> week* Thermodynamics of galvanic cells  
Concepts: Electrodes and galvanic cells. Diffusion potential and its elimination. Types of batteries. Chemistry of various batteries. Thermodynamics of batteries. The connection between electromotive force and reaction free enthalpy. Thermodynamic parameters from electrochemistry measurement.

*4<sup>th</sup> week* Transport processes  
Concepts: Flux. Diffusion. Fick I and Fick II law. Stokes-Einstein equation. Diffusion equation and their solutions. Convection, diffusion and chemical reaction. Heat conductance. Viscosity. Uniform discussion of transport processes.

*5<sup>th</sup> week* Movement of ions in electrolyte solutions. Conductance of electrolytes  
Concepts: Measurement of conductivity and conductance. Molar conductivity and its dependence on concentration. Conductivity of weak and strong electrolytes. Kohlrausch's law. Independent migration of ions. Transference number and its determination. Interaction among moving ions. -

*6<sup>th</sup> week* Reaction kinetics. Rate of chemical reactions. Rate law of chemical reactions  
Concepts: Definition of reaction rate. Experimental methods to determine reaction rates. Fast reaction kinetics. Flow, relaxation and other techniques. Types of reactors. Rate equation, rate coefficient and order of reaction. Experimental methods to determine rate equation. Methods to evaluate experimental results.

*7<sup>th</sup> week* Kinetics of simple reactions  
Concepts: Formal kinetics. Rate equation of first and second order reactions. Integral forms. Third order reactions. Formal kinetics of equilibrium. Consecutive reactions. Rate determining step. Half-life methods.

*8<sup>th</sup> week* Complex reaction systems  
Concepts: Elementary reactions and molecularity. Simplification of reaction rate determination, flooding or isolation. Steady state and pre-equilibrium. Unimolecular reactions and their Lindemann–Hinshelwood-mechanism. Enzyme reactions, Michaelis–Menten mechanism.

*9<sup>th</sup> week* Reaction encounters  
Concepts: Basic steps of chain reactions: initiation, propagation, branching, termination. Formation of hydrogen halogenides. Thermal and chain explosion, explosion limits. The Hinshelwood–Semenov mechanism. Catalysis, formal kinetic description and energetics of catalysis. Homogeneous and heterogeneous catalytic systems Autocatalysis and chemical feedback. Continuous and open reactors.

*10<sup>th</sup> week* Collision theory of chemical reactions

Concepts: Temperature dependence of rate coefficient, Arrhenius equation. Activation energy. Collision theory, its basic assumptions. Interpretation and calculation of pre-exponential factor. Steric factor, the anchoring mechanisms, Diffusion driven and activation energy driven reactions.

*11<sup>th</sup> week*                    The activated complex theory of chemical reactions

Concepts: The history of development of activated complex theory and the basic assumptions of the theory. Activated complex and its concentration, experimental evidences. Statistical mechanics in the activated complex theory. Thermodynamic approach in the activated complex theory. Activation free enthalpy activation enthalpy and entropy. Determination of activation parameters Non-thermal activation. Basics of photochemistry, industrial applications.

*12<sup>th</sup> week*                    Processes on solid surfaces

Concepts: Structure of solids and surfaces. Physisorption and chemisorption, their properties and differentiation. Isotherms, Langmuir- and BET-isotherms, basic assumptions of the models.

Adsorption enthalpy. Basic steps of surface processes, possible rate determining step.

Heterogeneous catalysis, the Langmuir–Hinshelwood- and Eley–Rideal mechanisms.

Heterogeneous catalytic processes in the chemical industry. Solid-liquid interface in electrochemistry. Basics of dynamic electrochemistry.

*13<sup>th</sup> week*                    Physical chemistry of colloid

Concepts: Introduction to the nature of colloidal systems, types of colloidal systems. The concept of surface tension. Wetting and spreading. Curved surfaces. Electric double layer, electrokinetic potential. The colloid stability.

*14<sup>th</sup> week*                    Application of colloids, nanoparticles

Concepts: Coherent incoherent systems. The basics of rheology. Liophobic colloids: aerosols, liosols, xerosols. Applications of colloids: nanoparticles, emulsions, suspensions foams.

Liophilic colloids: association and macromolecular systems. The theory of surfactants and cleaning

**Requirements:**

*- for a signature*

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

During the semester there is a written end-term test in the 14<sup>th</sup> week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

*- for a grade*

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

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or 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 on the basis of the result of the end-term test if the grade is at least satisfactory (3).
<b>Person responsible for course:</b> Dr. Attila Bényei, associate professor, PhD
<b>Lecturer:</b> Dr. Attila Bényei, associate professor, PhD

<b>Title of course:</b> Physical Chemistry II.	<b>ECTS Credit points:</b> 2
<b>Code:</b> TTKBG0402_EN	
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 2 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 28 hours</li> <li>- laboratory: -</li> <li>- home assignment: 30 hours</li> <li>- preparation for the exam: -</li> </ul>	
Total: 58 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0401_EN, TTKBE0201_EN, TTKBE0301_EN, parallel registration to TTKBE0402_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The problem solving classes are based on the topics of the lectures in the field of electrochemistry, reaction kinetics, and colloid chemistry. Calculations are made for better understanding the fundamental relations of physical chemistry. The course help to build and strengthen the concepts of physical chemistry in the students' scientific view. In this way the basic concepts and phenomena learned, especially in the General Chemistry course (prerequisite) will be placed into more exact and mathematically well-established surrounding. Application of the approach of physical chemistry in chemical engineering and industry is discussed through examples. The main chapters include: Homogeneous and heterogeneous equilibrium, electrochemistry, Transport processes, Kinetics of homogeneous and heterogeneous reactions, Physical chemistry of colloids.
<b>Literature</b>
<i>Compulsory:</i>

- 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.
- H. S. Fogler (2011): Elements of Chemical Reaction Engineering, 4<sup>th</sup> Edition, Prentice Hall, ISBN: 0-13-047394-4. ISBN: 9780130473943.
- R. M. Pashley, M. E. Karaman: Applied Colloid and Surface Chemistry. ISBN 13 978-0-470-86882-9(HB)
- List of problems, their solutions and other teaching material available via the e-learning system.
- R. Kandiyoti (2009): Fundamentals of Chemical Reaction Engineering, R. Kandiyoti and Ventus Publishing, ISBN: 9788776815103. Can be downloaded from bookboon.com

*Recommended:*

- R. Kandiyoti (2009): Fundamentals of Chemical Reaction Engineering- Examples, R. Kandiyoti and Ventus Publishing, ISBN: 9788776815127. Can be downloaded from bookboon.com

**Schedule:**

*1<sup>st</sup> week* Homogeneous equilibrium electrochemistry. Thermodynamics of electrolyte solutions. Problem solving and calculations in the following topics: Thermodynamic functions of ions. Standard state of ions. Activity in electrolyte solutions. Mean activity coefficient and its experimental determination. Debye-Hückel limiting law. Ionic strength. Solubility equilibria of salts and effect of ionic strength on the solubility. Calculation of solubility from thermodynamic tables Ostwald's law of dilution.

*2<sup>nd</sup> week* Heterogeneous equilibrium electrochemistry. Thermodynamics of electrodes. Problem solving and calculations in the following topics: Processes on electrodes. Main types of electrodes, gas electrodes, first and second kind electrodes, redox electrodes. Dependence of electrode potential on concentrations. Nernst equation. Standard electrode potential. Measurement of pH, glass electrode. Redox potentials and their application. Half reactions. Electrochemical series. Electrolysis, industrial applications.

*3<sup>rd</sup> week* Thermodynamics of galvanic cells

Problem solving and calculations in the following topics: Electrodes and galvanic cells. Diffusion potential and its elimination. Types of batteries. Chemistry of various batteries. Thermodynamics of batteries. The connection between electromotive force and reaction free enthalpy. Thermodynamic parameters from electrochemistry measurement.

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

Problem solving and calculations in the following topics: Flux. Diffusion. Fick I. and Fick II. law. Stokes-Einstein equation. Diffusion equation and their solutions. Convection, diffusion and chemical reaction. Heat conductance. Viscosity. Uniform discussion of transport processes.

*5<sup>th</sup> week* Movement of ions in electrolyte solutions. Conductance of electrolytes

Problem solving and calculations in the following topics: Measurement of conductivity and conductance. Molar conductivity and its dependence on concentration. Conductivity of weak and strong electrolytes. Kohlrausch's law. Independent migration of ions. Transference number and its determination. Interaction among moving ions.

*6<sup>th</sup> week* Reaction kinetics. Rate of chemical reactions. Rate law of chemical reactions

Problem solving and calculations in the following topics: Definition of reaction rate.

Experimental methods to determine reaction rates. Fast reaction kinetics. Flow, relaxation and other techniques. Types of reactors. Rate equation, rate coefficient and order of reaction.

Experimental methods to determine rate equation. Methods to evaluate experimental results.

*7<sup>th</sup> week* Kinetics of simple reactions

Problem solving and calculations in the following topics: Formal kinetics. Rate equation of first and second order reactions. Integral forms. Third order reactions. Formal kinetics of equilibrium. Consecutive reactions. Rate determining step. Half-life methods.

*8<sup>th</sup> week* Complex reaction systems

Problem solving and calculations in the following topics: Elementary reactions and molecularity. Simplification of reaction rate determination, flooding or isolation. Steady state and pre-equilibrium. Unimolecular reactions and their Lindemann–Hinshelwood mechanism. Enzyme reactions, Michaelis–Menten mechanism.

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

Problem solving and calculations in the following topics: Basic steps of chain reactions: initiation, propagation, branching, termination. Formation of hydrogen halogenides. Thermal and chain explosion, explosion limits. The Hinshelwood–Semenov mechanism. Catalysis, formal kinetic description and energetics of catalysis. Homogeneous and heterogeneous catalytic systems Autocatalysis and chemical feedback. Continuous and open reactors.

*10<sup>th</sup> week* Collision theory of chemical reactions

Problem solving and calculations in the following topics: Temperature dependence of rate coefficient, Arrhenius equation. Activation energy. Collision theory, its basic assumptions. Interpretation and calculation of pre-exponential factor.

Steric factor, the anchoring mechanisms, Diffusion driven and activation energy driven reactions.

*11<sup>th</sup> week* The activated complex theory of chemical reactions

Problem solving and calculations in the following topics: The history of development of activated complex theory and the basic assumptions of the theory. Activated complex and its concentration, experimental evidences. Statistical mechanics in the activated complex theory. Thermodynamic approach in the activated complex theory. Activation free enthalpy activation enthalpy and entropy. Determination of activation parameters Non-thermal activation. Basics of photochemistry, industrial applications.

*12<sup>th</sup> week* Processes on solid surfaces

Problem solving and calculations in the following topics: Structure of solids and surfaces. Physisorption and chemisorption, their properties and differentiation. Isotherms, Langmuir and BET isotherms, basic assumptions of the models. Adsorption enthalpy. Basic steps of surface processes, possible rate determining step. Heterogeneous catalysis, the Langmuir–Hinshelwood and Eley–Rideal mechanisms. Heterogeneous catalytic processes in the chemical industry. Solid-liquid interface in electrochemistry. Basics of dynamic electrochemistry.

*13<sup>th</sup> week* Physical chemistry of colloid

Problem solving and calculations in the following topics: Introduction to the nature of colloidal systems, types of colloidal systems. The concept of surface tension. Wetting and spreading. Curved surfaces. Electric double layer, electrokinetic potential. The colloid stability.

*14<sup>th</sup> week* Application of colloids, nanoparticles

Problem solving and calculations in the following topics: Coherent incoherent systems. The basics of rheology. Liophobic colloids: aerosols, liosols, xerosols. Applications of colloids: nanoparticles, emulsions, suspensions, foams.

Liophilic colloids: association and macromolecular systems. The theory of surfactants and cleaning

**Requirements:**

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 calculators or computers pencil and ruler to each practice class. 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.

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. The problems to be solved and calculated are highly analogous with the ones made available in e-learning system. Scoring system is also provided, i.e. possible maximum points for the given problem.

- for a grade

The course ends with signature and mark. The mark is based on the result of the two tests scored according to pre-set maximum points for each sub-problems.

The minimum requirement for the mark 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 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. Attila Bényei, associate professor, PhD

**Lecturer:** Dr. Attila Bényei, associate professor, PhD

<b>Title of course:</b> Physical Chemistry II. (lab.) <b>Code:</b> TTKBL0411_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> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	

**Its prerequisite(s):** TTKBL0101\_EN, TTKBE0402\_EN

**Further courses built on it:** -

### **Topics of course**

The aim of this course is to help students to get a deeper understanding of the complex physico-chemical theories by performing experiments with basic techniques. To teach them how to use laboratory equipments, how to carry out experiments and how to interpret experimental results. The tasks of this course are mainly based on kinetics, thermodynamics, phase equilibria, electrochemistry.

Set of measurements:

101. Measuring densities by pycnometer, composition of a binary mixture
102. Measuring the heat capacities of metals by calorimetry
103. Measuring electrical conductivity of solutions
104. Measuring the concentration of a coloured solute by spectrophotometry
105. Determination of  $\text{NaHCO}_3$  content of a solid sample by gas volumetry
106. pH-metric titration curves of hydrochloric and acetic acids
107. Study of Cooling Curve
108. Study of electrolysis
109. Mutarotation of glucose measured by polarimetry
110. Measuring electromotive force of a galvanic cell
111. Refractometry and viscosimetry
112. Determination of enthalpy of dissolution
113. Investigation of redox electrodes
114. Conductometry
115. Reaction rate of decomposition of  $\text{H}_2\text{O}_2$  measured by gas volumetry
116. Investigation of buffers
117. Electrochemical investigation of corrosion
118. Distillation of an alcohol-water mixture
201. Determination of heat of combustion by using a bomb calorimeter
202. Thermodynamic quantities by measuring the temperature dependent EMF
203. Determination of partial molar volumes by measuring densities
204. Determination of the enthalpy and entropy of vaporization of liquids
205. Redox potentials from potentiometric titrations
206. Investigation of Kohlrausch's law
207. Determination of activity coefficient for concentration galvanic cell
208. Determination of diffusion coefficient by layered ("schlieren") method
209. Study of the photochemical degradation of tris(oxalato)iron(III) complex
210. Determination of protonation constants of an indicator
211. Study of the iodine-iodide equilibrium
212. Dissociation constant of weak acids measured by conductometry
213. Dissociation equilibria of ampholites, determination of isoelectric pH
214. Study of stepwise complex formation
215. Decomposition kinetics of Kalmopyrin
216. Acid catalysed hydrolysis of saccharose
217. Kinetics of a second order reaction: hydrolysis of esters

218. Determination of activation energy  
 219. Initial rates and activation energy of the iodine clock

**Literature**

- Laboratory notes and additional teaching materials 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
- K. Ósz, 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 4 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

**Title of course:** Physical chemistry III.

**Code:** TTKBE0403\_EN

**ECTS Credit points:** 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, 2 <sup>nd</sup> semester
<b>Its prerequisite(s):</b> TTKBE0402_EN
<b>Further courses built on it:</b> TTKBE0504_EN, TTKBE0415_EN, TTKBE0617_EN

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Basic properties of interfaces.</li> <li>- Adsorption.</li> <li>- Electric double layer.</li> <li>- Kinetics of heterogeneous reactions.</li> <li>- Heterogeneous catalysis.</li> <li>- Dynamic electrochemistry.</li> <li>- Practical applications of electrochemistry.</li> <li>- Definition, discovery, application of radioactivity.</li> <li>- Parts, structure of atomic nucleus, stable and radioactive nuclei.</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, nuclear energy production.</li> <li>- Chemical and biological effects of radiation.</li> <li>- Detection and measurement of radiation.</li> <li>- Environmental radioactivity.</li> </ul>
<b>Literature</b>
<p><b>Compulsory:</b></p> <ul style="list-style-type: none"> <li>- Atkins, P.W. 1990. Physical Chemistry, Oxford University Press, Oxford.</li> <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> </ul>
<p><b>Schedule:</b>  <i>1<sup>st</sup> week</i></p>

Formation and properties of interfaces, methods for studying interfaces. Interfacial microscopic and macroscopic properties, surface analytical methods

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

Interfacial thermodynamics: adsorption of gases on solid surface, adsorption isotherms, determination of surface area. Decrease of surface energy by adsorption, quantitative description of the process

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

Solid/liquid interfaces, electric double layer. Surface excess concentration on solid/liquid interfaces, the role of interfacial electric properties

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

Kinetics of interfacial reactions. Heterogeneous catalysis. Steps of heterogeneous reactions, rate-determining step. Applications of heterogeneous catalysis

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

Dynamic electrochemistry. Rate of charge transport, activation free energy, relations of current and voltage (Erdey-Grúz and Volmer theory), exchange current, overpotential, polarization.

Definitions and relations on electrode reactions.

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

Effects determining the rate of charge transfer, the influence of transport on kinetics of electrode reaction: diffusion, migration, and convection. Diffusion current, diffusion limit. Effects determining the electron transfer, selection of potential determining process

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

Electrochemistry in practice, electrolysis, voltage sources, industrial electrochemical processes, corrosion and passivity. Application of electrochemistry

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

Discovery of radioactivity, consequences. Properties and constituents of nucleus. Stable and radioactive nuclei. Isobar nuclei. Cause and result of radioactive decay. Radioactivity is a natural process. Scientific and practical consequences of the discovery of radioactivity.

Stability/radioactivity of atomic nuclei, decay type are determined by the ratio of protons to neutrons.

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

Kinetics of radioactive decay. Simple radioactive decay. Branching decay. Successive decay.

Radioactive equilibria: secular and transient equilibria. Natural decay series. Formulas expressing the kinetics of radioactive decay. Radioactive equilibria in nature.

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

Radioactive nuclei. Types of radioactive decay. Alpha, beta decays, electron capture, isomeric transition (gamma radiation). Spontaneous fission. Interaction of radiation with matter.

Probability, of the interactions. Interaction of alpha radiation with matter. Types of radioactive decay, emitted particles and photons. Energy release. General aspects of radiation-matter interactions.

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

Interaction of beta radiation with matter: ionization, Brehms strahlung, Cherenkov radiation, annihilation (positron emission tomography), back-scattering, absorption, self-absorption.

Interaction of gamma and X-rayradiation with matter: Compton scattering, photoelectric effect, pair formation. General aspects of the interaction of beta radiation and high energy electromagnetic radiation, respectively, with matter.

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

Nuclear reactions, Conservation rules, kinetics. Nuclear reactions with neutrons. Nuclear reactions with charged particles. Nuclear energy production. Fission reaction with thermal neutrons. Main parts of nuclear reactors. Breeder reactors. Transformation of atomic nuclei. Basic reaction of nuclear energy production. Structure of nuclear reactors.

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

Environmental aspects of nuclear energy production, disposal of nuclear waste.

Detection and measurement of nuclear radiation. Detectors, electric units. Ionization, scintillation, semiconductor detectors. Imaging of radiation. Positive and negative impacts of nuclear energy production. Detection and measurement of radiation.

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

Dosimetry. Irradiation, absorbed, effective doses. The effect of nuclear radiation on living organisms: physical, chemical, biological effects, Radiolysis of water. Dose limits. Natural and artificial radionuclide in the environment. Effect of radiation on living organisms. Sources and quantity of environmental radioactivity.

**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

**Title of course:** Macromolecular Chemistry  
**Code:** TTKBE0611\_EN

**ECTS Credit points:** 3

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice:-
- laboratory: -
- home assignment: 12 hours
- preparation for the exam: 50 hours

Total: 90 hours

**Year, semester:** 3<sup>rd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTKBE0302\_EN

**Further courses built on it:** TTKBE1213\_EN

**Topics of course**

Principal definitions. Classification of polymers. The most important synthetic polymers. Methods for characterizing polymers. Polymolecularity. Correlation between the structure and properties of polymers. Physical states of polymers. Preparation methods of synthetic polymers and copolymers: radical polymerization and copolymerization, anionic, cationic, living cationic polymerization. Step polymerization: polycondensation and polyaddition.

**Literature***Compulsory:*

- 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

*Recommended:*

- Krzysztof Matyjaszewski, Thomas P. Davis: Handbook of Radical Polymerization (Wiley, 2002) ISBN: 978-0-471-39274-3

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

Principal definitions. Classification of polymers.

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

Chemical structure, shape and fine structure of polymers.

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

Polymolecularity. Average molecular weights, molecular weight distribution.

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

Determination methods for the molecular weight of polymers.

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

Physical states of polymers, I.: glass transition temperature, description of amorphous polymers.

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

Physical states of polymers, II.: crystallinity of polymers.

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

Synthesis of polymers: Radical polymerization I.

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

Synthesis of polymers: Radical polymerization II.

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

Synthesis of polymers: Types of copolymers, radical copolymerization.

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

Synthesis of polymers: Cationic, living cationic polymerization.

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

Synthesis of polymers: Anionic polymerization.

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

Synthesis of polymers: Coordination polymerization.

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

Synthesis of polymers: Step polymerization I.: Polycondensation.

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

Synthesis of polymers: Step polymerization II.: Polyaddition.

**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. Sándor Kéki, university professor, DSc

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

**Title of course:** Materials of Construction

**Code:** TTKBE1211\_EN

**ECTS Credit points:** 3

**Type of teaching, contact hours**

- lecture: 2 hours/week

- practice: -

- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 32 hours
- preparation for the exam: 30 hours

Total: 90 hours

**Year, semester:** 3<sup>rd</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBE0611\_EN

**Further courses built on it:** -

### Topics of course

Atomic structure of metals, structural forms of their crystal lattice, the effect of the crystallization method on the properties of the metal. Single-phase metals and solid solutions. Properties of alloys. The effect of deformation by forming on the mechanical properties. Basics of heat treatment methods (annealing, tempering, quenching, hardening). Types of iron-based alloys, their properties and applications. Properties and applications of non-ferrous metals. Mechanical testing of materials, destructive and non-destructive methods. Types of corrosion, protection. Properties and applications of nonmetal materials.

### Literature

#### *Compulsory:*

- A. Sauveur: The metallography of iron and steel (Nabu Press, 2010) ISBN 9781145880399
- J.M. Coulson, J.F. Richardson, R.K. Sinnot: ChemicalEngineering, Volume 6 (Pergamon, 1983) ISBN 9780080229690
- B.L. Bramfitt, A.O. Benscoter: Metallographer's guide: practices and procedures for irons and steels (ASM International, 2002), ISBN: 0871707489

#### *Recommended:*

- K. Elayaperumal, V.S. Raja: Corrosion failures: theory, case studies, and solutions (Wiley, 2015) ISBN 9780470455647

### Schedule:

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

Atomic structure of metals, structural forms of their crystal lattice. Pure metals.

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

Explanation for the mechanical properties of single-phase metals by their crystal lattice.

Modification of the mechanical properties by forming – defects of the lattice.

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

Types of solid solutions. Diffusion in solids. Annealing.

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

The effect of grain size on the mechanical properties. Polymorphic transformations.

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

Multi-phase metals, properties of alloys, their description by constitutional diagrams.

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

Types and properties of iron-carbon alloys.

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

Mechanical properties of unalloyed steels, physical basics of  $\gamma$ - $\alpha$  transformations, isothermal transformation of steels.

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

The effect of various alloying constituents. Types of cast iron.

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

Properties and applications of non-ferrous metals.

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

Basics of heat treatment methods, their effect on the mechanical properties. Surface heat treatment.

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

Mechanical testing of materials, destructive and non-destructive methods.

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

Types of corrosion, methods of protection.

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

Properties and applications of nonmetal materials: wood, glass, enamel, porcelain.

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

Properties and applications of nonmetal materials: ceramics, concrete, stones, plastics.

### **Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Active participation is rewarded by the teacher in every class.

Students have to **submit an essay** about a given topic as scheduled minimum on a sufficient level.

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**. Based on the average of the grades of the essay and the examination, the exam grade is calculated as an average of them:

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 both the essay and the end-term test is at least satisfactory (3). The offered grade is the average of them.

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

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

<b>Title of course:</b> Plastics and Processing I. <b>Code:</b> TTKBE1212_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 20 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 15 hours</li> <li>- preparation for the exam: 25 hours</li> </ul>	
Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0302_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The polymer industry in the world and in the region, perspectives. Synthesis of polyethylene (high-, low- and mid-pressure method), applications. Production of polypropylene, development of the technology, applications. Production of polystyrene (including high impact and expanded PS), application. Production methods of PVC an other chlorine- and fluorine-containing polymers, applications. Synthesis of poly(vinylacetate), poly(vinylalcohol), poly(vinyl-pyrrolidone), polyamides. Production of Polyamide-6, applications. Synthesis and properties of the most importandpolydienes, elastomers. Synthesis and properties of polyacrylates, polyesters, polyethers, epoxy and alkyd resins, polyurethanes, silicones and their derivatives. Additives of the polymer industry.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- J. Brandup, E.H. Immergut, E.A. Grulke (Wiley, 1999) ISBN: 0-471-16628-6</li> <li>- J.E. Mark: Polymer Data Handbook (Oxford University Press, 1999) ISBN: 9780195107890</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- L.H. Sperling: IntroductiontoPhysicalPolymer Science (Wiley, 2006) ISBN: 978-0-471-70606-9</li> </ul>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i></p> <p>Definition of polymers and plastics. Classification, types and aims of additives.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Synthesis, properties and application of polyethylene and polypropylene, their copolymers.</p> <p><i>3<sup>rd</sup> week</i></p>

Polyisobutylene, butyl rubber and thermoplastical elastomers.

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

Polystyrene, polybutadiene, poly(acrylonitrile) and their copolymers (SAN, SBR, NBR, ABS).

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

Chlorine- and fluorine-containing polymers (PVC, chlorinated PVC, PVdC, PTFE, PTFCE).

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

Poly(vinylacetate), poly(vinylalcohol) and their derivatives.

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

Poly(vinyl-pyrrolidone) and related polymers.

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

Synthesis and properties of the most important polydienes, elastomers (PB, polyisoprene, polychloroprene). Vulcanization.

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

Synthesis and properties of polyacrylates and their derivatives.

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

Synthesis, properties and application of saturated and non-saturated polyesters, polycarbonates.

Alkyd resins

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

Polyethers (aromatic and aliphatic types). Epoxy resins and their crosslinking.

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

Polyamides and polyimides. Synthesis and properties of phenol formaldehyde and aminoplast resins.

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

Polyurethanes, silicones, cellulose derivatives.

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

Test writing for an offered grade.

### **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 14<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 of 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. Sándor Kéki, university professor, DSc

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

<b>Title of course:</b> Plastics and Processing I. <b>Code:</b> TTKBL1212_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 - preparation for the tests: 32 hours Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0611_EN	
<b>Further courses built on it:</b> -	

#### Topics of course

Identification of plastics by simple methods. Molding of plastic sheets. Shore hardness determination. Determination of mechanical properties of plastics based on tensile test. Impact testing of polypropylenes. Determination of Ball and Rockwell Hardness of polymers. Measuring of MFI values of polymers.

#### Literature

##### *Recommended:*

1. ISO standards (one copy can be found in the laboratory)
2. Syllabus provided by the Department of Applied Chemistry
3. George Odian: Principles of Polymerization, McGraw-Hill, New York (1983)

#### Schedule:

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

Identification of plastics by simple methods.

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

Molding of plastic sheets. Shore hardness determination.

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

Determination of mechanical properties of plastics based on tensile test.

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

Impact testing of polypropylenes.

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

Determination of Ball and Rockwell Hardness of polymers.

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

Measuring of MFI values of polymers.

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

Test writing.

**Requirements:**

The laboratory practices will be done in blocks (4 hours a week, 7 weeks). Attendance at laboratory practices are compulsory.

All measuring groups will prepare a laboratory notebook (laboratory record) after every practice. The practice ends with a test for a partial grade. The test will cover the theoretical and the practical part of the laboratory practices. (The test is also compulsory!) The minimum requirement for the test is 50%. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

The practice grade will be calculated as a weighted average by the following way: 60% of the test result, 40% of the laboratory notebook.

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

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

<b>Title of course:</b> Informatics for Engineers <b>Code:</b> TTKBG0911_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b>	
- lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> practice grade	
<b>Workload (estimated), divided into contact hours:</b>	
- lecture: - - practice: 28 hours - laboratory: - - preparation for the tests: 32 hours	
Total: 60 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> TTKBG0912_EN	
<b>Topics of course</b>	

Application of spreadsheets: mathematical operations, equations, charts, curve fitting, least-squares fitting, numerical integration, numerical derivation, solving of nonlinear equations, solving of set of equations, linear regression, matrix operations, introductions to statistics.

## **Literature**

### *Recommended:*

1. Joan Preppernau, Joyce Cox and Curtis Frye. Microsoft® Office Home and Student 2007 StepbyStep, Microsoft Press, 2007
2. Robert de Levi. Advanced Excel® for scientific data analysis, Oxford University Press, New York, 2004
3. Robert de Levi. How to Use Excel® in Analytical Chemistry: And in General Scientific Data Analysis, Cambridge University Press, Cambridge, 2004

## **Schedule:**

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

Implementation of mathematical functions in the spreadsheet software. Plotting the result in *xy* scatter graphs.

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

Solving calculation problems in chemical engineering by implemented mathematical functions.

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

Numerical differentiation by spreadsheet software and its application for problem-solving in chemical engineering.

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

Numerical integration by spreadsheet software and its application for problem-solving in chemical engineering.

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

Regression, curve fitting

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

The application of interpolation for problem-solving in chemical engineering.

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

Solving nonlinear equations by spreadsheet software and its application for problem-solving in chemical engineering.

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

Solving nonlinear sets of equations by spreadsheet software and its application for problem-solving in chemical engineering.

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

Matrix operations

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

Solving sets of linear equations by matrix operations.

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

Application of spreadsheets in combinatorics and probability.

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

Application of spreadsheets in statistics. Probability distributions.

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

Maxwell–Boltzmann molecular speed distribution for gases. Typical speeds.

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

Application of t-tests for problem-solving in chemical engineering.

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

Participation at the classes is compulsory. 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 the 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 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.

*- for the practice grade*

The course ends with a test in the 14<sup>th</sup> week. The minimum requirement for the test is 50%. The 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)

The students are allowed to retake the test once to improve their scores. Further improvement is in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Ákos Kuki, associate professor, PhD

**Title of course:** Process Control I.

**ECTS Credit points:** 4

**Code:** TTKBG0612\_EN

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: 1 hours/week
- laboratory: -

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: 14 hours
- laboratory: -
- home assignment: 56 hours
- preparation for the exam: 22 hours

Total: 120 hours

**Year, semester:** 2<sup>nd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTKBG0911\_EN

**Further courses built on it:** TTKBG0613\_EN

<b>Topics of course</b>
Simple process control systems. Steady state and dynamic behaviour of chemical equipment. Determination of signal transmission of chemical equipments and control systems. Writing the balance/conservation equations. Basics of mathematical modelling.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ol style="list-style-type: none"> <li>1) Seborg D. E., Edgar T.F., Mellichamp D. A., Doyle III F. J.: Process Dynamics and Control., Third Edition, published by John Wiley &amp; Sons, Inc., 2011</li> </ol> <p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>2) Ingham J., Dunn I.J., Heinze E., Prenosil J.E., Snape J.B.: Chemical Engineering Dynamics. An Introduction to Modelling and Computer Simulation., Third completely revised ed., WILEY-VCH Verlag GmbH, Weinheim, 2007</li> <li>3) Smith A.C, Corripio A.B.: Principles and Practice of Automatic Process Control. Second ed., 2007</li> <li>4) Luyben W.L.: Process Modeling, Simulation, and Control for Chemical Engineers. McGraw-Hill, International Edition, 1996.</li> <li>5) Stephanopoulos G.: Chemical Process Control. An Introduction to Theory and Practice., published by Prentice Hall PTR, Englewood Cliffs, New Jersey, 1984</li> <li>6) Bequette B. W.: Process Dynamics. Modeling, Analysis, and Simulation., Prentice Hall International Series in the Physical and Chemical Engineering Sciences, Prentice Hall PTR, 1998</li> <li>7) Elnashaie S. S. E. M., Garhyan P.: Conversation Equations and Modelling of Chemical and Biochemical Processes., published by Marcel Dekker, Inc., 2003</li> </ol>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i></p> <p>Introduction. Determination of scope of Process Control. Classification of industrial automation.</p> <p><i>2<sup>nd</sup> week</i></p> <p>Single input and single output systems (SISOs). Feed-back Control (FBC) system and Feed-forward Control system (FFC). Symbols of process control and P&amp;I diagrams. Signals and hardware elements of process control systems. Operations of signals. Block diagram and schematic structure/diagram.</p> <p><i>3<sup>rd</sup> week</i></p> <p>Industrial examples for process control. Comparison of FBC and FFC.</p> <p><i>4<sup>th</sup> week</i></p> <p>Industrial examples for process control. Comparison of FBC and FFC.</p> <p><i>5<sup>th</sup> week</i></p> <p>Enhanced control strategies. Ratio control. Cascade control. Inferential control.</p> <p>Selective control.</p> <p><i>6<sup>th</sup> week</i></p>

Proportional signal transmission. Block diagram algebra. Block diagram reduction rules. Determination of equivalent summation amplification factor of FBC systems. Regulatory and servo operational mode of FBC systems.

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

Signal transmission. Basics of mathematical modelling. Total mass, component, energy and momentum conservation equations of chemical equipments and describe these balance equations for CSTR with exothermic first order chemical reaction. Solutions of different examples.

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

Solutions of different examples for CSTR.

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

Signal transmission. The basics of dynamic behaviour. The basics of transient behaviour. The signal transmission of hardware elements of process control which can be describe with ordinary linear differential equations (ODEs). The general equation of signal transmission in the time domain. Forcing functions, typical test signals.

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

Standard dynamic behaviours of hardware elements and processes. Proportional (P), integrative (I), derivative (D), first order process (PT<sub>1</sub>), second order process (PT<sub>1</sub>T<sub>2</sub>) and n-order process (PT<sub>1</sub>...T<sub>n</sub>).

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

Forcing functions' indicated respons functions of different behaviour of hardware elements and processes. Practical examples.

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

Difference between steady-state behaviour and dynamic behaviour of chemical equipments.

Operational point and operational line. Characteristic curves and diagrams of time domain.

Transient operational mode of chemical equipments.

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

Self regulating and unstable systems. Practical examples for self regulating systems and them operational point.

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

exam

### **Requirements:**

*- for a signature*

Participation in lectures and seminars. *The total number of absences for the semester does not exceed three (3).*

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*

At the end of the course based on the result of written exam (100%).

0 % - 40 % mark: 1 (fail), > 40 % - 60 % mark: 2 (pass, sufficient), > 60 % - 77 % mark: 3

(satisfactory or average), > 77 % - 90 % mark: 4 (good), > 90 % mark: 5 (excellent).

In the case of failure to perform of first exam, it is possible to write a second written exam.

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

**Lecturer:** Professor Dr. Péter Mizsey, PhD

<b>Title of course:</b> Process Control II. <b>Code:</b> TTKBG0613_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 3 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 42 hours</li> <li>- laboratory: -</li> <li>- home assignment: 56 hours</li> <li>- preparation for the exam: 22 hours</li> </ul> <p>Total: 120 hours</p>	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBG0612_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Process control systems with hardware elements which are described with ODE. Determination of equivalent summation function in time domain of these FBC systems used Laplace transformation. Frequency response analysis and the Bode and Nyquist diagrams. Stability requirements for process control systems. Basics of selection, adjustment and tuning of different controller (P, PI, PID).
<b>Literature</b>
<p><i>Compulsory:</i></p> <ol style="list-style-type: none"> <li>1) Seborg D. E., Edgar T.F., Mellichamp D. A., Doyle III F. J.: Process Dynamics and Control., Third Edition, published by John Wiley &amp; Sons, Inc., 2011</li> </ol> <p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>2) Ingham J., Dunn I.J., Heinze E., Prenosil J.E., Snape J.B.: Chemical Engineering Dynamics. An Introduction to Modelling and Computer Simulation., Third completely revised ed., WILEY-VCH Verlag GmbH, Weinheim, 2007</li> <li>3) Smith A.C, Corripio A.B.: Principles and Practice of Automatic Process Control. Second ed., 2007</li> <li>4) Luyben W.L.: Process Modeling, Simulation, and Control for Chemical Engineers. McGraw-Hill, International Edition, 1996.</li> <li>5) Stephanopoulos G.: Chemical Process Control. An Introduction to Theory and Practice., published by Prentice Hall PTR, Englewood Cliffs, New Jersey, 1984</li> </ol>

6) Bequette B. W.: Process Dynamics. Modeling, Analysis, and Simulation., Prentice Hall International Series in the Physical and Chemical Engineering Sciences, Prentice Hall PTR, 1998

7) Elnashaie S. S. E. M., Garhyan P.: Conversation Equations and Modelling of Chemical and Biochemical Processes., published by Marcel Dekker, Inc., 2003

**Schedule:**

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

Introduction. Repeat of standard dynamic behaviours chemical equipments and process control systems. Dead time.

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

Oscillating second order process (P $\zeta$ T). Examples for P $\zeta$ T.

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

The Laplace Transform. Example for solution of ordinary linear differential equations.

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

Definition of transfer function. Transfer functions of different dynamic behaviour elements.

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

Examples for determination of response function in time domain used Laplace transformation.

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

Transfer function of FBC with proportional (P) controller. Comparison the behaviour of process with controller and without controller. Residual control discrepancy. Transfer function of FBC with integral (I) controller.

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

Stability of dynamical systems. Stability condition according to Lyapunov. Stability in the Laplace-domain. Determination of stability on the basis of the locations of roots of characteristic polynomial equation (root-locus analysis).

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

Routh-Hurwitz criterion.

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

Periodical (cosine) function as a typical test signal. Frequency response analysis. Nyquist and Bode diagrams.

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

Nyquist and Bode diagrams of different behaviour elements.

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

Geometrical conditions of stability, Nyquist and Bode criteria. Impact of dead time.

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

Basics of selection, adjustment and tuning of different controller (P, PI, PID). Ziegler-Nichols tuning technique.

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

Introduction to using of Matlab Control System Toolbox and Simulink software systems.

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

exam

**Requirements:**

*- for a signature*

Participation in lectures and seminars. *The total number of absences for the semester does not exceed three (3).*

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

At the end of the course based on the result of written exam (100%).

0 % - 40 % mark: 1 (fail), > 40 % - 60 % mark: 2 (pass, sufficient), > 60 % - 77 % mark: 3 (satisfactory or average), > 77 % - 90 % mark: 4 (good), > 90 % mark: 5 (excellent).

In the case of failure to perform of first exam, it is possible to write a second written exam.

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

**Lecturer:** Professor Dr. Péter Mizsey, PhD

<b>Title of course:</b> Mechanics for Chemical Engineers I. <b>Code:</b> MFVGE31V03_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: 1 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: 14 hours</li> <li>- laboratory: -</li> <li>- home assignment: 28 hours</li> <li>- preparation for the exam: 20 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTFBE2111_EN, TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Further courses built on it:</b> MFVGE32V03_EN	

#### Topics of course

It reviews the fundamental rules of the formal requirements of the technical drawing, representing components by views and sectional views. After that it deals with the drawing of standardized machine elements and the concept of manufacturing tolerance and fitting, dimensional specification, geometrical and positioning tolerance, surface irregularity. Contact among machine elements. Elements for energy process in machine systems. Elements for material flow in machine systems: pipes, pipe fittings, tanks etc. Structural materials. Structure of non-ferrous metals. Iron-carbon double phased systems, crystallization and metamorphosis. Alloy steel and non-ferrous metals. Modification of material properties by heat treatment. Non-

destruction tests. Notation of steel. Formation of welded bound by smelting processes. Destruction tests and non-destruction tests of welded bounds. Works of chemical machines: determination of machine, grouping. Types of energy, energy sources. Efficiency. In seminar there are four tasks to elaborate: to elaborate the workshop drawing of different machine elements and components.

## Literature

### Compulsory:

- ZsoltTiba (2010): Machine Drawing, Debrecen University Press, ISBN 978-963-318-066-2
- A. Ugural (2004): Mechanical Design: An Integrated Approach, CRC Press, ISBN 13 9780072921854
- William D. Callister, David G. Rethwisch: Fundamentals of materials science and engineering : SI version, John Wiley and Sons, 2013., ISBN 978 1 118 32269 7

### Recommended:

## Schedule:

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

**Lecture:** Drawing standards, formal requirements of machine drawings. Drawing sheet dimensions, title block, defining the line types and thickness groups. Standardized letter and figure shape and sizes, scales, full size, reduction scales, enlarged scales.

**Practice:** issuing the task 1: Lettering

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

**Lecture:** Defining the surfaces of a part. Presentation method in machine drawing, views, auxiliary view, local view, breaking, sectional views and sections.

**Practice:** issuing the task 2: Drawing Machine Parts. Practicing the presentation methods.

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

**Lecture:** Complex sectional views, removed element, removed sections, specific sectional views and sections, conventional practice in machine drawing.

**Practice:** submitting the task 1: Lettering, elaborating the task 2. Practicing the presentation methods.

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

**Lecture:** General prescriptions for dimensioning, choosing basis surfaces. Conventional dimensioning methods.

**Practice:** elaborating the task 2. Practicing the presentation methods.

### 5<sup>th</sup> week

**Lecture:** ISO Tolerance system. Basic size, actual size, limits, deviations, fundamental deviation

**Practice:** Applying the dimensioning methods to dimensioning parts. Submitting the task 2.

Issuing the task 3: Shaft drawing.

### 6<sup>th</sup> week

**Lecture:** ISO Tolerance system. Defining fits: clearance, transition and interference fit.

**Practice:** elaborating the task 3.

### 7<sup>th</sup> week

**Lecture:** Defining the surface roughness. Feasible roughness with different processing methods. Correlation between the surface roughness and the IT grade of dimension.

**Practice:** submitting the task 3, issuing the task 4: Screw Fastening and Joints.

### 8<sup>th</sup> week

### **Mid-term test**

**Lecture:** Standardized Thread forms and its main features. Threads and threadsymbols in drawing. Threaded joints: bolted joint, studded joint, screw fastening.

**Practice:**elaborating the task 4.

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

**Lecture:** springs: standardized representation of helical spring, keyed joints with saddle keys, sunk keys, parallel keys and woodruff keys. Splined shaft joint. Gears and toothed parts. Spur and helical gears.

**Practice:**elaborating the task 4.

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

**Lecture:** Contact among machine elements. Elements fo renergy process in machine systems. Elements for material flow in machine systems: pipes, pipefittings, tanks etc.

**Practice:**study drive train components in the lab.

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

**Lecture:** equation of energy equilibrium. Defining and calculating stresses in different load situations. Works of chemical machines: determination of machine, grouping. Types of energy, energy sources. Efficiency.

**Practice:**submitting the task 4.

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

**Lecture:** Structural materials. Structure of non-ferrous metals. Iron-carbon double phased systems, crystallization and metamorphosis.

**Practice:**Destructive test methods.

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

**Lecture:** Alloysteel and non-ferrous metals. Modification of material properties by heat treatment. Non-destructive tests. Notation of steel.

**Practice:** Non-destructive test methods.

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

### **Mid-term test**

**Lecture:** Formation of welded bound by smeltingprocesses. Destruction tests and non-destruction tests of welded bounds.

**Practice:**Conducting destructive and non-destructive tests.

### **Requirements:**

*- for a signature*

Attendance on the **lectures** is recommended, but not compulsory.

Participation at **practice** is compulsory. Student must attend the practices and may not miss more than three practice during the semester. In case a student misses more than three, the subject will not be signed and the student must repeat the course. Student can't makeup a practice with another group. The attendance on practice will be recorded by the practice leader. Being late is counted as 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 the drawing tasks and drawing instruments for the course with them to each practice. Active participation is evaluated by the teacher in every class. If student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate their participation as an absence due to the lack of active participation in class.

Students have to **submit all the four drawing tasks** asscheduled minimum on a sufficient level. During the semester there are two tests: the mid-term test is in the 8<sup>th</sup>week and the end-term test in the 14<sup>th</sup>week. Students have to sit for the tests.

*- for a grade*

The course ends in **mid-semestergrade**. Based on the average of the marks of the drawings and the average of the test results, the mid-semester grade is calculated as an average of them:

- average grade of the four drawing tasks
- average grade of the two tests

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 four 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:** Dr.Zsolt Tiba, college professor, PhD

**Lecturer:** Dr.Zsolt Tiba, college professor, PhD

<b>Title of course:</b> Mechanics for Chemical Engineers II. <b>Code:</b> MFVGE32V03_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: 1 hour/week - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: 14 - laboratory: - - home assignment: 10 hours - preparation for the tests: 38 hours Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> MFVGE31V03_EN	
<b>Further courses built on it:</b> MFVGE33V03_EN	

## Topics of course

Transportation of fluids: Pascal's law, Bernoulli-equation, flow measurement, pressure drop and friction losses in pipes, pumps, head, pump power calculations, maximum suction height, cavitation, net positive suction head (NPSH), characteristic curves for centrifugal pump, duty point calculation.

Electric motors: Lorentz force, categorization of electric motors, DC motors, synchronous AC motors, single phase induction motors, three phase AC induction motors, basic calculations.

Heat engines: four-stroke engines (Otto cycle), two-stroke engines (Otto cycle), diesel engines, thermodynamics (Otto cycle), engine efficiency of thermal engines, octane and cetane values, Wankel engine, gas turbines, jet engines.

## Literature

### *Recommended:*

1. J. M. Coulson, J. F. Richardson, J. H. Marker, J. R. Backhurst, Chemical engineering, Volume 1, Butterworth – Heinemann, Oxford, 1999.
2. J. F. Richardson, J. R. Backhurst, J. H. Harker, Solutions to the Problems in Chemical Engineering Volume 1, Butterworth – Heinemann, Oxford, 2001.
3. Warren McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill, New York, 2005.

## Schedule:

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

Transportation of fluids: Pascal's law, Bernoulli-equation.

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

Flow measurement, pressure drop and friction losses in pipes.

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

Pump types used in the chemical industry.

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

Head and pump power calculations.

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

Maximum suction height, cavitation.

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

Net positive suction head (NPSH)

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

Characteristic curves for centrifugal pump, duty point calculation.

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

Lorentz force, force on current carrying wires.

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

Categorization of electric motors, DC motors.

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

Synchronous AC motors, single phase induction motors.

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

Three phase AC induction motors, basic calculations related to electric motor.

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

Heat engines, four-stroke engines (Otto cycle), two-stroke engines (Otto cycle).

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

Diesel engines, thermodynamics (Otto cycle), engine efficiency of thermal engines.

14<sup>th</sup> week

Octane and cetanevalues, Wankelengine, gasturbines, jetengines.

**Requirements:**

- *for a signature*

Attendance at lectures is recommended, but not compulsory.

Participation at the practice classes is compulsory. 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 the 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.

- *for the term grade*

The course ends with test for the term grade. The minimum requirement for the test is 50%. The 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)

The solution of the home assignments is counted into the score of the test by 5%.

The students can retake the test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Ákos Kuki, associate professor PhD

**Title of course:** Mechanics for chemical engineers III.

**ECTS Credit points:** 3

**Code:** MFVGE33V03-EN

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: 1 hours/week
- laboratory: -

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: 14 hours
- laboratory: -
- home assignment: 24 hours
- preparation for the exam: 24 hours

Total: 90 hours

**Year, semester:** 3<sup>rd</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** MFVGE31V03, MFVGE32V03

**Further courses built on it:** -

## Topics of course

Heat exchangers and reactors. Thermal conductivity. Thermal convection, heat transfer and basic concepts of heat exchangers. Overview and basic equations of heat exchangers. THE moderate temperature difference. The heat coefficient  $k$ . Heat transfer without phase change. heat transfer with convection. Heat transfer with free convection. Heat transfer during phase change. Heat transfer of ribbed tubes. Heat transfer in a mixer. Dimensional principles. Heat radiation. Applications and Types of Tubular Heat Exchangers. Other heat exchangers. Condenser. Cooling towers. Chemical reactors. Models of reactor model ideal for flow. Descriptive quantities and equations. Examples of industrial reactors. Devices of high temperature homogeneous gas reactions. Stability and selection of reactors. Intermittent reactors. Furnaces. Rotary, rotary, fluidizing furnaces. Breakdown of water. Water electrolysis. Industrial applications. Refrigerators. The chemical application of cooling. Compressor refrigerators. Carnot refrigeration cycle. Cold-running cycles. Refrigerants, media. The machines, devices and components of the refrigeration equipment. absorption refrigeration equipment. Steam jet cooling equipment. Heat pumps.

## Literature

### Compulsory:

- James O Wilkes - Fluid Mechanics for Chemical Engineers Second Edition with Microfluidics and CFD
- Reactor Design for Chemical Engineers, J. M. Winterbottom, Michael King
- EFFECTIVE THERMAL DESIGN OF COOLING TOWERS, By Jonny Goyal Air Liquide Engineering and Construction, Lurgi India | February 1, 2012
- Coulson and Richardson's Chemical Engineering (Seventh Edition) Volume 1b: Heat and Mass Transfer: Fundamentals and Applications 2018, Pages 471-528 Coulson and Richardson's Chemical Engineering Chapter 5 - Applications in Humidification and Water Cooling

## Schedule:

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

The basics of technical heat. Heat transfer is theoretical Fundamentals. Thermal conductivity, Convective heat transfer, thermal transmittance. Logarithmic medium temperature difference Heat transfer coefficient  $k$ .

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

Heat convection without phase change is free and forced flow.

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

Heat transfer during phase change. fin heat transfer Heat transfer in mixer.

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

Applications and Types of Tubular Heat Exchangers. Dimensional principles.

thermal radiation

### 5<sup>th</sup> week

Other heat exchangers.

### 6<sup>th</sup> week

Direct heat exchanger heat exchangers Condensation condensers.

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

Cooling towers.

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

Refrigerators. The chemical application of cooling.

Compressor refrigerators. Carnot Cooling Circuit.

Cold-running cycles.

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

Chillers are machines, devices, structural elements. Absorption chillers. Steam Radiation-refrigerators. Heat pumps.

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

Chemical reactors. Heat and component balance equations interpretation. Descriptive quantities and equations. Models of reactor model ideal for flow. Seamless and continuous cavity reactors, continuous cascade and tube reactors.

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

Isothermal and Adiabatic Reactors. The reactors thermal stability

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

Examples of industrial reactors. Stability of reactors and selection.

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

Intermittent reactors. Furnaces. Rotary, rotary, fluidizing furnaces.

Water electrolysis. Breakdown of water. water electrolysis devices. Industrial applications

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

*Systematic repetition of thermal operations.*

### **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.

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 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
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<ul style="list-style-type: none"> <li>- 0-59</li> <li>- 60-69</li> <li>- 70-79</li> <li>- 80-89</li> <li>- 90-100</li> </ul>	<ul style="list-style-type: none"> <li>fail (1)</li> <li>pass (2)</li> <li>satisfactory (3)</li> <li>good (4)</li> <li>excellent (5)</li> </ul>
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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 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:** Mr.Gábor Balogh, instructor

**Lecturer:** Mr.Gábor Balogh, instructor

<b>Title of course:</b> Unit Operations I <b>Code:</b> TTKBG0614_EN	<b>ECTS Credit points:</b> 6
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: 3 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: 42 hours</li> <li>- laboratory: -</li> <li>- home assignment: 50</li> <li>- preparation for the exam: 60 hours</li> </ul>	
Total: 180 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Further courses built on it:</b> TTKBG0615_EN	

#### Topics of course

The essence of chemical engineering science. Unit Operations of Chemical Engineering. Basis of chemical engineering thermodynamics of unit operations. Quantities describing the operational unit. easurement, units and dimensions in chemical engineering. Conversion of units. Conditions of thermal, mechanical and component equilibriums. Transport processes, component, heat and momentum streams. The extended- Damköhler's equation.The classification of operational units. The theory of similitude, dimensional analysis. Flow of fluids, energy and momentum relationships. Pumping of fluids. Pumps, compressors and

vacuum pumps. Separation of heterogeneous systems: Sedimentation, filtration, centrifugation, mixing of liquid, gas cleaning.

## Literature

### *Compulsory:*

McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of Chemical Engineering (7th Ed) - McGraw-Hill

Richard G. Griskey: Transport phenomena and unit operations: a combined approach, (2002), Wiley, ISBN 0-471-43819-7

Christie J Geankoplis: 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

## 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.

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

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.

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

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

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

Similarity and modelling. Dimensional analysis, dimensionless numbers.

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

Mass and energy balances for simple and complex unit operations.

### *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*

Flow near solids, in packed columns: Flow around immersed objects. Interpretation of Reynolds number. Types of flow around spherical particles. Stokes' law for the frictional force. Drag coefficient for laminar, transitional and turbulent regions. Ergun equation. Packed columns, characteristics and types of packings. Methods of flow measurement.

#### *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*

Mixing of solids, apparatus. Mixing of fluids. Momentum balance for the agitator. Power requirement of agitation. Fluid mixers.

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

Terminal velocity of sedimentation. Stokes' law. Drag coefficient as a function of Reynolds number. Apparatus for settling, dust removers, cyclones.

### **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, PhD

**Lecturer:**

**Title of course:** Unit Operations II.

**Code:** TTKBG0615\_EN

**ECTS Credit points:**  
6

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: 3 hours/week
- laboratory: -

**Evaluation: mid-semester grade**

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: 42 hours
- laboratory: -
- home assignment: 40 hours
- preparation for the exam: 40 hours

Total: 150 hours

**Year, semester:** 2<sup>nd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** Unit operations I. (TTKBG0614\_EN)

**Further courses built on it:** Unit operations III. (TTKBG0616\_EN)

**Topics of course**

Heat transfer. General characterization of heat transfer. Heat transfer by convection, conduction and radiation. Application of dimensional analysis to heat-transfer by convection. Heating and cooling. Heat transfer at standard- and changeable temperature difference. Unsteady- and steady state transfer of heat. The logarithmic mean temperature difference. Heat exchangers. Evaporation and evaporators. Cooling and coolers. Classification of reactors and choice of reactor type in the industry. Chemical kinetics. Residence time and distribution of residence time. Batch reactors and continuous reactors. Influence of heat of reaction on reactor type. Isothermal, adiabatic polytrophic reactors. Mechanical operations. Size reduction of solids. Methods of operating crushers: coarse-, intermediate-, fine crushers and colloid mills. Classification of solid particles and settling. Blending of solid particles.

**Literature**

**Compulsory:**

McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of Chemical Engineering (7th Ed) - McGraw-Hill

[Richard G. Griskey](#):Transport phenomena and unit operations: a combined approach, (2002), Wiley, ISBN 0-471-43819-7

Christie J Geankoplis: 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

### **Schedule:**

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

Heat transfer. General characterization of heat transfer.

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

Heat transfer by convection, conduction and radiation. Application of dimensional analysis to heat-transfer by convection. Analogies between momentum and heat transfer. Chilton-Colburn analogy.

#### *3<sup>rd</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.

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

Unsteady state heat conduction. Fourier-II equation. Dimensionless numbers for transient heat conduction: Fourier, Biot number and dimensionless temperature. Interpretation of the Heissler chart.

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

Boundary layer theory of heat transfer. The Nusselt and Prandtl number. Forced convection heat transfer. Natural convection heat transfer. Radiation heat transfer and solution of complex heat transfer problems

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

Heat exchangers. Stationary heat transmission with constant temperature difference through flat and cylindrical wall. Determination of heat flow and thermal resistances.

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

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.

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

Boiling of liquids. Boiling curves. Critical heat flux of boiling. Leidenfrost effect.

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

The aim of evaporation, Calandria, falling film and Robert-type evaporator. Multistage evaporators and their connections.

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

Cooling and coolers.

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

Introduction to chemical reactors. 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.

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

Heat balance of a reactor. Stability of reactors.

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

Methods of feed preparation and surface increase: size reduction, sieving, vaporization, homogenization: Crushers and grinders. Energy requirement of size reduction. Screening and classification. Sieve analysis.

14<sup>th</sup> week  
Practice.

**Person responsible for course:** Katalin Illyésné Dr. Czifrák, university professor, PhD

**Lecturer:**

**Title of course:** Unit Operations III.  
**Code:** TTKBG0616\_EN

**ECTS Credit points:** 6

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: 3 hours/week
- laboratory: -

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: 42 hours
- laboratory: -
- home assignment: 50
- preparation for the exam: 60 hours

Total: 180 hours

**Year, semester:** 3<sup>nd</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBG0615\_EN

**Further courses built on it:** -

### Topics of course

Mass transfer processes. Mass transfer across a phase boundary, the two-film theory. Common interpretation of the operating line and the equilibrium curve. Mass transfer in the columns, the transfer units. Mass transfer in the cascades, the equilibrium units. Absorption, Adsorption. Evaporation. Distillation. Rectification. Extraction. Crystallization. Humidification. Drying.

### Literature

*Compulsory:*

McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of ChemicalEngineering (7th Ed) - McGraw-Hill

Richard G. Griskey: Transport phenomena and unit operations: a combined approach, (2002), Wiley, ISBN 0-47 1-43819-7

Christie J Geankoplis: 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

**Schedule:**

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

Mass transfer theories. Two-film and boundary layer theory of component transfer.

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

Absorption-desorption: Concentration-space diagram of a continuous counter current absorption unit operation. Equation of operating line.

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

Transfer unit and its graphical determination. Chemisorption. Types of absorption-desorption apparatus.

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

Adsorption-desorption. Physical and chemical adsorption. Isotherms.

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

Types of absorption-desorption apparatus. The PSA adsorption.

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

Thermal separation operations: distillation: Batch and continuous distillation.

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

Rectification. Operating point. Types and parts of a continuous rectification apparatus.

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

Operating lines of a rectifier. The q-line. Equilibrium stage, its determination using McCabe-Thiele diagram.

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

Liquid-liquid extraction. Ternary phase diagram. Distributional diagram of the key component. Batch and continuous extraction. Continuous one-stage mixer-settler extractor.

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

Liquid-solid extraction and its apparatus.

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

Crystallization and its phase diagram. Apparatus for crystallization.

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

Humidification.

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

Drying. Types of moisture binding. Rate of drying. Enthalpy of moist air. Types, material-and energy balance of drying apparatus

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

Practice.

**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. Katalin Margit Illyésné Czifrák, associate professor, PhD

**Lecturer:**

<b>Title of course:</b> Computer Modeling of Chemical Technology Systems I. <b>Code:</b> TTKBG0912_EN	<b>ECTS Credit points:</b> 2
<b>Type of teaching, contact hours</b> - lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> practice grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: - - practice: 28 hours - laboratory: - - preparation for the tests: 32 hours Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> Unit Operation III. TTKBG0616_EN	
<b>Further courses built on it:</b> TTKBG0913_EN	

<b>Topics of course</b>
Application of a chemical process simulation software for the simulation of industrial processes. Drawing the flow charts. Creating a simulation step by step. Simulation of simple reactions, evaluation of the results, creating reports, exporting data. Study of vapor-liquid equilibrium. Modeling of flash distillation and three phase flash distillation. Application of sensitivity study. Applications of the controller module. Modeling of heat exchangers.
<b>Literature</b>
<p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>1. J. M. Coulson, J. F. Richardson: ChemicalEngineering. Volume 1-6. Pergamon Press. Oxford, New-York, Toronto, Sydney, Paris, Frankfurt</li> <li>2. ChemCADtutorial file</li> <li>3. J.H. Perry: ChemicalEngineersHandbook, McGraw-Hill, New York (2007)</li> <li>4. Warren L. McCabe, Julian Smith, Peter Harriott: Unit Operations of ChemicalEngineeringMcGraw-Hill, New York (2007)</li> </ol>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i> The main features of a process simulation software. The steps of the simulations. Drawing process flow diagrams.</p>
<p><i>2<sup>nd</sup> week</i> Simulation of simple reactions, evaluation of the results.</p>
<p><i>3<sup>rd</sup> week</i> Simulation of reactions with more feeds and unit operations, evaluation of the results.</p>
<p><i>4<sup>th</sup> week</i> Study of vapor-liquid equilibrium.</p>
<p><i>5<sup>th</sup> week</i> Modeling of flash distillation and three phase flash distillation.</p>
<p><i>6<sup>th</sup> week</i> Application of sensitivity study.</p>
<p><i>7<sup>th</sup> week</i> Introduction into the use of the <i>controller</i>.</p>
<p><i>8<sup>th</sup> week</i> Application of <i>controller</i> for problem-solving in chemical engineering.</p>
<p><i>9<sup>th</sup> week</i> Modeling of heat exchangers.</p>
<p><i>10<sup>th</sup> week</i> Various reactor models.</p>
<p><i>11<sup>th</sup> week</i> Simulation of chemical processes with reactors and separators</p>
<p><i>12<sup>th</sup> week</i> Simulation of chemical processes with recycling.</p>
<p><i>13<sup>th</sup> week</i> Simulation of more complex chemical processes.</p>
<p><i>14<sup>th</sup> week</i> Simulation of more complex chemical processes.</p>
<b>Requirements:</b>

*- for a signature*

Participation at the classes is compulsory. 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 the 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 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.

*- for the practice grade*

The course ends with a test in the 14<sup>th</sup> week. The minimum requirement for the test is 50%. The 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)

The students are allowed to retake the test once to improve their scores. Further improvement is in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Ákos Kuki, associate professor, PhD

**Title of course:** Computer Modeling of Chemical Technology Systems II.

**ECTS Credit points:** 2

**Code:** TTKBG0913\_EN

**Type of teaching, contact hours**

- lecture: -
- practice: 2 hours/week
- laboratory: -

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: -
- practice: 28 hours
- laboratory: -
- preparation for the tests: 30 hours

Total: 58 hours

**Year, semester:** 4<sup>th</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBG0912\_EN

**Further courses built on it:** -

<b>Topics of course</b>
Application of a process simulation software for design and simulation of mass transfer operations (distillation, rectification, extraction, absorption, adsorption, drying). Pipesystem sizing, pumps. Economic calculations. By using the software the students can broaden their knowledge in the field of industrial devices and processes, besides they can learn novel, up to date industrial and environmental technologies.
<b>Literature</b>
<p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>1. J. M. Coulson, J. F. Richardson: ChemicalEngineering. Volume 1-6. Pergamon Press. Oxford, New-York, Toronto, Sydney, Paris, Frankfurt</li> <li>2. ChemCADtutorial file</li> <li>3. J.H. Perry: ChemicalEngineersHandbook, McGraw-Hill, New York (2007)</li> <li>4. Warren L. McCabe, Julian Smith, Peter Harriott: Unit Operations of ChemicalEngineeringMcGraw-Hill, New York (2007)</li> </ol>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i> Fluid transportation. Pressure drop calculations in piping systems.</p> <p><i>2<sup>nd</sup> week</i> Simulation and sizing of pumps.</p> <p><i>3<sup>rd</sup> week</i> Simulation of piping systems, cost calculations.</p> <p><i>4<sup>th</sup> week</i> Pump duty point calculation.</p> <p><i>5<sup>th</sup> week</i> Modeling of distillation, <i>ShortCut</i> method.</p> <p><i>6<sup>th</sup> week</i> Modeling of distillation, <i>SCDS</i> model.</p> <p><i>7<sup>th</sup> week</i> Multi stepdistillation, <i>Tower</i> model.</p> <p><i>8<sup>th</sup> week</i> Application of stuffed columns.</p> <p><i>9<sup>th</sup> week</i> Simulation of absorption.</p> <p><i>10<sup>th</sup> week</i> Simulation of extraction.</p> <p><i>11<sup>th</sup> week</i> Simulation of more complex chemical processes.</p> <p><i>12<sup>th</sup> week</i> Simulation of more complex chemical processes.</p> <p><i>13<sup>th</sup> week</i> Simulation of more complex chemical processes.</p> <p><i>14<sup>th</sup> week</i> Simulation of more complex chemical processes.</p>
<b>Requirements:</b>
- for a signature

Participation at the classes is compulsory. 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 the 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 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.

*- for the practice grade*

The course ends with a test in the 14<sup>th</sup> week. The minimum requirement for the test is 50%. The 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)

The students are allowed to retake the test once to improve their scores. Further improvement is in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Ákos Kuki, associate professor, PhD

<b>Title of course:</b> Chemical Technology I.	<b>ECTS Credit points:</b> 3
<b>Code:</b> TTKBE1111_EN	
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 22 hours</li> <li>- preparation for the exam: 40 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Further courses built on it:</b> TTKBE1112_EN, TTKBL1112_EN	

<b>Topics of course</b>
Basic terms of chemical technology: continuous and batch processing, yield, conversion, efficiency, volume, basic laws of chemical technology. Combustion: burning and combustors. Water processing: production of drinking and process waters, wastewater, wastewater management. Nitrogen industries: synthesis of ammonia and nitric acid. Sulfur industries: production of sulfuric acid. Fertilizers. Electrolysis of brine. Production of alumina, iron and steel. Crude oil and natural gas: genesis (organic and inorganic theories), types, ingredients, mining. Engine fuels, destructive methods (thermic-, catalytic- and hydrocracking), reforming of gasoline.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH &amp; Co. KGaA., 2002, ISBN: 9783527306732</li> <li>- J.M. Coulson, J.F. Richardson and R.K. Sinnott: Chemical Engineering, Volume 6., Pergamon Press, 1983.</li> <li>- G N Pandey: Textbook of Chemical Technology Vol-1, 2, 2006.</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- Muhlynov I.: Chemical Technology I-II.</li> </ul>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i> Laws and description of Chemical Technology</p> <p><i>2<sup>nd</sup> week</i> Purification of water, water treatment</p> <p><i>3<sup>rd</sup> week</i> Water softening, hardness scales</p> <p><i>4<sup>th</sup> week</i> Nitrogen industry, steam processing</p> <p><i>5<sup>th</sup> week</i> Synthesis of ammonia</p> <p><i>6<sup>th</sup> week</i> Nitric acid production, nitrogen containing fertilizers</p> <p><i>7<sup>th</sup> week</i> Sulphur industry, sulphuric acid production</p> <p><i>8<sup>th</sup> week</i> Superphosphate production</p> <p><i>9<sup>th</sup> week</i> Brine electrolysis, products</p> <p><i>10<sup>th</sup> week</i> Alumina industry, electrolysis of alumina</p> <p><i>11<sup>th</sup> week</i> Manufacturing iron, processes in the blast furnace</p> <p><i>12<sup>th</sup> week</i> Atmospheric distillation of natural oil</p> <p><i>13<sup>th</sup> week</i> Vacuum distillation of atmospheric residue</p>

14<sup>th</sup> week

Processing of natural gas

**Requirements:**

*- for a signature*

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

During the semester there is one test: the end-term test in the 15<sup>th</sup> week. Students have to sit for the test

*- for a grade*

The exam grade is calculated by the result of end-term test.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test 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 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 is at least pass (2).

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

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

**Title of course:** Chemical Technology I.  
**Code:** TTKBL1111\_EN

**ECTS Credit points:** 4

**Type of teaching, contact hours**

- lecture: -
- practice: 2 hours/week
- laboratory: 2 hours/week

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: -
- practice: 28 hours
- laboratory: 28 hours
- home assignment: 40 hours
- preparation for the exam: 24 hours

Total: 120 hours

**Year, semester:** 2<sup>nd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTKBE0201\_EN, TTKBE0301\_EN, TTKBE0401\_EN

**Further courses built on it:** TTKBE1112\_EN, TTKBL1112\_EN

### **Topics of course**

Calculations related to the Chemical Technology I topics. Combustion: burning and combustors. Water processing: production of drinking and process waters, wastewater, wastewater management. Nitrogen industries: synthesis of ammonia and nitric acid. Sulfur industries: production of sulfuric acid. Fertilizers. Electrolysis of brine. Production of alumina, iron and steel.

Crude oil and natural gas: genesis (organic and inorganic theories), types, ingredients, mining. Engine fuels, destructive methods (thermic-, catalytic- and hydrocracking), reforming of gasoline. Knowing of the technologically important unit operation processes such as filtration, mixing, water softening, rectification and distillation, drying, sedimentation, sieve analysis.

### **Literature**

#### *Compulsory:*

- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA., 2002, ISBN: 9783527306732
- J.M. Coulson, J.F. Richardson and R.K. Sinnott: Chemical Engineering, Volume 6., Pergamon Press, 1983.
- G N Pandey: Textbook of Chemical Technology Vol-1, 2, 2006.

#### *Recommended:*

- Muhlynov I.: Chemical Technology I-II.

### **Schedule:**

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

Safety regulations

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

Determination of hardness of unknown water samples

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

Water softening with ion exchange resin

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

Sieve analysis

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

Distillation

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

Rectification, separation of ethanol-water mixture

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

Mixing

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

Determination of critical power of mixer

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

Sieve analysis of ground limestone

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

Drying, determination of moisture in unknown samples

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

Filtration

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

Sedimentation

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

Application of Stokes's law for sedimenting particles

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

Repeating of failed practices

**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.

During the semester there is one test: the end-term test in the 15<sup>th</sup> week. Students have to sit for the test. Furthermore, the students make reports about their laboratory practice results.

*- for a grade*

The exam grade is calculated by the results of end-term test and the laboratory reports.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test 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 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 is at least pass (2).

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

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

**Title of course:** Chemical Technology II.

**Code:** TTKBE1112\_EN

**ECTS Credit points: 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> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester
<b>Its prerequisite(s):</b> TTKBE1111_EN, TTKBL1111_EN
<b>Further courses built on it:</b> -

<b>Topics of course</b> Polyolefins. Properties of different polyethylene (PE) and polypropylene (PP) polymers. Typical industrial reactors for the production of LDPE, HDPE (LLDPE) and PP. Uses of polyolefins. Biotechnology. Phases and types of the industrial fermentation. Requirements of the mixed tank reactors in the biotechnology. Industrial production and types of solid dosage forms. Advantage, disadvantage and types of capsule dosage forms. Typical examination methods of the solid dosage forms.
<b>Literature</b> <i>Compulsory:</i> - H. A. Modi, Fermentation Technology (Vol: I and II), 2009 - J Joao B. P. Soares, Timothy F. L. McKenna, Polyolefin Reaction Engineering, 2012, ISBN: 978-3-527-31710-3 - Peter F. Stanbury, Allan Whitaker and Stephen J. Hall, Principles of Fermentation Technology, 2016 <i>Recommended:</i> - Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA., 2002, ISBN: 9783527306732
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Processing and refining crude oil <i>2<sup>nd</sup> week</i> Catalytic cracking <i>3<sup>rd</sup> week</i> Pyrolysis in the industry <i>4<sup>th</sup> week</i> Production of olefins, its products and side products <i>5<sup>th</sup> week</i>

Uses of ethylene and propylene	
<i>6<sup>th</sup> week</i>	
Classification and uses of polyethylene and polypropylene	
<i>7<sup>th</sup> week</i>	
Properties of the polyethylene and polypropylene polymers	
<i>8<sup>th</sup> week</i>	
Production of LDPE in the industry	
<i>9<sup>th</sup> week</i>	
Production of HDPE in the industry	
<i>10<sup>th</sup> week</i>	
Production of polypropylene in the industry	
<i>11<sup>th</sup> week</i>	
Basics of biotechnology	
<i>12<sup>th</sup> week</i>	
Industrial fermentation	
<i>13<sup>th</sup> week</i>	
Extraction of the pharmaceutically important components from the fermentation broth	
<i>14<sup>th</sup> week</i>	
Industrial production and types of solid dosage forms	

**Requirements:**

*-for a signature*

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

During the semester there is one test: the end-term test in the 15<sup>th</sup> week. Students have to sit for the test

*-for a grade*

The exam grade is calculated by the result of end-term test.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test 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 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 is at least pass (2).

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

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

<b>Title of course:</b> Chemical Technology II.	<b>ECTS Credit points:</b> 4
<b>Code:</b> TTKBL1112_EN	

**Type of teaching, contact hours**

<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 2 hours/week</li> <li>- laboratory: 2 hours/week</li> </ul>
<b>Evaluation:</b> mid-semester grade
<b>Workload (estimated), divided into contact hours:</b>
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 28 hours</li> <li>- laboratory: 28 hours</li> <li>- home assignment: 40 hours</li> <li>- preparation for the exam: 24 hours</li> </ul> <p>Total: 120 hours</p>
<b>Year, semester:</b> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester
<b>Its prerequisite(s):</b> TTKBE1111_EN, TTKBL1111_EN
<b>Further courses built on it:</b> -

<b>Topics of course</b>
Study the steps of fermentation processes. Manufacturing and qualifying of biofuels. Qualifying of lubricants. Study of catalytic processes such as dehydrogenation. Study of corrosion processes
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH &amp; Co. KGaA., 2002, ISBN: 9783527306732</li> <li>- J.M. Coulson, J.F. Richardson and R.K. Sinnot: Chemical Engineering, Volume 6., Pergamon Press, 1983.</li> <li>- G N Pandey:Textbook of Chemical Technology Vol-1, 2, 2006.</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- Muhlynov I.: Chemical Technology I-II.</li> </ul>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i> Manufacturing biodiesel</p> <p><i>2<sup>nd</sup> week</i> Qualifying of biodiesel</p> <p><i>3<sup>rd</sup> week</i> Study the corrosion of different metals</p> <p><i>4<sup>th</sup> week</i> Production of alcohol by fermentation</p> <p><i>5<sup>th</sup> week</i> Distillation of crude oil fractions</p> <p><i>6<sup>th</sup> week</i> Determination of flash point and firing point of crude oil fractions</p> <p><i>7<sup>th</sup> week</i> Bioconversion by yeast</p> <p><i>8<sup>th</sup> week</i></p>

Dehydrogenation of isopropanol on copper catalyst
<i>9<sup>th</sup> week</i>
Glyptal resin production
<i>10<sup>th</sup> week</i>
Study the viscosity of paraffin and lubricant oils
<i>11<sup>th</sup> week</i>
Determination of methane content in unknown gas sample
<i>12<sup>th</sup> week</i>
Study the cascade reactor hydrodynamic properties
<i>13<sup>th</sup> week</i>
Study the plug flow reactor hydrodynamic properties
<i>14<sup>th</sup> week</i>
Repeating of failed practices

**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.

During the semester there is one test: the end-term test in the 15<sup>th</sup> week. Students have to sit for the test. Furthermore, the students make reports about their laboratory practise results.

*- for a grade*

The exam grade is calculated by the results of end-term test and the laboratory reports.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test 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 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 is at least pass (2).

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

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

<b>Title of course:</b> Chemical Technology III. <b>Code:</b> TTKBE1117_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: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
<b>Year, semester:</b> 4 <sup>th</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE1112_EN, TTKBL1112_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b> Silicate industry: processes and products of glass, ceramics and enamell. Micromiologcal industries: types, conditions and products of fermentation. Production of yeast, ethanol, vinegar, antibiotics and beer. Production of sugar and vegetable-oil, usage of byproducts.
<b>Literature</b> <i>Compulsory:</i> - Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA., 2002, ISBN: 9783527306732 - J.M. Coulson, J.F. Richardson and R.K. Sinnott: Chemical Engineering, Volume 6., Pergamon Press, 1983. - G N Pandey:Textbook of Chemical Technology Vol-1, 2, 2006. <i>Recommended:</i> - Muhlynov I.: Chemical Technology I-II.

<b>Schedule:</b> <i>1<sup>st</sup> week</i> Biofuels, bioethanol production in the industry <i>2<sup>nd</sup> week</i> Biofuels, biodiesel production in the industry <i>3<sup>rd</sup> week</i> Yeast and acetic acid production <i>4<sup>th</sup> week</i> Manufacturing beer
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<i>5<sup>th</sup> week</i>
Uses of renewable energy sources
<i>6<sup>th</sup> week</i>
Manufacturing sugar
<i>7<sup>th</sup> week</i>
Paper industry
<i>8<sup>th</sup> week</i>
Classification of explosive materials
<i>9<sup>th</sup> week</i>
Nanotechnology
<i>10<sup>th</sup> week</i>
Polyurethanes
<i>11<sup>th</sup> week</i>
Nuclear energy
<i>12<sup>th</sup> week</i>
Manufacturing wine and champagne
<i>13<sup>th</sup> week</i>
Silicate industry, production of cement
<i>14<sup>th</sup> week</i>
Ceramic industry

**Requirements:**

*- for a signature*

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

During the semester there is one test: the end-term test in the 15<sup>th</sup> week. Students have to sit for the test

*- for a grade*

The exam grade is calculated by the result of end-term test.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test 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 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 is at least pass (2).

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

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

<b>Title of course:</b> Environmental Technology <b>Code:</b> TTKBE1114_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 6 hours</li> <li>- preparation for the exam: 56 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBL1111_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
The Relationship Between Nature and Man (the Technosphere). Sustainable Development. Types of Industrial Waste, Possibilities to Prevent Their Formation. Additive, Environmentally Integrated Production and Product. Technological Methods for the Treatment of Different Types of Waste. Air and Water Pollutants, Wastewater Treatment. Soil Contamination and Management. Noise and Vibration Protection. Radioactivity. Renewable Energy Sources. Case Histories.
<b>Literature</b>
<p><b>Compulsory:</b></p> <ul style="list-style-type: none"> <li>- D.A. Vallero: Fundamentals of Air Pollution (Academic Press, 2007) ISBN: 780123736154</li> <li>- N.L. Nemerow: Industrial Waste Treatment (Butterworth-Heinemann, 2007) ISBN: 9780123724939</li> </ul> <p><b>Recommended:</b></p> <ul style="list-style-type: none"> <li>- A. Malik, E. Grohmann: Environmental Protection Strategies for Sustainable Development (Springer, 2011), ISBN: 9789400715912</li> <li>- J.E. Andrews, P. Brimblecombe, T.D. Jickells, P.S. Liss and B. Reid: An Introduction to Environmental Chemistry, 2<sup>nd</sup> edition, 2004 by Blackwell Science Ltd, ISBN 0-632-05905-2</li> </ul>
<b>Schedule:</b>
<p><i>1<sup>st</sup> week</i></p> <p>Overpopulation (problems, effects and solutions). Causes of Environmental Pollution. Effects of Environmental Pollution (Greenhouse Effect, Global Warming, Climate Change).</p> <p><i>2<sup>nd</sup> week</i></p> <p>The Areas of the Environmental Protection. The Theory of the Sustainable Development.</p> <p><i>3<sup>rd</sup> week</i></p>

The Type and Composition of Waste. The Technology System of the Waste Management (Selective Collection, Transportation, Pre-Treatment, Utilization, Disposal and Landfilling).

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

The Principles of the Product and Production Integrated Environmental Protection.

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

Waste processing technologies. Description of Major Waste Treatment Equipments (Shredders, Mills, Comminutors...).

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

Description of the Waste Collection, Separation and Sorting Equipments and Technologies.

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

The Type of Air Pollutants. Description of Technologies to Remove Air Pollutants.

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

The Different Type of Water Pollutants (Oil, Detergents, Pesticides, Organic Substances). Determining the Organic Pollution of Waters (BOD, COD, TOC)

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

Main Soil Components. Type of Soil Pollution. Treatments Technologies of Contaminated Soil.

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

Description of a Sewage Treatment Plant. Near-Natural Wastewater Treatment Technologies

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

Noise and Vibrations. Effects and Noise Abatement.

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

Effect of Radioactivity on the Human Body. Application of Radioactivity (Medicine, Energy Production).

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

Renewable Energy Sources (Solar Energy, Hydropower Wind Energy, Sea Energy, Geothermal Energy)

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

Case Histories About Great Environmental Pollutions and Their Effects.

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

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

During the semester there is a written end-term test in the 14<sup>th</sup> week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

*- for a grade*

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

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or 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 on the basis of the result of the end-term test if the grade is at least satisfactory (3).

**Person responsible for course:** Dr. Katalin Margit Illyésné Czifrák university professor, PhD

**Lecturer:** Dr. Katalin Margit Illyésné Czifrák university professor, PhD

<b>Title of course:</b> Environmental technology Lab <b>Code:</b> TTKBL1114_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 - preparation for the tests: 32 hours Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE1114_EN parallel recording	
<b>Further courses built on it:</b> -	
<b>Topics of course</b> Identification of plastic wastes using simple physical and chemical methods. Desalination of waste water on ion exchange column. Removal of floating particles from waste water by sedimentation. Determination of the solvent content of waste water by GC method. Measurement of plasticizer content (qualitative and quantitative) from waste materials.	
<b>Literature</b> <i>Recommended:</i> 1. Syllabus provided by the Department of Applied Chemistry 2. D.A. Vallero: Fundamentals of Air Pollution (Academic Press, 2007) ISBN: 9780123736154 3. N.L. Nemerow: Industrial Waste Treatment (Butterworth-Heinemann, 2007) ISBN: 978012372493912 4. A. Malik, E. Grohmann: Environmental Protection Strategies for Sustainable Development (Springer, 2011), ISBN: 978940071591	

**Schedule:**

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

Identification of plastic wastes using simple physical and chemical methods.

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

Desalination of waste water on ion exchange column.

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

Removal of floating particles from waste water by sedimentation.

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

Determination of the solvent content of waste water by GC method.

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

Measurement of extractable matter content (plasticizer content) from (qualitative and quantitative) waste plastics. Carry out the extraction, prepare the sample.

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

Measurement of plasticizer content (qualitative and quantitative) from waste materials.

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

Test writing.

**Requirements:**

The laboratory practices will be done in blocks (4 hours a week, 7 weeks). Attendance at laboratory practices are compulsory.

All measuring groups will prepare a laboratory notebook (laboratory record) after every practice.

The practice ends with a test for a partial grade. The test will cover the theoretical and the practical part of the laboratory practices. (The test is also compulsory!) The minimum requirement for the test is 50%. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

The practice grade will be calculated as a weighted average by the following way: 60% of the test result, 40% of the laboratory notebook.

**Person responsible for course:** Katalin Illyésné Dr. Czifrák, university professor, PhD

**Lecturer:** Katalin Illyésné Dr. Czifrák, university professor, PhD

<b>Title of course:</b> Pilot Plant Work <b>Code:</b> TTKBL1115_EN	<b>ECTS Credit points:</b> 5
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**Type of teaching, contact hours**

- lecture:
- practice: 1 hours/week
- laboratory: 4 hours/week

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture:

- practice: 14 hours  
- laboratory: 56 hours-  
- home assignment: 80 hours  
- preparation for the exam:  
Total: 150 hours

**Year, semester:** 3<sup>rd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s): Chemical technologyI. (TTKBE1111\_EN) and (TTKBL1111\_EN)**  
**Unit Operation I. (TTKBG0614\_EN)**

**Further courses built on it:** -

### **Topics of course**

During the laboratory practice the students can learn the manual and computerized operation of pilot plant sized unit operations. They will record and calculate mass and energy balances for different processes such as: evaporation, absorption, grinding-size distribution, liquid- liquid extraction, distillation, fluidization and membrane separation.

### **Literature**

*Compulsory:*

McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of ChemicalEngineering (7th Ed)  
- McGraw-Hill

Richard G. Griskey:Transport phenomena and unit operations: a combined approach, (2002),  
Wiley, ISBN 0-471-43819-7

Ullmann'sEncyclopedia of Industrial Chemistry,5th ed., Weinheim, Federal Republicof  
Germany, VCH, Volumes:B1-B8,1990-1995.

MuhlynovI.:Chemical TechnologyI-II.

### **Schedule:**

1<sup>st</sup> week

Safety instructions. The basic requirements of laboratory work.

2<sup>nd</sup> week

Fluidization

3<sup>rd</sup> week

Grinding and sieve analysis. Comparison of grinding efficiencies.

4<sup>th</sup> week

Batch distillation.

5<sup>th</sup> week

PLC controlled reactor I.

6<sup>th</sup> week

PLC controlled reactor I.

7<sup>th</sup> week  
 Absorption.  
 8<sup>th</sup> week  
 Liquid-liquid extraction.  
 9<sup>th</sup> week  
 Heat exchange.  
 10<sup>th</sup> week  
 Falling film evaporator  
 11<sup>th</sup> week  
 Membrane separation. RO.  
 12<sup>th</sup> week  
 Vacuum evaporation.  
 13<sup>th</sup> week  
 Gas separation  
 14<sup>th</sup> week  
 Test

**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. 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.

*- for a grade*

The course is graded based on lab reports created individually. The reports should be prepared after the practices.

**Person responsible for course:** Dr.Tibor Nagy, Assistant Professor, PhD

**Lecturer:** Dr.Tibor Nagy, Assistant Professor, PhD

<b>Title of course:</b> Safety <b>Code:</b> TTKBE0711_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> </ul>	

- laboratory: -  
 - preparation for the tests: 62 hours  
 Total: 90 hours

**Year, semester:** 4<sup>th</sup> year, 1<sup>th</sup> semester

**Its prerequisite(s):** TTKBE1112\_EN

**Further courses built on it:** -

### Topics of course

General safety rules. Describing major accidents and causes. Poisoning, noise. Inerting of chemical vessels. Hazards of electricity (Static electricity, Direct current and alternating current). Dangers of chemical reactions. Safety valves, regulation of pressure, solutions in case of emergency.

### Literature

*Recommended:*

1. D. A. Crowl, J.F. Louvar: Chemical Process Safety, Pearson, Boston, USA (2011)
2. Roger L. Bauer: Safety and Health for Engineers, WileyInterscience, New York (2005)
3. Richard J. Lewis ed.: Sax's Dangerous Properties of Industrial Materials, John Wiley (2005)
4. C. D. Classen, Caserett and Doull's Toxicology, McGraw-Hill, New York (2008)

### Schedule:

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

General and basic security rules. Definition of accident, near-miss (quasi-accident) and first aid. Can we learn from accidents that have not happened?

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

Accident statistics, industry comparison. Conclusions from the figures.

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

Some major accidents are described, for example: in Bhopal, India (1984), Seveso, Italy (1976), Red Sludge (Red Mud) Disaster, Kolontar, Hungary (2010). Discussion of the possible causes of accidents.

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

Intoxications. Exposure and elimination of toxic substances to the body. Basic principles of toxicology. Definition of LD50. Cross effects of toxic substances, antidotes. Methanol poisoning.

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

Definition and classification of noise. Effect of the frequency and power of the noise. Dangers and diseases caused by noise. Work in a noisy workplace.

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

Purpose and implementation of inerting. Nitrogen-Purging, Vacuum, Pressure, Combination and Siphon Method. Advantages disadvantages. Simplification of a simple oxygen concentration calculation method.

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

Dangers of static electricity. Prevention of the formation of static electricity. The dust explosion. Electrical hazards. The role of insulation, earthing, residual current device (fi-relay) and fuse in the prevention of accidents

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

Dangers of chemical reaction. Run-away reaction and possible causes. Exothermic and/or gas producing reactions. Pyrophoric, peroxide-forming, reacting with water, highly oxidizing, self-reactive, impact-sensitive, heat-decomposing materials and their dangers.

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

Types of safety valves and their operation. Multiple protection. Comparison of safety valves, advantages and disadvantages.

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

Removal of excess pressure in case of danger. Technical solutions. Protective devices and their use.

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

Identification of hazards (environmental and safety). Solution options. Explosion limits of gas mixtures. Options for security protection.

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

Watching educational videos on safety. Learn the GHS pictograms and safety signs.

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

Consultation.

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

Test for a recommended grade.

### **Requirements:**

Attendance at lectures is recommended, but not compulsory.

The course ends with test for a recommended grade. (This test is not compulsory!) The minimum requirement for the test is 50%. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-80	satisfactory (3)
81-90	good (4)
91-100	excellent (5)

The students can retake the test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr.Tibor Nagy, Assistant Professor, PhD

**Lecturer:** Dr.Tibor Nagy, Assistant Professor, PhD

**Title of course:** Basics of Petrochemistry  
**Code:** TTKBE1113\_EN

**ECTS Credit points:** 3

### **Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

### **Workload (estimated), divided into contact hours:**

- lecture: 28 hours

<ul style="list-style-type: none"> <li>- practice: -</li> <li>- laboratory: -</li> <li>- preparation for the tests: 62 hours</li> </ul> <p>Total: 90 hours</p>
<b>Year, semester:</b> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester
<b>Its prerequisite(s):</b> TTKBE1111_EN
<b>Further courses built on it:</b> -

<b>Topics of course</b>
<ul style="list-style-type: none"> <li>- Possible application of distilled fractions.</li> <li>- Processes of fuel fractions.</li> <li>- Basic thermal and catalytic cracking procedures</li> <li>- Role of isomerization and oligomerization in the petroleum industry.</li> <li>- Chemicals as product of crude oil</li> <li>- Main technology of oil based monomers</li> <li>- Production of biofuels.</li> </ul>
<b>Literature</b>
<p><i>Recommended:</i></p> <ol style="list-style-type: none"> <li>1. Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim, Volumes: 1-40, (2002)</li> <li>2. Fundamentals of Petroleum Refining, Mohamed A. Fahim, Taher A. Alsahhaf, AmalElkilani, Elsevier, (2010)</li> <li>3. Chemistry of Petrochemical Processes, SamiMatar, Lewis F. Hatch. Elsevier (2001)</li> <li>4. Fundamentals of petroleum and Petrochemical Engineering, Uttam Ray Chaudhuri, CRC Press (2010)</li> </ol>
<b>Schedule:</b>
<i>1<sup>st</sup> week</i>
Topic of petrochemistry, classification of procedures, first step of oil process
<i>2<sup>nd</sup> week</i>
Thermal cracking processes, visbreaking and delayed cooking.
<i>3<sup>rd</sup> week</i>
Basics of catalytic cracking, role of these processes in the petroleum refining.
<i>4<sup>th</sup> week</i>
Fluid catalytic cracking and hydrocracking.
<i>5<sup>th</sup> week</i>
Catalytic reforming, aims and main reactions.
<i>6<sup>th</sup> week</i>
Aim of isomerization, classification based on the feeds.
<i>7<sup>th</sup> week</i>
Technology of alkylation and oligomerization. Production of ethylbenzene.
<i>8<sup>th</sup> week</i>
Production, separation and purification of benzene, toluene and xylene (BTX fraction) and their main products.
<i>9<sup>th</sup> week</i>

Aim of steam cracking, main reactions and possible feeds.

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

The main part of the steam cracker furnaces. comparison of different technologies and the applied furnaces. Procedure of the product.

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

Second generation monomers: vinylchloride, ethylene- and propylene oxide. Production of the monomers and product of ethylene, propylene and butadiene.

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

Hydrogen production, aim of steam reforming. Application of synthesis gas.

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

Production of biodiesel, classification of procedures based on the catalyst.

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

Production of bioethanol, possible. Possible sources and pretreatment of the feeds. Production of ethyltert-butylether.

**Requirements:**

Attendance at lectures is recommended, but not compulsory.

The course ends with exams at the exam periods. The minimum requirement for the test is 50%.

The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-64	pass (2)
65-74	satisfactory (3)
75-84	good (4)
85-100	excellent (5)

The students can retake the test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Tibor Nagy, Assistant Professor, PhD

**Lecturer:** Dr. Tibor Nagy, Assistant Professor, PhD

**Title of course:** Waste Management

**Code:** TTKBE1116\_EN

**ECTS Credit points:** 3

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 32 hours
- preparation for the exam: 30 hours

Total: 90 hours
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester
<b>Its prerequisite(s):</b> TTKBE1111_EN
<b>Further courses built on it:</b> -

<b>Topics of course</b>
Basic definitions of waste management. Classification of wastes. Waste management strategies, reduction of waste amount. 4R: reduction-reuse-recycle-recover. Landfilling and incineration of solid wastes. Advanced thermal processing technologies, aerobic and anaerobic digestion, composting. Mechanical–biological treatment. Integrated solid waste management.
<b>Literature</b>
<p><i>Compulsory:</i></p> <ul style="list-style-type: none"> <li>- Stephen Burnley: Solid Wastes Management (Wiley, 2014) ISBN 9781118863923</li> <li>- John Pichtel: Waste management practices: municipal, hazardous, and industrial (Taylor and Francis, 2005) ISBN 9781466585188</li> <li>- Nicholas P. Cheremisinoff: Handbook of solid waste management (Butterworth-Heinemann, 2003) ISBN 9780750675079</li> </ul> <p><i>Recommended:</i></p> <ul style="list-style-type: none"> <li>- Nicholas P. Cheremisinoff, Paul N. Haber: Hazardous materials and waste management (Elsevier Science &amp; Technology, 1996) ISBN 9786612769269</li> <li>- Alireza Bahadori: Waste Management in the Chemical and Petroleum Industries (Wiley, 2013) ISBN 9781118731758</li> </ul>
<p><b>Schedule:</b></p> <p><i>1<sup>st</sup> week</i> Basic definitions of waste management. Classification of wastes.</p> <p><i>2<sup>nd</sup> week</i> Waste management strategies, waste reduction.</p> <p><i>3<sup>rd</sup> week</i> Landfilling – cell method</p> <p><i>4<sup>th</sup> week</i> Landfilling – leachate control and gas collection</p> <p><i>5<sup>th</sup> week</i> Landfilling – site restoration</p> <p><i>6<sup>th</sup> week</i> Incineration – conventional incinerators</p> <p><i>7<sup>th</sup> week</i> Incineration – rotary kiln, fluidised bed incineration</p> <p><i>8<sup>th</sup> week</i> Incineration – Emissions abatement technologies</p> <p><i>9<sup>th</sup> week</i> Advanced thermal processing technologies – gasification and pyrolysis</p> <p><i>10<sup>th</sup> week</i> Anaerobic digestion</p> <p><i>11<sup>th</sup> week</i></p>

Composting
<i>12<sup>th</sup> week</i>
Materials recycling – MRF, SRF
<i>13<sup>th</sup> week</i>
Materials recycling – MBT
<i>14<sup>th</sup> week</i>
Integrated solid waste management and waste strategies

**Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Active participation is rewarded by the teacher in every class.

Students have to **submit an essay** about a given topic as scheduled minimum on a sufficient level. 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**. Based on the average of the grades of the essay and the examination, the exam grade is calculated as an average of them:

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 both the essay and the end-term test is at least satisfactory (3). The offered grade is the average of them.

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

**Lecturer:** Dr. Tibor Nagy, Assistant Professor, PhD

<b>Title of course:</b> Spectroscopic methods I. <b>Code:</b> TTKBE0503_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 22 hours</li> <li>- preparation for the exam: 40 hours</li> </ul>	
Total: 90 hours:	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0302_EN, TTFBE2113_EN	
<b>Further courses built on it:</b> TTKBL0504_EN, TTKBL0004_EN	

<b>Topics of course</b>
Modern chemical analytics is based on different branches of spectroscopy. The series of lecture are based on the topics of Nuclear Magnetic Resonance, Mass Spectrometry (MS), Infrared Spectroscopy (IR) and Ultraviolet/Visible Spectroscopy (UV). It reviews: the fundamental relations of the angular momentum and nuclear magnetism, the connections between magnetic field and nuclear magnetisation, the selection rule for NMR and the resonance condition. After that it deals with connections between electron density shielding and chemical shifts; scalar spin-spin coupling, Karplus relationship, first order spectrum (weak coupling), first order rules, second-order spectrum ("strong" coupling), <sup>13</sup> C NMR. In addition, theory and practice of optical and mass-spectroscopy is covered.
<b>Literature:</b>
<ol style="list-style-type: none"> <li>1. Andrew Derome, Modern NMR Techniques for Chemistry Research, Pergamon, ISBN-10: 0080325149</li> <li>2. Timothy D.W. Claridge, High-Resolution NMR Techniques in Organic Chemistry, Elsevier, ISBN: 9780080999869</li> <li>3. Neil Jacobsen, NMR Spectroscopy Explained, Wiley, ISBN-10: 0471730963</li> <li>4. R.M.Silverstein, F.X.Webster: "Spectrometric Identification of Organic Compounds", Wiley, 1998.</li> <li>5. F.W.McLafferty: „Interpretation of massspectra”, W.A.Benjamin, INC, New York, 1967</li> <li>6. J.R.Chapman: „PracticalOrganicMassSpectrometry”, Wiley, 1995</li> <li>7. E.Pretsch, J.T.Clerc: „Interpretation of OrganicCompounds”, VCH, 1997</li> </ol>
<b>Schedule:</b>

**1<sup>st</sup> week Basics of NMR:** Magnetic dipoles in external  $B_0$  field, nuclear Zeeman effect, selection rules, transition frequency, populations, Boltzmann distribution, bulk magnetisation, vector model.  $B_1$  radiofrequency excitation, CW and pulse-Fourier spectrometer schemes. NMR active nuclei. Fields of applications: solid-state NMR, MRI, tomography in material science, relaxation for drug quality control and oil research.

**2<sup>nd</sup> week NMR parameters:** Spin-lattice ( $T_1$ ) and spin-spin ( $T_2$ ) relaxation. The nuclear Overhauser effect. Chemical shielding, chemical shift, ppm scale. Factors influencing chemical shifts. Indirect scalar spin-spin couplings. Splitting patterns of multiplets, multiplicity rules. Karplus curves for determining dihedral angles.

**3<sup>rd</sup> week Analysis of high resolution NMR spectra 1.** :  $^1\text{H}$  spin system labelling rules based on molecular structure. First order analysis of  $^1\text{H}$  NMR spectra. Strong couplings and their impact. Integration of  $^1\text{H}$  NMR spectra, rules for quantitative NMR.

**4<sup>th</sup> week Analysis of high resolution NMR spectra 2.** : Interpretation of homo- and heteronuclear NOE data. Basic types of  $^{13}\text{C}$  NMR spectra: broadband  $^1\text{H}$ -decoupled, j-modulated attached proton test, gated decoupling for heteronuclear couplings, and inverse-gated decoupling for quantitative  $^{13}\text{C}$  NMR.

**5<sup>th</sup> week Practicing organic molecule structure elucidation by NMR 1.** :  $^1\text{H}$  NMR: Major factors influencing proton chemical shifts: electronegative substituents, neighboring anisotropic shielding, H-bonds. Acids, aldehydes, aromatics, alkenes, aliphatics. Analyzing aromatic ring substitution patterns. Alcohols, ketones.

**6<sup>th</sup> week Practicing organic molecule structure elucidation by NMR 2.** :  $^{13}\text{C}$  NMR: Signal multiplicities in undecoupled spectra. Predicting the number of carbons from decoupled spectra. The carbon NMR chemical shift correlation chart. Assigning the  $^{13}\text{C}$  NMR spectra of aromatics, alcohols, ketones and aliphatics. Interpreting signal intensities in usual, decoupled and in "quantitative"  $^{13}\text{C}$  NMR.

### **7<sup>th</sup> week NMR written TEST**

**8<sup>th</sup> week** Electromagnetic radiation, ranges and energy of electromagnetic radiation. Conditions for generating infrared spectra. Rotational and vibrational spectra. Characteristic group frequencies, characteristic vibrational frequencies. Overtone frequencies. Typical ranges of chemical vibrations and their dependence on binding energy and binding stability.

**9<sup>th</sup> week** IR spectra of alkanes, alkenes, alkynes and aromatic compounds. Alcohol identification, the effect of hydrogen bond on the IR spectrum of alcohols. Intra- and intermolecular effects affecting the C-O vibration of the carbonyl group. IR spectra of carboxylic acids and carboxylic acid derivatives.

**10<sup>th</sup> week** Absorption spectra (UV, IR, Raman) of molecules. The Bauger-Lambert-Beer Law and its Analytical Applications. Electron excitation transitions. Maximum places and  $\epsilon$  values of the UV transitions of chromophores. Selection rules. The Jablonski diagram. Frank-Condon principle, batochromic, hypsochromic, hypochromic and hyperchromic shifts. The effect of conjugation, steric hindrance on chromophores.

*11th week* Conformation and geometry of polyene systems. Effect of solvent polarity on UV spectra. The basic concepts of mass spectrometry. The main ionization techniques of organic mass spectrometry. Ionization of molecules.

*12th week* General fragmentation and fragmentation of the molecular ion: mass spectrum. The advantages and disadvantages of ionization methods. Main parts of mass spectrometer. Optimal technical requirements for sample input aspects and multicomponent samples. Ion sources, EI ion source, CI ion source.

*13th week* Molecular ionization: ESI ion source, APCI ion source. The types of Mass analyzers. The Resolution. Signal Processing: detectors.

*14th week* Basic concepts of organic mass spectrometry, mol peak, molecular ion. The nitrogen rule, natural isotopes. General aspects of the interpretation of mass spectra. Main fragmentation processes:  $\alpha$ -, benzyl, allyl cleavage. The McLafferty rearrangement. Generic mass spectrometry of different class of organic compounds

### ***15<sup>th</sup> week MS & IR written TEST***

#### **Requirements:**

*- for a signature*

Attendance at **lectures** is highly recommended (not compulsory) since interactive evaluation of test problems are parts of the lectures.

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 7<sup>th</sup> week and the end-term test in the 14<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
- or the result of the oral 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 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.Gyula Batta, university professor, DSc

**Lecturers:** Prof. Dr.Gyula Batta, university professor, DSc

Dr. Attila Kiss, associate professor, PhD

<b>Title of course:</b> Quality Management <b>Code:</b> TTBEBVM-KT6-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> 3 <sup>rd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTBEBVM-KT4_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>  The series of lectures are based on the topics of Quality Management. This course introduces the participants into the philosophy, the theories and the basic calculations of quality management. Lectures give opportunity to discuss the topics and to get practice in basics techniques of measuring quality, quality improvement, statistical process control, quality management, international standards of quality.
<b>Literature</b>  <i>Compulsory:</i> - Foster S. Thomas (2017): <i>Managing Quality: Integrating the Supply Chain</i> . 6th edition. PearsonPrentice-Hall, New-Jersey, ISBN-13: 978-0133798258 <i>Recommended:</i> -Joel E. Ross – Susan Perry (2004): Total Quality Management, Text, Cases and Readings. 3rd Edition, VanityBooks International. -David L. Goetsch - Stanley Davis (2015): Quality Management for Organizational Excellence: Introduction to Total Quality. 8th Edition. PearsonPrentice-Hall, New-Jersey, ISBN-13: 978-0133791853
<b>Schedule:</b>

*1<sup>st</sup> week: Basic issues of quality: quality of products, KANO-model*

*2<sup>nd</sup> week :Basic issues of quality: quality of services, SERVQUAL model*

*3<sup>rd</sup> week: Product Design – Paired comparison*

*4<sup>th</sup> week: Quality theories- Taguchimethod (Design of Experiments)*

*5<sup>th</sup> week: Tools of quality - 7 basic tools of quality (Ishikawa)*

*6<sup>th</sup> week: Statistical Process Control I – Charts for Variables*

*7<sup>th</sup> week: Statistical Process Control II – Charts for Attributes*

*8<sup>th</sup> week: Process Capability*

*9<sup>th</sup> week: Quality management: International Quality standards (ISO, TQM, EFQM model)*

*10<sup>th</sup> week: LEAN Manufacturing and Quality*

*11<sup>th</sup> week: Six Sigma System*

*12<sup>th</sup> week: Product Design – Quality Function Deployment*

*13<sup>th</sup> week: Risk Evaluation: Failure Mode and Effects Analysis*

*14<sup>th</sup> week: Practicing Case Studies*

**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 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. Agnes Kotsis, assistant professor, PhD

**Lecturer:** Dr. Agnes Kotsis, assistant professor, PhD

<b>Title of course:</b> Design of Experiments <b>Code:</b> TTKBE0617_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b> - lecture: 2 hours/week - practice: - - laboratory: -	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b> - lecture: 28 hours - practice: - - laboratory: - - preparation for the tests: 62 hours Total: 90 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0403_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b> The basic data processing methods in the field of engineering. Introduction to statistics for engineers: distributions, statistical estimation, statistical hypothesis tests. Regression analysis, analysis of variance (ANOVA), factorial experiment design.
<b>Literature</b> <i>Recommended:</i> 1. Zivorad R. Lazic, Design of Experiments in Chemical Engineering, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004. 2. R. Mead, S. G. Gilmour, A. Mead, Statistical Principles for the Design of Experiments: Applications to Real Experiments, Cambridge University Press, Cambridge, 2012 3. Robert de Levi. How to Use Excel® in Analytical Chemistry: And in General Scientific Data Analysis, Cambridge University Press, Cambridge, 2004
<b>Schedule:</b> <i>1<sup>st</sup> week</i> Uncertain phenomena, population, sample, probability variable, probability density function, cumulative distribution function. <i>2<sup>nd</sup> week</i> Expected value, sample mean, variance, standard deviation. <i>3<sup>rd</sup> week</i>

Gaussian distribution, z-distribution.

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

T-distribution, f-distribution.

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

Estimations, confidence intervals.

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

Hypothesis tests.

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

T-test

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

Two sample t-test.

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

Paired t-test.

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

Correlation analysis.

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

Regression analysis.

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

Analysis of variance (ANOVA).

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

Factorial experiment design.  $2^p$  plans.

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

Factorial experiment design, significance of the estimated model parameters.

### **Requirements:**

Attendance at lectures is recommended, but not compulsory.

The course ends with test for the term grade. The minimum requirement for the test is 50%. The 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)

The students can retake the test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

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

**Lecturer:** Dr. Tibor Nagy, Assistant Professor, PhD

<b>Title of course:</b> BSc thesis I. <b>Code:</b> TTKBG2011_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> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> Completion of 140 credits	
<b>Further courses built on it:</b> TTKBG2012_EN	

<b>Topics of course</b>
The aim of the course is to solve a problem that can be approached by chemical or chemical engineering methods. The student is expected to get the following competences: planning, time management, handling of information (acquiring and analysing them from various sources, such as traditional library, electronic databases, search engines), ability to work alone or in a team, practical application of the acquired knowledge, communication in native language both in oral and written ways. The student gets deeper knowledge in methods and procedures of a particular field of chemistry or chemical industry. With the help of the supervisor he/she starts to plan and execute the literature search and experimental work related to the topic of the thesis.
<b>Literature</b>
<i>Provided by the supervisor.</i>
<b>Schedule:</b> <i>The student works by following the instructions of the supervisor.</i>
<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.

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

**Lecturer:** supervisors are staff members of the Institute of Chemistry, UD or specialists at the cooperating industrial partners (e.g. MOL Petrochemistry, TEVA Pharmaceutical, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continuously verifies the work.

**Title of course:** BSc thesis II.

**ECTS Credit points:** 13

**Code:** TTKBG2012\_EN

**Type of teaching, contact hours**

- lecture: -
- practice: -
- laboratory: 13 hours/week

**Evaluation:** practice grade

**Workload (estimated), divided into contact hours:**

- lecture: -
- practice: -
- laboratory: 182 hours
- home assignment: 208 hours
- preparation for the exam: -

Total: 390 hours

**Year, semester:** 4<sup>th</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBG2011\_EN

**Further courses built on it:** -

**Topics of course**

The student will complete the task started in the previous semester by critically evaluating the literature, studying and applying the experimental method(s) to solve the given problem, carrying out the necessary practical work, and summarizing the results in a thesis of 20-30 printed pages. Detailed requirements of the thesis is described in the first part of this bulletin and in the Education and Examination Rules and Regulations, which can be found at the homepage of the insitute.

**Literature**

*Provided by the supervisor.*

**Schedule:**

*The student works by following the instructions of the supervisor.*

**Requirements:**

*- for a signature*

The student have to take part in the research project coordinated by the supervisor.

*- for a grade*

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.

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

**Lecturer:** supervisors are staff members of the Institute of Chemistry, UD or specialists at the cooperating industrial partners (e.g. MOL Petrochemistry, TEVA Pharmaceutical, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continuously verifies the work.

<b>Title of course:</b> Crystallography <b>Code:</b> TTGBE5104_EN	<b>ECTS Credit points:</b> 3
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**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice:-
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice:-
- laboratory: -
- home assignment: 10 hours
- preparation for the exam: 52 hours

Total: 90 hours

**Year, semester:** 1<sup>st</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):**

**Further courses built on it:-**

#### Topics of course

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.

#### Literature

*Compulsory:*

W. D. Nesse: Introduction to Mineralogy. Oxford University Press. Oxford-New York, 2012  
(2nd edition)

*Recommended:*

**Schedule:**

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

Subject of crystallography. Properties of crystalline substances, definition of space lattice. Principles of morphology and crystallography.

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

Bravais-type unit cells and crystals systems. Crystallography. Definition of directions, latticeplanes and crystalfaces. 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 crystalform. Crystalforms and symmetry elements in triclinic, monoclinic and orthorhombic systems.

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

Crystalforms and symmetry elements in trigonal, tetragonal and hexagonal crystalsystems

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

Crystalforms and symmetry elements in cubic crystalsystem

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

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

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

Types of atomic lattices. Metallic lattice and the 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*

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

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

Crystaloptics. Isotropic and anisotropiccrystals. Birefringency and opticalactivity. Summary

**Requirements:**

- *for a signature*

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

During the semester therewill be be two tests, the mid-term test in week 6, and the end-term test in week 15. Students have to sit for he 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 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 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, assistant professor, PhD

<b>Title of course:</b> History of chemistry <b>Code:</b> TTKBE0007_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b> <ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: 32 hours</li> <li>- preparation for the exam: 30 hours</li> </ul> Total: 90 hours	
<b>Year, semester:</b> 3 <sup>nd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0101_EN	
<b>Further courses built on it:</b> The course is connected to other courses of chemistry teachers (Basics of chemistry teaching, Methods and devices of chemistry teaching)	

<b>Topics of course</b>
<p>The topic of this course is the history of chemical thinking, the philosophical foundations of the science, the thinking systems and the history of discovery and inventions. It also concerns the impact of the development of chemistry on culture, history, the worldview and the lifestyle of mankind. The lecture covers the ancient and medieval chemistry (metal processing, cleaning, cosmetics, chemistry of medicines) as well, namely, the age of alchemy. We analyse the conditions of the discovery of gases, the development of the interpretation of chemical reactions, the history of the formation of organic chemical concepts, the formation of a modern chemical industry and the age of modern atom theory, the age of electrochemistry and radiochemistry, and the history of medication development. The historical interpretations help to understand the complex relation between the chemistry and the human culture.</p>
<b>Literature</b>
<p>Compulsory:</p> <ul style="list-style-type: none"> <li>- L. Balázs: History of chemistry I-II. (1996), National Textbook Publisher (Budapest), 1996, p.1-1075. (editors: OláhZsuzsa, lector: I. Pais, E. Szilágyi)</li> </ul> <p>Recommended:</p> <ul style="list-style-type: none"> <li>- K. Simonyi (1981): Cultural history of physics, Publisher: "GondolatKiadó", Budapest</li> <li>- L. Kovács, D. Csupor, G. Lente, T. Gunda (2011): 100 chemical myths. Publisher: "AkadémiaiKiadó"</li> </ul>

**Schedule:**

1<sup>st</sup> week: The review of the requirement. Science philosophy. Chemistry knowledge in the prehistoric age.

2<sup>nd</sup> week: The history of the chemistry in the antiquity (Syria, Arabia, Mezopotámia, Egypt, Asia)

3<sup>rd</sup> week: Chemistry knowledges in the Greek and a Roman age. The appearance of the alchemy.

4<sup>th</sup> week: Age of alchemy.

5<sup>th</sup> week: Development of jatro-chemistry.

6<sup>th</sup> week: The age of discovery of gases.

7<sup>th</sup> week: Mixtures, compounds, elements, separation, qualitative analysis, chemical symbols, formulas, nomenclature.

8<sup>th</sup> week: Development of electrochemistry.

9<sup>th</sup> week: Development of organic chemistry.

10<sup>th</sup> week: Development of terminology and language of chemistry

11<sup>th</sup> week: Chemistry and the turn of the century.

12<sup>th</sup> week: The history of the discovery of medicines. The history of famous poisons and poisoning.

13<sup>th</sup> week: Test.

14<sup>th</sup> week: Evaluation. Declaring of results.

**Requirements:**

- *for a signature*

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

- *for a offered grade*

- During the semester there is an end-term test (70% of the total scores) in the 13<sup>th</sup> week.
- “*work at lecture*”: at the beginning of the weekly lecture they can write a test (four questions from the previous lecture) and obtain 4 points, the lecturer will add these points to the end points of term test (10% of the total scores)
- “*individual collecting work*”: If the students write and send an excellent collecting work (in themes of the lectures) for the lecturer, she/he can obtain further points (20% of the total scores)

Students can obtain an offered mark, if he/she accept this mark, the examination is not necessary for him/her.

If he/she do not accept the offered mark, the course ends in an writing or oral **examination**.

The minimum requirement for 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
- 0-49	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 take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

**Person responsible for course:** Dr. Ágnes Fejesné Dávid, Assistant Professor, PhD

**Lecturer:** Dr. Ágnes Fejesné Dávid, Assistant Professor, PhD

<b>Title of course:</b> Macroeconomics <b>Code:</b> TTBEVVM-KT3_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, 1 <sup>st</sup> semester (or any later fall semester)	
<b>Its prerequisite(s):</b> TTBEVVM-KT1_EN	
<b>Further courses built on it:</b> -	

#### Topics of course

The course is aimed at making students familiar with the basic issues of macroeconomics, and make them able to use those fundamental analytical tools which are needed to think about

macroeconomic questions. By the end of the course the students have to be able to use a model of a closed economy in analysing macroeconomic phenomena will have some basic insights about an open economy, too. The topics of the course cover the basic principles of macroeconomics, measuring GDP, inflation, and unemployment, the basics of the financial system, labour market processes, and economic policy.

## **Literature**

### *Compulsory:*

Mankiw, Gregory: Principles of Economics. Fifth Edition. South-Western, Mason, USA, 2009.

### *Recommended:*

Heyne, Paul – Boettke, Peter – Prychitko, David: The Economic Way of Thinking. Twelfth Edition. Pearson Education International, New Jersey, 2010.

Mankiw, Gregory: Macroeconomics. Sixth Edition. Worth Publisher, New York, 2007.

## **Schedule:**

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

The fundamental questions of macroeconomics.

LO: The students are aware of the main questions of macroeconomics and some of the connections between them.

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

Aggregates in macroeconomics.

LO: The students understand the meaning of aggregation and the aggregates that are used most often.

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

Measuring income: nominal and real GDP.

LO: The students understand the different approaches to measuring GDP and the relationships between these approaches.

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

Measuring the costs of living.

LO: The students understand the steps through which the consumer price index is calculated, and the meaning of that index.

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

Money, monetary system, money supply, demand for money, and inflation I

LO: The students know the functions of money and have a birds-eye view of the money creation process.

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

Money, monetary system, money supply, demand for money, and inflation II

LO: The students understand the role and structure of the banking sector in the economy, are aware of the basic roles of the central bank, are able to explain some of the social costs, and cause, of inflation.

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

The time value of money

LO: The students are aware of the methods of comparing future income flows with different timing.

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

Saving, investment, and the financial system.

LO: The students understand the function of savings, and that of the market for loanable funds in the economy. They know the basic types of financial assets such as stocks and bonds.

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

Labour market and unemployment.

LO: The students know the main measures to describe the labour market with, the main reasons, and the types of, unemployment.

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

Short-run economic fluctuations I.

LO: The students are familiar with the notion of aggregate demand and supply.

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

Short-run aggregate fluctuations II.

LO: The students are familiar with the possibilities and limitations of fiscal and monetary policy in countervailing recessions.

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

The economy in the long run.

LO: Students are familiar with the factors that determine aggregate income in the long run.

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

International economic relations.

LO: Students are familiar with the basic welfare implications of international trade, and the effects of protectionism.

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

Summary.

LO: Students have a birds-eye view of the relationships of the topics that will have been discussed.

**Requirements:**

*- for a signature*

There is no requirement for a signature.

*- for a grade*

Assessment is based on a written exam which will be evaluated according to the following grading schedule:

0 -50% – fail (1)

50%+1 point -63% – pass (2) 64% -75% – satisfactory (3) 76% -86% – good (4) 87% -100% – excellent (5)
<b>Person responsible for course:</b> Dr.PálCzeglédi, associate professor, PhD
<b>Lecturer:</b> Dr.Levente Sándor Nádasi, Assistant professor, PhD

<b>Title of course:</b> Special and dangerous materials. <b>Code:</b> TTKBE0204_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: 2 hours/week</li> <li>- practice: -</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> exam	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: 28 hours</li> <li>- practice: -</li> <li>- laboratory: -</li> <li>- home assignment: -</li> <li>- preparation for the exam: 62 hours</li> </ul> <p>Total: 90 hours</p>	
<b>Year, semester:</b> 2 <sup>nd</sup> –4 <sup>th</sup> year, 1 <sup>st</sup> semesters	
<b>Its prerequisite(s):</b> TTKBE0201_EN, TTKBE0301_EN, TTKBE0401_EN	
<b>Furthercoursesbuiltonit:</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

**Schedule:**

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

Narcotics, hard and softdrugs 1. General properties, groups, addiction, legalstate. Treatment of addiction. Cannabis.

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

Narcotics, hard and softdrugs 2. Opium, morphine, heroine, opioids. Treatment of addiction, withdrawalsyndroms.

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

Narcotics, hard and softdrugs 3. LSD, mescaline, and relatedderivatives.

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

Narcotics, hard and softdrugs 4. Natural materials: Catinone, harmine, harmaline, bufotenine, ibogaine, ephedrine, LSA, safrole, iso-safrole, myristicyn.

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

Narcotics, hard and softdrugs 5. Synthetics 1. Amphetamine and derivatives, Extasy, etc..

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

Narcotics, hard and softdrugs 6. Synthetics 2. DON, DOB, STP, designerdrugs.

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

Chemicalweapons 1. Major groups, targetorgans, toxicity. Teargases, lachrymators.

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

Chemicalweapons 2. Bloodpoisons, lungpoisons, vesicants..

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

Chemicalweapons 3. Nervegases. Floro organic poisons.

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

Chemicalweapons 4. Binary chemical weapons. Incendiaries, flame materials, heatsource materials.

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

Explosives, pyrotechnics 1. Basic concepts, definitions, modes of action. Deflagration: gunpowder. Energeticmaterials, propellants, highenergypolymers.

*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 gunpowders. 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, theDirty 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.

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

**Lecturer:** Dr. István Lázár, associate professor, PhD

<b>Title of course:</b> Computational Quantum Chemistry <b>Code:</b> TTKBG0903_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
- lecture: - - practice: 2 hours/week - laboratory: -	
<b>Evaluation:</b> mid-semestergade	
<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> 2 <sup>nd</sup> / 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTMBE0809_EN, TTMBG0809_EN, TTKBG0911_EN	
<b>Further courses built on it:</b> -	

#### **Topics of course**

Hartree-Fock Theory. DensityFunctionalTheory. Basissets. Solventeffect, Polarizable. Continuum Model. Geometryoptimization. Structuralanalysis. Calculatingenergies of chemical reactions

#### **Literature**

*Compulsory:*

<https://maker.pro/linux/tutorial/basic-linux-commands-for-beginners>

<http://gaussian.com/keywords/>

*Recommended:*

<http://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf>

### **Schedule:**

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

Basic theory of the Hartree-Fock method: approximations, LCAO-MO theory. Building structures by the GaussView program.

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

Basic Linux commands, using the WinSCP and Putty programs, connecting by SFTP. Using the Gaussian program package, optimizing simple molecules.

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

Geometry optimizations by different basis sets, comparing and calibrating the methods by structural parameters.

*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-Hartree-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. Oldamur Hollóczki, university professor, PhD

**Lecturer:** Dr. Oldamur Hollóczki , university professor, PhD

Dr. Attila Mándi, Assistant Professor, PhD

**Title of course:** Applied Radiochemistry  
**Code:** TTKBE0504\_EN

**ECTS Credit points:** 3

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 22 hours
- preparation for the exam: 40 hours

Total: 90 hours

**Year, semester:** 3<sup>rd</sup> year, 1<sup>st</sup> semester

**Its prerequisite(s):** TTKBE0403\_EN

**Further courses built on it:** -

**Topics of course**

- Interaction of radiation with matter and its practical aspects.
- Radioactive labeling.
- Production of radionuclides.
- Chemical, biological, medical applications
- Nuclear energy production.
- Tools and facilities of isotope laboratories.

## Literature

### *Compulsory:*

- 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,

## Schedule:

### *1<sup>st</sup> week and 2<sup>nd</sup> week*

Interaction of radiation with matter, general sketch of the applications.

### *3<sup>rd</sup> week and 4<sup>th</sup> week*

Applications of natural radioactive and stable isotopes

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

Production of radionuclides

### *6<sup>th</sup> week and 7<sup>th</sup> week*

Radiotracers, physical chemistry of carrier-free concentrations.

Basic rules of tracer studies.

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

Tracer studies in chemistry, nuclear medicine and chemical industry.

### *9<sup>th</sup> -12<sup>th</sup> week*

Nuclear and radioanalytical methods based on radiation-matter interactions.

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

New trends in nuclear energy production.

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

Operation, tools, and facilities of isotope laboratories.

## 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:** Dr.Noémi Nagy, professor, DSc

**Lecturer:** Dr.Noémi Nagy, professor, DSc

<b>Title of course:</b> Plastics and Processing I. <b>Code:</b> TTKBL1212_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 - preparation for the tests: 32 hours Total: 60 hours	
<b>Year, semester:</b> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0611_EN	
<b>Further courses built on it:</b> -	

### Topics of course

Determination the density of plastics. Molding of plastic sheets. Shore hardness determination. Determination of mechanical properties of plastics based on tensile test. Impact testing of polypropylenes. Determination of Ball Indentation and Rockwell Hardness of polymers. Determination of MFI value of plastics.

### Literature

#### *Recommended:*

1. ISO standards (one copy can be found in the laboratory)
2. Syllabus provided by the Department of Applied Chemistry
3. George Odian: Principles of Polymerization, McGraw-Hill, New York (1983)

### Schedule:

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

Determination the density of plastics.

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

Molding of plastic sheets. Shore hardness determination.

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

Determination of mechanical properties of plastics based on tensile test.

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

Impact testing of polypropylenes.

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

Determination of Ball Indentation and Rockwell Hardness of polymers.

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

Determination of MFI value of plastics.

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

Test writing.

**Requirements:**

The laboratory practices will be done in blocks (4 hours a week, 7 weeks). Attendance at laboratory practices are compulsory.

All measuring group will prepare a laboratory notebook (laboratory record) after every practice.

The practice ends with a test for a partial grade. The test will cover the theoretical and the practical part of the laboratory practices. (The test is also compulsory!) The minimum requirement for the test is 50 %. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

The practice grade will be calculated as a weighted average by the following way: 60 % of the test result, 40 % of the laboratory notebook.

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

**Lecturer:** Katalin Illyésné Dr. Czifrák, assistant professor, PhD

<b>Title of course: Plastics and Processing II.</b>	<b>ECTS Credit points: 2</b>
<b>Code:</b> TTKBE1213_EN	

**Type of teaching, contact hours**

- lecture: -
- practice: 2 hours/week
- laboratory: -

**Evaluation:** mid-semester grade

**Workload (estimated), divided into contact hours:**

- lecture: -
- practice: 28 hours
- laboratory: -
- preparation for the tests: 32 hours

Total: 60 hours

**Year, semester:** 3<sup>rd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** TTKBE0611\_EN

## Further courses built on it: -

### Topics of course

The current situation and future prospects of world and domestic plastics production and use. Production of polyethylene I. (high pressure). Production of polyethylene II. (high pressure tube reactor and medium pressure processes) and its applications. Production of polypropylene, newer technology development. Domestic technologies for production of polypropylene (bulk polymerization and gas phase processes), use of polypropylene. Production of polystyrene (high impact strength and expandable polystyrene) and its use. Possibilities of manufacturing PVC. Home production and use of PVC. Possibilities for producing polyamides. Production and use of polyamide-6. Production and use of polyacrylonitrile. Manufacture and use of polyester fabrics. Additives used in the plastics industry.

### Literature

#### *Recommended:*

1. Website of MOL Petrochemicals
2. *Ullmann's Encyclopedia of Industrial Chemistry*, Wiley-VCH Verlag GmbH & Co. KGaA (2002)
3. George Odian: *Principles of Polymerization*, McGraw-Hill, New York (1983)

### Schedule:

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

The current situation and future prospects of world and domestic plastics production and use.

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

Production of polyethylene I. (high pressure).

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

Production of polyethylene II. (high pressure tube reactor and medium pressure processes) and its applications.

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

Production of polypropylene, newer technology development.

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

Domestic technologies for production of polypropylene (bulk polymerization and gas phase processes), use of polypropylene.

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

Production of polystyrene (high impact strength and expandable polystyrene) and its use.

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

Possibilities of manufacturing PVC

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

Home production and use of PVC.

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

Possibilities for producing polyamides. Production and use of polyamide-6.

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

Production and use of polyacrylonitrile.

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

Manufacture and use of polyester fabrics.

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

Additives used in the plastics industry.

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

Consultation and PPT presentations.

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

Test and PPT presentations.

**Requirements:**

Attendance at seminars is compulsory.

The course ends with test for a partial grade. (This test is compulsory!) The minimum requirement for the test is 50%. The grade is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-80	satisfactory (3)
81-90	good (4)
91-100	excellent (5)

All the students will deliver a ppt presentation on a subject. They will get a second partial grade. The term grade will be calculated by the following way: 60% of the test result, 40% of the ppt presentation

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

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

<b>Title of course:</b> Colloid Chemistry <b>Code:</b> TTKBE0415_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> 3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0402_EN	
<b>Further courses built on it:</b> -	

**Topics of course**

The goal of this series of lectures is to give knowledge to the students about the relation between size and physico-chemical properties. Students are expected to get acquainted with the behaviour of nanosized particles, the role of the interfaces and their possible applications.

## **Literature**

### *Compulsory:*

- Lecture slides downloadable from the Department's homepage (<http://fizkem.unideb.hu>)
- Barnes, GT, Gentle, IR: *Interfacial Science*. Oxford UP. ISBN 0-a19-a927882-a2, 2005
- 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

## **Schedule:**

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

Introduction. The notion of colloids and the classification of colloid systems. Synthesis of colloids. Relation between colloids and nanotechnology. Average and types of average.

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

Molecular interactions. Quantitative description of electrostatic and van der Waals interactions, their role in the synthesis of colloids. Lennard-Jones potential. Hydrophilic and hydrophobic interactions.

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

Notion and characterization of interfaces. Fluid interfaces. Interfacial phenomena, the concept of surface tension. The Eötvös rule. Laplace pressure, importance of curved surfaces.

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

Nonfluid interfaces. Contact angle, wetting and spreading. Adhesion and cohesion. Adsorption at fluid interfaces, the Gibbs isotherm. Langmuir and Langmuir-Blodgett layers.

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

Adsorption at solid-liquid interfaces. Adsorption isotherms. Formation of charged interfaces and their significance. Chromatographies.

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

Formation of the electrostatic double layer, its structure and description. Comparison of the Helmholtz, Gouy-Chapman and Stern models. Potentials. Zeta potential.

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

Electrokinetic phenomena. Electrophoretic mobility. The phenomenon of electroosmosis and its practical use in capillary electrophoresis.

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

Stabilization and destabilization of lyophobic colloids. The Hamaker model. The DLVO theory. Sterical stabilization. Salting out. Destabilization of lyophilic colloids. The technology of butter-and cheese-making.

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

Gas-liquid disperse systems. Stability, preparation and importance of aerosols. Stability, preparation and practical use of foams.

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

Liquid-liquid disperse systems. Preparation and breaking of emulsions. Emulsifiers, the HLB value.

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

Solid-liquid disperse systems. Their preparation, stabilization, kinetic description of their formation.

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

Association colloids. Surface activity. Amphiphilic molecules and micelles. Micelle formation, the critical micelle concentration. Surfactants, detergents.

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

Types of macromolecular colloids. Macromolecules and plastics. Drug transport and targeted delivery.

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

Basics of rheology. Viscosity and its measurement. Viscosity- and flow curves. Basic rheological types. Applications.

**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

**Title of course:** Biochemistry III

**ECTS Credit points:** 3

**Code:** TTBBE0304\_EN

**Type of teaching, contact hours**

- lecture: 2 hours/week
- practice: -
- laboratory: -

**Evaluation:** exam

**Workload (estimated), divided into contact hours:**

- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment :
- preparation for the exam: 62 hours

Total: 90 hours

**Year, semester:** 2<sup>nd</sup> year, 2<sup>nd</sup> semester

**Its prerequisite(s):** Biochemistry I

**Further courses built on it:** -

**Topics of course**

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.

**Literature**

*Compulsory:* The lecture notes

*Recommended:*

Nelson D.L., Cox M.M.: LehningerPrinciples of Biochemistry (W. H. Freeman Sixthedition, 2012) ISBN-13: 978-14234146.

Berg J.M., Tymoczky J.L., Gatto G.J. and Styer L.: Biochemistry (W. H. Freeman; Eighthedition, 2015), ISBN-13: 978-1464126109.

Albert B., Bray D. EssentialCellBiology (Fouthedition, Garland Science, 2014) ISBN: 978-0-8153-4454-4.

**Schedule:**

*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 pyrimidin *de novo* biosynthesis. The interconversion of nucleoside mono- di- and triphosphates.

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

*The* purin *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 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.

<b>Title of course:</b> Biocolloids <b>Code:</b> TTKBE0405_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> /3 <sup>rd</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0402_EN	
<b>Further courses built on it:</b> -	

**Topics of course**

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.

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**Literature**

*Compulsory:*

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

*Recommended:*

- 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 0-470-08688-3-aX, 2004
- Cosgrove T.: Colloid science. Blackwell Publishing ISBN: 978-0-14051-026-73-a1, 2005

**Schedule:**

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

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".

*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

**Title of course:** NMR Operator Training Practice I.  
**Code:** TTKML0004\_EN, TTKBL0004\_EN

**ECTS Credit points:** 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> Spectroscopic methods I.TTKBE0503_EN
<b>Furthercoursesbuiltoin:</b> Advanced NMR practicalcourse 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. Lockpower, field, phase, gain, findingthelocksignal. Optimizinglockparametersavoidingsaturation of thedeuteriumsignal.  <i>3<sup>rd</sup> week</i> Homogenisation of the main magnetic field upto 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 in TMS signal.  <i>4<sup>th</sup> week</i> Recording proton NMR spectra. Measurement principles: pulse program zg and it's visualisation. Acqusition 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  $^1\text{H}$ -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 (zggd) and inverse gated (zgig) sequences. The former for measuring heteronuclear couplings with better sensitivity, the latter for quantitative  $^{13}\text{C}$ -NMR. Adjusting optimal parameters for carbon NMR. Explaining signal multiplicity of deuterated organic solvents. Peak picking (ppm) of spectra.

*8<sup>th</sup> week* Excercising  $^1\text{H}$  NMR signal acquisition and processing one by one.

*9<sup>th</sup> week* Excercising  $^{13}\text{C}$  NMR signal acquisition and processing one by one.

*10<sup>th</sup> week* Excercising  $^1\text{H}$  NMR signal acquisition and processing one by one.

*11<sup>th</sup> week* Excercising  $^{13}\text{C}$  NMR signal acquisition and processing one by one.

*12<sup>th</sup> week* Excercising  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR signal acquisition and processing one by one.

*13<sup>th</sup> week* Excercising  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR signal acquisition and processing one by one.

*14<sup>th</sup> week* Excercising  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR signal acquisition and processing one by one.

#### **Requirements:**

- *for a signature*

Attendance of laboratory excercises 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.Gyula Batta, university professor, DSc

**Lecturer:** Prof. Dr.Gyula Batta, university professor, DSc

<b>Title of course:</b> Plastics and Processing III. <b>Code:</b> TTKBE1214_EN	<b>ECTS Credit points:</b> 3
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 3 hours/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 42 hours</li> <li>- laboratory: -</li> <li>- home assignment: 22 hours</li> <li>- preparation for the exam: 28 hours</li> </ul>	
Total: 90 hours	
<b>Year, semester:</b> 4 <sup>th</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> TTKBE0611_EN	
<b>Further courses built on it:</b> -	

### Topics of course

The basics of the processing of different plastics. Classification of plastic types. Mixing and homogenization of plastics. Theory of extrusion, technological aspects. Extrusion of different product types (rod, tube, sheet, hollow bodies). Calendering, tube blowing, dry melt and wet spinning. Technology of injection molding. Compression molding. Thermoforming technologies (stretching, deep-drawing, pressure and vacuum forming). Forming methods without pressure (casting, die casting, centrifugal casting, rotational molding, dip-coating). Plastic coatings. Plastic foams, foaming. Basics of composites. Fixation of plastic components: adhesive bonding, screwing, welding, clamp joint. Liquid resin processes. Decorating and finishing.

### Literature

#### *Compulsory:*

- A.B. Strong: Plastics: Materials and Processing (Prentice Hall, 2006) ISBN: 9780131145580
- C.A. Harper: Handbook of Plastic Processes (Wiley, 2005) ISBN: 9780471662556

**Recommended:**

- Z. Tadmor, C.G. Gogos: Principles of Polymer Processing (Wiley, 2006), ISBN: 0471387703

**Schedule:**

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

The basics of the processing of different plastics. Classification of plastic types.

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

Mixing and homogenization of plastics.

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

Theory of extrusion, technological aspects. Extrusion of different product types (rod, tube, sheet, hollow bodies).

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

Calandering, tube blowing, dry melt and wet spinning.

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

Technology of injection molding. Available plastics, formed products.

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

Compression molding with pressure or vacuum. Available plastics, formed products.

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

Thermoforming technologies (stretching, deep-drawing, pressure and vacuum forming).

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

Forming methods without pressure (casting, die casting, centrifugal casting, rotational molding, dip-coating).

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

Plastic coatings on different materials: metals, glass, plastics.

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

Plastic foams, foaming. Foaming agents and methods.

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

Basics of composites. Reinforcing fiber types, physico-chemical background.

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

Fixation of plastic components: adhesive bonding, screwing, welding, clamp joint.

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

Liquid resin processes.

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

Decorating and finishing.

**Requirements:**

*- for a signature*

Attendance at **lectures** is recommended, but not compulsory. Active participation is rewarded by the teacher in every class.

Students have to **submit an essay** about a given topic as scheduled minimum on a sufficient level.

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**. Based on the average of the grades of the essay and the examination, the exam grade is calculated as an average of them:

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 both the essay and the end-term test is at least satisfactory (3). The offered grade is the average of them.

**Person responsible for course:** Prof. Dr. Sándor Kéki, universityprofessor, DSc

**Lecturer:** Prof. Dr. Sándor Kéki, university professor, DSc

<b>Title of course:</b> Organic Chemistry Seminar I. <b>Code:</b> TTKBG0311_EN	<b>ECTS Credit points:</b> 1
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 1 hour/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 14 hours</li> <li>- laboratory: -</li> <li>- home assignment: 16 hours</li> <li>- preparation for the exam: -</li> </ul>	
Total: 30 hours	
<b>Year, semester:</b> 1 <sup>st</sup> year, 2 <sup>nd</sup> semester	
<b>Its prerequisite(s):</b> General Chemistry I. (lecture) TTKBE0101_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Review the basic of organic chemistry. Types and theories of chemical bonds. Review the acid-base theories. Basic concepts of isomerism and stereochemistry. Classification of organic chemical reactions. Functional groups and the basics of organic nomenclature. The structure, nomenclature, synthesis and reactions of alkanes, alkenes, alkynes, mono- and polycyclic, homo- and heteroaromatic hydrocarbons.
<b>Literature</b>
<p><i>Compulsory:</i>  Course material, concept and task collection for lectures, seminars in the e-learning system.</p> <p><i>Recommended:</i></p> <p>J. G. Smith: Organic Chemistry, 5<sup>th</sup> Edition, 2016, McGraw Hill; ISBN-13: 9780077354725  J. McMurry: Organic Chemistry, 8<sup>th</sup> Edition, 2012, Brooks/Cole; ISBN-13: 9780840054449  J. Clayden, N. Greeves, and S. Warren: Organic Chemistry, 2<sup>nd</sup> Edition, 2012, Oxford University Press; ISBN-13: 9780199270293  F. A. Carey: Organic Chemistry, 4<sup>th</sup> Edition, 2000, The McGraw-Hill Companies; ISBN-13: 9780072905014  L. G. Wade: Organic Chemistry, 8<sup>th</sup> Edition, 2012, Pearson; ISBN-13: 9780321768148  T. W. G. Solomons, C. Fryhle, Organic Chemistry, 10<sup>th</sup> Edition, 2009, Wiley&amp;Sons; ISBN-10: 0470556595  H. Meislich, E. K. Meislich, J. Sharefkin: 3000 Solved Problems in Organic Chemistry, 1<sup>st</sup> Edition, 1994, McGraw-Hill Companies; ISBN-13: 978-0070564244</p>

<b>Schedule:</b>
<i>1<sup>st</sup> week</i> Comparison and exercise of representation of organic compounds. Determination of the order (primary, secondary, tertiary, quaternary) of carbon atoms in compounds.
<i>2<sup>nd</sup> week</i> The use of resonance structures and hybridization in the interpretation of the structure of organic compounds. Interpretation of electron shift or delocalization phenomena (inductive and mesomeric effect, conjugation and hyperconjugation).
<i>3<sup>rd</sup> week</i> Exercise the recognition of organic compounds and functional groups.
<i>4<sup>th</sup> week</i> Use of the substitutive and functional class nomenclature in naming hydrocarbons. Practice the names of alkyl groups.
<i>5<sup>th</sup> week</i> Exercise of the most important types of organic chemical reactions, recognition of reactive particles (electrophile, nucleophile, radical).
<i>6<sup>th</sup> week</i> Exercise the concept of constitution, conformation and configuration. Recognition and differentiation of enantiomers and diastereomers.
<i>7<sup>th</sup> week</i> Practice the representation and projection of the organic molecules. The absolute configuration of chiral compounds, Fischer and Cahn-Ingold-Prelog convention.
<i>8<sup>th</sup> week</i>

Interpretation of radical transformations of alkanes. Statistical and regioselective halogenation of alkanes. Synthesis of alkanes.

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

Methods for the synthesis of alkenes, cycloalkenes. Addition reactions of alkenes, regioselectivity and its interpretation in addition reactions.

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

Addition reactions of conjugated dienes, partial and complete addition. 1,2- and 1,4- addition and its interpretation based on kinetic and thermodynamic control. Diels-Alder cycloaddition.

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

Synthesis of alkynes. Chemical transformations of alkynes: C-H acidity, addition reactions and their significance. The role of acetylene in the chemical industry, coal-based chemical industry.

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

Exercise the criteria of aromaticity. Interpretation of aromatic electrophilic substitution reactions.

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

The  $S_{EA}$ -reactions of substituted benzene derivatives –the reactivity and regioselectivity.

Classification of substituents and interpretation of their effect on reactivity and regioselectivity.

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

Reactions of aromatic hydrocarbons containing alkyl residues, interpretation of the stability of benzyl-type reactive intermediates. Most important representatives of polycyclic aromatic hydrocarbons.

**Requirements:**

The course is recommended in parallel with the lecture Organic Chemistry I. (TTKBE0301\_EN).

**Evaluation:**

*- for a signature*

Attendance at seminars is **compulsory**. A student may not miss the seminar 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.

The performance of the students in the seminar is verified 4 times in the form of written tests.

*- for a grade*

The term mark is based on the average of the grades of written tests.

The minimum requirement for the 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)

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

**Lecturer:** László Dr.Juhász, associate professor, PhD

<b>Title of course:</b> OrganicChemistry Seminar II. <b>Code:</b> TTKBG0312_EN	<b>ECTS Credit points: 1</b>
<b>Type of teaching, contact hours</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 1 hour/week</li> <li>- laboratory: -</li> </ul>	
<b>Evaluation:</b> mid-semester grade	
<b>Workload (estimated), divided into contact hours:</b>	
<ul style="list-style-type: none"> <li>- lecture: -</li> <li>- practice: 14 hours</li> <li>- laboratory: -</li> <li>- home assignment: 16 hours</li> <li>- preparation for the exam: -</li> </ul>	
Total: 30 hours	
<b>Year, semester:</b> 2 <sup>nd</sup> year, 1 <sup>st</sup> semester	
<b>Its prerequisite(s):</b> Inorganic Chemistry I. (lecture) TTKBE0201_EN, OrganicChemistry I. (lect. and sem.) TTKBE0301_EN, PhysicalChemistry I. (lecture) TTKBE0401_EN	
<b>Further courses built on it:</b> -	

<b>Topics of course</b>
Overview and exercising of the structure, physical, chemical properties of hydrocarbons possessing heteroatoms as halogenated hydrocarbons, organometallic derivatives, alcohols, phenols, ethers and their thio analogues; amines, nitro derivatives, diazonium salts, aldehyde, ketones, carboxylic acids and their derivatives, derivatives of carbonic acid
<b>Literature</b>
<p><i>Compulsory:</i> Coursematerial, concept and taskcollectionforlectures, seminars in the e-learningsystem.</p> <p><i>Recommended:</i></p> <p>J. G. Smith: OrganicChemistry, 5<sup>th</sup> Edition, 2016, McGrow Hill; ISBN-13: 9780077354725  J. McMurry: OrganicChemistry, 8<sup>th</sup> Edition, 2012, Brooks/Cole; ISBN-13: 9780840054449  J. Clayden, N. Greeves, and S. Warren: OrganicChemistry, 2<sup>nd</sup> Edition, 2012, Oxford University Press; ISBN-13: 9780199270293  F. A. Carey: OrganicChemistry, 4<sup>th</sup> Edition, 2000, The McGraw-Hill Companies; ISBN-13: 9780072905014  L. G. Wade: OrganicChemistry, 8<sup>th</sup> Edition, 2012, Pearson; ISBN-13: 9780321768148  T. W. G. Solomons, C. Fryhle, OrganicChemistry, 10<sup>th</sup> Edition, 2009, Wiley&amp;Sons; ISBN-10: 0470556595  H. Meislich, E. K. Meislich, J. Sharefkin: 3000 SolvedProblems in OrganicChemistry, 1<sup>st</sup> Edition, 1994, McGraww-Hill Companies; ISBN-13: 978-0070564244</p>

**Schedule:**

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

Practice the classification and synthesis of halogenated hydrocarbons.

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

Practice the elimination and substitution reactions of halogenated hydrocarbons.

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

Practice the preparation of Grignard compounds and their application.

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

Preparation of alcohols, ethers, phenols and their thioanalogues. The acid-base properties of alcohols, phenols and their thioanalogues

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

Practice the chemical properties of alcohols and phenols, ethers and their thioanalogues.

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

Practice the classification of amines and characterization of their bonding systems. Practice the synthetic methodologies of aliphatic and aromatic amines, industrial methods.

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

Practice the basicity and chemical transformations of the amines (alkylation, acylation, sulfonamide formation, reaction with nitric acid). Reactions of aromatic rings of anilines.

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

Practice the preparation of nitro compounds, diazonium salts. Reactions and practical significance of aromatic diazonium salts.

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

Practice the synthetic possibilities of aldehydes and ketones and an overview of their acid-base properties.

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

Practice the transformations of aldehydes and ketones. Reactions of the carbonyl group (nucleophilic addition reactions with O-, S-, N- and C-nucleophiles) and reactions on the  $\alpha$ -carbon atoms.

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

Practice the classification and preparation of carboxylic acids and their derivatives.

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

Practice the acid-base properties of carboxylic acids and its derivatives. The acyl nucleophilic substitution and the reductive transformations of carboxylic acid derivatives, transformation of their carbon skeleton.

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

Chemical properties of  $\beta$ -dicarboxylic acids, malonester synthesis.

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

Chemical properties of  $\beta$ -oxocarboxylic acid derivatives, acetoacetic ester and cyanoacetic ester syntheses.

**Requirements:**

The course is recommended in parallel with the lecture Organic Chemistry II. (TTKBE0302\_EN).

**Evaluation:**

- *for a signature*

Attendance at seminars is **compulsory**. A student may not miss the seminar 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.

The performance of the students in the seminar is verified 4 times in the form of written tests.

*- for a grade*

The term mark is based on the average of the grades of written tests.

The minimum requirement for the 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)

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

**Lecturer:** Dr.László Juhász, associate professor, PhD, dr.habil

<b>Title of course:</b> Advanced Organic Chemistry Seminar <b>Code:</b> TTKBG0313_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: 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> OrganicChemistry II. (lect .and sem.) TTKBE0302_EN	
<b>Further courses built on it:</b> -	

#### **Topics of course**

The aim of the course is to enable students to master the complex organic chemistry problem solving skills, and to be able to apply the knowledge acquired in basic courses in solving complex synthetic tasks and designing syntheses.

## Literature

### *Compulsory:*

Course material, concept and task collection for lectures, seminars in the e-learning system.

### *Recommended:*

J. G. Smith: Organic Chemistry, 5<sup>th</sup> Edition, 2016, McGraw Hill; ISBN-13: 9780077354725

J. McMurry: Organic Chemistry, 8<sup>th</sup> Edition, 2012, Brooks/Cole; ISBN-13: 9780840054449

J. Clayden, N. Greeves, and S. Warren: Organic Chemistry, 2<sup>nd</sup> Edition, 2012, Oxford University Press; ISBN-13: 9780199270293

F. A. Carey: Organic Chemistry, 4<sup>th</sup> Edition, 2000, The McGraw-Hill Companies; ISBN-13: 9780072905014

L. G. Wade: Organic Chemistry, 8<sup>th</sup> Edition, 2012, Pearson; ISBN-13: 9780321768148

T. W. G. Solomons, C. Fryhle, Organic Chemistry, 10<sup>th</sup> Edition, 2009, Wiley & Sons; ISBN-10: 0470556595

H. Meislich, E. K. Meislich, J. Sharefkin: 3000 Solved Problems in Organic Chemistry, 1<sup>st</sup> Edition, 1994, McGraw-Hill Companies; ISBN-13: 978-0070564244

## Schedule:

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

The basics of retrosynthetic analysis, the concept of synthones and retrones. Types of disconnections. Interconversion of functional groups. The use of the method in the exploration of simple synthetic possibilities for compounds.

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

Retrosynthetic analysis of aromatic compounds. Use of the directing and activating/deactivating effects to form the appropriate substituent pattern.

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

Methods for forming C-C bond I. Base catalyzed conversions I. (aldol condensation and its variants).

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

Methods for forming C-C bond II. Base catalyzed conversions II. (malonic ester and acetoacetic ester syntheses).

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

Methods for forming C-C bond III. Acid catalyzed transformations.

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

Methods for forming C-C bond IV. Possibilities for the formation and use of Grignard compounds.

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

Methods for forming C-C bond V. Transition metal (Pd, Pt, Ru, Cu, etc.) catalyzed conversions.

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

Methods for forming carbon-oxygen and carbon-sulfur bonds.

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

Possibilities for forming carbon-nitrogen bonds.

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

Reactions suitable for the synthesis of oxo compounds.

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

Reactions for the preparation of carboxylic acids and their derivatives.

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

Preparation and reactions of amino acids. Peptide synthesis.

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

The basic chemical properties of monosaccharides. Protecting Groups. Essential questions of synthesis of di- and oligosaccharides.

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

The synthesis of basic heterocycles and their chemical properties.

**Requirements:**

The course is recommended in parallel with the lecture Organic Chemistry III. (TTKBE0303\_EN).

*- for a signature*

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

Attendance at seminars is compulsory. A student may not miss the seminar 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.

*- 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.László Juhász, associate professor, PhD

**Lecturer:** Dr.László Juhász, associate professor, PhD