UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Organic Chemistry II

2425-2-E2702Q094-E2702Q095M

Aims

Intermediate Organic Chemistry (aromatic and heteroaromatic compounds).

Knowledge and understanding

At the end of the course the student knows:

- The concept of aromaticity and the main scientific approaches

- The main classes of aromatic and heteroaromatic substances

- The main structural, chemical and electronic properties of aromatic and heteroaromatic substances

- The main reactivity of aromatic and heteroaromatic substances

- The main synthesis methods of aromatic and heteroaromatic substances

Applying knowledge and understanding

At the end of the course the student is able to:

- Recognize and interpret the main properties of aromatic and heteroaromatic substances

- Synthesize and apply the main reactions of aromatic and heteroaromatic substances

Making judgments

At the end of the course the student is able to:

- Select the main classes of aromatic and heteroaromatic substances based on their use and properties

- Select the main reactions and synthesis of aromatic and heteroaromatic substances based on the products to be obtained

Communication

Knowing how to describe in a clear and concise way in writing and orally with the language properties the main concepts of aromaticity and the properties and reactivity of aromatic and heteroaromatic substances

Lifelong learning skills

Being able to apply the acquired knowledge to different classes and compounds of aromatic and heteroaromatic organic substances, even in contexts different from those presented during the course. Being able to extend knowledge independently through the study and analysis of advanced texts in Organic Chemistry, scientific literature, patents and scientific-technical reports.

Contents

Molecular orbitals. Huckel molecular orbital method. Aromaticity. Mono- and polycyclic aromatic and heteroaromatic systems: properties, synthesis, reactions.

Detailed program

In-depth teaching of the fundamental concepts presented in the Organic Chemistry 1 course. It is positioned at an intermediate level, contributing to the foundational knowledge considered essential for a first-cycle (Bachelor's) graduate.

Main topics.

a) Monocomponent carbocyclic aromatic systems (34 hours). Molecular orbitals and Huckel method (HMO). Benzene: aromaticity, resonance, resonance and delocalization energy. Hückel's Rule. Definition of aromaticity. Nomenclature. Reactions in the side chain. Reductions and oxidations. Electrophilic aromatic substitution reactions on benzene and benzene derivatives. Effect of substituents and orientation theory. Nitro derivatives. Aromatic amines: synthesis and reactivity. Diazonium salts: preparation, reactivity and synthetic usefulness. Arylsulphonic acids: mechanism of sulphonation and synthetic utility. Aromatic halogen derivatives: synthesis. Aromatic nucleophilic substitution. Cross-coupling reactions catalyzed by transition metals. Phenols and phenol ethers. Synthesis of Kolbe, reactions with formaldehyde, of ReimerTiemann, of coupling with diazonium salts. Quinones: synthesis and reactivity, oxidation-reduction equilibria.

b) Polynuclear carbocyclic aromatic systems (2 hours). Biaryls. Naphthalene: synthesis and electrophilic substitution reactions. Anthracene and phenanthrene.

c) Heteroaromatic systems (6 hours). Nomenclature and main properties. Klopman-Salem relationship. Regiochemistry of the electrophilic substitution reaction through the theory of molecular orbitals. Pentatomic monohetero systems: nomenclature, properties, synthesis and reactivity. Hexatomic mono- and polyethero systems: nomenclature, properties, synthesis and reactivity. Pentatomic polyethero systems: overview. Natural derivatives of biological importance.

Prerequisites

General Chemistry (1st year). Organic Chemistry I (1st year).

Teaching form

21 2-hour lessons in person delivered didactics
0 2-hour lessons remotely delivered didactics

Type: lectures and exercises

Number of hours delivered remotely (synchronous, without recording). Target: to reach a larger number of students in the presence of lectures with communications and content of particular interest to all students; can also be delivered in the afternoon-evening to better achieve the goal)

Textbook and teaching resource

P. Y. Bruice, Organic Chemistry, Edises
A. Abbotto, N. Manfredi, O. Bettucci, Chimica Organica, Scienza Express, 2025 (only italian)
A. Abbotto, G. Pagani - Chimica Eterociclica, Piccin (only italian)

Semester

Second year, first (fall) semester

Assessment method

The exam consists of an oral test. The oral test can be taken during any of the exam sessions throughout the year. It includes several questions covering all topics addressed in the course. The duration is approximately 1 hour.

The oral test may include written parts (on a blackboard or on paper) in front of the examination committee.

The oral test (including the written presentation assessment) aims to evaluate: the level of acquired knowledge; the ability to analyze and make judgments independently; the student's communication skills; the accuracy and clarity of the presentation and description of concepts and knowledge both orally and in writing.

It is mandatory to register for the oral exams on the official exam board. Students who are not registered will not be admitted to the tests.

The following grading criteria are applied based on these parameters:

1. Conceptual knowledge and understanding
2. Ability to apply knowledge and understanding
3. Communication and argumentative skills
4. Learning ability, self-assessment, and self-regulation

Grade 14-17

Conceptual Knowledge and Understanding
The student identifies only partially the characteristics of the concepts covered in the course. Connections between concepts are fragmented and poorly supported by theoretical knowledge.

Ability to Apply Knowledge and Understanding
The student identifies only some relevant elements of a phenomenon without integrating them into a comprehensive analysis.

Communication and Argumentative Skills
In the oral test, the student provides a basic argument, lacking logical articulation and characterized by numerous inaccuracies.

Learning Ability, Self-assessment, and Self-regulation
The student is able to reconstruct only some aspects of their learning and professional development.

Grade 18-22

Conceptual Knowledge and Understanding
The student recognizes and describes most of the conceptual characteristics of the course content and provides a relatively coherent explanation, although with some inaccuracies. Theoretical references are present but not always rigorously applied.

Ability to Apply Knowledge and Understanding
The student can identify a significant number of elements and provide a partial explanation, though showing some gaps in analysis.

Communication and Argumentative Skills
In the oral test, the student constructs a basic argument with a minimal structure but with some inaccuracies.

Learning Ability, Self-assessment, and Self-regulation
The student demonstrates basic awareness of their learning path, establishing essential connections between learning components, albeit with some inaccuracies.

Grade 23-27

Conceptual Knowledge and Understanding
The student demonstrates a thorough understanding of the conceptual characteristics of the course content. In the oral test, explanations are well-structured 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 and/or concept. The application of knowledge is methodologically rigorous, though not always entirely consistent.

Communication and Argumentative Skills
In the oral test, the student develops a coherent and well-organized argument, demonstrating good command of the language and a solid logical-argumentative structure. Communication is clear and effective.

Learning Ability, Self-assessment, and Self-regulation

The student analyzes their learning path clearly and systematically, highlighting significant relationships between different stages of learning and demonstrating a good ability for critical reflection.

Grade 28-30

Conceptual Knowledge and Understanding
The student exhibits complete mastery of the concepts covered in the course, articulating complex connections and providing comprehensive explanations. Theoretical references are used with accuracy and rigor.

Ability to Apply Knowledge and Understanding
The student demonstrates advanced analytical skills in interpreting and understanding a phenomenon and/or concept, identifying and interpreting all the key elements comprehensively. The application of knowledge is methodologically rigorous, supported by solid and articulated reasoning.

Communication and Argumentative Skills
In the oral test, the student presents a solid and well-structured argument, with a rigorous logical framework and a high level of textual coherence. The speech is fluent and well-organized.

Learning Ability, Self-assessment, and Self-regulation
The student demonstrates an advanced capacity for self-reflection, providing a detailed and in-depth analysis of their learning and professional development. The connections between learning stages and theoretical concepts are clear, coherent, and rigorous.

To ensure a transparent evaluation, the criteria adopted for the exam assessment are presented here.
Oral test: questions on at least two main concepts covered in the course and further inquiries on additional topics addressed during the test, including the knowledge of related concepts.

The final grade is given out of thirty.

Statistics

Data collected since the academic year 2005-06.

Average final exam grade: 25/30.

Office hours

Monday to Friday upon e-mail request

Sustainable Development Goals

QUALITY EDUCATION