UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Principles of Sustainable Chemistry

2627-1-F7503Q031-F7503Q03101

Aims

The teaching of the first module of 6 CFUs is aimed at providing the knowledge and the methodological basis to know and understand the principles that define sustainable and / or green chemistry. The course will focus on some processes and practices currently attributable to the concept of sustainability and respect for the environment in various sectors of society, as examples for specific in-depth discussions on the issues addressed during the course.

The topics of this module are closely related to some aspects of the second module, and teaching will, as necessary and beneficial for genral understanding of interconnectivities of taught aspects, see incorporation of parts of the second module.

The students are invited to consult the syllabus of the entire course for details regarding learning- and skill-related objectives, etc.

Contents

• The concepts of green chemistry and sustainable chemistry, their commonalities and their differences.
• The concept of biorefinery for the production of sustainable raw materials.
• Responsible and sustainable use of non-renewable resources such as metals, aspects of recycling within a circular economy.
• The reactivity of chemical compounds in the environment.
• Sustainable processes for the production of standard materials, platform chemicals and performance materials.
• Sustainable processes in the field of chemistry for the production of fine chemicals.
• Sustainability in the field of nanomaterials.
• Aspects on sustainable energy.

Detailed program

• Evolution of sustainability in industrial syntheses on the basis of selected examples.
• Evolution of the concepts of green chemistry and sustainable chemistry.
• Common points and differences between green chemistry and sustainable chemistry.
• Description of the main renewable resources suitable for substituting oil as main raw material source for the chemical industry with particular reference to the structure of lignocellulosic materials.
• The concept of bio-refinery with examples and applications in Italy and Europe, also in view of the circular economy.
• Synthesis of chemicals from renewable sources with sustainable processes.
• Sustainable and / or green concepts for performing chemical reactions, for example flow chemistry.
• Sustainable processes in chemistry-related fields: point-of-care-devices, organ-on-a-chip, model organisms.
• Synthesis and advantages of sustainable nanomaterials, and associated regulatory aspects.
• Synthesis of new biodegradable and non-biodegradable materials starting from renewable sources with sustainable processes.
• Recycling, downcycling and upcycling as tools for the circular economy.
• The integration of sustainable processes within the circular economy and their construction.
• Description of the challenges associated with the recycling and reuse of various materials, including precious metals, concept of urban mining.
• Sustainable mining activities.
• Distribution of elements across various environments using (anthro)biogeochemical cycles.
• Case studies.

Prerequisites

• Basic knowledge of organic and inorganic chemistry and biology.
• Basic notions of thermodynamics.

Teaching form

• 6 CFUs of theoretical lessons in the classroom (48 hours):
-> 20 two-hour lectures, in person, Delivered Didactics;
-> 4 two-hour lectures, in person, reading and discsussing scientific articles and/or case studies in aula, Interactive / Mixed Didattics / Seminar.
• Case studies, to be prepared during the lessons by the students in groups according to various schemes, with final discussions together.

Textbook and teaching resource

• M. Aresta, A. Dibenedetto, F. Dumeignil
Biorefineries – An introduction
De Gruyter
• P.T. Anastas
Green Chemistry - Theory and Practice
Oxfod University Press
• slides

• notes shown during lectures and additional material on selected topics, i.e., scientific articles, made available on the e-learning website of the course.

Semester

I semester (October - November/December)

Assessment method

The final exam consists of a single oral exam at the end of the course, with a score between 18-30 / 30 *cum laude*, which comprises the discussion of various topics covered in the course, with an emphasis also on the connections between concepts and processes, such as to arrive at a critical evaluation of work from the point of view of sustainability in chemistry as a whole.

The final score will range from 18/30 to 30/30 with honors, based on the overall assessment, taking into account the following criteria:

1. conceptual knowledge and understanding
2. ability to apply knowledge and understanding
3. communication and argumentation skills
4. learning, self-assessment, and self-regulation skills

Grade < 18
Knowledge and Understanding: The student only partially identifies the characteristics of the concepts. The connections between the concepts are fragmented and poorly supported by theoretical knowledge.
Ability to apply knowledge and understanding: The student identifies only a few relevant elements in a phenomenon, unable to integrate them into a coherent analysis.
Communication and Argumentation Skills: In the oral exam, the student develops a basic argument, lacking logical structure and characterized by numerous expository inaccuracies.
Learning, self-assessment, and self-regulation skills: The student is able to reconstruct only some aspects of their learning and professional development journey.

Grade 18-22
Knowledge and Understanding: The student recognizes and explains most of the conceptual features and is able to provide a relatively coherent explanation, albeit with some inaccuracies. Theoretical references are present but not always rigorously.
Ability to apply knowledge and understanding: The student is able to recognize a significant number of elements and provide a partial explanation, while highlighting some gaps in the analysis.
Communication and argumentation skills: In the oral exam, the student constructs a basic argument, with a minimal structure but with some inaccuracies.
Learning, self-assessment, and self-regulation skills: The student demonstrates a basic awareness of their learning path, managing to draw essential connections between learning experiences, albeit with some inaccuracies.

Grade 23-27
Knowledge and Understanding: The student demonstrates a thorough understanding of conceptual characteristics. In the oral exam, explanations are well-articulated and supported by an appropriate use of theoretical references.
Ability to apply knowledge and understanding: The student accurately identifies the essential elements of a phenomenon. The application of knowledge occurs with methodological rigor that is not always solid.
Communication and argumentation skills: In the oral exam, the student develops a coherent and well-organized

argument, demonstrating good command of language and a solid logical-argumentative structure. Communication is clear and effective.
Learning, self-assessment, and self-regulation skills: The student analyzes his or her learning journey in a clear and structured manner, highlighting significant relationships between the various developmental stages and demonstrating a good capacity for critical reflection.

Grade 28-30
Knowledge and Understanding: The student demonstrates a thorough mastery of concepts, articulating complex connections and providing comprehensive explanations. Theoretical references are used with relevance and rigor.
Ability to apply knowledge and understanding: The student demonstrates an advanced ability to analyze a phenomenon, comprehensively identifying and interpreting all salient elements. Knowledge is applied with methodological rigor, supported by solid and detailed argumentation.
Communication and argumentation skills: In the oral exam, the student develops a solid and detailed argument, with a rigorous logical structure and a high level of textual coherence. The presentation is fluent and well-structured.
Learning, self-assessment, and self-regulation skills: The student demonstrates an advanced capacity for self-reflection, developing a detailed and in-depth analysis of their learning and professional development journey. The connections between learning experiences and theoretical concepts are clear, coherent, and rigorous.

Office hours

Always, after scheduling an appointment via phone or e-mail.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION