

**Synthetic Methods**

Code: 102527  
ECTS Credits: 6

Degree	Type	Year	Semester
2502444 Chemistry	OB	3	1

## Contact

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## Teaching groups languages

You can check it through this [link](#). To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

## Teachers

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## Prerequisites

Considering that the content of this course is a continuation and extension of the matter in Structure and Reactivity of Organic Compounds (SROC), we strongly recommend to pass this course previously to enrolling to Synthetic Methods.

## Objectives and Contextualisation

Deepen the study of the reactivity of organic compounds, considering the following aspects:

1. Studying new methods for carbon-carbon and carbon-heteroatom bond formation and for functional group interconversion.
2. Studying reaction mechanisms: kinetic and non-kinetic tools and theoretical models.
3. Studying the influence of reaction conditions on selectivity and yield.
4. Facilitating synthetic tools to the students to be able of designing synthetic paths of new organic compounds from simple, commercially available precursors.

## Competences

- Adapt to new situations.

- Apply knowledge of chemistry to problem solving of a quantitative or qualitative nature in familiar and professional fields.
- Be ethically committed.
- Communicate orally and in writing in one's own language.
- Have numerical calculation skills.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Manage, analyse and synthesise information.
- Obtain information, including by digital means.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Resolve problems and make decisions.
- Show an understanding of the basic concepts, principles, theories and facts of the different areas of chemistry.
- Show initiative and an enterprising spirit.
- Show motivation for quality.
- Show sensitivity for environmental issues.
- Use IT to treat and present information.
- Work in a team and show concern for interpersonal relations at work.

## Learning Outcomes

1. Adapt to new situations.
2. Be ethically committed.
3. Communicate orally and in writing in one's own language.
4. Describe the different types of isomerism in organic compounds.
5. Describe the mechanisms of the principal organic reactions and the various factors that affect them.
6. Describe the most relevant synthetic methodologies for the inter-conversion of functional groups and the formation of simple and multiple carbon-carbon bonds.
7. Determine and represent the configuration of chiral centres in organic compounds.
8. Have numerical calculation skills.
9. Identify the basic reactivity associated with the various functional organic groups.
10. Identify the functional groups of the principal natural organic products and their most important reactions.
11. Identify the isometric relationship between different structures of organic compounds.
12. Learn autonomously.
13. Manage the organisation and planning of tasks.
14. Manage, analyse and synthesise information.
15. Obtain information, including by digital means.
16. Predict the reactivity of different organic functional groups under certain reaction conditions, as well as the structure of the products obtained.
17. Propose creative ideas and solutions.
18. Propose reaction mechanisms in processes involving organic compounds.
19. Propose simple synthetic methods to obtain certain organic compounds from certain reagents.
20. Reason in a critical manner
21. Resolve problems and make decisions.
22. Show initiative and an enterprising spirit.
23. Show motivation for quality.
24. Show sensitivity for environmental issues.
25. Use IT to treat and present information.
26. Work in a team and show concern for interpersonal relations at work.

## Content

Lesson 1. C-C bond formation from compounds with active methylene e groups: Enolates formation. Regioselectivity. Kinetic and thermodynamic control. Elements influencing this process (base -counter ion-, solvent). C versus O reactivity. Formation of lithium enolates, silyl enol ethers, enamines and azaenolates; application to alkylation reactions. Directed aldol additions and acylations. The Knoevenagel reaction. Aldehyde alkylation using dithianes. The Mannich reaction. Conjugate additions. The Robinson's anelation.

Lesson 2. C-C bond formation via organometallic reagents: General properties of organo-lithium and organo-magnesium compounds. The Felkin-Anh model. Organo-cuprates. The Reformatsky reaction. Palladium promoted reactions.

Lesson 3. C=C bond formation: Thermal b-eliminations: the Hofmann and Cope elimination reactions, elimination from selenoxides. The Wittig reaction: types of ylides, preparation, reactivity and stereoselectivity. The Horner-Wardsworth-Emmons reaction. Sulphur ylides: types, preparation and reactivity. The metathesis reaction of alkenes.

Lesson 4. C-C bond formation through concerted reactions: Molecular frontier orbitals. The Woodward-Hoffman selection rules. Electrocyclic reactions. Thermal and photochemical [2+2] cycloadditions. The Diels-Alder reaction: region- and stereoselectivity. [3,3] Sigmatropic processes: Cope and Claisen rearrangements.

Lesson 5. Reactions through highly reactive intermediates: Radical intermediates: addition of thiols to alkenes. Cationic intermediates: the Wagner-Meerwein rearrangements, cyclisations. Carbenes: preparation and reactivity, cyclopropanation, the Simmons-Smith reaction, the Wolff rearrangement, the Arndt-Eistert homologation. Nitrenes: preparation and reactivity, the Curtius, Schmidt, Hofmann and Beckmann rearrangements.

Lesson 6. Reduction reactions: Hydrogenation: heterogeneous and homogenous catalysis. Boron and aluminum hydrides: selectivity. Reductive amination. Reduction with alkaline metals in solution: the Birch and Bouveault-Blanc reactions, dehalogenation. Deoxygenation: the Clemensen and Wolff-Kishner reactions. Desulphuration of dithianes.

Lesson 7. Oxidation reactions: Oxidation of alcohols: Cr(VI) reagents,  $MnO_2$ , the Swern and Dess-Martin reactions. Oxidation of alkenes:  $KMnO_4$ ,  $OsO_4$ , peroxides and peracids, the Sharpless asymmetric epoxidation, oxidative cleavage. Oxidation of aldehydes and ketones: to carboxylic acids and the Baeyer-Villiger reaction.

Lesson 8. Methods to investigate reaction mechanisms. Effect of the molecular structure on reactivity: Kinetic and thermodynamic data. The Curtin-Hammett principle. Kinetic isotope effect. Introduction to Hammett's correlations. Non-kinetic methods: product identification; isotopic labeling; crossing experiments; stereochemical data; detection/trapping of intermediates.

Tema 9. Organic Synthesis. Introduction to retrosynthetic analysis. Synton concept. Linear synthesis and convergent synthesis. Chemo-, region- and stereoselectivity. Protection of functional groups.

## Methodology

The Virtual Campus will be used for delivering the necessary material to the students, according to the professor criterion. This material will include: the course program, exercises and problems to be solved, copies of the classroom presentations, etc.

Along the course, the student should participate in various formative activities, with the aim of acquiring the established knowledge and skills. Four kind of activities will be developed:

1.- In-person theoretical classes

In a part of the classroom session, the professor will explain the basic knowledges of the matter of each lesson, in which the students should later work on individually, consulting the appropriate bibliography. Time will also be devoted to solving students' doubts and discussing the most relevant aspects of each topic.

## 2.- In-person problem classes

Over the course, the student will receive a collection of exercises and problems to be solved autonomously. Their solution proposals will be discussed in the classroom. Special emphasis will be done in their active participation.

## 3.- Resolution of exercises to be delivered (individual work)

Over the course, the professors will distribute some exercises that should be solved by the students and returned in face-to-face sessions or telematically on due date.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

## Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Master classes	37	1.48	1, 12, 3, 22, 23, 4, 5, 6, 7, 13, 14, 10, 9, 11, 2, 24, 15, 16, 17, 18, 19, 20, 26, 25
Problem and exercise classes	12	0.48	1, 12, 3, 22, 23, 4, 5, 6, 7, 13, 14, 10, 9, 11, 2, 24, 15, 16, 17, 18, 19, 20, 21, 8, 26, 25
Type: Autonomous			
Preparing exercises to hand in	5	0.2	1, 12, 3, 22, 23, 4, 5, 6, 7, 13, 14, 10, 9, 11, 2, 24, 15, 16, 17, 18, 19, 20, 21, 8, 26, 25
Studying, problem solving	82	3.28	

## Assessment

With the aim of encouraging the constant student work to favor the learning, a continuous evaluation will be applied. This methodology will inform the professor about the content's assimilation by the student as well as their ability to apply them to problem solving. The evaluation will be individual.

Exercise handing in:

Along the course, on professor criterion, the students will have to solve some exercises in the classroom or hand them in at the scheduled date. These exercises may include matter of the previous Organic Chemistry courses. Overall, this work will contribute in a 10% to the final mark of the continuous evaluation.

In order to evaluate the knowledge related to the master classes and the problem-solving ability of the students, two partial exams will be performed.

### First Partial Exam

This exam will evaluate the contents of approximately a 50% of the course program. The exam will formulate questions either theoretical or practical (problems) and will contribute in a 45% to the final mark of the

continuous evaluation (this will depend on the contents evaluated). In this exam a minimum of 4 points out of 10 must be obtained to be able to average the other qualifications of the evaluation.

### Second Partial Exam

This exam will evaluate the contents of approximately a 50% of the course program. The exam will formulate questions either theoretical or practical (problems) and will contribute in a 45% to the final mark of the continuous evaluation (this will depend on the contents evaluated). In this exam a minimum of 4 points out of 10 must be obtained to be able to average the other qualifications of the evaluation.

To pass the course in the first instance, it will be mandatory obtaining 5 points out of 10 after averaging all the qualifications resulting of the continuous evaluation (2 exams and exercises handing in).

### Second-chance Examination

The students who did not pass the continuous evaluation will have the opportunity to perform a second-chance exam. To pass the course, it will be mandatory obtaining 5 points out of 10 in the second-chance exam and the final qualification will be, in this case, the weighted average between the mark of this exam and the mark of the exercises (10%).

\* The students who did not pass the continuous evaluation, but have obtained a minimum of 6 points out of 10 in one of the partial exams, will be exempt of doing the corresponding part of the second-chance exam and will keep the same mark for averaging with the other marks of the evaluation.

*To be eligible for the second-chance exam, any student should have been previously evaluated in a set of activities corresponding to a minimum of 2/3 of the overall qualification of the course. Hence, it will be mandatory to make the two partial exams to be entitled to the recovery of any of them.*

Single evaluation: Students who have taken the single evaluation modality will have to take a final exam which will consist of an examination of the entire subject to be carried out the same day of the second partial exam for the rest of students with continuous evaluation. The student's grade will be the mark of this exam, which will be mandatory obtaining 5 out of 10 to pass the subject. If the final grade does not reach 5, the student has another opportunity to pass the course through the second-chance examination that will be held on the day of the second-chance examination for the students with continuous evaluation. The student's grade will be the mark of this exam, which must be 5 out of 10 to pass the course.

## Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exercise handing in	10 %	4	0.16	1, 12, 3, 22, 23, 4, 5, 6, 7, 13, 14, 10, 9, 11, 2, 24, 15, 16, 17, 18, 19, 20, 21, 26, 25
Partial and second-chance exams	90%	10	0.4	1, 12, 3, 22, 23, 4, 5, 6, 7, 13, 14, 10, 9, 11, 2, 24, 15, 16, 17, 18, 19, 20, 21, 8, 26, 25

## Bibliography

### Text books:

Organic Chemistry (2nd Ed) de J. Clayden, Nick Greeves, S. Warren i P. Wothers. Oxford U. P. Oxford New York, 2012. ISBN: 978-0-19-927029-3.

Advanced Organic Chemistry: Part B: Reaction and Synthesis, Francis A. Carey and Richard J. Sundberg. Fifth Edition, Springer.

