Master's Program in Chemistry

Department of Chemistry
School of Sciences and Engineering
University of Crete

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First Semester
Specialization: Biological and Organic Chemistry

COURSE OUTLINE
GMP69 - STRUCTURE AND FUNCTION OF PROTEINS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP69	**SEMESTER**	WINTER
COURSE TITLE	Structure and Function of Proteins		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
LECTURES		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge Elective course		
PREREQUISITE COURSES:	THE COURSE REQUIRES A BASIC KNOWLEDGE OF BIOCHEMISTRY AND BIOLOGY		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes (If there are Erasmus students, it is taught in English)		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST103/		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course aims at understanding the structure and function of proteins and their role in organisms so that students are able to understand the molecular mechanisms that govern life. The course introduces the methodology of studying protein structure and the function of biological membranes. Then, the aim is to link the knowledge of proteins and the basic processes in which they participate to the understanding of the molecular basis of diseases and how therapeutic approaches work.

Upon successful completion of the course, students will
- will have a basic understanding of the structure of proteins, their interactions and supramolecular self-organisation
- have the basic knowledge to understand the molecular basis of protein function in organisms.
- will have been exposed to the molecular basis of disease and the use of proteins as therapeutic targets

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search, analysis and combination of data and information, using the necessary technologies
- Working independently

- Working in an interdisciplinary environment
- Generating new research ideas
- Promotion of free, creative and deductive thinking

(3) SYLLABUS

1 Introduction

Peptide bonding, secondary structures, forces that create the three-dimensional structure of proteins

2 Folding and evolution of proteins

Forces responsible for protein folding, thermostable proteins, ways of evolution of protein functions

3 Protein domains

Role of protein domains, role of intramolecular domains

4 Oligomers

Forces responsible for the formation of oligomers. Specification and control. Prokaryotic and eukaryotic transcription factors

5 Protein interactions in vivo

Proteins in the cell, modes of substrate recognition, specificity

6 Polyenzyme complexes: Catalytic nanomachines

Experimental approaches to study protein interactions, channel enzyme complexes, swing arm enzyme complexes

7 Self-assembly of proteins

Cytoskeletal proteins, Viral structures and functions

8 Membrane proteins

Asymmetry of membranous proteins, interactions with the lipid bilayer, monolayer membrane proteins

9 Cell signal

Generation and transport within the cell, effect on cell metabolism

10 Transport

Role of membrane proteins in transport, control and specificity, chemical energy production

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	
TEACHING METHODS *The manner and methods of teaching are described in detail.*	

Activity	*Semester workload*
Lectures	50
Study	90
Oral Presentation	60
Final Examination	55

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	<table><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td>Course total</td><td>255</td></tr></table>
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Evaluation language is Greek or English if there are foreign students. Two presentations of scientific articles on topics related to structural biology The final grade of the course is calculated by: - 60% from the grading of the presentations - 40% from the final oral examination, lasting 1 hour for each student

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Carl Branden & John Tooze “Introduction to Protein Structure” (1999, 2th Edition Garland Science)
- Mike Williamson “How proteins works” (2012, Garland Science)
- Alasdair Steven, Wolfgang Baumeister, Louise Johnson & Richard Perham “Molecular biology of assemblies and machines” (2016, Garland Science)
- Stephen H. White Gunnar von Heijne Donald M. Engelman “Cell Boundaries. How Membranes and Their Proteins Work” (2022, CRC Press)

- Related academic journals:

COURSE OUTLINE

GMP88 - BIOCATALYSIS-APPLICATIONS IN ORGANIC SYNTHESIS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	GMP88	**SEMESTER**	WINTER
COURSE TITLE	BIOCATALYSIS-APPLICATIONS IN ORGANIC SYNTHESIS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised in the applications of Biocatalysis in organic synthesis
PREREQUISITE COURSES:	Good knowledge of the undergraduate courses in Organic Chemistry and Biochemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Through the course, postgraduate students will acquire the necessary knowledge about Biocatalysis, as an alternative, often complementary methodology to classical organic synthesis. Included is the presentation of specific biocatalytic processes that have been established in organic synthesis. Knowledge about the application possibilities of biocatalysis in combination with chemocatalysis, for the synthesis of high added value products of industrial interest will be gained. Examples of biocatalysis applications from the chemical and pharmaceutical industry are presented.

The students, after the successful completion of the course

• they will possess the basic principles for the use of enzymes in organic transformations

• they will have familiarized themselves with the main types of biocatalytic processes used both on a laboratory and industrial scale

• they will have learned where biocatalysis can be applied in organic synthesis

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, using the necessary technology
- Working independently
- Teamwork
- Production of new research ideas
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

I. Introduction to Biocatalysis and Background Information

- History, Mechanistic aspects- Kinetics Michaelis-Menten
- Advantages-Disadvantages of Biocatalysts- Isolated enzymes versus whole cell systems
- Search for new enzymes-Modern technologies
- Protein engineering: Directed mutagenesis and random mutagenesis

II. Biocatalytic Applications

- Applications of enzymes in asymmetric organic synthesis
- Dynamic kinetic resolutions (DKR)
- Deracemization and enantioconvergent processes
- Enzymatic hydrolytic reactions

  Mechanistic and kinetic aspects

  Ester hydrolysis, Ester alcoholysis-Transesterification, Hydrolysis of nitriles, Hydrolysis of epoxides
- Enzymatic reductions

  Cofactor recycling

  Reduction of aldehydes and ketones, Reduction of C=C bonds

  Bioreductions in multienzymatic one-pot cascade processes

  Applications of bioreductions in the synthesis of APIs

  Montelukast, Atorvastatin, Profens, Levodione
- Enzymatic oxidation reactions

  Oxidation of alcohols and amines

  Oxygenation reactions of non-activated carbons, Hydroxylation of alkanes or aromatic compounds, Epoxidation of alkenes, Baeyer-Villiger oxidations, Formation

of peroxides, Peroxidation reactions, Formation of C-C bonds, Aldol reactions,

Michael-type additions

Enzymatic formation of C-N bond

III. Comparison of Biological and Chemical Catalysts for Innovative Processes

- Retrosynthetic approach to biocatalytic organic syntheses
- Criteria for the use of biocatalytic processes- Jacobsen's five criteria
- Ibuprofen (analgesic), Indigo (blue color), Menthol (mint aroma), Ascorbic acid (Vitamin C)

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face courses
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of information and communications technology in teaching, and in communication with students.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures	52
Study and analysis of bibliography	100
Project-Oral presentation	50
Final examination	55
Course total	257

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure*	Language of evaluation: Greek or English if there are non-Greek speaking students. Methods of evaluation:

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	- Oral presentation of scientific article on topics related to course content (30%) - Final written examination, duration 3 hours (70%) The final grade of the course results from: • 30% oral presentation • 70% written exam

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Kurt Faber, (2004) "Biotransformations in Organic Chemistry" A Textbook, Springer
- S. Bommarius, B. R. Riebel "Biocatalysis, Fundamentals and Applications", 2004, Wiley-VCH
- V. Gotor, I. Alfonso, E. Garcia-Urdiales (2008) "Asymmetric Organic Synthesis with Enzymes", WILEY-VCH
- "Synthetic methods for Biologically Active Molecules", edited by. Elisabetta Brenna, Wiley-VCH, 2014.
- "Biocatalysis in Organic Synthesis. The Retrosynthesis Approach" Nicholas J. Turner and Luke Humphreys, Royal Society of Chemistry, 2018.

- **Related academic journals:**

Articles from the current literature on topics related to course content.

COURSE OUTLINE

GMP89 - PROTEIN ENGINEERING

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND TECHNOLOGY		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	GMP89	**SEMESTER**	WINTER
COURSE TITLE	PROTEIN ENGINEERING		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and seminar	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special background, skills development
PREREQUISITE COURSES:	Not needed. Basic knowledge of Biochemistry and Organic Chemistry is preferred
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST107/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The main aim of the course of protein engineering is the education of students in topics on protein evolution, attaining knowledges and skills related with state-of-the-art techniques on the field. The goal is the development of the capability to tackle synthetic challenges, exhibiting initiative and critical thinking for the development of novel biocatalysts, suitable for the desired process.

The expected learning outcomes and the competences that the students will acquire are the following:

- Deepening the microbiology and genetics foundations for the heterologous expression of proteins.
- Understanding the techniques of directed evolution and rational design of proteins.
- Deepening the knowledge of analytical chemistry and development of skills of reconstruction of knowledge for the development of innovative analytical tools with high throughput.
- Development of critical thinking in synthetic challenges that can be addressed via protein engineering
- Development of communication, management and cooperation competencies
- Development of competencies related to English language and terminology.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

environment .....

Production of new research ideas

Via seminars, the degree holders develop general competencies that will be useful both in research and industrial working environments, in order to be able to meet the current challenges of the field. More specifically, a few general competences that are acquired in the framework of this course are the following:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Production of new research ideas
- Team work
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Lectures:

- Introduction on enzymes and biocatalysis: Amino acid properties – Protein structure – Clasification of enzymes
- Introduction to molecular biology: From the DNA to the protein - Heterologous expression of proteins
- Principles of Bioinformatics – Tools of bioinformatic for protein analysis
- Introduction to protein engineering. Differences between directed evolution and rational design
- Error-prone PCR
- Protein engineering techniques based on recombination (gene shuffling, StEP, ITCHY, SCRATCHY) – Circular permutation
- Site directed mutagenesis – Primer design –Degenerate codons – Semi-rational design – Scanning mutagenesis – Iterative Saturation Mutagenesis – Reconstruction of ancestral proteins
- Computational protein design – loop grafting – de novo design of proteins – Prediction of protein folding
- Introduction to high throughput screening
- Surface display and its application in protein engineering
- Selected examples of protein engineering from literature

Projects:

1) Identification and study of a metabolic / synthetic pathway
2) Virtual cloning of a gene and creation of mutant libraries
3) Establishment of a high-throughput assay

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face-to-face. It can be provided as distance learning (synchronous)</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>Several tools of bioinformatic analysis are discussed in the lectures and are used in the three projects. Namely, softwares for visualizing 3D structures of enzymes, softwares for the handling of DNA and amino acid sequences, online platforms and databases related to the field.

Moreover, the projects are delivered as round table discussions, where the students work in group of two people, and the discussion after the presentation includes all the groups, in order to identify the optimal solution to the problems that were given. The students are also trained on the use of communication technology, such as presentation softwares, via the defense of their projects.</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td><table><tr><th>Activity</th><th>Semester workload</th></tr><tr><td>Lectures</td><td>39</td></tr><tr><td>Seminar Presentations</td><td>13</td></tr><tr><td>Projects (3)</td><td>75</td></tr><tr><td>Study & analysis of bibliography</td><td>75</td></tr><tr><td>Course total</td><td>252</td></tr></table></td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer</td><td><u>Language of evaluation:</u> Greek or English

<u>Methods of evaluation:</u>
70 % based on an oral examination with open-ended questions and problem solving, on the topics covered by the lectures,
30% based on self-evaluation of their presentations and the final essays for the three projects. The evaluation is performed with a questionnaire to the whole auditorium during the presentations, with given criteria (completion of</td></tr>
</table>

questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	the tasks, design of slides, theoretical background, collaboration, time management in presentation etc). The students should have a passing grade on both evaluations, in order to calculate the final grade.

(5) ATTACHED BIBLIOGRAPHY

• U.T. Bornscheuer & M. Höhne "Protein Engineering – Methods and protocols" (2018) Springer Verlag, ISBN: 978-1-4939-7364-4

• K.M. Poluri & K. Gulati "Protein Engineering Techniques" (2017) Springer Verlag, ISBN: 978-981-10-2732-1

• Sheldon J. Park and Jennifer R. Cochran "Protein Engineering and Design", 2010, CRC Press, ISBN: 978-1-4200-7658-5

• U. Bornscheuer & S. Lutz, "Protein Engineering Handbook" Volumes 1, 2 and 3, (2011-2012) Wiley VCH, ISBN: Vol. 1 & 2: 978-3-527-31850-6, Vol. 3: 978-3-527-33123-9

COURSE OUTLINE

ASFD13 - CHEMISTRY OF NATURAL PRODUCTS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	ASFD13	**SEMESTER**	WINTER
COURSE TITLE	CHEMISTRY OF NATURAL PRODUCTS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized in the mechanistic pathways for the biosynthesis of the main classes of natural products.
PREREQUISITE COURSES:	The student must have a deep knowledge of undergraduate Organic Chemistry classes.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
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- *Guidelines for writing Learning Outcomes*

This course introduces the student in the field of the mechanistic approach, from the perspective of organic chemistry, of the biosynthesis of natural products, with emphasis on terpenes, steroids, phenolic compounds, as well as natural products deriving via the polyketide and shikimic acid pathways. The students must have a deep knowledge of undergraduate Organic Chemistry classes.

After successfully completing the course, the students will:

• Possess the basic principles for the biosynthetic pathways of natural products.

• Will be able to predict the biosynthesis of a given natural product depending on it structural characteristics.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Production of new research ideas
- Production of free, creative and inductive thinking

(3) SYLLABUS

1. Biosynthesis of terpenes and steroids
2. Biosynthesis of phenolic compounds
3. Biosynthesis via the polyketide pathway
4. Biosynthesis via the shikimate pathway

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face courses
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of information and communications technology in teaching, and in communication with students.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	Semester workload
Lectures	40
Study and analysis of bibliography	70
Project	12
Final examination	28
Course total	150

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	The evaluation is in the Greek language, except if there are non-Greek speaking students. The final grade consists of in class presentation of themes on the biosynthesis of given natural products (30%) and written exams (70%).

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography: Medicinal Natural Products: A Biosynthetic Approach (Paul M Dewick), Wiley.

- Related academic journals: Articles from the recent literature on subjects dealing with biosynthetic pathways of natural products.

COURSE OUTLINE

ASFD 14 - SYNTHETIC ORGANIC CHEMISTRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	ASFD 14	**SEMESTER**	WINTER
COURSE TITLE	SYNTHETIC ORGANIC CHEMISTRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Seminars	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	ELECTIVE COURSE, SPECIALISED GENERAL KNOWLEDGE.
PREREQUISITE COURSES:	Good Knowledge of Undergraduate Organic Chemistry Courses
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (English as a Reading Course in ERASMUS Students).
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The main purpose of the course is the knowledge of modern synthetic organic chemistry and the method of retrosynthetic analysis of complex molecular structures. Students become familiar with a detailed analysis of the most useful synthetic reactions through a presentation of the total synthesis of structurally complex natural products.

The expected learning outcomes and skills that students will develop are as follows:
• Deepening the field of synthetic methodology, retrosynthesis and rational design of new compounds.
• Understanding of synthetic techniques

• Deepening the knowledge of chemical reaction mechanisms and developing synthetic skills in extreme experimental conditions.

• Develop critical thinking in synthetic challenges that can be addressed through retrosynthesis.

• Development of communication, organization and cooperation skills

• Development of English language skills and technical terminology.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Searching, analysis and synthesis of data and information in the field of organic Synthesis, using the necessary technologies

Independent work on editing informational material in the field-related lectures

Group work in cases of group presentations

Generating new research ideas via proposals for solving synthetic problems.

Promotion of free, creative and inductive thinking

(3) SYLLABUS

Module 1: Retrosynthetic Approaches

- Classification of Synthetic Methods
- Synthetic Design Methodology
- "Synthons" and reagents
- History of Retrosynthesis
- Chemical Group disconnections
- Regioselectivity-Chemoselectivity
- Rules for solving synthetic problems.
- Research Seminar: The First Retrosynthesis Attempts: Synthesis of Thyroxin by Hems et al

Module 2. Oxidations and Reductions

- Baeyer-Villiger oxidation
- Jones oxidation
- Collins' reagent
- Dess-Martin oxidation
- Swern oxidation
- Wacker process-Wacker oxidation
- Parikh–Doering Oxidation
- Reductions in Organic Synthesis – Linlard Hydrogenation
- Birch Reduction
- Sodium in Ammonia Reduction of Alkynes
- Research Seminar. Synthesis of Kostic Acid Analogs

Unit 3. Metal-Catalyzed Cross-Coupling Reactions

- Sonogashira Reaction

- Heck Reaction
- Suzuki Reaction
- Stille Reaction
- Negishi Coupling
- Research Seminar: Synthesis of an of Arachidonic Acid Analog

Section 3. Metathesis Reactions

- The olefin Metathesis
- Olefin Metathesis – Mechanism
- Cross Metathesis Reaction
- The ring-closing Metathesis
- Ethenolysis
- Research Seminar: The Synthesis of Periplanone B

Unit 4. Enantiomerism and Organic Synthesis Mechanisms of Reactions Inducing or Affecting Chiral Centers

- The SN2 Reaction
- The Mitsunobu Reaction
- Sharpless epoxidation
- Sharpless epoxidation – Mechanism
- Sharpless epoxidation – Examples
- Second-generation asymmetric synthesis: Chiral auxiliary control
- Research Seminar. Synthesis of Amphotericin B

Module 5 Combinatorial chemistry, MCRs, automated synthesis (By Prof. Neochoritis)

Module 6. Seminar on the Presentation of a Research Project

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face. Distance learning only on Health Allerts
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	•E-mail • Department website-Study guide • Database Search on the web

TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS

Activity	*Semester workload*
Lectures	52
Seminar on Research Presentation	20
Literature research and data analysis	100
Presentation preparation	40
Research Project Presentation (ppt)	45
Course total	257

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Research Seminar presentation to audience, on a topic related to Synthetic Chemistry chosen by the student from topics suggested by the Instructor

Evaluation Criteria, accessible to students:

DURATION OF SEMINAR-NUMBER OF SLIDES

PRESENTATION STYLE

PUBLISHED MATERIAL REVIEW

REACTION MECHANISMS

EXAMPLES

BIBLIOGRAPHY

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. K.C. Nicolaou, Tamsyn Montagnon Molecules that changed the world : a brief history of the art and science of synthesis and its impact on society, WILEY-VCH, Weinheim, 2008.
2. House, Herbert O., Modern synthetic reactions, Benjamin, San Fransisco, 1972

3. March, Jerry, Advanced organic chemistry : reactions, mechanisms, and structure 7th edition WILEY INDIA; 2015

3. Hassner, Alfred,Organic syntheses based on name reactions and unnamed reactions Elsevier, London, 2011

4.Greene, Theodora W.Protective groups in organic synthesis, John Wiley & Sons, New York. 1999.

5. Peter G. M. Wuts and Theodora W. Greene.Greene's Protective Groups in Organic Synthesis. Fourth Edition. John Wiley & Sons, Inc., Hoboken, NJ. 2006.

6. S. Warren Organic Synthesis: The Disconnection Approach, Wiley: New York, 1982

7. A. Burrows, J. Holman, A. Parsons, G. Pilling, G Pric, Chemistry3, Oxford University Press NY, 2017

8. H. E. Katerinoppoulos, Retrosynthetic Approaches, Lecture Notes, 2023.

- Related academic journals: All Journals on the field of Organic Chemistry

COURSE OUTLINE

ASFD16 - ORCANIC PHOTOCHEMISTRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	ASFD16	**SEMESTER**	WINTER
COURSE TITLE	ORCANIC PHOTOCHEMISTRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised in the applications ofStereochemistry in organic synthesis
PREREQUISITE COURSES:	Good knowledge of the undergraduate courses in Organic Chemistry and Biochemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Through the course, postgraduate students will acquire the necessary knowledge about Stereochemistry, as a required knowledge to classical organic synthesis. Included is the presentation of specific stereochemical processes that have been established in organic synthesis. Knowledge about the application possibilities of stereochemistry to solve the structure of natural and synthetic compounds throughout the synthesis of high added value products of industrial interest will be gained. Examples of stereochemical analysis from compounds utilized in the chemical and pharmaceutical industry are presented.

The students, after the successful completion of the course

• they will possess the basic principles for the stereochemical control in organic transformations

• they will have familiarized themselves with the stereochemical control of processes used both on a laboratory and industrial scale

• they will have learned where stereochemical control can be applied in organic synthesis

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, using the necessary stereochemical knowledge
- Working independently
- Teamwork
- Production of new research ideas
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

1. Introduction

1.1. History - background

1.2. Stereochemical presentations

1.3. Classification of isomers

1.4. The chiral center

2. Determination of Configuration

2.1. Carbohydrates

2.2. Amino acids

2.3. Sequence rule

3. Symmetry

3.1. Introduction

3.2. Symmetry Elements, Operation, Symbols

3.3. Symmetry Point Groups

4. Configuration

4.1. Methods for the Determination of Relative and Absolute Configuration

4.2. Chiroptical, Spectroscopic and other Physical Methods

5. Conformation

5.1. Conformation of Ethane and Butane

5.2. Physical and Spectral Properties of Diostereomers and Conformers

5.3. Conformation and Reactivity

6. Separation and Analysis of Stereoisomers

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face-to-face courses</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>Use of information and communications technology in teaching, and in communication with students.</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>52</td></tr>
<tr><td>Study and analysis of bibliography</td><td>100</td></tr>
<tr><td>Project-Oral presentation</td><td>50</td></tr>
<tr><td>Final examination</td><td>55</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total</td><td>257</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</td><td>Language of evaluation: Greek or English if there are non-Greek speaking students.

Methods of evaluation:
- Oral presentation of scientific article on topics related to course content (20%)
- Final written examination, duration 2 hours (50%)

The final grade of the course results from:

• 10% evaluation of weekly written exercises
• 20% homework from all the course content
• 20% bibliographic 15 minutes of oral presentation related to course context, presented in the classroom.
• 50% final examination, in the class , 2 hrs. duration</td></tr>
</table>

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- B. K. Carpender, Determination of Organic Reaction Mechenism, John Wiley and Sons, New York, 1984.
- E. L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, John Wiley and Sons, New York, 1994.

- Related academic journals: Articles from the current literature on topics related to course content

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

1. GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Promoting free, creative and inductive thinking

3. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	

Use of ICT in teaching, laboratory education, communication with students	
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language: English

Activity	*Semester workload*
Lectures	180
Study and preparation	70
Course total	250

Specialization: Analytical and Environmental Chemistry

COURSE OUTLINE

EMP50 -ENVIRONMENTAL CHEMISTRY AND PHYSICS - CLIMATE CHANGE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMP50	SEMESTER	WINTER
COURSE TITLE	ENVIRONMENTAL CHEMISTRY AND PHYSICS - CLIMATE CHANGE		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	WEEKLY TEACHING HOURS	CREDITS
Lectures and training experiments	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge, skills development
PREREQUISITE COURSES:	Basic knowledge of analytical chemistry, organic chemistry, and physical chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English depending on the trainees
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES in English
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST110/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to present the environmental processes that affect the composition of the atmosphere and the climate of our planet, with emphasis on the physico-chemical processes that take place in the atmosphere and their impact on climate, ecosystems and humans.
- The course also aims to highlight the connection between the atmosphere, oceans, land and vegetation through energy and mass fluxes (of different chemical composition and physical characteristics), which are crucial for the quality of the atmosphere and the climate of our planet.
- Students should acquire the ability to critically search and consult the scientific literature on Earth Science.
- Students should acquire the ability to present a summary of a scientific article related to the environment and climate change in an interesting and scientifically correct way.
- Students should be able to present a summary of an environment and climate change related scientific article in an interesting and scientifically sound manner.
- Student will also learn to work as a team.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Module I

Structure of the atmosphere, Chemical composition of the atmosphere, Radiation balance (blackbody, absorption, radiation emission, the greenhouse effect), Changes in Earth's climate - clues, Atmospheric circulation (Mixing layer, Temperature inversion, Sea and continental breezes, general circulation, Hadley's cycles, high low barometric, fronts, precipitation, true winds, monsoons, stratospheric/tropospheric exchanges, monsoons, Valley, Southern Oscillation).

Module II

Marine Circulation, interactions between atmosphere and sea, Ekman's spiral, deep water formation, marine layers, currents, upwelling. The water cycle and climate. Cloud formation and types of clouds.

Module III

Carbon cycle (carbon dioxide) and climate, Greenhouse effect. Air pollutants with climate impact. Milankovich cycles. Carbon, oxygen and sulphur isotopes, use of isotopes to understand and date processes in the environment

Module IV

Stratospheric chemistry, Chapman mechanism, Catalytic cycles for stratospheric ozone destruction (active hydrogen, nitrogen and halogen cycles). Storage compounds and cycle coupling. Stratospheric observations and predictions. The ozone hole (Arctic and Antarctic). Polar stratospheric clouds. Heterogeneous reactions in non-polar regions of the stratosphere. ODP of halogenated compounds. Supersonic effect of airplanes. The Junge layer and COS.

Module V

Tropospheric Chemistry: Ozone/NOx/CO, B. Ozone balance and the role of nitrous oxides, C. Free radicals : OH and NO3, D. CH4, E. Anthropogenic NMVOCs, F. Biogenic NMVOCs, H. Nitrogen cycle, I. Sulphur cycle, I. Halogenated compounds, K. Liquid phase in the troposphere, Henry's Law Equilibria between liquid and gas phases in the troposphere, Liquid phase reactions, Air - sea exchanges, L. Particulate phase in the troposphere, Physical properties, Characterization, Chemical composition, Atmospheric distributions in different parts of the troposphere, M.

Photochemical particle production, N. Heterogeneous reactions at the surface of suspended particles. O. Atmospheric Acidity.

Module VI

Impacts of air pollution on Health and on ecosystems.

Satellite observations of the Earth and its Atmosphere.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and activities will be conducted face-to-face. Remote teaching will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION	**Student** evaluation in GREEK or ENGLISH

Activity	*Semester workload*
Lectures (18 lectures 4 hrs)	72
Assignments (4 assignment literature research)	32
Student Presentations (preparation and presentation time)	30
2 written Exams (mid-term, end- exam time + study time = 2x 30 h)	60
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Study duration in weeks =14)	56
Total hrs	250
ECTS (25 hrs / ECTS)	10
Course total ECTS	10

Description of the evaluation procedure *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	**Type of Evaluation** / **Points per evaluation** **Home assignments** — 4 home assignments x 5 points per assignment = 20 points **Student presentation** — 1 presentation = 30 points **Written Exam** — 2x 25 points = 50 points Total = 100 points Students will be instructed on how to perform literature research and their assigned work as well as how to best make their presentations. Assignments: will include an in-depth study of the functioning of the Earth system with an emphasis on chemical processes which will then be discussed in the group. Presentations: Students will choose a recent research topic that is relevant to the course from the international literature, i.e. a research paper published in the last 5 years, and present it in a brief 20-minute presentation. Grading: Rubrics will be provided for each graded assignment. Final Exam: The final exam will contain multiple-choice questions that will cover the topics of the lectures and the discussed assignments, as well as a number of topics to develop that will enable the evaluation of the acquired knowledge by the students.

(5) ATTACHED BIBLIOGRAPHY

1. Σημειώσεις μαθήματος διαθέσιμες στο eclass
2. Atkinson R, Evaluated kinetic and photochemical data for atmospheric chemistry: Volume I – gas phase reactions of Ox, HOx, NOx and SOx species, Atmos. Chem. Phys., 4, 1461–1738, 2004 (kinetic data) & 2005
3. Barry, R. G. and Chorley, R. J. (1998) Atmosphere, weather and climate. Routledge, London, Great Britain.
4. Bernninkmeijer C.A.M., et al., Nature, 356, 50-52, 1992.
5. Duplessy J-C, and Morel P., (1990) Gros temps sur la planete, Editions Odile Jacob, 15 rue Soufflot 75005 Paris.
6. Falkowski P. et al., (2000) The Global Carbon Cycle: A Test of Our Knowledge of Earth as a System, Science 290, 291-296.
7. Finlayson-Pitts, B. J. (2003) The Tropospheric Chemistry of Sea Salt: A Molecular-Level View of the Chemistry of NaCl and NaBr, Chemical Reviews, 10.1021/cr020653t
8. Finlayson-Pitts B.J., Pitts, J.N., Jr., (2000) Chemistry of the Upper and Lower Atmosphere, Academic Press.
9. Graedel, T. E. and Crutzen, P. J. (1993) Atmospheric change: an Earth system perspective. W. H. Freeman and Company, New York, USA.
10. Grant W. Petty, A first Course in Atmospheric Radiation, Sundog Publishing, Madison Wisconsin.

11. Jacobson M.Z., Fundamentals of Atmospheric Modeling, Cambridge Univ. Press, 1999.
12. Jacob D., Introduction to Atmospheric Chemistry, Princeton University Press, 2000
13. Joussaume S., Climat d'hier a demain, Science au present, CNRS edition/CEA, 1993.
14. Legrand M., Jouzel, J., Raynaud, D, (1994) Past climate and trace gas content of the atmosphere inferred from polar ice cores, Chapter XXI, ERCA, Topics in Atmospheric and interstellar physics and chemistry, edited by C. F. Botron, published by Les editions de Physique, 453-477.
15. Lowe D. C. et al., Nature 332, 522-525, 1988.
16. Platt, U., Hoenninger, G. (2003) The role of halogen species in the troposphere, Chemosphere, 52, 325–338.
17. Platt U., Moortgat G.K. (1999) heterogeneous ad Homogeneous Chemistry of reactive Halogen Compounds in the Lower troposphere, J. Atmospheric Chemistry, 34, 1-8.
18. Seinfeld J., Pandis, S, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley-Interscience eds, 2006.
19. Spyro, Th G, & Stigliani W. M., Chemistry of the Environment, Porentice Hall, Pearson Education LTD, 2003.
20. Wayne, P., Chemistry of Atmospheres, Oxford Science Publications (2000).
21. Wells, N. (1997) The atmosphere and ocean, John Wiley and sons, New York, USA.
22. Williams J., (1997) The Weather Book, USA TODAY, Vintage Books, A division of Random House inc., New York.
23. IPCC reports: http://www.ipcc.ch
24. https://ozonewatch.gsfc.nasa.gov/
25. https://csl.noaa.gov/assessments/ozone/2022/ Scientific Assessment of Ozone Depletion. WMO reports, Geneva
26. https://csl.noaa.gov/assessments/ozone/2022/twentyquestions/ Twenty Questions and Answers about the Ozone Layer.

COURSE OUTLINE

EMP51-MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL CHEMISTRY AND BIOANALYSIS

(1) GENERAL

SCHOOL	SCHOOL of SCIENCES & ENGINEERING		
ACADEMIC UNIT	Department of Chemistry		
LEVEL OF STUDIES	Graduate		
COURSE CODE	EMP51	**SEMESTER**	winter
COURSE TITLE	MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL CHEMISTRY AND BIOANALYSIS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
courses	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised
PREREQUISITE COURSES:	Organic Chemistry, Analytical Chemistry, Environmental Chemistry, Physical Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek. English if Erasmus students take the course
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST106/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The objectives of the postgraduate course MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL AND BIOANALYTICAL CHEMISTRY (EMP…), "Mass Spectrometry & Chromatographic Techniques: Theory and Applications in Environmental Chemical Analysis & Bioanalysis", are:

1) To consolidate the basic principles of Mass Spectrometry and Chromatography,

2) To present the modern instrumentation of Mass Spectrometry, Chromatography, and Mass Spectrometry - Hyphenated Chromatographic Techniques for Environmental Analysis & Bioanalysis

3) To acquaint postgraduate students with the identification of chemical structures and quantitative determination in complex matrices with combined techniques of Mass Spectrometry and Chromatography.

4) To practice with the applications of Mass Spectrometry-Chromatography techniques in Environmental Analysis and Bioanalysis:

- ✓ Gas Chromatography/Mass Spectrometry (GC/MS)
- ✓ Liquid Chromatography/Mass Spectrometry (LC/MS)
- ✓ Inductively Coupled Plasma Mass Spectrometry (ICP/MS) and for comparison X-ray Fluorescence (XRF).

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
	Respect for difference and multiculturalism
	Respect for the natural environment

Adapting to new situations *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas*	*Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

(3) SYLLABUS

1 Mass Spectrometry

- ✓ Theory of Mass Spectrometry

- ✓ Basic instrumentation of modern Mass Spectrometry:
  - Vacuum System
  - Sample Introduction Devices: Direct introduction; Sample introduction from chromatography (GC & LC)
  - Ion Sources and Ionization Techniques – Theory and Operation: Electron Impact (EI); Chemical Ionization (CI); Electrospray Ionization (ESI); Matrix Assisted Laser Desorption Ionization (MALDI);
  - Mass Analyzers & separation of charged masses (ions) – Theory and Operation: Double Focusing (Sector) Analysis; Quadrupole Mass Analyzer (Q; full scan and selected ion monitoring); Tandem Mass Spectrometry; Ion Trap; Orbitrap; Time-of-flight (TOF); Combinations (ESI-TOF; TOF-MALDI; Q-TOF); Inductively Coupled Plasma Mass Spectrometry (ICP-MS); Resolution of Mass Analyzers

- ✓ Detection of Ions

- ✓ Mass Spectra:
  - Interpretation of Mass Spectra – Theory and applications
  - EI mass spectra
  - CI mass spectra

- ESI mass spectra

✓ Special seminars of Mass Spectrometry:
- Analysis of Organic compounds (EI-MS; CI-MS; ESI-MS)
- Analysis of Biomolecules (ESI-MS) (proteomics)

✓ Elemental Analysis (ICP-MS) & X-ray Fluorescence (XRF).

✓ Applications of Mass Spectrometry – Hyphenated Chromatographic Techniques in Environmental Analysis:
- Analysis with GC-tandem MS of polycyclic aromatic hydrocarbons (PAHs) and persistent organic pollutants (POPs) in the atmosphere
- Analysis of drinking water disinfection by-products with GC-EI/CI-MS and LC-ESI-MS
- Determination and separation of bisphenol A, phthalate metabolites and structural isomers of parabens in biological liquids with LC-ESI-tandem MS
- Analysis of atmospheric particle-bound trace metals with ICP-MS
- Bioanalysis-Metabolomics.

✓ Applications of Mass Spectrometry techniques for real time environmental analysis:
- PTR-MS (Proton Transfer Reaction – Mass Spectrometry) the benchmark method for simultaneous real-time monitoring of volatile (organic) compounds (VOCs)
- Aerosol Mass Spectrometry (AMS) for the determination of the chemical composition of aerosols and in particular for components in ultrafine particles.
- Chemical Ionisation Mass Spectrometry (CIMS), for the determination of compounds of atmospheric interest.

2 Chromatography

✓ Basics, theory and types of separation

✓ Basics, theory and types of chromatography

✓ Gas-chromatography

✓ Liquid-chromatography
- Normal phase HPLC
- Reverse phase HPLC

✓ Separation modes in IC

✓ Qualitative and quantitative analysis in HPLC

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and visits-demonstrations will be conducted in the mass spectrometry instrument laboratories (all face-to-face). Remote teaching (on ZOOM platform) will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting

<table>
<tr><td>education, communication with students</td><td>of announcements and grades with immediate and automatic notification of students via their e-mail.</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures & exercises (24 lectures 4 hrs)</td><td>96</td></tr>
<tr><td>Assignments: Bibliographic research</td><td>30</td></tr>
<tr><td>Student Presentations (preparation and presentation time)</td><td>24</td></tr>
<tr><td>Final Exam (exam time + study time)</td><td>44</td></tr>
<tr><td>Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00
Course duration in weeks =14)</td><td>56</td></tr>
<tr><td>TOTAL HOURS</td><td>250</td></tr>
<tr><td>ECTS (25 hrs/ECTS)</td><td>10</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</td><td>Examination

✓ Written Examination (70% of total grade)
✓ Presentation of bibliographic research (30% of total grade)

Delivery of exercise solutions after the completion of the syllabus (without grading)</td></tr>
</table>

(5) ATTACHED BIBLIOGRAPHY

In addition to the notes and references provided during the course presentation, students can also access specialized textbooks in the University of Crete's library and on the internet.

Proposed Books:

1) J. Throck Watson, O. David Sparkman, "Introduction to Mass Spectrometry: Instrumentation, Applications and Strategies for Data Interpretation", ISBN:9780470516348 |Online ISBN:9780470516898 |DOI:10.1002/9780470516898

2) R. Ekman, et al. "Mass Spectrometry: Instrumentation, Interpretation, and Applications", Wiley, ISBN: 978-0-471-71395-1

3) Handbook of Advanced Chromatography/Mass Spectrometry Techniques, Edited by:

M. Holčapek and W. C. Byrdwell, Academic Press, ISBN: 978-0-12-811732-3

Proposed Sites:

https://masspec.scripps.edu/learn/ms/

https://chem.libretexts.org/Courses/Purdue/Purdue%3A_Chem_26200%3A_Organic_Chemistry_II_(Wenthold)/Chapter_11%3A__IR_and_Mass_Spectrometry/11.06%3A_Introduction_to_Mass_Spectrometry

COURSE OUTLINE

EMP54- STATISTICAL TOOLS FOR DATA ANALYSIS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMP54	**SEMESTER**	WINTER
COURSE TITLE	STATISTICAL TOOLS FOR DATA ANALYSIS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Laboratory Exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	special background, specialised general knowledge, skills development
PREREQUISITE COURSES:	Analytical Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English depending on the students
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to introduce the student to the analysis of environmental data from laboratory experiments, measurements in simulation chambers, in the field and from numerical simulations, multi-factor analysis, identification of trends and sources of pollution.
- Introduction to statistical tools to determine correlations between environmental variables and to calculate source apportionment analysis.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search, analysis and synthesis of data and information, using the necessary technologies

-Working independently

-Team work

- Decision-making

- Promotion of free, creative and inductive thinking

(3) SYLLABUS

INTRODUCTION TO STATISTICAL ANALYSIS

- Analytical problems
- Errors in quantitative analysis
- Types of errors
- Propagation of errors
- Significant digits
- Computers in statistical calculations

APPLICATIONS OF STATISTICS TO REPEATED MEASUREMENTS

- Mean and standard deviation
- The distribution of repeated measurements
- Normal and logarithmic distribution
- Confidence intervals

EXPERIMENTAL TESTING (a)

- Comparison of results with theoretical values
- Comparison of results with other results
- t-test
- F-test

EXPERIMENTAL TESTING (b)

- Suspicious outlier and unacceptable value
- Analysis of price variance
- ANOVA calculations
- The statistical criterion $\chi 2$ (chi-square)

QUALITY CONTROL OF ANALYTICAL MEASUREMENTS

- Sampling and influence on the quality of results
- Separation of variances using ANOVA
- Design of sampling strategy
- Introduction to quality control methods
- Shewahart charts

STATISTICAL CALIBRATION METHODS IN INSTRUMENTAL ANALYSIS

Calibration curves in instrumental analysis

Regression analysis, linear correlation and least squares method

Errors in regression analysis and unacceptable values

Detection limits

Addition of a reference sample

Comparison of analytical techniques using regression

Non-linear regression

NON-PARAMETRIC STATISTICS

Applications of statistics to a small number of data

The median and quartiles

Box-and-whisker chart

Non-parametric regression

U-test

Kolmogorov-Smirnov method

MULTIVARIATE ANALYSIS

Cluster analysis

Multiple regression

Multivariate statistical analysis

Principal Component Analysis, PCA

EXPERIMENT DESIGN AND OPTIMISATION

Randomness and error prediction

ANOVA two-way analysis of variance

Experiment optimisation

ADDITIONAL APPLICATIONS OF EMBEDDING

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face lectures in the classroom and computer-based laboratory exercises
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory*	Support of the learning process through MS TEAMS that supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching material, and the posting of announcements and grades.

education, communication with students

TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS

Activity	***Semester workload***
Lectures (14 presentations of 4 hours)	56
Laboratory exercises (laboratory time for 14 exercises)	42
Student presentations (preparation and presentation time)	36
2 X Written exams (χρόνος εξέτασης και μελέτης)	60
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks= 14)	56
Total hrs	250
ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	Points per evaluation
Lab exercises	14 lab exercises x 2 points per exercise = 28 points
Student presentation	1 presentation x 22 points per presentation = 22 points
Intermediate Progress Exam	15 points
Final Exam	15 points
	Total = 100 points

Students will be given a sample lab exercise that they can follow for their own exercises.

The intermediate and finals exam will contain multiple choice questions covering the material covered in the lecture topics. In the topics requiring calculations, the relevant equations will be given.

	For their presentations, an indicative bibliography from peer-reviewed international journals will be provided and students will choose an article related to analytical chemistry.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Miller J.N. and Miller J.C., Statistics and Chemometrics for Analytical Chemistry, Pearson Education Limited, 2000.
- Ν. Χανιωτάκης, Μ. Φουσκάκη, Κ. Περδικάκη, Β. Βαμβακάκη, Μ. Χατζημαρινάκη (2009). Ποσοτική Χημική Ανάλυση (Μετάφραση D. C. Harris). Quantitative Chemical Analysis. Πανεπιστημιακές Εκδόσεις Κρήτης, Ηράκλειο.
- T.P. Hadjiioannou, G.D. Christian, M.A. Koupparis, P.E. Macheras (1993). Quantitative Calculations in Pharmaceutical Practice and Research. VCH, New York.
- G. D. Christian (1994). Analytical Chemistry. J. Wiley and Sons, New York.
- D. C. Harris (2007). Quantitative Chemical Analysis. W. H. Freeman, New York.

- Related academic journals:

- Analytical Chemistry (ACS)
- Journal of Chromatography B
- Science of the Total Environment

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

(1) **GENERAL**

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT
General Competences *Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?* *Search for, analysis and synthesis of data and information, with the use of the necessary technology* *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas* *Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Promoting free, creative and inductive thinking

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	

Use of ICT in teaching, laboratory education, communication with students	
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	*Semester workload*
Lectures	180
Study and preparation	70
Course total	250

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language: English

Specialization: Advanced Materials and Physical Chemistry

COURSE OUTLINE

GMP83 - MODERN CLUSTER CHEMISTRY: SYNTHESIS AND APPLICATIONS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP83	**SEMESTER**	WINTER
COURSE TITLE	Modern Cluster Chemistry: Synthesis and Applications		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	general background, special background, specialised general knowledge		
PREREQUISITE COURSES:	-		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek/Greek or English/English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/milios/teaching.htm		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The learning outcome of this course is understanding advanced principles and complicated phenomena of Coordination Chemistry and Molecular Magnetism. The specific knowledge, skills and competences acquired by the students are as follows:

- Understanding the basic theoretical aspects of multiple metal-metal bonding.
- Familiarization with the modern aspects and applications of coordination chemistry.
- Familiarization with the employment of Supramolecular-chemistry principles in synthetic cluster chemistry.
- Understanding advanced and complicated aspects of magnetochemistry and molecular magnetism.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work

- Working in an interdisciplinary environment
- Production of new research ideas
- Production of free, creative and inductive thinking

(3) SYLLABUS

I. Coordination Chemistry - Complexes

1) Werner's theory

2) Crystal-filed theory

3) Coordination geometry – hybridism

II. Metal-Metal multiple bonding

1) From Werner to multiple metal-metal bonding

2) Quadruple M═M bond

3) Quadruple bond, δ bond, eclipsed and staggered configurations

4) Multiple metal-metal bonds in Re2 compounds

5) Multiple Cr-Cr bonds

6) Dinuclear Rh clusters

7) Mo, W compounds

IV. Non M-M containing clusters

1) Synthesis – Suitable Ligands

2) Supramolecular Chemistry

3) Applications of metallic complexes

V. Molecular Magnetism

1) History – Single-Molecule Magnets

2) Paramagnetism

3) Magnetic exchange interactions

4) Basic Principles of molecular magnetism: ferromagnetism, antiferromagnetism, g, magnetic susceptibility, magnetization, spin-orbit coupling, Van-Vleck equation, Kambe vector.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face-to-face</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>email, course web page, e-Class</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>48</td></tr>
<tr><td>Research presentation</td><td>40</td></tr>
<tr><td>Study & analysis of bibliography</td><td>90</td></tr>
<tr><td>Project</td><td>40</td></tr>
<tr><td>Essay writing</td><td>32</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total</td><td>250</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure
Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other
Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</td><td>Language of Evaluation: Greek or English

Methods of evaluation

1) 20% Public research presentation

2) 80% Written exam (short-answer questions, problem solving)</td></tr>
</table>

(5) ATTACHED BIBLIOGRAPHY

- **Suggested bibliography:**

1) Multiple Bonds Between Metal Atoms, Eds F. A. Cotton, C. A. Murillo, R. A. Walton, 3rd edition, Springer Science and Business Media.

2) Metal-Metal Bonding, Ed G. Parkin, Structure and Bonding, Volume 136, 2010.

3) Metal Clusters in Chemistry, Eds P. Braunstein, L. A. Oro, P. R. Raithby, Wiley VCH.

4) Course's notes

- Related academic journals:

1) Journal of American Chemical Society (ACS)

2) Inorganic Chemistry (ACS)

3) Angewandte Chemie, Int. Ed. (Willey)

4) Chemical Communcations (RSC)

5) Dalton Transactions (RSC)

COURSE OUTLINE

GMP67 - COMPUTATIONAL STUDY OF MOLECULES & NANOMATERIALS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP67	**SEMESTER**	WINTER
COURSE TITLE	Computational study of molecules & nanomaterials		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
LECTURES	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge Elective course
PREREQUISITE COURSES:	Basic knowledge of Physical and Computational Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (If there are Erasmus students, it is taught in English)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	http://www.chemistry.uoc.gr/wordpress/σπουδές/μεταπτυχιακές-σπουδές/ύλη μαθημάτων/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course exposes the student to the Computational study of molecules & nanomaterials. Students, after successfully completing the course, will have the basic principles Computational study of molecules & nanomaterials and will be able to conduct computational experiments. They will know the basic methods of computational chemistry and basic computer programs.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

• Students will have been exposed to issues of self-organization and hierarchical organization in these very important systems
• Search, analysis and synthesis of data and information, using the necessary technologies
• Adaptation to new situations
• Autonomous work
• Autonomous presentation
• Work in an interdisciplinary environment
• Generation of new research ideas
• Promotion of free, creative and inductive thinking

(3) SYLLABUS

A. THEORETICAL PRESENTATIONS

• Ab-initio Calculations

1. Introduction to the theory of Molecular Orbitals
2. Born-Oppenheimer approach
3. Hartree-Fock theory
4. Development of Molecular Orbitals in Basis Functions

• Semiempirical Calculations

1 Introduction
2. MNDO, AM1, PM3 methods

• Electronic Correlation Calculation Methods

1. Introduction to Configuration Interaction Theory
2. Moller-Plesset theory
3. Coupled Cluster Theory
4. Density Functional Theory

B. LABORATORY PRESENTATIONS (ON COMPUTER)

• Gaussian Program Package

1. Data Entry
2. Basic Commands
3. Molecule description with internal coordinates (Z-Matrix)
4. Run in a Linux environment
5. Analysis of Results

• Molden Molecule and Orbital Imaging Package

1. Analysis of the Program's Graphical Environment
2. 'Communication' with Gaussian
3. Run in a Windows NT environment
4. Graphical presentation of chemical reactions, three-dimensional molecular orbitals, modes of oscillation, etc.

C. LABORATORY EXERCISES

1. Example 2.1, 2.4: Formaldehyde energy calculation with various bases and visualization of HOMO and LUMO orbitals.

2. Exercise 3.1, 3.1: Ethylene and Fluoroethylene Geometry Optimization.

3. Exercise 3.6: Study of C60O isomers by Semiempirical methods.

4. Example 6.4: Comparison of electron correlation methods (MP2, CC) for Ozone geometry.

5. Exercise 6.4: Evaluation of FOOF geometry using DFT. Comparison with MP2, CC methods.

6. Example 9.1: Study of Excited States of Ethylene.

(4)TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face (classroom) – Distance learning (when needed, e.g., during the pandemic)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Use of ICT in teaching • Electronic mail • Departmental Website-Study guide
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures	50
Study	100
Written project	50
Class Presentation	50
Course total	250

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure*	Greek language (English if a student prefers or if there is an Erasmus student) During the course, students undertake to prepare and present a compulsory paper, based on a research article or overview article on a topic in the Computational Study of Molecules & Nanomaterials area, which they choose. The students will perform relevant calculations which they will

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	present in writing and orally and compare with the literature. The written paper must be less than 10 pages (and not a translation of the article) and a 20-minute oral presentation in powerpoint format must be prepared and presented by the examinee. The final grade of the course results from: • Written term-paper on a research publication (30% of the final grade) • Oral presentation of the term-paper, degree of understanding the research subject and response to questions, (70% of the final grade)

(5)ATTACHED BIBLIOGRAPHY

'Exploring Chemistry with Electronic Structure Methods' των J.B. Foresman & A. Frisch

COURSE OUTLINE

GMP68 - SOFT CONDENSED MATTER

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP68	**SEMESTER**	WINTER
COURSE TITLE	SOFT CONDENSED MATTER		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
LECTURES	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge Elective course
PREREQUISITE COURSES:	Basic knowledge of Physical Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (If there are Erasmus students, it is taught in English)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	http://www.chemistry.uoc.gr/wordpress/σπουδές/μεταπτυχιακές-σπουδές/ύλη μαθημάτων/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course aimed at exposing the students to the subject of soft condensed matter. Soft matter or soft condensed matter is a subfield of condensed matter comprising a variety of physical systems that are neither simple liquids nor crystalline solids of the types studied in other fields of solid state physics. Such systems include polymers, colloids, liquid crystals, amphiphilic molecules, biomolecules, etc. Many of such materials are familiar from everyday life such as plastics, glues, paints, soaps, shampoo and foams, food as well as many electronic devices. Basic common characteristic is that they can be deformed or structurally altered by thermal or mechanical stresses of the magnitude of thermal fluctuations.

The materials we discuss include colloidal dispersions, where submicrometer particles of solid or liquid are dispersed in another liquid, polymer melts and solutions, where the size and connectivity of the macromolecules lead to striking new properties (like viscoelasticity) that are very different to those of a simple liquid, and liquid crystals, where an anisotropic molecular shape leads to states with a degree of ordering intermediate between a crystalline solid and a liquid.

What is common among these systems? It is these common characteristics that allows us to consider them as a class of materials:

- The importance of length scales (from ~10 nanometers to <1 micrometer) intermediate between atomic sizes and macroscopic scales
- Their basic interactions are week interactions van der Waals, which, however, can lead to phases with different symmetries and to phase transitions between those
- The importance of Browning motion and thermal fluctuations that control their behavior
- The propensity of soft matter to self-assemble. This self-assembly can take place at the level of the molecules but even more complexity occurs when ordering takes place hierarchically, with molecules coming together to form supramolecular structures, which themselves order at a higher level.

The students, after successfully completing the course, will

- understand the basic principles of interactions, dynamics, phase transitions and supramolecular self-assembly that characterize soft condensed matter
- possess the basic knowledge for some of the basic characteristics and properties of polymers, colloids, liquid crystals, amphiphiles, biomaterials
- be exposed to issues of self-assembly and hieratchical organization in these important systems

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Adapting to new situations
- Working independently
- Working in an interdisciplinary environment
- Production of new research ideas
- Production of free, creative and inductive thinking

(3) SYLLABUS

1. **Introduction**

   What is soft condensed matter

2. **Forces, Energies and Timescales in Condensed Matter**

   Intermolecular forces and condensed matters; Viscous, elastic and viscoelastic behavior; Liquids and glasses

9. **Phase transitions**

   Basic principles; Liquid-liquid phase separation and phase separation kinetics; Liquid-solid phase transitions

9. **Polymers**

   Basic principles; Random walks and the dimension of polymer chains; Viscoelasticity and the reputation model

9. **Colloidal Dispersions**

   Stokes' law and the Brownian motion; Forces between colloidal particles; Stability and phase behavior of colloids

6. **Liquid Crystals**

   Liquid crystal phases; The nematic/isotropic transition; Topological defects in liquid crystals; Electrical and magnetic properties; Polymer liquid crystals

7. **Supramolecular Self-Assembly**

   Amphiphilic molecules and self-assembled phases; Self-assembly in polymers

8. **Biomolecules**

   Soft matter and nature; Nucleic acids; Proteins; Polysaccharides; Membranes

9. **Organic Electronic Materials and Devices**

   Basic principles of electronic materials; Basic semiconductor devices; Electronic devices based on organic/polymer materials

(4) TEACHING and LEARNING METHODS – EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face (classroom) – Distance learning (when needed, e.g., during the pandemic)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Use of ICT in teaching • Electronic mail • Departmental website-Study guide
TEACHING METHODS	

Activity	***Semester workload***
Lectures	52

The manner and methods of teaching are described in detail. *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Study: 50 Literature project-presentation, Final examination: 48 Course total: 150
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Greek language (English if a student prefers or if there is an Erasmus student) During the course, the students are responsible to prepare and present an obligatory literature project, based on a research publication or a review article that they choose on a subject that belongs to the general area of soft condensed matter. The written term paper on the paper should be less that ~10 pages (it should not be a translation of the article) whereas the students have to prepare and present an oral presentation utilizing powerpoint The final grade of the course results from: • Written term-paper on a research publication (30% of the final grade) • Oral presentation of the term-paper, degree of understanding the research subject and response to questions, (70% of the final grade)

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography: - Related academic journals:
- Suggested bibliography: • R. A. L. Jones, "Soft Condensed Matter", Oxford University Press, Oxford, 2002 • I. W. Hamley, "Introduction to Soft Matter", John Willey and Sons, New York, 2000

- M. Daoud & C. E. Williams, Eds. “Soft Matter Physics”, Springer, 1999
- P. C. Hiemenz & T. P. Lodge, “Polymer Chemistry”, 2nd Edition, CRC Press, Boca Raton, 2007
- G. Strobl, “Condensed Matter Physics: Crystals, Liquids, Liquid Crystals, and Polymers”, Springer, 2004
- W. D. Callister, Jr., “Materials Science and Engineering. An Introduction”, Wiley, New York, 5th Edition, 1999
- Κ. Παναγιώτου, “Επιστήμη και Τεχνολογία Πολυμερών”, Εκδόσεις Πήγασος 2000, Θεσσαλονίκη, 1996.
- M. Doi, “Introduction to Polymer Physics”, Oxford Science Publ. Oxford, 1996.
- A. Yu Grosberg, A. R. Khokhlov, “Giant Molecules”, Academic Press, 1997
- M. Rubinstein and R. H. Colby, “Polymer Physics”, Oxford University Pres, Oxford, 2003
- Κ. Παναγιώτου, “Κολλοειδή”, Θεσσαλονίκη, 1998.
- D. F. Evans, H. Wennerström, “The Colloidal Domain, Where Physics, Chemistry, Biology and Technology Meet”, 2nd Edition, John Willey and Sons, New York, 1999.
- J. B. Park, R. S. Lakes, “Biomaterials: An Introduction”, Plenum Pub. Corp., 1992.
- B. D. Ratner, F. J. Schoen, A. S. Hoffman, J. E. Lemons, “Biomaterials Science: An Introduction to Materials in Medicine”, Elsevier Science & Technology Books, 2nd Edition, 2004
- S. O. Kasap, “Principles of Electronic Materials and Devices”, McGraw Hill; 2rd edition, 2002

- Related academic journals:

- Materials Today
- Nano Today
- Soft Matter
- Macromolecules
- Biomacromolecules
- Nature Materials
- Advanced Materials
- Journal of Colloid and Interface Science
- Journal of Colloid and Polymer Science
- Journal of Chemical Physics
- Journal of Physical Chemistry B
- Langmuir
- Nanoscale
- Polymer
- Small
- Colloids and Surfaces A
- Progress in Biomaterials
- Regenerative Biomaterials
- ACS Nano
- Nanomaterials
- Polymers

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

(1)GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

(2)LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT
General Competences *Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?* *Search for, analysis and synthesis of data and information, with the use of the necessary technology* *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas* *Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Promoting free, creative and inductive thinking

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory*	

education, communication with students	
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	<table><tr><th>*Activity*</th><th>*Semester workload*</th></tr><tr><td>Lectures</td><td>180</td></tr><tr><td>Study and preparation</td><td>70</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td>Course total</td><td>250</td></tr></table>
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language: English

Second Semester
Specialization: Biological and Organic Chemistry

COURSE OUTLINE
ASFD19 - MEDICINAL CHEMISTRY

(1) GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	ASFD19	**SEMESTER**	SPRING
COURSE TITLE	Medicinal Chemistry		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	special background		
PREREQUISITE COURSES:	Organic Chemistry, Biochemistry		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English		
COURSE WEBSITE (URL)			

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Understanding the basic principles of drug discovery and design, the application of organic chemistry, biochemistry and analytical chemistry in drug innovation and the synthetic approaches on certain scaffolds.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Adapting to new situations, Decision-making, Working independently, Team work

Working in an international environment, Working in an interdisciplinary environment

(3) SYLLABUS

The course introduces students to the design and development of active pharmaceutical ingredients (APIs) with applications in modern drug discovery. The course consists of the following chapters:

- Drug targets
- Drug discovery and development
- Tools for the drug design
- Synthetic approaches towards APIs
- Introduction to specific software e.g. pymol, molecular docking, cheminformatics, crystal structural database

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Powerpoint, email, open e-class
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures	70
Study and preparation	120
Assigned project	10
Final exam	50
Course total	250

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure*	Language: Greek or English Oral presentation of assigned projects, concerning of articles in medicinal chemistry (30% of the total grade) and written examination (70% of the final grade)

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	

(5) ATTACHED BIBLIOGRAPHY

- ΦΑΡΜΑΚΕΥΤΙΚΗ ΧΗΜΕΙΑ, GRAHAM L. PATRICK, (κωδικός Εύδοξος: 102071627)
- R. B. Silverman, The Organic chemistry of Drug Design and Drug Action Elsevier, New York, 2004

- Related academic journals: JMedChem, EurJMedChem, BioorgMedChem, BioorgMedChemLett, Angew.Chem.Int.Ed., ChemRev, ChemMedChem, ChemBioChem.

COURSE OUTLINE

GMP87 - BIOLOGICAL MEMBRANE SYSTEMS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	GMP87	**SEMESTER**	SPRING
COURSE TITLE	BIOLOGICAL MEMBRANE SYSTEMS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge on biological membrane systems Elective course		
PREREQUISITE COURSES:	The course requires a good background in Biochemistry		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes (If there are Erasmus students, it is taught in English)		
COURSE WEBSITE (URL)			

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The main objective of the course is a good understanding of the properties and function of biological membrane systems.

Processes such as respiration, photosynthesis, transport across membranes and signal transduction are carried out by membrane systems. Thus, it is important for postgraduate students to acquire the necessary knowledge regarding the structural and functional properties of these systems. Understanding these systems is important for the elucidation of the molecular aspects of vital processes. Since membrane systems are the target of many natural products and drugs, through this course the students will better understand the function of these compounds at a molecular level. Such a knowledge will be necessary especially for those who will be involved in the pharmaceutical section.

The students, after the successful completion of the course

•will understand the unique properties of membrane protein systems

•will know the basic principles of bioenergetics

•will know the unique properties of hormones and neurotransmitters and their role in signal transduction

•will be introduced in various aspects of certain drug and natural product function on a molecular level

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Team work	*Production of free, creative and inductive thinking*
Working in an international environment	*……*
Working in an interdisciplinary environment	*Others…*
Production of new research ideas	*…….*

- Search for, analysis and synthesis of data and information, using the necessary technology
- Working independently
- Teamwork
- Production of new research ideas
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

- Membrane properties
- Introduction to bioenergetics
- Oxidative phosphorylation
- Photosynthesis
- Membrane transport
- Membrane pumps
- Ion channels
- Neurotransmission
- Sensory systems
- Hormone properties and function

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face courses
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of information and communications technology in teaching, and in communication with students.
TEACHING METHODS *The manner and methods of teaching are described in detail.*	***Activity*** / ***Semester workload*** Lectures: 52 Study and analysis of bibliography: 100

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Project-Oral presentation: 50 Final examination: 55 Course total: 257
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language of evaluation: Greek or English if there are non-Greek speaking students. Methods of evaluation: - Oral presentation of a topics related to course material (40%) - Final written examination, duration 2 hours (60%) The final grade of the course results from: • 40% oral presentation • 60% written exam

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Molecular Aspects of Cell Biology by Garrett and Grisham. Saunders College Publishing
- Biochemistry by J.M. Berg, J.L. Tymoczko and L. Stryer. W.H. Freeman and Company

- Related academic journals: Articles from the current literature on topics related to course content.

COURSE OUTLINE
ASFD17 - ORCANIC PHOTOCHEMISTRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	ASFD17	**SEMESTER**	SPRING
COURSE TITLE	ORCANIC PHOTOCHEMISTRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised in the applications of Photochemistry in organic synthesis
PREREQUISITE COURSES:	Good knowledge of the undergraduate courses in Organic Chemistry and Biochemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Through the course, postgraduate students will acquire the necessary knowledge about Photochemistry, as a required knowledge to classical organic synthesis. Included is the presentation of specific photochemical processes that have been established in organic synthesis. Knowledge about the application possibilities of stereochemistry to solve the structure of natural and synthetic compounds throughout the synthesis of high added value products of industrial interest will be gained. Examples of photochemical processes utilized in the chemical and pharmaceutical industry, are presented.

The students, after the successful completion of the course

• they will possess the basic principles of organic photochemistry and its synthetic applications.

• they will have familiarized themselves with the photochemical processes used both on a laboratory and industrial scale

• they will have learned where photochemistry can be applied successfully in organic synthesis of complicated products.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

Production of new research ideas
• Search for, analysis and synthesis of data and information, using the necessary photochemical knowledge • Working independently • Teamwork • Production of new research ideas • Criticism and self-criticism • Production of free, creative and inductive thinking

(3) SYLLABUS

(1) . Introduction
(2) 1.1. The Fundamentals
(3) 1.2. Absorption – Emission
(4) 1.3 Chemiluminesence
(5) 2. Photochemistry of the Carbonyl Group
(6) 2.1. Norrish type I
(7) 2.2. Norrish type II
(8) 2.3. Enolization Reactions
(9) 3. Photochemistry of the Carbon – Carbon double Bond
(10) 4. Sensitized Photooxidations
(11) 4.1. Molecular Oxygen
(12) 4.2. Photooxidation Type I (radical reactions)
(13) 4.3. Photooxidation Type II (singlet oxygen chemistry)
(14) 5. Photochemistry of Pericyclic Reactions
(15) 6. Photochemistry in Biochemistry.
(16) Photochemistry in Biology and Medicine

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face courses
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of information and communications technology in teaching, and in communication with students.
TEACHING METHODS *The manner and methods of teaching are described in detail.*	***Activity*** / ***Semester workload*** Lectures: 40 Study and analysis of bibliography: 70

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Project-Oral presentation: 12 Final examination: 28 Course total: 150
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language of evaluation: Greek or English if there are non-Greek speaking students. Methods of evaluation: - Oral presentation of scientific article on topics related to course content (20%) - Final written examination, duration 2 hours (50%) The final grade of the course results from: • 10% evaluation of weekly written exercises • 20% homework from all the course content • 20% bibliographic 15 minutes of oral presentation related to course context, presented in the classroom. • 50% final examination, in the class , 2 hrs. duration

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1) Molecular Photochemistry, Nicholas Turo, WA Benjamin, Inc. 1967
2) Brief typed notes of the course

- Related academic journals: Articles from the current literature on topics related to course content

COURSE OUTLINE

EMF04- NMR SPECTROSCOPY, THEORY AND APPLICATIONS

(1) GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMF04	**SEMESTER**	
COURSE TITLE	NMR SPECTROSCOPY, THEORY AND APPLICATIONS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	GENERAL BACKGROUND, SKILLS DEVELOPMENT		
PREREQUISITE COURSES:	-		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK OR ENGLISH		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/aspyros/spyweb/nmr_course.html		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The learning outcome of this course is understanding the basic theoretical principals of Nuclear Magnetic Resonance (NMR) spectroscopy and its applications in chemistry and related scientific fields. The specific knowledge, skills and competences acquired by the students are as follows:

- Understanding of the basic principles of NMR theory
- Familiarization with the multitude of available NMR experimental techniques, methodologies and protocols (1D NMR, 2D NMR, HR-MAS, CP-MAS, BioNMR, κλπ)
- Sample preparation, acquisition, and processing of NMR spectra
- Structure elucidation of organic compounds by NMR spectroscopy
- Quantitative analysis of complex mixtures (foods, plant extracts, biological samples, polymers/materials, etc.)

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Decision-making
- Working independently
- Team work
- Working in an interdisciplinary environment
- Production of new research ideas
- Production of free, creative and inductive thinking

(3) SYLLABUS

1. Introduction in NMR spectroscopy
   - NMR spectroscopy
   - NMR spectroscopy applications
   - Basic NMR principles

2. 1H NMR –Chemical shift
   - Shielding constants
   - Shielding, de-shielding and chemical shift
   - The δ scale
   - Inductive effects
   - Magnetic anisotropy

3. J coupling constant
   - Chemical equivalence of nuclei and molecular symmetry
   - First order coupling between chemically equivalent nuclei
   - Two bond coupling (geminal)
   - Three-bond coupling (vicinal)
   - Long range coupling (W)

4. Heteronuclear NMR spectroscopy
   - Basic principles, sensitivity, natural abundance
   - 13C NMR spectroscopy, INEPT, DEPT pulse sequences
   - 13C NMR chemical shifts
   - 13P NMR spectroscopy

5. Two-dimensional NMR δύο διαστάσεων-Homonuclear correlation
   - Spin-spin coupling
   - Dipole-dipole interaction (Nuclear Overhauser Enhancement)
   - 1H-1H COSY, 1H-1H NOESY 2D NMR

6. Two-dimensional NMR δύο διαστάσεων-Heteronuclear correlation
   - Direct correlations of 1H-13C, 13P, 15N (HSQC experiment)
   - Long range correlations 1H-13C (HMBC experiment)

7. NMR spectroscopy of less common nuclei
- NMR of Spin ½ nuclei
- Quadrupolar NMR

8. Proteins and BioNMR
- 3D structure of proteins by NMR
- Molecular interactions, ligand binding and kinetics

8. Solid state NMR
- High resolution-Magic Angle Spinning (HR-MAS) NMR
- Cross Polarization- Magic Angle Spinning (CP-MAS) NMR

9. Lab courses
- Sample preparation
- NMR processing software, Topspin
- NMR database searching
- Processing of 1D and 2D NMR spectra
- NMR spectrum integration – Quantitative analysis

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face (classroom and computer room)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	email, course web page, e-Class, Topspin software, web-based searching
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study*	

Activity	Semester workload
Lectures	48
Laboratory practice	8
Research Presentation	24
Study and analysis of bibliography	70
Course total	150

according to the principles of the ECTS	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	(50%) Written exam with problem solving questions and NMR spectral assignment (50%) Public research presentation on an NMR-related subject chosen by the student

(5) ATTACHED BIBLIOGRAPHY

1. NMR – From Spectra to Structures, Terence N. Mitchell, Burkhard Costisella, Springer Verlag, Berlin 2004.

2. A Complete Introduction to Modern NMR Spectroscopy," R. S. Macomber, Wiley NY 1998

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

(1) **GENERAL**

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

(2) **LEARNING OUTCOMES**

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT
General Competences *Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?* *Search for, analysis and synthesis of data and information, with the use of the necessary technology* *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas* *Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Promoting free, creative and inductive thinking

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS	

<table>
<tr><td>TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td></td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>180</td></tr>
<tr><td>Study and preparation</td><td>70</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total</td><td>250</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION
Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</td><td>Language: English</td></tr>
</table>

Specialization: Analytical and Environmental Chemistry

COURSE OUTLINE

EMP55 - USE OF NUMERICAL MODELS TO SIMULATE ATMOSHERIC PROCESSING OF SATELLITE DATA

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMP55	SEMESTER	SUMMER
COURSE TITLE	Use of numerical models to simulate atmospheric processes and processing of satellite data		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	WEEKLY TEACHING HOURS	CREDITS
Lectures and hands-on exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge, special background, skills development
PREREQUISITE COURSES:	Basic knowledge of environmental chemistry Basic knowledge of computer programming
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English depending on the trainees
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES in English
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST111/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to introduce students to the numerical simulations of pollutant emissions and the chemical composition of the atmosphere, as well as the processing of environmental data bases with an emphasis on satellite and meteorological data for their categorization and the extraction of correlations.

They are presented briefly

1. Problems in the calculations due to the complexity and non-linearity of the chemistry and physics in the environment and how they are solved.
2. Databases of Air Pollutant Emissions used in Air Quality Models and climate models, Types of emissions and what they depend on (parameterizations), how to create emission databases, examples, hands-on in creating and using emission data and using modern Dispersion Models and Chemistry with online exercises
3. Databases from satellite observations of atmospheric composition and from numerical simulations of climate parameters and how to process them with examples and hands-on exercises.

- For an in-depth understanding of the usefulness of numerical simulations, the student is invited to experiment with the computer, creating his own programs in the fortran programming language and linux operating environment to understand selected environmental processes.
- To process model results and databases, the student is invited to experiment with the computer, creating his/her own programs in python programming language (worksheets with jupyter notebooks) to familiarize him/herself with environmental data management, their visualization and extracting correlations between them.
- Students should acquire the ability to critically search and consult the literature and the Internet to find appropriate databases for the study at hand.
- Students should acquire the ability to organize their thinking, analyze problems in individual questions and compose actions for the success of the final goal. Thus students will learn to create algorithms both for numerical simulations of atmospheric processes and for data processing.
- Students will also learn to work as a team.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Module I

Presentation of examples of numerical simulations of pollutant emissions and the chemical composition of the atmosphere, databases including satellite and meteorological data and their usefulness.

A summary of

1) problems in calculations due to the complexity and non-linearity of chemistry and physics in the environment and how they are solved, examples

2) Air Pollutant Emission Databases used in Air Quality Models and Climate Models, Types of emissions and what they depend on (parameterizations), how to create emission databases, examples

3) Databases from satellite observations of atmospheric composition, meteorological data, and from numerical simulations of climate parameters and how to process them with examples.

Module II

Hands-on for the generation and use of emission data and use of modern Dispersion and Chemistry Models with online exercises

- For an in-depth understanding of the usefulness of numerical simulations, the student is invited to experiment with the computer by creating his/her own programs in fortran programming language and linux operating environment to understand selected environmental processes.

- 5 exercises with program development in fortran (emissions of compounds from the sea, calculation of thermal, trimolecular and photolytic reaction constants and lifetime under various atmospheric conditions of temperature pressure and sunshine, diurnal variation of tropospheric ozone, formation of suspended particles in the atmosphere, effect of temperature and sunshine on gas emissions from vegetation)

Module III

Hands-on exercises on Processing of environmental databases with emphasis on satellite and meteorological data for their categorization and extraction of correlations.

- To process model results and databases, the student is invited to experiment with the computer, creating his/her own programs in python programming language (worksheets with jupyter notebooks) to familiarize himself/herself with the management of environmental data, their visualization and the extraction of correlations between them.

- 5 exercises with program development in python (data reading, calculation of averages, daily, monthly, seasonal, longitudinal trends, identification of outliers, statistical comparison and correlations of data series, graphs, data maps, data interpolation to change geographical or temporal resolution, creation of histograms). Use of meteorological data from ERA5 and satellite data from TROPOMI.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>All lectures will be given in the classroom and activities will be conducted face-to-face. Remote teaching will only be resorted to in exceptional cases.</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.</td><td><table><tr><th>Activity</th><th>Semester workload</th></tr><tr><td>Lectures (10 lectures 4 hrs)</td><td>40</td></tr></table></td></tr>
</table>

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Hands-on exercises (10 x 8 h/ exercise)	80
	Individual work (computer program, problem analysis, algorithm creation, program creation, reporting)	60
	written Exam (exam time + study time)	30
	Self-study (study hrs / lecture hrs x lecture hrs = 1,00 x 40 = 40,00 Study duration in weeks =14)	40
	Total hrs	250
	ECTS (25 hrs / ECTS)	10
	Course total ECTS	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in GREEK or ENGLISH

Type of Evaluation	**Points per evaluation**
Hands-on exercises	10 exercices x 2 points per exercice = 20 points
Individual work	60 points
Written Exam	20 points
	Total = 100 points

Students will be given an algorithm to understand the distribution of grades and the criteria by which their reports will be graded.
The final examination will contain multiple choice questions covering the material covered in the lecture topics.
For the individual assignment students will be required to study a topic related to the Environment by creating a fortran or python program. They will do problem analysis, algorithm creation, program creation, and finally report. The assignment requires delivery of the program and report with results.

(5) ATTACHED BIBLIOGRAPHY

27. Lecture notes available on eclass
28. Jacobson M.Z., Fundamentals of Atmospheric Modeling, Cambridge Univ. Press, 1999.
29. Kanakidou, M., 1996. Tropospheric Chemistry Models, in ERCA book Volume 2, C. F. Bourton (eds.), Les éditions de physique, Les Ulis, France, 245-264

30. Brasseur G. P. and Jacob D.J., Modeling of Atmospheric Chemistry, Cambridge University Press, pp. 606, 2017.
31. https://www.python.org/
32. https://fortran-lang.org/
33. ΑΒΟΥΡΗΣ, Ν., ΚΟΥΚΙΑΣ, Μ., ΠΑΛΙΟΥΡΑΣ, Β., ΣΓΑΡΜΠΑΣ, Κ., PYTHON – ΕΙΣΑΓΩΓΗ ΣΤΟΥΣ ΥΠΟΛΟΓΙΣΤΕΣ – Πανεπιστημιακές Εκδόσεις Κρήτης, 2023

COURSE OUTLINE

EMP57- ADVANCED TOPICS IN MASS SPECTROMETRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	ΕΜΠ57	**SEMESTER**	SPRING
COURSE TITLE	ADVANCED TOPICS IN MASS SPECTROMETRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Lab experiments	5	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized background, skills development
PREREQUISITE COURSES:	Undergraduate Analytical Chemistry courses: On Qualitative and Quantitative Analysis, Instrumental Analysis)
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	eClass website: https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST104/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- Students should fully understand and be able to explain the operating principles of all advanced mass spectrometry techniques and associated separation methods. They should be able to explain the advantages and disadvantages of each technique, as well as be able to present applications of the techniques.
- Students should be able to recommend appropriate mass spectrometry techniques for each group of analytes and the different types of samples (sample matrices).
- Students should understand the logic of the sample preparation steps that precede instrumental analyses, and have the skill to select appropriate processing steps depending on the type of sample they need to analyse.
- Through laboratory experiments students will acquire the skills and knowledge on the correct and efficient operation of selected mass spectrometers (atomic and molecular mass) for advanced analyses.
- Students will acquire knowledge on the correct processing of data recorded with each technique and for each type of sample and analyte.
- Students should acquire the ability to present a summary of an analytical chemistry-related scientific article in an interesting and scientifically sound manner.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary	*……*
	Others…

environment .....

Production of new research ideas

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Decision-making
- Project planning and management
- Exercise criticism and self-criticism
- Promotion of free, creative and inductive thinking

(3) SYLLABUS

Wk #	Activity Title	Activity Type	Student Assignments
1	Advanced inductively coupled plasma mass spectrometry (ICP-MS)	Lecture + Lab tour	Home exercise
2	Water Analysis using ICP-MS	Lab experiment	Lab Report
3	Single-Particle ICP-MS for the determination of metal-containing nanoparticles	Lecture	
4	Determination of Ag and Au nanoparticles	Lab experiment	Lab Report
5	Multi Collector (MC) ICP-MS for accurate isotope ratio determination in geological, environmental, and archaeological samples	Lecture	
6	Advanced Topics in Mass Spectrometry - Instrumentation	Lecture + Lab tour	
7	Accurate Mass MS for determining the chemical formulas of unknowns	Lecture + Lab	Lab Report
8	Proteomics using MS – Part 1 (peptide mapping, top-down proteomics)	Lecture	
9	Proteomics using MS – Part 2 (database search for protein identification)	Lecture	Home exercise
10	Peptide sequencing	Lecture + Lab	Lab Report
11	Real-Time Air Quality Monitoring Using Direct MS (SIFT-MS-based environmental applications)	Lecture	
12	Physical chemistry experiments using Mass Spectrometry: Determination of the gas-phase basicity of amino acids	Lecture + Lab	Lab Report
13	LC – MS/MS for quantitative analysis: Quantitation of caffeine and benzoic acid in beverages and energy drinks	Lecture + Lab	Lab Report
14	Student Presentations (topics to be assigned during weeks 3-6)		Student Presentation

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and experiments will be conducted in the mass spectrometry instrument laboratories (all face-to-face). Remote teaching will only be resorted to in exceptional cases (e.g. illness).
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail. Use of databases and special software to interpret the results of mass spectrometry experiments.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well*	

Activity	*Semester workload*
Lectures (14 lectures 4 hrs)	56
Laboratories (lab time for 6 lab experiments + writing lab reports)	66
Assignments (2 home assignments)	18
Student Presentations (preparation and presentation time)	17

as the hours of non-directed study according to the principles of the ECTS	Final Exam (exam time + study time)	37
	Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks =14)	56
	Total hrs	250
	ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem-solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	Points per evaluation
Home assignments	2 home assignments x 5 points per assignment = 10 points
Lab Reports	6 lab reports x 10 points per report = 60 points
Student presentation	1 presentation = 15 points
Final Exam	15 points
	Total = 100 points

Lab reports: Students are given a lab report template for writing their lab reports.

Assignments: Home assignments will include numerical calculations, questions based on lecture materials, and other types of assignments in which student creativity is emphasized.

Presentations: Students will choose a recent research topic from the analytical chemistry literature, i.e. a research paper published in the last 5 years, and present it in a brief 15-minute presentation.

Grading: Rubrics will be provided for each graded assignment.

Final Exam: The final exam will contain 15 multiple-choice questions on the physical-chemical principles of operation of the analytical techniques covered, as well as the advantages and disadvantages of each technique for a specific type of analysis.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Quantitative Chemical Analysis, Daniel C . Harris , Charles A . Lucy , 10th Ed, W.H. Freeman & Company
- Instructor Notes: Advanced Mass Spectrometry Experiments for Chemistry Students, S.A. Pergantis, Univ. of Crete
- Mass Spectrometry for Chemists and Biochemists, Robert A. W. Johnstone and Malcolm E. Rose, Cambridge University Press.

- Related academic journals:

- Journal of Chemical Education (ACS)
- Analytical Chemistry (ACS)
- Reviews in Mass Spectrometry
- The Analyst
- Analytica Chimica Acta
- Journal of the American Society for Mass Spectrometry
- Journal of Chromatography B
- Talanta

COURSE OUTLINE

EMF04- NMR SPECTROSCOPY, THEORY AND APPLICATIONS

(1) GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMF04	**SEMESTER**	
COURSE TITLE	NMR SPECTROSCOPY, THEORY AND APPLICATIONS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	GENERAL BACKGROUND, SKILLS DEVELOPMENT		
PREREQUISITE COURSES:	-		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK OR ENGLISH		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/aspyros/spyweb/nmr_course.html		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The learning outcome of this course is understanding the basic theoretical principals of Nuclear Magnetic Resonance (NMR) spectroscopy and its applications in chemistry and related scientific fields. The specific knowledge, skills and competences acquired by the students are as follows:

- Understanding of the basic principles of NMR theory
- Familiarization with the multitude of available NMR experimental techniques, methodologies and protocols (1D NMR, 2D NMR, HR-MAS, CP-MAS, BioNMR, κλπ)
- Sample preparation, acquisition, and processing of NMR spectra
- Structure elucidation of organic compounds by NMR spectroscopy
- Quantitative analysis of complex mixtures (foods, plant extracts, biological samples, polymers/materials, etc.)

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Decision-making
- Working independently
- Team work
- Working in an interdisciplinary environment
- Production of new research ideas
- Production of free, creative and inductive thinking

(3) SYLLABUS

1. Introduction in NMR spectroscopy
   - NMR spectroscopy
   - NMR spectroscopy applications
   - Basic NMR principles

2. 1H NMR –Chemical shift
   - Shielding constants
   - Shielding, de-shielding and chemical shift
   - The δ scale
   - Inductive effects
   - Magnetic anisotropy

3. J coupling constant
   - Chemical equivalence of nuclei and molecular symmetry
   - First order coupling between chemically equivalent nuclei
   - Two bond coupling (geminal)
   - Three-bond coupling (vicinal)
   - Long range coupling (W)

4. Heteronuclear NMR spectroscopy
   - Basic principles, sensitivity, natural abundance
   - 13C NMR spectroscopy, INEPT, DEPT pulse sequences
   - 13C NMR chemical shifts
   - 13P NMR spectroscopy

5. Two-dimensional NMR δύο διαστάσεων-Homonuclear correlation
   - Spin-spin coupling
   - Dipole-dipole interaction (Nuclear Overhauser Enhancement)
   - 1H-1H COSY, 1H-1H NOESY 2D NMR

6. Two-dimensional NMR δύο διαστάσεων-Heteronuclear correlation
   - Direct correlations of 1H-13C, 13P, 15N (HSQC experiment)
   - Long range correlations 1H-13C (HMBC experiment)

7. NMR spectroscopy of less common nuclei

- NMR of Spin ½ nuclei
- Quadrupolar NMR

8. Proteins and BioNMR
- 3D structure of proteins by NMR
- Molecular interactions, ligand binding and kinetics

8. Solid state NMR
- High resolution-Magic Angle Spinning (HR-MAS) NMR
- Cross Polarization- Magic Angle Spinning (CP-MAS) NMR

9. Lab courses
- Sample preparation
- NMR processing software, Topspin
- NMR database searching
- Processing of 1D and 2D NMR spectra
- NMR spectrum integration – Quantitative analysis

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face (classroom and computer room)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	email, course web page, e-Class, Topspin software, web-based searching
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	Semester workload
Lectures	48
Laboratory practice	8
Research Presentation	24
Study and analysis of bibliography	70
Course total	150

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	(50%) Written exam with problem solving questions and NMR spectral assignment (50%) Public research presentation on an NMR-related subject chosen by the student

(5) ATTACHED BIBLIOGRAPHY

1. NMR – From Spectra to Structures, Terence N. Mitchell, Burkhard Costisella, Springer Verlag, Berlin 2004.

2. A Complete Introduction to Modern NMR Spectroscopy," R. S. Macomber, Wiley NY 1998

COURSE OUTLINE

EMP52- PHYSICOCHEMICAL AND BIOCHEMICAL PROCESSES IN WASTE TREATMENT

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	ΕΜΠ52	**SEMESTER**	SUMMER
COURSE TITLE	Physicochemical and Biochemical Processes in Waste Treatment		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Lab experiments	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized background, skills development
PREREQUISITE COURSES:	Environmental Chemistry, Analytical Chemistry, General Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English, depending on the students' fluency
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to acquire basic knowledge in the fields of waste and industrial water treatment and management.
- The aim is to familiarise students with the basic physico-chemical processes applied in waste management, as well as with laboratory methods for the determination of the main environmental parameters in water and waste.
- Students should acquire the ability to critically search and refer to scientific literature.
- Students will also learn to work in teams.
- Students should acquire the ability to present a summary of an environmental chemistry related scientific article in an interesting and scientifically sound manner.
- Students will learn how to correlate various physicochemical and biochemical processes with their impact on the environment.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology

- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative, and inductive thinking

(3) SYLLABUS

Content of lectures and laboratory exercises

Module 1

Wastewater treatment technologies

Sources and flows of wastewater & treatment stages

Characteristics of wastewater

Preliminary & primary treatment

Secondary treatment: activated sludge systems - prolonged aeration

Tertiary treatment: Nitrogen & phosphorus removal, wastewater refining

Disinfection

Treatment of excess sludge

Reuse of treated wastewater for irrigation

Module 2

Metallic corrosion and its control in industrial waters.

Formation of insoluble salts in industrial waters and their prevention.

Development of micro-organisms and biofilms in industrial waters and their management.

Module 3

Introduction to the concepts of solid waste management

Aerobic treatment

Anaerobic treatment

Energy recovery

Processes for the production of high added value products

The course will include **laboratory exercises** such as the following:

- Solids measurement.
- Total Solids (volatile - non-volatile) - Suspended Solids (SS), Total Dissolved Solids (T.D.S), Precipitated Solids (Imhoff cone).
- Measurement of physico-chemical water parameters. (temperature, pH, conductivity, total dissolved solids, hardness, determination of Ca+2, Mg+2, Na+1, residual chlorine.
- Ion chromatography. Analysis of basic ions in water (Cl-, SO4-2, NO2-, NO3-, PO4-3).
- Organic pollution parameters. (Dissolved oxygen, BOD, COD).
- Measurement of total nitrogen (NO3-N) and total phosphorus (PO4-P).
- BMP test.
- Processing of results and assignment of written work.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td colspan="2">All lectures will be given in the classroom and experiments will be conducted in the laboratories (all face-to-face). Remote teaching will only be resorted to in exceptional cases.</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td colspan="2">The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>Activity</td><td>Semester workload</td></tr>
<tr><td></td><td>Lectures (13 lectures 4 hrs)</td><td>52</td></tr>
<tr><td></td><td>Laboratories (lab time for lab experiments + preparation of experiments + writing lab reports)</td><td>52</td></tr>
<tr><td></td><td>Student Assignments αnd presentations (preparation and presentation time)</td><td>30</td></tr>
<tr><td></td><td>Final Exam (exam time + study time)</td><td>38</td></tr>
<tr><td></td><td>Self-study (study hrs / lecture hrs x lecture hrs</td><td>78</td></tr>
</table>

	per week = 1,50 x 4 = 6,00 Course duration in weeks =13)	
	Total hrs	250
	ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student Evaluation

Type of Evaluation	Points per evaluation
Lab Reports	25
Student presentation	15
Final Exam	60
	Total = 100 points

Students will be given a sample lab report that they can follow for their own lab reports.

Students will be also instructed on how to perform literature research and their assigned work as well as how to best make their presentations.

The final examination will contain development questions & multiple choice questions covering the material covered in the lecture topics, as well as design & sizing problems for waste treatment plants. The topics requiring calculations will be given the relevant equations.

For their presentations, students will select a waste treatment/waste management topic from a scientific article published in an international scientific journal within the last 5 years.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- “Wastewater Engineering: Treatment, Disposal, Reuse”, Metcalf & Eddy (revised by G. Tchobanoglous, F. L. Burton, McGraw-Hill, Inc. 1991, 3rd Edition.
- Solid Waste Engineering and Management: Volume 1 by Lawrence K. Wang, Springer Nature Switzerland A&G

-Instructor notes

- Mineral Scales and Deposits: Scientific and Technological Approaches, Amjad, Z.; Demadis, K.D., Editors, Publisher: Elsevier, 2015, ISBN: 9780444632289.
- Water-Formed Deposits: Fundamentals and Mitigation Strategies, Amjad, Z.; Demadis, K.D., Editors, Publisher: Elsevier, 2022, ISBN: 9780128228968.

- Related academic journals:

Selected articles from relevant journals:

Applied Catalysis B: Environmental

Chemical Engineering Journal

Environmental Science and Technology

Catalysis Today

Waste Management

Agricultural Water Management

Industrial & Engineering Chemistry Research (ACS)

Desalination (Elsevier)

International Journal of Corrosion and Scale Inhibition

COURSE OUTLINE

EMP53- MONITORING AND CONTROLING AIR POLLUTION

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMP53	**SEMESTER**	SUMMER
COURSE TITLE	MONITORING AND CONTROLING AIR POLLUTION		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Laboratory Exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	special background, specialised general knowledge, skills development
PREREQUISITE COURSES:	Analytical Chemistry, Physical Chemistry, Environmental Chemistry, Organic Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English depending on the students
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to study the systems for collecting, monitoring and limiting air pollution.
- The students will be familiarized with field measurements of gaseous and particulate pollutants in the atmosphere and of meteorological parameters.
- The principle of operation of air pollution control systems is examined.
- The student is also informed about the legislation, the structure and the methodology of preparing an environmental impact study.
- Students should be able to present a scientific article in a short and understandable way on environmental field measurements.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search, analysis and synthesis of data and information, using the necessary technologies

-Working independently

-Team work- Decision-making

- Promotion of free, creative and inductive thinking

- Respect for the natural environment

(3) SYLLABUS

- Introduction to air pollution control.
- Air pollutants and their effects on humans, materials and crops.
- Pollution control legislation and strategies, emission estimation, general principles and basic philosophy for designing emission control systems.
- Particulate pollution - particle dynamics - particle behaviour in the atmosphere - particle distribution functions (mass, size, number)
- Gaseous pollutants - active compounds, greenhouse gases
- Air pollution monitoring systems.
- Automatic sensors of meteorological parameters.
- Sampling and laboratory analysis of atmospheric samples of gases, aerosols, precipitation.
- Automatic aerosol measurements.
- Automatic measurements of air pollutants.
- Remote sensing observation methods.
- Particulate pollution control systems - system performance and penetration; System design and calculations.
- Air pollution control systems from air pollutants - Systems design.
- Application of emission control of pollutants from stationary combustion sources:
  - SO2 control
  - Control of NOx
- Indoor air pollution.
- Air pollution from mobile sources.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face lectures in the classroom and visits and laboratory experiments at the environmental measurement station of the University of Crete at Finokalia, Lassithi and the air pollution monitoring station in the city of Heraklion.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Support of the learning process through MS TEAMS that supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching material, and the posting of announcements and grades. Use of databases from international networks.
TEACHING METHODS	Activity | Semester workload

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS

Lectures (5 presentations of 4 hours)	20
Laboratory exercises (laboratory time for 5 exercises and report writing)	60
Field exercise (10 visits to air pollution measuring stations	60
Student presentations (preparation and presentation time)	20
Final Exam (exam time + study time)	15
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks =5)	20
Project (management of a research station, measurement conduction, sample collection and data analysis)	55
Total hrs	250
ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	Points per evaluation
Project assignment	1 project x 15 points per project= 15 points
Lab Reports	6 lab reports x 10 points per report = 60 points
Student presentation	1 presentation x 10 points per presentation = 10 points
Final Exam	15 points
	Total = 100 points

Students will be given a sample lab report that they can follow for their own lab reports.

The final exam will contain multiple choice questions covering the material covered in the lecture topics. In the topics requiring calculations, the relevant equations will be given.

For their presentations, an indicative bibliography from peer-reviewed international journals will be provided and students will choose an article related to atmospheric measurements.

	The study involves an air pollution monitoring station management activity: conducting measurements, data visualization and analysis, sample collection.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

«Σημειώσεις Ατμοσφαιρικής Τεχνολογίας»: Α. Μπάη, Δ. Μελά, Δ. Μπαλή, ΑΠΘ, 2011
«Guide to Meteorological Instruments and Methods of Observation»: ISBN 978-92-63-10008-5, World Meteorological Organization, 2008

- Related academic journals:

Atmospheric Chemistry and Physics

Atmospheric Environment

Atmospheric research

Science of the Total Environment

Atmosphere

Aerosol Science and Technology

Atmospheric Measurement Techniques

Journal of Geophysical Research

Geophysical Research Lett

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

(1) **GENERAL**

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

(2)LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT
General Competences *Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?* *Search for, analysis and synthesis of data and information, with the use of the necessary technology* *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas* *Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Promoting free, creative and inductive thinking

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	

Use of ICT in teaching, laboratory education, communication with students	
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language: English

Activity	*Semester workload*
Lectures	180
Study and preparation	70
Course total	250

Specialization: Advanced Materials and Physical Chemistry

COURSE OUTLINE
GMP 84 - SUPRAMOLECULAR CHEMISTRY

(1)GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP84	**SEMESTER**	2
COURSE TITLE	SUPRAMOLECULAR CHEMISTRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE **general background, special background, specialised general knowledge, skills development**	Special background Graduate course
PREREQUISITE COURSES:	Basic knowledge of General, Inorganic, Organic Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO
COURSE WEBSITE (URL)	-

(2)LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course introduces the postgraduate student to the field of Supramolecular Chemistry. Following undergraduate courses in basic/general, inorganic and organic chemistry, students will acquire basic and more specialized knowledge of Supramolecular Chemistry, which deals mainly with the structure and properties of compounds, the formation of which is based on interactions beyond the covalent bond, e.g. hydrogen bonds, or coordination bonds. Specifically, it includes and focuses on the composition, structure and physicochemical properties of supramolecular compounds, with emphasis on those that meet the "host-guest" architecture. The course offers an extensive analysis of supramolecular compounds, which includes a detailed analysis of the molecules that act as the "host", those that act as the "guest", their structures, geometries and spectrochemical properties. Many applications arising from the structure of supramolecular complexes are also presented.
Students, after successfully completing the course:

• will possess the basic principles of the chemistry of supramolecular compounds. • will be familiar with chemical species and molecules that can participate in the formation of supramolecular compounds.

• will be able to predict to some extent the structure of supramolecular compounds.

• will be familiar with the forces and interactions that govern the formation of supramolecular compounds.

• will possess the content of the theories that have been proposed to explain their properties.

• will have knowledge of selected applications of supramolecular compounds in industry, medicine, pharmaceuticals, catalysis, etc.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking
……
Others…
…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Adapting to new situations
- Working independently
- Team work
- Production of free, creative and inductive thinking
- Production of new research ideas
- Criticism and self-criticism

(3)SYLLABUS

1. INTRODUCTION TO THE CHEMISTRY OF SUPRAMOLECULAR COMPOUNDS
2. STRUCTURE OF THE COMPONENTS THAT MAKE UP A SUPRAMOLECULAR COMPOUND
3. CHELATE EFFECT
4. COOPERATION
5. THE MACROCYCLIC AND MACROBICYCLIC PHENOMENON
6. PRE-ORGANIZATION, SOLVATION
7. INTERACTIONS: HYDROGEN BONDS, DIPOL-DIPOL, π-π, π-CATION, Van der Waals
8. IONOPHORE, CATION TRANSPORT
9. MACROCYCLIC RINGS: PORPHYRINS, TETRAPYRROLES, CROWN ETHERS, CYCLAMS
10. CATION-HOSTING MOLECULES
11. SUPRAMOLECULAR COORDINATION CHEMISTRY
12. SELECTIVITY
13. ANION-HOSTING MOLECULES
14. MOLECULES HOSTING ION PAIRS
15. CHEMICAL APPLICATIONS
16. BIOLOGICAL APPLICATIONS

(4)TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face (classroom)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Electronic mail • Departmental website-Study guide • Classweb
TEACHING METHODS *The manner and methods of teaching are described in detail. Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well*	

Activity	Semester workload
Lectures	52
Study	70
Literature project-presentation, Final examination	28
Course total	150

as the hours of non-directed study according to the principles of the ECTS	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Student assessment is based on two activities: (a) the final exam at the end of the semester, and (b) the oral presentation at the end of the semester. The language of the course, as well as the evaluation process, is Greek. The final grade of the course results from: • 50% from the final written exam (duration 3 hours) • 50% from the oral presentation The criteria are accessible to students during the first lecture and from the slides sent to everyone via email.

(5)ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- «Supramolecular Chemistry», Jonathan W. Steed, Jerry L. Atwood, John Wiley & Sons, Ltd.
- PowerPoint presentation slides and other electronic material used during teaching in the class

COURSE OUTLINE

GMP65 - TRANSMISSION ELECTRON MICROSCOPY (TEM)

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP65	**SEMESTER**	SPRING
COURSE TITLE	Transmission Electron Microscopy (TEM)		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	• Special background • Specialised general knowledge		
PREREQUISITE COURSES:	Chemistry undergraduate level courses on: • Physics, Inorganic Chemistry, Inorganic Chemistry Laboratory Also preferred / recommended: • Analytical techniques, Diffraction methods, Symmetry elements		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (or English)		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/ptrikalitis		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course is addressed to graduate students of the Chemistry Department (typically holding a Chemistry BSc). This is an introductory course in theory and practical use of the transmission electron microscope (TEM). It consists of both lecture and laboratory instruction that focuses on the theory, fundamental operating principles, specimen preparation techniques, and electron diffraction of electron microscopy. The laboratory course is offered through the Laboratory of Electron Microscopy (Biology Bldg.) and includes demonstration of the TEM instrument for recording images and performing X-ray microanalysis and electron diffraction.

After successfully attending the class, students are expected to:

- Have understood the basic working principles of an transmission electro n microscope
- Have understood the basic principles of electron scattering and electromagnetic lenses
- Have understood the basic principles of electron diffraction
- Have acquired important skills and expertise for the basic operation of a transmission electron microscope.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Adapting to new situations
- Working independently
- Team work
- Production of free, creative and inductive thinking
- Working in an interdisciplinary environment
- Production of new research ideas

(3)SYLLABUS

LECTURES

A. Principles of the TEM

1. Introduction to TEM
    - History of TEM
    - Electron vs. light microscopy

2. Electron Scattering and Diffraction
    - Coherent and incoherent scattering
    - Elastic and inelastic scattering
    - Scattering vs. diffraction

3. Optical theory and electron lenses
    - Resolution
    - Electromagnetic lens
    - Electrostatic lens

B. Design of the TEM

4. Electron guns and electron lenses
    - Thermionic guns and field-emission guns (FEGs)
    - Condenser, objective and projector lens
    - Apertures and diaphragms
    - Lens aberrations (spherical aberration, chromatic aberration and astigmatism)
    - Depth of focus and depth of field

5. Vacuum systems
    - Mechanical pump
    - Diffusion pump
    - Sputter-ion pump
    - Turbomolecular pump

C. Other modes on TEM

6. X-ray microanalysis
    - X-rays formation
    - Energy dispersive X-ray spectroscopy

7. Electron diffraction

- Atomic Scattering Factor
- Diffraction by crystals and Bragg's law
- Camera length and camera constant
- Producing the diffraction pattern

D. Sample preparation

8. Specimens preparation for materials science
   - Specimen support grids
   - Creating thin disks (polishing, ion milling)
   - Microtomy

(4)TEACHING and LEARNING METHODS – EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face (classroom)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• E-class – course website (lecture ppt slides, literature papers) • E-mail
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure*	Greek language Attendance of lectures (L) Laboratory attendance (P)

Activity	***Semester workload***
Lectures	100
On-site TEM training	67
Final exam	90
Course total	257

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Final exam (F) (Written cumulative exam, Critical questions) Overall grade G (scale 0-10) = 0,15*L + 0,25*P + 0,6*F The evaluation procedures and criteria are presented in the introductory lecture (and reminded often during the semester). Model exam questions are handed out.

(5)BIBLIOGRAPHY

- Suggested bibliography:

1. D.B. Williams, C.B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Plenum Press, New York, 1996.
2. Brent Fultz, James M. Howe. Transmission Electron Microscopy and Diffractometry of Materials, 3rd Ed., Springer, Berlin, 2008

• Relevant literature and review articles

• Lecture pptx slides

COURSE OUTLINE

GMP62 - SOLID STATE CHEMISTRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP62	**SEMESTER**	SPRING
COURSE TITLE	SOLID STATE CHEMISTRY		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special background Specialised general knowledge		
PREREQUISITE COURSES:	Chemistry undergraduate level courses on: • Inorganic Chemistry, Inorganic Chemistry Laboratory Also preferred / recommended: • Diffraction methods, Symmetry elements		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (or English)		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/ptrikalitis		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course is addressed to graduate students of the Chemistry Department (typically holding a Chemistry BSc).

Its main objective is to present, in the context of lectures, solid state chemistry as an important scientific area that is very relevant to our modern society and technology. The students will become familiar with the basic principles regarding synthesis, structure, properties and applications of solid materials, mainly inorganic as well a hybrid compounds (organic-inorganic). This knowledge will bring the chemists into the realm of materials science through a "bottom-up" approach. In this way Chemists will better understand the properties of the matter and be able to design, synthesize and develop novel materials for advanced applications.

After successfully attending the class, students are expected to:

- Have understood the basic principles of crystallography
- Describe crystalline structures
- Have understood the nature of the bonds in the solid state
- Have understood the principles behind the characterization of materials using X-rays diffraction techniques
- Have understood the basics of important synthetic techniques

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

Working in an international environment	……
Working in an interdisciplinary environment	*Others…*
Production of new research ideas	

- Adapting to new situations
- Working independently
- Team work
- Production of free, creative and inductive thinking
- Working in an interdisciplinary environment
- Production of new research ideas

(3) SYLLABUS

LECTURES

- Introduction to the solid state
- Basic elements of crystallography:
  - Unit cell,
  - Crystal systems
  - Lattice, symmetry elements, space groups
  - Lattice planes and Miller indices
- Crystal structure description:
  - closed packed structures
  - Ionic solids
  - Analysis of representative basic crystal structures: NaCl, ZnS, CaF_2, Na_2O, CsCl, TiO_2, CdI_2, NiAs, Perovskite-ABX_3, Spinel-AB_2O_4
- Bonding in solids:
  - Principles of ionic solids
  - Pauling's rules
  - Lattice energy –Born-Haber cycle
  - Homopolar bonds and their influence in the structure of solids
  - Bond valence and bond valence sums
- Characterization of materials using X-ray diffraction
  - Bragg Law and Lattice parameters
  - Atomic structure factor
  - Indexing of diffraction patterns
  - Real and reciprocal space
- Synthetic methods:
  - Solid state reactions
  - Sol-gel synthesis
  - Hydro(solvo) thermal reactions
  - Templated syntheses
  - Intercalation reactions

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face to face (classroom)

Distance learning (MS Teams platform)</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>• E-class – course website (lecture ppt slides, literature papers)
• E-mail</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>90</td></tr>
<tr><td>Study work, Homework, Problem sets</td><td>40</td></tr>
<tr><td>Oral presentation of literature paper/review</td><td>67</td></tr>
<tr><td>Final exam</td><td>60</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total</td><td>257</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</td><td>Greek language

Attendance of lectures (L)

Problem sets (P)
(3 sets during the semester)

Oral presentation (O)
(Topic selected from recent literature)

Final exam (F)
(Written cumulative exam, Critical questions)

Overall grade
G (scale 0-10) = 0,1*L + 0,1*P + 0,3*O + 0,5*F

The evaluation procedures and criteria are presented in the introductory lecture (and reminded often during the semester). Model exam questions are handed out.</td></tr>
</table>

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	

(5) BIBLIOGRAPHY

- Suggested bibliography:

1. Basic Solid State Chemistry 2nd Edition, 1999
2. Solid State Chemistry and its Applications, 2nd Edition. Anthony R. West, 2022
3. Structure Determination by X-ray Crystallography, M.F.C. Land and R.A. Palmer
4. Crystals, X-rays and Proteins, D. Sherwood and J. Cooper
5. Inorganic Chemistry, Mark Weller, Tina Overton, Jonathan Rourke and Fraser Armstrong
6. Chemistry of the Elements, N.N. Greenwood and A. Earnshawn

• Relevant literature and review articles

• Lecture pptx slides

- Related academic journals:

- Chemistry of Materials

- Journal of Materials Chemistry A

- Inorganic Chemistry

COURSE OUTLINE

EMF04- NMR SPECTROSCOPY, THEORY AND APPLICATIONS

(1)GENERAL

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	EMF04	**SEMESTER**	
COURSE TITLE	NMR SPECTROSCOPY, THEORY AND APPLICATIONS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	GENERAL BACKGROUND, SKILLS DEVELOPMENT		
PREREQUISITE COURSES:	-		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK OR ENGLISH		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/aspyros/spyweb/nmr_course.html		

(2)LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The learning outcome of this course is understanding the basic theoretical principals of Nuclear Magnetic Resonance (NMR) spectroscopy and its applications in chemistry and related scientific fields. The specific knowledge, skills and competences acquired by the students are as follows:

- Understanding of the basic principles of NMR theory
- Familiarization with the multitude of available NMR experimental techniques, methodologies and protocols (1D NMR, 2D NMR, HR-MAS, CP-MAS, BioNMR, κλπ)
- Sample preparation, acquisition, and processing of NMR spectra
- Structure elucidation of organic compounds by NMR spectroscopy
- Quantitative analysis of complex mixtures (foods, plant extracts, biological samples, polymers/materials, etc.)

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary environment

Production of new research ideas

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

Others…

…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Decision-making
- Working independently
- Team work
- Working in an interdisciplinary environment
- Production of new research ideas
- Production of free, creative and inductive thinking

(3)SYLLABUS

1. Introduction in NMR spectroscopy
   - NMR spectroscopy
   - NMR spectroscopy applications
   - Basic NMR principles

2. 1H NMR –Chemical shift
   - Shielding constants
   - Shielding, de-shielding and chemical shift
   - The δ scale
   - Inductive effects
   - Magnetic anisotropy

3. J coupling constant
   - Chemical equivalence of nuclei and molecular symmetry
   - First order coupling between chemically equivalent nuclei
   - Two bond coupling (geminal)
   - Three-bond coupling (vicinal)
   - Long range coupling (W)

4. Heteronuclear NMR spectroscopy
   - Basic principles, sensitivity, natural abundance
   - 13C NMR spectroscopy, INEPT, DEPT pulse sequences
   - 13C NMR chemical shifts
   - 13P NMR spectroscopy

5. Two-dimensional NMR δύο διαστάσεων-Homonuclear correlation
   - Spin-spin coupling
   - Dipole-dipole interaction (Nuclear Overhauser Enhancement)
   - 1H-1H COSY, 1H-1H NOESY 2D NMR

6. Two-dimensional NMR δύο διαστάσεων-Heteronuclear correlation
   - Direct correlations of 1H-13C, 13P, 15N (HSQC experiment)
   - Long range correlations 1H-13C (HMBC experiment)

7. NMR spectroscopy of less common nuclei
- NMR of Spin ½ nuclei
- Quadrupolar NMR

8. Proteins and BioNMR
- 3D structure of proteins by NMR
- Molecular interactions, ligand binding and kinetics

8. Solid state NMR
- High resolution-Magic Angle Spinning (HR-MAS) NMR
- Cross Polarization- Magic Angle Spinning (CP-MAS) NMR

9. Lab courses
- Sample preparation
- NMR processing software, Topspin
- NMR database searching
- Processing of 1D and 2D NMR spectra
- NMR spectrum integration – Quantitative analysis

(4)TEACHING and LEARNING METHODS – EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face (classroom and computer room)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	email, course web page, e-Class, Topspin software, web-based searching
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study*	

Activity	Semester workload
Lectures	48
Laboratory practice	8
Research Presentation	24
Study and analysis of bibliography	70
Course total	150

according to the principles of the ECTS	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	(50%) Written exam with problem solving questions and NMR spectral assignment (50%) Public research presentation on an NMR-related subject chosen by the student

(5)ATTACHED BIBLIOGRAPHY

1. NMR – From Spectra to Structures, Terence N. Mitchell, Burkhard Costisella, Springer Verlag, Berlin 2004.

2. A Complete Introduction to Modern NMR Spectroscopy," R. S. Macomber, Wiley NY 1998

COURSE OUTLINE

GMP90 - LASER SPECTROSCOPY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES AND ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	GMP90	**SEMESTER**	SPRING
COURSE TITLE	LASER SPECTROSCOPY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	• Special background • Specialised general knowledge • Skills development
PREREQUISITE COURSES:	Chemistry undergraduate level courses on: • Mathematics, Physics, Physical Chemistry, Physical Chemistry Laboratory) Also preferred / recommended: • Spectroscopy, Introductory Quantum Mechanics
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (or English)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	E-class: https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST102/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course is addressed to graduate students of the Chemistry Department (typically holding a Chemistry BSc).

Its main objective is to present, in the context of lectures and advanced laboratory experiments, the use of modern laser methods in the study of atoms, molecules and materials and demonstrate applications of these techniques in cutting-edge science and technology with examples drawn from the fields of nanotechnology, biology, environmental monitoring, space research and heritage science.

After successfully attending the class, students are expected to:

- Have understood in a theoretical and practical context aspects related to applications of laser-based in the study of atoms, molecules and materials.
- Know basic laser spectroscopy techniques used in materials analysis and characterization.
- Have a basic understanding of non-linear interactions of high intensity electromagnetic radiation (light) with matter and the study of ultrafast phenomena in atoms, molecules and materials.
- Have obtained a good overview of research in Physical Chemistry (with emphasis on laser spectroscopy) that will help in further graduate studies and their potential professional or research career

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology

Adapting to new situations

Decision-making

Working independently

Team work

Working in an international environment

Working in an interdisciplinary

Project planning and management

Respect for difference and multiculturalism

Respect for the natural environment

Showing social, professional and ethical responsibility and sensitivity to gender issues

Criticism and self-criticism

Production of free, creative and inductive thinking

……

environment	*Others…*
Production of new research ideas	*…….*

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Adapting to new situations
- Working independently
- Team work
- Production of free, creative and inductive thinking
- Working in an interdisciplinary environment
- Production of new research ideas

(3) SYLLABUS

LECTURES

- Lasers: Basic principles and types of lasers. Laser safety.
- Fundamental processes of interactions between electromagnetic radiation and matter (semi-classical approach, time-dependent perturbation theory)
- Spectroscopy Instrumentation
- Laser spectroscopic techniques. Study of dynamic phenomena.
- Absorption and Fluorescence Spectroscopy. Fluorescence microscopy. Applications in the study of biomolecules and materials
- Non-linear optics and multi-photon processes
- Laser light scattering techniques in the study of macromolecules

LABORATORY EXPERIMENTS

1. Optics and Lasers
2. Photoelectron spectroscopy and imaging. Chemical Dynamics (Vacuum systems)
3. Time-resolved fluorescence spectrometry
4. Non-linear laser spectroscopy
5. Laser-induced plasma spectroscopy (atomic, molecular emission)
6. Raman microscopy
7. Dynamic light scattering

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face to face (classroom)

Distance learning (MS Teams platform)</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>• E-class – course website (lecture ppt slides, problem sets, literature papers)
• E-mail</td></tr>
<tr><td>TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>40</td></tr>
<tr><td>Laboratory sessions</td><td>20</td></tr>
<tr><td>Study work, Homework, Problem sets</td><td>45</td></tr>
<tr><td>Experiment preparations and Laboratory reports</td><td>60</td></tr>
<tr><td>Oral presentation of literature paper/review</td><td>30</td></tr>
<tr><td>Final exam</td><td>62</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total</td><td>257</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</td><td>Greek language

Attendance of lectures (L)
Problem sets (P)
(4 sets during the semester)
Laboratory experiments and reports (E)
(4-5 experiments, 3 reports)
Oral presentation (O)
(Topic selected from recent literature)
Final exam (F)
(Written cumulative exam, Critical questions and calculations)
Overall grade
G (scale 0-10) = 0,1*L + 0,15*P + 0,3*E + 0,15*O + 0,3*F
The evaluation procedures and criteria are presented in the introductory lecture (and reminded often during the semester). Model exam questions are handed out.</td></tr>
</table>

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	

(5) BIBLIOGRAPHY

- **Suggested bibliography:**

1. P. W. Atkins, 'Molecular Quantum Mechanics', Oxford
2. M. Young, 'Optics and Lasers
3. J. Wilson, J. Hawkes, 'Optoelectronics
4. W. Demtröder, 'Laser Spectroscopy' Vol.1, Basic Principles, 4th ed. Springer
5. W. Demtröder, 'Laser Spectroscopy' Vol. 2, Technology, 4th ed. Springer
6. P. F. Bernath, Spectra of Atoms and Molecules, Oxford University Press
7. P.W. Atkins, J. de Paula, J. Keeler, 'Physical Chjemistry'
8. D.C. Harris, M.D. Bertolucci, 'Symmetry and Spectroscopy' (Dover, NY 1978)
9. J.M. Hollas, 'Modern Spectroscopy' (John-Wiley & Sons, NY 1996)
10. C.S. Johnson, D.A. Gabriel "Laser Light Scattering" (Dover, 1994)

- Relevant literature and review articles
- Lecture pptx slides

- Related academic journals:

Physical Chemistry and Spectroscopy Journals

COURSE OUTLINE
GMP50 - SUMMER SCHOOL

(1) **GENERAL**

SCHOOL	FACULTY OF NATURAL AND TECHNOLOGICAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	MASTER		
COURSE CODE	GMP50	**SEMESTER**	WINTER and SPRING
COURSE TITLE	SUMMER SCHOOL		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General knowledge specialisation
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, English
COURSE WEBSITE (URL)	

(2)LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The aim of the course is to attend workshops organized by the CHEMISTRY DEPARTMENT
General Competences *Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?* *Search for, analysis and synthesis of data and information, with the use of the necessary technology* *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas* *Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Promoting free, creative and inductive thinking

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	

Use of ICT in teaching, laboratory education, communication with students	
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language: English

Activity	*Semester workload*
Lectures	180
Study and preparation	70
Course total	250