Course Outline

1) General

SCHOOL	SCIENCE		
DEPARTMENT	CHEMISTRY		
DEGREE	MASTER		
COURSE CODE	**18B9**	**SEMESTER**	**2**
COURSE TITLE	INORGANIC CHEMICAL TECHNOLOGY AND ENTREPRENEURSHIP		

INDEPENDENT TEACHING ACTIVITIES in the case that the credits are awarded to separate parts of the course e.g. Lectures, Laboratory Exercises, etc. If the credits are awarded uniformly for the entire course, enter the weekly teaching hours and total credits	**TEACHING HOURS PER WEEK**	**CREDITS**
Lectures	7	10
Add lines if necessary. The teaching organization and methods used are described in detail in (d).		

COURSE TYPE *general background, special background, general knowledge specialization, skill development*	Special background, skills development
PREREQUISITE COURSES:	No
COURSE AND EXAM LANGUAGE:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS ?	Yes, if needed
COURSE WEBSITE (URL)	**https://eclass.uoa.gr/courses/CHEM313/**

(1) LEARNING OUTCOMES

LEARNING OUTCOMES

The learning outcomes, specific knowledge, skills and abilities of an appropriate level that the students will acquire after the successful completion of the course are described.

Consult Appendix A

• Description of the Level of Learning Outcomes for each course of study according to the Qualifications Framework of the European Higher Education Area

• Descriptive Indicators for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Annex B

• Comprehensive Guide to writing Learning Outcomes

The aim of the course is to introduce students to industrial processes targeting or involving inorganic and organometallic compounds. The main applications of Inorganic Chemistry in industry are described, with emphasis on raw materials, production lines, economic and environmental factors, the transition from the linear to the circular economy, the connection between research and industry, and ways of transferring technology to the economy.

More specifically, in the context of this course, students are taught about the following topics:

Circular Economy.

- Basic principles of circular economy (6R).
- The role of chemistry and especially of inorganic chemistry in supporting and strengthening the transition from the linear to the circular economy.

Applications of inorganic chemistry in Industry.

- Industrial production of mineral acids (sulfuric acid, phosphoric acid).
- The metallurgy of copper (pyro- and hydro-metallurgy).
- Titanium oxide and the removal of contaminants from treated municipal wastes.
- Pharmaceutical industry. Inorganic drugs.

Renewable energy sources with emphasis on solar energy.

- Introduction to *P*hoto*V*oltaic systems (PV), general classification, classification of silicon PV elements. Advantages disadvantages of the various classes.
- Silicon PV cell technology: basic principles with references to state of the art. Geograpical distribution of the Si PV production.
- Economic and technical case studies, legislative framework and correlation with the microelectronics industry.
- Thin film technologies.
- Third generation *Ph*oto*e*lectrochemical *c*ells (PHEC or Grätzel-type cells), as alternatives to silicon PVs and molecular analogues of artificial photosynthesis,.
- Operating mechanism of a device, its individual components with emphasis on the photosensitizer.

- Examples of pigments used in PHEC, general synthetic processes. Molecular design of pigments.
- Economic and technical studies and perspectives for commercialisation.

Description and explanation of selected industrial processes based on organometallic catalysis.

- Carbonylation of methanol to acetic acid (Monsanto and BP-Cativa and their variants).
- Hydroformylation of alkenes by H_2/CO (Oxo process).
- Selective ethylene oligomerization (Sasol and BP process).
- Homogeneous polymerization of ethylene and the homogeneous stereospecific polymerization of propylene with single site catalysts.
- Biodegradeable polymers

Knowledge and understanding are acquired on

- The basic principles of the circular economy and the pivotal role played by chemistry.
- applications of inorganic chemistry in Industry and current trends for further development.
- modernization of inorganic technologies.
- the basic principles of and current trends in renewable energy sources with emphasis on solar energy.
- thin film technologies.
- molecular analogs of artificial photosynthesis, as alternatives to silicon PV.
- pigments.
- economic and technical feasibility studies and commercialisation perspectives.
- selected industrial processes based on organometallic catalysis.

Skills are acquired on

- identifying problems that arise during the implementation of processes in chemical industry, with an emphasis on the circular economy.
- research and/or innovation for the development of new knowledge and processes.
- integrating new methods and technologies applied inorganic chemical technology.
- new methods applied in the utilization of solar energy.
- economic and technical case studies on commercialization.
- research of the scientific literature, scientific writing and public presentation of a scientific paper.

Abilities are developed on

- the linking of the basic chemical knowledge, acquired at the undergraduate level, with specialized knowledge related to inorganic chemical technology.
- The linking of new chemical technologies with sustainable development and the economy.
- working and occupational safety in a chemical laboratory.
- interpreting literature data and relating it to specific chemical processes applied in the inorganic chemical industry.
- interact with other students.
- conducting literature research, general scientific writing and presenting scientific work to groups.

General Skills

Taking into account the general skills that the graduate must have acquired (as stated in the Diploma Appendix and listed below) which of the following is/are the course aimed at?.

Reearch, analysis and synthesis of data and information, using the necessary technologies
Adaptation to new situations
Decision making
Independent work
Teamwork
Working in an international environment
Working in an interdisciplinary environment
Generating new research ideas
Project planning and management
Respect for diversity and multiculturalism
Respect for the environment
Demonstrating social, professional and ethical responsibility and sensitivity to gender issues
Exercise criticism and self-criticism
Promotion of free, creative and inductive thinking
Other…….

The course aims at equipping students with the following general skills:

- Searching, analyzing and combining data and information, using bibliographic databases.
- Working independently.
- Working in groups.
- Applying knowledge to problem solving.
- Promoting of free, creative and inductive thinking.
- Generating new research ideas.
- Decision making.
- Planning and managing projects

(2) COURSE CONTENT

Basic principles of the circular economy (6R). The role of Chemistry and especially of Inorganic Chemistry in supporting and strengthening the transition from the linear to the circular economy. Industrial production of mineral acids (sulfuric acid, phosphoric acid). Copper metallurgy (pyro- and hydro-metallurgy). Titanium oxide and the removal of pollutants from treated municipal wastes. Pharmaceutical industry. Inorganic drugs. Renewable energy sources with an emphasis on solar energy. Introduction to Photovoltaic systems (PV), general division, categorization of silicon PV cells. Advantages disadvantages. Technology base of silicon PV cells with references to current status and producing countries. Economic studies, legislative framework and correlation with the microelectronics industry. Thin film technologies. Photoelectrochemical cells of the third generation (PHEC) or Grätzel-type cells as molecular analogues of artificial photosynthesis, as an

alternative to silicon PVs. Mechanism of operation of the device, individual components with emphasis on the photosensitizer. Examples of dyes, general synthesis routes. Molecular design of pigments. Economic studies and market introduction perspectives. Description and explanation of selected industrial processes based on organometallic catalysis. Carbonylation of methanol to acetic acid (Monsanto and BP-Cativa and their variants). Hydroformylation of alkenes with H2/CO (Oxo process). Selective ethylene oligomerization (Sasol and BP process). Homogeneous polymerization of ethylene and the homogeneous stereospecific polymerization of propylene with single site catalysts.

(3) TEACHING AND LEARNING METHODS – EVALUATION

LECTURES' DELIVERY
In person, distance, etc..

In person

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGIES
Use of I.C. T. in Lectures, Laboratory Exercises, Communication with students

In Teaching:

- Presentations with multimedia content (power point)

In Communication with students:

- Support the learning process through the e-class electronic platform (announcements, information, messages, documents, user groups, etc.).
- Email.

TEACHING ORGANIZATION
The teaching style and methods are described in detail.
Lectures, Seminars, Laboratory Exercises, Field Exercises, Literature Study & Analysis, Tutorial, Internship (Placement), Clinical Exercises, Art Workshop, Interactive Teaching, Educational Visits, Study Preparation (Project), PaperWriting Assignments, Artistic Creation, etc. etc.

The student's study hours for each learning activity as well as unguided study hours according to ECTS principles are listed

Activity	*Semester workload*
Lectures	91
Unguided study	80
Paper writing	50
Educational visit	2
Seminar/Lecture	2
Study preparation	25
Total	250

STUDENT EVALUATION
Description of the evaluation process

Assessment Language, Assessment Methods, Formative or Deductive, Multiple Choice Test, Short Answer Questions, Essay Development Questions, Problem Solving, Written Assignment, Report / Report, Oral Examination, Public Presentation, Laboratory Work, Clinical Patient Examination, Artistic Interpretation, Other / Others

The evaluation of the course takes place in greek and includes:

- written exam that includes multiple choice questions, short development of theoretical issues, judgment, as well as problem solving.
- evaluation of work from the literature
- evaluation of the presentation in front of group of work from the literature.

Explicitly defined evaluation criteria are mentioned, and if and where they are accessible by students.	

(4) RECOMMENDED BIBLIOGRAPHY

- P.W.M. van Leeuwen Homogeneous Catalysis Understanding the Art Kluwer Academic 2004
- K. H. Buchel. Industrial Inorganic Chemistry, D. Werner et al Wiley 2008.
- Mark A. Benvenuto. Industrial Inorganic Chemistry. Walter de Gruyter GmbH, Berlin/Boston. 2015.
- Mineral Commodity Summaries. https://www.usgs.gov/centers/national-minerals-information-center/mineral-commodity-summaries
- P.T. Anastas, J. B. Zimmerman. THE PERIODIC TABLE OF THE ELEMENTS OF GREEN AND SUSTAINABLE CHEMISTRY. Press Zero, Madison, Connecticut USA, 2020.
- O'Regan, B.; Gratzel, M., A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO2 films. Nature 1991, 353, 737-740.
- Hagfeldt, A.; Boschloo, G.; Sun, L.; Kloo, L.; Pettersson, H., Dye-Sensitized Solar Cells. Chemical Reviews 2010, 110, 6595-6663.
- Vougioukalakis, G. C.; Philippopoulos, A. I.; Stergiopoulos, T.; Falaras, P., Contributions to the development of ruthenium-based sensitizers for dye-sensitized solar cells. Coordination Chemistry Reviews 2011, 255, 2602-2621.
- K. Kalyanasundaram, M. Grätzel, Applications of functionalized transition metal complexes in photonic devices, Coordination Chemistry Reviews, 1998, 177, 347-414.